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By CHARLES W. MERRIAM *and* WAYNE E. HALL

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Stratigraphic revision of the Inyo section is made, and two new formations are described—the Keeler Canyon formation of Pennsylvanian and early Permian age and the Owens Valley formation of Permian age

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CONTRIBUTIONS TO GENERAL GEOLOGY

PENNSYLVANIAN AND PERMIAN ROCKS OF THE SOUTHERN INYO MOUNTAINS, CALIFORNIA

By CHARLES W. MERRIAM and WAYNE E. HALL

ABSTRACT

Pennsylvanian and Permian strata constitute about a third of the exposed Paleozoic rocks in the southern Inyo Mountains, Calif. Recent detailed mapping in the New York Butte and Darwin quadrangles and comparison, with upper Paleozoic rocks of the Eureka district, Nevada and other areas in the Great Basin calls for a complete stratigraphic revision of the Inyo section. Two formations are described, the Keeler Canyon formation of Pennsylvanian and early Permian age and the Owens Valley formation of Permian age. The Owens Valley locally rests with angular unconformity on the Keeler Canyon. Paleontologic zonation is based mainly on fusulinids, which are abundant in both formations.

INTRODUCTION

Folded rocks of Paleozoic and Triassic ages underlie the southern Inyo Mountains, Calif. The Paleozoic rocks are of marine origin, but the Triassic includes both marine sediments and subaerial volcanic rocks. At the south end of the Inyo Mountains, the older rocks are covered in large part by Cenozoic flows and pyroclastic rocks of andesitic and basaltic composition.

Strata of Pennsylvanian and Permian age which constitute about a third of the exposed Paleozoic rocks were studied in 1912 and 1913 during a reconnaissance by the United States Geological Survey (Knopf, 1918); at this time they were compared (Kirk, 1918) with similar formations in the Eureka mining district, Nevada (Hague, 1883; 1892; Walcott, 1884). In subsequent years detailed geologic mapping and stratigraphic work in the Inyo Mountains as well as the Eureka district and neighboring areas (Nolan and others, 1956) made possible a more thorough comparison of these rocks. Beginning in 1943, special geologic studies of the Cerro Gordo mine area and adjoining parts of the Inyo Mountains were initiated by the Geological Survey; these led to detailed structural and stratigraphic investigations relating to the strata of later Paleozoic age.

Since 1946, geologic mapping of several quadrangles in this general region has been carried forward by the Geological Survey in cooperation with the California State Division of Mines.

Except for reconnaissance stratigraphic work by the Geological Survey in 1912–13 (Kirk, 1918), published investigations dealing with Paleozoic stratigraphy of the Inyo Mountains relate mainly to older rocks farther north. Among these are Walcott's Cambrian studies (1908, p. 185–188), the Ordovician contribution of Phleger (1933), and Devonian investigations by Stauffer (1930). Hopper (1947, p. 393–432) mapped a strip from the Sierra Nevada to Death Valley through the Darwin area. In this work the Ordovician to upper Paleozoic rocks are described and correlated with other formations in the Great Basin. McAllister (1952), in mapping and describing Paleozoic rocks of the Quartz Spring area 24 miles northeast of Cerro Gordo, proposed stratigraphic terms applicable to most of the southern Inyo rocks, with exception of those Pennsylvanian and Permian strata here described.

Acknowledgment is made to the late James Steele Williams and to Lloyd G. Henbest, of the Geological Survey, who read and criticized the manuscript. Unless otherwise indicated, fossil determinations were made by the senior author.

GENERAL FEATURES OF THE ROCKS

Upper Paleozoic rocks which form the subject of the present contribution lie mainly in the New York Butte and Darwin quadrangles at the south end of the Inyo Mountains, continuing thence southeast into the Darwin Hills (fig. 1). Of a Paleozoic sequence approximately 12,000 feet thick, including all systems from Ordovician to Permian (table 1), about one-third, or 4,000 feet, is combined Pennsylvanian and Permian.

Pennsylvania and Permian rocks of this region are predominantly impure carbonates with subordinate shale, calcareous shale, siltstone, sandstone, conglomerate, and chert. Most of these are mildly metamorphosed; carbonate rocks are in part recrystallized to marble, and argillaceous rocks, to argillite and hornfels. Commonly, within a mile of granitic intrusions, the limestones are altered to calc-hornfels and tactite.

