IN REPLY REFER TO:

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
WASHINGTON 25, D. C.

November 27, 1956

AEC - 199/7

Mr. Robert D. Nininger
Assistant Director for Exploration
Division of Raw Materials
U. S. Atomic Energy Commission
Washington 25, D. C.

Dear Bob:

Transmitted herewith are three copies of TEI-447, "Proposed nomenclature of part of Upper Triassic strata in southeastern Utah," by John H. Stewart, September 1956.

On September 12, 1956, Mr. Hosted approved our plan to submit this report for publication in the Bulletin of the American Association of Petroleum Geologists.

Sincerely yours,

John H. Eric

for W. H. Bradley
Chief Geologist

Geology and Mineralogy

This document consists of 51 pages.
Series A

UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

PROPOSED NOMENCLATURE OF PART OF UPPER TRIASSIC STRATA IN SOUTHEASTERN UTAH*

By

John H. Stewart

September 1956

Trace Elements Investigations Report 447

This preliminary report is distributed without editorial and technical review for conformity with official standards and nomenclature. It is not for public inspection or quotation.

*This report concerns work done on behalf of the Division of Raw Materials of the U. S. Atomic Energy Commission.

USGS - TEI-447

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PROPOSED NOMENCLATURE OF PART OF UPPER TRIASSIC STRATA IN SOUTHEASTERN UTAH

By John H. Stewart

ABSTRACT

The Triassic rocks in southeastern Utah have previously been divided into the Moenkopi formation of Early and Middle(?) Triassic age, and the Shinarump conglomerate, Chinle formation, and Wingate sandstone of Late Triassic age. Recent work has shown that the strata called Shinarump conglomerate in southeastern Utah consist, in places, of a lower sandstone and conglomerate unit, a middle claystone and clayey sandstone unit, and an upper sandstone and conglomerate unit. The lower and upper units are "Shinarump-type" deposits whereas the middle unit is a "Chinle-type" deposit. Deposits of "Shinarump type" and "Chinle type" are interstratified and intertonguing. The author proposes that the two types be grouped together in the Chinle formation and that the Shinarump conglomerate be redefined as the Shinarump member of the Chinle formation. The lower unit correlates with strata in southwestern Utah, originally designated as type Shinarump conglomerate, and the author proposes that the term Shinarump member be restricted in southeastern Utah to this lower unit. The middle and upper units, although formerly included in the Shinarump conglomerate, are considered as separate members of the Chinle formation. The middle unit has been defined as the Monitor Butte member of the Chinle formation and the name Moss Back member is here proposed for the upper unit.

In southeastern Utah the Shinarump conglomerate included, in places, all of the Shinarump, Monitor Butte, and Moss Back members of the Chinle formation. In other places, the Shinarump conglomerate consisted only of the Moss Back member, and in still other parts of southeastern Utah the Shinarump conglomerate consisted of just the Shinarump member. Locally in the San Rafael Swell area, Emery County, a thin unit now called Temple Mountain member was included by previous workers in the Shinarump conglomerate.

In addition to subdividing the strata previously included in the Shinarump conglomerate, the overlying part of the Chinle formation has been subdivided into members. As now recognized, the Chinle formation consists of seven members in southeastern Utah. They are, in ascending order, the Temple Mountain, Shinarump, Monitor Butte, Moss Back, Petrified Forest, Owl Rock, and Church Rock members.

INTRODUCTION

Recent geologic study in southeastern Utah has yielded new information on the stratigraphy of the Shinarump conglomerate and Chinle formation, both of Late Triassic age, and has led to a reappraisal of the nomenclature of these strata. This report proposes changes in the nomenclature of the Shinarump conglomerate and the Chinle formation and summarizes the new knowledge of these formations.

The field work on the stratigraphy of the Shinarump conglomerate and Chinle formation was done during the field seasons of 1952-54, in connection with a regional study of all the Triassic

rocks in the Colorado Plateau province and adjoining regions (fig. 1). This study was made by the U. S. Geological Survey on behalf of the Division of Raw Materials of the U. S. Atomic Energy Commission.

The author is indebted to many geologists of the U. S. Geological Survey and the U. S. Atomic Energy Commission for valuable suggestions concerning the geology. G. A. Williams, L. C. Craig, H. F. Albee, O. B. Raup, F. G. Poole, and R. F. Wilson worked on various parts of the study. Their specific contributions are acknowledged, where possible, in the text, but these people also have contributed in many other phases of the work and their help is gratefully acknowledged. The author is also indebted to the geologists of the geologic mapping programs of the U. S. Geological Survey. Many of the details of the distribution of some of the Upper Triassic units were taken from unpublished maps of parts of southeastern Utah: particularly from maps by T. E. Mullens in the Clay Hills area; A. F. Trites, Jr., in the White Canyon area; R. Q. Lewis, Sr., in the Elk Ridge area; F. A. McKeown in the Orange Cliffs area; and R. C. Robeck in the San Rafael Swell area.

PROPOSED NOMENCLATURE

The Triassic rocks in southeastern Utah have previously been divided into the Moenkopi formation of Early and Middle(?) Triassic age, and the Shinarump conglomerate, Chinle formation, and Wingate sandstone of Late Triassic age. Recent work on the Colorado Plateau has shown that the strata called Shinarump conglomerate in southeastern Utah consist, in places, of a lower sandstone and conglomerate unit,

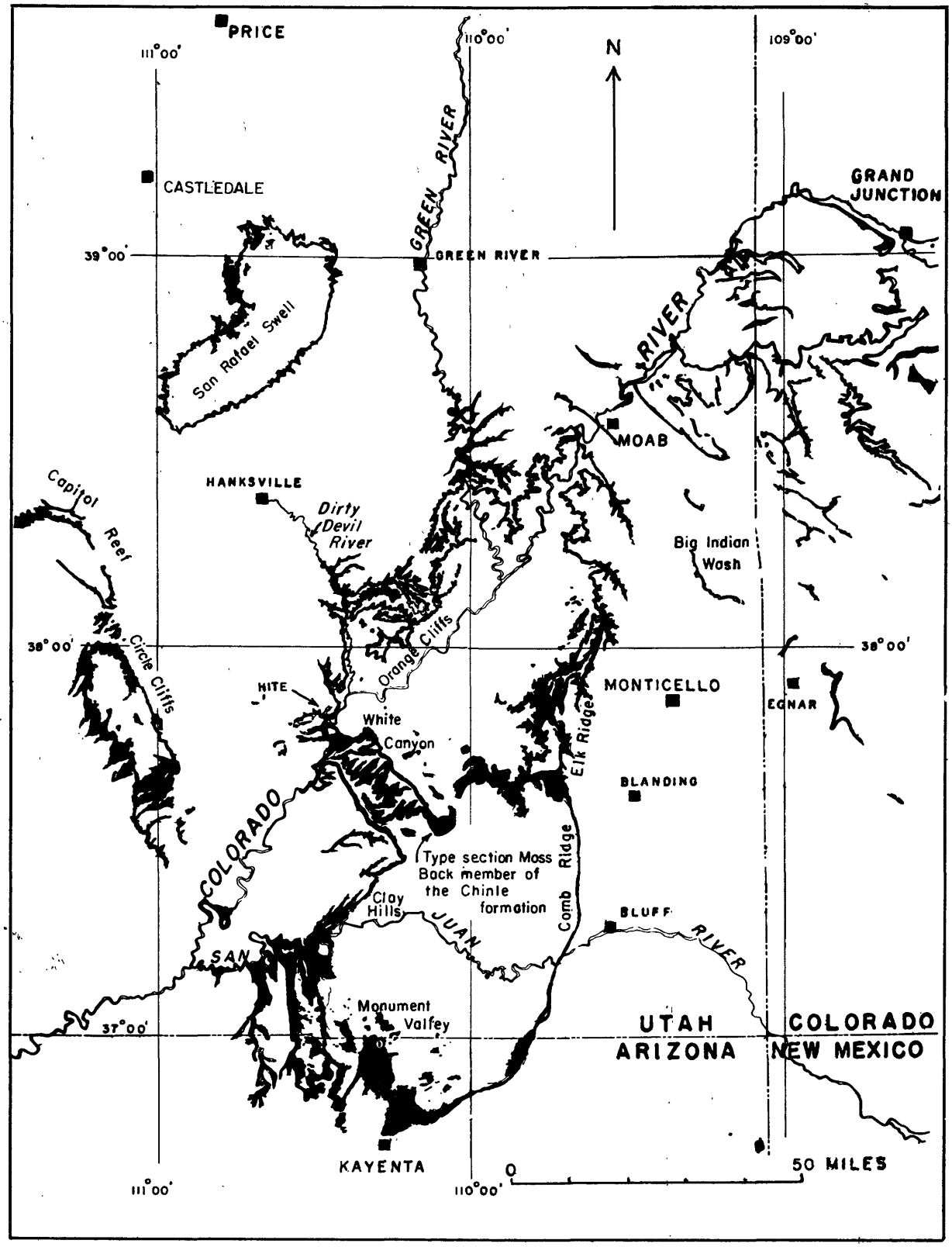


FIGURE 1.--INDEX MAP SHOWING OUTCROP OF CHINLE FORMATION.

a middle claystone and clayey sandstone unit, and an upper sandstone and conglomerate unit. These units are independent, distinctive, and persistent over large areas of the Plateau. Only the lower two units are present in the southern part of southeastern Utah. All three units are present in the White Canyon area and the southern part of the Elk Ridge area. Northward from White Canyon and the southern part of Elk Ridge, the upper unit overlaps the lower two and this upper unit is the only one of the three present in the northern part of southeastern Utah.

