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DEVONIAN STRATA OF CENTRAL UTAH

by

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A thesis presented to the faculty of the Department of Geology, Brigham Young University, in partial fulfillment of the requirements for Master of Science

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1956

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ABSTRACT

The area investigated extends from the Lakeside Mountains to the South Tintic Range. The area studied is closely associated with the strand-line of the Devonian miogeosyncline, and includes the eastern margin of this depositional basin.

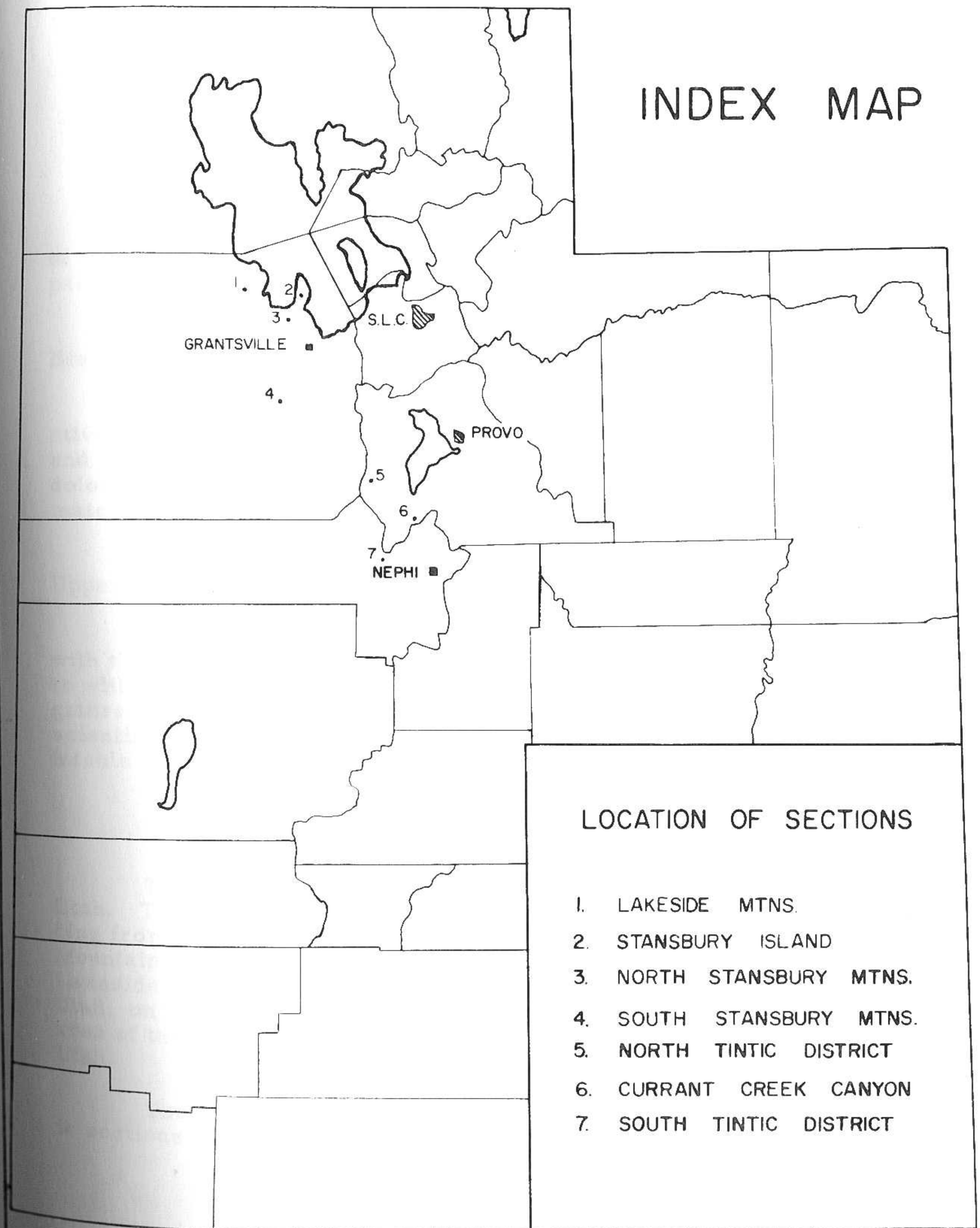
The Devonian of central Utah is considered to contain representatives (but not all) of the Lower, Middle, and Upper series of the system.

The Devonian system attains an aggregate thickness of 142 to 1,620 feet in central Utah thinning to a "feather edge" a short distance to the east.

The writer encountered many unnecessary duplications in stratigraphic nomenclature. Emendations, as well as possible correlations, are suggested in this report.

Microstructures present as well as field studies showing lithologic assocations indicate the entire Devonian system was deposited in very shallow water, probably the shallow epineritic zone, on a stable to slightly unstable shelf. Laboratory data indicate that the dolomites of the system are secondary and represent penecontemporaneous replacement of calcite (or aragonite) by dolomite.

Rocks of the Devonian in the area have little economic value at the present time and are unfavorable in most instances for future use in industry.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INTRODUCTION

General Statement

The object of this investigation is to study the Devonian strata of central Utah in an attempt to establish environment of deposition, paleogeography, paleotectonics, and stratigraphic relations.

The thesis problem was suggested to the writer by Dr. H. J. Bissell, committee chairman.

The Devonian system of central Utah is characterized by a relatively thin sequence of carbonate rocks (most of which are dolomite) and lenticular arenites. The lower part of the system is essentially dolomite; the upper portion consists of limestone with some arenaceous material.

Rocks of this system in Utah are considered to be Middle and Upper Devonian in age by Lindgren and Loughlin (1919), and Nolan (1935).

It became evident upon completion of the field work associated with this study that formations in various localities have been referred to with a multiplicity of formal stratigraphic names by various investigators. This fact resulted in the writer's use of the older (and where scientifically sound, the more applicable) terminology whenever correlatable units were encountered.

Location

The area studied by the writer encompasses most of central Utah. The study involved measuring selected Devonian sections extending from the Lakeside Mountains on the north to the South Tintic Mountains on the south. The east-west boundary extends from the Lakeside Mountains on the west to Currant Creek Canyon near Goshen, Utah, on the east. The study was limited to the eastern shore line area of the Devonian miogeosyncline which extended through central Utah.

The following are the names of the localities at which stratigraphic sections were measured by the writer:

A. Lakeside Mountains
B. Stansbury Island
C. North Stansbury Mountains
D. South Stansbury Mountains
E. Rattlesnake Spur-North Tintic district

F. Currant Creek Canyon-Goshen
G. South Tintic Mountains

In addition, the following areas were studied by Dr. H. J. Bissell who provided the writer with certain stratigraphic information:

I. Granite Peak area, northern Confusion Range
J. Kings Canyon, southern Confusion Range.

Previous Work

The initial work on the Devonian system of central Utah was done by Wheeler's Hundredth Meridian survey of 1875. Another pioneer work in the area was King's Fortieth Parallel Survey of 1878.

An important and significant work concerning the Devonian system of central Utah was presented by Lindgren and Loughlin (1919) for the Tintic district, Utah. These geologists also did some work in the Lakeside Mountains of Utah as field reconnaissance associated with the major work in the Tintic district. The Tintic district is a classic locality for certain Devonian exposures in central Utah.

Gilluly (1932) studied the Stockton-Fairfield area; however part of what he mapped as the Jefferson (?) dolomite of Devonian age is now known to be Lower Mississippian.

Billingsley (1933) studied the geology of the Tintic mining district, noting rocks of Devonian age.

A very significant work dealing with Devonian rocks in Utah was the study of the Gold Hill area by Nolan (1935), because certain standard nomenclature was effected there.

Baker (1947) studied the stratigraphy of the Provo, Utah area. In this work he considered a part of what is now known as Lower Mississippian as the Devonain Jefferson (?) dolomite.

Lovering, et al. (1951) studied the geology of the Tintic district, and made mention of the Devonian stratigraphy of the area in the light of new geologic findings.

Hintze (1949) discussed the Devonian system of Utah in a bulletin concerning the oil and gas possibilities of Utah (Hansen and Bell, 1949, pp. 58-66).

Lovering, et al. (1951) restudied the Tintic district, Utah, at which time they redated the Victoria quartzite (until then considered to be Mississippian age) as Devonian and placed it stratigraphically below the Devonian Pinyon Peak limestone.

The following unpublished Master's theses from Brigham Young University discuss Devonian strata for the particular areas under consideration: Calderwood (1951), Cedar Valley Hills Area, Lake Mountain, Utah; Hoffman (1951), Mosida Hills Area; Williams (1951), North Selma Hills Area; Rigby (1952), Selma Hills Area; Croft (1956), Northern Onaqui Mountains; Elison (1952), Keigley Quarries and Genola Hills Area; McFarlane (1955), Eastern Great Basin; Peacock (1953), Government Hills Area; Petersen (1953), Currant Creek Area; and Sirrine (1953), Warm Springs Mountain.

Bissell (1955) attempted an integration of information concerning the paleotectonics of the Upper Ordovician, Silurian, Devonain, and Lower Mississippian rocks of part of the Great Basin.

Bissell and Rigby (1955) made a study of the stratigraphic terminology of the Paleozoic rocks in the Southern Great Salt Lake Basin.

