New Mexico Geological Society

Downloaded from: http://nmgs.nmt.edu/publications/guidebooks/9

The Redwall Limestone

Edwin D. McKee, 1958, pp. 74-77

in:
Black Mesa Basin (Northeastern Arizona), Anderson, R. Y.; Harshbarger, J. W.; [eds.], New Mexico Geological Society 9th Annual Fall Field Conference Guidebook, 205 p.

This is one of many related papers that were included in the 1958 NMGS Fall Field Conference Guidebook.

Annual NMGS Fall Field Conference Guidebooks

Every fall since 1950, the New Mexico Geological Society (NMGS) has held an annual Fall Field Conference that explores some region of New Mexico (or surrounding states). Always well attended, these conferences provide a guidebook to participants. Besides detailed road logs, the guidebooks contain many well written, edited, and peer-reviewed geoscience papers. These books have set the national standard for geologic guidebooks and are an essential geologic reference for anyone working in or around New Mexico.

Free Downloads

NMGS has decided to make peer-reviewed papers from our Fall Field Conference guidebooks available for free download. Non-members will have access to guidebook papers two years after publication. Members have access to all papers. This is in keeping with our mission of promoting interest, research, and cooperation regarding geology in New Mexico. However, guidebook sales represent a significant proportion of our operating budget. Therefore, only *research papers* are available for download. *Road logs*, *mini-papers*, *maps*, *stratigraphic charts*, and other selected content are available only in the printed guidebooks.

Copyright Information

Publications of the New Mexico Geological Society, printed and electronic, are protected by the copyright laws of the United States. No material from the NMGS website, or printed and electronic publications, may be reprinted or redistributed without NMGS permission. Contact us for permission to reprint portions of any of our publications.

One printed copy of any materials from the NMGS website or our print and electronic publications may be made for individual use without our permission. Teachers and students may make unlimited copies for educational use. Any other use of these materials requires explicit permission.

This page is intentionally left blank to maintain order of facing pages.

THE REDWALL LIMESTONE

by **EDWIN D. McKEE**
U. S. Geological Survey

The Redwall limestone of Mississippian age was named by Gilbert (1875, p. 176-177) who examined it in the walls of Grand Canyon. A type locality in Redwall Canyon, north of the Colorado River in east central Grand Canyon, was later selected by Darton (1910, p. 21). In 1922 the formation was redefined by Noble (1922, p. 54) to include only strata of Mississippian age. As thus restricted, it rests unconformably on the Temple Butte limestone of Devonian age (locally on the Muav limestone of Cambrian age) and is overlain by the Supai formation, the lower part of which is Pennsylvanian in age.

The Redwall limestone extends across a major part of northern Arizona with remarkably little lithologic variation. In the northeastern part of the state it is relatively thin (less than 350 feet) and appears to lap against the ancient Defiance uplift; in the northwestern corner it is more than 900 feet thick. The change in thickness from one area to the other is regular (fig. 1) and very gradual, and the vertical subdivisions or members are recognized virtually throughout this region.

As its name implies. the Redwall limestone characteristically forms a sheer cliff or wall on outcrop. Throughout most of the Grand Canyon it is about midway in the stratigraphic section and forms the most prominent single cliff, having a vertical face ranging from 500 to 800 feet in height. Commonly four members of which it is composed are eroded rather uniformly to form one massive wall; however, in some places thin beds of the uppermost member have receded to form a series of small ledges above the main cliff and in other localities either or both of the lower two members have receded. These lower units locally form steep slopes or broken cliffs in contrast to the persistent massive cliff of the third member. Erosion of the overlying Supai formation has stained the Redwall cliffs with iron oxide.

The Redwall limestone is subdivided into four members that are typically represented along the Bright Angel trail, south section (fig. 2). They consist of (1) a basal thick-bedded unit, composed of limestone in most northern and western sections but of dolomite throughout southeastern Grand Canyon, (2) a resistant series of alternating chert and limestone beds, each averaging about 1 to 3 inches in thickness, and together appearing as a conspicuous banded cliff, (3) a very thick-bedded, massive, cliff-forming unit composed of both aphanitic limestone and coarse-grained, largely crinoidal, limestone, and (4) thin-bedded limestone, mostly aphanitic and including some thin chert beds like those below.

