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# Late Ordovician and Silurian Carbonate-Platform Margin Near Bovine and Lion Mountains, Northeastern Utah. Late Ordovician and Silurian of the Eastern Great Basin, Part 7

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## Abstract

Upper Ordovician and Silurian strata at Bovine Mountain, northwestern Utah, belong to the Ely Springs and Laketown dolomites. The stratigraphic sequence is characteristic of carbonate-platform facies, especially those near the outer margin of the platform. In contrast, strata in a faulted section at nearby Lion Mountain are assigned to the Ely Springs and Roberts Mountains formations, with facies that are characteristic of an upper slope environment. These localities establish the position of the Lower Paleozoic carbonate-platform margin in the region between northern Nevada and central Idaho.

## Introduction

During the late Ordovician and Silurian, the margin of the Cordilleran carbonate platform was located in northwestern Utah (Fig. 1; Sheehan, 1979). This margin is defined by a change from carbonate-shelf facies to carbonate-slope facies. Regionally the margin has a north-south trend in central Nevada, is abruptly deflected near Carlin, Nevada, into an east-west trend, and in the vicinity of the Utah border the margin curves northward again (Fig. 1). In southern Idaho, the margin is obscured beneath volcanic cover, but the margin is exposed again in southcentral Idaho (Dover and Ross, 1975; Skipp and Sandberg, 1975). The lower Paleozoic margin continued to be an important tectonic feature into the upper Paleozoic (Stevens, 1981). This study establishes the position of the north-trending margin in northwestern Utah.

The position of the margin has been quite accurately located along an east-west band in northern Nevada where upper-slope facies are present in the Pequop Mountains, Toano Range, Pilot Range, and the northern Silver Island Mountains (Fig. 2; Sheehan, 1979; Sheehan and Pandolfi, 1983; Hurst, Sheehan and Pandolfi, 1985). An alternate interpretation of the east-west margin in northern Nevada was presented by Thorman (1970) and Thorman and Ketner (1979). They considered the eastward deflection of lithofacies in northern Nevada to have resulted from a major right-lateral fault, termed the Wells Fault, which displaced the Silurian shelf margin from central Nevada into the area of the Utah-Nevada border. In their view, the region in northern Nevada here considered to be a north-facing depositional slope, contains a major right-lateral fault which separates shelf sediments on the south from basinal sediments on the north. If their fault model is correct, the sections still represent important control points along the shelf edge, but the margin was offset more than 200 km eastward by the Wells Fault.

Until now there has been relatively little evidence concerning the position of the shelf margin in northwestern Utah and adjacent southern Idaho, because Paleozoic sequences in this area are a widespread metamorphic-core complex. The metamorphism precludes distinguishing slope from shelf facies. An exposure of an unmetamorphosed carbonate-shelf sequence has been discovered recently at Bovine Mountain (Jordan, 1983). Upper-slope facies are present at Lion Mountain, but a complete section is not present because of faulting. These two localities provide critical control points for establishing the location of the shelf margin in northwestern Utah.