Senior and graduate geology students of Brigham Young University under supervision of the faculty of the Department of Geology during the summer field camp have mapped areas within central Utah containing Devonian formations. Most significant of these was a study of the Boulter Mountains-Fivemile Pass Area (1953) and the Stansbury Range (1954). Further work is presently being planned.

Present Work

Preliminary work for this investigation was begun in the spring of 1955 when the writer visited and studied various stratigraphic sections throughout Utah. The work pertaining directly to this study was begun in September, 1955 and completed in the Spring of 1956.

The project was divided into three phases: (1) field work, (2) laboratory investigations, and (3) interpretation and illustration of data.

Field Work-- Field work for this study began as reconnaissance trips throughout various localities in central Utah followed by detailed study of strategic areas. The writer visited the two classic sections of the Devonian formations of the Great Basin area of Utah: Gold Hill district, Utah, and Tintic district, Utah. These trips were followed by detailed measurements of selected Devonian stratigraphic sections throughout the area. The formations were identified by the writer by relative stratigraphic position, comparison of lithology with the classic localities observed by the writer at Gold Hill and Tintic, Utah, and whever possible, by distinctive fossils. Stratigraphic measurements were made using a steel tape and Bruton compass.

Laboratory Investigations-- Laboratory work involved making thin-sections of the various units within the measured sections and examination of these thin-sections with petrographic and binocular microscopes. Insoluble residues were also prepared from stratigraphic samples collected by the writer.

Interpretation and Illustration of Data--The Data bearing on the paleotectonics and paleogeography of central Utah during Devonian time were marshalled from laboratory and field information. Environments of deposition of the various Devonian formations were deducted from these investigations. Illustrations consisting of a fence diagram, a stratigraphic diagram, a lithofacies map, and a stratigraphic nomenclature chart were prepared by the writer.

<table>
<tr><th colspan="6">SUGGESTED STRATIGRAPHIC NOMENCLATURE</th></tr>
<tr><th>Age</th><th>Confusion Range</th><th colspan="2">Tintic Mining District</th><th>Stansbury Mountains</th><th>Lakeside Mountains</th></tr>
<tr><td>Upper</td><td>Pilot shale
(950 ft.)</td><td colspan="2">Pinyon Peak ls.
(73-300 ft.)</td><td>Absent</td><td>Pinyon Peak ls.
(132 ft.)</td></tr>
<tr><td rowspan="3">Middle</td><td rowspan="2">Guilmette
fm.
(2555 A.)</td><td colspan="2">Victoria qtzte.
(280 ft.)</td><td rowspan="2">Victoria qtzte.
(0-1000 ft.)</td><td rowspan="2">Guilmette
fm.
(859 ft.)</td></tr>
<tr><td rowspan="3">Bluebell dolomite (Upper 300 ft.)</td><td>Guilmette fm. (?)</td></tr>
<tr><td>Simonson dol.
(1445 ft.)</td><td>Simonson dol. (?)</td><td>Simonson dol.
(?250 ft.)</td><td>Simonson dol.
(409 ft.)</td></tr>
<tr><td>Lower</td><td>Sevy dol.
(527 ft.)</td><td>Sevy dol. (?)</td><td>Sevy dol.
(?100 ft.)</td><td>Sevy dol.
(220 ft.</td></tr>
</table>

Plate II. Stratigraphic Relations of the Devonian Strata in Central Utah.

STRATIGRAPHY

General Statement

Devonian strata of central Utah include the following formations in ascending order: Sevy dolomite, Simonson dolomite, Guilmette formation, Victoria quartzite, Pinyon Peak limestone.

The type localities for the Sevy, Simonson, and Guilmette formation is east of Ibapah, Utah in the Deep Creek Range; these formations were named by Nolan in that area twenty-one years ago (1935, pp. 18-20). The Victoria quartzite and the Pinyon Peak limestone were named by Lindgren and Loughlin in 1919 for exposures in the Tintic district, Utah (1919, pp. 36-38). The Upper Devonian sandstone and conglomerate of the Stansbury Mountains will be named by Professors J. Keith Rigby and R. Celdon Lewis." This lithofacies will be referred to in this study as the Victoria quartzite (pending outcome of studies by Rigby and Lewis this formation is tentatively regarded as Victoria or is equivalent).

The Sevy dolomite which is likely Lower Devonian in age forms the basal part of the system in the area, overlain in ascending order by the Simonson dolomite, Guilmette formation, Victoria quartzite, and Pinyon Peak limestone.

The formations have an aggregate thickness varying from 142 to 1,620 feet. The sediments of the area are characteristic of the miogeosynclinal suite, consisting dominantly of carbonates with a few lenticular arenaceous beds. The carbonates are consistently dolomite.

The Devonian formations of the Great Basin represent portions of the lower, middle and upper parts of the period. Due to insufficient paleontological studies, correlation with the eastern subdivisions of the period (Ulsterian, Erian, Senecan, Chautauguan, and Bradfordian epochs) has not been attempted. Thus the writer throughout his work has merely designated the various parts of the system either Lower, Middle, or Upper.

Sevy Dolomite

General Description--The Sevy dolomite throughout the area under investigation is for the most part characteristic of the formation as described by Nolan (1935, p. 18) at the type locality. According to Nolan:

> The Sevy dolomite is remarkably homogeneous throughout the area of outcrop. The typical work is a well-bedded mouse-gray dolomite in layers 6 to 12 inches thick

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* Paper in preparation-personal communication with Dr. J. Keith Rigby March, 1956.

and weathers to a very light gray. It is of extremely dense texture and has a conchoidal fracture. In most of the beds a faint lamination parallel to the bedding is visible in part at least, because of slight differences in color in adjoining laminae. A few beds of darker dolomite occur near the top of the formation, and locally there are present beds containing tiny nodules of light-colored chert.

The writer also found a relatively consistent arenaceous bed, commonly less than ten feet in thickness, occurring at the top of the Sevy dolomite. This harmonizes with the findings of Osmond (1954, p. 1914) throughout east-central Nevada. Bissell also found this to be true throughout much of the Great Basin.*

With the exception of the thin arenaceous bed at the top of the Sevy dolomite, no distinctive lithotopes occur as separate facies variants within the formation. Regardless of thickness the Sevy dolomite remains essentially homogeneous throughout central Utah. The term "aphanic" (Deford, 1946, p. 1923) can appropriately be applied to the dolomites of this formation (see also Osmond, 1954, p. 1914).

Age and Correlation--The Sevy dolomite was dated by Nolan (1935, p. 19) as Middle Devonian age. He based his conclusions on three factors which have been summarized by Osmond (1954, p. 1929).

> (1) it truncates the upper member of the Laketown dolomite at Gold Hill, (2) there are 30 feet of dolomite sand and conglomerate at the base of the Sevy, and (3) the Sevy grades upward into the Simonson which contains Middle Devonian fossils.

Fossils are extremely rare in the Sevy dolomite as reported by Osmond (1954, p. 1914) in east-central Nevada. The present writer concurs, from his findings throughout central Utah.

Nolan (1935, p. 19) found small crinoid stems and several poorly preserved gastropods near the base of the Sevy. According to Edwin Kirk, none of these were sufficiently diagnostic for determination of age.

It is the general consensus of the workers today that Nolan did not have sufficient evidence for dating the Sevy dolomite Middle Devonian.

Odmond (1954, p. 1929) dates the Sevy dolomite as Siluro-Devonian.

Merriam (1940, p. 51) places the upper portion of the Lone Mountain formation (restricted) as Lower Devonian. McAllister (1952, p. 14) dates the Hidden Valley dolomite as Lower Devonian also. According to Bissell the upper part of the Lone Mountain formation (restricted) and also the upper part of the Hidden Valley dolomite can be correlated

* Personal communication with Dr. H. J. Bissell, February, 1956.

with the Sevy dolomite of Gold Hill and central Utah. At Lone Mountain near Eureka, Nevada the term "Lone Mountain" should not be applied. Instead, the Silurian Laketown dolomite is present and is overlain in succession by approximately 775 feet of Sevy dolomite, about 800 feet of argillaceous limestone containing a Lower Devonian fauna, and 450 feet of Simonson dolomite. This is overlain by about 2,400 feet of the Guilmette formation. *

The possibility exists however, that the Nevada and California exposures of Merriam and McAllister could, in reality, be Lower Devonian and due to the transgressive nature of the seaways during Sevy time from west to east (if such is true) would make the Sevy dolomite of Gold Hill, and therefore central Utah, Middle Devonian in age. Osmond (1954, p. 1929) also believes this to be a possibility.

The Sevy dolomite can be correlated with a portion of the Red Warrior limestone in the San Francisco district, Utah (McFarlane, 1955, p. 19). The Sevy may possibly be correlated with the "Dora dolomite" of the Bluebell dolomite exposed in the Tintic mining district (McKinney and Petersen, 1956, p. 163). The Sevy dolomite may also be correlated with the lower portion of the Jefferson dolomite (McFarlane, 1955, p. 19).

Petrology and Petrography -- The Sevy dolomite ranges from very light gray to medium gray. Commonly a light pinkish-gray color is apparent on freshly fractured surfaces. In various localities it has a brownish-gray hue, this being due possibly to small amounts of organic material and/or arenaceous substances in the dolomite. Osmond (1954, p. 1917) states the origin of what he describes as an olive-gray color as being the result of internal absorption of light caused by the exceedingly small, transparent grains. The weathered surfaces of the Sevy range from a light ash-gray to that which is chalky-white. The light color, characteristic of the weathered surface of the Sevy dolomite, served as a valuable field guide due to the marked contrast in color of the rocks both above and below this formation.

