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A RE-EXAMINATION OF THE TYPE SECTION OF THE SCHERRER FORMATION (PERMIAN) IN COCHISE COUNTY, ARIZONA

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INTRODUCTION

Recent and current stratigraphic studies of Pennsylvanian and Permian strata in southeastern Arizona have shown a need for re-examination of these rocks. Many of the type sections appear to have been measured without detailed lithologic descriptions of the rock units present. This treatment is particularly undesirable in the case of the abundant carbonate rocks. New methods of study are available to classify the limestones and dolomites readily, and to help make environmental interpretations. A preliminary reconnaissance of the type section of the Scherrer Formation showed that many of the rock types could be better described, and other units, previously missed, were now exposed by very recent erosion.

The sedimentary rock nomenclature used is essentially that of R. L. Folk (1965). The term "orthoquartzite" is used for a quartz sandstone well cemented with silica in optical overgrowth.

The rocks' colors were determined through use of the Rock-Color Chart (Goddard, 1948).

PREVIOUS WORK

Gilluly, Cooper and Williams (1954, p. 27) named the Scherrer Formation and described the type section on Scherrer Ridge. The Scherrer Formation has since been described and/or mapped in many scattered localities in southeastern Arizona: the Mustang Mountains, Cottonwood-Montosa canyons area, Helvetia district, Helmet Peak, the Empire Mountains, and the Canelo Hills (Bryant, 1955); the Waterman Mountains and Kohtkohl Hill (McClymonds, 1957, 1959a, 1959b); the Chiricahua Mountains (Sabins, 1957); the Pedregosa Mountains (Epis, 1956); The Whetstone Mountains (Tyrrell, 1957; Creasey, 1967); Montosa Canyon (Sulik, 1957); and the Red Bird Hills (Cooper, 1960). Whitney (1957, p. 12) noted the presence of Scherrer strata in the Tucson Mountains but did not measure a section because of extensive thrust-faulting. Cooper and Silver (1964, p. 68-69) reviewed the type section of the Scherrer Formation.

The Scherrer Formation has also been reported in southwestern New Mexico. Gillerman (1958, p. 40) measured thirty to fifty feet of Scherrer strata in the Peloncillo Mountains of Cochise County, Arizona, and Hidalgo County, New Mexico. Zeller (1965, p. 52) recorded five to twenty feet of Scherrer strata in the Big Hatchet Mountains.