In this report the Pennsylvanian and Permian strata, not previously differentiated and described adequately, are divided in two formations: the Keeler Canyon formation of Pennsylvanian to early Permian age inclusive and the Owens Valley formation of Permian age. Previously named units, the Reward conglomerate and Owenyo limestone (Kirk, 1918, p. 42–45) are localized lenticular members of the

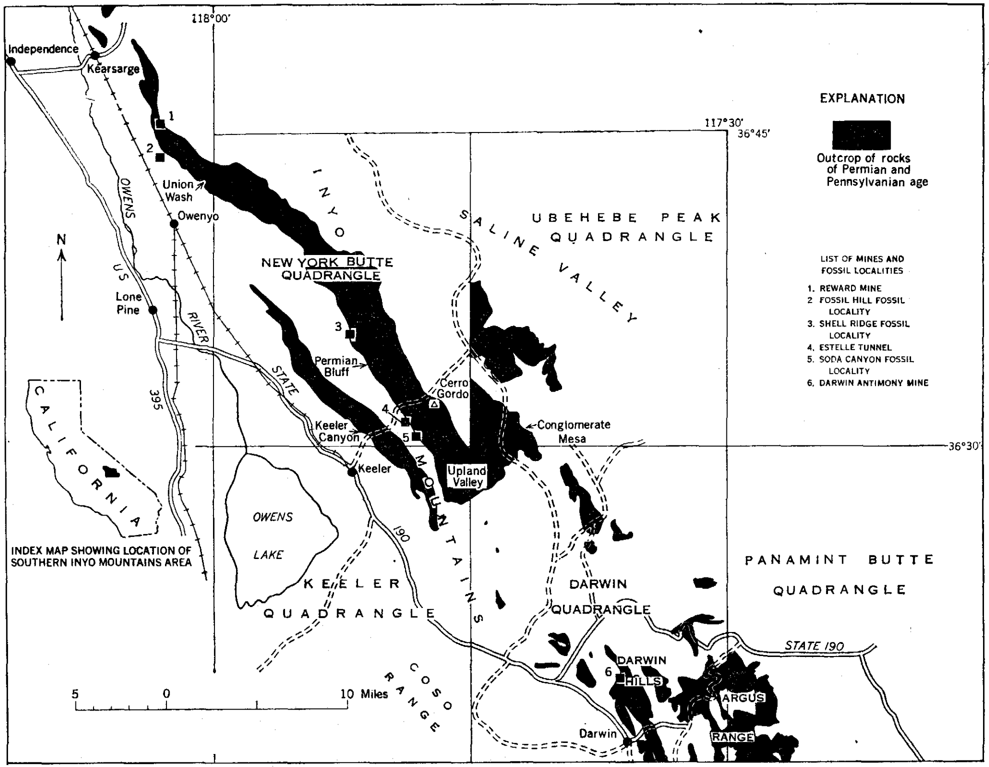

FIGURE 1.—Index Map showing distribution of Carboniferous and Permian rocks in the southern Inyo Mountains, Calif.

new Owens Valley formation; because they are local facies, they have not been utilized as map units.

TABLE 1.—*Paleozoic rocks of the southern Inyo Mountains, Calif.*

Age	Formation	Thickness (feet)	Lithology
Triassic	Unnamed rocks		Andesite flows and pyroclastic rocks, limestone and shale.
	—Unconformity—		
Permian	Owens Valley formation	1,800±	Silty and sandy limestone, fusulinid limestone, siliceous conglomerate, limestone conglomerate, shale, siltstone, sandstone, and hornfels.
	—Local unconformity—		
Pennsylvanian	Keeler Canyon formation	2,200±	Sandy and pebbly fusulinid limestone, shale, siltstone, and marble.
Mississippian	Chainman shale	1,000±	Dark-gray silty shale and phyllite. Limestone interbeds.
	Perdido formation	50–200	Limestone, chert, siltstone, quartzite.
	Tin Mountain limestone	350	Dark-gray limestone, chert nodules.
Devonian	Lost Burro formation	1,600±	Light- and dark-gray marble, dolomite, quartzite.
Silurian and Devonian.	Hidden Valley dolomite (lower boundary difficult to place in this area).	1,700±	Massive light- and dark-gray dolomite, quartzite.
Ordovician	Ely Springs dolomite	240–550	Light- and dark-gray cherty dolomite.
	Eureka quartzite	400±	Light-gray vitreous quartzite.
	Pogonip group (basal part not exposed in this area).	1,350±	Saccharoidal dolomite and limestone.

