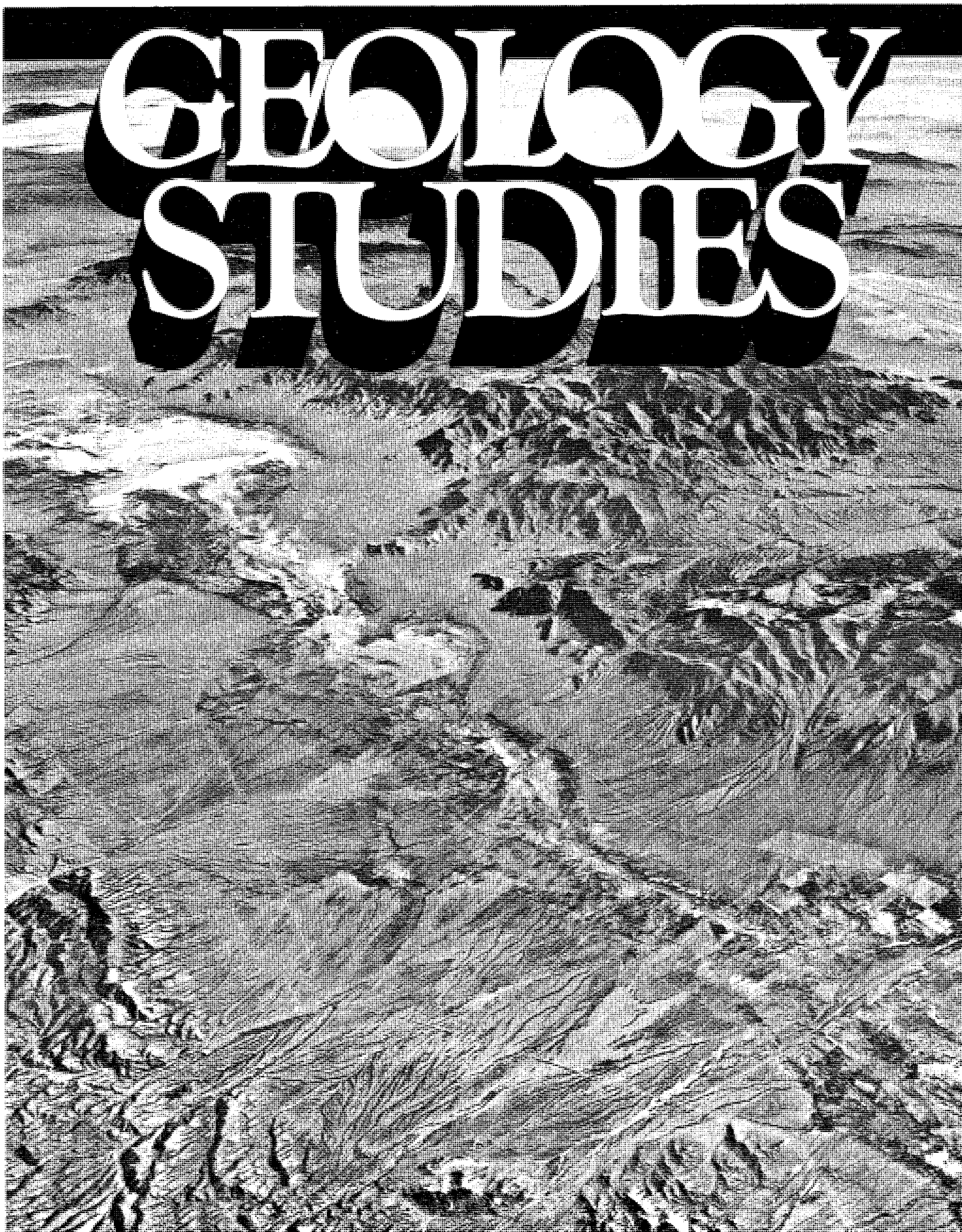
BRIGHAM YOUNG UNIVERSITY

GEOLOGY STUDIES



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Papers presented at the 31st annual meeting, Rocky Mountain Section, Geological Society of America, April 28–29, 1978, at Brigham Young University, Provo, Utah, reviewing stratigraphic and paleontologic research in the Great Basin and honoring Dr. Harold J. Bissell.

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THE GLORY OF GOD IS INTELLIGENCE

Cover: *The Great Basin seen from a high-altitude reconnaissance plane. Photo courtesy U.S. Geological Survey.*

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EDITOR'S PREFACE

For the 1978 Rocky Mountain Section of the Geological Society of America meeting in Provo, Utah, a symposium was organized to mark the retirement of Professor Harold J. Bissell (program below). During the course of the symposium, held on April 29, several hundred present and past students, colleagues, and friends participated. Papers given at the symposium were invited from colleagues and former students. The theme of the symposium was a review of stratigraphic and paleontologic research in the Great Basin.

Of the nine papers presented in Provo, six are printed in this commemorative volume, dedicated to Harold J. Bissell, an enthusiastic teacher and student of Great Basin geology.

