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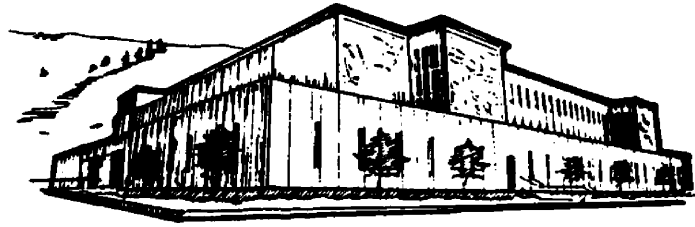
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**DEPOSITIONAL ENVIRONMENTS AND TECTONIC SETTING OF
THE LOWER CAMBRIAN ROSELLA FORMATION,
CASSIAR MOUNTAINS, NORTH-CENTRAL BRITISH COLUMBIA**

by

Michael C. Pope

B.S. University of California, Los Angeles 1985

Presented in partial fulfillment of the requirements

for the degree

Master of Science

University of Montana

1989

Approved by:



Chairman, Board of Examiners



Dean, Graduate School

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Depositional environments and tectonic setting of the Lower Cambrian Rosella Formation in the Cassiar Mountains, north-central British Columbia (99 pp.)

Director: Don Winston



The stratigraphy of Lower Cambrian carbonates of western North America suggest a continuous shallow shelf paralleled the Early Cambrian shoreline from Alaska to Mexico. The western edge of this shelf closely parallels the $Sr_{87}/Sr_{86} = .706$ isopleth, thus delineating the western limit of North American continental crust.

Between southern Idaho and northeastern Washington, the Western Idaho Suture Zone truncates westwardly thickening Late Proterozoic through Early Paleozoic miogeoclinal rocks. Lower Cambrian inner shelf sediments are present in this area, but the corresponding shelf carbonates and off shelf sediments are absent, suggesting the western edge of the continental crust has been displaced. Lund and Snee (1985) postulated that dextral strike-slip displacement occurred on the suture zone between 118-105 m.y.a.

In northern British Columbia and the Yukon Territories, dextral displacement on the Tintina-Northern Rocky Mountain Trench Fault juxtaposes allochthonous Late Proterozoic to Early Paleozoic miogeoclinal sedimentary rocks, in the Cassiar and Pelly Mountains, against similar autochthonous rocks of the Selwyn Basin and Mackenzie Mountains. This stratigraphic study of the Lower Cambrian Rosella Formation, in the Cassiar Mountains, concludes this formation was deposited in a shallow subtidal environment on a westward facing carbonate shelf. This indicates a structural repetition of the Lower Cambrian carbonate shelf, and thus continental crust, in this area.

Southward re-positioning of the allochthonous miogeoclinal fragment to all locations in the Cordillera produces an unexplainable doubling of the Lower Cambrian shelf and continental crust, except for the segment between northeastern Washington and southern Idaho. This suggests allochthonous miogeoclinal rocks of the Cassiar and Pelly Mountains were originally deposited near western Idaho on North American continental crust that was severed, approximately 118 m.y.a, and transported northward 1600-1800 km, along dextral strike-slip faults (such as the Tintina-Northern Rocky Mountain Trench, Western Idaho Suture Zone), to its present position.

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INTRODUCTION

This study was conducted in the McDame map-area (fig. 1) within the Cassiar Mountains of north-central British Columbia. Late Proterozoic through Late Paleozoic miogeoclinal rocks of the Cassiar Mountains and neighboring Pelly Mountains to the north, form the allochthonous "Cassiar Platform" of Tempelman-Kluit (1979). Dextral strike-slip displacement along the Tintina-Northern Rocky Mountain Trench Fault and associated faults is postulated for emplacement of this allochthonous block (Tempelman-Kluit, 1977, 1979). However, the amount of strike slip displacement on these faults is unresolved, with estimates ranging from 450 km (Tempelman-Kluit, 1979) to more than 1000 km (Gabrielse, 1985). Recent paleomagnetic data from the Cassiar Mountains suggest the Cassiar Platform was translated up to 600 km northwards within the last 105 m.y.a. (Butler et al., 1988).

The Cassiar Mountains consist of three distinct bodies of rock (fig. 2): 1) Late Proterozoic through Early Paleozoic miogeoclinal sedimentary rocks (Gabrielse, 1963); 2) tectonically emplaced Late Devonian to Late Jurassic mafic volcanics, volcanoclastic sediments, cherts, and rare ultramafics of the Sylvester Allochthon (Harms, 1985; Gordey et al., 1981; Nelson and Bradford, 1988); 3) Middle Cretaceous plutonic rocks of the Cassiar Batholith (Gabrielse and Reesor, 1974).

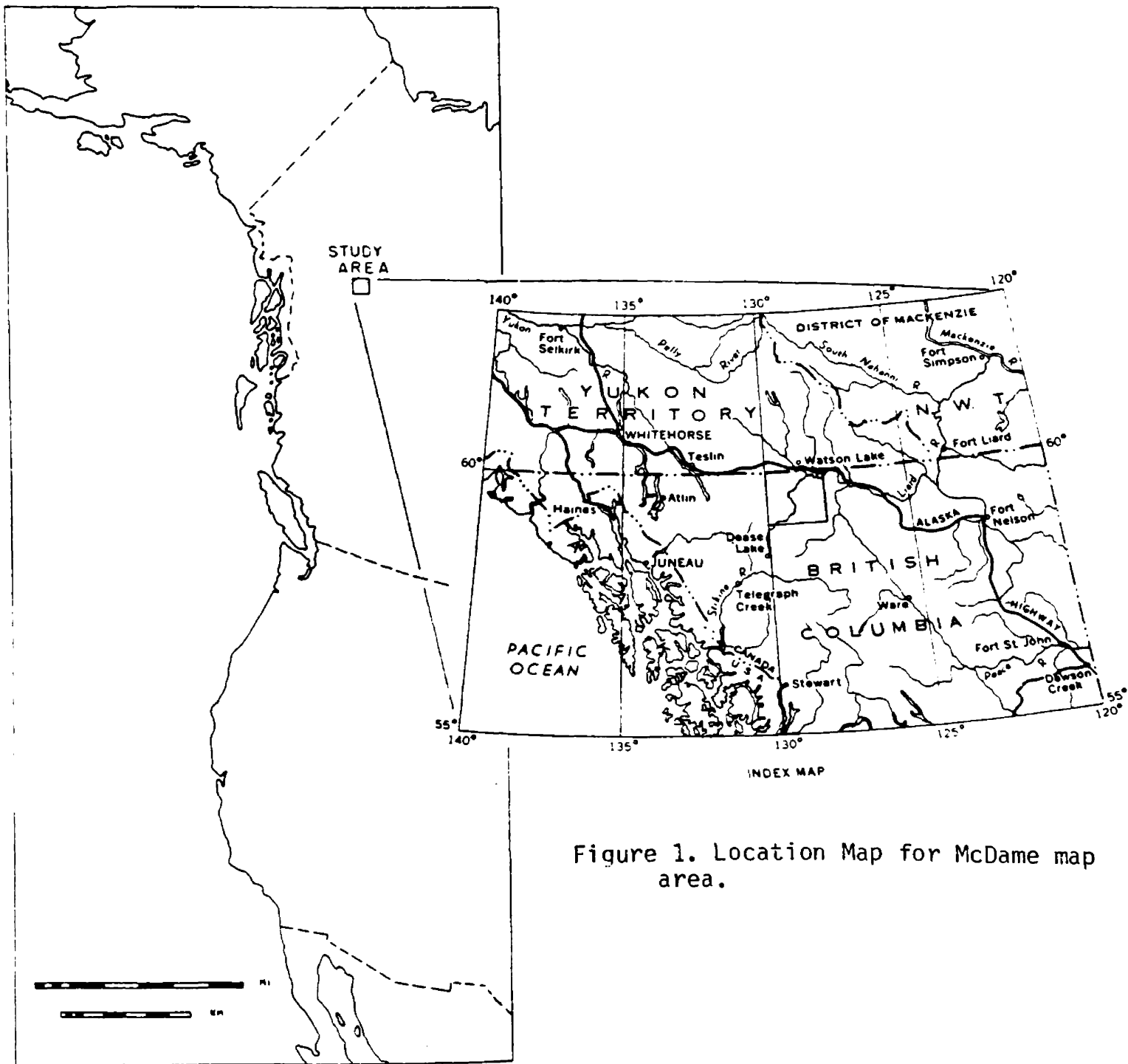


Figure 1. Location Map for McDame map area.

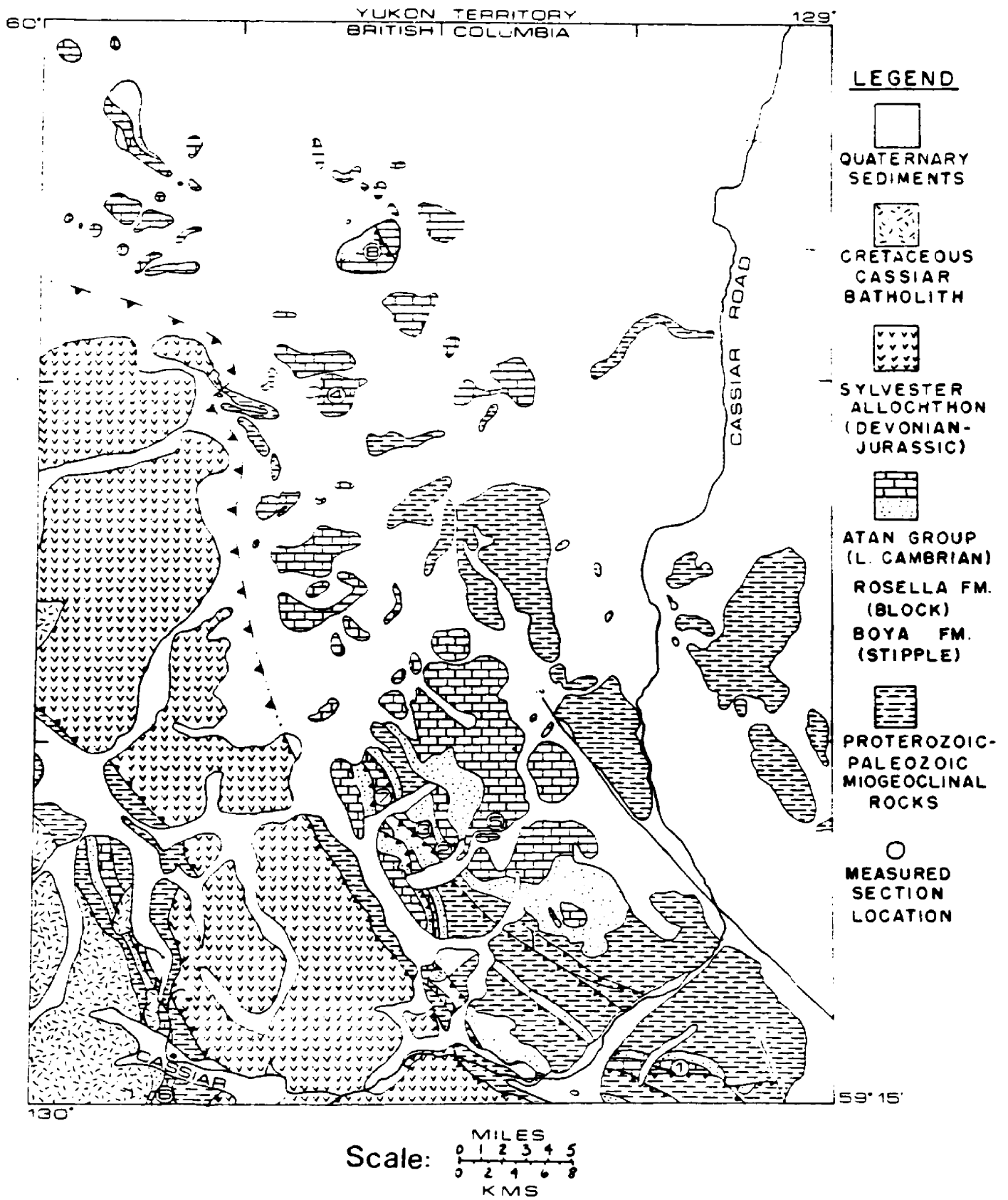


Figure 2. Generalized geologic map of the McDame area (modified from Gabrielse, 1963).