The two sandstone and conglomerate units are deposits of "Shinarump type", that is, thin widespread ledge-forming conglomerate beds lithologically similar to the Shinarump conglomerate originally described by Powell (1873) and Gilbert (1875). The middle claystone and clayey sandstone unit is a deposit of "Chinle type," that is, variegated slope-forming beds lithologically similar to the Chinle formation defined by Gregory (1917). In southeastern Utah, deposits of the "Shinarump type" and "Chinle type" are closely associated and interstratified. In other parts of the Colorado Plateau, "Shinarump-type" rocks are present not only at the base of the Upper Triassic rocks but also in the middle part of the Chinle formation. Individual units of "Shinarump-type" rock intertongue extensively with "Chinle-type" rocks.

The nomenclature of the Shinarump conglomerate and Chinle formation is greatly simplified if these closely related and interstratified types of rock are considered as part of the same formation. The author proposes, therefore, that both the "Shinarump-type"

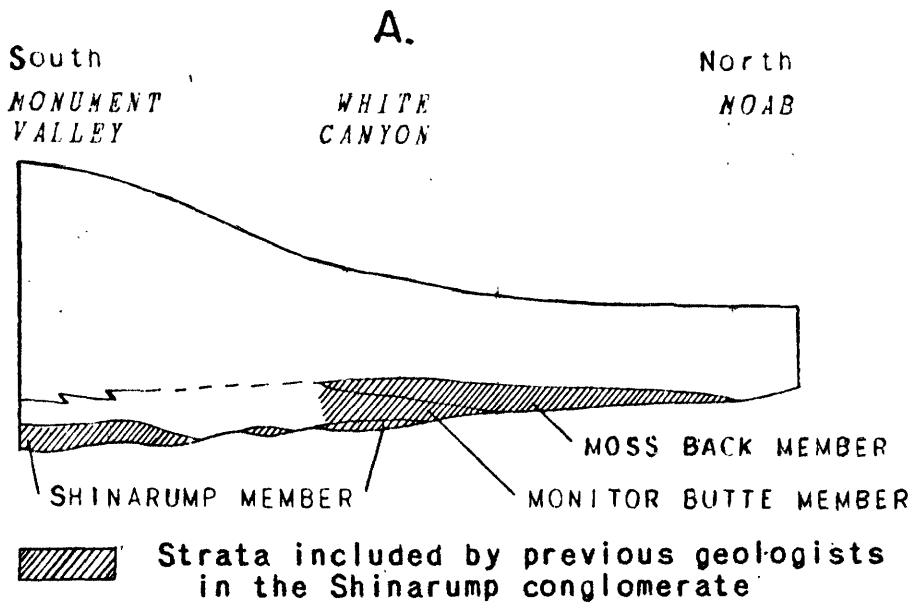
and Chinle-type" rocks be grouped together in the Chinle formation and that the Shinarump conglomerate be redefined as the Shinarump member of the Chinle formation. The word conglomerate is omitted from the Shinarump member because in many places the Shinarump is a sandstone and contains only minor amounts of conglomerate. Although this paper deals mainly with southeastern Utah, the author feels that the term Shinarump member of the Chinle formation should replace the term Shinarump conglomerate everywhere, and the term Shinarump member is so used in this report. The Shinarump member has the same type area, the Kanab area, Kane County, Utah, as the unit formerly called the Shinarump conglomerate.

In the past, the name Shinarump conglomerate has been applied to any sandstone or conglomerate unit resting on the Moenkopi formation regardless of whether this unit could be correlated with certainty with the type Shinarump conglomerate. The term Shinarump conglomerate was used in a broad and loose sense to describe the occurrence of "Shinarump-type" rocks below "Chinle-type" rocks. The use of the term Shinarump was not meant to imply a close correlation of all the units called Shinarump. The author proposes, in order to make a more exact nomenclature, that the Shinarump member be restricted to strata that can be correlated, with reasonable certainty, with the type Shinarump. Where correlations are less certain or where units can be shown to be distinct from the Shinarump, other names should be applied.

The lower sandstone and conglomerate unit in southeastern Utah is correlated with the type Shinarump. The name Shinarump member, therefore, is restricted to this lower sandstone and conglomerate unit. The middle claystone and clayey sandstone unit and the upper sandstone and conglomerate unit are separate from strata that correlate with the type Shinarump, and they are considered to be separate members of the Chinle formation. The middle claystone and clayey sandstone unit has been defined as the Monitor Butte member of the Chinle formation in a report currently being prepared by I. J. Witkind and R. E. Thaden. The name Moss Back member of the Chinle formation is here proposed for the upper unit of sandstone and conglomerate.

Following the practice of applying the name Shinarump conglomerate to any sandstone or conglomerate unit that rests on the Moenkopi formation, previous geologists have applied the name Shinarump conglomerate, in the southern part of southeastern Utah, to the unit called Shinarump member in this report (fig. 2). In this part of southeastern Utah, the Shinarump member is the only "Shinarump-type" unit present. In the White Canyon area and the southern part of the Elk Ridge area, the Shinarump conglomerate, in places, included all of the Shinarump, Monitor Butte, and Moss Back members. In the area near the junction of the Green and Colorado Rivers, the Shinarump conglomerate of previous authors is the Moss Back member. In this area, the Moss Back member is the only "Shinarump-type" unit present.

Locally in the San Rafael Swell area, a thin unit now called the Temple Mountain member (Robeck, 1956) was included by previous workers in the Shinarump conglomerate.



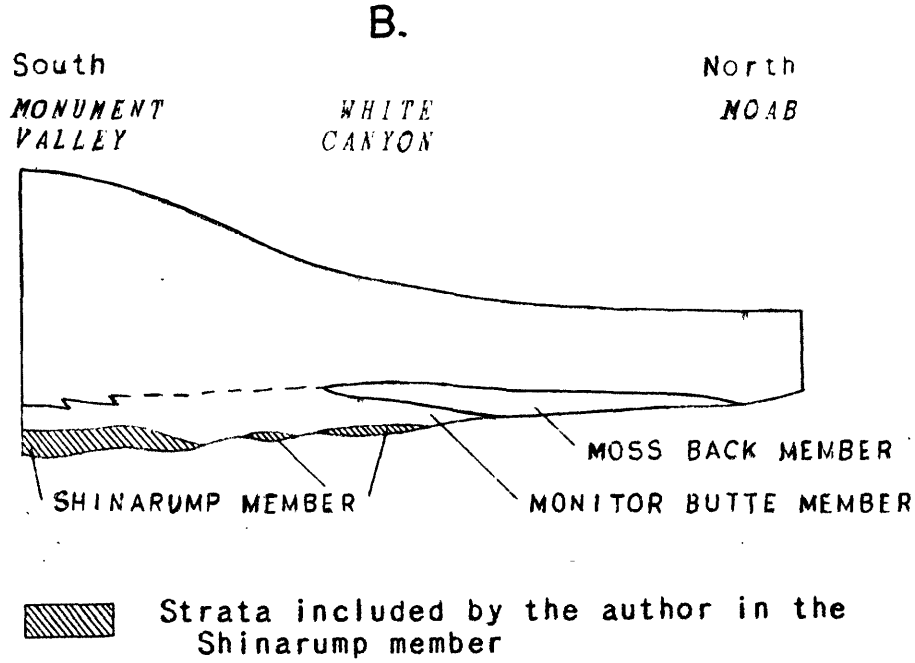


FIGURE 2.--GENERALIZED CROSS SECTIONS SHOWING, IN DIAGRAM A, STRATA INCLUDED BY PREVIOUS GEOLOGISTS IN SHINARUMP CONGLOMERATE AND, IN DIAGRAM B, STRATA INCLUDED BY THE

In addition to subdividing the strata previously included in the Shinarump conglomerate, the overlying part of the Chinle formation has been subdivided into members. These members are in ascending order, the Petrified Forest, Owl Rock, and Church Rock members of the Chinle formation. The Petrified Forest member is distinguished by bright-colored variegated bentonitic claystones and clayey sandstones that commonly weather to form badlands. The Owl Rock member is composed of pale-red, dominantly nonbentonitic siltstone and light-greenish-gray and pale-red limestone. The Church Rock member is noticeable as a reddish or brownish siltstone and sandstone unit lying above the limestones of the Owl Rock member.

STRATIGRAPHY OF CHINLE FORMATION IN SOUTHEASTERN UTAH

The Chinle formation is a brightly colored slope-forming unit composed of claystone, siltstone, sandstone, conglomerate, and minor amounts of limestone and limestone-pebble conglomerate. Gregory (1917, p. 42) named the Chinle formation for exposures in Chinle Valley, Apache County, Ariz.

The Chinle formation unconformably overlies the Moenkopi formation. The Moenkopi is composed of pale-reddish-brown[1] horizontally laminated

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[1] Color names used in this report are mostly after rock-color chart prepared by "Rock Color Chart Committee," E. N. Goddard and others, National Research Council, Washington 25, D. C., 1948.

and ripple-laminated[1] siltstone and some beds of very fine grained cross-stratified sandstone. In the Big Indian Wash and Egnar areas (fig. 1) the Moenkopi formation is absent, and the Chinle formation rests unconformably on the arkosic sandstone of the Cutler formation of Permian age.

[1] Stratification terminology used in this report is mostly after McKee and Weir, 1953.

The Chinle formation is disconformably overlain by the Wingate sandstone. The Wingate is composed of light-brown very fine grained sandstone which is cross-stratified on a large scale.

The Chinle formation in southeastern Utah is composed, in ascending order, of the Temple Mountain, Shinarump, Monitor Butte, Moss Back, Petrified Forest, Owl Rock, and Church Rock members. In most areas the Shinarump and Moss Back members are distinctive units. The lithologic differences between the Monitor Butte, Petrified Forest, Owl Rock, and Church Rock members, however, are small in some areas, and locally separation is extremely difficult or even impossible. These members intertongue and intergrade making it necessary in some places to raise or lower defined contacts as much as 100 feet in a lateral distance of a few thousand feet.

The thickness of the Chinle formation is about 1,200 feet in the Monument Valley area. The formation thins gradually northward to about 300 feet in central and east-central Utah. This thinning

is mostly caused by the northward pinchout of the Shinarump, Monitor Butte, Moss Back, and Petrified Forest members (figs. 3 and 4). The combined thickness of the Owl Rock and Church Rock members remains relatively constant in southeastern Utah.