Bedding is commonly thin to medium and appears laminated on the weathered surfaces. "Meringue type" weathering is also very characteristic of the Sevy dolomite (McFarlane, 1955, p. 27).

The Sevy dolomite is a homogeneous aphanic rock. It is typically an interlocking masaic of dolomite anhedra and subhedra ranging in size from 0.003 to 0.0087 mm. with the average being approximately 0.005 mm. This is also the size range for the Sevy dolomite as determined by Osmond in east-central Nevada (Osmond, 1954, p. 1917). Recrystallization in fractures throughout the rock produced dolomite crystals up to 0.1 mm. in diameter.

The dolomite crystals do not exhibit any evidence of clastic nature, but rather appear to have developed into a mosaic during recrystallization from the original calcitic anhedra.

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* Personal communication with Dr. H. J. Bissell, March, 1956.

The percentage of insoluble residue obtained from the Sevy dolomite ranges between 1.4% and 13.0%, averaging 4.31%. Qualitatively the residue consists predominantly of clastic quartz in the 1.0 to 0.017 mm. size range. Well-rounded to subrounded frosted quartz grains in the 0.017 to 0.034 mm. size range are also present. Doubly-terminated authigenic quartz crystals up to 0.7 mm. in length and minor amounts of authignec chert and clay-sized particles are present. Part of the chert was abraded to sub-rounded particles.

No bitumen was present, which according to Osmond (1954, pp. 1917-18) agrees with the paucity of fossils and indicates a lack of organic material which may be instrumental in the dolomitization of many calcareous sediments (see also Linck, 1937, p. 281).

Arenaceous Member of the Sevy Dolomite

The sandy member at the top of the Sevy dolomite ordinarily amounts to less than ten feet thick. Arenaceous material throuthout the Sevy dolomite, not necessarily at time parallel horizons relative to the other sections, is not uncommon in the area.

The arenaceous material which consists of dolarenite and/or quartz grains imparted little if any effect on the color of the dolomite on a fresh surface, however on a weathered surface it imparts a light tan hue. This appears to be due, at least in part, to the differential weathering effect between the softer dolomites and the arenaceous material the latter of which stands out as resistant grains on the rock surface.

The persistent arenaceous bed at the top of the Sevy dolomite differs from that described by Osmond (1954, pp. 1918-26) in that it consists of clastic angular quartz fragments as revealed by the insoluble residues, rather than being made up of rounded to well rounded fine-grained arenites similar to those in Nevada. The clastic fragments obtained by the writer average 0.017 mm. and are relatively well sorted. They are angular and have no indication of frosting.

Sedimentation -- It is not within the time limit of this paper to decide whether or not a regional unconformity exists between the Silurian and the Devonian. Many workers are divided on this issue. If a regional unconformity is present, it would be the fifth and most extensive emergence in central Utah prior to the Mississippian time (Lindgren and Loughlin, 1919, p. 38), and the Sevy would be a transgressive deposit. Osmond (1954, pp. 1915-16) believes the latter to be the case. McFarlane, (1955, p. 17), McAllister (1952, p. 17), Merriam (1940, p. 8), and Bissell* believe that evidence is insufficient to support such a view.

The uniformity of the dolomite, the absence of unstable minerals, the presence of fine laminations, the lack of fossils and other organic matter, as well as the presence of abraded chert particles within the dolomite indicate a rather thoroughly reworked shallow-water deposit.

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* Personal Communication with Dr. H. J. Bissell, April, 1955

The deposition was probably restricted to the epineritic zone, littoral zone, or both at different times and at different places.

Lack of organic matter can be attributed to the unfavorable environment caused by the reworking activity of the sediments and in part by the removal of the organic remains by scavengers.

The environmental conditions existing during the deposition of the Sevy dolomite may have been very similar to those of the present day Bahama Banks. (Newell et al., 1951, p. 13)

The provenance of the Sevy dolomite was probably an area of low relief situated to the east of the miogeosyncline, and west of the continental low craton. The eastern shore line of the Devonian miogeosyncline extended through central Utah. This shore line remained essentially the same from Ordovician through Devonian time, except for minor fluctuations in the strand line.

The Sevy dolomite probably originated as a "normal marine limestone" (Krumbein and Sloss, 1953, p. 137). The sediments were deposited as carbonate muds as evidenced by the plastimorphic deformation found by Osmond (1954, p. 1930) in Nevada. The presence of clastic quartz grains within the dolomite of central Utah likely indicates a terrigenous source for this mineral. The carbonate rocks of the Silurian and older provided the sediment and solute to the Devonian sea.

The relatively pure carbonate sequence from which the Sevy dolomite was derived explains the purity of the formation. It also explains the relative scarcity of clastic quartz except for the arenaceous material deposited at the top of the formation; in reality, this is a minor feature in central Utah and is not so significant as that described by Osmond (1954, pp. 1918-26). However, it is locally as much as 300 feet thick such as in the Diamond Range north of Eureka, Nevada. *

Dolomitization, or metasomatic replacement of the original carbonate deposit for dolomite occurred penecontemporaneously with the original deposition. The connate water surrounding the unindurated sediments provided a relatively easy passageway for the ions in the replacement process to move between the sea water and the calcium of the sediments. The stability of the depositional area would allow sufficient time for the replacement process to go to completion, particularly if the interface were also prolonged and stabilized.

The homogeneous nature of the dolomite and the blanket type of deposition characteristic of the Sevy dolomite does not lend itself to an explanation of the dolomitization by ground-water activity, or by the other explanations listed previously. The writer feels that the only dolomite deposited within the Sevy dolomite by ground-water activity is that due to subsequent recrystallization along minor fractures and joints.

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* Personal Communication with Dr. H. J. Bissell, March, 1956

Simonson Dolomite

General Description--The Simonson dolomite was named by Nolan (1935, p. 19) from exposures in Simonson Canyon, on the west side of the Deep Creek Mountains near the southern boundary of the Gold Hill quandrangle. Noaln describes the Simonson as follows:

> The typical rock of the Simonson is a dark to medium gray dolomite in which the individual grains are large enough to be distinguished by the unaided eye. Individual beds are from 1 to 2 feet thick. The most striking feature is the very general presency of a fine lamination, caused chiefly by variations in the amount of darker pigment present in the laminae and to a much less degree by variations in the grain size. The laminae are in general extremely irregular in detail, much of this irregularity being clearly the result of original variations in deposition. Locally the irregularities are even more pronounced, and these are thought to have been caused by subsurface solutions and subsequent slumping during the time the formation was being deposited.

The writer did not find consistent lithologies enabling him to divide the Simonson of central Utah into members. Osmond (1954, p. 1931) found sufficient evidence to subdivide the Simonson into four members, a basal cliff-forming tan, coarse-crystalline dolomite; an upper and a lower alternating light gray and dark brown dolomite separated by a massive brown, cliff-forming dolomite member.

The Simonson dolomite throughout central Utah is characteristically a sequence of alternating light and medium gray dolomites with occasional brownish beds present. The formation is particularly well developed in the northern Stansbury Mountains; however, complex faulting throughout the section prohibiting a measurement of the formation. The writer estimated the thicknesses shown on Plate I.

The laminations so characteristic of the Simonson dolomite of Gold Hill (Nolan, 1935, p. 19) are present in some sections, but not in others.

Age and Correlation--The Simonson dolomite was dated as Middle Devonian by Nolan (1935, p. 20). This was based on the following assemblage of fossils identified by Edwin Kirk:

Favosites (digitate form).
Bellerophon (sp.)
Stringocephalus burtoni Degrance
Martinia cf. *M. meristoides* Meek.
Atrypa reticurlaris Linnaeus.

Fossils in the Simonson dolomite are very rare throughout central Utah. Those found are usually badly broken or dolomitized and difficult to identify. The following assemblage was identified at the Lakeside Mountains by H. J. Bissell:

Chonetes sp.
Stringocephalus sp.
Favosites sp.

The following fossils were found in the Simonson dolomite bo the Southern Stansbury Mountains identified in the field by H. J. Bissell.

Stromatopora sp.
Cladopora sp.
Striatopora sp.
Favosites sp.

Osmond (1954, p. 1951) found faunal evidence supporting the dating of the Simonson as Middle Devonian. In addition to the above named fossils, Osmond found the following:

Thamnopora sp.
Productella sp.
Leiorhynchus sp.
Emanuella (?) sp.
Stryliolina sp.
Atrypa cf. missouriensis
Atrypa sp.

All evidence gathered by the writer indicates an agreement with the original dating of the Simonson dolomite by Nolan.

The Simonsons dolomite is correlated with the upper Jefferson dolomite of north-eastern Utah; the Nevada formation of Lone Mountain, Nevada; the lower portion of the Nevada formation of Eureka district, Nevada; the lower portion of the West Range limestone of the Pioche district, Nevada; the "Eagle dolomite" of the Bluebell dolomite of the Tintic mining district, Utah; the upper portion of the Red Warrior limestone of the San Francisco district, Utah; and the lower portion of the Lost Burro formation of Death Valley, California (McFarlane, 1955, p. 19).