Within the Late Proterozoic to Early Paleozoic miogeoclinal rocks is a Lower Cambrian sequence of archeocyathid-bearing limestone. Lower Cambrian archeocyathid bearing rocks are common along the Cordillera from Alaska to Mexico, except for the section between northern Nevada and northeastern Washington where the entire Late Proterozoic through Early Paleozoic miogeoclinal sedimentary package is absent. In this area the allochthonous Jurassic Wallowa Terrane is juxtaposed against the Idaho Batholith (Hyndman et al., 1988). Sears and Schmitt (1987, pers. comm.) hypothesized that the Cassiar Platform represents the western edge of cratonic North America that was originally deposited in Idaho and was severed from the continent during the Middle Cretaceous, then translated northward to its present position.

OBJECTIVES

This study has three objectives: first, to determine the depositional setting of the Lower Cambrian Rosella Formation defined by Fritz (1980a); second, to compare the depositional setting of the Rosella Formation with those of other Lower Cambrian Formations in the Cordillera to determine the Rosella's original site of deposition; and third to use the Rosella Formation's original site of deposition to constrain the amount and timing of displacement along strike-slip faults on the western edge of the North American craton.

PREVIOUS WORK

Gabrielse (1963) described the regional stratigraphy and mapped the stratigraphic relationships in the Cassiar Mountains. Fritz (1978, 1980a) showed that the Rosella Formation contains the Nevadella and Bonnia-Olenellus trilobite zones of the Lower Cambrian, and archeocyathids of the Rosella Formation also indicate a late Early Cambrian age for the Rosella Formation (Handfield, 1971). Rowland and Gangloff (1988) assign correlative Lower Cambrian limestones of the neighboring Pelly Mountains to the Late Atdabanian-Early Botomian stage of the Lower Cambrian Series.

Paimer (1960) and Robison (1960) proposed that Cambrian marine depositional environments in North America can be grouped into three lithostratigraphic belts that generally paralleled the Cambrian shoreline. They are: the inner detrital belt, middle carbonate belt, and the outer detrital belt (fig. 3). The inner detrital belt represents deposition in a sand and siliciclastic mud dominated environment landward of a carbonate bank, which is represented by the middle carbonate belt. The outer detrital belt represents black shale, silt and clay deposition seaward of the carbonate bank.

Fritz (1975) integrated Lower Cambrian trilobite zones, the model of parallel lithostratigraphic belts (Palmer, 1960; Robison, 1960), and Aitken's (1966) concept of cyclic sedimentation in Cambrian and Ordovician miogeoclinal rocks of the Cordillera, to define three

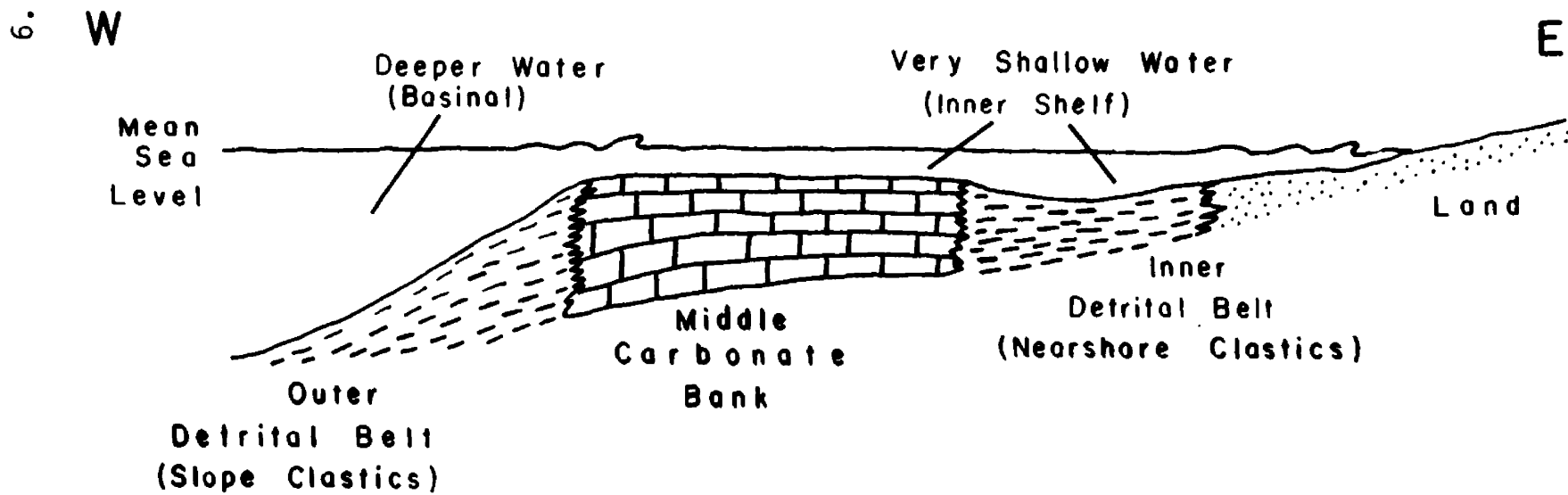


Figure 3. Generalized E-W cross-section of Cambrian depositional environments of western North America. Section has great vertical exaggeration (modified from Sprinkle, 1976).

grand cycles in the Lower Cambrian. Each grand cycle consists of a lower shaly half-cycle overlain by a carbonate half-cycle. Lower Cambrian rocks of the Cassiar Mountains represent deposition during grand cycles A and B of Fritz (1975; text-fig. 4). Grand cycle A formed during the Fallotaspis and Nevadella zones while grand cycle B was deposited during the Bonnia-Olenellus zone. The boundary between these two grand cycles corresponds closely to the base of the upper siltstone member of the Rosella Formation described in this thesis.

METHODS

The Rosella Formation was studied in eight stratigraphic sections measured by Jacob Staff in the McDame map area (see fig. 2). The sections, which range in thickness from 100 m to 380 m and are spread over a 4000 square kilometer area, are presented in Appendix I. The seven sections east of the Sylvester allochthon are located within eastwardly directed thrust sheets. Section 4, located on Cyathid Mountain occurs as an isolated outlier and is placed in the upper carbonate member based on mapping relationships (Nelson and Bradford, 1988). Section 6, just south of the town of Cassiar was contact metamorphosed along the Cassiar Batholith and was only measured to ascertain the relative thickness of the westernmost exposure of the Rosella Formation within the map area. This section is not included in the depositional interpretations.

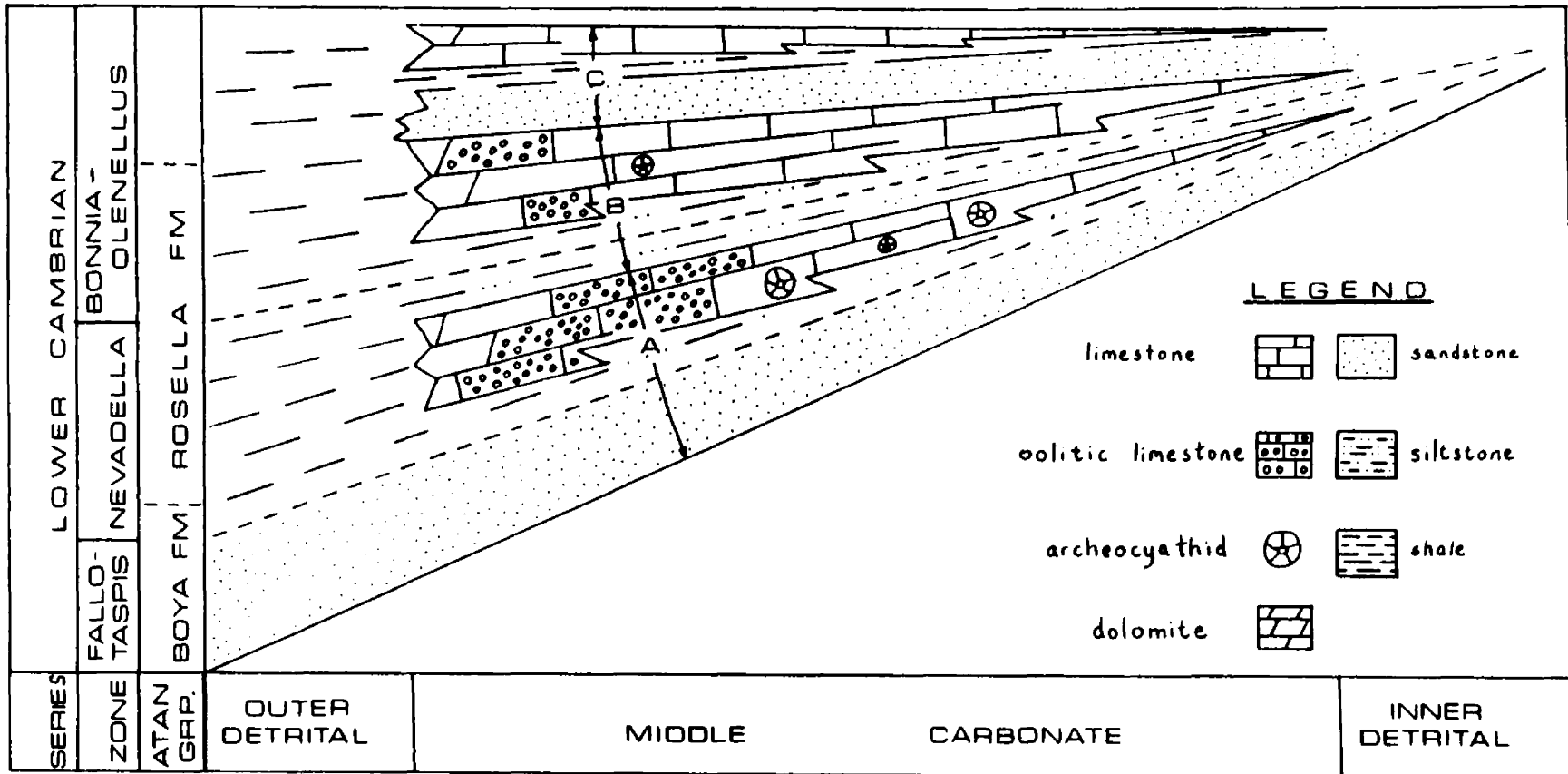


Figure 4. Theoretical model of Lower Cambrian strata in western North America (modified from Fritz, 1975). A, B, and C are grand-cycles.

In addition to hand sample descriptions 180 petrographic thin sections were studied to describe lithologic attributes from which the lithotypes were classified. Results of the petrographic analysis of thin sections are discussed in Appendix II. Also, the faunal constituents of the Rosella Formation were identified to aid in determining the Rosella's depositional environments. Description of the Rosella Formation's faunal constituents and their environmental interpretations are presented in Appendix III.

STRATIGRAPHIC FRAMEWORK

Overview of Lower Cambrian Stratigraphy

The Lower Cambrian Atan Group includes the Boya and overlying Rosella formations, and rests unconformably on the Late Proterozoic Stelkuz Formation (Mansy and Gabrielse, 1977; Fritz, 1978, 1980a). The basal Boya Formation is a coarse-grained sandstone and quartzite unit that grades upward into siltstone with scattered quartzite beds (Gabrielse, 1963; Fritz, 1978). The Rosella Formation is a richly fossiliferous sequence of interlayered limestone, siltstone, and shale, that overlies the Boya Formation. The Rosella Formation is the main focus of this study.