DLC

SYMPOSIUM
GREAT BASIN STRATIGRAPHY AND PALEONTOLOGY
29 April, 1978

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(Abstracts of papers published in vol. 10, no. 5, Geological Society of America Abstracts with Programs, March 1978)

A Middle Cambrian Platform-to-Basin Transition, House Range, West Central Utah

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ABSTRACT.—An abrupt transition from shallow platform to basinal environments existed in the area of the House Range during deposition of the Marjum Formation. The beginning of Marjum deposition was marked by the accumulation of deep-water limestones, but this pattern was soon interrupted by shoaling and development of a carbonate platform in the central and northern House Range. Supratidal to shallow subtidal carbonates formed on the platform as slope and basinal lithologies continued to accumulate a few kilometers to the south in a major deep-water embayment on the continental shelf. Fenestral fabrics, mud cracks, intraformational conglomerates, pelleted mudstones, and algal laminated limestones and dolomites reflect tidal flat and lagoonal conditions of the "restricted" platform interior. These lithologies pass laterally into cross-bedded grainstones of the platform margin. The grainstones consist of echinoderm and trilobite fragments and lithoclasts, many of which are coated. Erosional channels in this facies resulted from strong current activity on the margin. Dark laminated limestones and interbedded shales dominate the slope and basin facies. Occasional graded beds and concentration of sponge spicules and trilobites in the shale partings indicate relatively rapid or "pulselike" deposition of many limestone units. Mottled limestones, penecontemporaneous slump structures, coarse debris beds, and allodapic grainstones suggest relatively steep slopes existed on the edge of the platform.

INTRODUCTION

Exposures of the Middle Cambrian Marjum Formation in the House Range of west central Utah provide one of the few opportunities in the Great Basin to observe a platform-to-basin transition in nearly continuous exposure. During deposition of the Marjum, which is included within the *Bolaspidella* trilobite zone (Robison 1967, 1976), a major deep-water embayment extended eastward onto the shelf and into the area of the House Range (fig. 1). It is because of this embayment that the transition between shallow-platform carbonates and deeper-water limestones and shales occurs in this area.

Robison (1964) recognized the presence of a major lithofacies change within the Marjum in the House Range (fig. 2). He found that it was composed of interbedded shale and limestone to the south (Marjum Pass area), but was essentially pure carbonate a few miles to the north. Our objective in this paper is to interpret the paleoenvironmental significance of these facies variations in the Marjum in hopes of providing a better understanding of the nature of the transition between the carbonate belt and outer detrital belt which characterized the Cordilleran geocline throughout much of the Cambrian (fig. 1).

ENVIRONMENTS OF DEPOSITION

Introduction

Lithofacies of the Marjum Formation in the House Range reflect deposition in platform, platform margin, slope, and basinal environment (fig. 3). Rocks deposited on the platform are present in the central part of the range with deeper-water facies occurring both to the north and south. The most dramatic transition occurs between Swasey Peak and Marjum Pass as platform carbonates grade southward into basinal limestones and shales. The Marjum in the northern part of the House Range was deposited mainly in platform margin and slope environments. As illustrated in figure 3, the Marjum is an upward shoaling unit which began with deposition in relatively deep water throughout the area of the House Range.

Platform Environment

Carbonates were deposited on the platform in peritidal and lagoonal environments. They are medium- to light-gray, pellet-al-intraclastic dolomites and dolomitic limestones which exhibit many features typical of intertidal, supratidal, and shallow subtidal deposits (Shinn 1968, Heckel 1972). Skeletal fossils are generally absent, probably because of extremes in water temperature or salinity on the broad, shallow shelf. Only blue-green algae and a few soft-bodied burrowing organisms were able to thrive under these inhospitable conditions.

The presence of fenestral fabrics and shrinkage cracks in these carbonates indicates periodic subaerial exposure and

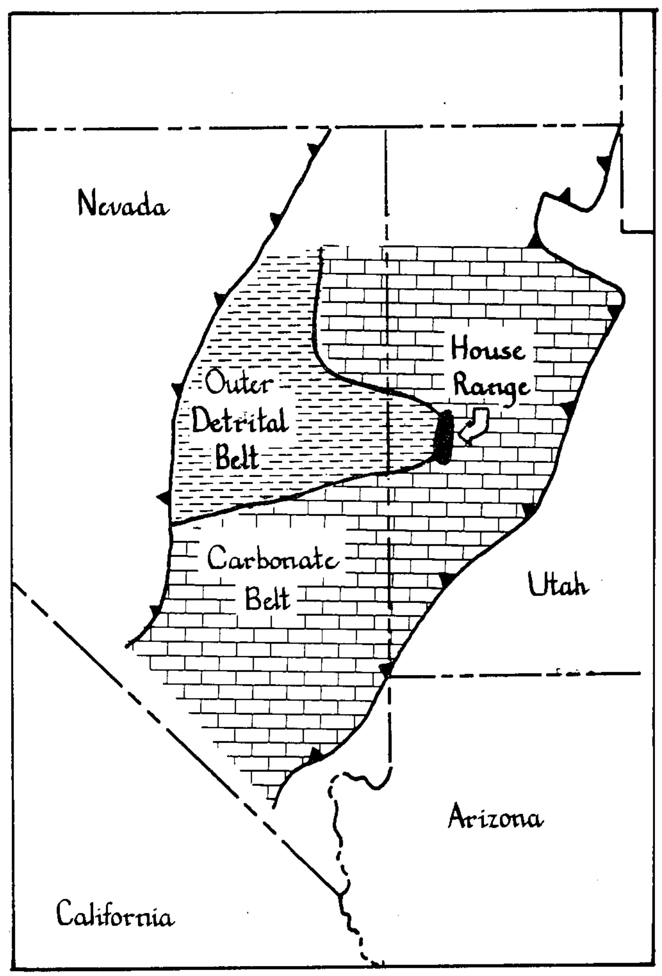

FIGURE 1.—Middle Cambrian (Middle and Late *Bolaspidella* Zone) lithofacies map for the eastern Great Basin showing the location of the House Range. (After Robison 1964).

drying as would be expected on tidal flats (figs. 4A, 4B, 4E). Erosional scours and intraformational conglomerates, including imbricated flat-pebble conglomerates, are intimately associated with these desiccation features. They were presumably deposited by storms ripping up clasts as they swept across the expansive tidal flats.