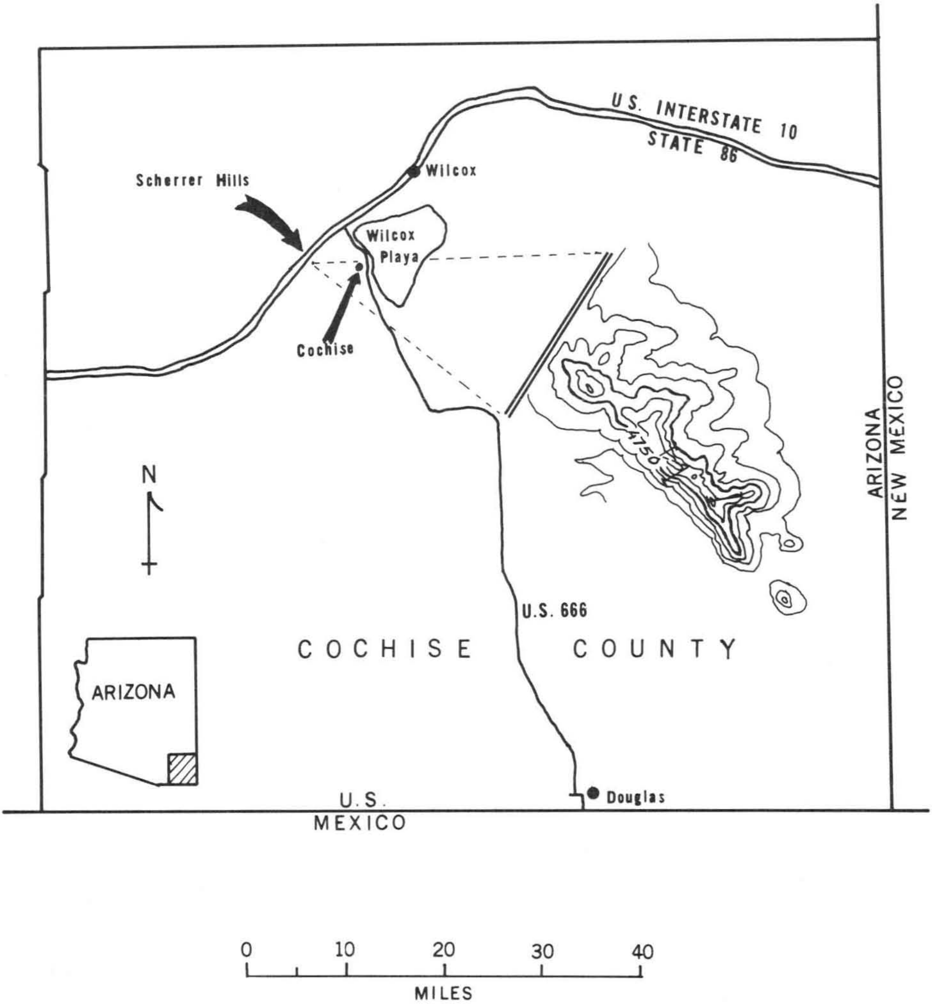

Figure 1.--Index Map Showing Location of the Type Section of the Scherrer Formation in Southeastern Arizona. Detailed Topographic Inset of the Scherrer Hills Drawn from the Dragoon, Arizona 15-minute Quadrangle (Sections 20, 21, 28, and 29, T. 15 S., R. 23 E. Scale: 2 inches = 1 mile).

STRATIGRAPHY

The Scherrer Formation is divided into four informal members: basal red beds, lower sandstone member, middle carbonate member, and upper sandstone member. In the type area, the Scherrer Formation is in conformable contact with both the underlying Colina Limestone and the overlying Concha Limestone.

Basal Red Beds

In the type section, the basal red beds consist of red calcareous siltstones and very fine grained sandstones. Two dolomite beds occur near the top of the unit. The sandstones and siltstones are slope-formers; the dolomites are ledge-formers. Asymmetrical, parallel ripples are present in the zone just above the Scherrer-Colina contact. Other sedimentary structures include ripple lamination, scour-and-fill structures, distorted bedding, and possible micro-cross-lamination. The basal red beds are 95 feet thick in the type section.

Lower Sandstone Member

The lower sandstone member consists of fine-grained and very fine grained sandstones and orthoquartzites, and two dolomite beds near the middle of the member. The sandstones form a steep, rounded slope above the basal red beds; the dolomite units form minor ledges. The sandstones are noncalcareous to very calcareous. The grains are subangular to rounded, and fair to well sorted. Rounded "berries" (grains of a substantially larger size than the average grain size in a rock) of medium-sand size are concentrated along the base of laminae in Unit 9 (see Description of Measured Section). The calcareous sandstones display silica "case-hardening." A fresh surface reacts with dilute (10%) hydrochloric acid, but a weathered surface does not.

Approximately five feet above the base of the lower sandstone member (Unit 5; see Description of Measured Section) is an eight-inch-thick bed of thinly laminated dolomite. The two dolomite units above the first 95 feet of sandstone (Units 6 and 8; see Description of Measured Section) contain silica nodules as much as $1\frac{1}{2}$ centimeters in diameter.

Cross-bedding occurs in parts of all the sandstone units. The apparent dips seem to be about thirty degrees; the nature of the outcrops is such that the cross-bedding can be seen in only one dimension, so no true dip angles can be obtained. Total thickness of the lower sandstone member is 251 feet.

Middle Carbonate Member

The carbonate member is a ledge former and occupies the saddle connecting Concha and Scherrer ridges. The total thickness is 153 feet.