In previous discussions of undifferentiated Pennsylvanian and Permian rocks of this region, they have been referred to provisionally as Bird Spring(?) formation. In the Ubehebe Peak quadrangle these strata increase in thickness to over 5,000 feet (McAllister, 1955). The Bird Spring formation of southern Nevada (Hewett, 1931, p. 21; 1956, p. 42; Longwell and Dunbar, 1936, p. 1202), is believed to embrace strata ranging in age from Late Mississippian to Permian.

KEELER CANYON FORMATION

NAME AND OCCURRENCE

The Keeler Canyon formation, of Pennsylvanian to early Permian age, is here named for exposures in upper Keeler Canyon, where the type section lies east of the Estelle Tunnel portal and 2 miles southwest of Cerro Gordo Peak (fig. 1). The formation is widely exposed in the southern Inyo Mountains and also underlies most of the Darwin Hills and the northern Argus Range. It generally forms smooth slopes, but resistant beds protrude locally to emphasize the incompetent folded nature of these strata.

In the earlier stratigraphic studies by Kirk (1918, p. 40–41), part of these beds were referred to as basal Pennsylvanian limestones and part as limestone and shale of later Pennsylvanian age; siliceous and silicated limestones west of the Cerro Gordo mine previously regarded as Diamond Peak quartzite appear in that particular area to be correctly assigned to the Keeler Canyon.

LITHOLOGY

The Keeler Canyon formation (table 2) comprises thin-bedded medium- to dark-gray impure silty and arenaceous to pebbly limestones and limy siltstones, with intercalations of pinkish or maroon fissile shale. Pebbly limestones occasionally grade into chert pebble conglomerate with limestone matrix. Silicified fusulinids are sometimes an important constituent of the pebbly limestones. All of these rocks, including the limestones, show clastic texture and bedding is inclined to be platy or flaggy with few layers as much as 3 feet thick.

The basal 150–200 feet of the Keeler Canyon formation differs lithologically from the overlying beds. These lower beds are purer, thin-bedded dark-gray crinoidal and fusulinid-bearing limestones containing nearly spheroidal black chert nodules ½–2 inches in diameter. The cherty *Fusulinella*-bearing strata, which were given the field designation "golf ball beds," constitute a reliable stratigraphic marker, having been recognized widely in the southern Inyo Mountains, the Darwin Hills, and the Argus Range.

THICKNESS AND STRATIGRAPHIC RELATIONS

Because of its incompetent, highly folded nature, the Keeler Canyon formation does not lend itself to accurate thickness measurement. In the New York Butte quadrangle, the formation averages about 2,200 feet in thickness, as judged by measurement of several sections which ranged from 1,300 to 2,500 feet. Where the section is greatly thinned, there is evidence that segments have been cut out by faulting. In the Darwin quadrangle, at the Darwin antimony mine, the Keeler Canyon thickens to about 4,000 feet.

The Keeler Canyon formation rests conformably upon the Chainman shale of Late Mississippian age in the New York Butte quadrangle. In the Darwin quadrangle it is underlain by an unnamed thinly bedded limestone which seemingly overlies the Chainman shale. In the New York Butte quadrangle the Owens Valley formation, of Permian age, rests unconformably on the Keeler Canyon, at some places with angular discordance of about 15°.

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TABLE 2.—*Pennsylvanian and Permian sequence in the southern Inyo Mountains, Calif.*

System	Formation		Thickness (feet)	Lithology	Characteristic fossils
Permian	Owens Valley formation	Upper part	180–500	Sandy and silty limestone with chert pebbles, calcareous sandstone, siliceous conglomerate, limestone cobble conglomerate, quartzite.	*Punctospirifer pulche-* (Meek), *Spirifer pseudocameratus* (Girty).
		Disconformity			
		Middle part	400–700	Calcareous shale with argillaceous, silty and sandy limestone intercalations; silty clay shale; fine sandstone; hornfels. Fusulinids abundant in limestone.	*Parafusulina, Pseudofusulina Heritschia, Parenteletes.*
		Lower part	1,000±	Silty fusulinid limestone, lenticular fairly pure organic limestone, limestone mud breccia, platy argillaceous limestone, blocky limestone conglomerate, hornfels.	*Pseudoschwagerina, Pseudofusulina,* subordinate *Parafusulina, Triticites, Heritschia, Omphalotrochus.*
	Unconformity[1]				
	Keeler Canyon formation	Upper part	2,200±	Arenaceous, silty, and pebbly limestone with shale intercalations; calcareous sandstone and siltstone. Shale intercalations commonly pink or maroon. Marble.	*Pseudofusulina, Triticites.*
		?			
?		Middle part			?
Pennsylvanian					*Triticites.*
		Lower part		Fine-textured fusulinid-crinoidal limestone with round black chert nodules in "golf ball beds." Tactite and marble.	*Fusulinella, Millerella.*

[1] Angular unconformity on west side of Inyo Mountains; not recognized in the Darwin quadrangle.