Two types of laminated carbonates, both of which have been attributed to algae, are common to the platform environment. One type, shown in figure 4C, consists of crinkly or undulose laminae which are obviously algal stromatolites (Donaldson 1963, Kepper 1972). The lack of desiccation features associated with these laminations indicates that they either

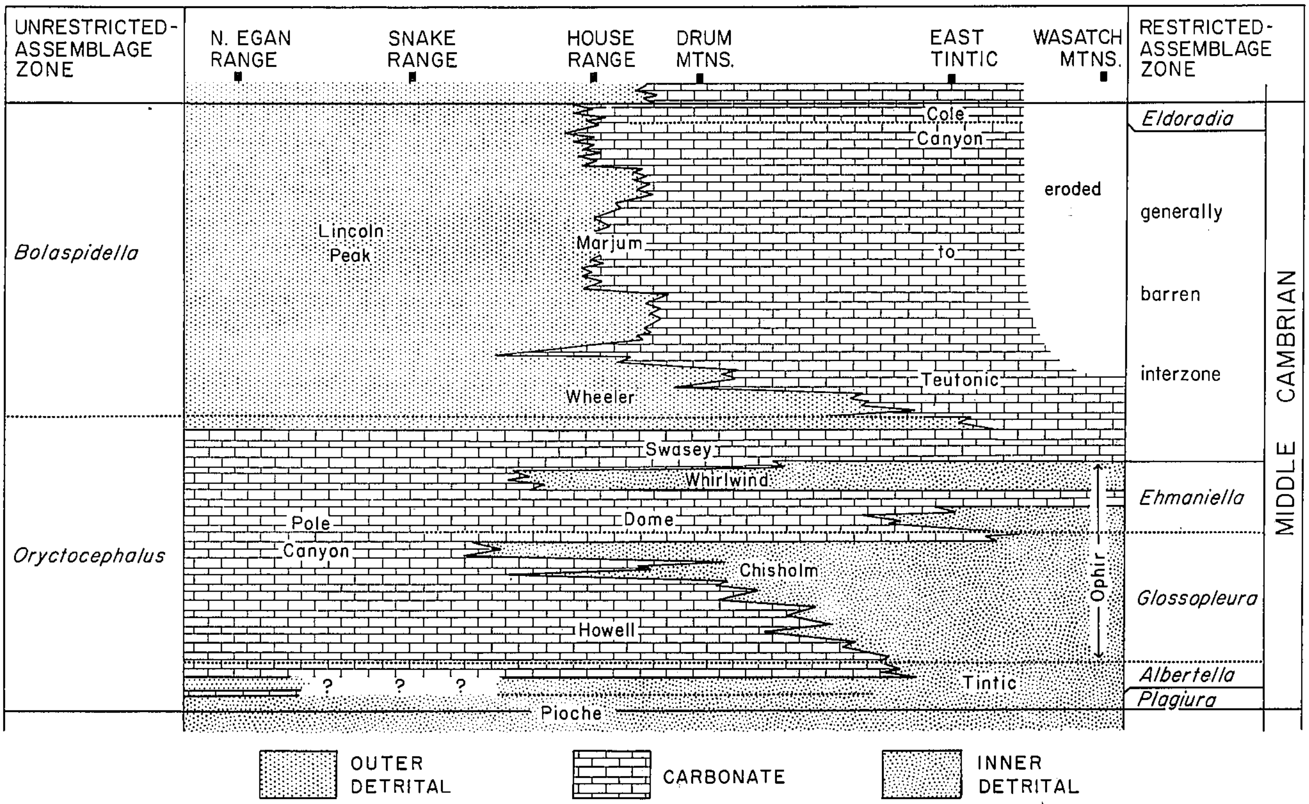

FIGURE 2.–Cross-sectional diagram from eastern Nevada (left) to central Utah (right) illustrating the abrupt lithofacies change from the carbonate belt to the outer detrital belt in the Marjum Formation of the House Range. (From Robison 1976).