Each of the lower two members ranges in thickness from 70 to a little more than 100 feet in the walls of Grand Canyon, thickening northwestward with trends similar to those of the formation as a whole. In the subsurface of the Four Corners area they range between 50 and 70 feet in thickness. Southward this thickness uniformly decreases and the members appear to be absent in the Amerada and Stanolind #1 Navajo Black Mountain well (Sec. 26, T. 32 N, R. 23 E) where the Redwall limestone is represented by a partial section (110 feet) consisting of the upper members, resting on Devonian strata. Both lower members, however, are recognized to the north, in the subsurface of eastern Utah; they are present in outcrops along much of the Mogollon Rim area in central Arizona; and they are believed to be represented by the Dawn limestone and Anchor limestone members, respectively, of the Monte Cristo limestone in southern Nevada (Hewett, 1931, p. 17).

The third member above the base is the thickest and most prominent in outcrops. It ranges in thickness from over 200 to nearly 500 feet from east to west in the Grand Canyon and is about 180 feet thick in the Four Corners area. This member is recognized in the subsurface of eastern Utah, in most exposures of the Redwall in central Arizona, and is believed equivalent to the Bullion dolomite member of the Monte Cristo limestone in Nevada.

The uppermost member is only 50 to 100 feet thick in most parts of the Grand Canyon. In outcrop it is readily distinguished from the third member by its thin bedding, but in the subsurface it can be separated only with difficulty. It likewise is represented in the Mogollon Rim area of central Arizona and probably is continuous with the Yellowpine limestone member of the Monte Cristo in Nevada.

Many varieties of limestone and dolomite are included in the Redwall limestone of northern Arizona but, except for chert, few minerals other than those of calcium and magnesium carbonate are included. No beds of sandstone, mudstone, or gypsum of Mississippian age[1] have been reported in the Redwall limestone of this area. Examination of insoluble residues from all members and from many parts of the Grand Canyon area has shown that few samples contain more than one percent insoluble material. These residues are composed largely of very fine-grained quartz sand, small amounts of an undetermined clay mineral, and grains of iron oxide, but the total amount of each is negligible. The limestone, however, includes much aphanitic rock believed to have formed as a calcareous ooze, numerous oolitic beds — mostly in the upper parts of the formation, and large amounts of coarse- to medium-grained clastic rock derived from various sources. Much of the limestone is bioclastic. No well-developed reef structures have been observed in any of the members, although small colonial coral masses are scattered through many parts of the formation and large accumulations of bryozoans are in the chert beds of the second member.

Bedded chert is so consistent a feature of the second and the uppermost members of the formation throughout the region as to constitute reliable marker units, but its origin is difficult to interpret. Evidence of replacement of limestone as observed in thin section and the inclusion of vast numbers of skeletal remains, originally of calcium carbonate, throughout much of the chert refute the suggestion of primary precipitation. The wide lateral distribution of the chert across some hundreds of miles with no appreciable change in character, and an apparent lack of relation between chert beds and structural features of the region suggest an early diagenetic, rather than a post-consolidation, development. Distribution of the silica into thin beds, rhythmically alternating with limestone beds of similar thickness but with relatively far fewer fossils, may

[1]Sink holes, caverns, and solution cracks common in upper parts of the Redwall limestone are in places partly or entirely filled with red mudstone accumulated during deposition of the overlying Supai formation.