The Rosella Formation has four distinct lithologic members (fig. 5), a lower siltstone, lower carbonate, upper siltstone, and an upper carbonate. The siliciclastic intervals are only 18 to 60 m thick and consist of siltstone and shale, with minor quartzite, sandstone, and

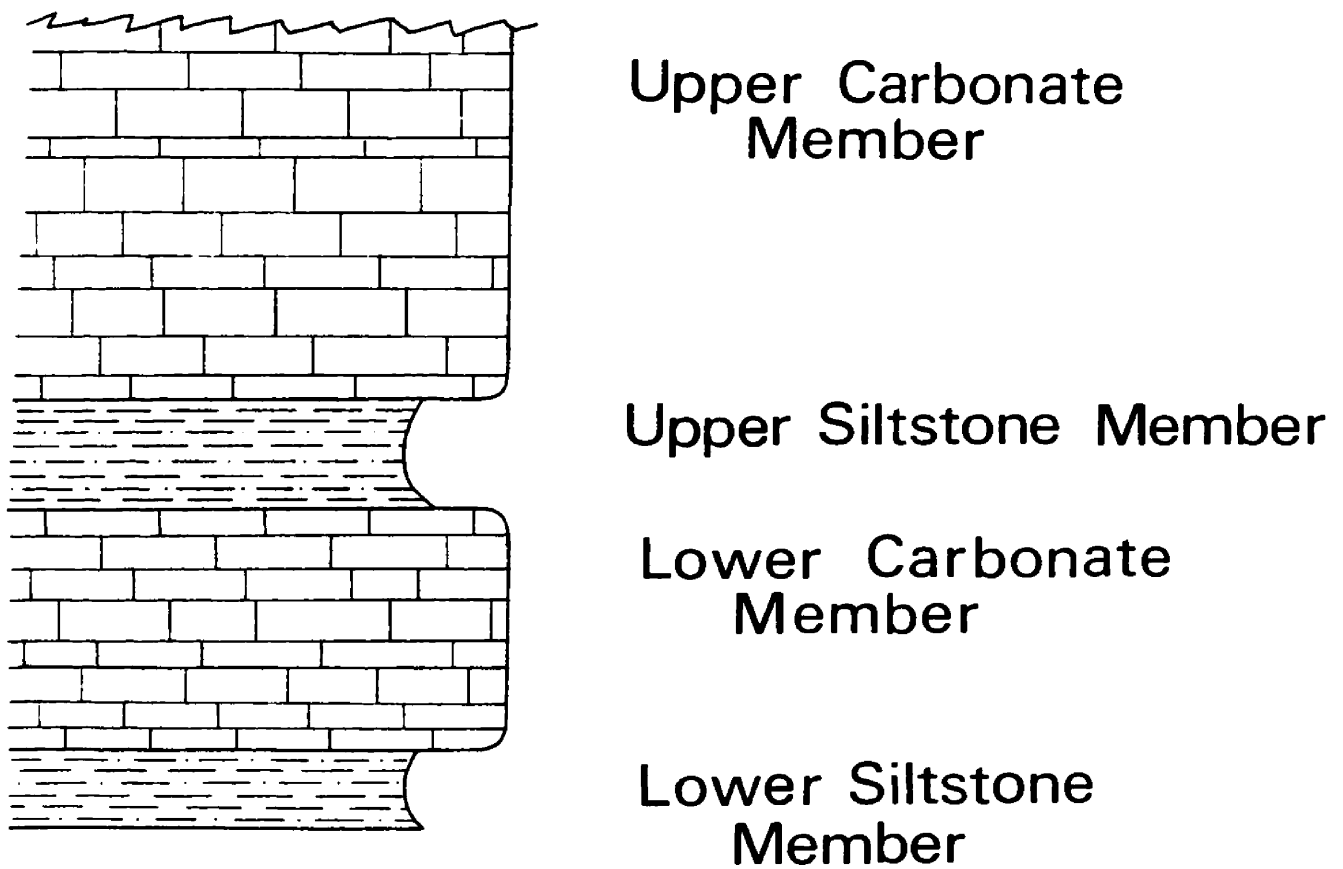


Figure 5. Generalized stratigraphic section of the Rosella Formation in the Cassiar Mountains.

limestone interbeds. The carbonate intervals are thicker, ranging from 50-240 m thick, and consist of thin- and thick-bedded limestone and local dolomite. Sedimentary structures and faunal constituents in the Rosella Formation, presented in the following discussion, indicate that the Rosella Formation was deposited in a shallow subtidal environment.

Lower Siltstone Member

The Rosella Formation conformably overlies the Boya Formation. Thin beds of shale and quartzite near the top of the Boya Formation become interbedded upward with limestone beds of lower Rosella lithology. Fritz (1978) defined the base of the Rosella Formation as the base of the lowest limy bed. The Boya-Rosella contact is usually poorly exposed or covered.

The base of the Rosella is well exposed at section 1 south of Good Hope Lake, where the lowest carbonate interval is a distinctive orange to tan weathering, fine- to very coarse- grained, well rounded, moderately well sorted, carbonate-cemented quartz sandstone (fig. 6). The sandstone forms tabular or elongate wedge shaped, thin to thick, discontinuous beds in siltstone and shale. Coarse quartz sand grains comprise up to 50% of this sandstone, of which 30% are polycrystalline. Mud chips, intraclasts, dolomitized ooids (?), and phosphate fragments covered with silt-sized quartz grains are minor constituents of the sandstone. Echinoderm

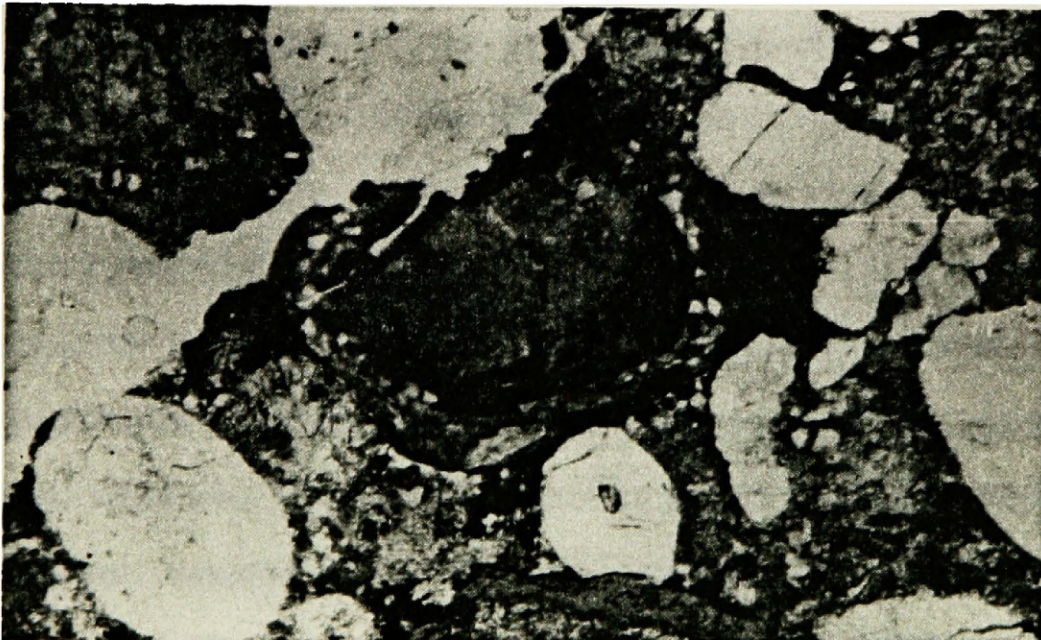
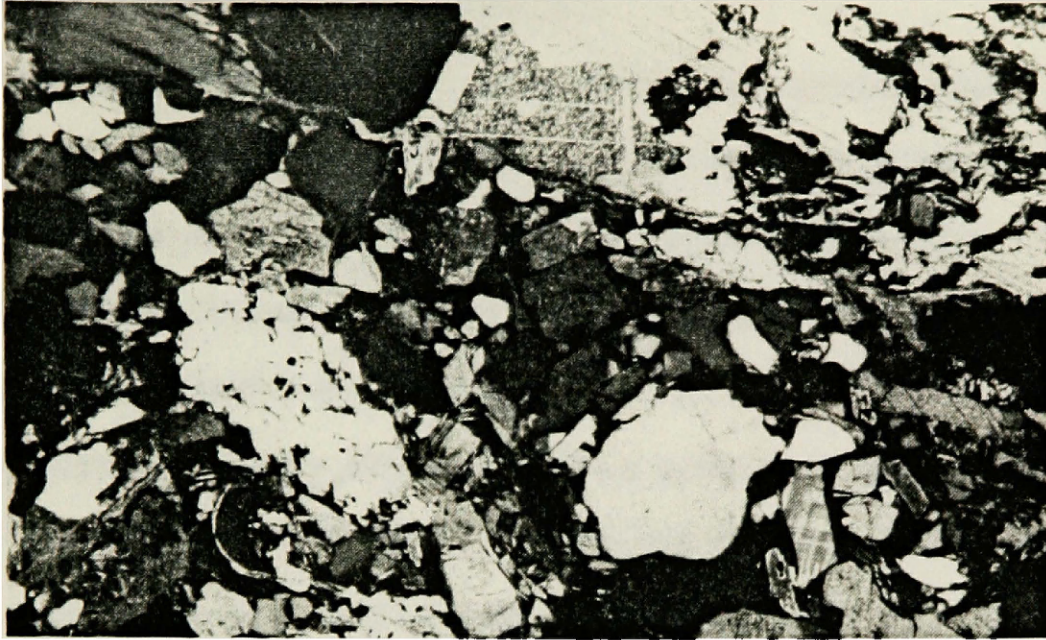


Figure 6. Photomicrographs of carbonate-cemented sandstone at/or near the base of the lower siltstone member.
Top-sample 3-2, field of view is 7 mm, cross nichols
Bottom-sample 1-2, field of view is 7 mm, note large phosphatic grain in center of field.

fragments are common in the sandstone.

This basal sandstone is 1.0 m thick where the section was measured, but east of section 1 the sand thickens to at least 2.3 m. The basal surface of the sandstone at the measured section 1 is conformable above brown siltstone and shale of the Boya Formation, but to the east is locally erosional with up to 15 cm of relief. The eastern exposures display abundant cross beds and contain more rip-up clasts of mudstone and siltstone than the western exposures.

Evidence of local scouring probably led Fritz (1978) to interpret the Boya-Rosella Formation boundary as disconformable. However, in five of the eight sections measured for this study, the basal limestone rests conformably above siltstone and shale. This relationship suggests the Boya-Rosella Formation boundary is locally a diastem.

At One Ace Mountain (section 8), approximately 70 km north of the Good Hope Lake section, a basal sandy lime wackestone marking the base of the Rosella Formation sharply overlies a recessive slope of brown shale, siltstone, and quartzite of the upper Boya Formation. The wackestone contains up to 15% well rounded quartz sand grains. Some of the sand grains possess reworked quartz overgrowths and 30% of the sand grains are polycrystalline. Intraclasts of micritic lime mud, along with archeocyathid and hyolithid fragments comprise up to 60% of the wackestone.

Most of the lower siltstone member (28-40 m) consists of brown to tan siltstone and shale with limy interbeds. The siltstone and shale is mostly flat-laminated, however, the siltstone locally displays ripple cross laminae. Trilobite fragments occur throughout the siltstone and shale.

Limestone in the lower siltstone member varies from silty lime mudstone to bioclastic wackestone. The silty lime mudstone is flat-laminated and forms thin interbeds in shale or siltstone. Some of the interbeds resemble "pinch" and "swell" structures (fig. 7). Small scale ripple cross beds are locally developed in some of the lime mudstone interbeds. The cross beds vary from gently dipping planar sets to complex sets of convex cross laminae.

The bioclastic wackestone beds commonly contain trilobite, hyolithid, and archeocyathid fragments randomly oriented in lime mudstone. Archeocyathid bioherms up to 3 m wide and 2 m high form rare resistant lenses in the lower silty member (fig. 8). The bioherms pass laterally into flat laminated siltstone, shale, and limestone. The amount of carbonate in the lower siltstone member gradually increases upward until it grades into the lower carbonate member.

Lower Carbonate Member

The lower carbonate member is 50 to 150 meters of medium- to thick-bedded limestone. It consists predominately of oolitic and intraclastic grainstone beds in the western exposures. Bioclastic



Figure 7. Photograph of "pinch" and "swell" features in the lower siltstone member.



Figure 3. Archeocyathid bioherm in the lower siltstone member at section 1.

wackestone, pelletal wackestone, and archeocyathid bioherms are common in the central sections of the lower carbonate member. In the east the lower carbonate member contains lime mudstone. The base of the lower carbonate member is placed at the base of the lowest resistant carbonate interval.

Ooid Grainstone.-Oolitic grainstone is the most common lithotype in the lower carbonate member (fig. 9). The grainstone is well sorted, fine- to medium-grained, and medium- to thick-bedded. The oololiths range in size from 0.5 mm to 1.5 mm. The nuclei of the oololiths are commonly micron-sized lime mud, however, few oololiths contain fossil fragments in their nuclei. Filamentous algal fragments are locally present in the oolitic grainstone (fig. 10). Oolitic grainstone is abundant in western sections, but is limited to the upper third of eastern sections (#1 & #8). Western exposures of the oolitic grainstone commonly display medium scale trough, and low angle planar, cross beds (fig. 11).