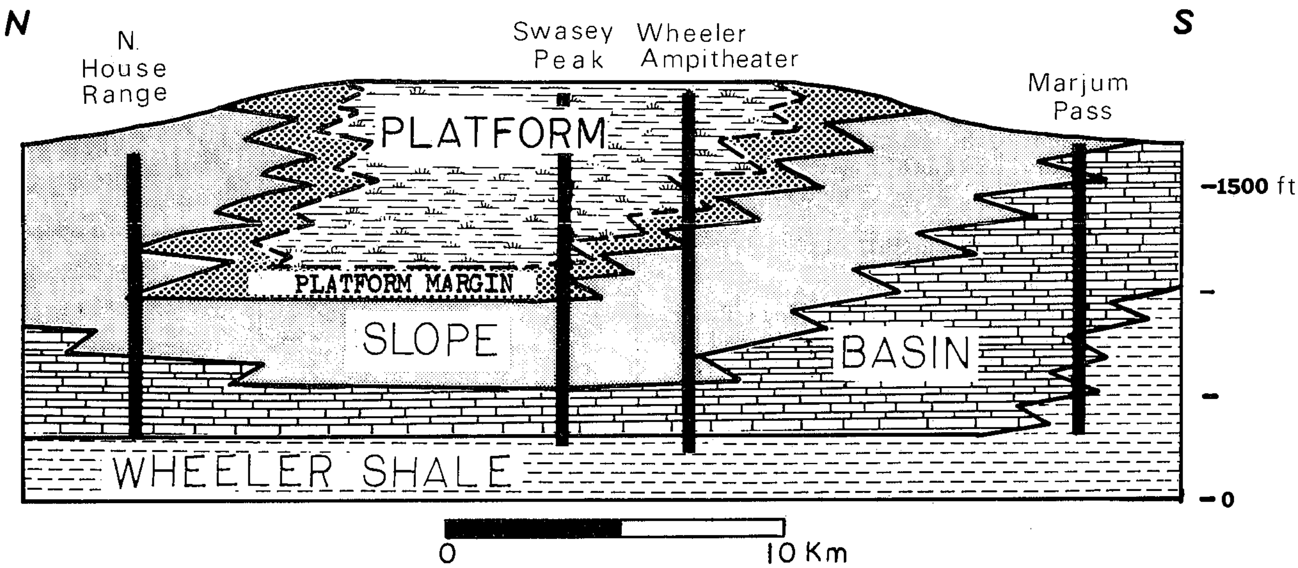

FIGURE 3.–Cross section showing the distribution of depositional facies in the Marjum Formation of the House Range. Locations of measured sections are shown with vertical lines.

