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SILURIAN STRATA OF THE EASTERN GREAT BASIN

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OF THE EASTERN GREAT BASIN

A thesis presented to the faculty of the Department of

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fulfillment of the requirements for

the degree of

Master of Science

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1955

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The writer wishes to thank Roy Harold Waite, a graduate student at the University of California, for his sharing of certain valuable information pertinent to this study.

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ABSTRACT

Silurian strata are present over much of the Great Basin. Two distinct facies are recognized: a western dominantly clastic facies and an eastern carbonate facies. The carbonate facies is prinicpally dolomite, and has been recognized at numerous localities throughout the eastern part of the Great Basin area.

The eastern facies is a widespread and uniform sedimentary unit; a typical stable shelf deposit in a miogeosyncline. It extends over the entire area studied with surprisingly little change in character.

Three poorly defined units are prsent in the formation: a dark gray, finely crystalline, commonly cherty unit, succeeded by a light gray, medium to coarsely crystalline unit, which is in turn overlain by a medium to dark gray finely crystalline unit. The latter is not everywhere present. Fossils are confined, in the main, to the darker colored beds.

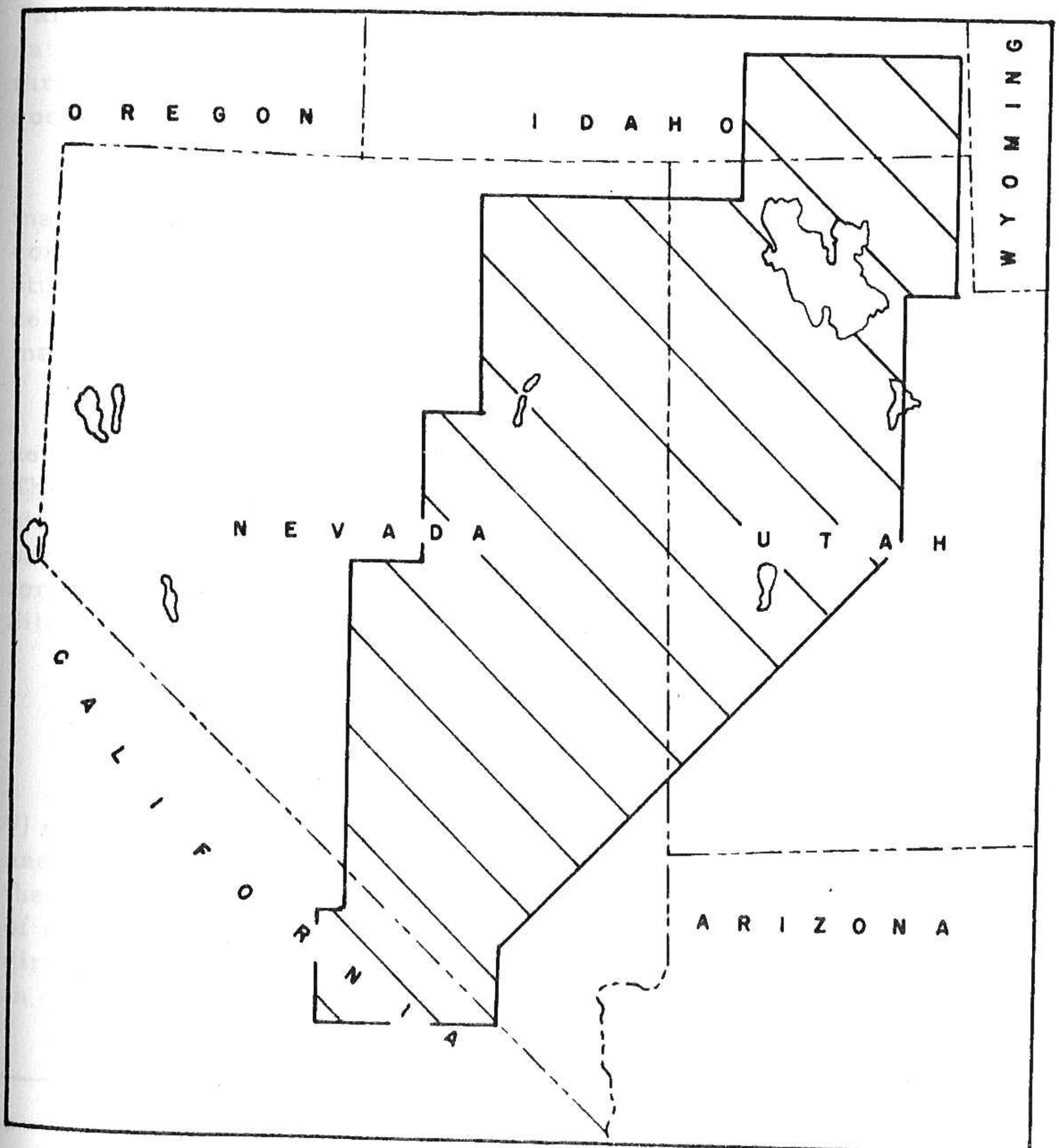
Laboratory studies indicate that the Silurian dolomites are secondary, and probably formed by penecontemporaneous replacement of calcite (or aragonite) by dolomite. Size distribution of the clastic quartz fraction in the insoluble residues prepared, indicates a northeastern or eastern provenance.

The Silurian of the Great Basin has in the past been assigned to the Middle Silurian (Niagaran). The faunal succession of the Great Basin Silurian is relatively unknown and includes many undescribed species. Recent evidence suggests that Upper Silurian is present and that Lower Silurian may be present also.

Relatively little work has been done with the Silurian of the western United States. Much of the early stratigraphic work in the Great Basin was done in the widely scattered mining districts. Different formational names were erected in these areas for correlatable stratigraphic units, which resulted in a needless multiplicity of names. The first formational name proposed to include beds of Silurian age exclusively in the area was the Laketown dolomite of northeastern Utah. It is proposed that this name be used for the Silurian of the entire eastern Great Basin.

The Laketown dolomite has little economic value at the present time. It has but few of the attributes of a petroleum reservoir rock, and does not constitute a logical source bed for petroleum. It is, however, a relatively pure dolomite extremely low in silica in certain areas.

INDEX MAP



AREA IN WHICH STUDY WAS MADE IS CROSS-HACHURED.

INTRODUCTION

General Statement

A thick sequence of carbonate rocks comprises the middle Paleozoic section of the eastern Great Basin. Dolomite predominates over limestone in strata ranging in age from Upper Ordovician through Middle Devonian; the opposite is true of the younger Paleozoic rocks.

Silurian strata have been recognized in the Great Basin for many years, but the paucity of diagnostic fossils has made positive correlation of these units difficult. The Silurian fauna of the area studied has, until recently, been assigned to the Niagaran. New evidence indicates that both Upper Silurian* and Lower Silurian** beds may be present as well.

Various workers in the Great Basin have subdivided the Paleozoic section and have erected new formational names at separate localities. This has resulted in some variation in terminology for correlatable stratigraphic units. The needless multiplicity of names was noted particularly in studying the Silurian of the region, where at least five formational names have been proposed to include clearly correlatable Silurian beds.

Location

The area studied is located within the Millard belt (Kay, 1951, p. 9) of the Cordilleran region and includes parts of Nevada, Utah, Idaho, and California. It is located in the eastern part of the Great Basin of the Basin and Range province. The area extends from the Portneuf area of southern Idaho to Death Valley California in a northeast-southwest direction, and investigations were made as far east as the Canyon Range in central Utah, and as far west of the Toquima Range in central Nevada.

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* Waite, Roy Harold, written communication to the writer dated May 16, 1955.

** Carlisle, Donald, and Nelson, C. A., paper delivered at meeting of the Cordilleran Section of the Geological Society of America, Pacific Coast Section of the Paleontological Society and Seismological Societies of America April 1955 at Berkeley, California

Description of Area

The north-south trending block-fault mountains, typical of the Basin and Range Province, are separated by wide, relatively flat-bottomed valleys bordered on either side by extensive alluvial aprons which extend out with gradually decreasing gradients to approach asymtotically the valley floor. Aridity has given the area a desert appearance. The scarcity of vegetation on the mountains enhances the geology of the region by making stratigraphic units more easily recognizable from greater distances, and by leaving almost continuous outcrops exposed on the mountains slopes.

The wide separations between mountain ranges does not lend itself to the east-west correlation of sedimentary units in a detailed study, but for a broad correlation, as in this study, the effects of this are negligible. Nevertheless, lateral continuity may be traced with greater certainty in a north-south direction.

Location of Measured Sections

The following stratigraphic sections were measured during the summer of 1954:*

A. Laketown Canyon, Utah
B. Portneuf, Idaho
C. Promontory Range, Utah
D. Desert Range, Utah
E. Indian Springs, Nevada
F. South Ward Mountain, Nevada
G. South Egan Range, Nevada
H. Pahranagat Pass, Nevada
I. Star Mining District, Utah

In addition to the above, several other localities are significant. They are as follows:

J. Simonson Canyon, Utah
K. Sunnyside, Nevada
L. Canyon Range, Utah
M. Tintic District, Utah
N. Stansbury Island, Utah
O. Logan, Utah
P. Randolph, Utah

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* See appendix for detailed descriptions.

Q. Independence Mountains, Nevada
R. North Ruby Range, Nevada
S. Roberts Mountains, Nevada
T. Blackrock Canyon, Nevada
U. North Panamint Range, California
V. Needle Range, Utah
W. Kings Canyon, Utah
X. Arbon, Idaho

Previous Work

Little work was done with the Silurian of the Great Basin prior to 1900. The scarcity of fossils in the Silurian and Lower Devonian beds of the region may have led certain of the early workers in Great Basin stratigraphy to include Silurian strata with either Ordovician or Devonian beds. More recent investigations have led to the recognition of Silurian rocks over most of the Great Basin.

Among those to include Silurian strata with the Ordovician and Devonian were Hague and Emmons (1877). Subsequently, Hague (1892, p. 57) designated the Lone Mountain limestone as Silurian. Although this latter designation later proved to be only partially correct, it served to focus attention upon the presence of Silurian rocks in the region. Ball (1907, p. 165) probably included Silurian rocks in what he mapped and described as the Pogonip limestone of Ordovician age (see McAllister, 1952, p. 17).

Spurr (1903, p. 86) identified fossils of probable Niagaran age in the Hot Creek Range, Nevada. Waring (McAllister, 1952, p. 5) recognized Silurian strata in the Death Valley region. Butler (1913, p. 33) recognized a Silurian unit in the San Francisco district, Utah, which he included in the Red Warrior limestone. In the same year, Richardson (1913, p. 410) recognized a Silurian unit in northeastern Utah which he called the Laketown dolomite. Richardson was the first to propose a formational name restricted to beds of Silurian age in the Great Basin area.

Later publications on the Great Basin describe Silurian rocks, to which no name was applied, such as in the Spring Mountain region (Nolan, 1929, p. 462), in the Pioche region (Westgate and Knopf, 1932, p. 462), and in the Nopah Range (Hazzard, 1937, p. 326).

Recent work on the Paleozoic section of the Great Basin has been done by the United States Geological Survey and by the many oil companies which have been active there. However, relatively little attention has been focused on the Silurian system specifically, because of its present limited economic significance. Roy Harold Waite, who at the time of this writing is doing graduate work at the University of California at Berkeley, has conducted extensive investigations of the Silurian fauna of the Great Basin. Rush (1951, p. 44) investigated the Silurian in Millard County, Utah.

Other workers, too numerous to mention, have recognized and mapped Silurian beds at various localities in the Great Basin.

Present Work

The work pertaining to this investigation was begun in the late spring of 1954. The initial phase of the project consisted of a general reconaissance of the area to be studied at which time certain sections, to be measured at a later date, were located. The first section measured is that located at Pahranagat Pass, west of Caliente, Nevada. This section was used as a standard for comparison with those sections measured subsequent to it. Later in the season, the type section of the Laketown dolomite was measured at Laketown Canyon, Utah.

After the initial reconaissance, the work was divided into three phases: (1) field work, (2) laboratory investigations, and (3) map construction and interpretation.

Field work. --The field work in general consisted of systematic measurement and sampling of selected stratigraphic sections of the Silurian beds of the eastern Great Basin. Samples were taken representative of each distinct lithology encountered in each section. All thickness measurements were made with steel tape and Brunton compass.

Laboratory work. --Work in the Laboratory involved the making of thin sections and the preparation of insoluble residues from the samples taken in the field. Subsequent examination and evaluation of thin section and insoluble residue data formed the basis for certain conclusions, and was the source of certain quantitative data incorporated in the study.

Map construction and interpretation. --After the measured sections were carefully examined, an isopachous map and isometric fence diagram were constructed. These data were then used to assist in the tectono-environmental reconstruction of the sedimentary history.

Scope and Limitations

It was the writer's original intention to confine the scope of the present investigation to a broad, regional correlation of Silurian strata in the eastern Great Basin. However, in some areas formations included within their vertical limits strata representing as many as three systems. So it was necessary to treat briefly the Ordovician and Devonian strata also.

Because of the scarcity of fossils in certain areas, the correlation of the three principal units was done on the basis of distinctive lithofacies and characteristic microscopic features combined with identical stratigraphic position. In almost every case, however, sufficient faunal evidence was available to ascertain the Silurian age of the enclosing beds.

In an effort to grasp the problems encountered in various areas where Silurian rocks were described, the writer visited numerous localities and particularly those where formational names had been erected. This procedure gave a familiarization with the stratigraphic nomenclature applied in these different localities.

It is not the writer's intention to propose new names or to do away with old ones, but rather to point out certain significant similarities and identities in the Silurian beds within the area studied. By the law of priority, the writer chooses to apply the name Laketown dolomite to beds of Silurian age which are clearly correlatable with those described by Richardson (1913, p. 410) in northeastern Utah, and which are located in unmapped areas where sections were measured for this study. The name Laketown dolomite was first applied in the Great Basin proper when it was used to describe the Silurian section at Gold Hill, Utah (Nolan, 1935, p. 18). However, it remains that the name Laketown was the first name applied to Silurian beds alone in the eastern portion of the Cordilleran geosyncline.