Osmond (1954, p. 1950) suggests the possibility of correlating the Simonson dolomite with the Devil's Gate formation or possibly upper Nevada limestone due to the fossils he found in the Simonson dolomite. However, Bissell* re-measured and re-studied the section on Lone Mountain and recognized both Sevy and Simonson dolomite below Guilmette formation, the latter of which should be used in lieu of Devil's Gate.

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* Personal communication with Dr. H. J. Bissell, April, 1956.

Petrology and Petrography -- The Simonson dolomite consists of characteristic light medium gray and dark gray (almost black) dolomite beds in alternate succession. Light ash-gray beds are also present as are those which have a faint to strong brownish-gray color; however, these are not as common as those of the light and medium hues, excwpt locally as in the Confusion Range.

The light and darker beds are interbedded giving a characteristic color pattern to the sequence. The darker dolomites alternating with the light beds are easily distinguished from the underlying almost chalk-white Sevy dolomite. Furthermore the Simonson dolomite is alternately coarse to fine crystalline, whereas the Sevy dolomite is predominantly aphanic.

The weathered surface of the formation is commonly slightly lighter than the fresh color. No pronounced difference exists between the colors on the fresh and weathered surfaces, other than a dull surface where weathered.

The Simonson dolomite is commonly thin- to medium-bedded, but locally thick bedded units are common. Laminations due to textural differences are apparent on the weathered surface; thin-sections show them to be present within the fresh rock. The laminations so characteristic of the formation at Gold Hill, Utah (Nolan, 1935, p. 19) and in east-central Nevada (Osmond, 1954, p. 1934) are not so obvious in central Utah, however, they exist. They appear to be the result of the same process, or processes, responsible for the deposition of those to the west, the differences being due to the position of accumulation relative to the shore line of the geosyncline. They are not merely a function of mode of weathering but are depositional.

Rocks of the Simonson dolomite consist essentially of dolomite, but contain significant amounts of arenaceous material. Some chert, shale, and intraformationsl-conglomerate are also present as interbeds.

In thin-section the rock is dominantly a mosaic of dolomite anhedra and subhedra averaging 0.03 mm. in diameter. The Simonson dolomite differs from the Sevy dolomite in that laminae of dolomite anhedra and subhedra averaging between 0.05 and 0.1 are present in most of the Simonson dolomite sections measured.

The Simonson dolomite consists of between 0.8% and 22.7% insoluble material averaging 7.3% for all rock tested. The insoluble fraction of the formation consists of clastic quartz grains ranging between 0.03 mm. and 0.15 mm. averaging 0.07 mm. Authignic silica in the form of doubly-terminated quartz crystals up to 0.42 mm. in length, abraded chert particles which were partially converted over to transparent quartz, and transparent quartz dolocasts averaging 0.1 to 0.14 mm. are also present. A small amount of mica and some clay-sized particles were found. Bitumen was noted and is especially dominant in the darker beds; this is probably one of the more important coloring agents in the darker beds of the formation.

Sedimentation -- The laminations are the most apparent sedimentary feature of the Simonson dolomite. The formation is devoid of unstable minerals and contains rounded chert particles. The dolomite is relatively clean and homogeneous within each particular laminae. Fossils are relatively rare in the formation. These data are indicative of a very shallow water depositional environment. Deposition of the Simonson dolomite probably occurred in the littoral or possibly epineritic zone; this may have been upon the tidal flat, or in the littoral zone, and was probably upon a relatively flat area where the tidal range was rather broad. The conditions that existed during deposition of the Simonson dolomite were probably similar to those described by Hantzschel (1955, pp. 195-204) for some recent sediments. Hantzschel found laminations caused by the inter-lamination of thin layers of fine arenaceous material in the more argillaceous basic substance. The laminations were the result of the tidal range over the littoral area; these were not destroyed by subsequent reworking or deposition. Organic matter was profuse in the area.

Osmond (1954, p. 1952) postulates the origin of the laminations as being due to plant life, tides, seasonal changes or by atmospheric disturbances. He also considers the Simonson dolomite to be a deeper water deposit than the underlying Sevy dolomite. The present writer, however, cannot concur with this idea, mostly because the possibility of the Simonson dolomite being characteristic of deeper water deposition seems remote. It is conceivable that part of the formation could be associated with local downwarps of the miogeosynclinal floor during an episode of sedimentation. Local "highs' also punctuated the geosyncline giving rise to tidal flat deposits great distances from the major provenance. This theory provides an explanation for the exceptionally well developed laminae even to what amounted to the axial part of the geosyncline.

The alternating light and dark dolomites of the Simonson dolomite appear to be largely a function of relative percentage of bitumen, and not to dark-colored minerals.

The writer postulates that the darker beds probably represent slower accumulation of sediments relative to the lighter bitumen-poor beds. During the deposition of the lighter beds, the more rapid sedimentation effected unfavorable environmental conditions for the growth of organic material. Much of this may have been due to scavenger action also. However, it is a noticeable fact that upon the surface of the littoral area conditions may exist which at times are conclusive to the preservation of organic matter, but at other times the conditions are destructive to organic matter.

Guilmette Formation

General Description -- The Guilmette formation, named by Nolan (1935, p. 20) for exposures in Gold Hill, Utah, is described by him as follows:

> The Guilmette formation is composed chiefly of dolomite but contains also some thick limestone beds

and several lenticular sandstones. The dolomites for the most part differ in character from those found in the Simonson dolomite, although a few laminated beds are present near the bottom of the formation. The most abundant variety is a fine-grained dolomite, dark to medium gray on fresh fracture and weathering to light shades of gray that contains numerous vugs almost completely filled with white coarsely crystalline dolomite.

The Guilmette formation of central Utah is commonly a dolomite, however, in some places it is limestone. Arenaceous material is very common within the formation but does not maintain any particular stratigraphic position. In places it is at the base and in others it is found in the middle of the formation. The Guilmette formation is commonly nottled with crystalline dolomite or calcite.

Age and Correlation -- The Guilmette formation was dated by Nolan (1935, p. 21) as Middle Devonian. The following fossils were found at Gold Hill and were identified by Edwin Kirk who reports on them as follows:

Stringocephalus burtoni Defrance.
Atrypa reticularis Linnaeus.
Fayosites (digitate form).
Syringopora sp.
Martinia meristoides Meek.
Pycinodesma (?) sp.
Platyschisma (?) cf. *P. Mccoyi* Walcott
Cyclonema (?) sp.
Pycinodesma (?) sp.

Also reported by Kirk were a large number of *Cladopora* sp., and associated with them *Striatopora* sp. Occasional heads of "*Stromatopora*" were found.

With the exception of a single Stromatoporoid bed at the Lakeside Mountains no fossils were found within the Guilmette formation of central Utah.

McFarlane (1955, p. 19) tentatively correlates the Guilmette with the following: the Threeforks limestone of northeastern Utah; the Devil's Gate formation of Lone Mountain, Nevada; the upper portion of the Nevada limestone of the Eureka district, Nevada; the upper part of the West Range limestone of the Pioche district, Nevada; the Victoria quartzite of the Tintic district, Utah; and the upper part of the Lost Burro formation of Death Valley, California.

Petrology and Petrography - Rocks of the Guilmette formation vary in color from dark blue-gray to light gray, with a brownish tint characteristic of those areas containing substantial amounts of arenaceous material.

The formation does not lend itself to a unit-by-unit correlation within central Utah. It is commonly a dolomite in central Utah; however, limestone is characteristic in most localities in the Great Basin. Arenaceous material is relatively common throughout the sequence; however, a predominance of the material is noticeable in rocks of the upper half of the formation. It is especially common in the lakeside Mountains section. The arenaceous material in this section probably represents the westward extension of the Victoria quartzite interfingering with the carbonate sequence. The section cannot be traced eastward beyond the outcrops studied, but if such were possible the arenaceous beds would grade into the sandstone-conglomerate sequence of the Victoria on Stansbury Island and the Northern Stansbury Mountains.

The Guilmette formation is commonly thin to thick bedded, and in places is laminated. There appears to be a slight predominance of the thick bedded type, but this may possibly be due to the massive nature of the weathered outcrops.

The weathered surface of the rock normally is a lighter color than the fresh fracture. The arenaceous, or dolarenaceous, beds have a brownish hue on the weathered surface. This color is due in large measure to the arenaceous material present; however, the apparent percentage of the arenites as deduced from the coloration is misleading. Evidently relatively small amounts of arenaceous material can impart an apparent strong brown coloration of the weathered surface of the rock.

In thin-section it is noted that the fresh rock is composed mainly of a mosaic of dolomite anhedra and subhedra. A significant part of the formation is also made up of clastic dolomite. Microstructures are present indicating a reworking of the deposit.

The crystal size ranges from 0.4 mm. to 0.002 mm. in the mosaic pattern. The clastic dolomite crystals range in size from 0.5 mm. to 0.2 mm. in diameter. The matrix of the clastic fraction is composed of clay-sized particles for the most part. Well-rounded to subrounded quartz particles ranging in size from 0.3 mm. to 0.05 mm. with an average of 0.1 mm. were found in numerous of the samples collected from the lakeside region.

An average of approximately five per cent of the sampled rock of the Guilmette formation is insoluble; the highest per cent recorded is 21.5%, from rocks of the Lakeside section. The lowest per cent determined is 1.0% at the South Tintic district. No regional significance can be attached to these figures, as nearness or distance relative to the craton which lay to the east may or may not have been important.