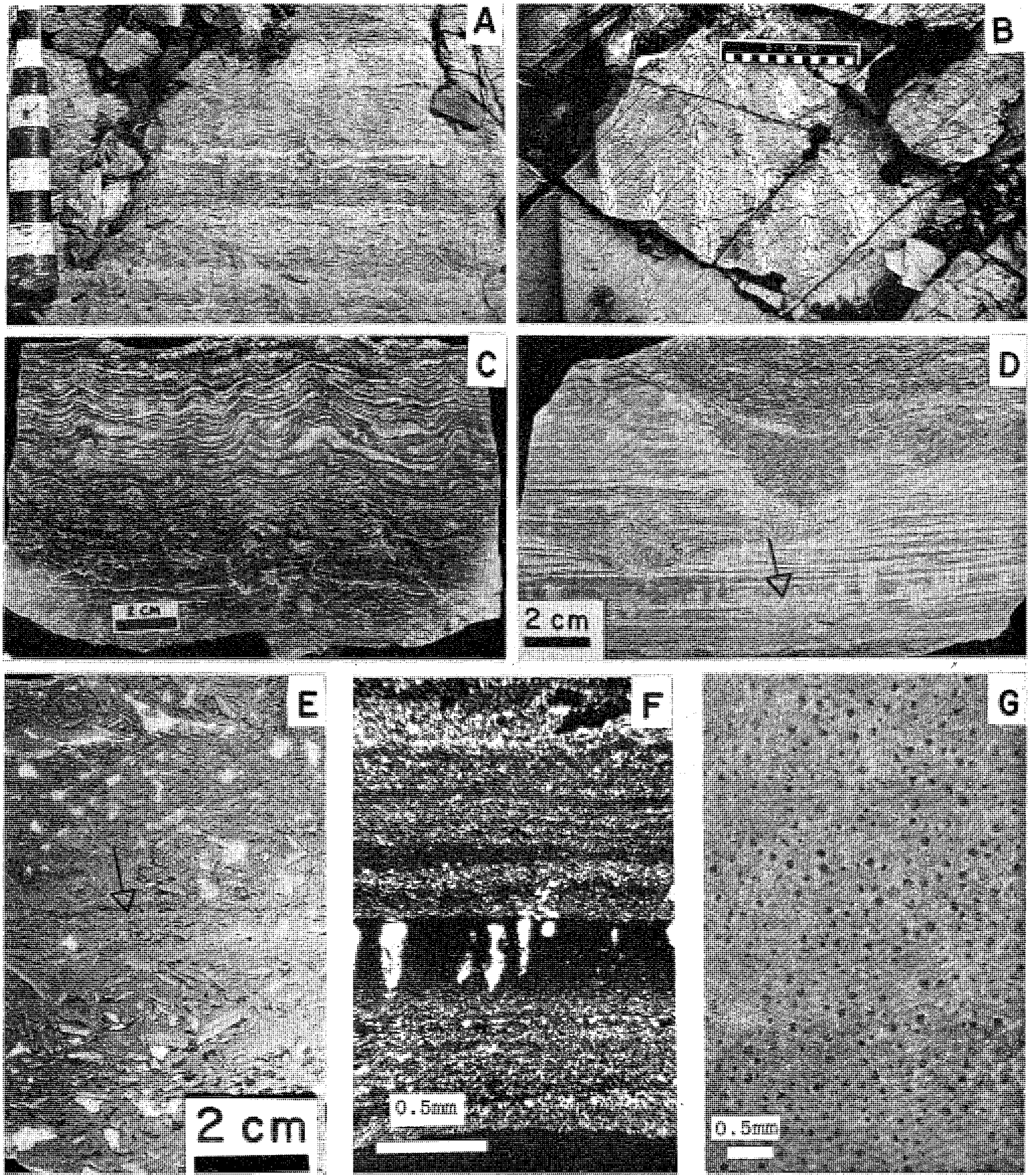

FIGURE 4.–Carbonate platform lithologies: A.–Desiccation cracks in supratidal dolomites. B.–Wave ripples with desiccation cracks in fine-grained sediment which was washed into the troughs. C.–Crinkly laminated algal stromatolite. D.–Evenly laminated pond or shallow lagoon dolomite overlain with erosional contact by intraclastic grainstone. Note burrow in left center. Arrow points to layer with fluid escape structures. E.–Intraclastic dolomitic limestone with layer of fenestral fabric indicated by arrow. F.–Graded lamina with fluid escape structures in evenly laminated pond or shallow lagoon deposit. G.–Horizontal view of fluid escape structures seen in 4F.

were seldom exposed or were exposed for only short periods—as would occur in the intertidal zone. Individual lamina are generally continuous for only a few centimeters and are thickest over the crests of the undulations, like algal mats in modern intertidal zones (Shinn et al. 1969). Laminae of the second type (fig. 4D, 4F) are very even and continuous, often over several meters, and have been interpreted as planar algal stromatolites (Howe 1968, Gebelein and Hoffman 1973). We found that these laminae are graded on a millimeter scale and often have fluid escape structures which we at first misinterpreted as desiccation cracks (figs. 4F, 4G). They occur as vertical spar-filled columnar structures which generally increase in diameter upward. They were produced by the vertical migration of gas or water during early compaction of some of the laminae. We believe the laminae were formed by pulselike deposition of sediment settling from suspension in tidal ponds or shallow lagoons rather than being algal stromatolites. Storms which formed the intraformational conglomerates on the supratidal flats may have dumped fine sediment into adjacent subtidal ponds and lagoons.

Platform Margin Environment

Coated skeletal grain packstones and grainstones containing oncolites and ooid grainstones accumulated along the high-energy platform margin. The skeletal grains are mainly rounded trilobite and echinoderm fragments. Many of the grainstones exhibit medium-scale trough cross-bedding and are better sorted than those deposited in any of the other environments (fig. 5). According to Wilson (1974) sands of this type accumulate in the zone of maximum wave action. Channels filled with cross-bedded grainstones suggest this environment was also affected by relatively strong tidal currents.

Some of the ooid grainstones exhibit a collapse phenomenon which we have observed in other Cambrian oolites of the Great Basin (e.g., Johns Wash Limestone, Swasey Limestone). This is a diagenetic process which involves cementation followed by dissolution of the ooids and subsequent collapse of the cement shards which are then bound by a later generation of cement (fig. 5C). The process has been described in detail by Conley (1977), who studied a limestone in southeast Kansas. However, why it is selective to certain laminae or patches is not yet clear. It is interesting to note that this process may result in compaction of a unit to half its original thickness.

Slope Environment

Fossiliferous wackestones and packstones and burrowed and mottled limestones are the dominant lithologies of the slope environment (fig. 6). The bioclasts consist of trilobites, echinoderms, sponge spicules, and phosphatic brachiopods which are generally unbroken and show no evidence of transport. The texture and faunal diversity of these rocks suggest deposition in low-energy, normal-marine waters.

Several types of gravity structures are evidence of the depositional slopes that characterized this environment. Penecontemporaneous folding produced by the downslope movement of lime mudstones and wackstones is the most obvious of these gravity features (fig. 6E). Other evidence includes debris beds and beds of graded or cross-bedded grainstones derived from the platform margin or upper part of the slope environment. Taylor and Cook (1976) observed similar gravity features in Upper Cambrian and lowest Ordovician slope deposits of Nevada.

The origin of the mottled beds, so typical of this environment, may be due in part to deposition on an inclined surface. Some of the mottling is obviously the result of burrowing, but no recognizable burrows were observed in many of the mottled units. All gradations from incipient to pervasively mottled limestones occur. Mottling is best developed in units with alternating bands of relatively pure dark-gray lime wackestones and light-gray to rust-colored argillaceous mudstone, which are commonly dolomitic. Much of the mottling in the Marjum was likely produced by a combination of load-casting, resulting from preferential compaction of the more argillaceous layers (fig. 6A), and downslope creep producing a type of sedimen-