Intraclastic Grainstone.-Intraclastic grainstone is the next most common lithotype in the lower carbonate member (fig. 12). The intraclastic grainstone is thin- to thick-bedded and is commonly interbedded with the oolitic grainstone. Most intraclasts, range in size from .5 mm to 2 cm in diameter, and are irregularly shaped, though the smaller ones are rounder. The intraclasts are composed of micron-size lime mud or microspar and commonly contain trilobite,

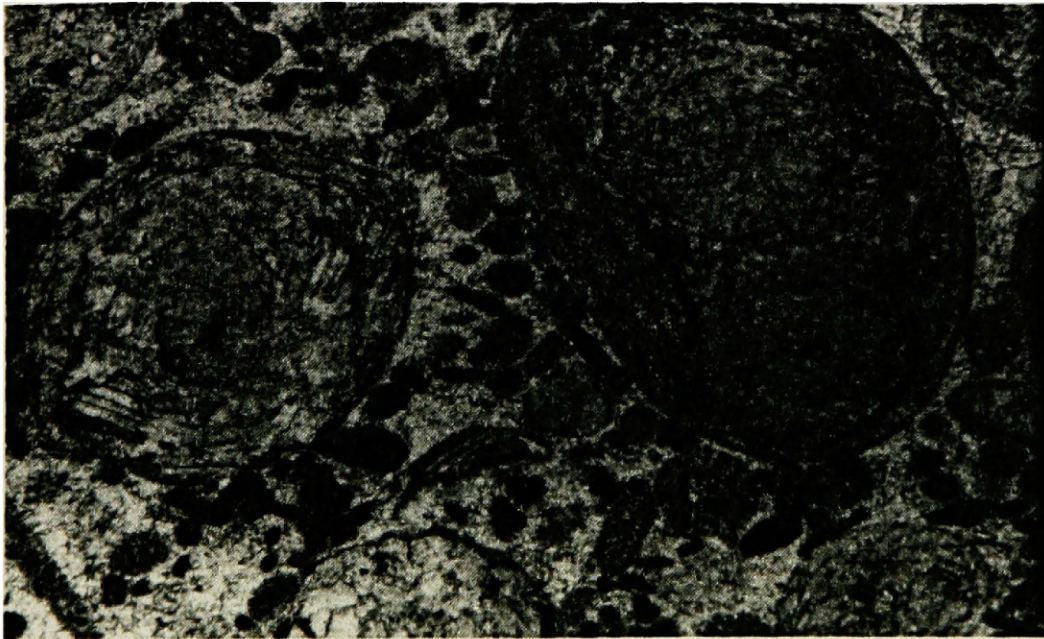
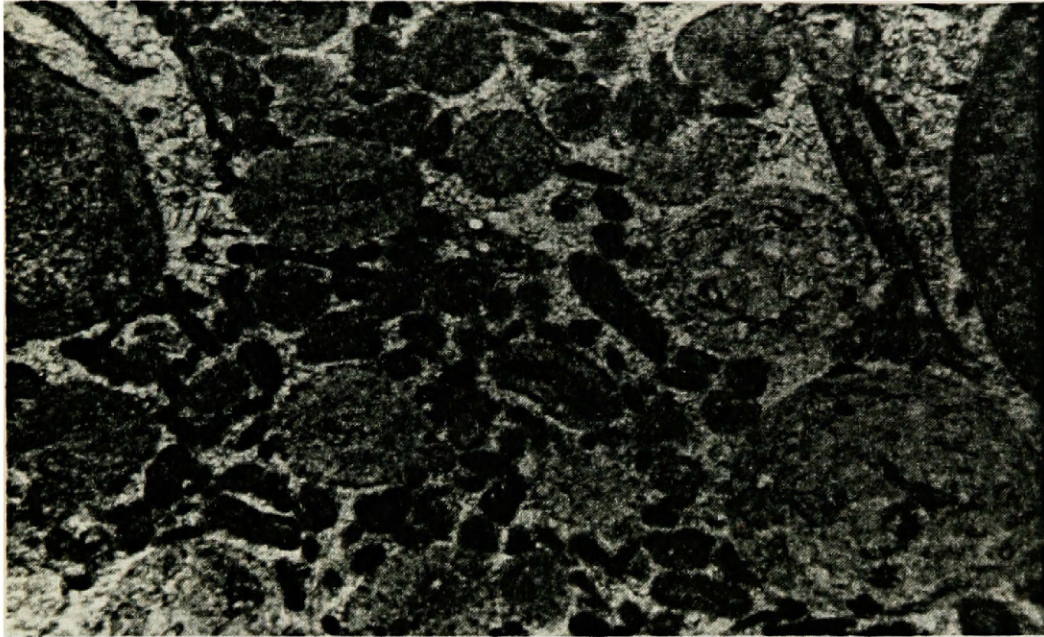


Figure 9. Photomicrographs of oolitic grainstone in the lower carbonate member. Both photos are of sample 5-2 and the field of view in both is 7 mm. Small elongate dark particles are interpreted to be filamentous algae.

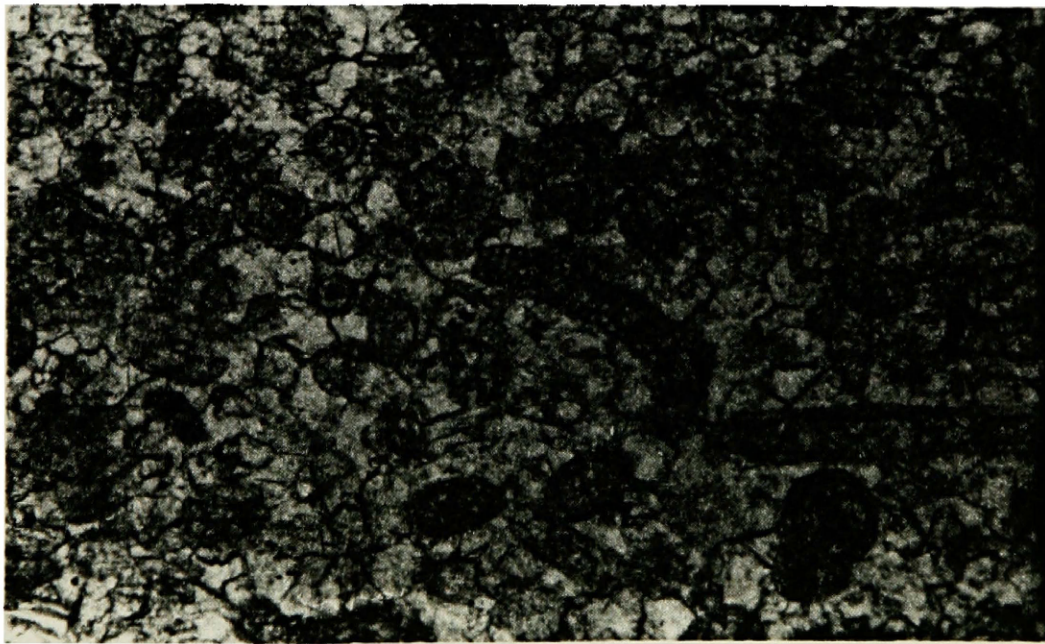
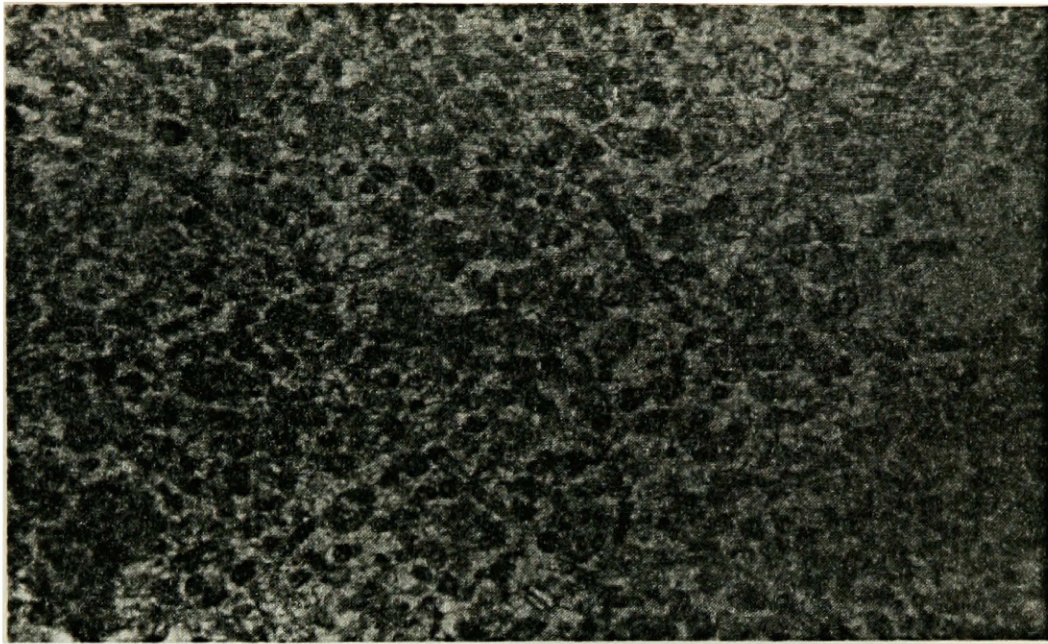


Figure 10. Photomicrographs of filamentous algae in oolitic grainstone, sample 2-11.
Top photo the field of view is 7 mm
Bottom photo the field of view is 2 mm



Figure 11. Photograph of cross bedding in the oolitic grainstone of the lower carbonate member.

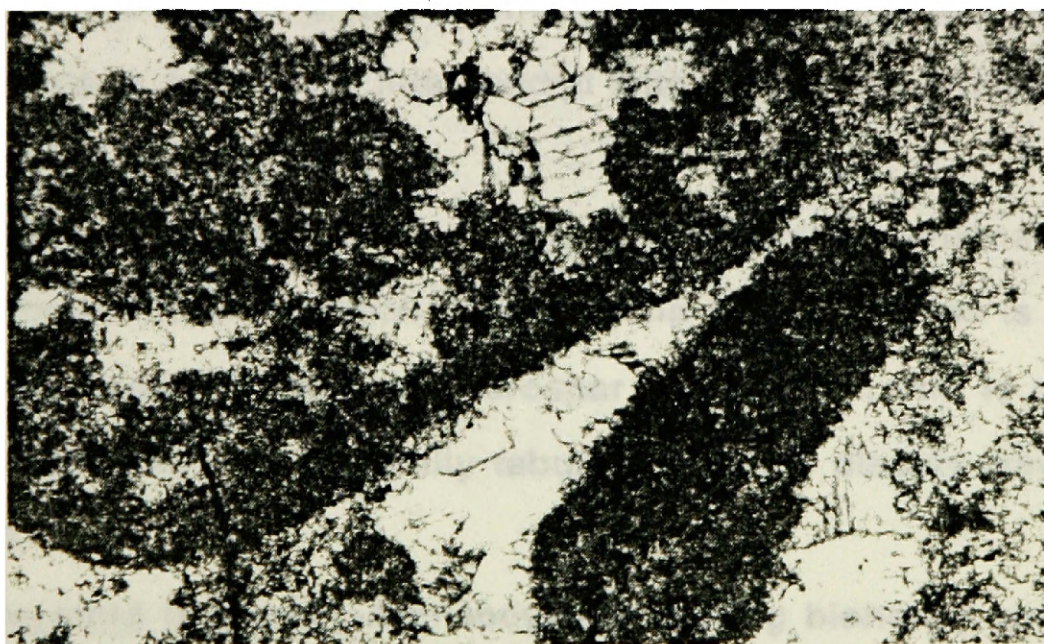


Figure 12. Intraclastic grainstone of the lower carbonate member.

12a. (top)- Outcrop photograph of intraclastic grainstone. Intraclasts are small dark spots near the hammer handle.

12b. (bottom)- Photomicrograph of sample 2-2, field of view is 7mm. Intraclasts are dark ovoid particles.

archeocyathid, or hyolithid fragments in their cores (fig. 13). Echinoderm plates and fragments are locally abundant in the intraclastic grainstone.