This member is divided into six units (Units 10-15; see Description of Measured Section). Unit 10 is a varicolored dolomite that is sandy in the lower part and nearly pure dolomite near the top. In outcrop near the contact between this unit and the lower sandstone member, there are quartz rosettes, 1-3 millimeters in diameter.

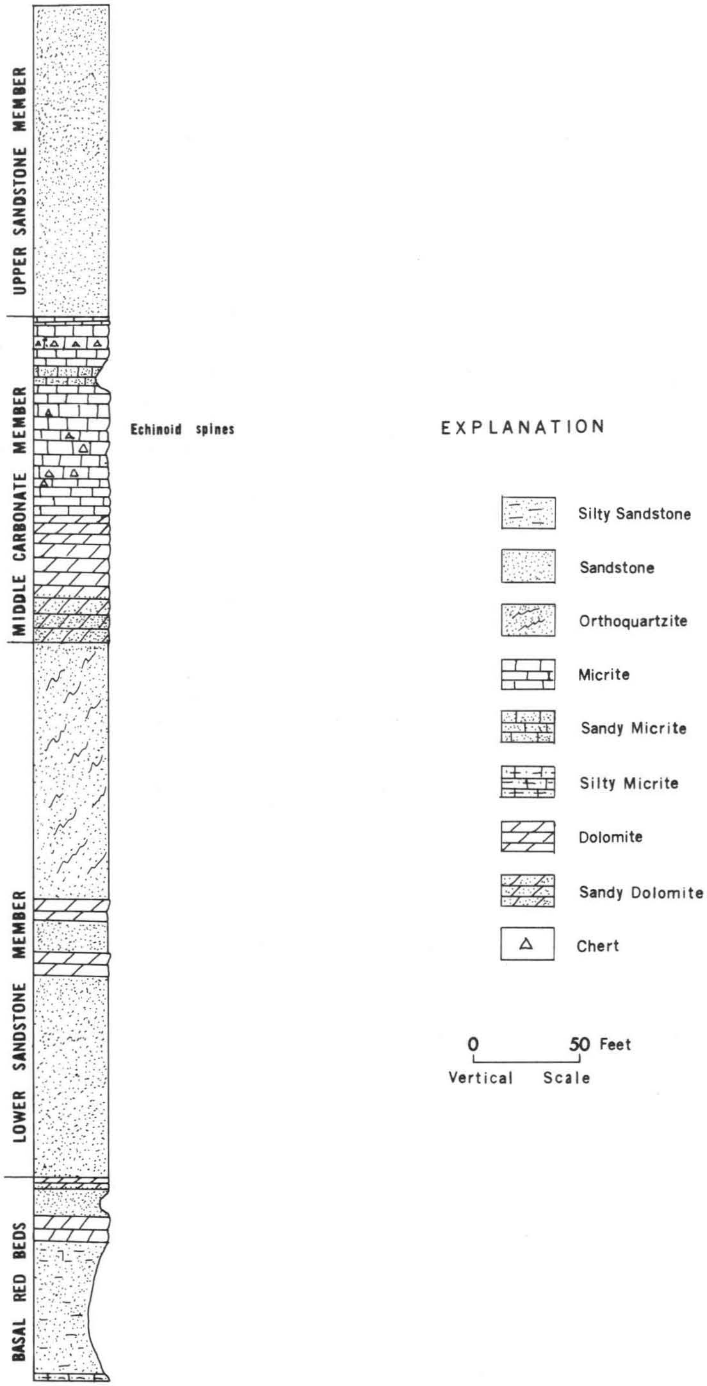

Figure 2.--Stratigraphic Column of Scherrer Lithologies in the Type Section.

All the other units of the middle carbonate member are micrites of various colors; all units within the member are separated on the basis of color change. Some units are markedly cherty, others have little or no chert. The units are also sandy in various degrees.