More detailed descriptions and interpretations of origin of the members of the Chinle formation are given in a report by Stewart and others, in preparation.

Temple Mountain member

The Temple Mountain member has been named by Robeck (1956) in the San Rafael Swell. Possibly some strata outside of the Swell may correlate with the Temple Mountain member, but these correlations are questionable, and the author believes the term Temple Mountain member should be restricted, at present, to the San Rafael Swell. Locally, strata similar to the Temple Mountain member underlie the Shinarump member, suggesting that the Temple Mountain member of the Swell may be the oldest member of the Chinle formation.

The Temple Mountain member consists mostly of mottled purple, reddish-brown, and white structureless siltstone containing scattered well-rounded medium to coarse quartz grains. Lenses of jasper and of greenish carbonaceous claystone are commonly present in the member.

Locally irregular lenses of light-gray, light greenish-gray, or, rarely, reddish-purple sandstone are present in the Temple Mountain member. The sandstone is cross-stratified, and ranges from very fine grained to conglomeratic in texture, but is generally medium

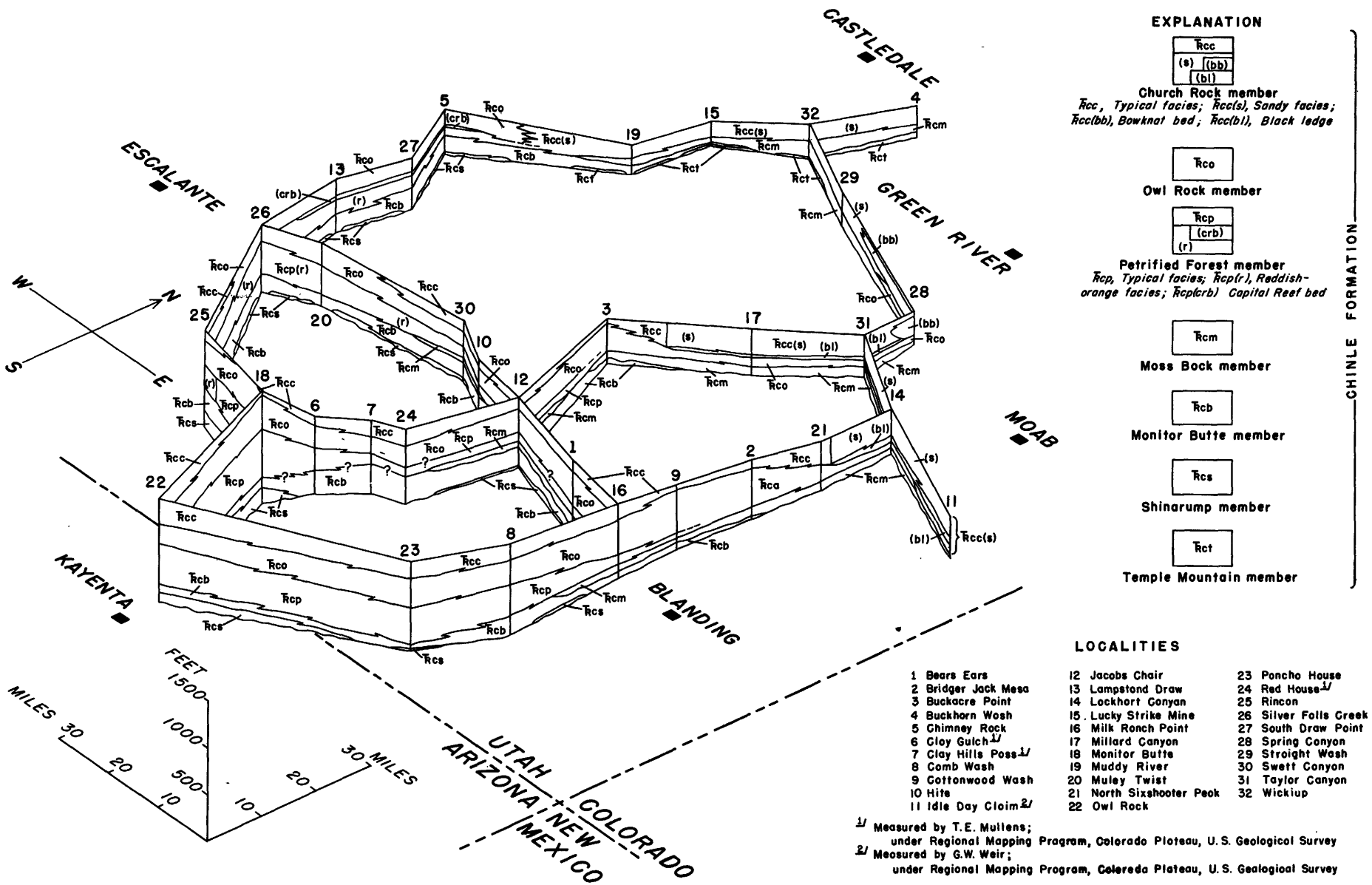


Figure 3.--FENCE DIAGRAM OF CHINLE FORMATION.

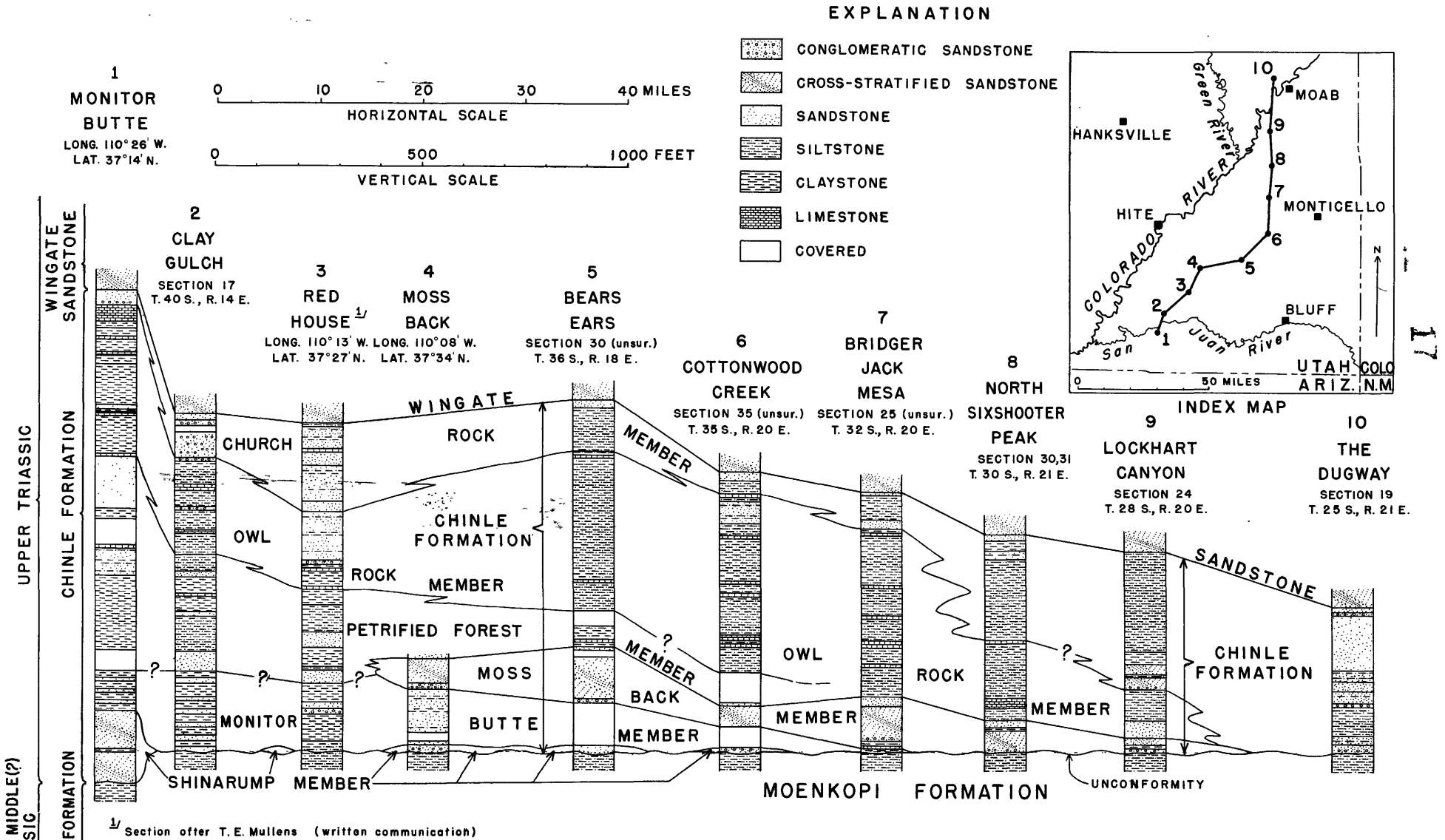


Figure 4.--SECTIONS AND CORRELATION OF CHINLE FORMATION NORTHWARD ACROSS SOUTHEASTERN UTAH.

to coarse grained. Conglomeratic portions contain granules and pebbles mostly of quartz. The sandstone is most commonly present at the base of the Temple Mountain member but may occupy any position in the member. The sandstone and conglomerate are lithologically similar to that in the Shinarump member, and possibly the sandstone and conglomerate correlate with the Shinarump of the type area. The term Shinarump, however, is not used in the Swell because of uncertainties of correlation and because the sandstone and conglomerate form an integral part of the larger more inclusive Temple Mountain member that is lithologically unlike the Shinarump.

The Temple Mountain member is distinguished in the San Rafael Swell from the overlying and underlying strata by several lithologic characteristics: the distinctive mottled purple and white coloration, the presence of medium to coarse quartz sand grains disseminated in the siltstone, the presence of sandstone containing coarse quartz pebbles, and the presence of iron oxide pebbles, carbonaceous material, and lenses of jasper (Robeck, 1956). The Temple Mountain member averages about 20 feet in thickness.