Where the section is overturned in the Darwin Hills near the Darwin antimony mine, the Keeler Canyon formation lends itself to a twofold informal division. The 2,300-foot lower member contains mainly thin-bedded medium-gray silty limestone with local chert nodules, iron-stained partings, and crinoidal beds. The upper member, 1,700 feet thick, contains largely pink limy shale and medium-gray thinly bedded silty limestone. In the type area the two divisions were not distinguished, pink shale appearing in the "golf ball beds" with *Fusulinella* only about 75 feet above the base of the formation.

AGE AND CORRELATION

Abundant fusulinids make possible a threefold paleontologic zonation of the Keeler Canyon formation as follows:

Upper part of the Keeler Canyon	*Pseudofusulina-Triticites* zone.
Middle part of the Keeler Canyon	*Triticites* zone.
Lower part of the Keeler Canyon	*Fusulinella* zone.

Fusulinella occurs only in the basal beds, essentially in the "golf ball beds" of the lower 200 feet. Locally, *Fusulinella* is associated with *Millerella* in the Santa Rosa Hills, Darwin quadrangle, and upper Soda Canyon, New York Butte quadrangle. The *Fusulinella*-bearing beds are Middle Pennsylvanian of about Atoka age.

Triticites is the characteristic genus throughout most of the middle and upper parts of the Keeler Canyon formation. From horizon to horizon across the section specific changes are apparent, but our studies are not sufficiently refined to recognize detailed zonation on the basis of species. At least some of these species of *Triticites* indicate Pennsylvanian age.

In the upper part of the *Triticites* zone, Permian fusulinids typified by species of *Pseudofusulina* become important constituents of the faunas. This association is found at two localities, one on the Cerro Gordo road, New York Butte quadrangle, and the other on the west side of the Santa Rosa Hills in the Darwin quadrangle. At the Cerro Gordo road occurrence, species of *Pseudofusulina* are associated with typical early Permian species of *Triticites* near the top of the formation. That the formation includes strata of both Pennsylvanian and Permian (Wolfcamp) age is therefore indicated.

The Keeler Canyon formation is correlated with the Pennsylvanian and the early part of the Permian division of the Bird Spring formation southern Nevada (Longwell and Dunbar, 1936), which also includes the zones of *Fusulinella* and *Triticites.* As earlier mentioned the Bird Spring formation restudied northwest of Las Vegas by Longwell and Dunbar is not wholly Pennsylvanian but embraces Upper Mississippian and Permian.

At least part of the little-known Ely limestone of central Nevada (Nolan and others, 1956, p. 61–63) is correlative with the Keeler Canyon, as demonstrated by occurrence of the *Fusulinella* zone near its base.

OWENS VALLEY FORMATION

NAME AND OCCURRENCE

The name Owens Valley formation is proposed for the highly diverse marine strata of Permian age which occupy large areas on the western slope of the Inyo Mountains near the Owens Valley border.

The type locality of the new formation is in the foothills between Union Wash and the Reward mine (fig. 1), about 9 miles southeast of Independence between Owenyo and Kearsarge. Owenyo limestone and Reward conglomerate, earlier described as formations by Kirk (1918, p. 42–45), are herein considered local members of the more inclusive Owens Valley formation.

The Owens Valley formation has been mapped in the Inyo Mountains from the Reward mine, 5 miles north of Owenyo, to Conglomerate Mesa in the Darwin quadrangle. It also underlies the east slope of the Darwin Hills and most of the northern part of the Argus Range in the Darwin and Panamint Butte quadrangles. Northwest of the Reward mine the formation strikes into the alluvium of Owens Valley and is not known to reappear again to the north.