Intraclastic grainstone is very common in the western sections and is rare in the eastern sections. Western exposures of the intraclastic grainstone occasionally display reverse and normal grading within individual beds (fig. 14).

Bioclastic and Pelletal Wackestone.-Thin to medium beds of bioclastic or pelletal wackestone are present in all sections of the lower carbonate member. Bioclasts include archeocyathid, hyolithid, trilobite, and echinoid fragments. The pellets range in size from .2 mm to 1 mm and are composed of globules of micron sized lime mud. The wackestone is commonly interbedded with oolitic and intraclastic grainstone.

Lime Mudstone.-Lime mudstone is rare in the lower carbonate member and is limited to the eastern sections. The lime mudstone is comprised of micron sized lime mud or microspar contained in thin to medium beds. These beds are generally tabular but some display wavy bedding (fig. 15).

Archeocyathid Bioherms.-Archeocyathid-bearing bioherms range in height from 1-5 m and in width and from 5 m to more than 20 m. The bioherms are represented by massive thick-bedded accumulations of light grey micrite or microspar. Archeocyathids are the most common

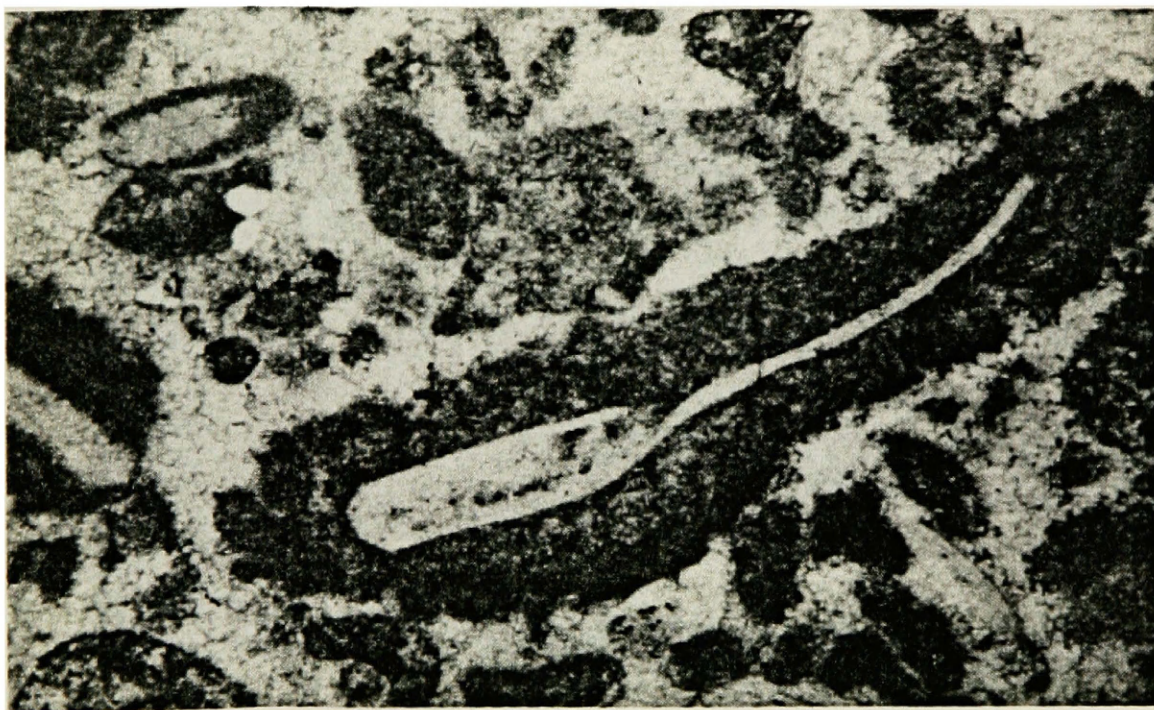


Figure 13. Photomicrograph of an intraclast containing a trilobite fragment. Sample 4-13, field of view is 7 mm.

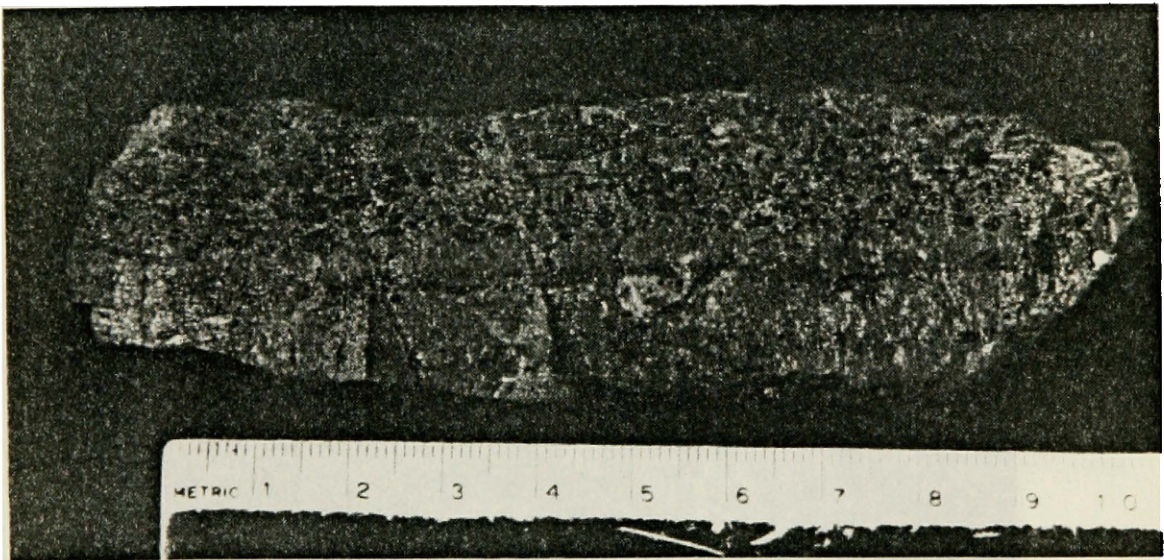


Figure 14. Photograph of a hand sample of intraclastic grainstone displaying graded bedding (sample 2-4).

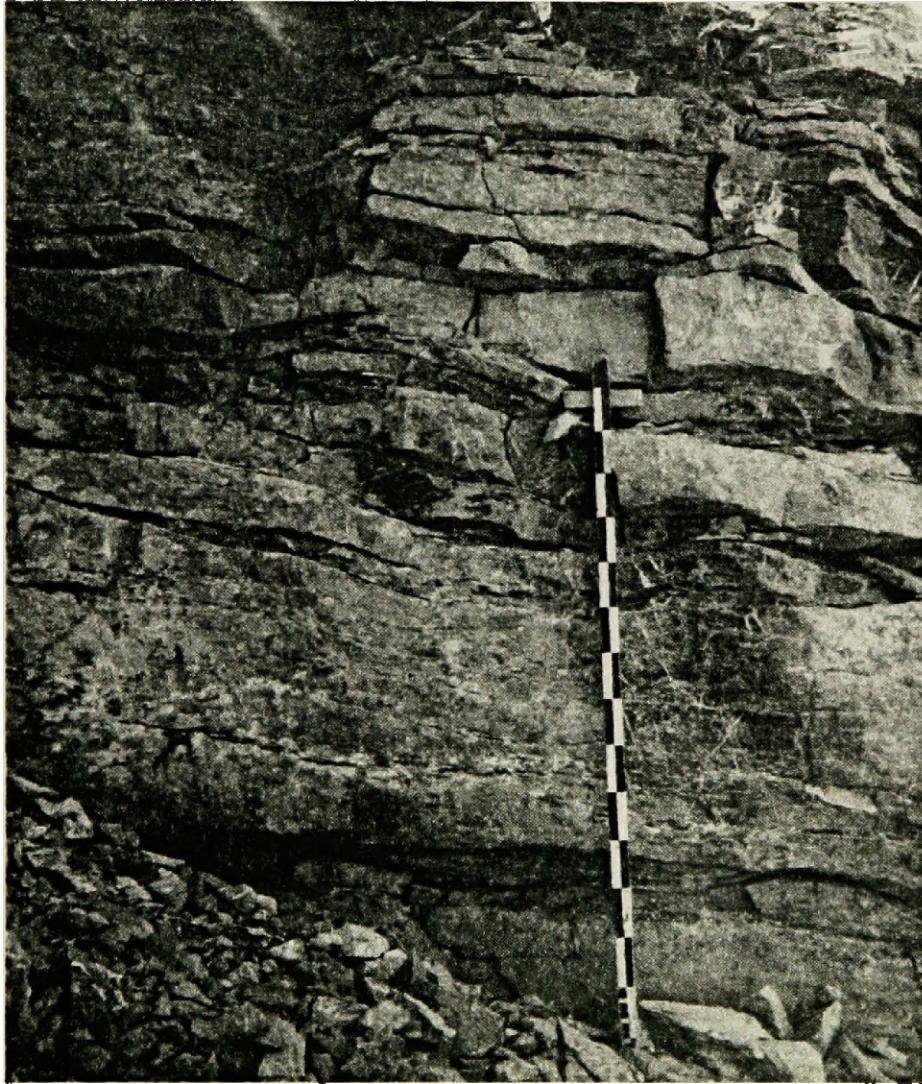


Figure 15. Photograph of wavy bedded lime mudstone in lower carbonate member.

organism in the bioherms, and are usually radially oriented toward the external surfaces of the bioherm. Trilobite, Articulate brachiopod, echinoderm, and hyolithid fragments are common in the bioherms. Algal fragments of Renalcis and Epiphyton are locally abundant.

Archeocyathid bioherms are concentrated in the central section (#5, Rosella Creek) of the study area, where they interfinger laterally with oolitic and intraclastic grainstone. A bioherm between 141 m and 156 m in the Rosella Creek section is capped by an oolitic grainstone bed that lies on an irregular upper bounding surface. Archeocyathid bioherms are rare in the eastern sections.

Upper Siltstone Member

The upper siltstone member ranges from 25 to 60 m thick and separates the lower and upper carbonate members. The upper siltstone consists of brown to tan siltstone and shale, with quartzite and carbonate interbeds.

Flat laminated brown siltstone and fissile brown shale are the dominant lithologies in the upper siltstone member. The siltstone is locally planar to ripple cross laminated. Siltstone and shale are locally cleaved at low angles to the bedding. The horizontal trace fossil Planolites is locally abundant in the shale and siltstone (fig. 16).

The shale contains abundant trilobite fragments; whole specimens are rare. A carapace of Olenellus was identified by the author, near

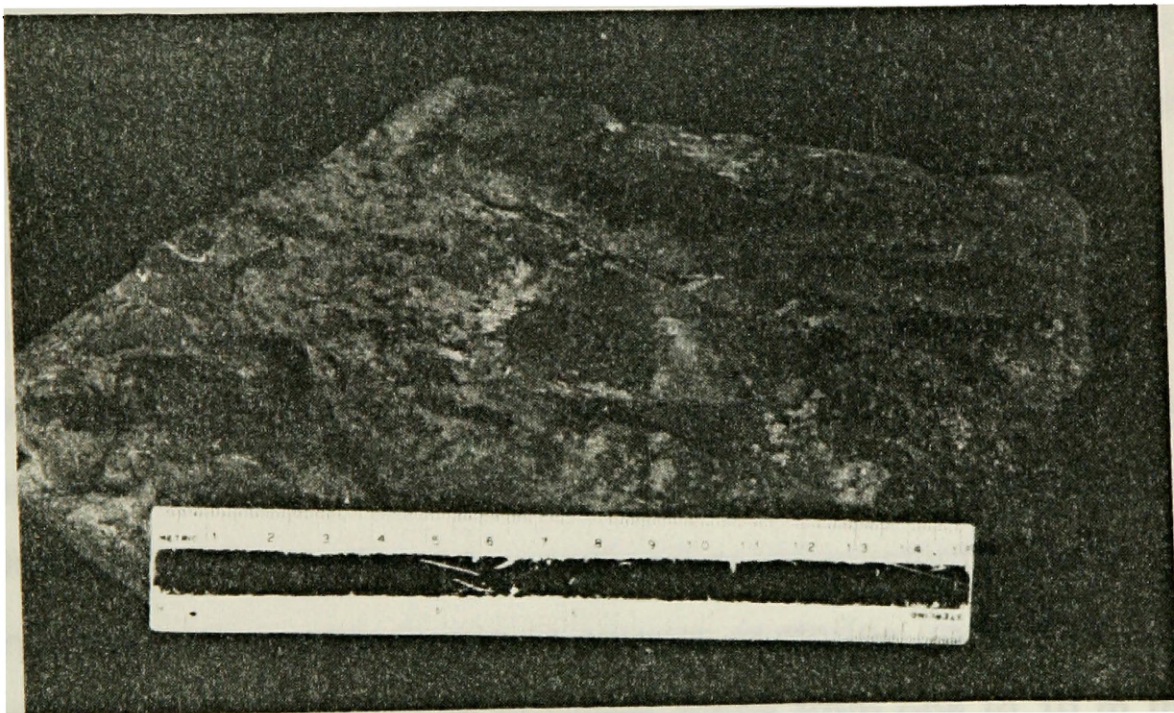


Figure 16. Trace fossil Planolites in the upper siltstone member at section 1.

the base of the upper siltstone member, placing the upper siltstone in the Bonnia-Olenellus zone (Fritz, 1978; 1980a).