The Temple Mountain member unconformably overlies the Moenkopi formation. It underlies the Monitor Butte member in the southern part of the Swell and the Moss Back in the northern part. The contact between the Temple Mountain and the Monitor Butte is conformable. The contact between the Temple Mountain and Moss Back is a surface of erosion, but the surface is not considered by the author to represent a significant break in deposition.

Shinarump member

The unit that previously has been called the Shinarump conglomerate was first noted by Powell (1873, p. 458). Powell selected the type locality (the Kanab area, Kane County, Utah), and applied the name Shinarump Cliffs to the topographic feature of the unit, but did not apply the name Shinarump conglomerate to the unit. Gilbert (1875, p. 176) was the first to use the name Shinarump conglomerate. Powell (1876), proposed the term "Shinarump group" for the strata that correspond, in general, with the units now called Moenkopi and Chinle formations (including the Shinarump member as used in this report). Gregory (1913) proposed that the Shinarump conglomerate should be considered a formation. Later workers adopted the term Moenkopi formation for the lower part of the "Shinarump group" and Gregory (1917, p. 42) proposed the term Chinle formation for the upper part of the "Shinarump group." The term "Shinarump group" was abandoned and the name "Shinarump" was left to apply to the conglomeratic unit. This report redefines the Shinarump conglomerate as the Shinarump member of the Chinle formation.

The Shinarump member is present in much of southeastern Utah. It reaches a northeastern limit along a poorly defined line passing through the middle of the Elk Ridge area, through the area near the junction of the Dirty Devil and Colorado Rivers, and probably through some point between exposures of the Chinle formation in Capitol Reef and the San Rafael Swell (fig. 5). The limit is difficult to locate, as strata correlative to the Shinarump member form thin, small

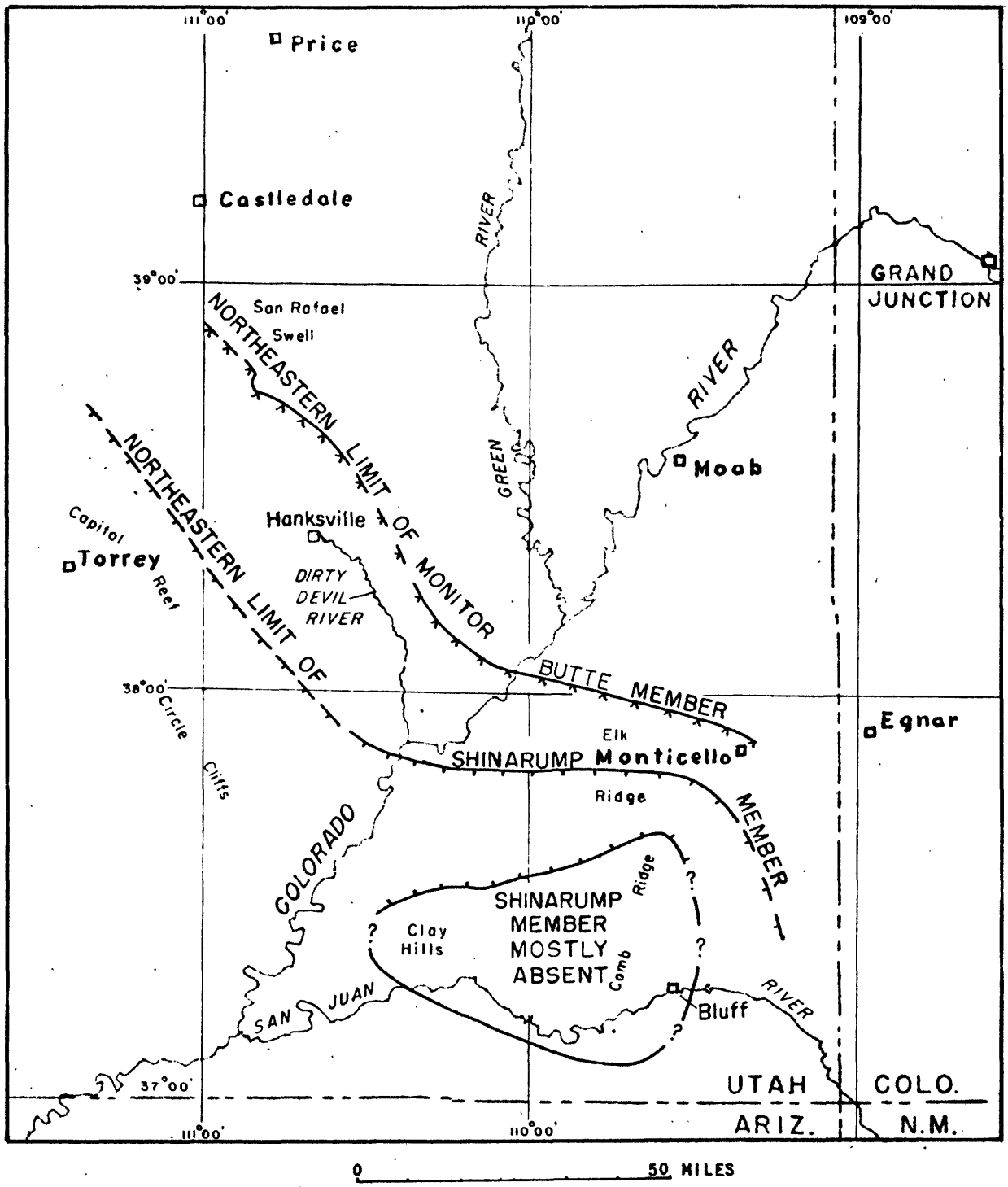


FIGURE 5.--MAP SHOWING NORTHEASTERN LIMIT OF SHINARUMP AND MONITOR BUTTE MEMBERS OF CHINLE FORMATION AND AREA WHERE SHINARUMP MEMBER IS MOSTLY ABSENT.

scattered lenses near the northern limit, and additional detailed work may find lenses north of those now known. Small lenses of sandstone and conglomerate in the Temple Mountain member in the San Rafael Swell may be the Shinarump member, but correlation of these beds with those in the type area is difficult, and the distribution of the Shinarump member in and near the Swell is not certain. The Shinarump member is thick in the Monument Valley, Circle Cliffs, and Capitol Reef areas; is thin, or in places absent, in the White Canyon area; is present as thin scattered lenses in the southern part of the Elk Ridge area; and is mostly absent in the Comb Ridge and Clay Hills areas (fig. 5). The member shows some lateral lithologic variation and probably incorporates strata that vary somewhat regionally in manner of deposition, in time of deposition, and in the source of sediments.

The Shinarump member is composed typically of yellowish-gray and pale-yellowish-orange medium-to coarse-grained sandstone. The sandstone is composed of subangular clear quartz. Lenses of conglomeratic sandstone and conglomerate containing granules and pebbles predominantly of quartz, quartzite, and chert are common. The Shinarump member consists of thin trough sets of medium-scale cross-strata and contains abundant silicified and carbonized wood. It weathers to form a vertical cliff and underlies benches.

The Shinarump member can be differentiated in many places from other sandstone units in the Chinle formation on the basis of the range of grain sizes and pebble assemblages. The sandstones in the

Shinarump member generally range from medium to coarse grained, whereas, the sandstone units in the overlying part of the Chinle generally range from very fine to medium grained. Albee (in press) describes several differences between the pebbles of the Shinarump and Moss Back members. The average ratios of quartz, quartzite, and chert are 82:16:2 for the Shinarump and 12:37:51 for the Moss Back, in areas where both units are present. Limestone and siltstone pebbles are rarely present in the Shinarump, but they are commonly present in the Moss Back. The colors of the Shinarump pebbles are generally lighter than those of the Moss Back pebbles; the Shinarump contains less gray and black pebbles and more red, orange, and white pebbles than the Moss Back. Conglomerate in Chinle units other than the Shinarump and Moss Back contains mostly siltstone and limestone pebbles and few, if any, quartz or quartzite pebbles. These conglomerates may contain a few weathered chert pebbles.

The Shinarump member ranges in thickness from a wedge-edge to 225 feet but is generally not more than 50 feet thick.

The Shinarump member overlies the Moenkopi formation except in a few places where it overlies strata possibly correlative to the Temple Mountain member. The contact of the Moenkopi and Shinarump is an unconformity, and channels cut as deep as 75 feet into the Moenkopi and filled with sediments of the Shinarump member are common. The contact between the possible Temple Mountain correlatives and the Shinarump is a surface of erosion, but the author does not consider this surface of erosion to represent a significant break in

deposition. The Shinarump conformably underlies the Monitor Butte member. In many areas the contact between the Shinarump and Monitor Butte members is transitional and intertonguing. Locally the contact is difficult to place.

The Shinarump member is recognized in many areas outside of southeastern Utah. It extends through much of northern and southern Utah and may be present in Nevada and New Mexico. Longwell (1928), Glock (1929), and Hewett (1931) have recognized Shinarump conglomerate (Shinarump member of this report) in southeastern Nevada, but the author considers this a tentative correlation. The unit mapped by Darton (1928) as the Shinarump conglomerate on the north and west sides of the Zuni uplift, west-central New Mexico, lies 400 feet above the base of the Chinle formation and was incorrectly called Shinarump conglomerate. C. A. Repenning, M. E. Cooley, and J. P. Akers (written communications) have correlated Darton's Shinarump conglomerate with the Sonsela sandstone bed of the Petrified Forest member; they have correlated a lower unit in west-central New Mexico with the Shinarump, but the author considers this correlation as tentative.

The unit called Shinarump conglomerate in northeastern Utah (Kinney, 1955) and in northern Colorado (Thomas, McCann, and Raman, 1945) is correlated by the author with strata higher stratigraphically than the type Shinarump, and the author does not feel that the term Shinarump is justified in these areas. This so-called Shinarump of northeastern Utah and northwestern Colorado may correlate with strata at the base of the Church Rock member at Moab, Utah. (See description under Church Rock member).