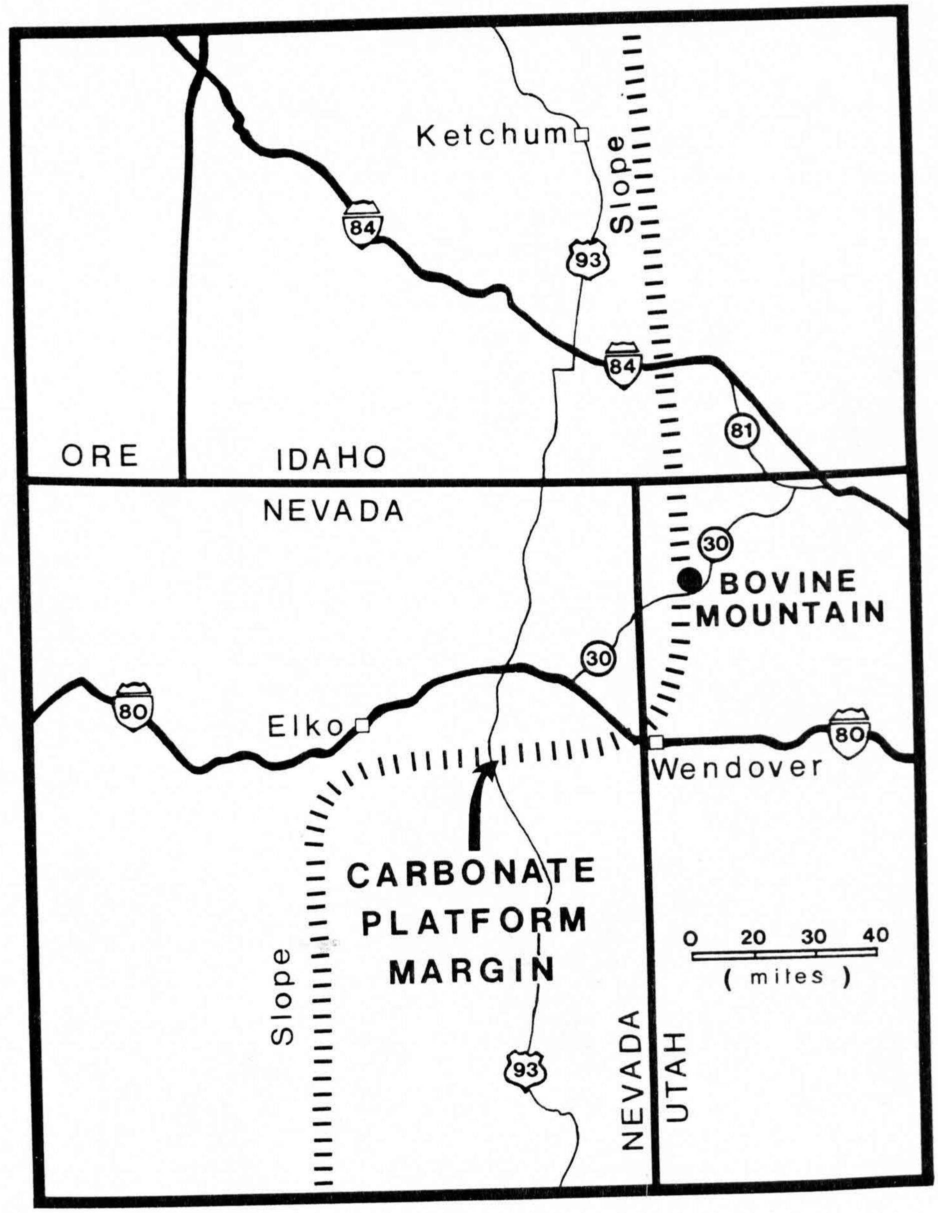



**Figure 1.** Index map of the eastern Great Basin. The location of the Upper Ordovician-Silurian platform margin is indicated.

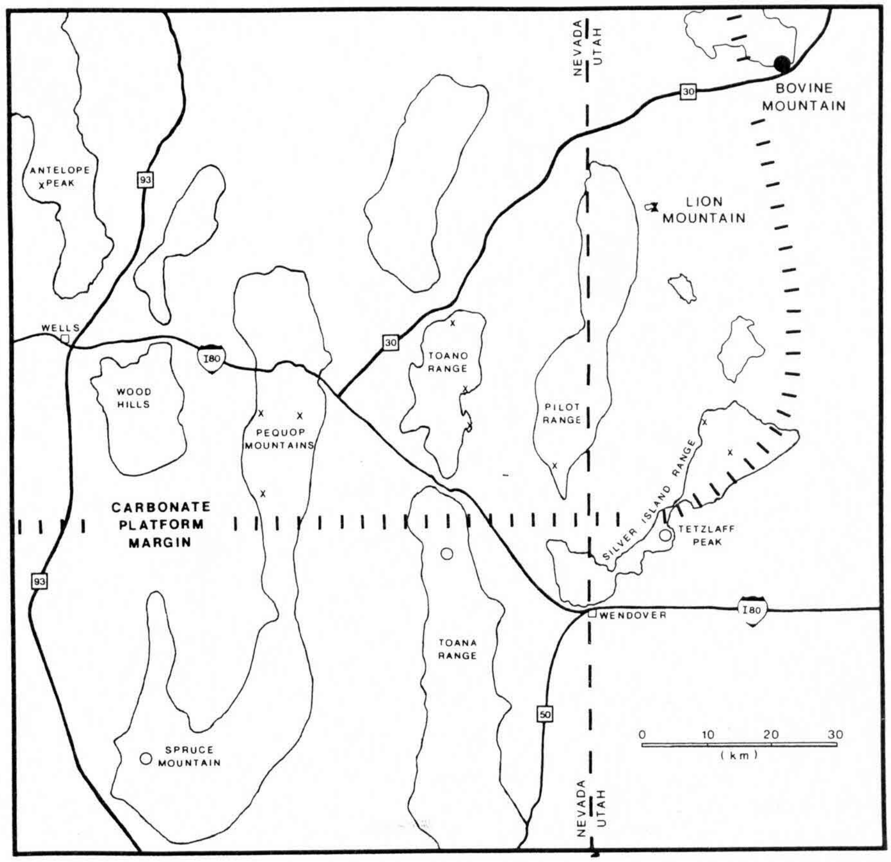



**Figure 2.** Index map of northeastern Nevada and northwestern Utah. Sections with Silurian slope facies are indicated by an X and sections with carbonate-platform facies by an O.

## Location and Previous Investigations

Bovine Mountain is at the south end of the Grouse Creek Mountains in Box Elder County, Utah. Bovine Mountain is adjacent to the Raft River-Grouse Creek-Albion Mountains metamorphic core complex (Compton and others, 1977; Jordan, 1983). The section at Bovine Mountain is at the margin of the core complex and, hence, is unmetamorphosed and has not been ductily thinned (Jordan, 1983). The strata could be part of the lower allochthon of the core complex or they could be autochthonous (Jordan, 1983). The Ordovician and Silurian section was overturned by the north-trending Bovine fold and was later over-folded by a major northeast-trending fold (Jordan, 1983).

Jordan (1983, figs. 2 and 4) presented detailed maps of the Ordovician Garden City, Swan Peak and Fish Haven formations and the Silurian Laketown Dolomite. Descriptions of the rocks presented by Jordan are elaborated upon below. Strata she assigned to the Fish Haven Dolomite are here referred to the Ely Springs Dolomite, and its contact with the Laketown Dolomite is moved upwards.

Lion Mountain in Box Elder County, Utah, is a small hill northeast of the Pilot Range. The rocks have been intensely faulted, and low-angle faults have eliminated some of the stratigraphic interval under study here (Miller and Schneyer, 1983). The Fish Haven and Lone Mountain dolomites were recognized by Miller and Schneyer (1983). Their Fish Haven Dolomite is reassigned to the Ely Springs Formation, and the Roberts Mountains Formation is recognized in the basal part of their Lone Mountain Dolomite.

Upper Ordovician and Silurian sediments deposited on the carbonate platform form a monotonous sequence of stratigraphic units (Fish Haven, Ely Springs and Laketown dolomites and their members) which have been recognized widely in western Utah and eastern Nevada (Budge and Sheehan, 1980). At the platform margin, facies change, and a separate stratigraphic nomenclature must be applied to ramp and slope strata (Hanson Creek and Roberts Mountains formations). This facies change marks the platform margin (Sheehan, 1979 and Fig. 2). The section at Bovine Mountain contains facies characteristic of the carbonate-shelf sequence, while the partial section at Lion Mountain is characteristic of upper-slope sequences.