LITHOLOGY AND STRATIGRAPHIC RELATIONS

The Owens Valley formation (table 2) comprises interbedded silty and sandy limestones, fairly pure biogenic limestone, argillaceous shale, siltstone, sandstone, and conglomerate. The formation is highly diverse lithologically both laterally and across the section. Because of this heterogeneity and absence of marker beds, mappable subunits are for the most part very local and of the nature of large tongues or lenses. Nonetheless, on the basis of lithology and fossil faunas, certain broad stratigraphic zones are recognized; these are referred to informally as lower, middle, and upper parts of the Owens Valley formation.

In areas of plutonic intrusion, especially on the west side of the Inyo Mountains, this formation has been altered to argillite, minor quartzite, and calc-hornfels. Rocks previously classified as Diamond Peak quartzite (Kirk, 1918, p. 40) are in considerable part altered middle and lower Owens Valley. The Diamond Peak formation, an Upper Mississippian unit in central Nevada (Nolan and others, 1956, p. 60–61), has not been traced to the Inyo Mountains.

The Owens Valley formation rests with local angular unconformity upon the Keeler Canyon formation, as shown south of Cerro Gordo road on the west side of the Inyo Mountains. It is overlain by beds of very early Triassic age bearing species of the ammonoid genus *Ussuria*. No compelling evidence of angular discordance was noted at the base of the Triassic rocks. Disconformity is suggested because the Lower Triassic *Ussuria* zone rests on beds ranging in age from late Owens Valley to late Keeler Canyon.

The lower part of the Owens Valley comprises tan-weathering shales, sandy limestones, lenticular bodies of massive fairly pure limestone, conglomerate, and heavy limestone sedimentary breccia. At the base of the formation are limestone breccias, containing angular blocks of limestone up to 3 feet in diameter. Lenticular masses of this breccia rest with angular discordance upon truncated beds of the Keeler Canyon. Also quite lenticular and localized are the clean gray limestones partly composed of crinoidal, fusulinid, molluscan, coral, and other shell materials. Such carbonate lenses often form prominent ridges or bold craggy outcrops of medium dark gray.

The lower part of the Owens Valley formation differs from the underlying Keeler Canyon by lacking pinkish or maroon punky shales and by containing large fairly pure biogenic limestone bodies. Crossbedding, a common feature in sandy limestone of the Owens Valley formation, is rare in the Keeler Canyon beds.

In the Darwin quadrangle the lower beds of the Owens Valley are widely exposed in low rolling hills from 1 to 3 miles east of Conglomerate Mesa (fig. 1). These beds also crop out in the southeastern part of the quadrangle, where they are well shown east of the Darwin antimony mine, at the north end of Darwin Wash, and on the west slope of the Argus Range.

Contact of the Keeler Canyon and the lower part of the Owens Valley is found 3 miles east of the northwest corner of the Darwin quadrangle. West of this point the lower part of the Owens Valley contains numerous large fairly clean limestone lenses in sandy and silty limestones, while the underlying Keeler Canyon to the east includes silty limestone, siltstone, and pink shale interbeds. In the Darwin Hills the same contact was delineated 4,500 feet east of the Darwin antimony mine, at the base of a 450-foot-thick brown-weathering siltstone bed. The siltstone is overlain in an overturned section by crossbedded silty and sandy limestone with many thick lenses of pure limestone and limestone breccia. Pink shale is abundant in the underlying Keeler Canyon formation at the Darwin antimony mine.

Generally speaking, the middle part of the Owens Valley includes much more shale than the lower, and fossiliferous limestones are less numerous. At Conglomerate Mesa a 200-foot unit in the upper part of the middle portion of the Owens Valley shows conspicuous brick-red, greenish-gray, and yellowish-brown fissile shales with thin siltstone beds.

Change from lower to middle Owens Valley lithology is gradational and may be observed east of Conglomerate Mesa (fig. 1) near the old Saline Valley road 1.8 miles east of the northwest corner of the Darwin quadrangle.

The upper beds of the Owens Valley formation, in which conglomerate and sandstone are abundant, nearly everywhere are mappable separately. At the type locality and southeastward through the western Inyo Mountains, this part of the formation comprises calcareous sandstones, arenaceous limestones, and conglomerates. Some of the conglomerates are highly siliceous; others are limestone conglomerates.

The upper beds of the Owens Valley of the type area are best shown at Fossil Hill (fig. 1). Here they are 300 feet thick and consist of fossil-bearing calcareous sandstone, sandy and silty limestone, and siliceous conglomerate. Beneath the upper beds at this exposure are phyllitic shale and hornfels. A somewhat undulant contact is shown with overlying shales of Early Triassic age.