Monitor Butte member

The Monitor Butte member was defined in a report currently being prepared by I. J. Witkind and R. E. Thaden for exposures in southeastern Utah near the San Juan River south of the Clay Hills area.

The member is present in much of southeastern Utah and pinches out along a northwest line passing through the northern part of the Elk Ridge area and through the southern part of the San Rafael Swell (fig. 5).

The member consists of claystone and clayey sandstone with interstratified lenses of sandstone. The claystone and clayey sandstone is greenish gray and contains some pale reddish-brown parts. It is bentonitic and weathers to form a "frothy" appearing slope. The sandstone lenses are interstratified with the claystone or clayey sandstone and comprise from 5 to 20 percent of the member. Locally the sandstone lenses may be absent. The lenses are mostly 1 to 10 feet thick and about 1,000 feet wide. The sandstone is very fine grained, micaceous, well cemented, ripple laminated or rarely cross-stratified, and platy splitting. A few of the sandstone lenses are conglomeratic with pebbles of limestone, siltstone, and uncommon weathered chert. In many places, the sandstone lenses are highly contorted by many small-scale folds and faults.

The Monitor Butte member is noticeable on exposures as a greenish and sandy interval near the base of the Chinle. The lenses of sandstone are the main features by which the member can be separated from the rest of the Chinle. In some places there are no sandstone lenses, and separation of the Monitor Butte from the rest of the Chinle is difficult or even impossible.

The Monitor Butte member in southeastern Utah ranges in thickness from a wedge-edge to 250 feet thick, although in most places it is from 100 to 150 feet thick. In the San Rafael Swell it ranges in thickness from a wedge-edge to as much as 100 feet.

The Monitor Butte member conformably overlies the Shinarump member in most of southeastern Utah, and unconformably overlies the Moenkopi formation in places where the Shinarump is absent. The Monitor Butte member conformably overlies the Temple Mountain member in the San Rafael Swell. The Monitor Butte member underlies the Petrified Forest member in the southern part of southeastern Utah, and underlies the Moss Back member in the rest of southeastern Utah. The contact of the Monitor Butte and Petrified Forest members is conformable and intertonguing. The contact of the Monitor Butte and Moss Back members is a surface of erosion, but the surface is not considered to represent a significant break in deposition.

The Monument Valley area, Arizona, is the only area outside of southeastern Utah where the Monitor Butte member can be recognized. A lower member of the Chinle formation recognized by C. A. Repenning, M. E. Cooley, and J. P. Akers (written communications) in parts of northeast and east-central Arizona, exclusive of the Monument Valley area, is probably partly equivalent to the Monitor Butte member. The "D" division of the Chinle formation described by Gregory (1917, p. 43) in northeastern Arizona also corresponds to the Monitor Butte member. Gregory (1950, p. 67) recognized in northwestern Arizona and southwestern Utah a unit called the "lower sandstones" of the Chinle formation, and this unit may correlate with the Monitor Butte member.

Moss Back member

The Moss Back member of the Chinle formation is named for a topographic feature in the eastern part of the White Canyon area, San Juan County, Utah (fig. 1). The Moss Back, as shown on the Natural Bridges, Utah, topographic map of the U. S. Geological Survey, is a northwest-trending ridge capped by three conspicuous buttes. The Moss Back member is exposed on a part of the ridge and is the resistant stratum forming an extensive bench directly east of the ridge. The type section (see appendix and figs. 1 and 6) of the Moss Back member is located at longitude 110° 08' 51" W. and latitude 37° 34' 46" N. on the northwesternmost part of the ridge.

The Moss Back member forms a northwest-trending lens about 50 miles wide and 155 miles long (fig. 7), extending from near the Utah-Colorado State line to central Utah. The Moss Back is discontinuous near its northern limit in the area near the junction of the Green and Colorado Rivers, and is absent in two places within the main part of the lens; one place is in the western part of the White Canyon area and the other is near the junction of the Dirty Devil and Colorado Rivers.

Correlation of the Moss Back member with rocks in the Big Indian Wash and Egnar areas is tentative. Strata in the Big Indian Wash and Egnar areas which occupy the same stratigraphic position as the Moss Back are finer grained and contain more claystone and siltstone lenses than typical Moss Back. In addition, the strata contain less quartz, quartzite, and chert pebbles than typical Moss Back. The

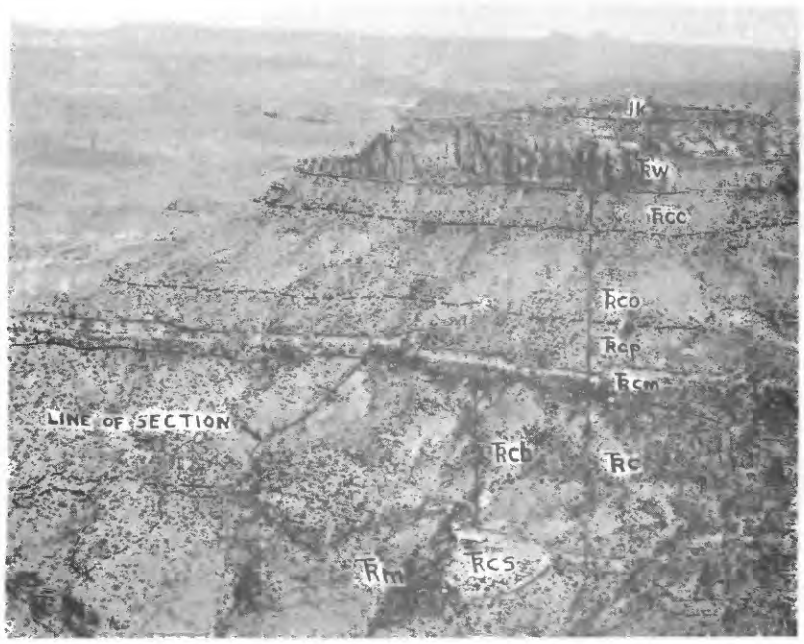
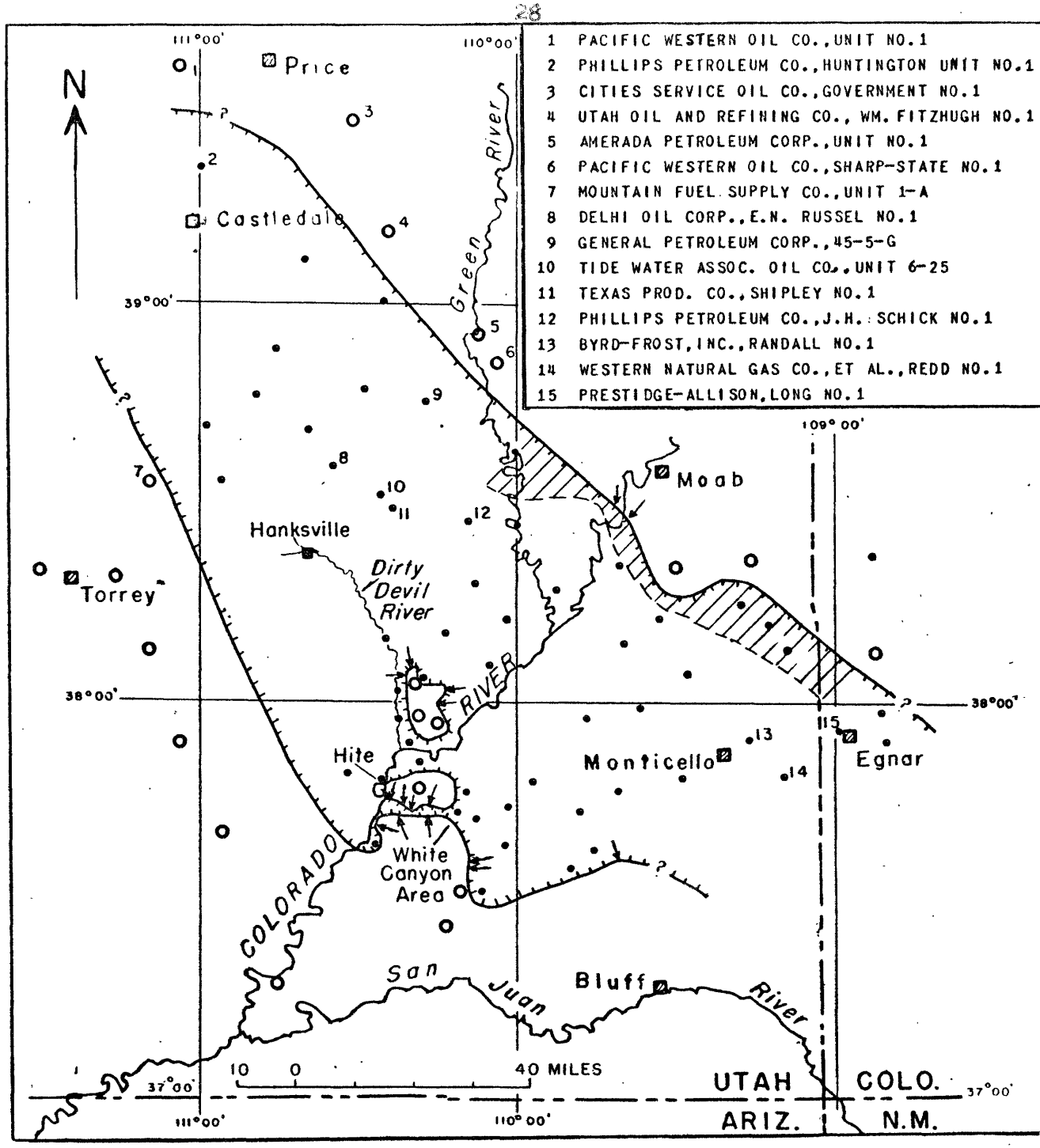