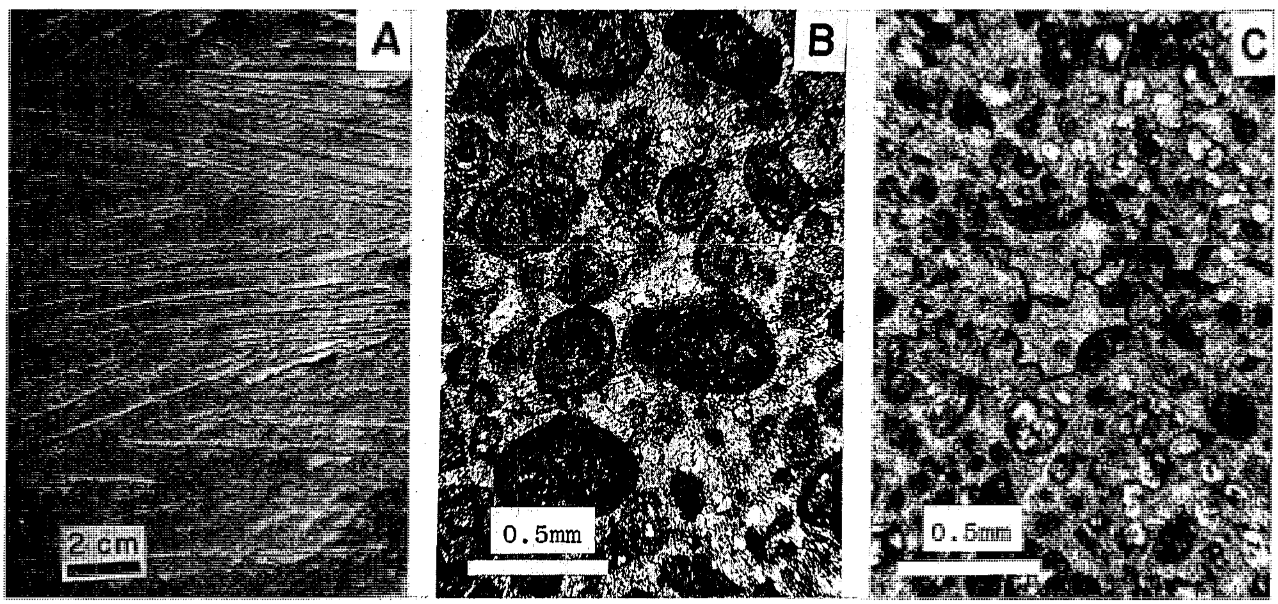

FIGURE 5.—Platform margin lithologies: A.—Cross-bedded skeletal-ooid grainstone. B.—Ooid grainstone. C.—Collapsed oolite. Several cement shards are outlined.

tary boudinage (fig. 6B). All the gravity features of the rocks deposited on the slope could have formed on a surface with an inclination as low as one degree (Cook et al. 1972). The abrupt transition from supratidal to basinal limestones in the southern part of the House Range, however, implies slopes of at least 2–3 degrees.

Basinal Environment

We use the term *basinal* merely to refer to rocks deposited in deep water and do not intend to imply an oceanic basin. The basin we discuss here is likely one which developed on the continental shelf by differential subsidence.

Dark, thin-bedded limestones with interbedded shales characterize the basinal rocks of the Marjum (fig. 7A). These rocks form the lower part of the formation at all localities and comprise most of the Marjum Pass section in the southern part of the range (fig. 3). Many of the features described by Wilson (1969) as typical of "deeper-water" lime mudstones are present in these rocks which display no evidence of wave or strong current activity. The limestones are generally composed of clay- and silt-size particles and are finely laminated (figs. 7B, 7C). The laminae are occasionally graded and sometimes exhibit small-scale cut-and-fill structures. Except for small load casts the limestones are evenly bedded, and individual beds extend over great distances. Fossils include sponge spicules, brachiopods, and trilobites, particularly planktonic agnostid forms (Robison 1972). The fauna is not uniformly distributed within depositional units as is the case in the fossiliferous wackstones of the slope facies. Rather, fossils are concentrated on the surfaces of the limestone beds and in the shale partings. We interpret the distribution of fossils to reflect the diluting effects of relatively rapid influxes of carbonate sediment derived from the platform and slope and deposited in the basin where shales were slowly accumulating. The shale partings, although generally thin, may represent longer time spans than individual limestone beds, accounting for the concentration of fossils in these layers.

Occasional graded units, debris beds, and allodapic grainstones are present in the basinal sequences (figs. 7D, 7E). The