Followed southeast through the western Inyo Mountains, the upper part of the Owens Valley shows more limestone conglomerate and less of the siliceous or chert conglomerate. The intensely siliceous lenticular Reward conglomerate described by Kirk (1918, p. 42–43) is herein reduced to a member of the upper part of the Owens Valley, which probably for the most part underlies the 300-foot unit at Fossil Hill. However, at Fossil Hill the upper part of the Owens Valley exposures are separated from the typical Reward conglomerate member by a broad wash, so that the stratigraphic relations are not clear. A half mile south of the Reward mine, the typical Reward conglomerate member is actually in large part quartzite and has a maximum thickness of 500 feet.

The Owenyo limestone, 125 feet in thickness, crops out between Union Wash and the Reward mine three-fourths of a mile southeast of Fossil Hill. Herein reduced to a local member of the Owens Valley formation, it may be correlative with part of the 300-foot section of the upper part of the Owens Valley at Fossil Hill. The Owenyo limestone member includes a lower partly silicated white limestone with chert pebbles overlain by dense hornfels.

At Conglomerate Mesa the contact between the middle part and the upper part of the Owens Valley is sharp and possibly disconformable. The upper division, about 180 feet thick, consists of limestone cobble conglomerate, calcareous sandstone, and siltstone forming the resistant cap rock of the mesa. In the adjacent Ubehebe Peak quadrangle, the upper limestone conglomerate is reported to be 600 feet thick (McAllister, 1955, p. 14). The conglomerate contains fragments of gray silty limestone 1–4 inches in diameter in a calcareous sandy matrix. There are at Conglomerate Mesa local patches of silicification in the conglomerate, similar to those of the Reward conglomerate member.

THICKNESS

No precise thickness can be given for the Owens Valley formation because of its folded and faulted nature. At Fossil Hill in the type area the formation is about 1,800 feet thick, while from Conglomerate Mesa eastward in the Darwin quadrangle it may increase to about 3,000 feet. This figure is, however, an estimate made in highly folded and faulted terrane, where allowance must be made for duplication of beds. North of Cerro Gordo road in the New York Butte quadrangle the formation locally pinches out completely between the Keeler Canyon formation and the Lower Triassic rocks.

AGE AND CORRELATION

The Owens Valley formation is of Permian age, ranging from late Wolfcamp or early Leonard to Word and possibly Guadalupe age. Correlation and paleontologic subdivisions are based largely on fusulinids, by far the most numerous fossils. In the upper part of the Owens Valley formation, however, all known faunas represent brachiopod and molluscan facies, the fusulinids being conspicuously absent except in reworked cobbles. In the middle and lower parts of the formation, molluscan, coral, and brachiopod facies are very much localized.

The three paleontologic zones recognized are follows:

3. *Spirifer pseudocameratus* zone
2. *Parafusulina* zone
1. *Pseudoschwagerina* zone

The upper, or *Spirifer pseudocameratus* zone, coincides with the upper part of the Owens Valley in the lithologic sense. *Parafusulina* of the middle part of the Owens Valley is not restricted to this part of the column, for it occurs below associated with *Pseudoschwagerina* in beds regarded as of late Wolfcamp or early Leonard age.

Spirifer pseudocameratus Girty is very abundant in the calcareous sandstones associated with limestone conglomerate in the upper part of the Owens Valley. Beds loaded with this gregarious form have been recognized here and there from the type area at Fossil Hill southward to a point near the formational pinch-out north of Cerro Gordo road. *Punctospirifer pulcher* (Meek) is less common, sometimes occurring in beds with a cephalopod fauna. This species occurs at Fossil Hill from which locality the Phosphoria fauna identified by Girty (Kirk, 1918, p. 44–45) may have come. *P. pulcher* is less abundant than *S. pseudocameratus*. These two species were not associated at most of the fossil localities, the beds with prolific *S. pseudocameratus* apparently being for the most part lower in the section than those with the *Punctospirifer* fauna.