Abundant echinoid spines and a few coronal plates are present in Unit 12. The spines represent perhaps three species of Archaeocidaris. The spines of one of the species resembles a short, thick baseball bat; this was earlier identified as Permocidaris (Bryant, 1955, p. 40), now generally considered a synonym of Archaeocidaris.

"Ghosts" of gastropods are present in the lowest part of the carbonate member in the type section. One bellerophontid gastropod was found in a piece of float.

Sparry calcite "eyes" occur in the reddish-hued micrites of Units 13 and 14. Near the upper part of Unit 13, the "eyes" show apparent orientation along bedding planes. Here also are quartz nodules, some of which show subhedral crystal development.

Except for some apparent wavy laminations in Unit 13, no other sedimentary structures were noted in the middle carbonate member.

Upper Sandstone Member

The upper sandstone member of the Scherrer Formation in the type section forms a rounded hill on Concha Ridge west of the Concha Limestone outcrops. The total thickness is 148 feet.

The sandstone is slightly calcareous, and the weathered surface is commonly silica "case-hardened." It is fine-grained, well sorted, with subangular to subrounded grains. Rounded, medium-grained "berries" are concentrated along the base of laminae. The quartz grains commonly display overgrowths.

High-angle (twenty degrees apparent dip) cross-bedding occurs in this member. Most of the cross-bedding was noted in float blocks, so no direction could be measured. Ripple marks with wavelengths of $1\frac{1}{4}$ to 2 inches were also noted, but their type could not be determined.

ENVIRONMENT OF DEPOSITION

A sea occupied the region of southeastern Arizona during most of Pennsylvanian and Permian time. Isopachs on Pennsylvanian strata show a northwest-trending depositional basin extending into southeastern Arizona from Mexico (McKee, 1951, pl. 2A). This basin existed but was not as well defined in Permian time (McKee, 1951, pl. 2B).

In Permian time, according to McKee (1951, p. 492), a positive element existed between Silver City and Las Cruces in New Mexico. Permian strata generally thicken to the west and southwest of this area.

The basal red beds of the Scherrer Formation were deposited as the sea in southeastern Arizona regressed toward the southeast. The red beds are probably of deltaic origin. Coleman and Gagliano

(1965, P. 135, 137) have noted ripple lamination in cores from the Mississippi River delta that resemble those of the Scherrer red beds. The thin, dark dolomites in the red bed sequence probably represent minor transgressions of the sea.

The origin of the light-colored calcareous and noncalcareous sandstones is not so positive. Poole (1964, p. 396) lists characteristics of ancient eolian sandstones: light-colored, composed mostly of quartz, calcareous or siliceous cement, very fine to coarse-grained (mostly fine-grained), fair to well sorted, grains subangular to well rounded (commonly pitted or frosted), "berries" on cross-strata surfaces. The sandstones of the Scherrer type section have most of these characteristics, although no definite pitting or frosting of grains was noted.

Bedding, however, is the most diagnostic criterion for eolian origin, and the cross-bedding present in the Scherrer sandstones could not be accurately measured. Thicknesses of sets of the cross-strata could not be measured exactly, but nowhere did the thicknesses of sets appear to be over four feet. Thin sets of cross-strata with low to high dip angles have been noted in beach sands and may also be present in shallow-water marine sands. The two dolomite beds associated with the sandstones in the lower sandstone member may be an indication of a beach or shallow-water marine environment for the sandstones.

The sandstones may also represent a mixed environment of deposition. The sands could have been beach or dune sands reworked by shallow marine waters. Or they might have been shallow-water marine sands subjected to wind and wave action on or near a beach.

The limestones and dolomites of the middle carbonate member represent a transgression of the sea. The lower part of the member is dolomite, the upper part is micrite. This probably reflects a gradual increase of the distance from shore. Dolomites are generally thought to be a nearshore carbonate facies. The basal part of the dolomite is markedly sandy; the sand grains appear to have been derived from the underlying sandstone. The upper part of the dolomite has only a trace of clastics. The micrites are slightly sandy, except one light gray unit that is very sandy (Unit 14). The generally low clastic content of the micrites probably indicates that there were few nearby sources supplying clastics to this sea.