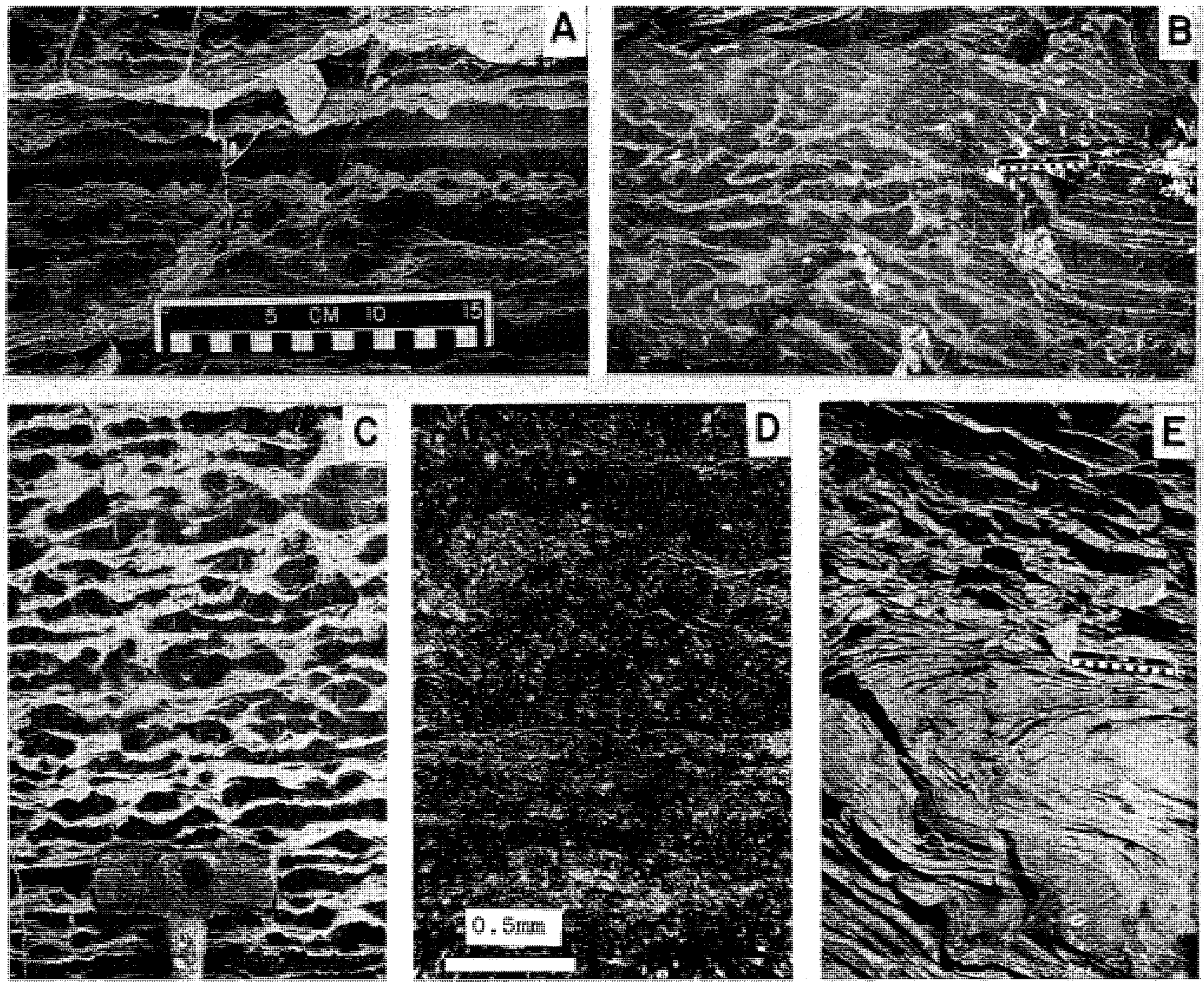

FIGURE 6.–Slope lithologies: A.–Incipient mottling produced by load-casting. B.–Mottling resulting from downslope creep. C.–Mottled limestone produced by combination of load-casting and downslope creep. D.–Trilobite-echinoderm wackestone-packstone. E.–Penecontemporaneous fold.

debris beds are usually a meter or so thick and mainly composed of dark, laminated limestone clasts presumably derived from the lower slope. The fact that the clasts originated in deep water implies that paleoslopes must have extended well below wave base. The allodapic grainstones are composed of pellets, coated grains, fossils, and intraclasts characteristic of the platform environment. These grainstone beds usually are neither graded nor cross-bedded and appear to have been transported by a "grain-flow" mechanism from the platform and slope into the basin.

DEPOSITIONAL SUMMARY

Figure 8 illustrates our proposed depositional model for the Marjum Formation of the House Range. Initial deposition of the Marjum was in deep water throughout the area, but this pattern was soon altered by shoaling and the development of platform conditions in the central House Range. Algal laminated and pelleted dolomitic mudstones, many of which exhibit fenestral fabrics and contain intraformational conglomerate lenses, were deposited in the lagoonal and peritidal environments on the platform. Wave ripples and desiccation features associated with these lithologies are further evidence of their shoal-water origin and periodic exposure. Cross-bedded, coated-grain packstones and grainstones accumulated along the platform margin in the zone of maximum wave action. These higher energy deposits pass laterally into deeper-water bioclastic wackestones and laminated mudstones with interbedded shales, which were deposited below normal wave base. The presence of agnostid trilobites, sponge spicules, and small-scale cut-and-fill structures is typical of these dark, thin-bedded basinal limestones. Relatively high depositional slopes marked the transition from platform to basin as indicated by penecontemporaneous slump structures and debris lenses deposited by submarine slides.

The platform-to-basin transition which occurs in the Marjum Formation of the House Range corresponds to the transi-