LOWER AND MIDDLE PALEOZOIC SECTION

The Cambrian sequence in east-central Nevada has an aggregate thickness of approximately 7000 feet (Wheeler and Lemmon, 1939, pp. 13 and 31). In southern Nevada the aggregate thickness of the Cambrian exceeds 18,000 feet (Nolan, 1943 , p. 147). A thick, arenaceous facies, the Prospect Mountain quartzite, is overlain by shales and argillaceous limestones of the Pioche shale or its equivalent. The Pogonip limestone represents the Lower Ordovician over most of the area, and attains a thickness of 3000 feet (Hintze, 1951, p. 38). This formation is overlain, almost generally, by 400 to 500 feet of arenites, the Eureka quartzite. The Middle Ordovician Eureka quartzite is overlain, almost universally, by the Fish Haven dolomite or its equivalent. In west-central Utah, the Eureka quartzite is underlain by an unnamed dolomite member, 85 feet thick in the Ibex area, that is in turn underlain by another quartzite. This lower quartzite, the Swan Peak, apparently thickens to the northeast as the Eureka thins in the same direction until in northeastern Utah, the Eureka has disappeared completely. At the latter locality, Upper Ordovician Fish Haven dolomite rests conformably (?) upon the Swan Peak rather than on the Eureka as it does elsewhere.

According to Hintze(1951, p. 23) "The Upper Ordovician, typically a dolomite only a few hundred feet thick, is one of the most persistant stratigraphic units in the Great Basin." The writer found the Silurian unit of the same area to be equally as persistant as the "Upper Ordovician dolomite" of Hintze, in fact the two units were noted to be coextensive over the entire area studied.

(The characteristic dark gray, somber dolomites of the Fish Haven and its equivalents, underlain by the tan to white Eureka and/or Swan Peak quartzites, served as an excellent marker and datum for locating and measuring the overlying Silurian beds.)

Silurian strata over the area studied attain a thickness of over 1100 feet in some localities. The thinnest section noted was 26 feet at Stansbury Island, Utah. The only formational names which are limited exclusively to the Silurian are the Laketown dolomite and the Roberts Mountains formation. The latter of the two formations includes only the lower part of the Silurian.

A thick Devonian sequence consisting largely of carbonate rocks with occasional lenticular arenites, aggregates roughly 4000 feet. The stratigraphic nomenclature for the Devonian is equally as complex as is that for the Silurian. The units most easily recognizable over the widest area were those designated by Nolan (1935) at Gold Hill, Utah, as the Sevy and Simonson dolomites and the Guilmette formation. The

Sevy is typically a light gray, aphanic dolomite, the Simonson consists largely of alternating light and dark dolomite beds, and the Guilmette is a blue-gray to brown weathering fossiliferous limestone.

LOWER AND MIDDLE PALEOZOIC PALEOGEOGRAPHY AND PALEOTECTONICS

In Cambrian time, eastward advancing seas covered most of what is now the Great Basin, and extended upon the hedreocraton (Kay, 1951, p. 7) over what is now Wyoming, Montana, and part of Colorado. Zones of greatest sedimentation were located in the Cordilleran geosynclinal trough where (in southern Nevada) over 18, 000 feet of Cambrian sediments are present (Nolan, 1943, p. 147). The Cambrian sequence thins rapidly to the east where in the space of 50 miles, in the vicinity of the Virgin Mountains, Nevada, less than a thousand feet of Cambrian rocks are present. The western limit of the deep Cambrian trough is not definitely known, but it is thought to have been in the vicinity of the present Sierra Nevada Mountains (Nolan, 1943, p. 147).

Two distinct facies were deposited in the Cordilleran geosyncline during Cambrian time: a western, dominantly clastic, facies, and an eastern carbonate facies. Sediments transitional between the two types were noted by Holtz and Willden* in the Osgood Mountains quadrangle, Nevada. The western facies is consistently thicker than the eastern facies and the two are separated by a "sinuous zone extending from the Rocky Mountain front in Yukon and Alberta through western Montana and Wyoming across Utah into southeastern Nevada and western Sonora" (Kay, 1951, p. 7). In the Sulphur Springs Range, Nevada, Donald Carlisle and C. A. Nelson* recognized two distinct facies in the Paleozoic sequence of that area; an "autochthonous dominantly carbonate succession overlain, above the Roberts Mountains thrust, by a dominantly clastic allochthonous western facies. Both western and eastern facies range from Ordovician to late Devonian in age."

A transgressive, Lower Cambrian sea deposited largely shallow water quartz arenites which "extend eastward with decreasing age until they are in the Upper Cambrian" (Kay, 1951, p. 7). The Middle Cambrian sea extended farther eastward into embayments on the hedreocraton, and the Upper Cambrian sea extended far beyond the limits of the earlier Cambrian seas, inundating much of the southern interior of the continent (Kay, 1951, p. 8)

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* Paper delivered at meeting of the Cordilleran Section of the Geological Society of America, Pacific Coast Section of the Paleontological Society, and Seismological Society of America, Berkely, California, April 1955.

A land, Montania (Walcott, 1915, p. 147, Deiss, 1941, p. 1095), may have separated the Cambrian geosyncline into a northern and a southern component near the present United States-Canadian border.

Lower Ordovician seas, though notably less widespread than the earlier Cambrian seas, covered much of the Great Basin area. Two distinct facies were deposited in the Ordovician also. The eastern facies of limestone and dolomite gives way to a western facies characterized by shales (Nolan, 1943, p. 150). Apparently no long periods of erosion occurred generally between the Cambrian and Ordovician (Walcott, 1915), but certain "highs" of regional dimensions appeared in Middle or Late Ordovician time. One prominent structural "high," extending from the vicinity of Provo, Utah, westward toward Wendover, began in Ordovician time and continued into Mississippian time when the feature materially aided in "nearly splitting the Utah-Nevada trough by Joana (Mississippian) time."*

The eastern shoreline of the Ordovician seas lay in central Utah. The shoreline thus defined persisted in approximately the same position until Devonian time when the strand-line moved eastward.

According to Nolan (1943, p. 151), "The Middle Ordovician sedimentary rocks in the Great Basin have a smaller areal extent and are notably thinner than the Lower Ordovician sequence." Extensive quartz arenites or orthoquartzites derived from the hedreocraton to the east were laid down in Middle Ordovician time. The Lower Ordovician Swan Peak quartzite of northern Utah may have been eroded, and thus contributed to the sedimentation of the Eureka quartzite of western Utah and central Nevada.

The Upper Ordovician seaway appears to have shifted to the east somewhat, as Upper Ordovician rocks are present in several Utah localities where rocks of Middle Ordovician age are missing as at Tintic and at Gold Hill (Nolan, 1943, p. 151). The Upper Ordovician strata are dominantly dolomite.

Rocks of the entire Ordovician system evidently pass westward into argillite (Kay, 1951, p. 12).

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* Bissell, H. J., Paper delivered at meeting of the Cordilleran Section of the Geological Society of America, Pacific Coast Section of the Paleontological Society, and Seismological Society of America, Berkeley, California, April 1955.

The "Manhattan Geanticline" (Nolan, 1943, p. 152) may have begun to rise as early as Middle Ordovician time. Recent evidence points to this structural feature as being an orogenic belt rather than the broad, epeirogenic uplift postulated by Nolan.* Evidence of thrusting in Mississippian and likely early Pennsylvanian time has been noted in the Carlin area of Nevada by Roberts and Lehner.

The eastern limit of the Silurian sea, as mentioned above, coincides approximately with that of the sea which formed the Upper Ordovician dolomite (Nolan, 1943, p. 151). The eastern strand-line passes through Utah in a generally north-south direction. The western limits of the Silurian seas are not known, but beds of Silurian age are present as far west as the Taylorsville region, California. This represents an expansion westward of the geosyncline beyond its extent in Cambrian and Ordovician time (Nolan, 1943, pp. 151-2).

By Silurian time, the orogenic belt in central Nevada had divided the Cordilleran geosyncline into two elongate belts or zones of sedimentation, each of which contained subsidiary basins or zones of relatively greater subsidence. The tectonic framework of these elongate belts (the Frazer and Millard belts, Kay, 1951, p. 9.) being different, resulted in two different facies or tectotopes (Krumbein and Sloss, 1953, p. 382). Terriginous sediments, largely shales, characterize the western facies; carbontes the eastern. Widespread, uniform conditions of sedimentation obtained in the eastern or Millard belt. Slow subsidence of the depositional surface together with a source area of low relief provided ideal conditions for carbonate deposition. According to Sloss (1947, p. 111) subsidence "was less likely when detritus from emergent positive areas was incapable of reaching the site of carbonate deposition." In contrast, terriginous sediments were poured rapidly into the western or eugeosynclinal trough which resulted in rapid subsidence and deposition of the thick shale facies. It is objectionable, in the writer's opinion, to propose anything but a western source for the terriginous sediments of the western facies.

A depositional "high" with a northeast-southwest trend was present slightly to the east of the recognized axis of the central Nevadan orogenic belt. This relatively narrow zone is characterized by rapid thinning of the Silurian rocks toward this zone from both east and west. West of this feature, the Silurian strata thicken very rapidly. This "high" does not seem to represent the boundary or transition zone between eastern

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* Roberts, Ralph J., and Lehner, Robert E., Paper delivered at the meeting of the Cordilleran Section of the Geological Society of America, Pacific Coast Section of the Paleontological Society, and Seismological Society of America, Berkely, California, April 1955.

and western facies, as the transition appears farther to the west. The thinning noted along this zone is probably due to convergence rather than to non-deposition or erosion as no conspicuous unconformity was observed to coincide with this feature.

In Devonian time, most of the Basin and Range area was inundated. Lower, Middle, and Upper Devonian rocks were deposited over the major part of the region. The central nevadan "orogenic belt" was the major tectonic feature of this period; its long axis roughly parallelled the line of maximum sedimentation in the Cambrian and Ordovician. Orogenic movements in the Late Devonian caused the almost complete removal by erosion of the earlier Devonian sediments along the axis of the orogenic belt, and caused the zone of greatest sedimentation to shift eastward (Nolan, 1943, p. 152). *

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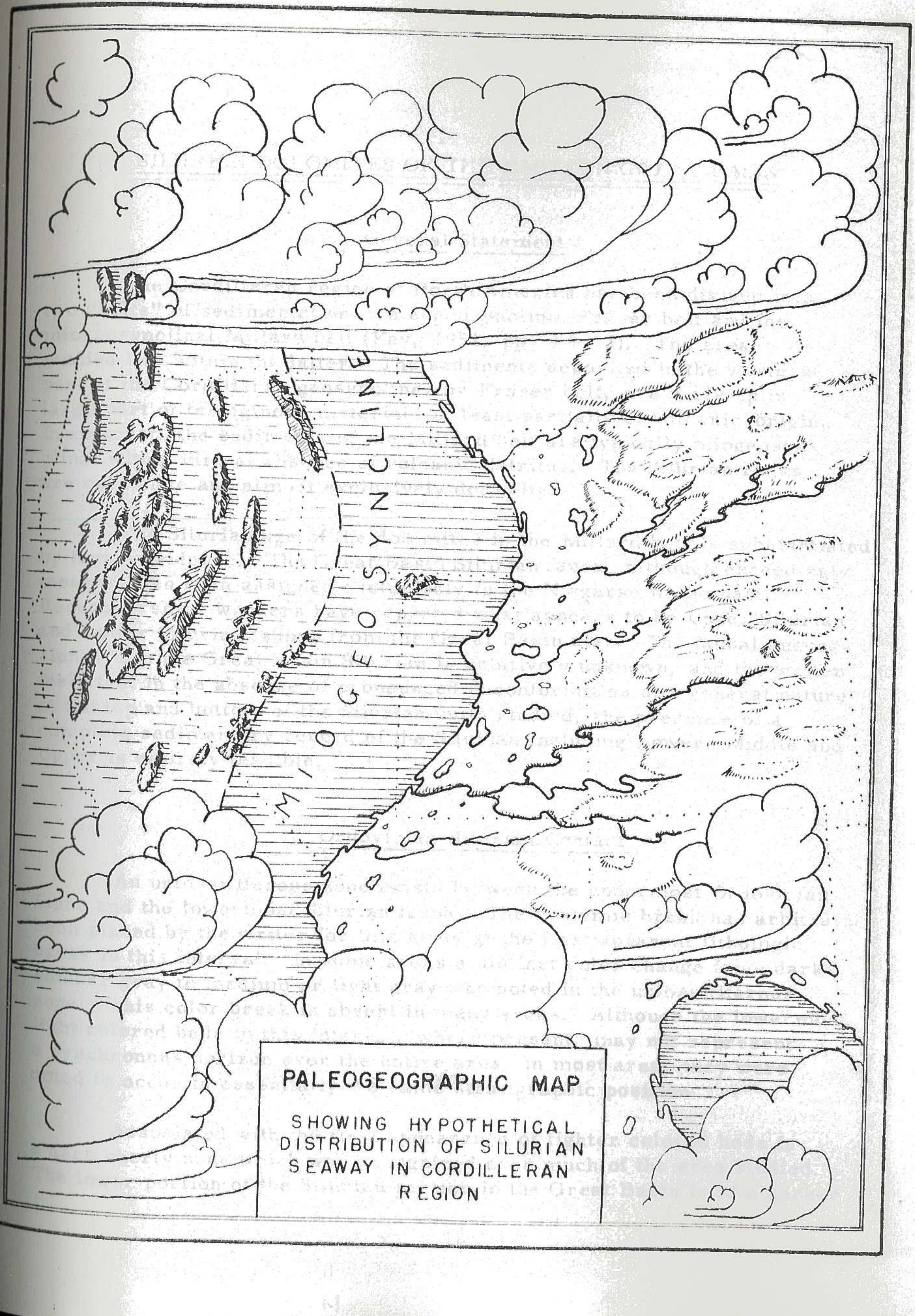
* The writer has chosen to use the term "orogenic belt" in lieu of Nolan's terms "geanticline" and "arch."