The insoluble fraction of the formation consists of subhedral and anhedral quartz fragments, doubly-terminated quartz crystals, rounded and pitted quartz grains, and some bitumen. The quartz fragments measure from 1.8 mm. to 0.12 mm. The authigenic quartz crystals which are unusually common, range in size from 0.3 mm. to 0.1 mm. in length. The crystals of siliceous material likely represent the replacement of dolomite by silica. Rounded and pitted quartz grains present average 0.12 mm. in diameter. The sand is well sorted wherever it was noted. The above evidence indicates a windblown origin for the sand grains, but likely a terrigenous source with eventual and final deposition in the marine environment.

Sedimentation-- Sediments of the Guilmette formation in central Utah indicate they were most likely deposited on a stable to slightly unstable shelf. The almost complete absence of shale, the microstructures present, the clastic nature of a portion of the carbonates, and quartz particles indicate the deposit was reworked and probably deposited very near sea leve. The shelf during the deposition of the Guilmette formation was essentially similar in conditions to the deposition of the Sevy dolomite and Simonson dolomite. The depth of water in the depositional basin probably never exceeded beyond the epineritic zone. To the west was located the miogeosyncline which in the Confusion Range received the greatest thickness known of this formation.

Characteristic of the Devonian system and thus the Guilmette formation in central Utah is the relative absence of argillaceous material. This is probably the result of the removal of the argillaceous material by turbidity currents, longshore currents and others. The Pinyon Peak limestone is an exception, being composed of argillaceous limestone in most localities.

The dolomitization of the Guilmette formation is not so complete on a regional scale as are the Sevy dolomite and Simonson dolomite. The Guilmette formation can be shown to consist in most localities of limestone, and in others a dolomitized limestone. The original deposit was probably a "normal marine limestone" and subsequently has been dolomitized in those areas. The reason for dolomitization in one area and not in another might be explained by minor submarine and/or subaerial barriers which restricted the circulation of waters, thus bringing about variances in the chemistry of the bottom waters. As has been mentioned in periods pages, slight variations in the chemistry of the sea water can completely change the depositional history in an area where exsolutional sediments are forming. The explanation of the occurrence of limestone interbedded with dolomite, as exists at Gold Hill, Utah, is explained by Nolan (1935, p. 23) as follows:

> It is thought that these (limestones) represent periods when sedimentation was slightly slower than downwarping or in which downwarping was somewhat spasmotic, allowing rather thick beds to be deposited before baselevel was reached and then sinking was again initiated before dolomitization was complete.

For the origin of the thick dolomite sequence Nolan (1935, pp. 22-23) postulates the following conditions of deposition:

> If the rate of sinking is slower than the rate of deposition, there must, of necessity, be many periods during which there is no deposition of sediment, and any material deposited will be above the baselevel of wave or current action and will be swept away to regions that are below wave base. Calcareous muds will thus be subject to reworking and alteration by the sea water

for some time, and it is thought that in this factis the chief explanation of dolomitization. . . . A prolonged exposure of the same calcareous mud to wave and current action would also permit selective leaching of calcium carbonate by sea water, a phenomenon which is known to occur in nature. (See also Clarke, 1924, p. 574).

The latter hypothesis employing the effect of selective leaching could also supply sound reasoning explaining the interbedded nature of the limestones and dolomites. The process as outlined by Nolan appears plausible to the present writer.

The lack of organic material exposures of the Guilmette in central Utah is a marked contrast to the exposures in King's Canyon, Utah. The latter locality contains numerous reefs to which the field name "Elephant member" has been applied. This can best be explained by the geographic position of the two localities. The organic material deposited in central Utah along the shore line was probably removed by scavenger activity.

Victoria Quartzite

General Description--The Victoria quartzite was named from the Victoria Mine in the Tintic district, Utah (Lindgren and Loughlin, 1919, 138.) Total thickness at the type section is only 85 feet. At the base is a sandy limestone, overlain by a gray limestone 25 feet thick, which is in turn overlain by a 50 foot bed of sandy limestone and quartzite (Lindgren and Loughlin, 1919, pp. 38-39). The quartzite of the Tintic district is fine grained, even textured, having some small quartzite pebbles an inch or more in diameter. The limestones are fine to medium-grained; some are conglomeratic containing limestone pebbles up to two inches in diameter. The pebbles and matrix are both dolomitic (Lindgren and Loughlin, 1919, p. 39).

The Victoria quartzite of central Utah normally is a quartzose sandstone with interbedded medium gray dolomites. The thickness of the formation varies considerably; however, the same is true for exposures in the Tintic district where marked variations occur. Furthermore, in some places it is entirely absent (Lindgren and Loughlin, 1919, p. 22).

The Victoria quartzite of the Stansbury Mountains and Stansbury Island is represented by a conglomerate and sandstone sequence in the respective localities. On Stansbury Island it is a thick sandstone and orthoquartzite that is in excess of 800 feet thick, and is overlain unconformably by the Lower Mississippian Gardner dolomite. Also it unconformably overlies the Simonson dolomite. Less than ten miles directly to the south of the island, the formation is composed of a thick conglomerate section which contains interbedded orthoquartzite, especially near the top of the formation. The latter is similar to the orthoquartzites of the island. The Victoria quartzite thins rapidly toward the south, being only 33 feet thick on the south end of the Stansbury Mountains.

Fig. 1. Conglomerate facies of Victoria on the North Stansbury Mountains

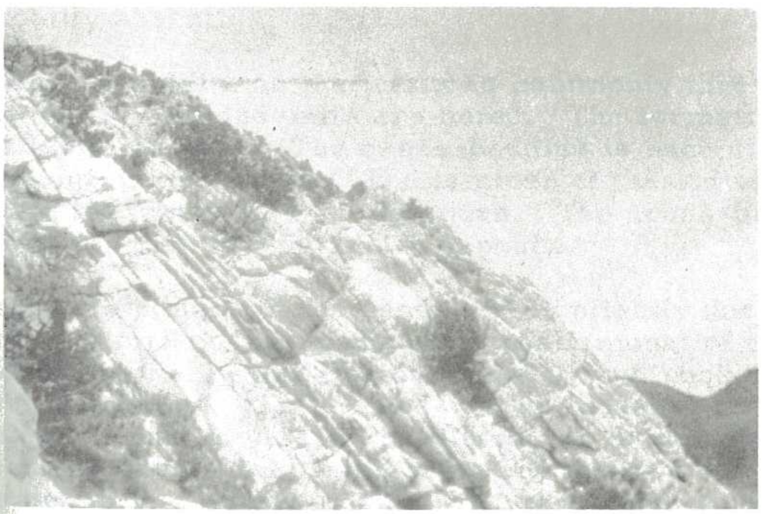

Fig. 2. Massive and cross-bedded sandstone of Victoria on Stansbury Island

Age and Correlation-- The Victoria quartzite was originally dated by Lindgren and Loughlin (1919, p. 38) as Lower Mississippian. Recent work by Lovering, Morris, Proctor, and Lemish in the Tintic district, Utah, has revised the previous work of Lindgren and Loughlin, and placed the Victoria quartzite in the Devonian, stratigraphically below the Upper Devonian Pinyon Peak limestone (Lovering et al, 1951, pp. 1505-06).

The Victoria is correlated by the writer with the upper part of the Guilmette formation and therefore can be considered Upper Middle Devonian in age.

Petrology and Petrography-- From the standpoint of facies the Victoria quartzite is the most variable of the Devonian formations. It is characteristically composed of lenticular units of intercalated orthoquartzite, dolomite, and dolarenite.

The formation attains its greatest thickness on Stansbury Island and in the Northern Stansbury Mountains where thicknesses of 869 and 1,015 feet respectively are present.

The sandstone varies in color from very light grayish-white to light and medium buff. Iron oxide within the cementing material normally imparts a brownish hue to the quartz grains. The cementing material of the quartz grains in chiefly silica, however some calcite is present and in some units it is the dominant binding substance. There is very little argillaceous material within the sandstone, and in many localities it is totally absent.

The Victoria quartzite on the island is commonly thin to medium bedded; some massively bedded units are noted. The formation weathers massive for the most part. The cross-bedding is exceptionally well developed throughout the exposure. The laminae of the individual cross-bedded units attain lengths of 20 feet and more. The cross-bedding exhibits the concave nature of wind blown deposit.

The weathered surface of the sandstone is slightly darker than the freshly fractured surface due to the additional amount of oxidized iron on the exposed surface. Weathering has produced pock-marks on the surface of the sandstone. These pock-marks measure approximately two inches in diameter and in places are equally as deep. They are probably the result of differential weathering and erosion due to inherent weakness of the cementing material within the pocks and/or around their edges. The surfaces of some of the sandstones are friable to variable depths due to the weathering action. Other beds are dense and hard on the weathered surface due to their resistant silica cement.

In thin-section the sandstone of the Victoria typically is composed of pitted and frosted quartz grains. The rock is essentially devoid of matrix and heavy minerals. The quartz grains range in size from 1.0 mm. to 0.02 mm. averaging approximately 0.5 mm., and have an average sphericity of 0.9 and an average roundness of 0.5 (Krumbein and Sloss, 1953, p.81).

This rock can be classified as a quartzose sandstone (Krumbein and Sloss, 1953, p. 129), or for some beds the term orthoquartzite is applicable (Pettijohn, 1949, p. 237).