The coarser grained siliciclastic rocks within the upper siltstone consist of tightly cemented quartz sandstone with more than 90% quartz grains and friable sandstone with 15-20% feldspar and 5-10% opaque minerals. The tightly cemented sandstone is fine- to coarse-grained, well rounded, and moderately to well sorted. The friable sandstone is fine- to coarse-grained, subrounded to subangular, and poorly to moderately sorted. These sandy beds form thin lenses less than one meter thick and up to 30 m wide. Low angle cross stratification is common in both rock types.

Limestone beds in the upper siltstone member are thin- to medium-bedded bioclastic packstone and oolitic grainstone. Beds of bioclastic packstone are very fossiliferous containing fragments of trilobites, hyolithids(?) and occasional archeocyathids. These randomly oriented bioclastic fragments comprise up to 70% of individual beds. Packstone intervals range from one to 10 m thick.

Sections 2 and 8 contain gray oolitic grainstone beds in the upper siltstone member. The grainstone is thin-bedded, fine- to coarse-grained, and moderately to well sorted. The cumulative thickness of oolitic grainstone ranges from one to 7 m.

A distinctive orange to tan dolomite bed, 9.2 m thick at section 1, contains randomly oriented gray archeocyathids suspended in the

dolomite matrix (fig. 17).

Upper Carbonate Member

The upper carbonate member consists of 100 to 240 m of gray limestone and buff to tan dolomite. Gray thick bedded intraclastic and pelletal wackestone dominates in this unit. Oolitic, intraclastic, pisolitic, and oncolitic grainstone beds are also present.

Archeocyathid bioherms are rare in the upper carbonate. Coarse, crystalline tan dolomite is locally common and displays no primary bedding features. The top of the Rosella Formation is cut out by thrusts or not exposed.

Pelletal Wackestone.-Light gray, thick-bedded pelletal wackestone of the upper carbonate member forms resistant blocky outcrops in the field (fig. 18). The pellets, composed of micron-sized lime mud are less than one mm in diameter and comprise up to 50% of examined samples. Matrix surrounding the pellets is predominantly lighter colored micrite or microspar. Echinoderm, archeocyathid, and trilobite fragments are common in the wackestone.

Ooid Grainstone.-The oolitic grainstone of the upper carbonate member is thin- to thick-bedded, fine- to coarse-grained, and moderately to well sorted. The ooliths range in size from .5 to 2.5 mm and are supported in a sparry calcite matrix (fig. 19). Although cross beds are common in western exposures of oolitic grainstone in the lower carbonate member, they are absent in the oolitic

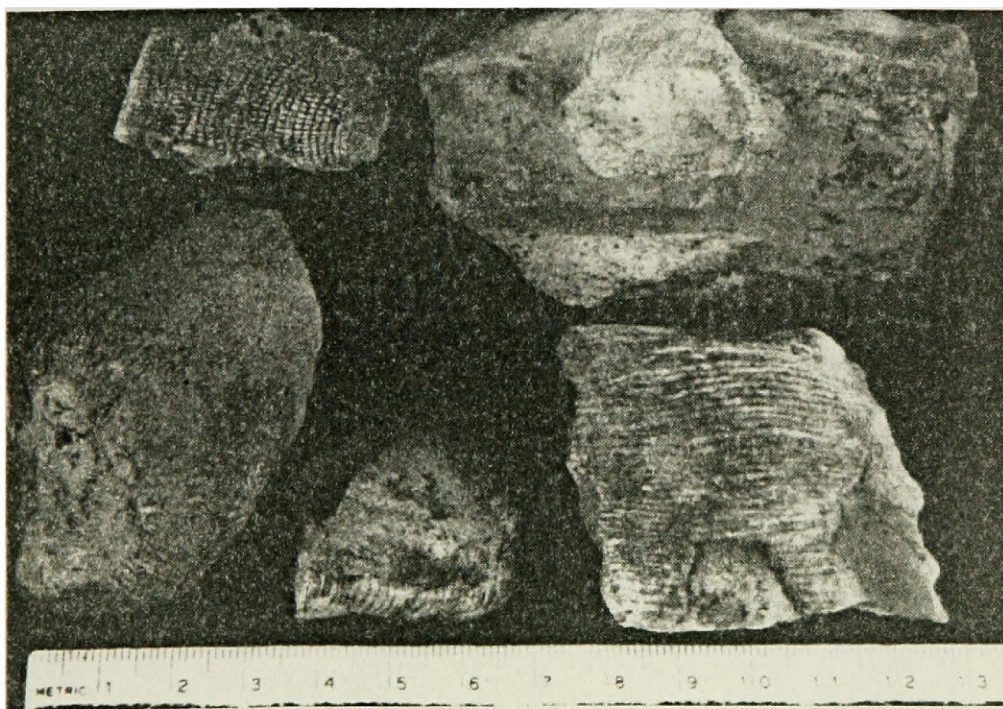
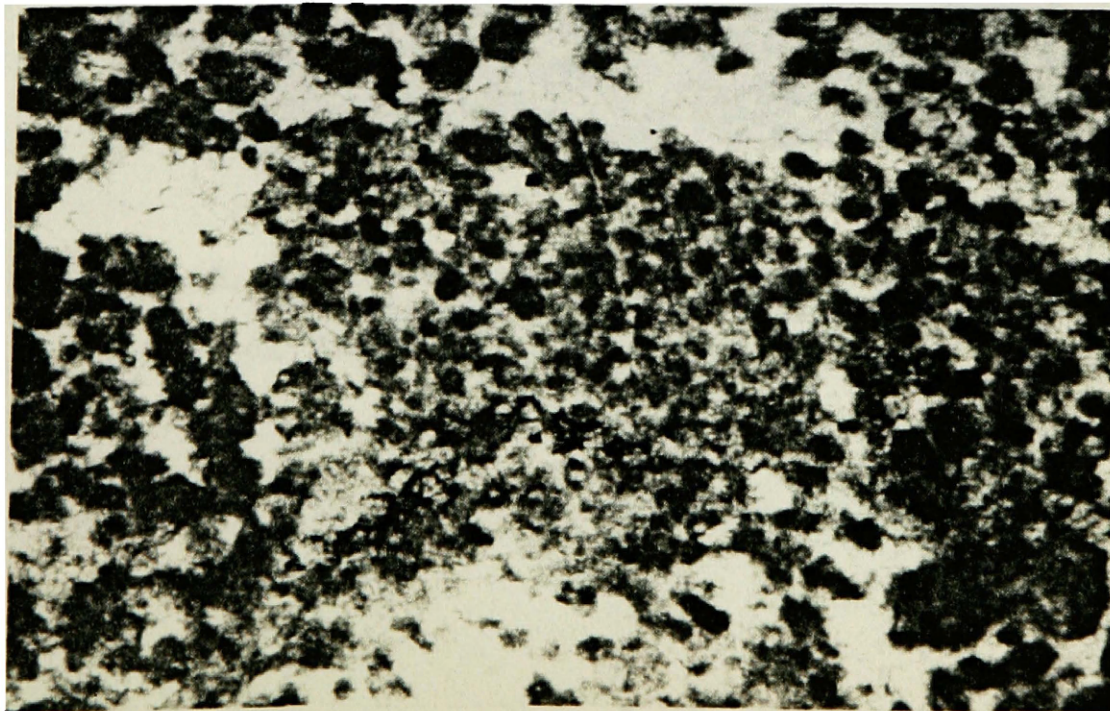
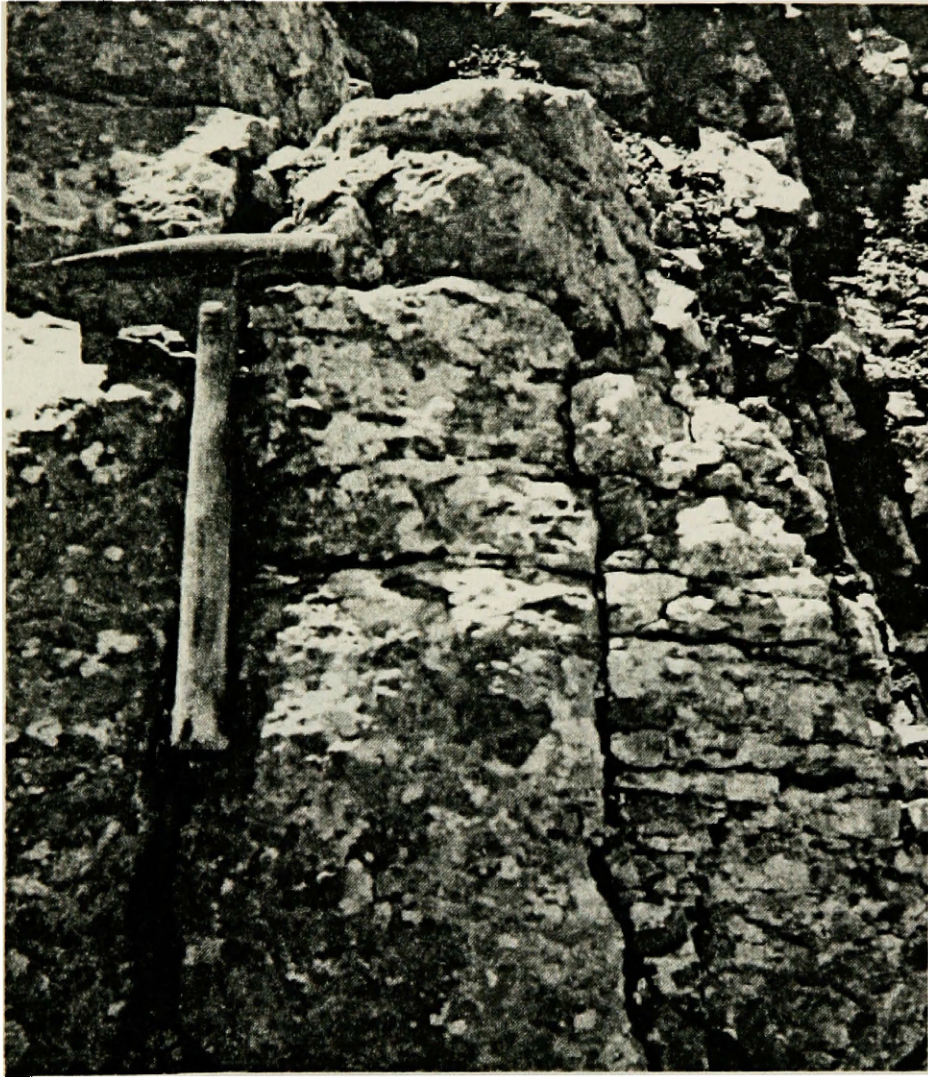


Figure 17. Large colonial Regulare archeocyathids from an orange dolomitic bed in the upper siltstone member at section 1.

Figure 18 (following page). Pelletal wackestone of the upper carbonate member.

Top- photograph of thick-bedded blocky nature of pelletal wackestone in section 1 (sample 1-11).

Bottom- photomicrograph of pelletal wackestone (sample 1-11) field of view is 7 mm.