FIGURE 6.—VIEW OF TYPE SECTION OF MOSS BACK MEMBER OF CHINLE FORMATION, LOOKING NORTHEAST, IN EASTERN PART OF WHITE CANYON AREA, (Rm -*Moenkopi formation;* Rc -*Chinle formation;* Rcs -*Shinarump member,* Rcb -*Monitor Butte member,* Rcm-*Moss Back member,* Rcp -*Petrified Forest member,* Rco -*Owl Rock member,* Rcc-*Church Rock member;* Rw-*Wingate sandstone;* Jk -*Kayenta formation).*



EXPLANATION

- MOSS BACK MEMBER PRESENT, SHOWS SPACING OF IMPORTANT OUTCROPS AND WELLS DRILLED FOR OIL; NUMBER INDICATES DATA FROM WELL AND REFERS TO WELL LISTED ABOVE
- MOSS BACK MEMBER ABSENT IN OUTCROP AND IN WELLS DRILLED FOR OIL; NUMBER INDICATES DATA FROM WELL AND REFERS TO WELL LISTED ABOVE
- → PINCHOUT POINT OF MOSS BACK MEMBER LOCATED IN FIELD; A FEW OF THE POINTS IN THE WHITE CANYON AREA MARK A CHANGE IN FACIES FROM TYPICAL LIGHT-COLORED MOSS BACK TO A PURPLISH SANDSTONE NOT INCLUDED IN THE MOSS BACK MEMBER
- //// AREA OF DISCONTINOUS MOSS BACK MEMBER
- EXTENT OF MOSS BACK MEMBER

— SHOWING DISTRIBUTION OF MOSS BACK MEMBER OF CHINLE FORMATION.

lithologic differences may indicate a separate unit in the Big Indian Wash and Egnar areas; or, more likely, the lithologic difference is the result of local facies changes near the northeast limit of the Moss Back.

The Moss Back member is typically a yellowish-gray and very pale orange fine- to medium-grained well-sorted sandstone. The sandstone is composed of subrounded clear quartz and rare black accessory grains. The stratification is dominantly thin to thick, trough to planar sets of medium-scale cross-strata, but horizontally stratified sets are common. Conglomerate and conglomeratic sandstone lenses are common in the member. The pebbles occur in two suites, one suite is light-brown and gray siltstone and limestone, and the other is quartz, quartzite, and chert. A lens commonly has only one pebble suite; however, both pebble suites generally are present in all outcrops. The member generally contains a few lenses of greenish siltstone or claystone. Carbonaceous material and silicified wood are common throughout the member. The Moss Back typically weathers to form a vertical cliff and underlies benches.

A silty facies of the Moss Back member is present in an elongate area along the northern limit of the member in the area near the junction of the Green and Colorado Rivers. This silty facies extends from outcrops along the Colorado River to outcrops along the Green River and is about 10 miles wide. The facies contains abundant interstitial greenish silt and clay and interstratified lenses of greenish siltstone and claystone and contains few, if any, quartzose pebbles. The Moss Back member in the Big Indian Wash and Egnar areas may be part of this facies.

In the White Canyon area and the area near the junction of the Dirty Devil and Colorado Rivers, a purplish-appearing sandstone ledge locally occupies the stratigraphic position of the Moss Back member. This sandstone is pale red purple, pale red, and light greenish gray, very fine to fine grained, and cross-stratified on a small scale. It ranges in thickness, where present, from a wedge-edge to as much as 48 feet. In some places, this sandstone is probably laterally continuous with the typical light-colored sandstone of the Moss Back, whereas in other places, the typical light-colored sandstone of the Moss Back cuts out the purplish sandstone, suggesting that the purplish sandstone is, in places, an older deposit than the typical light-colored Moss Back. The author has excluded the purplish sandstone from the Moss Back, but some geologists may prefer to consider it a facies of the Moss Back. The lithologic differences between the purplish sandstone and the Moss Back suggest that the two units should be separated. In addition, the light-colored Moss Back forms a distinct unit whose limits can be accurately located in most places, whereas the purplish sandstone is similar to many other sandstone beds in the Chinle and its limits are difficult or impossible to locate in many places.

The Moss Back member can be distinguished lithologically from the Shinarump member and other sandstone units in the Chinle on the basis of grain size and pebble types. The Moss Back is generally fine to medium grained, whereas the Shinarump is medium to coarse grained and the other sandstone units in the Chinle are generally

very fine to fine grained. In addition, the Moss Back contains a different pebble assemblage than the Shinarump member and other conglomerates in the Chinle formation. (See description under Shinarump member.)

The Moss Back member averages about 60 feet thick but may be as much as 150 feet thick where it fills channels.

The Moss Back member overlies the Monitor Butte member along its southwestern margin, overlaps the Monitor Butte to the northeast, and overlies the Moenkopi formation along its northeastern margin (figs. 3 and 4). The tentative correlatives of the Moss Back in the Big Indian Wash and Egnar areas overlie the Cutler formation. The contact between the Moss Back and the Monitor Butte is sharp and a surface of erosion but is not considered to represent a significant break in deposition. The contact between the Moss Back and the Moenkopi or Cutler is sharp and unconformable.

The basal contact of the Moss Back member is marked by channels in many areas. These channels are cut out into sediments of either the Moenkopi, Cutler, or Monitor Butte and are filled with sandstone and conglomerate of the Moss Back. In cross section the channels are mostly 10 to 20 feet deep and 100 to 1,000 feet wide. The widest, deepest, and longest channel observed is in the White Canyon area, where a channel cut into the Monitor Butte member is a mile wide, 50 to 100 feet deep, and has been traced for 14 miles. This channel forms a neck (fig. 7) across an area where the Moss Back is absent and connects areas where the Moss Back is widely distributed.

The Moss Back member is conformably overlain by either the Petrified Forest member, Owl Rock member, or Church Rock member. In places, the top contact is gradational and intertonguing and arbitrarily placed at the most conspicuous change in the lithologic character of the strata.

The Moss Back member may correlate with stratigraphic units in southwestern Colorado and northwestern New Mexico. The member might correlate with a basal sandstone unit of the Dolores formation in the San Juan Mountains near Stoner, Montezuma County, Colo., and near Durango, La Plata County, Colo. Possibly the Moss Back correlates with the Poleo sandstone lentil of the Chinle formation, typically developed in the southeastern part of Rio Arriba County, N. Mex. (Wood and Northrop, 1946).

Petrified Forest member

The Petrified Forest member was named by Gregory (1950, p. 67) for exposures in the Zion Park region, Washington County, southwestern Utah, although he derived the name from the Petrified Forest in east-central Arizona. The member is present in the southern part of southeastern Utah and is present as a distinctive unit as far north as White Canyon and the southern part of the Elk Ridge area. Recent work indicates that the member probably extends as far north as the area near the junction of the Green and Colorado Rivers. North of White Canyon and Elk Ridge, the member is thin and is not differentiated from the Owl Rock member on figure 3. The member consists

of bentonitic claystone and clayey sandstone. The rocks are variegated with red, purple, green, and yellow colors. The beds are mostly structureless although a few cross-stratified beds have been observed where the beds are well exposed. The member weathers to form a "frothy" surfaced slope which results from the weathering of swelling clays.

The reddish-orange facies of the Petrified Forest member is present in the Circle Cliffs, Capitol Reef, and the western part of the White Canyon areas. This facies of the member consists of pale-reddish-brown, light-brown, moderate-reddish-orange, and grayish-red siltstone and minor amounts of pale-red and light-greenish-gray sandstone. A persistent ledge-forming unit--the Capitol Reef bed--is present at the top of the reddish-orange facies in the Capitol Reef area and the northern part of the Circle Cliffs area.

In the Monument Valley area, the Petrified Forest member ranges from about 500 to 700 feet in thickness. Northward from Monument Valley area it thins to about 100 feet in the White Canyon area and the southernmost part of the Elk Ridge area. North of these areas its thickness is 70 feet or less. In the area near the junction of the Green and Colorado Rivers, the member loses identity probably by intertonguing and intergrading with the Owl Rock member.

The Petrified Forest member conformably overlies the Monitor Butte member in most of southeastern Utah, and conformably overlies the Moss Back member in part of the White Canyon and Elk Ridge areas. The Petrified Forest member conformably underlies the Owl Rock member.

The Petrified Forest member is recognized in many areas outside of southeastern Utah. It is present in all of northern Arizona and southern Utah and extends into southeastern Nevada and west-central New Mexico. In most of these areas it forms the thickest and most characteristic part of the formation.

The Petrified Forest member corresponds to the "C" division of the Chinle formation described by Gregory (1917, p. 43) in northeastern Arizona.

Owl Rock member

The Owl Rock member was defined in a report currently being prepared by I. J. Witkind and R. E. Thaden, for exposures in the Monument Valley area, Arizona. The member is present in most of southeastern Utah, but is absent in the San Rafael Swell and Moab areas. The member is composed of pale-red and pale-reddish-brown structureless siltstone interstratified with thin to thick beds of limestone. The limestone generally comprises from 5 to 10 percent of the member. The limestone is pale red and light greenish gray, dense, and commonly grades to limy siltstone. The member ranges in thickness from a wedge-edge to 450 feet although it is generally 150 to 250 feet thick in southeastern Utah.

The Owl Rock member conformably overlies the Petrified Forest member, or the Moss Back member where the Petrified Forest is absent. It is conformably overlain by the Church Rock member, or disconformably overlain by the Wingate sandstone in places where the Church Rock member is absent.

The base of the Owl Rock member marks, in general, the change in the Chinle from strata composed dominantly of variegated bentonitic claystone below to strata composed dominantly of reddish, non-bentonitic siltstone above. These lithologic differences mark the most conspicuous lithologic change within the Chinle formation.

The Owl Rock member intertongues extensively with the overlying Church Rock member, and the absence of the member in the San Rafael Swell and Moab areas is probably due to lateral replacement of the Owl Rock member by the Church Rock member.

The Owl Rock member is recognized in many areas outside of southeastern Utah. It is present in most of northeastern Arizona and extends into west-central New Mexico.