Sparry calcite "eyes" occur only in micrites of red or pink hues. Folk (1965, p. 147) attributes these "eyes" to disturbance of the micrite by boring organisms or by soft sediment deformation, with the resulting openings being filled with sparry calcite. In the Scherrer Formation, these "eyes" in the pink micrites show orientation, apparently along bedding planes. They were probably caused by soft sediment deformation; this "deformation" could have been caused by the formation and filling of dessication cracks on a lime-mud flat that was briefly exposed to subaerial conditions. The pink colors of the micrite indicate oxidizing conditions. After the initial cracks were made in the mud, the edges of the mud polygons curled, and the sparry calcite filled the openings under these mud curls. If this interpretation is correct, it would be evidence of shallow water conditions, at least at the time of the formation of the cracks.

The echinoid spines and plates are further evidence that at least some of the time the sea was shallow. The structure of Paleozoic and Mesozoic cidaroids is similar enough to the structure of living cidaroids to imply that the ecology of earlier forms is the same as that of living forms (Fell, 1966, p. U313).

Living cidaroids are inactive and move only very slowly over the bottom. Cidaroids with large, decorated, club-shaped spines probably lived in nearshore turbulent water (Cooper, 1957). Echinoids of all kinds tend to shun hypersaline and brackish waters; they are especially sensitive to changes in salinity and pH because of their water vascular systems (Chenoweth, 1966, p. 282). Echinoids in general are most abundant in clear water with either a sandy or a limy bottom (Cooke, 1957). Turbulent water does not necessarily imply muddy water.

Fell (1966) noted that some modern cidaroids prefer seas in which the surface temperatures do not vary beyond definite limits throughout the year. Cidaroids have been found in present seas to depths of 4000 meters. Most cidaroids prefer hard bottoms, but forms with long, slender spines seem to be able to live in soft mud (Fell, 1966).

The literature on the ecology and paleoecology of echinoids is scant. But from the information available, the cidaroids of the Scherrer Formation probably lived on a limy botton in clear, shallow, nearshore water of moderate temperatures and normal salinity. The salinity is thought to have been normal because there are no associated evaporite deposits to imply hypersaline conditions.

The spines could have been transported to their place of burial. They could have been rolled without extensive damage along a gently sloping lime-mud flat by nearshore currents. Their well-preserved state is probably also due in part to selective coating or entire replacement of the spines with silica. The spines could also have remained where they fell after the death of the organism. In either case, nearshore currents were no doubt responsible for orienting them to lie in bedding planes.

Lack of other kinds of fossils in the type section of the Scherrer Formation may be due to preservation conditions. Fossil "ghosts" of gastropods have been noted in the dolomites in the middle carbonate member. Dolomitization commonly destroys fossila. But well-preserved gastropods, brachiopods, and other fossils have been noted in other Scherrer sections (Bryant, 1955; Epis, 1956). Perhaps only certain "nooks" in the shallow sea were favorable living places.

The source of the Scherrer Formation was probably from the northwest (Sabins, 1957). The sea lay to the south and southeast, and a positive element seems to have been present to the northeast (McKee, 1951). Isopachs of Permian strata show a regular thinning toward the positive element; this would indicate that the zero-isopach line is partly depositional. The Scherrer Formation clastics in the Peloncillo and Big Hatchet Mountains, the Scherrer outcrops nearest to the positive element, are medium- to fine-grained (Gillerman, 1958; Zeller, 1965). For this reason these clastics do not appear to have been derived from this particular positive area.

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DESCRIPTION OF MEASURED SECTION

On Scherrer Ridge, the Scherrer Formation is broken up by many faults and locally cut by a pre-Cretaceous erosion surface. Because of these faults, the type section is a composite section (see Figure 1).

Section of the Scherrer Formation on Scherrer Ridge and Concha Ridge, Gunnison Hills. Top of Section measured along the crest of Concha Ridge, SW 1/4 NW 1/4 Section 28, T. 15 S., R. 23 E., Dragoon Quadrangle.