The insoluble portion of the rock ranges from 99.7% to 1.63%, averaging 64.8%. Qualitatively the residue consists of frosted quartz grains averaging approximately 0.5 mm. in diameter. Partially recrystallized chert particles are very common, having the appearance of aggregates of fine crystalline quartz. Chert particles and some clay sized particles were also noted.

The Victoria quartzite of the Northern Stansbury Mountains consists of a polymictic conglomerate (Pettijohn, 1949, pp. 208-09) with interbedded units of sandstone having the characteristics of the rock discussed above. There is also a 203 foot unit of dolomite within the exposure.

The conglomerate consists of rocks recognizable as having been derived from Silurian, Ordovician, and Cambrian formations. The discrete particles range in size from one foot to 1.0 mm. averaging approximately six inches in diameter. This places the average particle in the cobble size range of Wentworth's scale. These discrete particles are subangular to subrounded.

Lithologically the cobbles consist chiefly of dolomite and quartzite. Lithologic type counts of the pebbles and larger particles within a specified area reveal that 95% of the particles consist of dolomite, with the remaining five per cent being quartzite. This measurement was counted near the base of the formation; nearer the top of the deposit, the quartzite amounts to as much as ten per cent of the total voluem. This is probably due to the increased number of exposures of the Lower Cambrian Tintic quartzite which was probably one of the sources of the quartzite particles.

The dolomite particles of the conglomerate vary in color from light to dark gray. The quartzites are normally medium to dark brownish red in color.

The matrix surrounding the particles commonly consists of arenaceous dolomites and limestones, and varies in color from medium buff to medium or light maroon; the former color predominates except in one 35-foot unit. Iron oxides have played an important role in the coloring of the matrix throughout the outcrop.

Varying proportional amounts of matrix and particles at different localities along the exposure appear to be a characteristic feature of the formation. The only trend in the variances was a greater proportion of the finer materials nearer the top of the outcrop. This trend could have been produced as the "high" or source provenance was brought nearer to baselevel by erosion.

The writer was unable to find well defined bedding within the massive conglomerate. The interbedded sandstones and dolomites are thin to medium bedded, but weather massive. At the contact of the maroon matrix unit with the buff-colored matrix unit evidence of channeling was observed, but the writer was unable to find any additional evidence of channeling other than at this one locality.

Insoluble residues were not prepared from the conglomerate; however, the matrix, the sandstone beds, and the dolomite bed were sampled and thin-sectioned. The thin-sections indicated that the arenaceous material within the matrix is essentially the same as that studied on Stansbury Island, indicating probably an identical source for the arenties of both areas.

The Victoria quartzite of the remaining sections throughout the area under investigation consists of interbedded arenites and dolomites with minor amounts of shale. The outcrops show very thin, lenticular and lithologically variable units.

The arenites of the formation of these areas are characteristically light to medium brown on their weathered surface. Their purity as quartzose sandstones makes them a light milk gray on a fresh surface varied by iron oxide stains around and coating some of the grains. The dolomites are medium gray and weather slightly lighter.

The formation commonly is thin bedded and weathers from a platy to thick bedded nature.

The insoluble fraction of the formation ranges between 99.0% and 2.5%, averaging 54.0% for these areas. The residue consists of quartz fragments, clay sized particles, and well sorted, pitted and frosted quartz grains averaging 1.0 mm. in diameter. The grains have a sphercity of 0.9 and a roundness of 0.9.

Sedimentation--According to the writer's interpretation the Victoria was deposited on a stable to slightly unstable shelf along the eastern part of the Paleozoic Cordillerian miogeosyncline. The extremely long, concave laminae of the corss-bedding indicate the arenites to be of eolian origin. Likely, many of these dunes marched into the sea, thus providing much of the quartz sand for the formation. Substantiating this is the purity of the deposit, the well rounded, well sorted, frosted, and pitted nature of the individual quartz grains, and relative high degree of sorting.

The arenites of the formation likely were deposited very near the shore line as a beach or dune sand and at times in its depositional history it was inundated allowing the arenaceous dolomite bed, as well as some of the sands within the formation, to accumulate. These were deposited in very shallow water, probably the littoral or shallow epineritic zone. Increased rate of sedimentation pushed the sea back and the eolian deposits again began to accumulate as terrestrial to littoral deposits.

The source of the arenites for the Victoria quartzite throughout the area under investigation probably was the Ordovician Eureka and Swan Peak quartzites and/or the Lower Cambrian Tintic quartzite.

The siliceous cement of the sandstone was deposited subsequent or penecontemporaneous with the deposition of the arenite. Ground-water activity has either removed the cement in various zones, or it was never completely cemented, likely due to aquicludes or aquifuges restricting the flow of the fluids carrying the dissolved silica. This produced friable sand zones overlain and underlain by dense and hard, firmly cemented orthoquartzites.

The sandstone pinches out very rapidly to the west. In the Lakeside Mountains it is represented by nothing more than an arenaceous dolomite in the upper part of the Guilmette formation or expression of a vertico-lateral facies change. Beach sands and chenieres of the Guld Coastal Plain area today display this facies.

The conglomerate facies of the Victoria at the Stansbury Mountains was accumulating at the same time as the sandstone, and is a lateral coarser-textured facies expression.

A local positive area near the eastern shore line of the geosyncline was elevated likely quite rapidly giving rise to highlands from which the pebble to boulder conglomerate exposed in the Stansbury Range was derived. The polymictic conglomerate is the coarse grained representatives of the sub-graywacke and arkose clan. The "high" developed during Upper Devonian, but was leveled before Mississippian time. The thickest section exposed is in the northern part of the Stansbury Range where is aggregates 1,015 feet, and pinches out very rapidly to the north and south. The writer measured 33 feet of this conglomerate on the south end of this range. It occupies the same stratigraphic position as the large deposit and may have been derived from the same provenance; however, intraformational conglomerates are not uncommon throughout the Devonian system and this unit may have been no more than one of these, locally derived. The outcrop disappears beneath the alluvium west of the town of Grantsville, Utah, and the writer could not find any unquestionable outcrops southeast of that locality. No outcrops could be located on the west side of the range (other than the local 33-foot bed) due to complex faulting and folding, therefore the detailed study was limited to the small outcrop band northeast of Grantsville.

From the fact that all the overlying and underlying formations thin toward the east it can be safely assumed that the Victoria does the same. Therefore, the "high" was possibly located to the west and possibly parallel to and very near the shoreline of the geosyncline. A marked instability along the shore line to the east elevated rugged cliffs from which the coase clastics were shed. The conglomerate was poured into the shallow water and shortly after deposition the interstices of the conglomerate were filled by the sands which to this time were of eolian origin. Furthermore, carbonates were added to the matrix. The interbedded sandstones within the conglomerate probably represent varying rates of sedimentation. The rapid deposition of the conglomerate probably raised the deposit above the water level as the subaerial part of a delta, and the sandstone accumulated for a time also above water, followed by additional deposition of these coarse clastics. Identical facies relations exist today on the northern margin of the Gulf Coast miogeosyncline (Howe, et al., 1936, pp. 45-48).