During the Late Ordovician and earliest Silurian, the transition from platform to basin was along a carbonate ramp (Fig. 3A; Sheehan and Pandolfi, 1983; Carpenter, Pandolfi and Sheehan, 1986). The terms carbonate ramp, rimmed shelf, and carbonate platform follow the usage of Read (1982). North African glaciation probably induced glacio-eustatic regression at the Ordovician-Silurian boundary, producing a break in deposition on the platform, while depositional environments shallowed on the carbonate ramp (Fig. 3B; Sheehan, 1973; Carpenter and others, 1986). In the early Silurian, glacio-eustatic transgression re-established a depositional pattern similar to that in the Late Ordovician (Fig. 3C).

In the Late Llandovery, subsidence along possible growth faults transformed the carbonate ramp into an abrupt, rimmed carbonate-shelf margin (Fig. 3D; Johnson and Potter, 1975; Sheehan and Pandolfi, 1983; Hurst and Sheehan, 1985; Hurst and others, 1985). Deposits on the slope beyond the carbonate-shelf margin are characterized by allodapic sediments and both translational and rotational slumping (Fig. 3E; Sheehan and Pandolfi, 1983; Hurst and others, 1985). The transition from rimmed shelf to basin occurred over a relatively short distance compared to the gradual transition which had characterized the carbonate ramp.

Widespread shallow-water facies and sedimentary structures on the carbonate platform are easily distinguished from those deposited beyond the margin. Platform deposits are subdivided into formations and members (Fig. 4) which can be recognized from northern and western Utah into central and southwestern Nevada (Budge and Sheehan, 1980). On the platform, shallow-water facies include cryptalgal and stromatolitic laminites, storm beds, and intensely bioturbated dolomites deposited within and slightly below wave base (Carpenter and others, 1986).

Carbonate-ramp facies include argillaceous dolomite and limestone deposited below wave base grading basinward into laminated argillaceous limestones (Carpenter and others, 1986). Carbonate slope facies are dominated by below-wave-base carbonates, turbidites and debris flows (Hurst and Sheehan, 1985). Outer-slope and basinal facies include distal turbidites, graptolite shales, cherts, siltstones, and argillites (Riva, 1970; Oversby, 1972; Coats and Riva, 1983; Sheehan, Pandolfi and Ketner, in prep).

## Upper Ordovician and Silurian Strata at Bovine Mountain

The overturned rocks at Bovine Mountain are folded and faulted to such an extent that no complete section can be identified. The Ely Springs Dolomite is exposed at the southernmost tip of Bovine Mountain (Jordan, 1983, figs. 2 and 4). Jordan assigned these strata to the similar Fish Haven Dolomite, but the rocks more closely resemble the open-marine rocks of the Ely Springs Dolomite as exposed in the Silver Island Range (Budge and Sheehan, 1980) rather than the Fish Haven Dolomite as exposed in the Lakeside Mountains, where restricted cryptalgal laminites and stromatolites are common (Budge and Sheehan, 1980; Carpenter and others, 1986). Folding and faulting prevents accurate measurement of the section, and thicknesses of units can only be estimated.

Above the Eureka Quartzite is the Ibex Member of the Ely Springs Dolomite. The member is a dark dolomite (about 3 m thick) with some quartz sand grains. Immediately above the Ibex member is a slightly lighter colored unit about 50 m thick which is not assigned to a member. Just above the Ibex Member in the small fault block that is west of the line B-B′ on figure 4 of Jordan (1983) is a silicified-fossil locality (MPM loc. 3720) with *Hypsiptycha* sp., *Thaerodonta* sp., *Diceromyonia* sp., and a rugose coral. This fauna is common in the Ely Springs Dolomite. Cephalopods and possible stromatoporoids are also present in the lower part of the 50 m-thick interval. In the middle of the unit storm beds are present, and in the upper part of the interval are two horizons with oncolites. The biota and sedimentary structures indicated that the lower part of the Ely Springs Dolomite was deposited in an open-marine environment that was at times within normal wave base.

The Floride Member overlies the unnamed 50 m-thick unit and is at the top of the Ely Springs Dolomite. Regionally, the member has a distinctive basal slope-forming unit of argillaceous, grayish-orange (10YR6/4) dolomite. This 9 m thick unit is well developed at Bovine Mountain (Fig. 5), and was used to mark the base the Laketown Dolomite by Jordan (1983). The intense tectonic deformation of this unit may result from compressional forces being concentrated in this relatively soft, argillaceous carbonate which characteristically is a slope-forming interval in an otherwise resistant formation. Silicified brachiopods are present, but they are so extensively fractured that identification is not possible. The unit is well exposed about 200 m east of the B-B′ on Figure 4 of Jordan (1983). The stratigraphic interval