Concha Limestone:

Micrite, sandy, medium dark gray (N4), weathers medium light gray (N6), sand is fine-grained, angular, well sorted, white or brown-stained; rough weathering surface; forms minor ledge.

Strike N. 37° W., Dip 28° NE.

Scherrer Formation: Upper sandstone member

Unit — Thickness (feet)

16. Sandstone, slightly calcareous, surface commonly hardened by silica; white to grayish orange pink (5YR 7/2), weathers light brown (5YR 5/6) and grayish orange (10YR 7/4); fine-grained, laminated; locally cross-bedded, ripple-marked; forms rounded hill west of Concha Limestone outcrops........................148

Total thickness of Upper sandstone member: 148

Dip 24° NE.

Middle carbonate member

15. Micrite, medium dark gray (N4) grading upward to hue between moderate orange pink (10R 7/4) and pale reddish brown (10R 6/4) and pale red (10R 6/2), weathers medium gray (N5) grading upward to moderate orange pink (10R 7/4) and pale yellowish brown (10YR 6/2); sparry calcite "eyes" in pinkish parts; forms ledge.......... 11

14. Micrite, grayish orange pink (5YR 7/2), weathers very light gray (N8) with yellowish cast; sandy, very cherty; chert in nodular and disseminated masses; forms ledge.. 5

Strike N. 36° W., Dip 23° NE.

13. Micrite, grades from pale red (10R 6/2) at unit's bottom to brownish gray (5YR 4/1) to reddish pink (5R 6/4) to dark gray (N3.5) at unit's top; weathers from pale red (10R 6/2) to light gray (N7) to grayish orange pink (5YR 7/2) to medium gray (N5.5); middle of unit is slightly sandy; subhedral quartz nodules concentrated along laminae in reddish pink part; sparry calcite "eyes" abundant in pinkish parts; light brown chert in upper part; locally laminar; red layers form slopes, gray layers form ledges.............................. 26.3

12. Micrite, light gray (N7) to light brownish gray (5YR 6/1), weathers light gray (N7) with lavender cast; slightly sandy; chert nodules common, echinoid spines abundant, coronal plates rare; spines are Archaeocidaris, possibly three different species--short, thick "baseball bat" with nodes; long, smooth cone; and long spine with nodes; unit occupies saddle.. 29

11. Micrite, dolomitic near base, dark gray (N3.5) to medium gray (N5), weathers medium light gray (N6) to yellowish gray (5Y 8/1); shell outlines of brachiopods? and pelecypods? in basal dolomitic part; chert rare except near unit's top, where it is bedded and nodular; silty near top; forms ledge.... 22

10. Dolomite, all hues from dark gray (N3) to medium light gray (N6), weathers from medium gray (N5) to light gray (N7), light olive gray (5Y 6/1), and pinkish gray (5YR 8/1); sandy in lower part, sand is very fine grained and subangular; chert nodules 2-3 inches in diameter rare; quartz rosettes 1/16-1/8 inch diameter very common near unit's base; "ghosts" of bellerophontid? gastropods near unit's base; occupies hillslope............................. 60

Total thickness of middle carbonate member: 153

(Because of faults and cover in the lower part of the section at this locality, lower units were measured about 1,750 feet to the northwest on the west face of Scherrer Ridge. Unit 9 was measured about 200 feet further northwest on Scherrer Ridge than Units 1-8 because of an erosion surface filled with Cretaceous Glance Conglomerate along this part of Scherrer Ridge. NE 1/4 NE 1/4 Section 29, T. 15 S., R. 23 E., Dragoon Quadrangle).

Strike N. 30° W., Dip 19° NE.

Lower sandstone member

9. Orthoquartzite, white and very pale orange (10YR 8/2), weathers light brown (5YR 5/6) and moderate reddish brown (10R 4/6), very fine grained, subangular, well sorted; laminated; subrounded to rounded, fine- to medium-sand size "berries" concentrated along the base of laminae; locally cross-bedded; forms steep, rounded slope... 120

Strike N. 58° W., 24° NE.