PLATE I



PALEOGEOGRAPHIC MAP

SHOWING HYPOTHETICAL DISTRIBUTION OF SILURIAN SEAWAY IN CORDILLERAN REGION

SILURIAN DOLOMITES OF THE EASTERN GREAT BASIN

General Statement

The Cordilleran region of North America has been divided into two "belts" of sedimentation: the eugeosynclinal Fraser belt and the miogeosynclinal Millard belt (Kay, 1951, pp. 9 & 13). The area studied lies within the latter. The sediments deposited in the western part of the Cordilleran geosyncline, or Fraser belt, are made up in large part of terriginous materials at least partially of volcanic origin. In contrast, the sediments of the Millard belt are typically miogeosynclinal with a virtual absence of volcanic detritus. The Silurian rocks are carbonate and almost exclusively dolomite.

The Silurian age of the dolomites in the Millard belt is substantiated by faunal evidence. The Great Basin Silurian fauna, although exceedingly meager, has been assigned exclusively to the Niagaran in the past. Recently, some workers have reported what appears to be Upper Silurian and Lower Silurian faunas from the Great Basin also. The faunal succession within the Great Basin Silurian is relatively unknown, and the writer feels that in the absence of pronounced unconformities of a general nature at the top and bottom of the Silurian units studied, the presence of a complete sedimentary record of the Silurian including Lower, Middle and Upper is entirely feasible.

Ordovician-Silurian Contact

An unfossiliferous zone exists between the uppermost Ordovician fauna and the lowermost Silurian fauna. The systemic break has arbitrarily been placed by the writer for this study at the first apparent lithologic break in this interval. In some areas a distinct color change from dark somber gray to medium or light gray was noted in the unfossiliferous zone. This color break is absent in many areas. Although the lowermost light colored beds in this interval, where present, may not represent a synchronous horizon over the entire area, in most areas they were noted to occur in essentially the same stratigraphic position.

Associated with the first appearance of lighter colored beds is a dark cherty zone which was recognized over much of the area studied. The lower portion of the Silurian section in the Great Basin is of a darker gray color than the upper part. In central Nevada, Merriam (1940) includes the lower dark beds of the Silurian in the Roberts Mountains formation which he named. In describing the formational break between the Ordovician Hansen Creek formation and the Silurian Roberts Mountains formation, Merriam states:

> The basal chert and cherty dolomite of the Roberts Mountains formation lie 320 feet above the Eureka quartzite, whereas this zone lies 560 feet above the Eureka on Pete Hansen Creek. The main body of the siliceous deposit is better developed at Lone Mountain, cropping out boldly with a thickness of from 85 to 100 feet. As in the Roberts Mountains, occasional chert beds and lenses persist upward for some distance in the overlying dolomites above the main chert belt. It appears desirable here, as at Roberts Creek Mountain where there is fossil evidence, to draw the base of the Silurian Roberts Mountains formation at the base of the chert zone... From a distance the outcrop is distinguishable from that of the overlying typical Lone Mountain dolomite by its much darker color and somewhat less massive character.

The writer found some chert present in the basal part of the Laketown dolomite in most of the areas where it was studied, and the chert zone may, in most localities prove to be a fairly reliable break. The occurrence of some chert in the Ordovician beds poses a problem in certain areas, but these areas are of limited areal extent.

At the type locality of the Laketown dolomite (Silurian) the lower contact is somewhat transitional. Richardson (1913) describes the contact as follows:

> . . . . because of the scarcity of fossils, the lower boundary and consequently the thickness of the Laketown dolomite has not been determined.

An analogous condition was noted in the Promontory Range of northern Utah, and in the Desert Range of western Utah. However, in the Promontory section, a few one to two-foot beds of light gray dolomite were noted immediately below a zone of an unidentified pentameroid brachiopod of Silurian affinities. A cherty zone was noted a short stratigraphic distance above the first light beds. In the Desert Range, the systemic break between Ordovician and Silurian strata occurs within a continuous sequence of dark somber gray weathering dolomite.

A diagnostic Ordovician fauna was not recognized in the upper part of the Fish Haven dolomite in the Desert Range, but the small, white cystoid (?) stem fragments noted elsewhere in the Upper Ordovician beds are present there. Excellent lithological affinities, in addition to stratigraphic position above the Eureka quartzite are considered prima facie evidence for correlating the Ordovician strata of that area with the Fish Haven dolomite of northeastern Utah.

The lowermost fauna noted in the Ordovician-Silurian interval in the desert Range consists of a small pentameroid (?) brachiopod and an nondescript colonial coral. Poor state of preservation prevented even generic identification. A similar fossil assemblage occurs at Pahranagat Pass, Nevada, above the first definitely recognizable pentameroid brachiopod zone. On this evidence the Ordovician-Silurian time break was placed at the base of the brachiopod-coral zone in the Desert Range.

Another zone which may prove useful for correlation purposes in the northern part of the area studied is a thin (one to four foot) zone containing "spaghetti-like" bodies. These may represent poorly preserved sponges. In all areas where the "spaghetti bed" was noted, it is associated with the lower cherty zone of the unit. In the Promontory Range, the "spaghetti bed" was observed to lie in a cherty zone above the lowest appearance of pentameroid brachiopods.

It may reasonably be concluded that in most parts of the area under consideration a distinct color "break" occurs between Ordovician and Silurian strata, which makes an easily mappable contact; in the northern parts of the area this does not generally hold true. Along the eastern edge of the area, particularly in the Tintic district of Utah, some light colored dolomites occur in the lower Bluebell dolomite (Ordovician). However, in the latter area, a so-called "ribbon bed" which the writer tentatively correlates with the "spaghetti bed" of northern Utah occupies a position directly above the uppermost dark, mottled, lower Bluebell bed.

The scarcity or complete absence of fossils at or near the Ordovician-Silurian systemic boundary, together with relatively uniform conditions of sedimentation prevailing throughout Upper Ordovician time and into Lower Silurian time, has rendered the designation of a "knife-edge" contact between the two systems difficult, if not impossible. However, the writer feels that the contact or systemic break may be successfully limited by means of any combination of the foregoing criteria to a zone not exceeding 50 feet in vertical (stratigraphic) extent.

Silurian-Devonian Contact

The upper contact of the Silurian was placed by the writer, for this study, at the base of the unfossiliferous Sevy dolomite where the latter was present. However, Osmond (1954, p. 1929) considers the Sevy to be Siluro-Devonian in age. The writer does not ignore the possibility that this might be true, but feels that insufficient evidence has been mustered to definitely substantiate it.

The uppermost Silurian beds over most of the area studied consist of massive, dark dolomite. At a few localities this upper dark unit is not apparent, but instead a lighter colored coarsely crystalline dolomite represents the higher Silurian strata. Osmond (1954, p. 1916) describes the upper dark unit of the Silurian as follows:

> At Steptoe, Blackrock Canyon, Lund, Trough Spring Canyon, and Kings Canyon the top of the massive dark dolomite contains abundant dark chert and over-silicified fossils.

These localities are all located in east-central Nevada and in western Utah.

In the northeast-Utah - southern Idaho area, the Silurian beds (Laketown dolomite) are overlain by the medium gray-brown to medium brown, fine to medium crystalline Jefferson dolomite (Devonian), which weathers to a light gray color. The contact appears to be conformable.

Over the remainder of the area, that is the southern part, the Silurian beds are overlain by the very fine grained to sub-lithographic Sevy dolomite which weathers to light gray and commonly exhibits a finely laminated structure. The beds appear massive, but on close examination the weathered surface appears laminated. These laminations are seen only with difficulty on a fresh surface. This unit was named by Nolan (1935, p. 18) at Gold Hill, Utah. At Long Mountain, Nevada the unit described above probably comprises the upper part of the Lone Mountain (restricted) formation of Merriam (1940, pp. 13-14). In Death Valley, McAllister (1952) apparently includes the Sevy dolomite in the upper beds of what he termed the Hidden Valley dolomite. The same unit was recognized by the writer in the Tintic district, Utah as the upper-middle portion of the Upper Bluebell dolomite of that area (Lindgren and Loughlin, 1919, p. 34, Lovering, et al, 1951, pp. 1505-1506).

Nolan assigned the Sevy to the Middle Devonian (1935, p. 19):

The only fossils found in the Sevy dolomite were small crinoid stems at a few horizons and several poorly preserved gastropods near the base. None of these, according to Edwin Kirk, who examined the formation in the field, are sufficiently diagnostic for determination of age. The formation grades into the overlying Simonson dolomite, which contains a Middle Devonian fauna. The Sevy dolomite is therefore considered to be Devonian and probably Middle Devonian.

Nolan (1935, 1. 18) recognizes an unconformity between the top of the Laketown dolomite and the base of the Sevy dolomite:

> The truncation of beds at the top of the Laketown dolomite, as shown by the disappearance northward of the upper light-gray, coarsely crystalline member, and the local presence, in the basal Devonian formation, of conglomerate containing pebbles of the underlying Silurian formation, leave little doubt that there is a pronounced unconformity between the Laketown dolomite and the Sevy dolomite.

Osmond (1954, pp. 1915-1916) cites evidence of a regional unconformity between the Laketown dolomite and the Sevy dolomite in east-central Nevada. He states that the upper dark, cherty, fossiliferous member of the Laketown dolomite recognized at Steptoe, Blackrock Canyon, Lung, Trough Spring Canyon, and Kings Canyon, and reported by others from several other localities is missing in some areas. He states the following:

> Beneath the Sevy at Indian Spring, Blue Eagle Mountain, and Big Springs Ranch is tan-gray, medium- to coarse-crystalline, massive dolomite quite different from the cherty member which underlies this unit at the other places. Nolan mentions the presence of the tan-gray medium crystalline unit at the top of the Laketown at Gold Hill and its absence locally as the result of pre-Sevy erosion. These relationships are evidence of a regional unconformity beneath the Sevy dolomite.

The light-colored, medium- to coarse-crystalline member which Osmond mentions above, may possibly be the same as that unit which the writer recognized at the top of the Laketown dolomite in the South Egan Range north of Pioche, Nevada. If this is true, the unit described above either underlies the dark cherty unit recognized elsewhere which has reportedly been eroded during pre-Sevy time, or represents a lateral facies change of the upper dark unit in the Upper Laketown dolomite.

At Death Valley, McAllister (1952, p. 15) does not recognize an unconformity at this horizon, nor does Merriam (1940) in the Roberts Mountains-Lone Mountain area.

It has not been the object of the present study to prove or disprove the presence of an unconformity between the Silurian and the Devonian. The sections measured by the writer are far enough apart to make positive correlation of the upper units of the Laketown dolomite difficult. However, in the current investigation, the writer did not see sufficiently conclusive evidence of an unconformity at this horizon to be considered substantiatory.

It is the writer's opinion, however, that local unconformities and diastems may be present at the Silurian-Devonian contact but that the unconformity of thickness over most of the area does not necessarily favor the hypothesis of a broad regional unconformity.

The writer does not consider a few inches, or even a few feet, of relief between any two beds or units sufficient proof of a regional unconformity. However, truncation of beds, if actually a fact, provides a more sound basis for postulating an unconformity.

Although Nolan (1935, p. 18) points out that "... the local presence, in the basal Devonian formation, of conglomerate containing pebbles of the underlying Silurian formation..." leaves "... little doubt that there is a pronounced unconformity between the Laketown dolomite and the Sevy dolomite.", the writer would like to point out the presence of similar "conglomerates" or mega-breccias present within the Silurian unit itself at Pahranagat Pass, Nevada, and to the flat-pebble conglomerates of the Silurian Laketown dolomite in the Promontory Range, Utah. The interformational conglomerate of Nolan is not unlike the intraformational conglomerates within the Silurian units of other areas. Similar conglomerates or breccias occur throughout the Devonian beds in the Pahranagat Pass area also.

The writer does not feel that the age assigned to the Sevy (Nolan, 1935, p. 19) is based upon firm enough evidence to use the apparent hiatus between Middle Silurian (?) and Middle (?) Devonian sedimentation, in itself, as proof of an unconformity. In other areas (McAllister, 1952, p. 17; Merriam, 1940, p. 8) the Sevy or its equivalent is thought to be Lower Devonian.

On the other hand, insufficient evidence was accumulated in the course of this investigation to refute completely the unconformity postulated by Nolan and others. It is altogether possible that certain of the uppermost Silurian units may have been removed by erosion before the overlying Sevy was deposited, but only detailed studies of the contact relationships will provide satisfactory data in this regard.

The Laketown Dolomite and its Equivalents

General Description.--The Laketown dolomite was named by Richardson (1913, p. 410) from exposures in Laketown Canyon, Rich County, Utah.

> The Laketown dolomite, named from Laketown Canyon 4 miles southeast of Laketown in the Randolph Quandrangle, is a massive light gray to whitish dolomite, containing lenses of calcareous sandstone, having a thickness of approximately 1000 feet... because of the scarcity of fossils, the lower boundary and consequently the thickness of the Laketown dolomite has not yet been determined. Fossils in general are rare in the Laketown dolomite although locally there occur considerable quantities of a poorly preserved Pentamerus cf. oblongus Sow. Specific identification is impossible, but they clearly point to the Silurian age of the containing beds... It is proposed to restrict the name of Laketown dolomite to beds of Silurian age.

The Laketown dolomite has been recognized at several localities in southern Idaho, but the exact extent of the formation in a northerly direction is not known to the writer.

The Laketown dolomite is present over a wide area in Utah, Nevada, and Idaho, and its equivalents are known to the writer as far south as Death Valley, California. No clear-cut subdivisions or lithotopes were recognized by the writer in the Laketown other than that the lower and upper parts of the section are commonly cherty and tend to be more dense and fine grained than the middle part. Some variation in color was noted in the different areas but, in general, the lower and upper parts of the formation are of a darker gray than the middle portion which is typically light gray.