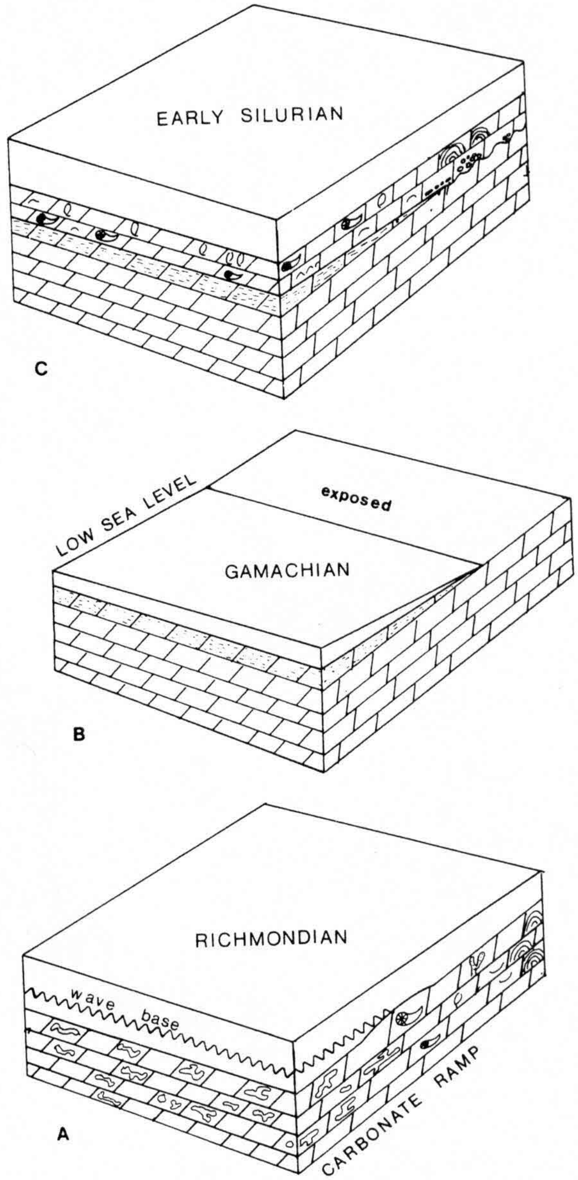
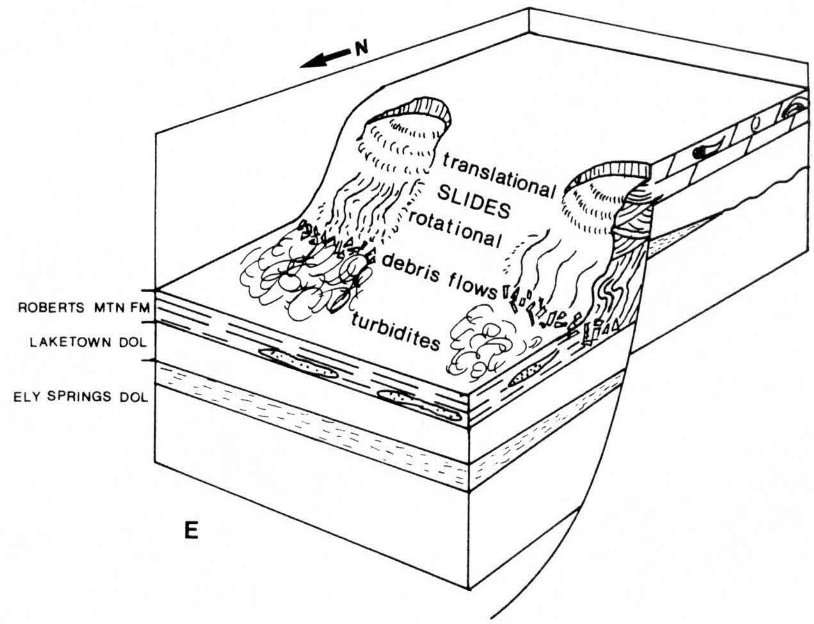
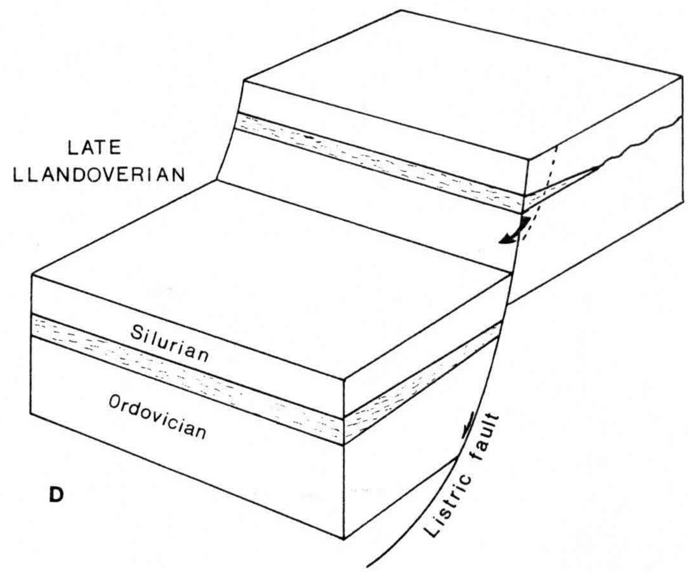



**Figure 3.** Block diagrams illustrate the evolution of the shelf-margin in northeastern Nevada and northwestern Utah. The Bovine Mountain section was located on the carbonate platform, east of the inferred listric fault. The Lion Mountain section was located on the upper ramp, immediately basinward of the inferred listric fault. 3A. During the Upper Ordovician a carbonate ramp was present at the platform margin. Lithofacies reflect gradual deepening into the basin. As is characteristic of carbonate ramps, allodapic sediments such as turbidites and debris flows were uncommon. 3B. Glacio-eustatic regression at the Ordovician-Silurian




boundary caused a break in sedimentation on the carbonate platform. Lithofacies commonly reflected shallowing on the upper part of the carbonate ramp. 3C. Early Silurian glacio-eustatic transgression was accompanied by resumption of the earlier pattern of sedimentation. 3D. Subsidence of the shelf margin terminated the carbonate ramp and established an abrupt rimmed carbonate shelf margin. 3E. Sediments on the carbonate slope include turbidites and debris-flow deposits, unlike previous sedimentation on the carbonate ramp.

above the basal Floride unit seems to be more deformed than below the unit, and the rock below the basal Floride may have been protected from intense deformation by the soft basal part of the Floride Member.