The Genus *Parafusulina* occurs abundantly with *Pseudofusulina* in the middle part of the Owens Valley formation, locally with coral, molluscan, and brachiopod assemblages. *Heritschia* and *Parenteletes* are among the common genera recognized. A large limestone lens of the middle part of the Owens Valley 1.3 miles southeast of the northwest corner of the Darwin quadrangle has yielded an abundant but poorly preserved megafossil assemblage. Material from this fauna determined by the late James Steele Williams (written communication, Dec. 7, 1953), of the Geological Survey, as probably Leonard or younger includes *Dictyoclostus* aff. *D. ivesi bassi* McKee, *Dictyoclostus* aff. *D. ivesi* (Newberry), *Meekella* sp., *Enteletes?* sp. and *Peruvispira* sp. The *Peruvispira* was identified by Ellis Yochelson, of the Geological Survey. All fossils not otherwise credited were determined by the senior author.

The *Pseudoschwagerina* zone is characterized not only by this genus but also by *Pseudofusulina* and a species classed with question as *Triticites*. *Pseudofusulina* and *Triticites* carry over from the Keeler Canyon formation. Fusulinids are often prolific in the purer limestone bodies of the lower part of the Owens Valley, where they are associated with corals of the genus *Heritschia* and a large *Omphalotrochus* resembling *O. whitneyi* Meek.

The lower part of the Owens Valley formation correlates with the part of the Bird Spring formation in southern Nevada that contains the *Pseudoschwagerina* zone. In central Nevada the lower part of the Garden Valley formation with *Parafusulina* and associated *Pseudoschwagerina* is likewise correlative with the lower part of the Owens Valley, while the Carbon Ridge formation at Eureka, Nev. (Nolan and others, 1956, p. 64–67), with *Omphalotrochus* cf. *O. whitneyi* Meek and *Parafusulina* may be alined with the lower and middle parts of the Owens Valley. *Pseudoschwagerina* and *Omphalotrochus* cf. *O. whitneyi* point to a correlation with lower part of the McCloud limestone of northern California, while the upper part of the McCloud and the Nosoni with *Parafusulina* may be alined with the middle part and possibly the upper part of the Owens Valley. The upper part of the Owens Valley with *Punctospirifer pulcher* (Meek) is with little doubt correlative with the Phosphoria.

LITERATURE CITED

Hague, Arnold, 1883, Abstract of report on the geology of the Eureka district, Nevada: U. S. Geol. Survey 3d Ann. Rept., p. 237–272.

——— 1892, Geology of the Eureka district, Nevada: U. S. Geol. Survey Mon. 20 [with atlas].

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

——— 1956, Geology and Mineral Resources of Ivanpah quadrangle, California and Nevada: U. S. Geol. Survey Prof. Paper 275.

Hopper, R. H., 1947, Geologic section from the Sierra Nevada to Death Valley, Calif.: Geol. Soc. America Bull., v. 58, p. 393–432.

Kirk, Edwin, 1918, The Stratigraphy of the Inyo Range, *in* Adolph Knopf, A geologic reconnaissance of the Inyo Range and the eastern slope of the Sierra Nevada, Calif.: U. S. Geol. Survey Prof. Paper 110, p. 19–48.

Knopf, Adolph, 1918, A geologic reconnaissance of the Inyo Range and the eastern slope of the Sierra Nevada, Calif.: U. S. Geol. Survey Prof. Paper 110.

Longwell, C. R., and Dunbar, C. O., 1936, Problems of Pennsylvanian-Permian boundary in southern Nevada: Am. Assoc. Petroleum Geologists Bull., v. 20, no. 9, p. 1198–1207.

McAllister, J. F., 1952, Rocks and structure of the Quartz Spring area, northern Panamint Range, Calif.: Calif. Div. Mines Special Rept. 25.

——— 1955, Geology of mineral deposits in the Ubehebe Peak quadrangle, Inyo, County, Calif.: Calif. Div. Mines Special Rept. 42.

Nolan, T. B., Merriam, C. W., and Williams, James Steele, 1956, The stratigraphic section in the vicinity of Eureka, Nev.; U. S. Geol. Survey Prof. Paper 276.

Phleger, F. B., Jr., 1933, Notes on certain Ordovician faunas of the Inyo Mountains, Calif.: S. Calif. Acad. Sci. Bull., v. 32, p. 1–21.

Stauffer, C. R., 1930, The Devonian of California: Calif. Univ. Pub. Geol. Sci., v. 19, p. 81–118.

Walcott, C. D., 1884, Paleontology of the Eureka district: U. S. Geol. Survey Mon. 8.

——— 1908, Cambrian sections of the Cordilleran area: Smithsonian Misc. Coll., v. 53, p. 185–188.

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