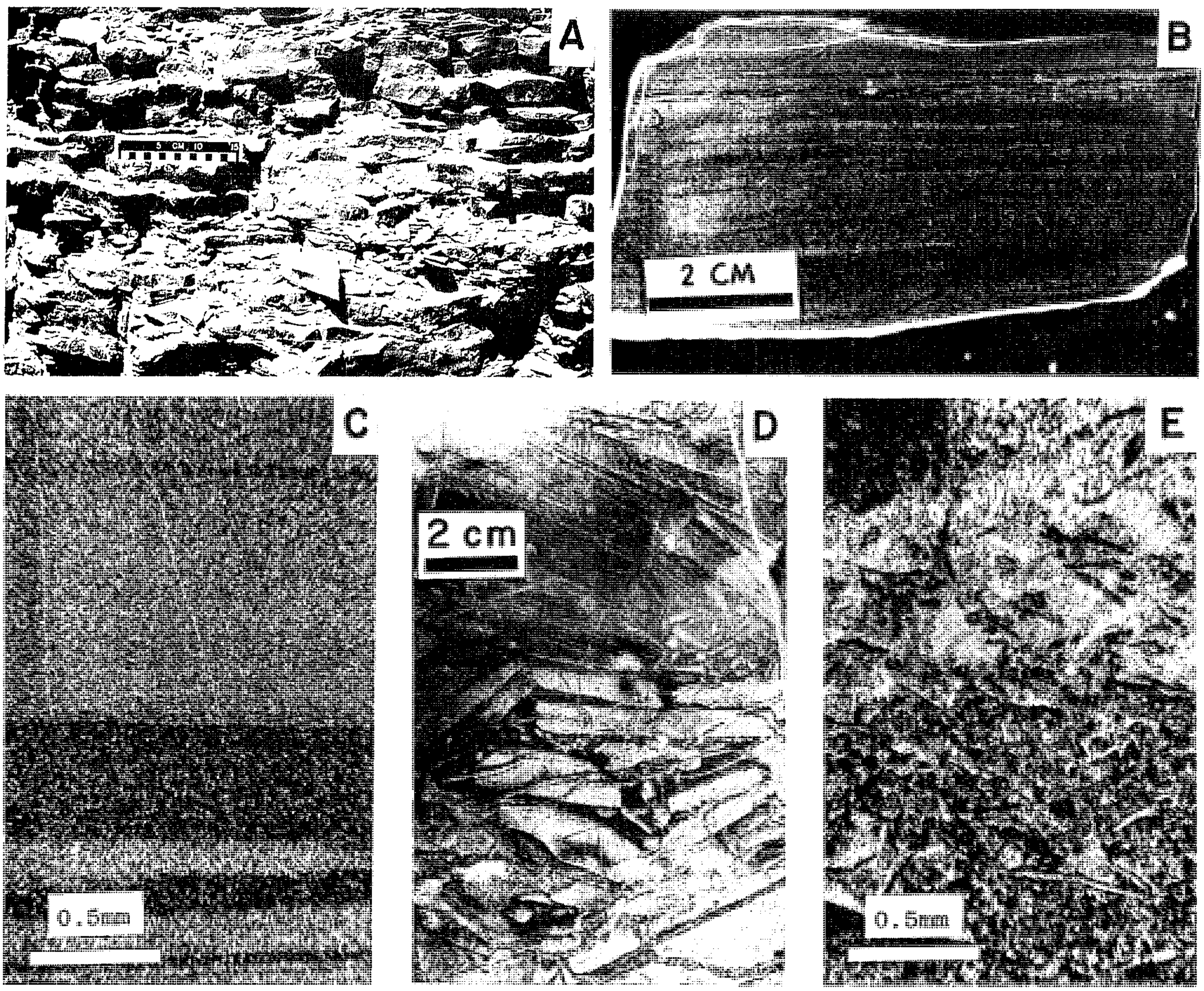

FIGURE 7.—Basinal lithologies: A.—Thin-bedded limestones interbedded with shale. B.—Dark gray, laminated limestone with small-scale cut-and-fill structures. C.—Laminated limestone with low-angel truncations. D.—Debris bed overlain by cross-bedded grainstone. E.—Allodapic grainstone containing echinoderms, trilobites, and pellets.

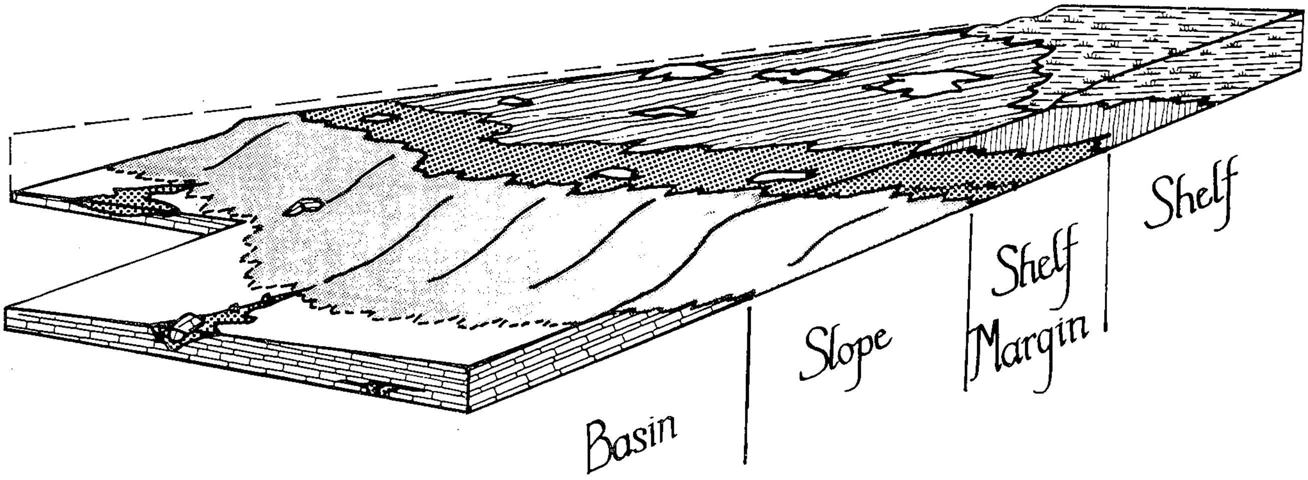

FIGURE 8.–Diagrammatic depositional model for Marjum Formation of the House Range. Not to scale.

tion from the carbonate belt to the outer detrital belt that was recognized by Robison (1964, fig. 2D). In this instance both lithofacies apparently accumulated on a fairly high-relief continental shelf rather than representing a depositional facies change at the continental margin.

ACKNOWLEDGMENTS

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