The Floride Member above the argillaceous interval is characterized by intense *Thalassinoides* bioturbation (Fig. 5; Sheehan and Schiefelbein, 1984). The Floride Member is an easily recognized unit which was deposited below normal wave base (Sheehan and Schiefelbein, 1984).

The dark-gray Tony Grove Lake Member of the Laketown Dolomite is immediately above the Floride Member in the upper part of the unit mapped as S1, 200 m east of line B-B′ (Jordan, fig. 4, 1983). The member is characterized by trough cross lamination, storm beds and storm scouring, and is about 30 m thick. It is intensely folded, and the contact with the Floride Member is faulted and has chevron folds on a scale of 1 to 10 m. Halysitid and *Palaeophyllum?* sp. coral colonies as much as 1 m in diameter are common, and stromatoporoids are also present. Although not common, pentamerid brachiopods, possibly *Virgiana* sp., are present in bioclastic beds. This fauna is characteristic of the Tony Grove Lake Member. The large pentamerid establishes a Silurian age. *Virgiana,* which is common in the member elsewhere (Sheehan, 1980), is of early or middle Llandovery age. Regionally, the systemic boundary is at the base of the Laketown Dolomite (Budge and Sheehan, 1980).

Above the Tony Grove Lake Member is a light-colored, coarse-grained dolomite with crinoid stems. The unit is typical of the High Lake Member of the Laketown Dolomite. The contact between the High Lake and Tony Grove Lake members is faulted and intensely deformed. In the eastern part of the outcrop described above, the High Lake Member is in fault contact with the Floride Member. Only the lower part of the High Lake Member is present in the area of Figure 4 of Jordan (1983). A thicker section of the High Lake Member is exposed 2.5 km northeast of the latter exposure in a small hill adjacent to a bend in Highway 30. The hill is mapped as O-S on Figure 2 of Jordan (1983). Faults with meter-scale displacements are ubiquitous. The strata are fractured typically on a 10 cm scale. The High Lake Member could be as much as 200 m thick.

Midway through the low hill are several dark units, from 5 to 20 m thick, interbedded with light-colored dolomite that is similar to that of the High Lake Member (Fig. 7). The dark beds include bioturbated intervals, storm layers, bioclastic beds and a few cryptalgal laminites. The interval with alternating light and dark beds is characteristic of exposures of the Portage Canyon Member of the Laketown Dolomite near the platform margin, for example in the Pancake Range (Budge and Sheehan, 1980). An open marine fauna is present in the dark beds. Favositid, heliolitid, syringoporid and halysitid corals are present. The brachiopod *Pentameroides* sp. is present with a cruralium supported by a very low septum. This species resembles the Upper Llandovery (C4-5) species of *Pentameroides* that is common in the Portage Canyon Member at other localities (Sheehan, 1982). A single cephalopod 2 cm in diameter also was found.

Above the Portage Canyon member is an interval about 50 m thick that closely resembles the High Lake Member, although it is somewhat coarser grained. This unit is the Decathon Member of the Laketown Dolomite (Budge and Sheehan, 1980). The top of the member is not exposed. Regionally the Decathon Member is only a few m thick on the platform, but it thickens toward the rimmed carbonate-shelf margin where it intertongues with the Lone Mountain Dolomite (Fig. 4).

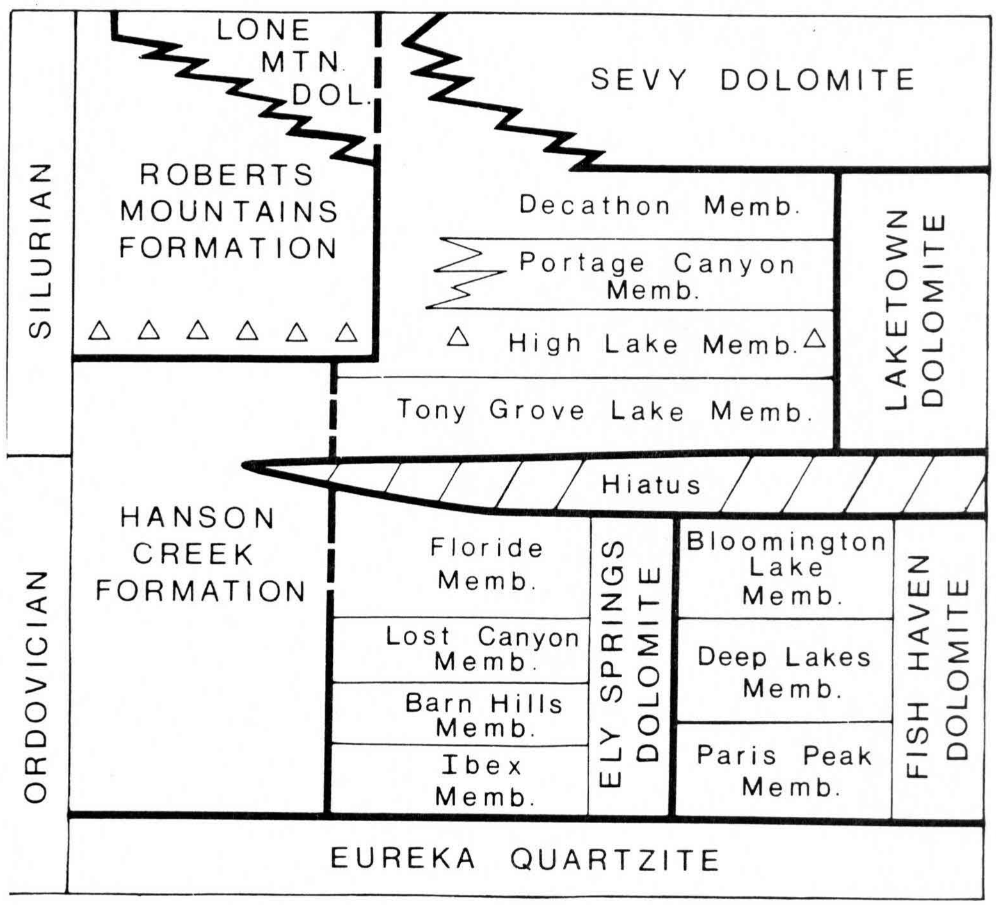



**Figure 4.** Upper Ordovician and Silurian stratigraphic units from the carbonate platform margins. Slope facies in central and northern Nevada are to the left.