Correlation and age.--Richardson did not correlate the Laketown dolomite with any other Silurian unit of the Great Basin when he described it at its type locality. Nolan (1935, p. 18) recognized the similarity between the Laketown and the Silurian section located in the Gold Hill district and chose to bring the name Laketown dolomite into the Great Basin. Nolan correlates the Laketown of the Gold Hill district with that of northeast Utah as follows:

> This formation (Laketown) may be considered of Niagaran age. It is correlative in part with the

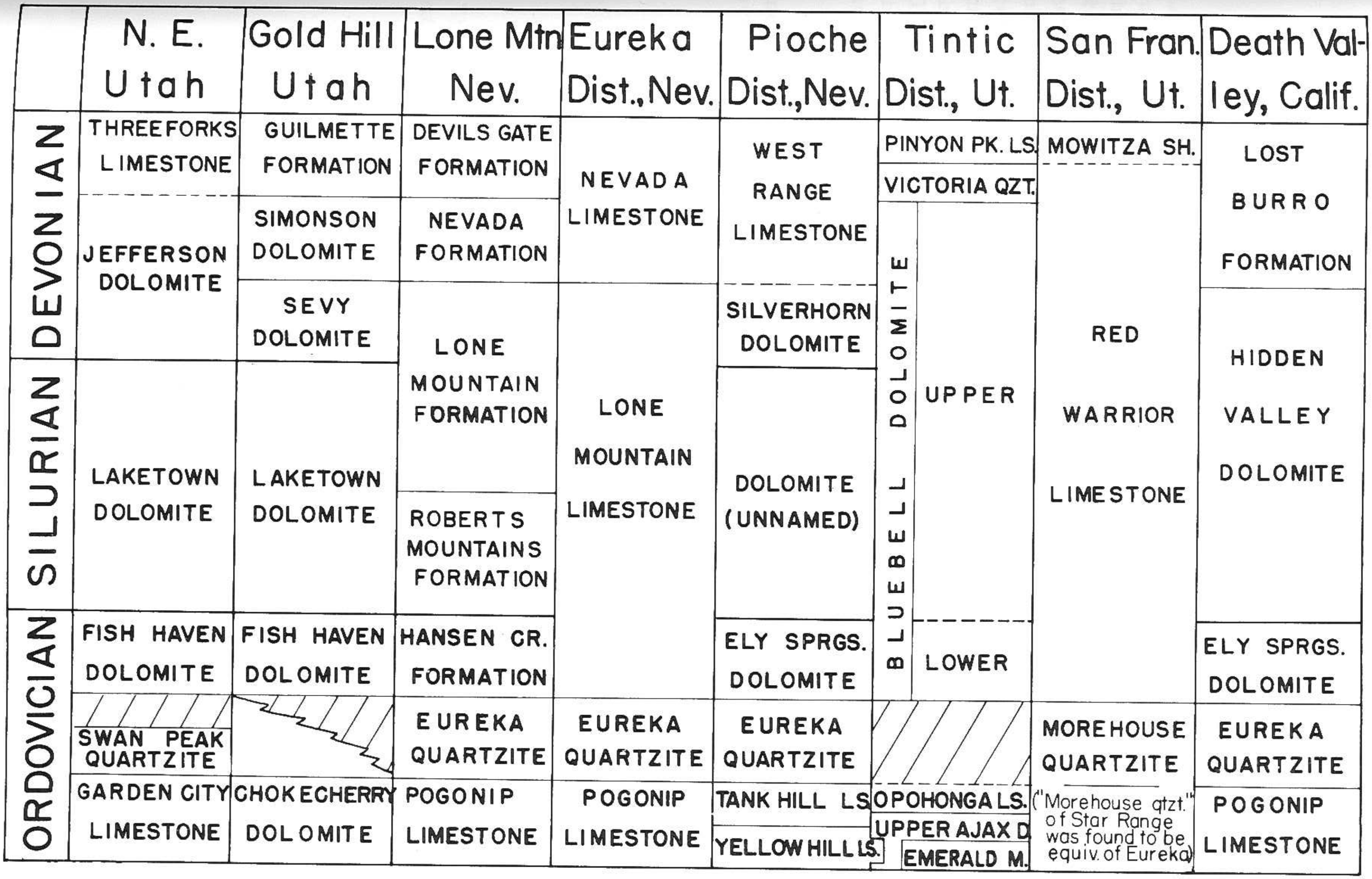


Figure 1. -- Tentative correlation chart of Middle Paleozoic formations in the eastern Great Basin Area.

Fusselman limestone of Texas and New Mexico, the Laketown dolomite of northern Utah, and probably the upper portion of the Lone Mountain limestone of the Eureka district.

The Laketown dolomite correlates with the upper part of the Lone Mountain limestone of Hague (1892), with the Roberts Mountains formation and in part with the Lone Mountain formation (restricted) of the Roberts Creek Mountain - Lone Mountain area. The dark colored Roberts Mountains formation correlates with the dark colored lower portion of the Laketown dolomite. The Lone Mountain formation (restricted) (Merriam, 1940) correlates in part with the lighter colored beds of the middle and upper Laketown. The upper part of the Lone Mountain formation (restricted) appears to correlate with the Sevy dolomite and possibly part of the Simonson dolomite of the Gold Hill district. In the writer's opinion, little doubt exists as to the correctness of this correlation; it is supported by both lithologic and faunal evidence.

The original Lone Mountain limestone of Hague (1892, p. 57) included representatives of the Ordovician, Silurian, and Devonian systems. According to Merriam (1940, p. 13):

> The present study brings out strongly that the "Lone Mountain limestone" as originally designated embraces stratal units ranging from Ordovician (Mohawkian) into the Silurian. It is furthermore a possibility that in its upper members it also includes beds of Lower Devonian age.

At Death Valley, in the Panamint Range, McAllister (1952, p. 17) correlates the Hidden Valley dolomite (Silurian-Devonian) in part with the Lone Mountain formation as follows:

> Merriam's restricted Lone Mountain formation is approximately equivalent to the middle and some of the upper part of the Hidden Valley dolomite and his Roberts Mountains formation (the middle unit of the original Lone Mountain limestone) is equivalent to the lower part of the Hidden Valley dolomite. . . The uppermost part of the Hidden Valley dolomite corresponds in age to the lowermost part of the Nevada formation as defined by Merriam (1940, pp. 13-14).

In the writer's opinion, Merriam's description of the uppermost part of the Lone Mountain formation coincides with Nolan's description of the lower Simonson dolomite. According to Merriam (1940, p. 14)

> A characteristic feature of its upper portion is an alternation of heavy beds of light mouse-gray and darker smoky-gray members.

Nolan (1935, p. 19) in speaking of the Simonson states:

> The base of the formation was placed at a dark crystalline dolomite... The contact between the two formations is merely a change in proportions of light and dark gray dolomites and does not indicate any time break.

The unnamed Silurian unit recognized in the Pioche district of Nevada (Westgate and Knopf, 1932, p. 16) was correlated with the Fusselman limestone of the El Paso region. The writer found this unit to correlate with the Silurian Laketown dolomite measured at Pahranagat Pass, Nevada, and with that measured at South Ward Mountain; the latter two formations were correlated with the Silurian section measured by the writer at Indian Springs, and with the section at Gold Hill, Utah. The Pioche section was also correlated by the writer with Merriam's (1940, p. 11) Roberts Mountains formation and in part with his restricted Lone Mountain formation as well as in part with McAllister's (1952, p. 15) Hidden Valley dolomie in Death Valley.

The Red Warrior limestone (Butler, 1913, p. 33) was named for the Red Warrior mine in the Star mining district of Utah. Although this formation was thought to be Silurian and Devonian, the writer found that it actually indludes representatives of the Ordovician, Silurian and Devonian systems. The lower Red Warrior limestone was correlated with the Ordovician Fish Haven dolomite of northern Utah.

In the Canyon Range of central Utah, Christiansen (1951, p. 717) recognized "... several hundred feet of light gray, dense, even bedded dolomite which is litholocially similar to the Laketown dolomite of Silurian age." The writer noted the same similarities in the two sections and correlates the Silurian of the Canyon Range with that of northeastern Utah also.

In the Tintic district of Utah, the Bluebell dolomite (Lindgren and Loughlin, 1919, p. 34) correlates in part with the unrestricted Lone Mountain limestone of the Eureka district, Nevada, having represented within it units of Ordovician, Silurian and Devonian age. The Tintic section may also be correlated with that at Gold Hill, Utah. The Lower Bluebell dolomite (Lovering, et al., 1951, pp. 1505 and 1506) is Upper Ordovician in age; the upper part of the Bluebell dolomite is Silurian and Devonian. Apparently the Gold Hill terminology could be applied in the Tintic district with very little difficulty. Stratigraphic units corresponding to the Fish Haven, Laketown, Sevy, and Simonson dolomites were recognized on Rattlesnake Spur in the north Boulter Mountains.

The Laketown dolomite was designated as Silurian (Richardson, 1913, p. 410) with no reference as to whether it was Lower, Middle, or Upper at its type locality. Subsequent workers with the Laketown and its equivalents have designated it as Niagaran. Recent reports of Upper Silurian and possibly Lower Silurian have cast some doubt as to the correctness the Laketown's assignment to the Niagaran only.

Nine fossil collections made in the Gold Hill District (Nolan, 1935, p. 18) included:

Halysites catenularia	Zaphrentis sp.
Favosites sp.	Favosites sp. (digitate form)
Virgiana? sp.	Syringopora 2 sp.
Coenites sp.	Trimerella sp.
Amplexus sp.	Heliolites sp.
Huronia sp.	

These fossils identified by Edwin Kirk of the United States Geological Survey, were thought to indicate a Niagaran age for the containing beds.

A fauna collected near Roberts Creek Moutain, the type locality for the Roberts Mountains formation (Merriam, 1940, p. 12) included:

Monograptus	Heliolites
Halysites	Favosites
Conchidium	Strombodes ?
?Syringopora	

also an unidentified
streptelasmoid rugosa

Conchidum? and a smaller pentameroid brachiopod were noted by the writer at several localities. The small pentameroid is suggestive of Platymerella?. The Platymerella and Conchidium zones were recognized by the writer in the Ely Springs Range, at Pahranagat Pass in the Pahranagat Range, in the Cherry Creek Range, and in the South Egan Range.

McAllister (1952, p. 16) assigns the Silurian part of the Hidden Valley dolomite to the Middle Niagaran, and bases this primarily on a coral and brachiopod fauna.

Fossil collections made by McAllister and others (1952, pp. 16-17) in the Quartz Spring Area include the following:

Halysites catenularia (linnaeus)
H. microporus (whitfield)
Favosites cf. F. niagarensis Hall
Porpites porpita (linnaeus)
Amplexus (?)
Ptychophyllum (?)
Hindia
Alveolites (?) sp.
Halysites sp. aff. H. catenularia var. simplex Lamb
Cladopora (?)
Atrypa cf. A. reticularis
Parmorthis sp.
Rhipidomella sp.

In addition to the forms listed above, several undescribed species of corals were collected including a syringoporoid type. The pygidium of a bumastid trilobite was listed also. Faunal identifications were made by Jean M. Berdan in consultation with Edwin Kirk, Helen Duncan, and G. A. Cooper as well as by McAllister.

In the Tintic district, the writer and others made a fossil collection from the Upper Bluebell dolomite (Laketown) which included a small pentameroid brachiopod of the sub-family Gypidulinae. The small brachiopod had the external morphology of Gypidula and Sieberella.* Because this brachiopod ranges from middle Silurian to Lower Devonian, it is not diagnostic of the exact age of the enclosing beds.

In the Sacramento Mountains of New Mexico, Pray (1953, p. 1915) reports a fauna of apparent Alexandrian age from the Fusselman formation of that area. No Silurian rocks crop out in Arizona or northern New Mexico, so it is doubtful that any interconnection existed between the New Mexico and Great Basin areas of deposition. Further investigation may prove contemporaneity of the two seas when faunal successions of both areas are better known.

Waite, in a personal communication to the writer, ** reports the following:

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* Identifications by Roy Harold Waite--written communication to the writer dated May 16, 1955.

** dated May 16, 1955.

> I have no definite proof of Lower Silurian in the Great Basin. All of the so called "Lower" Silurian fossils that I have seen have been Niagaran in age. . . I have found what I believe to be Upper Silurian (fossils) in Nevada just below the Sevy.

He further suggests that if Lower Silurian beds are to be found, that they might best be sought out in the deeper parts of the Silurian trough.

Nolan (1943, p. 17) did not recognize Lower Silurian in the Great Basin. In regard to this, he staes the following:

> The absence of basal Silurian rocks and the occurrence of beds at different horizons in the Ordovician beneath the contact indicate a fairly long interval of erosion preceeding the deposition of the Silurian formations.

The writer did not note any corroborative evidence of the unconformity postulated by Nolan between the Ordovician and the Silurian. In fact, the placement of the systemic boundary, in the sections measured, posed a problem because of the transitional nature of the contact.

Waite (1953)* recognized an unconformable relationship between the Ordovician and Silurian in the Independence quadrangle, California. McAllister (1952, p. 15) did not note a similar relationship in the Northern Panamint Range.

Regardless of the presence or absence of an unconformity at the base of the Silurian, only detailed paleontologic work will prove or disprove the presence of Lower Silurian beds. It must be kept in mind, and the writer stresses it again, that the faunal succession of the Great Basin Silurian is relatively unknown. The resemblance of fossil forms, in what is thought to be Upper Silurian, to oriental rather than to occidental forms** is suggestive that the Niagaran fauna of the eastern United States may not correspond exactly with the "Niagaran" of the Great Basin area. Osmond (1954, p. 1929) mentions what is reported to be Upper Silurian from the Great Basin also. According to Kirk, Duncan, and Cooper (McAllister, 1952, p. 17), many of the corals found in the Death Valley Silurian are probably undescribed species.

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* Carlisle, Donald, and Nelson, C. A., -quoted from abstract of paper in Official Program, Cordilleran Section of the Geological Society of America, Pacific Coast Section of the Paleontological Society Seismological Society of America, April 1955.