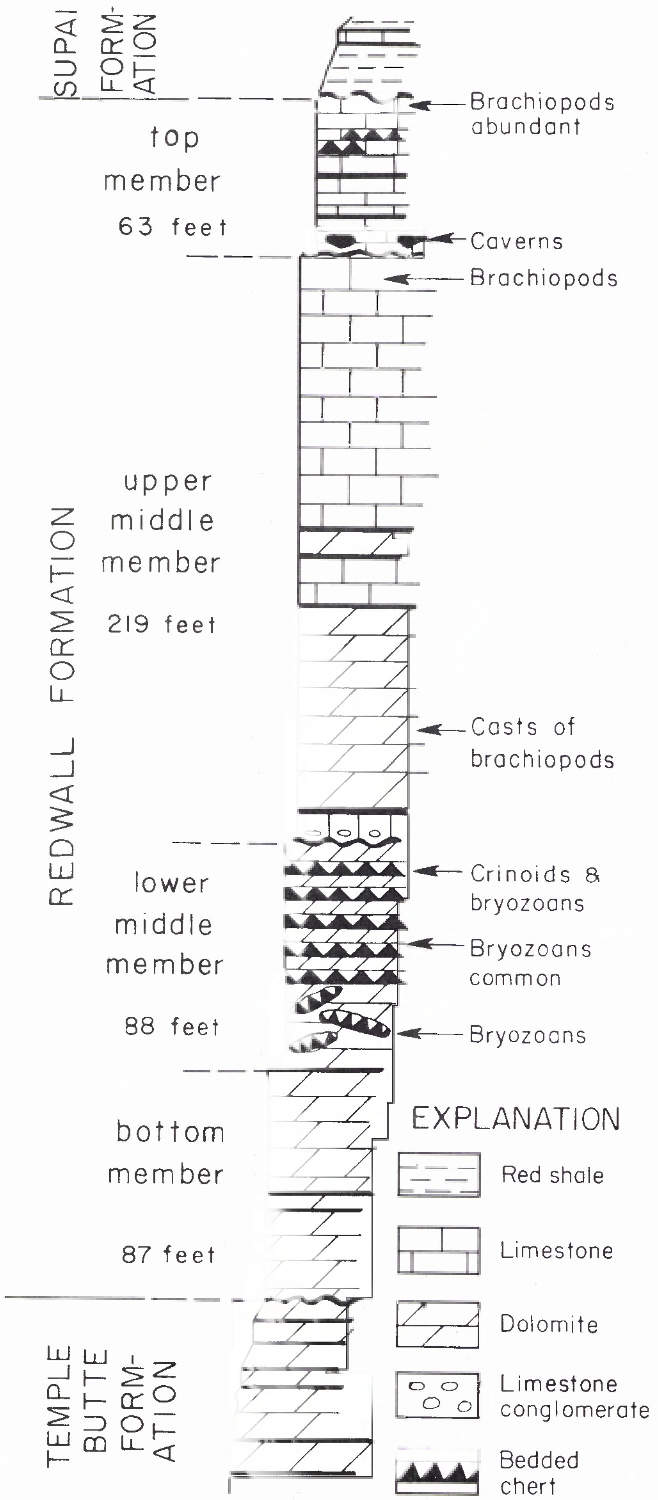

FIGURE 2 - SECTION OF REDWALL LIMESTONE ALONG BRIGHT ANGEL TRAIL, GRAND CANYON

be a function of original permeability related to the abundance or absence of organisms. An adequate source for the vast amount of silica represented, however, is not readily apparent.

Fossils are abundant in many parts of the Redwall limestone but, for the most part, are poorly preserved and difficult to study. In many places they are fragmental, having been broken and worn at or prior to the time of deposition. Elsewhere they are altered through recrystallization or are preserved as external molds. Well-silicified specimens are uncommon; however, extensive fossil collections have been made from many areas and include numerous species of brachiopods, corals, bryozoans and mollusks, and lesser numbers of well preserved crinoids, blastoids, trilobites, and endothyroid foraminifers. Specimens from all of these groups are currently being studied, but an analysis of results must await completion of the reports.

Available information on the age of the Redwall is relatively meager and conflicting. Based on a study of brachiopods by Wooddell from the area of Jerome in central Arizona, Stoyanow (1948, p. 319) reports that these fossils "collectively have an Osage aspect." Cephalopods from the uppermost member near Jerome, examined by Miller, Downs, and Youngquist (1949, p. 607), "seem to indicate that the containing beds are Kinderhookian in age" but might possibly be Osagian. A rather large collection of corals from both the Grand Canyon and the region to the south was studied and described by Easton and Gutschick (1953, p. 5) with the conclusion that they "indicate a lower Mississippian (Kinderhook) age for the entire formation in the area studied." These authors point out, however, that some brachiopods, crinoids, and blastoids, especially from the third member above the base "clearly suggest an Osage (Burlington) correlation for that unit." In contrast to the results of other studies, an examination of endothyroid foraminifers from Havasu Canyon in Grand Canyon led Zeller (1957, p. 685) to the conclusion that foraminifers from the upper half of the Redwall there were "of Meramecian age."

A change from thick to thin bedding between the lower two members of the Redwall limestone and a similiar change between the upper two members probably result from original differences in base level. In each case, development of a relatively shallow base level with constant interruptions to sedimentation is indicated by the change. Furthermore, deposition of the thin, upper beds in each sequence appears to have terminated with general bevelling of the surface as illustrated in a number of sections (e. g. fig. 2). Thus, the suggestion is made that the thin strata represent deposits of regression, whereas the underlying thick beds formed during times of transgression and of maximum advance of the sea. Thus, the Redwall limestone in the Grand Canyon region is believed to be the result of sedimentation during two principal advances and two principal retreats of the sea across a shelf area from the geosynclinal area to the northwest.