## Upper Ordovician and Silurian Strata at Lion Mountain

Intense faulting at Lion Mountain makes study of stratigraphic units difficult. Low-angle faults have eliminated some of the section. The Eureka Quartzite is overlain by a 15 m thick covered interval which includes fault breccia in the talus. A 75 m thick section of dark, fault-brecciated dolomite forms the base of the section here assigned to the Ely Springs Dolomite. The dark, bioturbated dolomite is assigned to the Lost Canyon Member, and it resembles sections which are found near the transition between the Ely Springs Dolomite and the Hanson Creek Formation in the Silver Island and Toano ranges. Fossils are primarily rugose corals and stromatoporoids.

The dark basal unit of the Ely Springs Dolomite is overlain by a topographic saddle in the position of the basal, slope-forming part of the Floride Member. The saddle represents about 10 m of unexposed section which is overlain by 17 m of *Thalassinoides* burrowed dolomite that is typical of the Floride Member.

The Floride Member is overlain by 7 m of clean, light-gray, coarse grained dolomite deposited within wave base. This unit has yet to be assigned a name. Regionally this unit is correlative with the glacio-eustatic regression at the Ordovician-Silurian boundary (Fig. 3C; Carpenter and others, 1986). It is present only in sections that were west of the carbonate platform and deep enough on the carbonate ramp to receive some deposition during the regression (e.g., northern Silver Island Range, Toano Range). This unit represents a shallowing of depositional environments during the regression.

Miller and Schneyer (1983) mapped a low-angle fault at the top of the light-colored unit. The fault zone is 2.7 m thick and has apparently eliminated the upper part of the Ely Springs Dolomite and the lower part of the Roberts Mountains Formation. The lower part of the Roberts Mountains Formation is commonly a platy, argillaceous carbonate. The low-angle fault was probably emplaced in the relatively non-resistant lower part of the Roberts Mountains Formation. An undetermined thickness of section was removed by this fault. The section in the northeastern part of the Silver Island Range (Fig. 2) has about 200 m of section in this stratigraphic position, providing a reasonable estimate of the thickness of strata missing because of faulting.

Above the low-angle fault is a 19 m thick, argillaceous, medium-gray, medium- to thick-bedded dolomite with abundant shells. Miller and Schneyer (1983) included these rocks in the basal part of the Lone Mountain Dolomite, but these rocks more closely resemble the "thick-bedded" facies of the Roberts Mountains Formation, which has been described in central Nevada by Berry and Boucot (1970), in the Toano Range by Sheehan and Pandolfi (1983), in the Pilot Range by Carpenter and others (1986), and in the Silver Island Range by Sheehan (1976). Brachiopods occur in distinct layers, some of which are basal turbidites similar to those present in this formation in the Silver Island Range, the southern part of Pilot Peak and the Toano Range. The presence of *Kirkidium* sp. and *Eospirifer* sp. establishes a Late Silurian age (Upper Wenlock or younger).

The Roberts Mountains Formation is overlain by a light-colored, massive dolomite assigned to the Lone Mountain Dolomite. No fossils were recovered from the Lone Mountain Dolomite.

## Location of the Carbonate-Platform Margin

The sequence of Ely Springs and Laketown dolomites at Bovine Mountain is typical of the monotonous units present on the carbonate platform. No unit at Bovine Mountain resembles any of the slope facies. The margin of the carbonate platform must have been west of Bovine Mountain. The section was deposited near the shelf margin in the Silurian because the Portage Canyon member is composed of interbedded light and dark units, and the Decathon Member is relatively thick, as is characteristic of shelf-margin sequences.

It is unclear whether these rocks are 1) autochthonous or are 2) part of the lower allochthonous plate of the core complex (Jordan, 1983; Compton, 1983). To the north, tectonic transport has moved the lower allochthonous plate as much as 30 km to the east (Compton and others, 1977). In either case, the platform margin was originally west of the present position of Bovine Mountain.

Upper Ordovician carbonate-ramp facies at Lion Mountain resemble similar rocks from upper-ramp environments in the Silver Island and Toano ranges near the lateral transition between the Ely Springs and Hanson Creek formations. The light-colored regressive unit is especially distinctive. The Roberts Mountains Formation was deposited on the carbonate slope following the down-dropping event which established an abrupt carbonate-shelf margin (Johnson and Potter, 1975). The "thick-bedded facies" resembles the shallowing-upward part of the formation on the upper part of the carbonate slope, just beyond the rimmed shelf margin (Sheehan and Pandolif, 1983; Hurst and others, 1985; Hurst and Sheehan, 1985). Similar slope facies are present near the top of the formation in the northern Silver Island and Toano ranges. The part of the Roberts Mountains Formation preserved at Lion Mountain is younger than the Laketown Dolomite, further establishing the distinctive nature of these rocks. By the time the upper part of the Roberts Mountains Formation was being deposited at Lion Mountain, the broad carbonate shelf to the east was either emergent or the restricted cryptalgal laminites of the Sevy Dolomite had begun to be deposited.

Carbonate-ramp and slope facies are present at Lion Mountain and in the northern Silver Island Range. Platform facies are present at Tetzlaff Peak in the southern Silver Island Range, and also at Bovine Mountain. The carbonate- platform margin was located between these sections (Figs. 1 and 2).