** Waite, Roy Harold, written communication to the writer.

Figure 2. --Laketown dolomite of South Promontory Range, Utah. View looking north

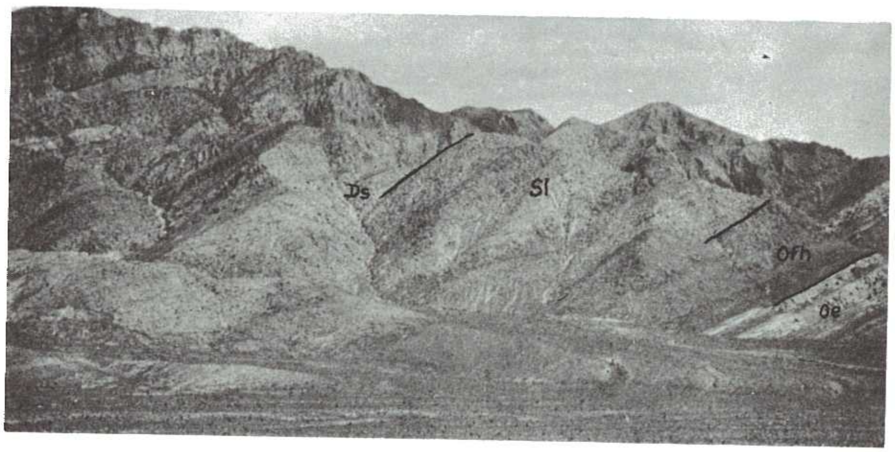

Figure 3. --Laketown dolomite two miles south of Pahranagat Pass, Nevada. View looking south.

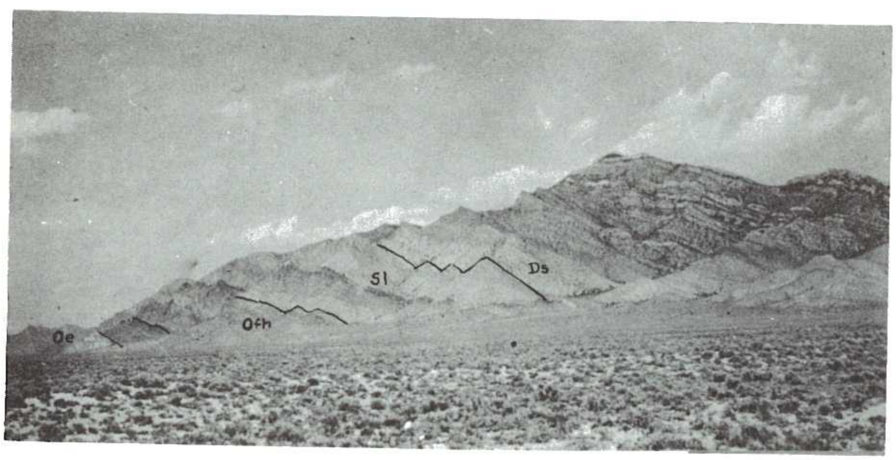

Figure 4.--Laketown dolomite near Sunnyside, Nevada. View looking north.

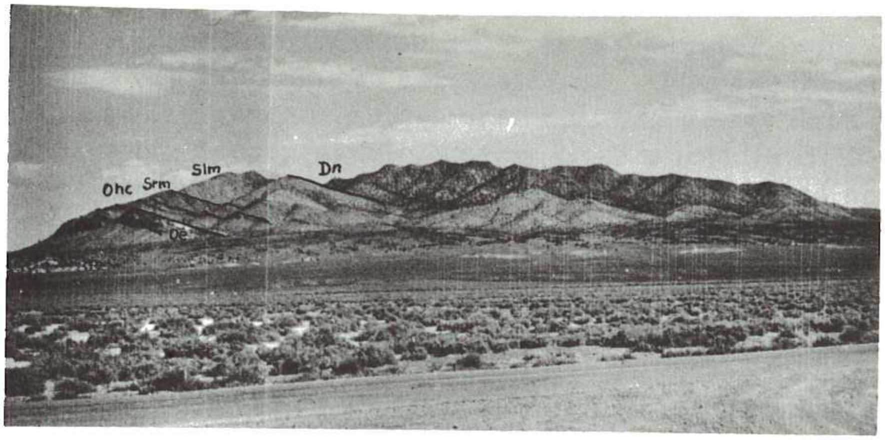

Figure 5. --Silurian Roberts Mountains and Lone Mountain formations at Lone Mountain, Nevada. View looking north.

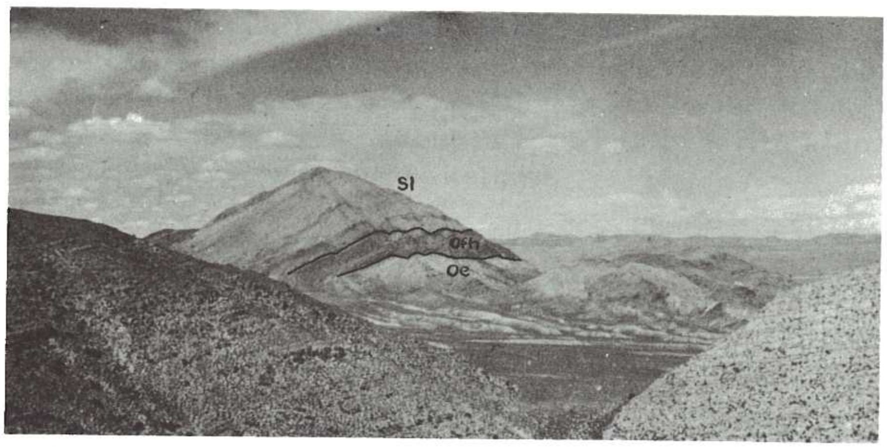

Figure 6. --Laketown dolomite of South Seaman Range north of Hiko, Nevada. View looking north.

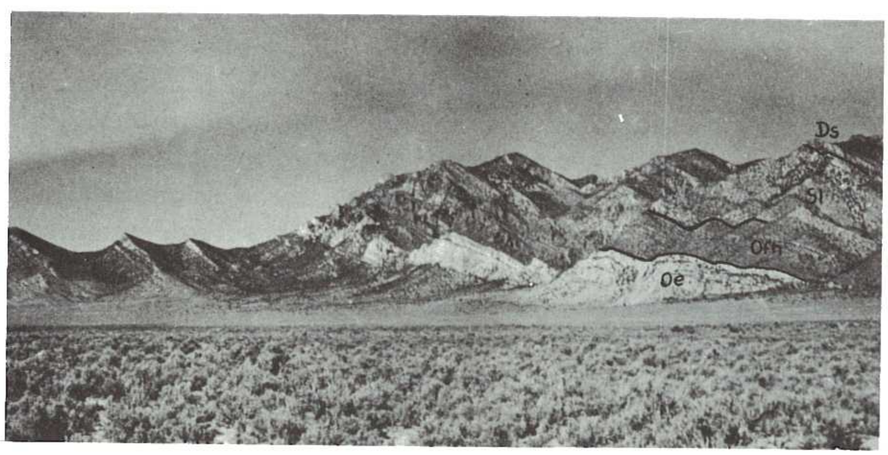

Figure 7. --Laketown dolomite near Sunnyside, Nevada. View looking northeast.

Petrology. -- The Laketown dolomite varies in color from dark to light gray, with a brownish hue in certain areas. In most localities it can be subdivided very generally into three units: a lower dark gray-to-dark brownish-gray, dense, usually cherty unit, a middle light gray unit, and an upper medium to dark gray unit. The latter unit is not everywhere present in the area studied. Color variation is due to unequal amounts of organic matter (bitumen) in the containing beds. Insoluble residue studies indicate that the darker colored dolomites contain proportionately more bitumen than do the lighter colored rocks.

Other than by means of its poorly defined threefold nature, the formation does not lend itself readily to a unit - by-unit correlation on a regional scale. The character of the lower dark gray unit varies from locality to locality in the number and distribution of lighter colored beds intercalated with the dark beds. In certain areas, as at Tintic, a sufficient number of light colored dolomite beds occur in the basal part of the Silurian to render the "lower dark" unit unrecognizable. In most other areas, with some notable exceptions, a few light colored beds occur within the lower dark gray unit, and in some areas, as at Pahranagat Pass, Hiko, and Pioche, the light beds appear to be grouped together to form a conspicuous white band at or near the base of the Laketown.

Bedding exhibits considerable variation over the area, with most beds falling into the medium-bedded to massive range. At certain localities the massive nature of the beds renders bedding planes indistinct, and makes it difficult to ascertain the attitude of the beds.

The weathered surface of the outcrops is commonly lighter colored than that of the fresh rock, and exibits certain characteristic weathering features. Upon close examination of the weathered surface, small dolomite grains are seen to stand out in bas-relief, giving the surface a sandy, "dolarenaceous" texture. This texture is more pronounced on the coarser grained rocks than on the fine grained ones. More than likely this dolarenaceous texture is due to differential solution of the rock at the weathered surface. A small amount of calcareous matrix, in the dolomites exhibiting this weathering phenomenon, when taken into solution would contribute greatly to it. Another phenomenon of weathering exhibited by the Laketown, in common with numerous other carbonate units, is that by which the beds acquire a "meringue" surface. With this, the beds exhibit countless small cones (1/16 to 1/2 inches across the base), needle sharp at the apex and separated by small, shallow depressions of like magnitude. The height of the cones is roughly one fourth the diameter of the base, and the sides represent parabolic curves. This gives the rock's surface the appearance of the top of a "meringue" pie.

Petrography. --In thin-section the Laketown dolomite is typically an interlocking mosaic of dolomite anhedra and subhedra. Grain size varies between .01 mm. and .30 mm. in the stratigraphic sections measured by the writer. The lower dark gray unit of the Laketown is finely crystalline with an average grain size of .10mm. The upper, medium to dark gray unit is finely crystalline also, with the crystal size varying between .05 mm. and .15 mm. Recrystallization has resulted in a few scattered subhedra and euhedra. The euhedra are rare except where "healing" has occurred along small fractures in the rock and along certain fine lamellar surfaces. The middle unit of the Laketown is medium to coarsely crystalline, having an average crystal size of approximately .25 mm. Although many beds within this unit are composed almost entirely of dolomite anhedra, some beds exhibit abundant subhedra up to .30 mm. in size. Very rarely, large dolomite anhedra which range in size up to 1.0 mm. in greatest dimension are present, but due to their scarcity they were not considered in average grain size calculations.

It is doubtful that any of the dolomite crystals represent original clastic forms. The typical interlocking mosaic of dolomite anhedra suggests recrystallization due to certain post-depositional adjustive processes. Continued solution and reprecipitation of the original dolomitic constituents of the rock under ideal temperature-pressure relationships in a connate water medium, probably represents the principal process involved.

Insoluble residues obtained by digesting carefully weighed rock samples in concentrated hydrochloric acid were found to constitute from 0.45% to 23.0% of the total weight of the rock. Bitumen was found to be relatively abundant in the dark colored rocks, and relatively scarce in the light colored ones. It is most abundant in the dark colored dolomites of the Laketown at its type locality, and in the Laktown of the Promontory Range. Fossils were found to be more prolific in the dark colored dolomites than in the light colored ones. However, at the southern end of the Egan Range, Nevada, the writer found poorly preserved, completely dolomitized crinoid or cystoid stem fragments in the light gray, coarsely crystalline middle unit of the Laketown. The lack of fossil remains in the light colored beds of some localities may be due to a prolonged reworking of the sediments with attendant destruction of fossils and gradual elimination of organic matter.

The solid fraction of the insoluble residues consists of appoximately 10% clastic quartz in the .01-.08 size range, 2.0% doubly terminated authigenic quartz crystals up to .25 mm. in length, and 88% authigenic chert and possibly rock flour .01 mm. and smaller. Small hexagonal flakes of biotite mica were observed in the insoluble residues prepared from samples of the Pahranagat Pass section. The ratio of constituents in the insoluble residues appears to be fairly constant regardless of the percentage of total rock weight which the residue represents.

The average grain size of the clastic quartz fraction of the insoluble residues shows a decrease going from northeast to southwest. Although not as marked, a slight decrease in average grain size was noted in insoluble residues from a suite of samples taken from sections going from each to west. This is at least partially indicative of a provenance to the east of the area studied. The highest percentage of insoluble residue was noted in the samples taken from the type locality of the Laketown dolomite in northeastern Utah; the lowest percentage of insolubles was noted in samples obtained at Hiko, Nevada. At Laketown Canyon, of the lower 363 feet of the formation, an average of 18.8% of the total rock weight is insoluble. In contrast to this, at Hiko, Cherry Creek, and Pahranagat Pass, Nevada, less than 2.0% of the total rock weight is insoluble.

The writer has not attempted to go beyond a field classification of the rocks as to relative amounts of dolomite and calcite which was based upon their relative solubility with attendant effervescence of CO_2 in a solution containing a known concentration of hydrochloric acid. However, Williams (1948, p. 1157) states that the Laketown dolomite of the Logan quadrangle, Utah, is 95% dolomite.

The only occurence of limestone in any of the stratigraphic sections studied, was at Laketown Canyon, Utah. In all other areas, the Laketown or its equivalents appeared to be a relatively pure dolomite.

Tectono-Environmental Conditions of Sedimentation. Sedimentary tectonics and sedimentary environment are so intimately related, that a single treatment of the two subjects seems advisable. The writer found it impossible to treat adequately the depositional history of the Laketown dolomite without considering the tectonic framework of the area and its direct bearing upon types of sediment and conditions and rates of sedimentation.

The Laketown dolomite was deposited on a stable shelf in a shallow, temperate sea. The coral-brachiopod fauna of the Laketown suggests an epineritic to shallow infraneritic environment with water depths probably not exceeding 150 feet for any extended period of time. At the time of deposition of the light colored beds, the surface of deposition was very near sea-level.