8. Dolomite, dark gray (N3), weathers medium dark gray (N4); silica nodules as much as 1/8-inch diameter, partly replaced by secondary calcite; lower surface of bed is irregular; forms minor ledge.. 10

Strike N. 59° W., Dip 15° NE.

7. Sandstone, noncalcareous, white and light brown (5YR 6/4), weathers grayish orange pink (5YR 7/2) and moderate reddish brown (10R 4/6), very fine grained, subangular to subrounded, well sorted; forms steep slope.................................. 15

Strike N. 55° W., Dip 18° NE.

6. Dolomite, dark gray (N3) to medium dark gray (N4), weathers medium gray (N5) to light olive gray (5Y 6/1); silica nodules as much as 1/2-inch diameter; light brown chert present near unit's top; forms minor ledge.................................. 11

Dip 21° NE.

5. Sandstone, calcareous to very calcareous, surface commonly hardened by silica; locally noncalcareous, poorly cemented; varicolored, most common color is grayish orange pink (5YR 7/2), basal part is pale red (5R 6/2) to moderate red (5R 5/4); weathers all hues from pale yellowish brown (10YR 6/2) to dusky yellowish brown (10YR 2/2), basal part weathers light red (5R 6/6) to moderate pink (5R 7/4); fine-grained, subrounded to rounded, fair to well sorted; laminated, locally cross-bedded; forms rounded slope. Five feet above the base of this unit is an 8-inch-thick bed of dolomite, medium dark gray (N4), weathers medium gray (N5) and light olive gray (5Y 6/1), thinly laminated, breaks into thin, smooth slabs...... 95

Total thickness of Lower sandstone member: 251

Strike N. 47° W.

Basal red beds

4. Dolomite, sandy, grayish red (5R 4/2), weathers light brown (5YR 6/4); sand is very fine grained, angular to subangular; grades upward into dolomite, brownish gray (5YR 4/1), weathers light brown (5YR 6/4) to grayish orange pink (5YR 7/2); slightly silty; partly laminated; sandy dolomite forms slope, silty dolomite forms ledge.......................... 5

Dip 20° NE.

3. Sandstone, calcareous, silty; pale reddish brown (10R 5/4), weathers moderate orange pink (10R 7/4), very fine grained, subangular, fair sorted; weathers crumbly in lower eight feet; forms slope........ 13

2. Dolomite, grayish black (N2) to medium dary gray (N4) and brownish gray (5YR 4/1), weathers dark gray (N3) to medium light gray (N6) and light brownish gray

(5YR 6/1); dusky red (5R 3/4) laminae near base; iron oxide pseudomorphs-after-pyrite common; forms ledge with beds 2 inches to 2.6 feet thick............. 12

Strike N. 30° W., Dip 34° NE.

1. Sandstone, silty, and siltstone, sandy, calcareous, locally noncalcareous; grayish red (5R 4/2), dusky red (5R 3/4), pale red purple (5RP 6/2), moderate pink (5R 7/4), dark reddish brown (10R 3/4), and pale reddish brown (10R 5/4); weathers same or slightly lighter hues; medium silt to very fine grained sand, commonly bordering on coarse silt and very fine sand; angular to subangular, fair sorted; locally laminated, ripple laminated; some scour channels, disturbed bedding. Basal 2 feet is micrite, silty, same and similar fresh and weathered colors, fine to medium silt, angular; chalcedony nodules common; laminated, locally ripple-marked. Entire unit forms a prominent slope 65

Total thickness of Basal red beds: 95
Total thickness of Scherrer Formation: 647

Colina Limestone:

Dolomite and micrite, dark gray (N3) to medium gray (N5), weathers medium gray (N5) and light olive gray (5Y 6/1), light brown chert present near contact with Scherrer Formation; forms cliff.................................... 17.5

The remainder of the unit below the Scherrer formation is like or similar to the rocks just described; chert is uncommon or not present.

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