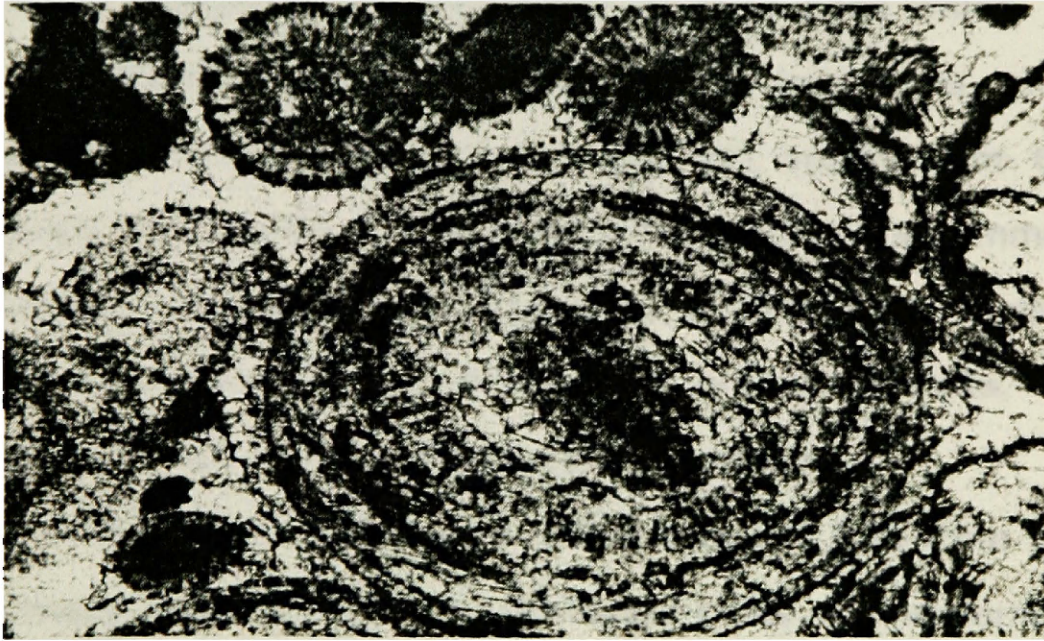


Figure 19. Photomicrograph of oolitic grainstone in the upper carbonate member (sample 4-10). The field of view is 7 mm.

grainstone of the upper carbonate member. Instead, the oolitic grainstone is massive or flat-laminated. Ooid grainstone beds occur at the base of the upper carbonate member in each of the measured sections, but above this, correlation between sections is obscure. Echinoderm, trilobite, archeocyathid, and algal fragments are common in the grainstone.

Intraclastic-Pisolitic-Oncolitic Grainstone.-Intraclastic, pisolitic, and oncolitic grainstone beds are common in the upper carbonate member. These grainstone units form thin to thick beds which commonly interfinger with oolitic grainstone. The intraclasts, which are composed of micron sized lime mud (fig. 20), are medium- to coarse-grained, and poorly to well sorted. The intraclasts commonly contain bioclastic fragments, and rare ooids, in their nuclei. Trilobite fragments are the most common bioclasts in grainstone beds, followed by brachiopod and archeocyathid fragments.

Pisoliths in the upper carbonate member range in size from .5 to 2 cm, and many display irregularly laminated coats of undetermined origin (fig. 21). The nuclei of the pisolites are composed of lime mudstone; and occasionally contain bioclastic fragments. Oncoliths range in size from .5 to 3 cm in diameter and display irregularly spaced algal laminations (fig. 22). The oncolites commonly contain intraclasts, oolites, and bioclastic fragments in their nuclei.

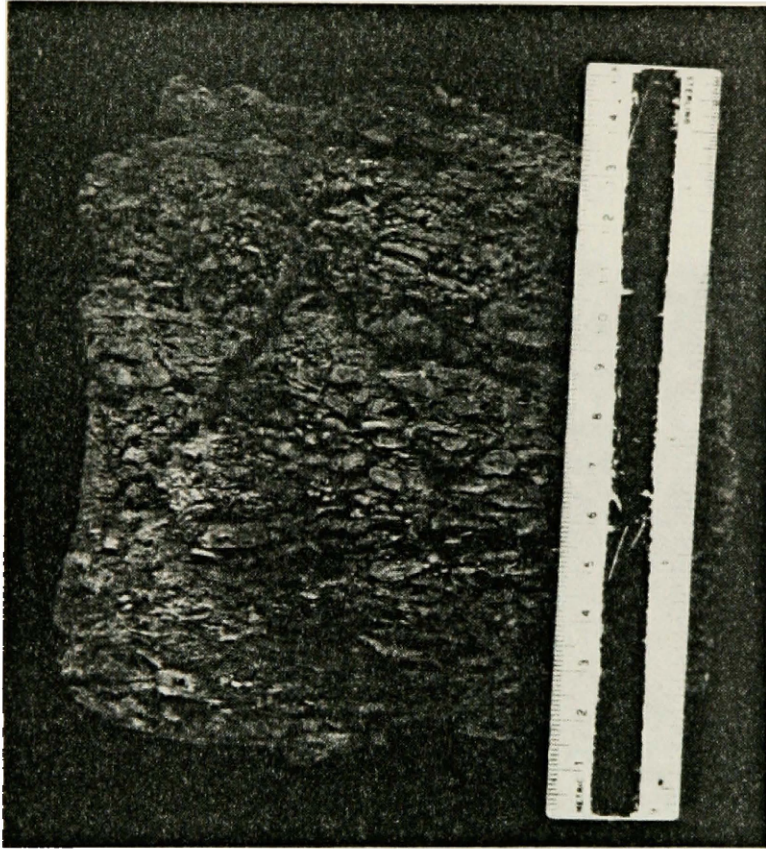


Figure 20. Hand specimen of intraclastic grainstone in the upper carbonate member (sample 01-7).

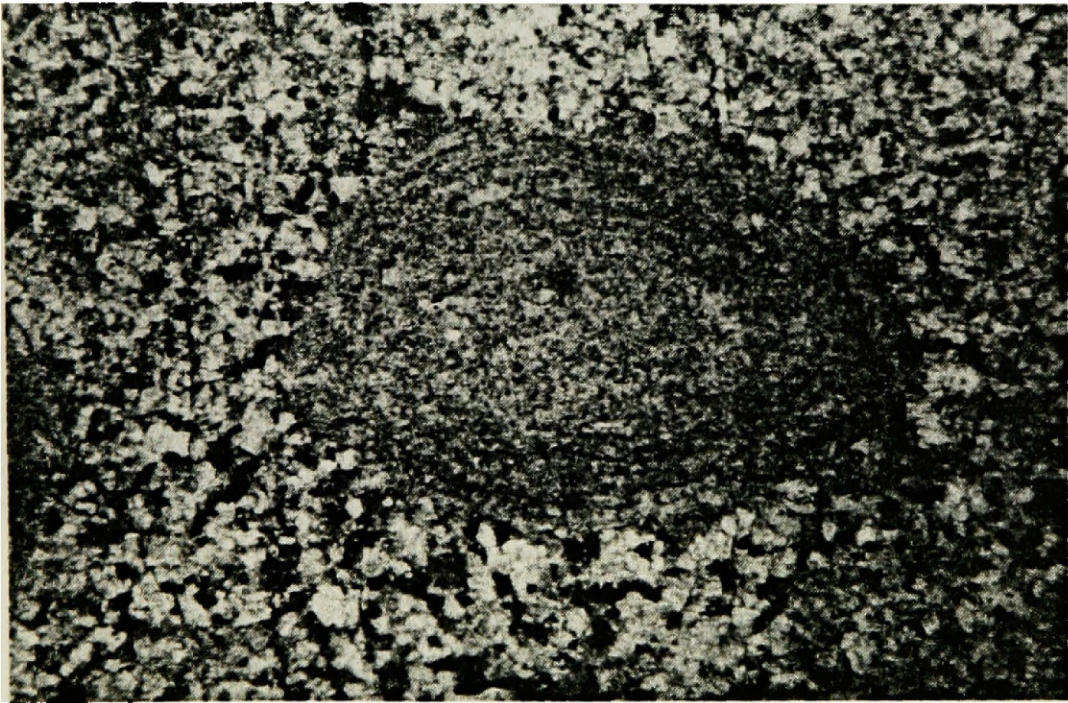


Figure 21. Photomicrograph of pisolith in grainstone of the upper carbonate member (sample 1-8). Field of view is 7 mm.

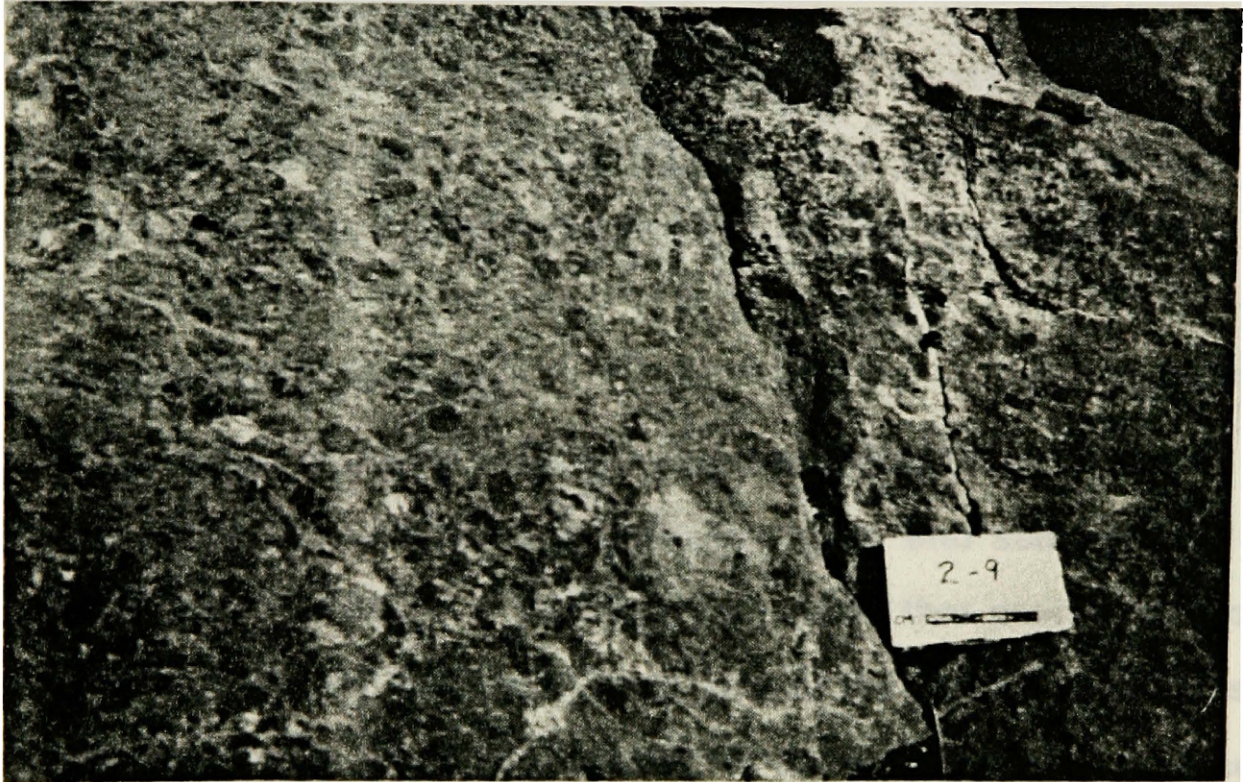


Figure 22. Outcrop photograph of oncolitic grainstone near the top of the upper carbonate member at section 2 (sample 2-9). The scale bar on photo identification tag is in centimeters.

Lime Mudstone.-Lime mudstone is rare in the upper carbonate member. The gray lime mudstone is thin to medium bedded, and locally contains 5-8% bioclastic fragments.

Brachiopod Packstone.-Located near the top of Section 4 are three distinctive beds of brachiopod packstone, ranging in thickness from one to 2 m. The packstone contains up to 50% randomly oriented articulate brachiopod shells and rare trilobite fragments. Most of the shells are disarticulated, but many whole specimens are preserved intact.

DEPOSITIONAL ENVIRONMENTS

By identifying the separate lithofacies and analyzing their internal constituents, including texture, faunal assemblages, and sedimentary structures, one can deduce a hydrodynamic regime that produced each lithofacies in the Rosella Formation. The vertical and lateral lithofacies relationships reveal the lateral distribution of these processes and one can compare these processes with modern depositional systems to determine the depositional environment which produced the lithofacies.