The Owl Rock member corresponds to the "B" division of the Chinle formation described by Gregory (1917, p. 42) in northeastern Arizona.

Church Rock member

The Church Rock member was defined, in a report currently being prepared by I. J. Witkind and R. E. Thaden, for exposures in the Monument Valley area, Arizona. The member is present in most of southeastern Utah. It is absent in the Capitol Reef area and most of the Circle Cliffs area. The member is composed of pale-reddish-brown and light-brown very fine grained sandy siltstone. The sandy siltstone may be structureless, horizontally laminated to very thick bedded, or, in places, ripple laminated. The member contains minor amounts of pale-red and light-greenish-gray very fine grained cross-stratified sandstone. The sandstone is more common in the northern

part of southeastern Utah and is shown as a sandy facies on figure 3. The "Black ledge" and "Bowknot bed" (fig. 3) are conspicuous sandstone beds in the sandy facies.

In the Moab area, a conglomeratic sandstone bed is locally present at the base of the Chinle formation and below reddish and greenish siltstone and sandstone of the overlying part of the Chinle formation. The correlation of the members of the Chinle formation with rocks in the Moab area is not certain, but tentatively the conglomeratic sandstone bed, as well as the rest of the Chinle, is assigned to the Church Rock member. The conglomeratic sandstone bed is dominantly light greenish gray, medium to very coarse grained, conglomeratic in parts, cross-stratified and generally less than 20 feet thick. The bed is lithologically similar to the Shinarump but coarser grained than typical Moss Back. It is absent in much of the Moab area. The bed has been mapped as the Shinarump conglomerate by Baker (1933), at the Big Bend of the Colorado River, about 6 miles northeast of Moab, where it attains an unusual thickness of 200 to 300 feet (Baker, 1933, p. 37). McKnight (1940) mapped the bed as Shinarump conglomerate at Little Canyon, about 7 miles northwest of Moab. Dane (1935, p. 55-56) called this bed the "basal grit" of the Chinle formation and regarded it as the eastern equivalent of the Shinarump. The bed may be a correlative of the unit called Shinarump conglomerate in northeastern Utah (Kinney, 1955) and northwestern Colorado (Thomas, McCann, and Raman, 1945). However, this bed in

the Moab area is considered to be higher stratigraphically than the type Shinarump, and the name Shinarump member is not applied to the bed by the author.

The Church Rock member ranges in thickness from a wedge-edge to 400 feet in southeastern Utah.

The Church Rock member conformably overlies the Owl Rock member in most of southeastern Utah. It conformably overlies the Moss Back member in the San Rafael Swell and unconformably overlies the Moenkopi formation in the Moab area. It is disconformably overlain by the Wingate sandstone. The member thickens abruptly north of the Elk Ridge area, probably by incorporating strata which are equivalent to the Owl Rock farther south. In many areas the siltstone of the Owl Rock member and those of the Church Rock member are identical and separation of the two members is based entirely on the presence of limestone in the Owl Rock member.

Strata that correlate with the Church Rock member, or strata called Church Rock member, are present in many areas outside of southeastern Utah. The Church Rock member extends into the Monument Valley area in northeastern Arizona. The Rock Point member (named by Harshbarger and others, in press) of the Wingate sandstone, which is largely the same unit as the Church Rock member, is present in a large part of northeastern Arizona and locally extends into west-central New Mexico. The name Church Rock member is used in southeastern Utah, and in areas in Arizona north of Laguna Creek (a creek that lies a few miles south of the Monument Valley area)

and the name Rock Point member of the Wingate sandstone is used in New Mexico and in areas of Arizona south of Laguna Creek by Witkind and Thaden, in a report currently being prepared. The Church Rock member of the Chinle formation and Rock Point member of the Wingate sandstone correspond to the "A" division of the Chinle formation described by Gregory (1917, p. 42) in northeastern Arizona.

The Church Rock member extends into west-central Colorado, and constitutes the entire Chinle formation in this area. The Dolores formation of southwestern Colorado is equivalent to the Church Rock member although it may contain some strata equivalent to the Wingate sandstone. Possibly the strata in the Chinle formation of northwestern Colorado and northeastern Utah could be assigned to the Church Rock member.

PREVIOUS NOMENCLATURE OF PART OF UPPER TRIASSIC STRATA IN SOUTHEASTERN UTAH

The strata called Shinarump conglomerate in publications prior to 1952, in southeastern Utah were composed of part or most of the units now called Temple Mountain, Shinarump, Monitor Butte, and Moss Back members of the Chinle formation. The unit called Shinarump conglomerate by Baker (1936), Miser (1924a and 1924b), Gregory and Moore (1931), Hunt (1953), and Gregory and Anderson (1939) in the Monument Valley, Circle Cliffs, and Capitol Reef areas, is essentially the same as the Shinarump member of this report (fig. 8). In some places, they included the Shinarump member and a part, or locally

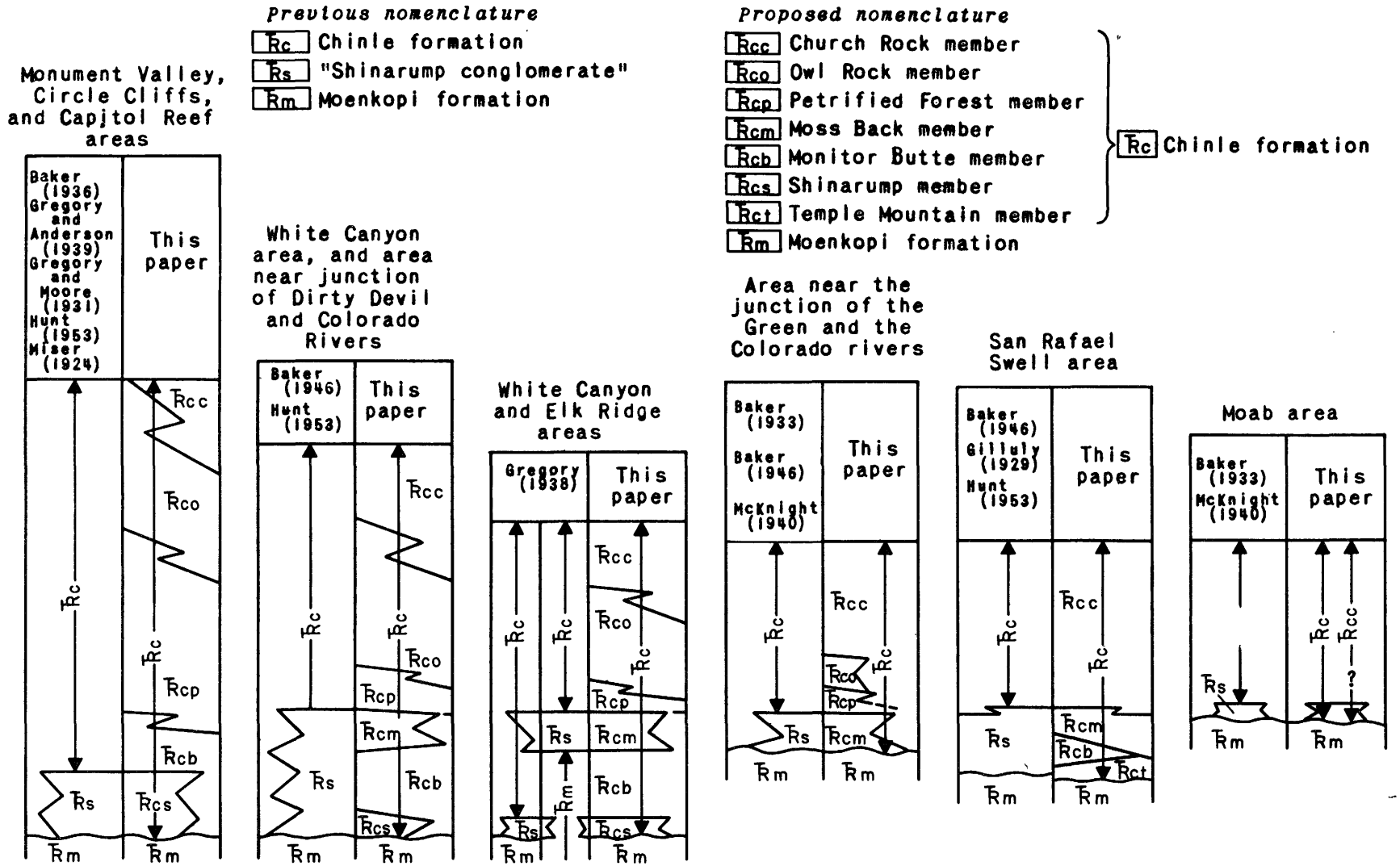


Figure 8.--PREVIOUS AND PROPOSED NOMENCLATURE OF PART OF UPPER TRIASSIC STRATA IN SOUTHEASTERN UTAH.

perhaps all, of the overlying Monitor Butte member in the Shinarump conglomerate. In a few places where the Shinarump member is absent, the Shinarump conglomerate of some of these authors was a part, or locally perhaps all, of the Monitor Butte member. In the White Canyon area, and in the area near the junction of the Dirty Devil and Colorado Rivers, the Monitor Butte and Moss Back members, and the Shinarump member where it is present, collectively form what was previously mapped as Shinarump conglomerate by Baker (1946) and Hunt (1953). Locally where the Moss Back member is absent and the Monitor Butte member does not contain any ledge-forming sandstone beds, Baker (1946) did not map Shinarump conglomerate. In part of the White Canyon and Elk Ridge areas, the Shinarump conglomerate of Gregory (1938) is the Moss Back member. In these places, he included the Monitor Butte member and the Shinarump member, where present, in the Moenkopi formation. In other places in the White Canyon and Elk Ridge areas, Shinarump conglomerate of Gregory (1938) is apparently the Shinarump member, and he included the Monitor Butte and Moss Back members in the Chinle. In the area near the junction of the Green and Colorado Rivers, the Shinarump and Monitor Butte members are absent, and the unit mapped as Shinarump conglomerate by Baker (1933, 1946) and McKnight (1940) is the Moss Back. McKnight's Shinarump, however, does not extend as far up the Green River as the Moss Back of this report. In the San Rafael Swell, the Shinarump conglomerate of Gilluly (1929), Baker (1946), and Hunt (1953) consists mostly of the Moss Back and Monitor Butte members, or of

the Moss Back member where the Monitor Butte is absent. In the San Rafael Swell these authors included the Temple Mountain member in the Shinarump, in some places; in other places, they included it partly in the Shinarump and partly in the Moenkopi; in still other places, they included it entirely in the Moenkopi. In the Moab area, the unit called Shinarump conglomerate by Baker (1933) and McKnight (1940) is not considered by the author to correlate with either the Shinarump or Moss Back but is a stratigraphically higher conglomeratic sandstone bed at the base of the Chinle and is arbitrarily assigned to the Church Rock member.