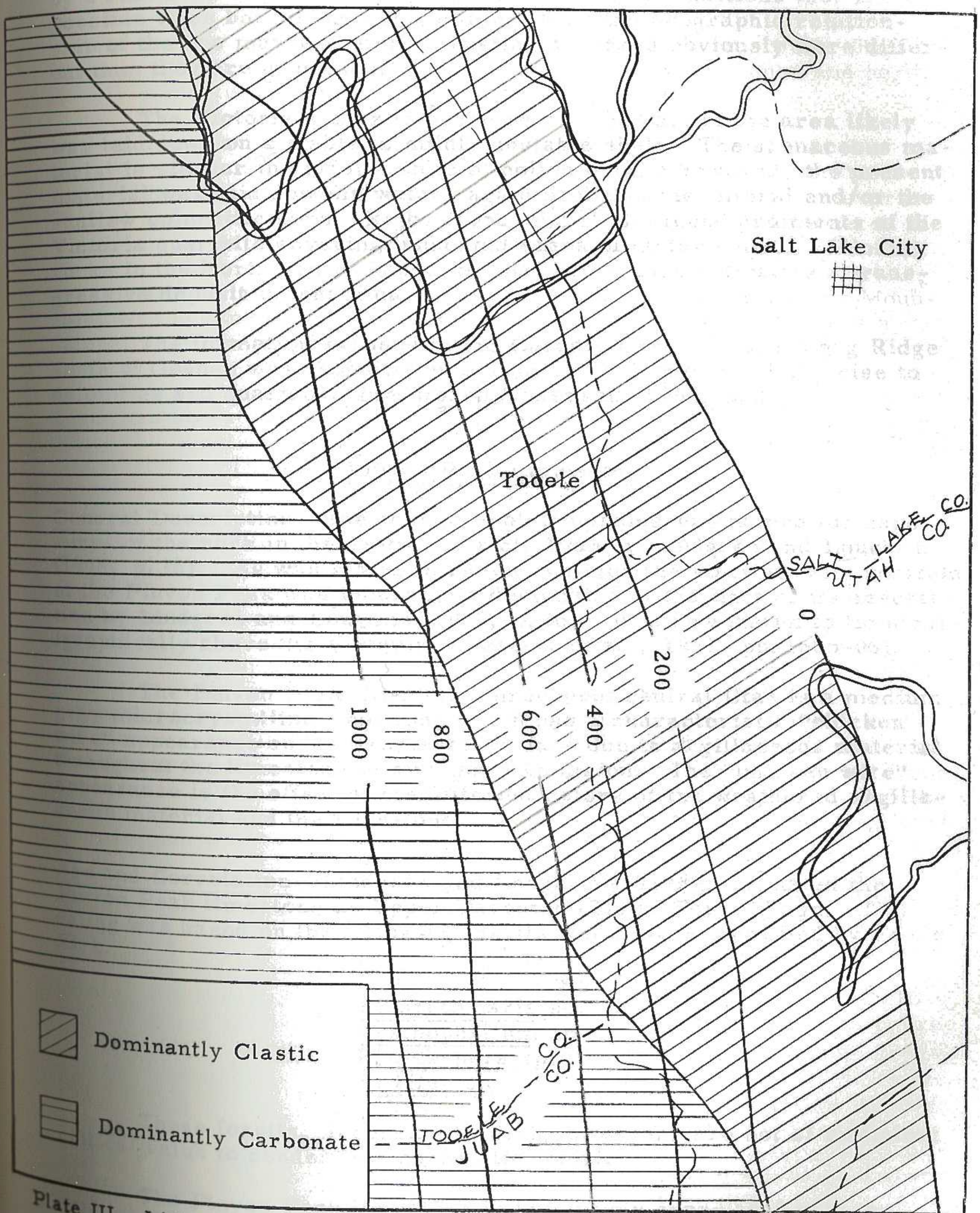

Plate III. Lithofacies map of the Victoria quartzite and Guilmette formation in central Utah.

The absence of conglomerates on Stansbury Island less than ten miles to the north of the thickest accumulation can best be accounted by a realization of the varying environments and conditions that are possible when bordering a shore line. Also the geographic relationship of the two masses before thrusting occurred obviously were different than they are at present.

The Victoria quartzite of the remaining part of the area likely was laid down on a stable to mildly unstable shelf. The arenaceous material is similar in that it also is of eolian origin; however, the present material was laid down in water, again probably the littoral and/or the shallow epineritic zone. Rigby (1952, pp. 31-32) found sediments of the Victoria quartzite covering truncated edges of Ordovician and Silurian rocks in the North Tintic Range (Selma Hills), thus indicating a transgressive deposit in that area.

The formation exposed in the Currant Creek area in Long Ridge south of Goshen was deposited in a similar environment giving rise to dolomites and quartzose sandstones (Petersen, 1953, p. 23).

Pinyon Peak Limestone

General Description--The Pinyon Peak limestone was named for exposures of the rock in the Tintic district, Utah by Lindgren and Loughlin (1919, p. 36). As was stated in previous pages the startigraphic position of the Pinyon Peak was incorrectly designated at the time of its description by Lindgren and Loughlin (1919, p. 36). It is now known to lie stratigraphically above the Victoria (Lovering et al., 1951, pp. 1605-06).

The Pinyon Peak limestone throughout central Utah is a medium gray microcrystalline limestone which has a characteristic "chicken wire" appearance on its weathered surface due to argillaceous material throughout the limestone in stringer like fasion. The "chicken wire" appearance is the effect of the different colors of the weathered argillaceous material and the limestone.

Age and Correlation--Lindgren and Loughlin (1919, p. 36) dated the Pinyon Peak limestone as Upper Devonian (Three Forks?) age. This dating was based on the following fossils which were identified by Edwin Kirk.

Pleurotomaria sp.
Cyathophyllum sp.
Rhombopora sp.
Spirifer sp.

These fossils, according to Kirk, however, are not of sufficient critical value to render this correlation final.

The Pinyon Peak limestone is tentatively correlated with the Pilot shale (in part at least) of eastern Nevada. Some paleontologists consider the upper part of the Pilot shale to be Lower Kinderhookian in age*.

Petrology and Petrography--The Pinyon Peak limestone varies in color from medium gray to dark blue-gray. The typical color of the freshly broken surface is dark blue-gray. The argillaceous material imparts a light to medium brownish-gray color to the rock.

The Pinyon Peak limestone was not subdivided into members in central Utah in this study. It is essentially homogeneous in external and internal features throughout its entire thickness.

The bedding of the formation is commonly thin bedded and weathers to a platy habit. Normally the weathered surface has a flaky appearance. The most apparent weathering effect of the rock is the mottled appearance; this characteristic surface has a "chicken-wire" appearance and so this term has been applied in field descriptions of the formation. The chicken-wire weathering is the result of irregular intercalations of argillaceous material within limestone lenses. The weathered limestones of the formation are slightly lighter in color than the freshly fractured rock. The argillaceous material weathers light buff in color. The limestones commonly display the common meringue-type weathering feature so prevalent in the lower Paleozoic limestones and dolomites of the area.

Microscopic study of fresh rock from the Pinyon Peak limestone indicates that it is composed of calcite anhedra and subhedra. Some of the crystals are interlocked into a mosaic, others show signs of abrasion and appear as detrital material within the mosaic. Clastic quartz fragments are also present, but the quartz fraction of the formation composes less than five per cent of the entire rock. The detrital crystals vary in size from 0.009 mm. to 1.0 mm. The subangular to angular quartz fragments range in size from 0.1 mm. to 0.5 mm. Clay sized particles are present in relatively large quantities, and 10% to 20% of the rock is not uncommon for the argillaceous fraction.

The insoluble portion of the formation consists of angular quartz grains, clay sized particles and minor amounts of bitumen. The insoluble fraction ranges from 13.4% to 2.5%, averaging 3.1% of the rock by weight.

Sedimentation--The fine grained limestone, absence of organic material, presence of the argillaceous material as well as the detrital quartz grains, and abraded calcite crystals indicate that the environment of deposition for the Pinyon Peak limestone was probably within the neritic zone. The comparative lack of quartz particles might exclude the littoral zone as a possible site of origination, but not necessarily so. The probable site would be the epineritic zone, and no doubt its shallow portion.

Rigby (1952, pp. 36-37) considered the environmental conditions existing during the deposition of the Pinyon Peak limestone were very similar to those existing on the present day Bahama Bank.

* Personal communication with Dr. H. J. Bissell, March, 1956.

DOLOMITIZATION

Theories pertaining to the origin of dolomite can be grouped essentially into three categories: (1) primary precipitation, (2) selective leaching of the calcite from calcite (or aragonite) and dolomite, and (3) replacement of an original limestone (Pettijohn, 1949, p. 316).

The most accepted theory of the origin of dolomite is some variation of the replacement concept. Evidence in favor of replacement is overwhelming (Pettijohn, 1949, p. 316). The theory can be further subdivided into two types: (1) ground water replacement, and (2) marine water or penecontemporaneous replacement of $CaCO_3$ by $MgCO_3$, the sea water being the source of the $MgCO_3$.

Experimentation has shown that replacement, or dolomitization, is most effective at higher than normal sea water temperatures (Van Tuyl, 1941, p. 402).

The most important factors in the replacement process are those controlling calcium carbonate solubility. Of the variables that control the solubility of calcium carbonate, pH is by far the most important. "A pH decrease of one unit causes approximately a hundredfold increase in solubility" (Garrels and Dreyer, 1952, p. 377). The pH, in turn, is dependent upon the CO_2 content of the solution which would be a function of the temperature-pressure relationship (McFarlane, 1955, p. 32). The pH value is also increased by the absorption of free $CO2$ by several vegetable organisms (Chilingar, 1955, p. 1886).

A change of temperature amounting to a few tens of degrees or of a pressure change on a scale of a few hundreds of bars has little effect on the solubility of calcium carbonate (Garrels and Dreyer, 1952, p. 377). These workers also found a relationship between the grain size and rate of dolomitization, the finer the grain size the higher the rate of reaction. Clark (1954, p. 24) found evidence to support this latter view for rocks of Lower Mississippian age in central Utah.

Skeats (1918, p. 199) studied the shallow-water contemporaneous replacement of calcite by dolomite; his conclusions demonstrate the equal solubility of $CaCO_3$ and $MgCO_3$ in a saturated aqueous solution containing CO_2 at a critical pressure of one to four atmospheres.

DEVONIAN PALEOTECTONICS OF CENTRAL UTAH

The techtonic activity of the Devonian system throughout central Utah was very mild in Lower and Middle Devonian times. The shelf suffered little deformation except for local irregularities which were brought into play for a time and soon leveled.

Bissell (1955, p. 1644) postulates a "high" which developed during Ordovician time and remained until Mississippian time extending from the vicinity of Provo, Utah to Wendover, Utah approximately 90 miles west. This could also have been the source area in part at least for the clastic sediments of central Utah. The "high" evidenced by the Currant Creek Canyon section in Lower and Middle Devonian times is probably a reflection of this east-west tectonic belt.

In Upper Devonian times orogenic movements were more active. The orogenic belt (called an arch or geanticline by Nolan) in west-central Nevada was activated shedding sediments into the two great geosynclines it separated (Nolan, 1943, p. 152). This was the most important tectonic feature of the Devonian times in the western United States.

In central Utah during Upper Devonian time the positive area which gave rise to the deposition of the conglomerate facies of the Victoria quartzite was elevated and subjected to rapid erosion. The Stansbury tectonics may be an eastward reflection of the tectonic activity of Nevada. There is no evidence to support this possibility except that of similarity in time. The uplift in Utah was, as was pointed out previously, a local feature.