Section on Bright Angel Trail, Grand Canyon

(Top member and upper half of upper middle member measured on west side of fault)

	Feet
Supai Formation:	
Mudstone, deep red, crumbly; forms slope.	
Dolomite, dark yellowish brown, aphanitic, thick-bedded (3 feet); weathers to massive, rough surface; forms resistant ledge	5.0

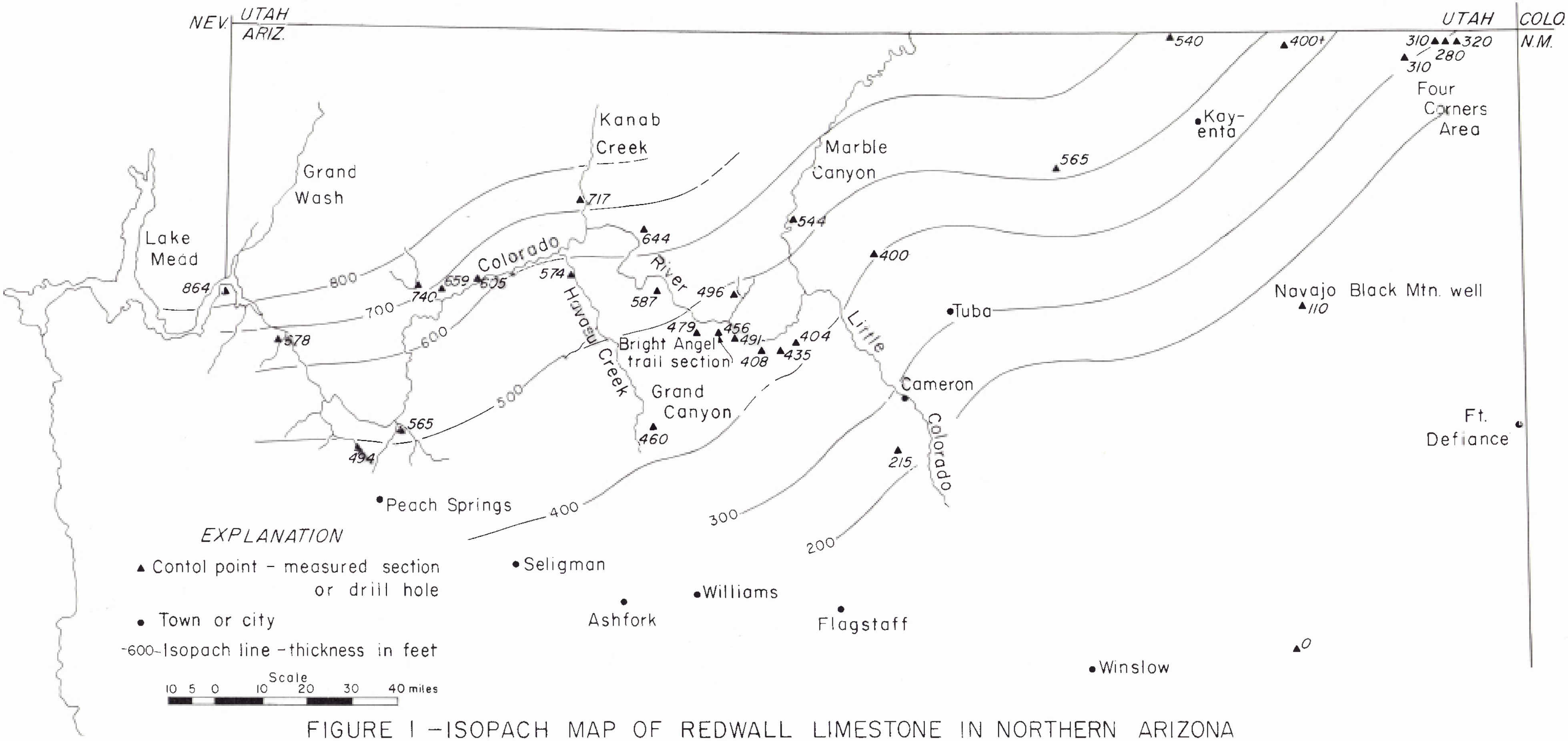

FIGURE I – ISOPACH MAP OF REDWALL LIMESTONE IN NORTHERN ARIZONA

Limestone, dark yellowish brown (grayish-orange at top), aphanitic, thin-bedded (4-8 in.), flat bedded; surface commonly covered with worm tubes; forms series of ledges 19.5

Unconformity:

Assumed: contact largely concealed.