The preponderance of carbonate sediments in the Silurian points conspicuously to the absence of nearby tectonic lands. Erosion and reworking of pre-Laketown carbonate rocks along the zone of flexure at the eastern edge of the Millard belt and upon the craton introduced carbonate sediment and solute into the Silurian sea. This provenance was an area of extemely low relief, as is attested by the apparent slow rate of deposition and subsidence. The low clastic quartz ratio in the sediments is what one would expect of sediments derived from the erosion of a dominantly carbonate land.

The Laketown dolomite and its equivalents were deposited ubiquitously in the Millard belt. Two large negative areas, one in northeastern Utah, the other with its center on the Utah-Nevada line, received the bulk of sediment. These negative areas, together with two major positive areas, one located in central Utah, the other extending from a point west of the present location of Ely, Nevada, into northeastern Nevada and possibly into south central Idaho, formed the major tectonic features of the Silurian period in the area studied.

Of interest is the observation that the most positive area in east central Nevada during Sevy time (Osmond, 1954, p. 1912), coincides exactly with the most negative area of east central Nevada during the Silurian.* These areas of greatest sedimentation during the Silurian apparently became slightly positive "highs" during Sevy time.

At the end of Ordovician time the depositional surface was at or very near sea-level. Reworking of the organic-rich Upper Ordovician dolomites with attendant loss of organic matter resulted in the lighter colored dolomites found at the base of the Laketown. Under these conditions minor disconformities and diastems might be expected locally at this horizon. In the more rapidly subsiding portions of the Millard belt, the light colored dolomites of the basal Laketown are rare or missing. Uniform subsidence after deposition of the light colored beds resulted in the deposition and preservation of more dark colored organic-rich beds similar to those of the Upper Ordovician. The best preserved and most abundant Silurian fauna is located in this sequence. Again during the deposition of the light colored middle unit of the Laketown, the depositional surface was very near sea-level, and extensive reworking of the sediments destroyed much of the accumulated faunal evidence and once again eliminated most of the dark organic matter. Toward the close of the Silurian, more dark colored dolomite was deposited in moderately shallow water in which corals were prolific in certain areas. At the close of The Silurian, or at least at the close of Laketown time, the depositional surface was once again near sea level. Local unconformities and diastems once more occurred in certain areas. The overlying Sevy was deposited under these prevailing conditions of extremely shallow water sedimentation. The reason for the depositional surface approaching sea-level periodically, was probably due to unequal rates

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* See isopachous map of Laketown dolomite in Appendix.

of subsidence in the belt of sedimentation; subsidence being generally more rapid during certain periods of time than during certain others. The thickness and persistence of dark, organic-rich beds may serve to indicate relatively constant rates of subsidence during the particular span of time represented by those deposits. The writer observed that the Silurian strata located within the zones of greatest and apparently most uniform subsidence contained more organic matter than those of the peripheral areas, which bears out the theory that slow, erratic rates of subsidence and attendant reworking may have caused a definite loss of organic matter in the areas thus affected.

The Laketown was probably deposited originally as a carbonate mud, as was the overlying Sevy (Osmond, 1954, p. 1930), but may have contained a higher percentage of clastic material than the Sevy. Local plastimorphic deformation noted within certain beds and fragmentation due to sub-marine slumping may indicate the existence of the sediments at one time as a limy ooze. Unfortunately, recrystallization has destroyed any evidence of original texture.

Dolomitization by metasomatic replacement probably occurred penecontemporaneously with or soon after deposition. The middle Paleozoic seas were probably more favorable composition-wise to this sort of dolomitization than were those of any other similar period of time in the Paleozoic era. High magnesium content together with other necessary conditions such as the proper pH for the dolomitization reaction were undoubtedly important features of the middle Paleozoic sea. That conditions unusually well suited to extensive dolomitization obtained in the middle Paleozoic is attested by the remarkably thick dolomite sequences of the Ordovician-Silurian-Devonian of the Millard belt.

Lateral gradation of dolomite into limestone and magnesian limestone at the type locality of the Laketown indicates that dolomites of the Silurian are secondary. The widespread, uniform nature of the Silurian dolomites precludes the possibility of dolomitization due to ground water circulation. The presence of limestone in the Silurian of northeastern Utah indicates a limited selectivity in the dolomitization process. The writer feels that only the "healings" of small fractures in the rocks were due to solution and re-precipitation of dolomite from the adjacent beds by gound water activity.

Slow subsidence and slow deposition provided a long period of contact between magnesium-bearing sea-water and newly deposited sediments. Logically, the longer the period of contact between the two, the greater the possibility for dolomitization.

Skeats (1918, p. 199) summarizes the processes involved in the contemporaneous replacement of calcite by dolomite. His theory considers the equal solubility of $CaCO_3$ and $MgCO_3$ in CO_2 saturated water at the critical pressure of one to four atmospheres.

Experimentation with dolomitization under laboratory conditions has shown that dolomitization proceeds most favorably at elevated temperatures (Van Tuyl, 1914, p. 402). It is not known whether temperature was important in dolomitization during Silurian time, although it may be one of the more important factors influencing it. Garrels and Dreyer (1952, p. 377) found that dolomite replacement of limestone was most rapid in fine grained rocks. Clark (1954, p. 24) shows some correspondence between average grain size and per cent MgO for the Gardner (Mississippian) formation in Central Utah. According to Garrels and Dreyer (Clark, 1954, p. 14), the key to the replacement process includes factors which govern the solubility of calcium carbonate, of which pH is the most important. They showed that a pH decrease of one unit would increase the solubility of calcium carbonate one-hundred fold. The pH would, of course, vary with the amount of CO_2 in solution which in turn would be governed by a temperature-pressure relationship.

After dolomitization, certain diagenetic changes took place, of which recrystallization is most noteworthy. Recrystallization was probably facilitated by intimate contact of the sediments with magnesium-bearing connate water under ideal conditions of temperature and pressure. Continued solution and reprecipitation of dolomite in the rock resulting from variations in compactional stresses, may have been important.

ECONOMIC APPLICATIONS

The dark colored beds of the lower and upper parts of the Laketown contain notable amounts of bitumen. The presence of bitumen is thought, by some, to be indicative of indigenous petroleum. It is doubtful in the writer's opinion that the dark dolomites are actually petroliferous. They are finely crystalline and dense, and they lack the "sweet gas" odor peculiar to most petroliferous rocks. Fixed carbon in the rock probably accounts for much of the organic matter present in the residues. Unsuccessful attempts were made to take the organic matter in the rock into solution by means of various organic solvents. The bitumen was released from the rock only by completely digesting the rock in concentrated hydrochloric acid.

Intercrystalline porosity is well developed locally in the middle light colored unit of the Laketown, but by and large the Laketown cannot be considered a good reservoir rock. Fracture porosity in the formation is limited by the dolomite "healings" that are almost universally associated with the fractures. The writer was not able to test the permeability of beds which show intercrystalline porosity, but it is doubtful that the permeability is very high. The Laketown of northeastern Utah has higher porosity than that of any other locality in which the formation was studied. This high porosity was noted in the calcarenites of the Laketown at its type locality, and may be a phenomenon restricted to the weathered zone.

The Laketown dolomite being a relatively pure dolomite may, as such, have a certain economic value. Its low silica content makes it desirable for use in the steel industry, but the geographic location of the more favorable deposits in relation to the steel-making centers of the western United States renders its use for steel-making highly impractical.

The Laketown may have certain other economic applications, such as in the manufacture of scouring powders and water softeners, but its ultimate usefulness will depend again upon the nearness of the utilizing industry.

CONCLUSIONS

The Laketown dolomite and its equivalents are typical miogeosynclinal deposits laid down upon a stable to mildly unstable shelf. These Silurian dolomites are characterized by remarkably uniform lithology over the entire area studied.

Two distinct facies are recognized in the Great Basin Silurian. The Laketown and its equivalents representing the eastern carbonate facies passes westward into the eugeosynclinal shale facies. A definite transition zone exists between the two facies and represents the western edge of the miogeosyncline.

The source area for the Silurian dolomites was to the east of the depositional site. Erosion of a dominantly carbonate "land" provided both sediment and solute for the formation of these dolomites. The source area was one of extremely low relief, and the introduction of clastic sediments into the miogeosyncline was very slow.

Two dominantly negative areas received the bulk of sediments during Silurian time in the area. These same areas became slightly positive depositional "highs" during subsequent Sevy time.

Near sea-level deposition together with extremely slow subsidence permitted extensive reworking of Laketown sediments with attendant loss of organic material to give rise to the light colored dolomites.

The dark colored dolomites were formed either in deeper water or at times of more rapid and uniform subsidence under which conditions reworking of the sediments was less complete.

The shallow-water conditions which prevailed during most of Laketown time, where locally the depositional surface may have been subject to subaerial erosion for short periods of time, provided the necessary conditions for the formation of minor disconformities and diastems. These minor breaks in the sedimentary record may have been interpreted as major unconformities by some workers. In the course of the field investigations connected with this study, the writer did not see any conclusive evidence of a major unconformity at either the base or the top of the Laketown.

The Silurian of the great basin was probably deposited as a limy mud derived in part from transported clastic carbonates, and possibly in part from direct precipitation of calcium carbonate from solution. Although originally clastic textures have largely been destroyed by recrystallization of the rock, some beds show hints of a clastic origin.

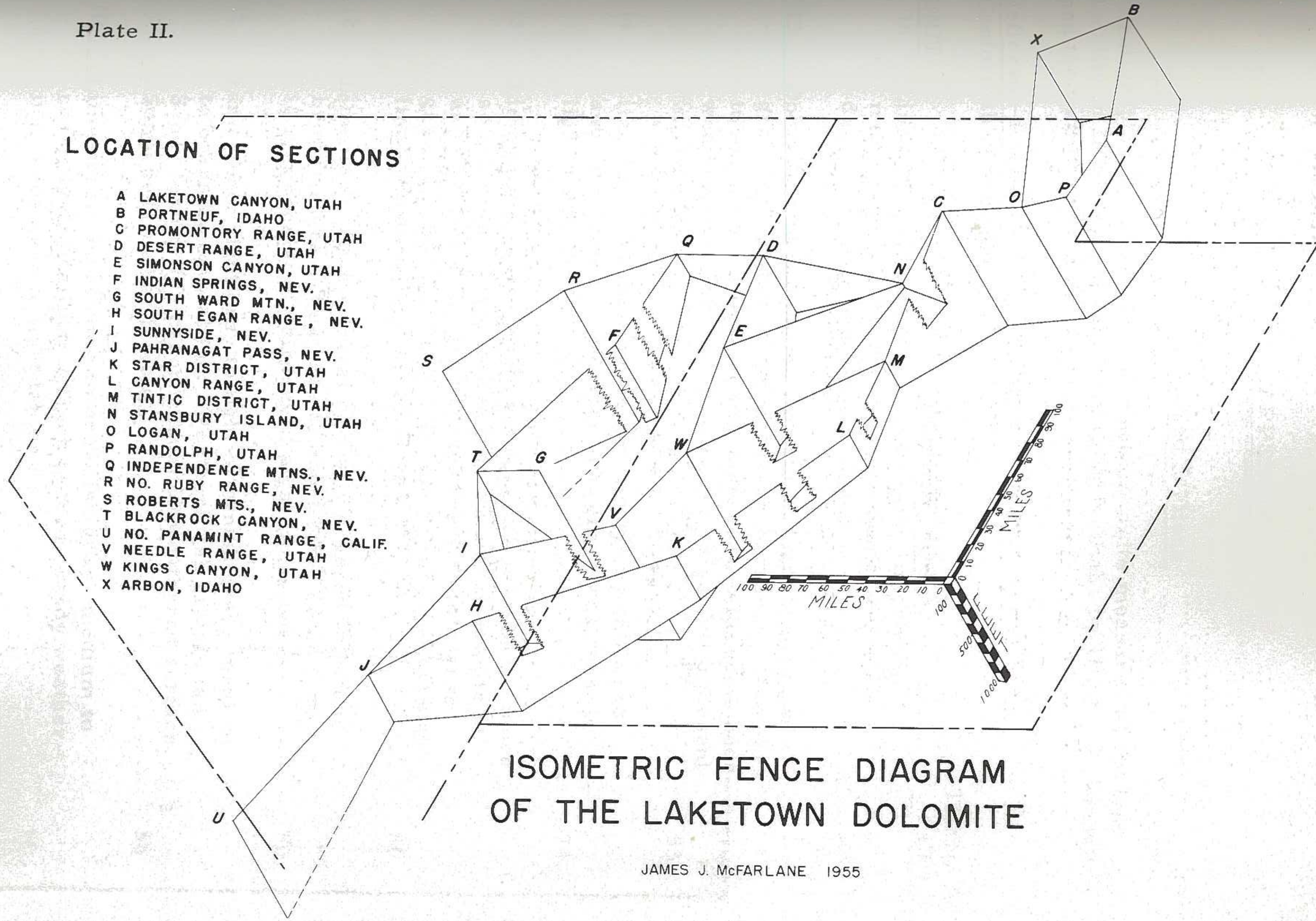
Dolomitization of the limy sediments was syngenetic. The Silurian sea undoubtedly contained abundant magnesium salts and where warm temperatures and pressures not exceeding four atmospheres prevailed, dolomitization occurred quite readily. These conditions obtain in shallow waters which, being frequently agitated, were saturated with carbon dioxide. This tended to increase the acidity of the water and under these conditions the carbonates of magnesium and calcium are equally soluble. The dolomitization reaction probably occurred at the interface between solid and solute, and represented a metasomatic volume-for-volume replacement. That the dolomite was formed by the alteration of limestone before the overlying stratum was laid down is evidenced by very distinct thin dolomite intercalations in limestone beds at Laketown Canyon.

The basal part of the Laketown together with the upper part of the formation is more finely crystalline than the middle portion in most areas. Grain-size varies between the limits of .01 mm. and 1.0 mm. for the entire formation.

The faunal succession of the Great Basin Silurian is relatively unknown in the literature. Some of the coral forms, which make up a large part of the fauna in some areas, are probably undescribed species. Recent paleontological work (largely unpublished as yet) has indicated the presence of Upper Silurian and possibly Lower Silurian in addition to the generally recognized "Niagaran" of the Great Basin. In the absence of major regional unconformities at the top and at the base of the Silurian this is entirely feasible.