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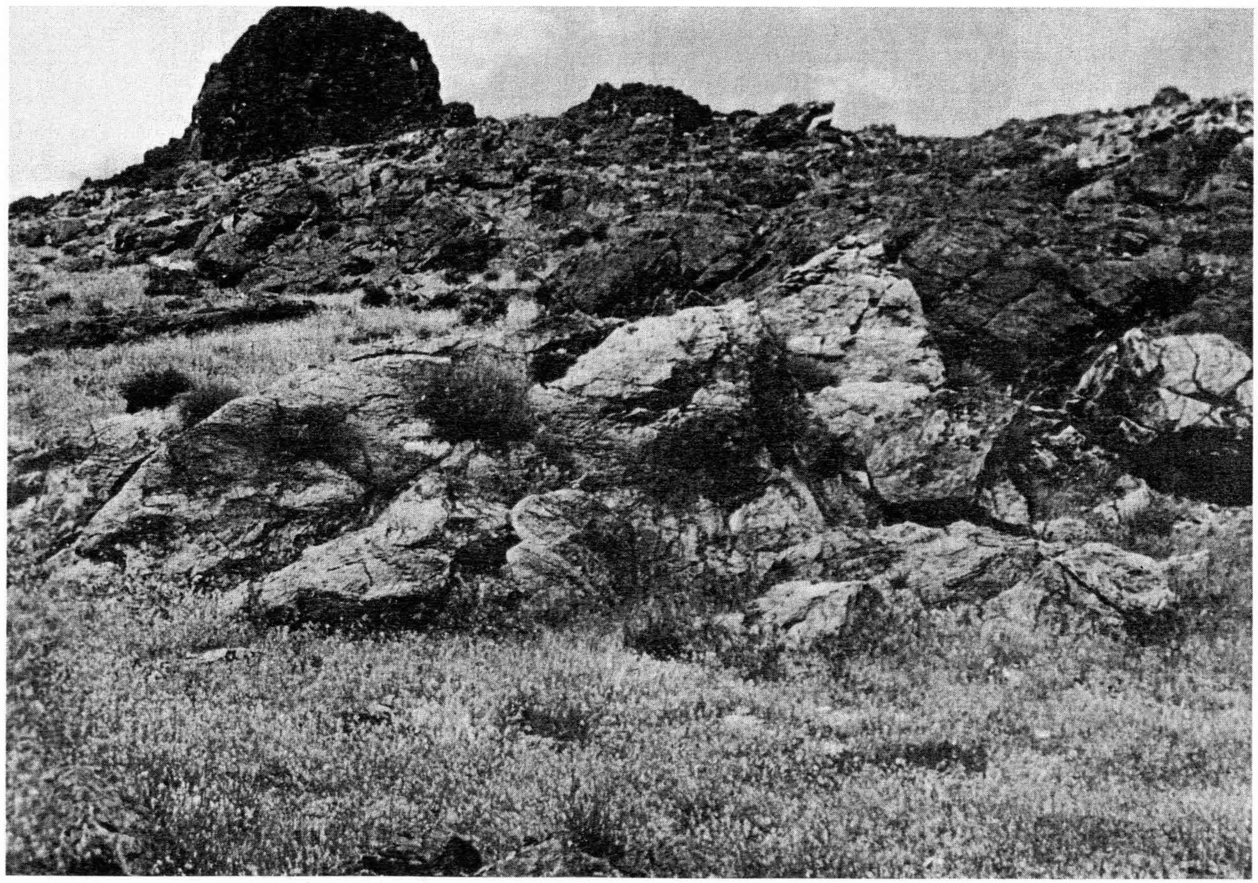

**Figure 5.** Argillaceous unit at base of the Floride Member of the Ely Springs Dolomite is in the middle of photograph. Bovine Mountain, Utah.