Since 1952, many published reports have mentioned the Shinarump conglomerate. In most of these reports the term Shinarump conglomerate was used to describe the same strata that had previously been called Shinarump conglomerate. In the White Canyon area, Benson and others (1952), Trites and Chew (1955), and Miller (1955) applied the name Shinarump conglomerate to the unit called Shinarump member in this report and included in the Chinle formation the units called Monitor Butte and Moss Back in this report.

Most of the geologists previously working in southeastern Utah did not recognize subdivisions of the Chinle formation. Prior to 1952, none of the subdivisions now recognized were given member status. Benson and others (1952) and Trites and Chew (1955) recognized lower, middle, and upper members of the Chinle formation in the White Canyon area. The lower member is composed of the units called Monitor Butte and Moss Back in this report; the middle member, of the units called Petrified Forest and Owl Rock in this report; and the upper member, of the unit called Church Rock in this report.

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APPENDIX

TYPE SECTION OF MOSS BACK MEMBER OF CHINLE FORMATION, SAN JUAN COUNTY, UTAH

MOSS BACK section, measured 0.4 mile west and 0.2 mile south of the northern tip of the northwesternmost of the four conspicuous buttes (the ridge formed by the westernmost three buttes is called Moss Back) that are located on or near the divide between Fry and Red Canyons and are capped by rocks of the Wingate sandstone and Kayenta formation. Long. 110°08'51" W., and lat. 37°34'46" N.

(Measured by J. H. Stewart and D. A. McManus, July 1954)

Feet

Top of section; top of good exposures.

Chinle formation (incomplete):

Petrified Forest member (unmeasured):

9. Silty sandstone, greenish-gray (5GY6/1)[1/] and grayish yellow (5GY7/2), weathering light greenish-gray (5GY8/1), very fine grained; composition masked, abundant fine- to coarse-grained accessory dark and white mica; firmly cemented, slightly calcareous; horizontally laminated and ripple-laminated;[2/] papery to platy splitting; weathers to form slope. About 10 feet of unit exposed. . . . Not measured

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1/ Rock-color chart prepared by "The Rock-Color Chart Committee," E. N. Goddard and others, National Research Council, Washington 25, D. C., 1948.

2/ Stratification terminology after McKee and Weir, 1953.

Feet

Contact of Moss Back member and the overlying part of the Chinle formation is placed at the change from yellowish-gray fine- to medium-grained cross-stratified sandstone to grayish-yellow-green very fine grained horizontally laminated silty sandstone.

Moss Back member:

8. Sandstone, yellowish-gray (5Y8/1), weathering same color, fine- to medium-grained, rare coarse grains, well-sorted; composed of subrounded to rounded clear quartz and rare green and orange accessory grains; poorly cemented, calcareous; composed of medium-scale cross-laminae, rare small-scale cross-laminae, and horizontal laminae to low-angle cross-laminae; massive splitting; weathers to form vertical cliff and underlies narrow bench. Unit contains rare (5 percent) thin to thick sets containing 5 to 10 percent siltstone, quartzite, and quartz granules and pebbles. 56.4

7. Sandstone (30 percent) and conglomeratic sandstone to conglomerate (70 percent). Sandstone, light-greenish-gray (5GY8/1) to greenish-gray (5GY6/1) and yellowish-gray (5Y8/1), weathering yellowish-gray (5Y7/2) and light-brown (5YR6/4); very fine to fine-grained; composed of subrounded grains of clear quartz; well-cemented, calcareous; composed of thin trough sets of

Feet

medium-scale cross-laminae. Conglomeratic sandstone to conglomerate, same fresh and weathering colors as sandstone; composed of granules, pebbles, and cobbles of siltstone, sandstone, limestone, quartzite, quartz, and chert in a sand matrix the same as the sandstone in the rest of the unit. Siltstone cobbles reach maximum size of 0.5 foot, whereas quartzite, quartz, and chert pebbles reach maximum size of 2.5 inches. About 50 percent of the pebbles are siltstone, sandstone, and limestone; the other 50 percent are quartzite, quartz, and chert. The most characteristic pebble appears to be a black quartzite. Granules to cobbles comprise from a few to 60 or 70 percent of the conglomeratic parts of the unit. The conglomeratic sandstone to conglomerate is structureless and well cemented, calcareous. The sandstone is present as thin lenses interstratified with the conglomeratic sandstone to conglomerate. Along the exposure, the unit is highly variable in lithology and the sandstone lenses are present at many different horizons. In addition, the amount of sandstone in the unit ranges widely along the exposure. The unit contains rare carbonized and silicified fossil logs as large as 0.4 foot in diameter. Unit weathers to form vertical cliff continuous with that of overlying unit. 16.1

Total Moss Back member. 72.5

Feet

Basal contact of Moss Back member well-exposed and sharp. Contact shows minor undulations up to about 0.5 foot. Contact placed at change from a greenish-gray (5GY6/1), in part horizontally laminated siltstone containing abundant fine- to medium-grained accessory white mica to a light-greenish-gray (5GY8/1) and yellowish-gray (5Y8/1) sandstone to conglomeratic sandstone.

Monitor Butte member:

6. Unit poorly exposed in parts but appears to be mostly silty claystone to siltstone, greenish-gray (5GY6/1) and grayish-red (5R4/2), weathering same; firmly to well cemented, slightly calcareous; stratification mostly concealed, horizontally laminated in top foot of unit. Unit contains a slumped exposure of ripple-laminated clayey sandstone the same as that in the underlying unit. Unit weathers to form a talus-covered slope. Top foot contains abundant fine- to medium-grained accessory white mica. 23.3

5. Silty claystone to clayey sandstone (75 percent) and clayey sandstone (25 percent). Silty claystone to clayey sandstone, greenish-gray (5GY6/1), light-gray (N7), pale-olive, (10Y6/2) and uncommon dusky-yellow (5Y6/4) and grayish-yellow (5Y8/4); grayish-red (10R4/2 and 5R4/2) from 22.0 to 26.0 feet above base, weathering mostly greenish-gray (5GY6/1), grading

Feet

from silty claystone to very fine grained clayey sandstone; well-cemented; stratification concealed. Clayey sandstone, greenish-gray (5GY6/4) weathering same color and dark yellowish-brown (10YR4/2); very fine grained; abundant fine- to medium-grained accessory white mica; firmly cemented, calcareous; ripple-laminated; platy splitting. Clayey sandstone is present as thick to very thick sets interstratified with rest of unit and is found only in upper half. Unit contains common carbonaceous material in flakes and small fossil tree fragments in the silty claystone to clayey sandstone. The clays in this unit are bentonitic. Unit weathers to form frothy-surfaced badlands. 82.6

4. Covered; exposures about 2,000 feet to the southeast of line of section indicate that this unit is part of the overlying unit. 20.8

3. Sandstone, grayish-yellow green (5GY7/2) and pale-greenish-yellow (10Y8/2), weathering same colors, very fine to fine-grained, silty in parts, fair-sorted; composition masked; firmly to well-cemented, slightly calcareous; composed of slightly wavy horizontal very thin beds; unit exposed in gully bottom. Unit contains rare grayish-red purple (5RP4/2) beds. 8.4

Total Monitor Butte member. 135.1

Feet

Contact of Shinarump and Monitor Butte members placed at change from light-colored relatively clean and friable cross-stratified conglomeratic sandstone of the Shinarump to the greenish well-cemented silty fine-grained sandstone of the Monitor Butte.

Shinarump member:

2. Sandstone, grayish-orange (10YR7/4), very pale orange (10YR8/2), and dark-yellowish-orange (10YR6/6), weathering very pale orange (10YR8/2), medium-grained to coarse-grained and partly very coarse grained; commonly contains abundant interstitial white clay, fair to poor sorting; composed of subangular clear quartz; firmly cemented, calcareous; stratification indistinct but contains common poorly defined thin- to thick-trough sets of medium-scale cross-laminae; massive splitting; weathers to form conspicuous light-colored ledge and underlies prominent bench. About 20 percent of the unit contains granules and pebbles. These granules and pebbles are either widely disseminated or concentrated to form as much as 40 percent of the rock and are dominantly of clear or white quartz. Basal foot contains conspicuous conglomeratic sandstone with pebbles as much as 2.5 inches in largest dimension 17.0

Total Shinarump member. 17.0

Total incomplete Chinle formation 224.6

Feet

Contact of Shinarump member and Moenkopi formation sharp but wavy; waves as much as 3 inches high. Contact placed at change from reddish siltstones of Moenkopi to light-colored pebbly sandstone of the Shinarump.

Moenkopi formation:

1. Siltstone, grayish-red (10R4/2) and minor pale yellowish-green (10GY7/2), weathering same colors; abundant fine-grained accessory white mica; firmly cemented, slightly calcareous; thin horizontal laminae and rare very thin sets of ripple laminae; papery splitting; units exposed in gully. Only top 8 feet of unit were examined. Top 1.4 feet of unit is pale-yellowish-green (10GY7/2). . . . . Not measured

Base of section; not base of exposure.