Redwall limestone:

Top member:

Limestone, grayish-orange to brownish-gray, aphanitic to finely crystalline, thin to medium-bedded; upper beds very irregular; grayish-orange chert beds that weather black at two horizons; topmost bed very fossiliferous (brachiopods of several species); forms top of weak cliff 30.0

Limestone, light olive gray, coarsely crystalline, medium-bedded; weathers to rough surface; forms weak cliff 16.5

Limestone, light olive gray, aphanitic to crystalline, inequigranular; planar cross-bedding on large scale; weathers to rough surface; basal contact very irregular 16.5

Total top member 63.0

Upper middle member:

Limestone, light olive gray, aphanitic to crystalline, inequigranular, massive, thick-bedded; fossiliferous (brachiopods near top); weathers to rough surface; forms massive cliff that contains caverns; plane of upper surface forms prominent line along ¼ mile of exposure in section 104.5

(Lower half of upper middle member measured on east side of fault)

Feet

Limestone, pale-brown, aphanitic, thick-bedded; weathers to rough surface; forms massive unit in cliff continuous with underlying 7.0

Limestone, light olive gray, aphanitic to crystalline, inequigranular, forms part of massive cliff 18.0

Limestone, pale-brown, aphanitic, thick-bedded; contains molds of fossils; weathers to black, rough surface; forms massive cliff 77.0

Dolomitic limestone, grayish-orange and crystalline, in part; moderate orange pink and finely crystalline, in part; locally crinoidal; forms base of massive cliff 12.0

Total upper middle member 218.5

(Lower two members measured on west side of valley)

Lower middle member:

Limestone, pale-brown to pale yellowish brown, finely crystalline, medium to thin-bedded (Upper half): alternating with

Chert, white to light gray, irregularly bedded (Lower part), even-, thin-bedded (2-8 in.) above middle; limestone weathers to rough, dark-gray surface; chert weathers black, locally, red to white elsewhere; prominent bench developed at base; fossiliferous (abundant fenestellid bryozoans at 10 feet and at 39 feet above base) 89.0

Total lower middle member 89.0

Bottom member:

Dolomite, pale-red, finely-crystalline, locally friable; like underlying 46.5

Dolomite, yellowish-gray, finely crystalline, thick-bedded (2-4 ft.); forms cliff continuous with underlying 6.0

Dolomite, brownish-gray, finely crystalline, equigranular, thick-bedded (2-4 ft.); weathers to rough, gray surface; forms prominent cliff 34.0

Total bottom member 86.5

Total Redwall limestone 456.0

Unconformity:

Assumed; not apparent in section.

Temple Butte limestone:

Limestone, gray to lavender, finely crystalline, sugary, thin-bedded (½-2 ft.); alternating with Dolomite, gray, aphanitic, thin-bedded, laminated; weathers to creamy white; unit forms slope with series of ledges 7.0

REFERENCES CITED

Darton, N. H., 1910, A reconnaissance of parts of northwestern New Mexico and northern Arizona: U. S. Geol. Survey Bull. 435, 88 p.

Easton, W. H. and Gutschick, R. C., 1953, Corals from the Redwall limestone (Mississippian) of Arizona: So. Calif. Acad. Sci., Bull., v. 52, pt. 1, p. 1-27.

Gilbert, G. K., 1875, Report upon the geology of portions of Nevada, Utah, California, and Arizona, examined in the years 1871 and 1872: U. S. Geog. and Geol. Surveys W. 100th Mer., pt. 3, p. 17-187.

Hewett, D. F., 1931, Geology and ore deposits of the Goodsprings quadrangle, Nevada: U. S. Geol. Survey Prof. Paper 162, 172 p.

Miller, A. K., Downs, H. R., and Youngquist, Walter, 1949, Some Mississippian Cephalopods from central and western United States: Jour. Paleontology, v. 23, no. 6, p. 600-612.

Noble, L. F., 1922, A section of the Paleozoic formations of the Grand Canyon at the Bass trail: U. S. Geol. Survey Prof. Paper 131, p. 23-73.

Stoyanow, A., 1948, Some problems of Mississippian stratigraphy in southwestern United States: Jour. Geol., v. 56, no. 4, p. 313-326.

Zeller, E. J., 1957, Mississippian Endothyroid Foraminifera from the Cordilleran Geosyncline: Jour. Paleontology, v. 31, no. 4, p. 679-704.