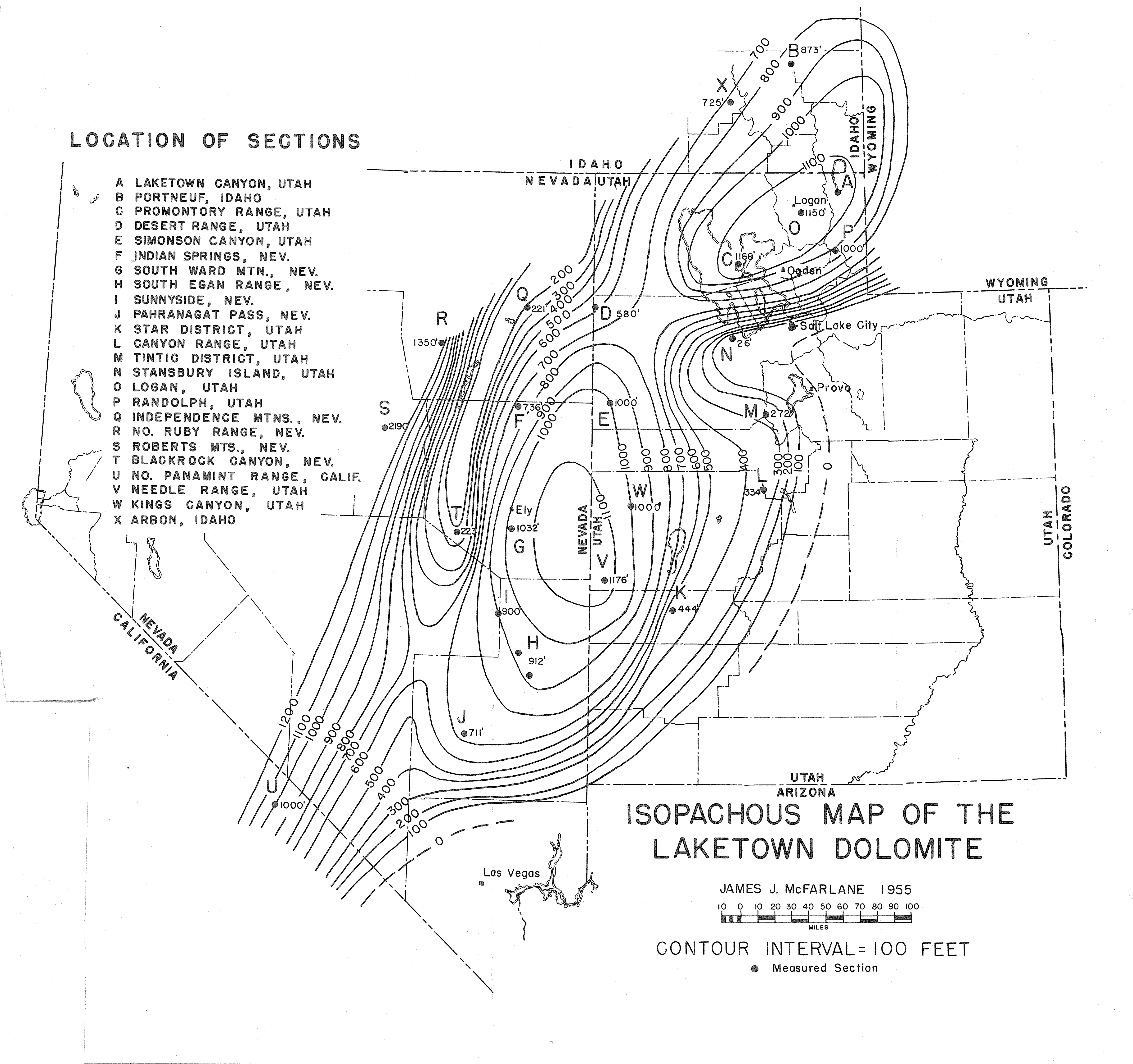
The Silurian of the Eastern Great Basin is clearly a single stratigraphic entity. The complex nomenclature applied to clearly correlatable Silurian units is confusing and needless. Hence, it is only logical that the Silurian strata thus affected be considered under a single formational name. The writer proposes that the name "Laketown dolomite" be applied to the entire eastern carbonate facies of the Great Basin Silurian.

Plate II.



ISOMETRIC FENCE DIAGRAM
OF THE LAKETOWN DOLOMITE

JAMES J. McFARLANE 1955


LOCATION OF SECTIONS
A LAKETOWN CANYON, UTAH
B PORTNEUF, IDAHO
C PROMONTORY RANGE, UTAH
D DESERT RANGE, UTAH
E SIMONSON CANYON, UTAH
F INDIAN SPRINGS, NEV.
G SOUTH WARD MTN., NEV.
H SOUTH EGAN RANGE, NEV.
I SUNNYSIDE, NEV.
J PAHRANAGAT PASS, NEV.
K STAR DISTRICT, UTAH
L CANYON RANGE, UTAH
M TINTIC DISTRICT, UTAH
N STANSBURY ISLAND, UTAH
O LOGAN, UTAH
P RANDOLPH, UTAH
Q INDEPENDENCE MTNS., NEV.
R NO. RUBY RANGE, NEV.
S ROBERTS MTS., NEV.
T BLACKROCK CANYON, NEV.
U NO. PANAMINT RANGE, CALIF.
V NEEDLE RANGE, UTAH
W KINGS CANYON, UTAH
X ARBON, IDAHO
IDAHO
NEVADA
UTAH
WYOMING
COLORADO
CALIFORNIA
ARIZONA
Logan
Ogden
Salt Lake City
Provo
Ely
Las Vegas
ISOPACHOUS MAP OF THE LAKETOWN DOLOMITE
JAMES J. McFARLANE 1955
MILES
CONTOUR INTERVAL = 100 FEET
Measured Section

APPENDIX

Detailed Sections

Stratigraphic Section of the Laketown dolomite measured at the type locality in Laketown Canyon, Rich County, Utah, by Dr. H. J. Bissell and the writer

Jefferson dolomite
Conformable(?) contact

UNIT	DESCRIPTION	THKN. IN FEET
16	Limestone, dolomite, and magnesian limestone, medium to light brownish gray. Some beds quite dense, others arenaceous textured.	57
15	Dolomite and magnesian limestone, light to medium gray, finely crystalline to sub-lithographic. Weathers to ash gray. Thick bedded in general, with some beds weathering to laminae on surface. Algal balls present in some beds	53
14	Limestone, magnesian, dense, finely crystalline to sub-lithographic. Medium light gray, weathers to lighter gray.	79
13	Limestone, sandy, slightly magnesian near base, more so near top. (Approaches magnesian calcarenite of unit 6). Brownish gray to tan, medium to coarse grained. Basal 15 to 20 feet more dense and crystalline. Algal balls in upper 20 feet	86
12	Limestone, (this interval partially covered) medium brownish gray, weathers to about same color. Lower 10 feet consist of "birdseye" algal limestone	50
11	Limestone, light gray to light brownish gray, medium to coarsely crystalline. Weathers ash gray to tan. Sandy texture (calcarenaceous) on weathered surface. Some beds rather friable	58
10	Limestone, light brown to brownish gray, medium to coarsely crystalline. Thick bedded, sandy weathering. Weathers to light tan or buff	50

UNIT	DESCRIPTION	THKN. IN FEET
9	Limestone, magnesian, very light gray, fine to medium crystalline, weathers ash gray. Massive bedded, friable	57
8	Limestone, medium to light bluish gray, fine to medium crystalline, weathers light gray. Cavernous, arenaceous texture. Some beds have higher Mg content.	82
7	Same as unit 6 but light gray colored in upper part rather than tan or buff.	93
6	Calcarenite, magnesian(?), tan or buff, scintillating, porous. Thick bedded. A typical friable, fine to medium grained arenite. Some beds slightly cavernous	81
5	Dolomite, light brownish gray, fine to medium crystalline, medium to thick bedded. Weathers light gray to buff. Uppermost bed is extremely porous	90
4	Dolomite, medium light gray, very fine grained to sub-lithographic, weathers light ashy grah. Mainly thick bedded. Two crystalline (medium) beds in middle of unit.	70
3	Dolomite, similar to unit No. 2, but slightly darker on fresh fracture. Mid portion of this section contains spaghetti-like bodies (worm trails?) on bedding planes. Blue-black nodular chert present . . .	89
2	Dolomite, medium light gray to medium light brownish gray, weathers light ashy buff. Finely crystalline, slightly mottled on weathered surface. Bluish-black, nodular chert present. Thick bedded	81
1	Dolomite, medium brownish gray, finely crystalline to sub-lithographic. Unfossiliferous. Weathers medium light gray to light gray. Thin to thick beds. Small bluish chert nodules appear in uppermost bed of unit. A black lichen growing on all exposed beds gives rock a darker appearance when viewed from a distance	68
	Total Thickness	1144

Conformable contact

Fish Haven dolomite

Stratigraphic section of the Laketown dolomite measured by H. J. Bissell and the writer near Portneuf, Idaho in section 32, T7S, R 40 E, Caribou and Bannock Counties, Idaho.

Jefferson dolomite
Conformable(?) contact

UNIT	DESCRIPTION	THKN. IN FEET
9	Dolomite, light gray and light brown; weathers medium-light to light gray; finely crystalline to sub-lithographic. Medium to thick bedded	52
8	Dolomite, dark to light gray, fine to very finely crystalline, weathers to medium-light to light gray. Dolarenaceous texture on weathered surface. Medium to think bedded	50
7	Dolomite, medium-light gray, finely crystalline, weathers medium-light gray to light gray. Medium to think bedded. Dolarenaceous texture on weathered surface.	87
6	Dolomite, medium to light gray, fine to medium crystalline, weathers medium-light gray to medium-light pinkish and bluish-gray. Medium to thick bedded, dolarenaceous texture on surface	160
5	Dolomite, medium gray to medium-light gray, medium to coarsely crystalline, weathers medium-light gray. Slightly more porous in basal 20 feet. Medium to thick bedded	159
4	Dolomite, same as below, very slightly porous (small pin-point to pin-head size holes). Holes have brown stain around them. Beds slightly friable.	125
3	Dolomite, medium-light gray, finely crystalline, weathers light gray. Medium to thick bedded. Dolarenaceous texture on weathered surface.	183
2	Dolomite, medium to medium-light brownish gray, very fine grained, weathers medium-light brownish-gray. Faint "pseudo-spaghetti" beds in upper part. . .	30
1	Dolomite, light to medium-light gray, finely crystalline to sub-lithographic, weathers ashy gray. Thick bedded	27
	Total Thickness	873

Conformable contact
Fish Haven dolomite

Stratigraphic Section of the Laketown dolomite measured in the Promontory Range, T 9 N, R 6 W, Box Elder County, Utah, by Dr. H. J. Bissell and the writer.

Top of Laketown dolomite not exposed; this probably represents most of the section.

UNIT	DESCRIPTION	THKN. IN FEET
16	Dolomite, medium dark "sooty" gray, fine clastic texture, weathers to dull gray. Thick bedded. Contains abundant Halysites sp?, Favosites sp?, and Syringopora?.	55
15	Dolomite, light gray to light bluish gray, very finely crystalline,, massive, quite dense, with fine dolarenaceous texture on weathered surface. Weathers to light ash gray	60
14	Dolomite, dark gray, fine crystalline to fine clastic texture, thick to massive bedded, weathers medium dark gray. Contains silicified Halysites sp? and crinoid or cystoid stems	31
13	Dolomite, same as below (12) but cherty in upper one-half.	92
12	Dolomite, light gray, fine to medium crystalline with somewhat clastic appearance. Weathers to light blue-gray or ash gray. Massive bedded. Unit has "vuggy appearance on dolarenaceous textured weathered surface. Lower 20 feet of unit has black, bedded chert present. This unit much as underlying unit (11)	81
11	Dolomite, light to medium light blue-gray, fine to medium crystalline, weathers to light gray; thick to massive bedded, dolarenaceous texture to weathered surface. Unit contains some crinoid or cystoid stem fragments	75
10	Dolomite, much as below (9), occasional nodules and stringers of "bull" quartz. Some beds exhibit "vuggy" weathering habit	70
9	Dolomite, light to medium-light blue-gray, fine to medium crystalline, weathers to light gray. Some beds have pronounced dolarenaceous texture on weathered surface. Thick to massive bedded, a few halysitid corals present.	72

UNIT	DESCRIPTION	THKN. IN FEET
8	Dolomite and chert; dolomite is medium-dark gray, crypto-crystalline to sub-lithographic. Chert is gray to white, with some resembling "bull" quartz. Above basal 10 feet, dolomite is medium to light gray with black, brown, and light blue nodular and bedded chert. Upper part of unit is finely crystalline.	56
7	Dolomite, light to medium gray, very fine grained to sub-lithographic, weathers from medium-light blue-gray to ash gray. Massive bedded. <u>Halysites</u> casts present	56
6	Dolomite, medium to medium light gray, finely crystalline, weathers ash gray, Massive beds weather to "meringue" surface. Sporadic black chert occurs in basal few feet. Molds of <u>Halysites</u> fairly abundant. Entire unit exhibits "vuggy" weathering habit . .	76
5	Dolomite, dark to medium gray, finely crystalline to clastic, weathers medium to medium dark blue-gray. White crystalline dolomite stringers appear throughout darker beds. A few small tan to white chert nodules occur in basal few feet	72
4	Dolomite, dark gray, weathers dark, somber gray in basal 40 feet and medium to medium dark gray in upper 40 feet. Fresh rock of lower one half of section somewhat lighter colored than above. Texture is finely crystalline to fine clastic. Fossill hash (unidentifyable) occurs throughout. Upper part contains a few thin, dark "spaghetti" beds. Thick to medium bedded	80
3	Dolomite, much as below (2) but contains abundant white chert stringers, nodules, and curtains. <u>Halysites</u> sp? occurs sporadically throughout. A few thin, flat-pebble conglomerates present in this unit.	77
2	Dolomite, dark gray, finely crystalline, weathers to dark "sooty" gray. Some beds are mottled dark and medium-dark gray. Medium to thick bedded. Occasional unidentified brachiopods, cystoid stem gragments and corals (<u>Streptalasma</u> and <u>Halysites</u>) present	76