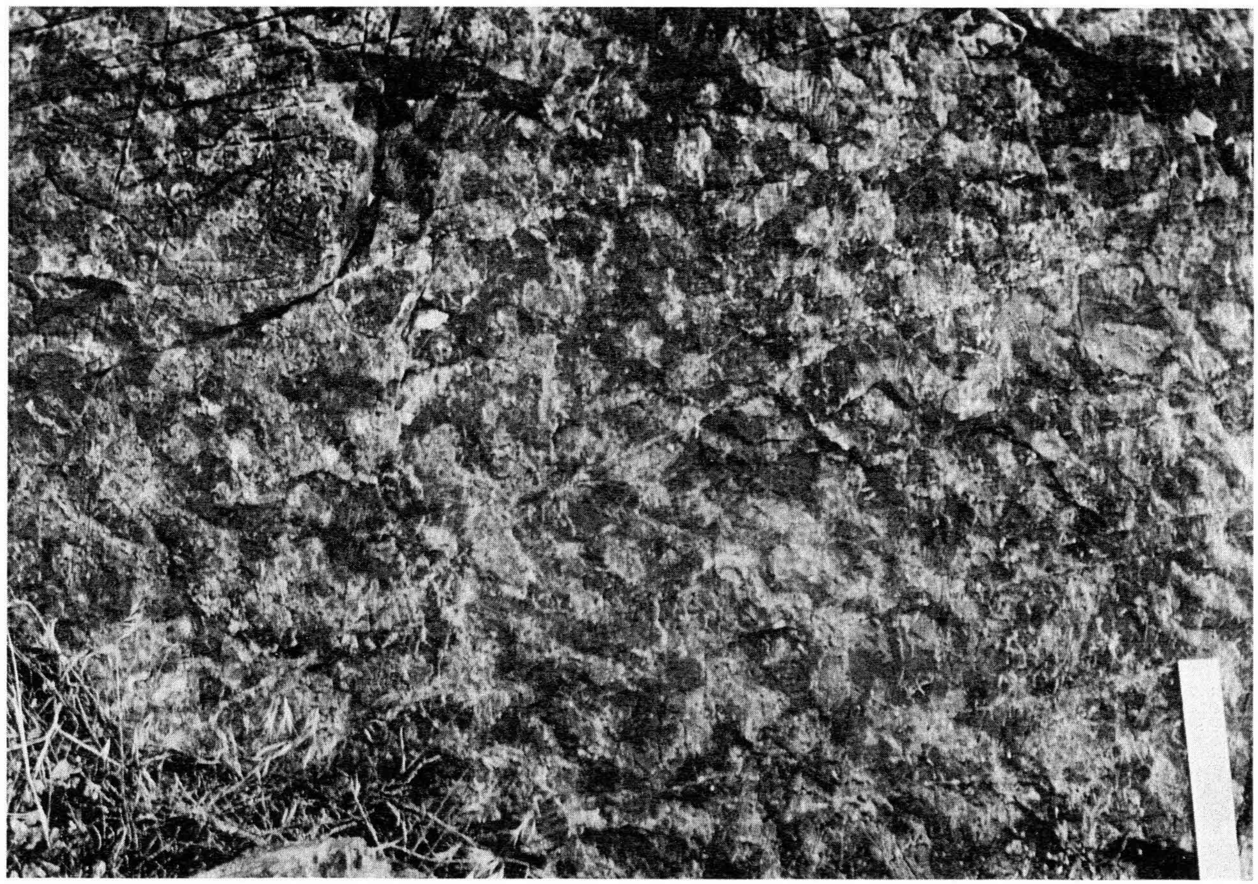

**Figure 6.** *Thalassinoides* burrows in the Floride Member of the Ely Springs Dolomite. The scale is 15 cm long. Bovine Mountain, Utah.

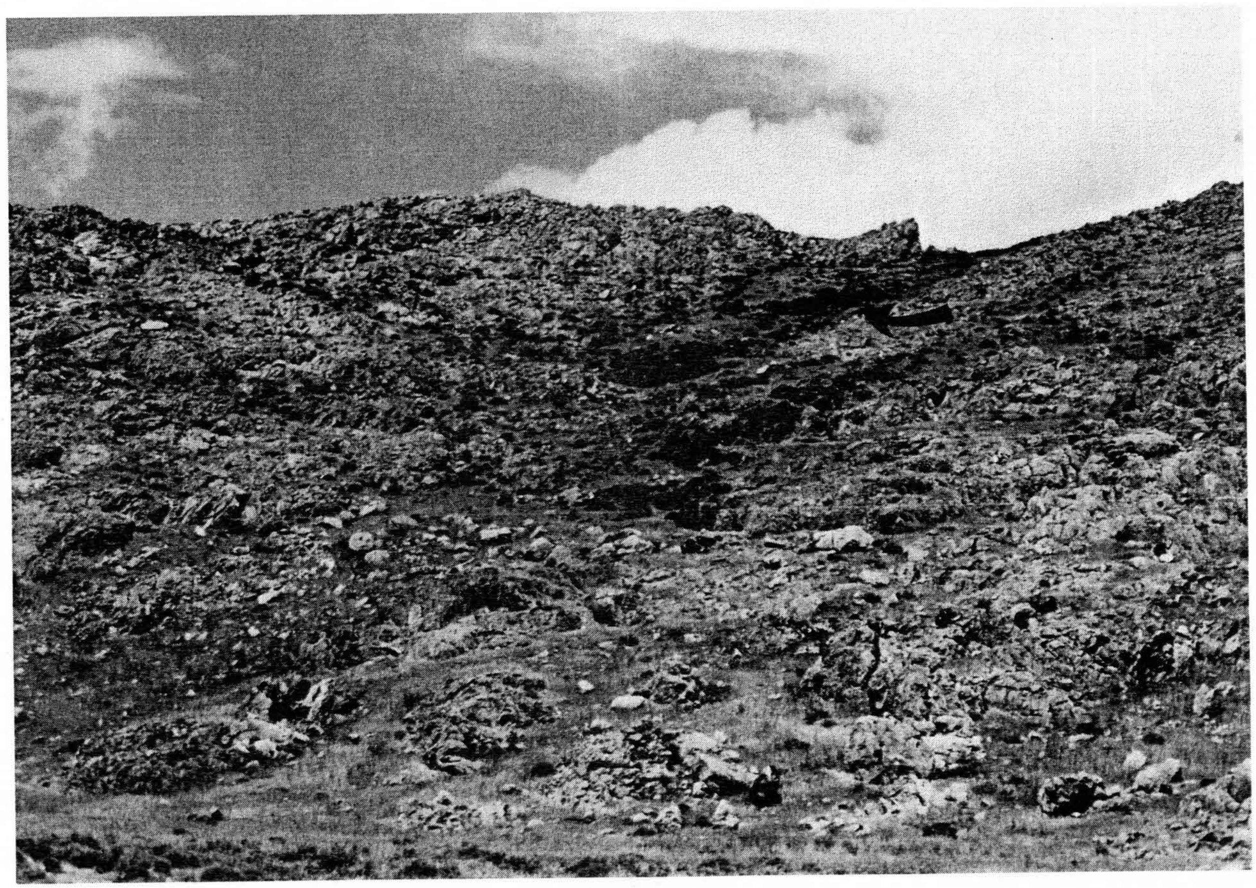

**Figure 7.** Upper part of the Laketown Dolomite on eastern hill. Light-colored High Lake Member is on the skyline to the left, alternating light and dark bands of the Portage Canyon Member in the middle of the hill, and light colored beds of the Decathon Member are on the right of the photograph. Arrow indicates the locality where *Pentameroides* sp. was found. Bovine Mountain, Utah.

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