In general the period was relatively quiet throughout the area under consideration as evidence by the character of the sediments deposited during this time.

ECONOMIC POSSIBILITIES

The economic possibilities of the Devonian formations in central Utah appear to be limited and therefore not very promising.

The Sevy dolomite does not appear to have petroleum possibilities; it is practically devoid of organic material and thus does not appear to be of value as a source bed. Its aphanic texture precludes any possibility of even moderate perosity, except possibly by fracturing, and its permeability, though not measured, would seem to be extremely low. It could function as an aquifuge and thus be of importance in petroleum and ground-water exploration. Its distribution would be the limiting factor if additional uses that could be found for the dolomite, such as flux, polishing powder, source of megnesium, etc.

The Simonson dolomite would hold more interest for the petroleum industry than does the Sevy dolomite. It contains considerably more bitumen, which to some might indicate indigenous petroleum. The intercrystalline porosity of the Simonson dolomite may be sufficiently high to serve as a reservoir rock. The writer, however, considers this only a remote possibility. Fracture porosity could be important in petroleum accumulation. The Simonson, as well as the other dolomites, could be of value in the manufacturing of lime or in the steel industry, but the distribution and availability would again be the restricting variable.

The economic picture for the Guilmette formation in central Utah is essentially that of the Simonson dolomite. In the western part of the state where fossils are prevalent and reefs are not uncommon the outlook is much brighter for petroleum possibilities. At numerous localities, such as the Desert Range near Wendover, much of the rock in the formation emits a petroliferous odor when the rock is fractured.

The Victoria quartzite in certain localities such as Stansbury Island in the southern part of central Utah could be a very excellent reservoir rock. The well rounded sand grains would probably have relatively high porosity and permeability, especially if the cementing material had been removed as it has in some units.

Its location would be the important factor in the steel or abrasive industry. The iron oxides of the Victoria quartzite render it of little value to the glass-making industry.

The meager distribution of the Pinyon Peak limestone throughout central Utah would be in itself the greatest single limiting factor in finding an economic use for the formation. The lack of organic material indicates that it would probably not be of value as a source bed. It could be of importance as a reservoir rock if it were thicker and had greater porosity. The argillaceous material present within the limestone limits its use in the lime-making and steel-making industries.

CONCLUSIONS

The Devonian system in central Utah consists of shelf sediments deposited near the eastern margin of the Cordilleran miogeosyncline, and/or marginal parts of the latter. In the writer's opinion the deposits were laid down under stable to slightly unstable tectonic conditions, except for the Victoria quartzite which was a characteristic tectotope formed under rather severe tectonism.

The source area for Devonian sediments in the area was one of relatively low relief situated to the east and/or west of the present outcroppings. East-west positive areas were also probably source areas for the sediments in the area. The emergent area was composed of relatively pure carbonates and sands which in turn gave rise to a similar sequence in the Devonian system.

The thickest accumulation of Devonian sedimentary rocks in the area studied is exposed in the Lakeside Mountains section where it attains an aggregate thickness of 1,620 feet. The thinnest section measured is located in Currant Creek Canyon near Goshen, Utah, where only 142 feet of sediments are present. This latter thickness, however, is made up of only two formations. The section represents the location of a positive area which was emergent through Lower and Middle Devonian times. The "high" coincides with the east-west positive area postulated by Bissell (1955, p. 1644).

In the present writer's opinion, shallow-water conditions persisted during the deposition of the entire sequence as shown by microstructures present and by associated lithologies. The zone of sedimentation was restricted to the littoral and shallow-water epineritic zones. Many of the sediments characteristically show signs of quite vigorous reworking which indicates they were within wave-base action at the time of their deposition. Others likely accumulated under greater quiescence.

The shallow-water deposition and the extremely slow subsidence of the shelf area permitted the dolomitization process to go to completion bringing about a homogeneous deposit. At times the sediments were subjected to subaerial erosion and deposition.

The dolomites of the Devonian system were deposited as clastic calcareous muds deriving their carbonate from the Cambrian, Ordovician and Silurian limestones and dolomites which were being eroded. Direct precipitation of calcium carbonate from the sea water also added appreciable quantities of the material to the sediments.

The clastic materials of the system were deposited on a slightly to moderately unstable shelf. The source area was located in the same position as discussed for the carbonates. The course clastics were derived from rugged cliffs which were elevated and quickly eroded.

Dolomitization of the sediments occurred as a penecontemporaneous metasomatic replacement process. Magnesium of the sea water likely was utilized in the replacement of the calcium within the unindurated sediments. The replacement was a volume-for-volume metasomatic process.

Eustatic and/or tectonic changes in sea level relative to the rate of deposition of the sediments was the probable cause which gave rise to interbedded limestone and dolomite units which are found in some sections.

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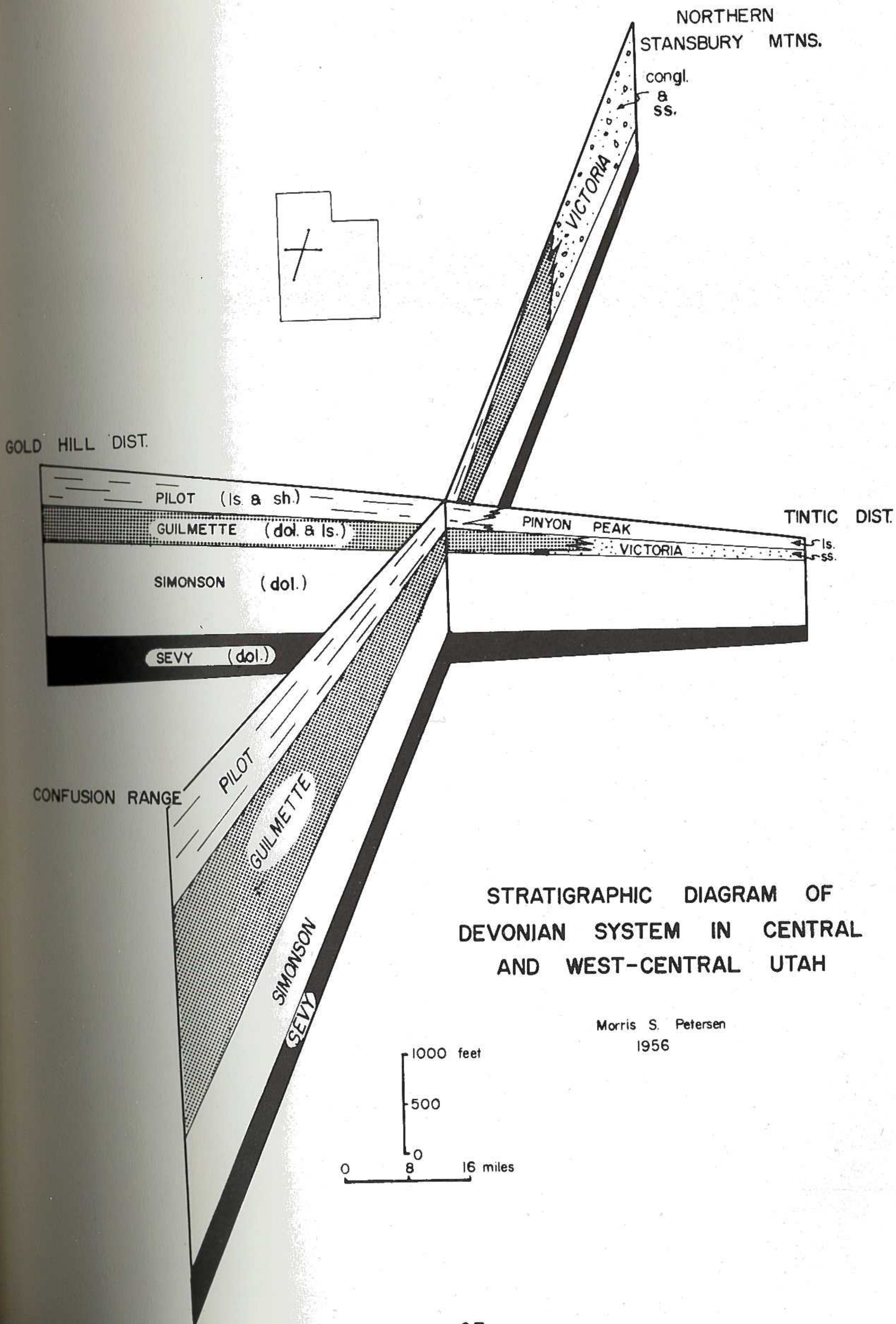
NORTHERN
STANSBURY MTNS.
congl.
&
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VICTORIA
GOLD HILL DIST.
PILOT (ls. & sh.)
GUILMETTE (dol. & ls.)
SIMONSON (dol.)
SEVY (dol.)
PINYON PEAK
VICTORIA
TINTIC DIST.
ls.
ss.
CONFUSION RANGE
PILOT
GUILMETTE
SIMONSON
SEVY
STRATIGRAPHIC DIAGRAM OF
DEVONIAN SYSTEM IN CENTRAL
AND WEST-CENTRAL UTAH
Morris S. Petersen
1956
1000 feet
500
0
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8
16 miles

PLATE I

FENCE DIAGRAM OF THE DEVONIAN SYSTEM OF CENTRAL UTAH

Morris S. Petersen
1956