UNIT	DESCRIPTION	THKN. IN FEET
1	Dolomite, dark to medium-dark gray, very finely crystalline, weathers to dark and medium-dark somber gray. Some beds appear to have fine clastic texture. Unit is medium to thick bedded. Occasional medium gray beds (which appear light colored in contrast to contiguous darker beds) 1 to 2 feet thick, occur in this unit. A zone of pentameroid brachiopods (Platymerella?) occupying a single bed is located at the top of this unit	39
	Total Thickness	1168

Conformable contact
Fish Haven dolomite

Stratigraphic section of the Laketown dolomite measured by H. J. Bissell and the writer in the Desert Range, T 3 N, R 17 W, Utah, and T 34 N, R 70 E, Nevada, north of Wendover, Utah

Sevy dolomite
Conformable(?) contact

UNIT	DESCRIPTION	THKN. IN FEET
6	Dolomite, medium to medium-dark gray, weathers dark bluish gray. Sandy dolomite intercalations. Also, "eyes" of white crystalline dolomite are present throughout the unit.	62
5	Dolomite, medium gray, finely crystalline, weathers medium-light bluish gray. A thick bedded ledge former.	102
4	Dolomite, medium gray, finely crystalline, weathers medium-light bluish gray. A slope former	121
3	Dolomite, dark gray, finely crystalline, weathers dark somber gray, almost black. Thick bedded. Small white cystoid (?) stem gragments are present in some beds. Upper 1/2 of unit contains grown nodular and bedded chert	105
2	Dolomite, dark gray, finely crystalline, weathers to dark somber gray. Thick bedded. Occasional chert-like stringers of sandy dolomite present in middle portion of unit. Uppermost bed of unit is a three foot bed of medium blue-gray dolomite. A small streptelasmoid horn coral is present in this unit . . .	129

UNIT	DESCRIPTION	THKN. IN FEET
1	Dolomite, dark gray, finely crystalline, weathers to dark somber gray. Thick bedded. Brown weathering black nodular chert is present throughout unit. A small (?)pentameroid brachiopod is present in this unit also	61
	Total Thickness	580

Conformable contact
Fish Haven dolomite

Stratigraphic section of the Laketown dolomite measured by H. J. Bissell and the writer at Indian Springs, North Cherry Creek Range, T 26 N, R 63 E, Elko and White Pine Counties Nevada.

Sevy dolomite
Conformable(?) contact

UNIT	DESCRIPTION	THKN. IN FEET
10	Dolomite, medium to medium-dark gray, very fine grained to sub-lithographic, weathers to medium light gray. Weathered surface has "meringue" appearance. Thick to massive.	65
9	Dolomite, medium-dark gray, very finely crystalline to sub-lithographic, weathers medium-light gray with "meringue" surface. Rock is very dense and shatters along joints and bedding. Thick bedded.	82
8	Dolomite, medium to medium-dark gray, weathers medium-light gray; exhibits "meringue" weathering on exposed surfaces. Texture is sub-lithographic. Thick to massive bedded	163
7	Dolomite, medium blue-gray, dense, very finely crystalline, Rock weathers to medium-light gray color. A few sandy and silty streaks are present near top of unit; these appear as wavy laminations	81
6	Dolomite, medium pinkish gray, medium to coarsely crystalline, weathers medium light gray. Rock becomes more finely crystalline upward in this unit. Dolarenaceous to dolsiltaceous texture on weathered surface. At top of this unit is a dark gray to black medium crystalline dolomite, 20 to 30 feet thick and containing pentameroid brachiopod steinkerns, possible <u>Halysites</u>, and imperfectly preserved streptelasmoid corals	53

UNIT	DESCRIPTION	THKN. IN FEET
5	Dolomite, medium to medium-dark gray, weathers medium dull gray, medium crystalline; thick bedded . . .	50
4	Dolomite, ash gray to pinkish gray, medium to coarsely crystalline, weathers about same color as fresh surface. Rock is distinctive because of bright pinkish gray fresh surface. Upward in unit the rocks become more finely crystalline and tend to have darker mottling. Crinoid stems up to 1/4 inch in diameter are present in this unit	74
3	Dolomite, medium to light gray, weathers very light gray; dense and finely crystalline. Unit possesses dolarenaceous texture, and is thick bedded	103
2	Dolomite, dark blue-black, weathers very dark somber gray; fine to medium crystalline. This unit contains abundant fevositid type colonial corals in lower part. Upper part is medium gray with very dark bed at top containing Synaptophyllum (?) and a small pentameroid brachiopod	35
1	Dolomite, light gray, medium crystalline, weathers to very light gray; dolarenaceous texture on weathered surface; thick bedded	30
	Total Thickness	736

Conformable contact
Fish Haven dolomite

Stratigraphic section the Laketown dolomite measured by H. J. Bissell and the writer near South Ward Mountain, Egan Range, T 15 N, R 63 E, White Pine County, Nevada

Sevy dolomite
Conformable(?) contact

UNIT	DESCRIPTION	THKN. IN FEET
7	Dolomite, medium to dark gray, finely crystalline, weathers dark somber gray near base, and light gray upward in the unit. Thick bedded. Pentameroid brachiopod casts and molds are present in dark bed at base of unit; upper beds have somewhat "twiggy" appearance	42

UNIT	DESCRIPTION	THKN. IN FEET
6	Dolomite, medium to dark gray, finely crystalline, weathers to dark, somber gray. Bedded and nodular chert present. Upper beds show faint laminations, but unit is mostly thick bedded	155
5	Dolomite, medium-light blue-gray, very finely crystalline, weathers to light blue-gray; thick to massive bedded; dolarenaceous texture on weathered surface. Stringers and "curtains" of brown weathering dolomite present in some beds of unit	174
4	Dolomite, medium to light gray, finely crystalline, weathers ash gray to medium gray; medium to massive bedded; upper part has brown weathering chert-like stringers, curtains, and nodules. Occasional sandy dolomite (brown) intercalations give some beds laminated appearance.	285
3	Dolomite, medium-dark gray, and dolomite, medium brownish gray; these beds strongly resemble siltstones on casual observation. Thick bedded. Upward in this unit beds become light dove-gray and show a slightly mottled character	179
2	Dolomite, medium-dark gray, finely crystalline; weathers medium gray. Bedding is thick to massive. Pentameroid brachiopod casts and molds are present in this unit along with other unidentifiable fossil fragments	64
1	Dolomite, medium gray, finely crystalline; weathers medium to medium-light gray. Some beds contain brown weathering chert-like bodies. Bedding is massive.	133
	Total Thickness	1032

Conformable contact

Fish Haven dolomite

Stratigraphic section of the Laketown dolomite measured by H. J. Bissell and the writer in the South Egan Range, T 1, 4, and 5 N, R 63 and 65 E, Lincoln County, Nevada.

Sevy dolomite
Conformable(?) contact

UNIT	DESCRIPTION	THKN. IN FEET
7	Dolomite, medium pinkish gray, weathers to medium-light gray; finely crystalline; medium to thick bedded. Upper part of unit weathers to medium-dark gray. Chert is rather abundant and weathers to a dark brown. Silicified halysitid and favositid corals occur in this unit	205
6	Dolomite, light gray, medium crystalline; weathers very light bluish-gray. Some beds in this unit are sugary and slightly friable. All weathered surfaces are dolarenaceous. Basal 20 feet of this unit contains abundant chert. Uppermost beds are coarsely crystalline. Thick to massive bedded with some beds weathering to laminae. A favositid colony coral is present in this unit.	239
5	Dolomite, medium to dark gray, fine to medium crystalline, weathers medium gray. Some beds exhibit brownish hue on fresh facture. Beds are thick to massive in the main with a few beds weathering to laminae. A sedimentary breccia occurs in upper part of unit.	212
4	Dolomite, dark gray, fine to medium crystalline, weathers medium dark to dark somber gray; thick to massive bedded. Small pentameroid brachiopods together with a small streptelasmoid horn coral occur intermittently throughout this unit. Uppermost bed of this unit contains Virgiana (?) and/or Conchidium	57
3	Dolomite, dark gray, fine to medium crystalline, weathers to dark somber gray. Thin to thick bedded. Pentameroid brachipod casts and molds occur in this unit.	33
2	Dolomite, dark gray, fine to demium crystalline; weathers medium-dark gray. Some beds in this unit have sugary (saccharoidal) texture. A small horn coral is present in this unit also	134

UNIT	DESCRIPTION	THKN. IN FEET
1	Dolomite, medium to medium-light gray, sublithographic; weathers light bluish gray. Rough meringue-weathering surface. Rock is very dense	32
	Total Thickness	912

Conformable contact
Fish Haven dolomite

Stratigraphic section of the Laketown dolomite measured by H. J. Bissell and the writer near Pahranagat Pass, T 6 S, R 59 E, Lincoln County, Nevada.

Sevy dolomite
Conformable(?) Contact

UNIT	DESCRIPTION	THKN. IN FEET
8	Dolomite, dark blue-gray, weathers medium to dark gray; finely crystalline to sub-lithographic texture. Fine laminations may be seen on the weathered surface of some beds. Unit contains much brown to black nodular and bedded chert.	116
7	Dolomite, medium-dark gray, finely cystalline; weathers medium to light gray. Chert present but scarce; faint orange argillaceous partings apparent in some beds. Thin to thick bedded with dolarenaceous "meringue" weathered surface	66
6	Dolomite, light gray, fine to medium crystalline; weathers light bluish gray with slight brownish hue. Brownish-green lumpy chert near base and top. "Meringue" dolarenaceous weathered surface. Thick bedded	41
5	Dolomite, medium-light gray at top, dark gray at base of unit, fine to medium crystalline; weathers light gray at top and dark somber gray at base. Rock exhibits vuggy, meringue weathering surface. Thick to massive bedded.	91
4	Dolomite, medium blue-gray with pink hue, finely crystalline to medium crystalline, weathers to light and medium-light gray. Occasional megabreccias throughout this unit. Vuggy, dolarenaceous weathering habit prominent; thick bedded. Sporadic chert and silicified favositid and halysitid corals present throughout unit	209

UNIT	DESCRIPTION	THKN. IN FEET
3	Dolomite, light to medium blue-gray, weathers light gray, very finely crystalline. Some beds exhibit plastimorphic deformation. Occasional mega-breccias occur throughout this unit. This unit is somewhat darker weathering near top; prominent dolarenaceous texture on weathered surface of all beds. Thick bedded to massive	33
2	Dolomite, gray to brownish-gray, finely crystalline, weathers to medium-dark and medium-light gray. Lowermost beds appear sandy; this may be a clastic texture. Synaptophyllum (?), Favosites (?), and a small streptelasmoid coral present. Thick to very thick bedded. Occasional mega-breccias present in unit	108
1	Dolomite, medium-light blue-gray, finely crystalline; weathers to medium-dark and medium-light gray. Thick bedded. Abundant pentameroid brachiopod (Platymerella (?)) casts and molds occur with small horn corals intermittently throughout this unit	47
	Total Thickness	711

Conformable contact

Fish Haven (Ely Springs) dolomite

Stratigraphic Section of the Laketown (Lower Red Warrior Limestone) dolomite in the Star Range, San Francisco Mining District, Beaver county, Utah, T 28 S, R 12 W. Measured by Dr. Harold J. Bissell and the writer.

Middle and Upper Red Warrior Limestone (Sevy dolomite)

Conformable(?) Contact

UNIT	DESCRIPTION	THKN. IN FEET
6	Dolomite, medium gray to medium dark-gray, strongly mottled dark and medium gra; fine to medium crystalline, weathers dark gray predominantly. Thick to massive, but most bedding indistinct. Possible pentameroid brachiopod steinkern present . . .	88
5	Dolomite, dark to medium dark blue-gray and gray-black, with some beds light cream gray, ash gray, and both mottled irregularly. Medium to fine-crystalline, and weather same colors as fresh except dull, drab, and somber; also has rough,	

UNIT	DESCRIPTION	THKN. IN FEET
	"meringue" surface where weathered. Albernate medium and thick bedded; imperfect Halysites(?) present. Some magnesian limestone beds are also present	67
4	Dolomite, and some slightly calcareous dolomite, upper beds highly mottled dark and medium pale grey-blue to gray, dense and sub-conchoidal to medium and finely crystalline. Less mottling lower beds. Most strata have hard, rough, dull medium-gray weathering surfaces. Imperfect remains suggesting Halysites are present. Thin- to medium bedded. Some rock has dolarenaceous texture on weathered surface	70
3	Dolomite, light gray to medium light gray in upper beds, very finely crystalline and dense. Rock weathers moderately smooth with medium gray color; exhibits conchoidal fracturing habit. Beds in lower part of unit differ only in being lighter gray weathering whereas the upper beds are darker and slightly mottled.	69
2	Dolomite, medium gray to medium dark gray and dark blue-gray; weathers dull somber gray-blue and blue-gray with meringue surface. Medium to thick bedded, some thin beds. Rock is sub-lithographic and breaks with conchoidal fracture. Lower beds of this interval are alternating medium dark to light gray. Some beds are slightly calcareous. Halysites (?) present	60
1	Dolomite, predominatly dark blue-gray. Weathers somber medium to light gray and blue-gray; very finely crystalline and dense. Rock is hard and brittle when broken and has sub-conchoidal fracture. Some beds are dense and sub-lithographic. Most beds have meringue appearing weathered surface. This unit is medium to thick bedded, with occasional thin beds. Hair-sized halysitid (?) corals and pentameroid (?) brachiopod steinkern present	90
	Total Thickness	444

Conformable contact

Fish Haven dolomite (lower Red Warrior limestone)

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