Archeocyathid, trilobite, hyolithid, echinoderm, algae, and articulate brachiopod fossils from the Rosella Formation demonstrate this unit was deposited in a marine environment (Rowland and Gangloff, 1988). Algal fragments and a proposed symbiotic relationship between archeocyathids and zooxanthellae (Rowland and Savarese, in press) confine the carbonate depositional environment to the photic zone.

Morgan (1976) postulated that archeocyathid bioherms were restricted to subtidal environments

Lower Siltstone Member

Flat-laminated siltstone and shale in the lower siltstone member indicates deposition of suspended load sediment in quiet water usually unaffected by current or tidal interaction, and probably below fairweather wave base. Ripple cross laminated siltstone records intermittent currents that carried fine sand and silt in traction transport across the sediment water interface.

Flat-laminated, silty lime mudstone interbeds within the siltstone and shale represent interfingering of the siliciclastic and carbonate depositional systems in an environment little affected by tidal currents. "Pinch" and "swell" features in these mixed siliciclastic-carbonate depositional systems represent dissolution of carbonate beds (Bathurst, 1975). Small archeocyathid bioherms developed in the flat-laminated carbonate and siliciclastic environment suggest that some archeocyathids lived in fairly quiet waters.

Small lenticular-shaped sandstone beds represent the localized influx of coarse-grained sand. The coarse grained polycrystalline carbonate cemented sandstone thins to the west, indicating the sand was derived from an eastern source with a metamorphic source component. The round grains indicate extended transport. The sandstone is interpreted to represent low relief channels which

discharged into a quiet water marine environment; possibly in a deltaic setting.

Bioclastic wackestone represents the periodic dispersal of organic remains into a quiet water depositional environment. I interpret the bioclastic wackestone to represent storm or unusually high currents that transported the fragments into this usually calm environment from a carbonate bank environment to the west.

The faunal constituents, lithologies, and bedding characteristics of the lower siltstone member indicate it was deposited in a shallow subtidal "lagoon" landward of a carbonate bank (Wilson, 1975; Reading, 1983).

Lower Carbonate Member

Gradually a complex carbonate environment, represented by the lower carbonate member, transgressed over the lagoon. Sedimentary structures in the lower carbonate member indicate it was deposited in a shallow subtidal environment.

Oolitic grainstone in the lower carbonate member indicates deposition in an environment almost continually agitated by currents strong enough to transport medium-sized grains. Cross-bedded oolitic grainstone indicates that some of the currents were probably bi-directional and may have produced large scale bedforms. The abundance of oolitic grainstone in western exposures suggests an oolitic shoal complex formed toward the exposed seaward edge of the

carbonate environment. The shoals probably dampened wave and current agitation. I interpret oolitic grainstone to represent deposition on a mobile oolitic shoal similar to the mobile fringe of Joulters Key on the Great Bahama Bank described by Harris (1979).

Intraclastic grainstone, commonly interbedded with the oolitic grainstone, indicates episodic wave agitation powerful enough to rip lime mud from the sea floor. Graded bedding in the intraclastic grainstone indicates fluctuating moderate to high energy storm or tidal currents. The interfingering of oolitic grainstone with intraclastic grainstone suggests environments of nearly continuous wave or current agitation passed laterally to surfaces occasionally swept by waves or currents. This relationship is analogous to oolitic shoals of the northern Bahama Bank that pass laterally to muddy inner shelf environments (Harris, 1979).

Restriction of extensive archeocyathid bioherms to the central section (#5), and the interfingering relationship of archeocyathid bioherms with oolitic grainstone, suggests that archeocyathids constructed bioherms near the eastern, more protected edge of the oolitic shoal complex. An oolitic grainstone bed overlying a archeocyathid bioherm in section 5 suggests the oolitic shoals shifted and occasionally buried the bioherms.

Lime mudstone, pelletal wackestone, and bioclastic wackestone, which are the dominant lithotypes in the eastern sections of the lower

carbonate member, indicate deposition in a quiet water environment. These lithologies are interpreted to represent deposition in a lagoon that formed in quiet waters shoreward of the oolitic shoal complex.

As shown above, the lower carbonate member displays three distinct lithofacies, which correspond to changes in current velocity, from east to west (fig. 23). The inferred seaward edge of the carbonate environment is not preserved in the study area.

The lower siltstone and carbonate members represent deposition in the inner detrital and middle carbonate belts. A proposed model for the deposition of the lower siltstone and carbonate members is depicted in figure 24.

Oolitic and intraclastic grainstone near the top of the eastern sections suggests that the oolitic shoal complex migrated east before the onset of upper siltstone member deposition. Furthermore, this suggests that the carbonate environment was either 1) deepening to the west forcing the shoal to migrate eastward; or 2) the carbonate environment shoaled upward and flattened out into a series of oolitic shoals, which spread over the whole area.

Upper Siltstone Member

The transition from the lower carbonate member upward into the upper siltstone resembles in an inverse sequence the lagoon to carbonate transition at the base of the lower carbonate member. I interpret this to represent progradation of a lagoon environment over

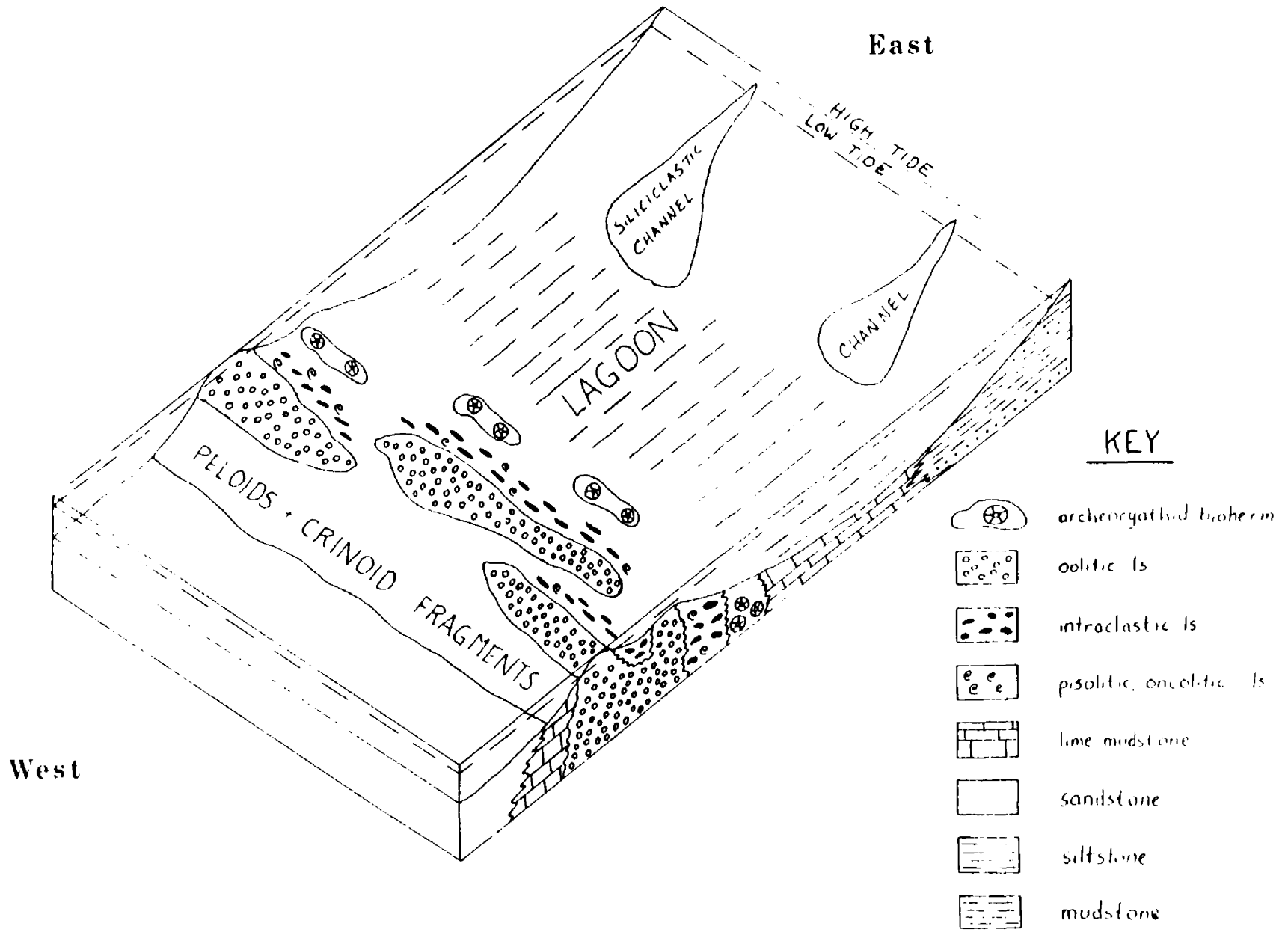


Figure 24. Paleogeographic reconstruction of the lower siltstone and lower carbonate members of the Rosella Formation in the Cassiar Mountains.

the oolitic shoal complex of the upper part of the lower carbonate member. The lithologies, sedimentary structures, and faunal constituents of the upper siltstone member indicate terrigenous sedimentation in a shallow subtidal depositional system.

The depositional environment postulated for the upper siltstone is very similar to the one proposed for deposition of the lower siltstone. Flat-laminated siltstone and shale demonstrate deposition in a quiet water setting. Ripple laminated siltstone indicates infrequent tides or currents modified the sediment water interface. Lensoidal shaped beds of quartzite and sandstone in this member represent channels which emptied into this lagoon from the east. Bioclastic packstones represent rapid deposition of storm transported fossils periodically washed into the lagoon.

There are also some differences between the lagoon environments of the lower and upper siltstone members. A dolomite bed bearing large colonial Regulare archeocyathids in the upper siltstone shows that Regulare archeocyathids apparently lived in carbonate mud on the lagoon floor.

Oolitic grainstone in this member represents the local incursion of well agitated shallow water carbonate into the lagoonal environment. The oolitic grainstone represents a locally established oolitic shoal in the siliciclastic environment.

Upper Carbonate Member

The upward transition from the upper siltstone member to the upper carbonate member represents renewed transgression during the Bonnia-Olenellus zone. Coincident with this transgression is the re-establishment of a carbonate depositional environment. However, the carbonate depositional system recorded by the upper carbonate member differs markedly from the depositional system postulated for the lower carbonate member.

The abundance of pelletal wackestone in the upper carbonate member indicates most of the deposition in this carbonate environment occurred in low turbulence settings unaffected by wave agitation. However, oolitic and intraclastic grainstone beds indicate local prolonged current agitation. Similarly, pisolitic and oncolitic grainstone indicate periodic current transport within the photic zone.

The predominance of quiet water sediments indicates the upper carbonate depositional environment was deeper or simply more protected than the lower carbonate depositional environment. Interbedded oolitic and intraclastic grainstone suggests local oolitic shoals developed. However, they never coalesced to form an extensive oolitic shoal complex in the study area. The lack of cross beds in the oolitic grainstone supports this interpretation. Alternately, oolitic grainstone at the base of the upper carbonate member may be interpreted to represent the transgression of an

oolitic shoal complex to a location east of the study area. This may suggest that the upper carbonate member records a much broader carbonate depositional system than the one postulated for the lower carbonate member.

In general, the lithologies, sedimentary structures, faunal constituents of the upper carbonate member indicate deposition in a subtidal environment (Wilson, 1975; Reeckmann and Freidman, 1982)

REGIONAL SETTING

The fine-grained siliciclastic-to-carbonate sequences of the Lower Cambrian are interpreted by Fritz (1975) to represent grand cycles proposed by Aitken (1966) for Cambrian and Ordovician miogeoclinal sediments of the Cordillera. Marine transgression and regression, as shown by the development of a carbonate shelf in successive cycles, is inferred to have formed the grand cycles (Aitken, 1966). Thus, Lower Cambrian siliciclastic to carbonate cycles of the Cordillera record a worldwide Early Cambrian marine transgression (Matthews and Cowie, 1979). The upper siltstone member represents a minor widespread regression punctuating the stepwise transgression of the lower Sauk sequence (Peterson, 1988).

Lower Cambrian archeocyathid-bearing formations of Late Atdabanian to Early Botomian age extend discontinuously from Mexico to northern Nevada and from northeastern Washington to Alaska (Stewart and Suczek, 1977; Stelck and Hedinger, 1975). Archeocyathid localities and

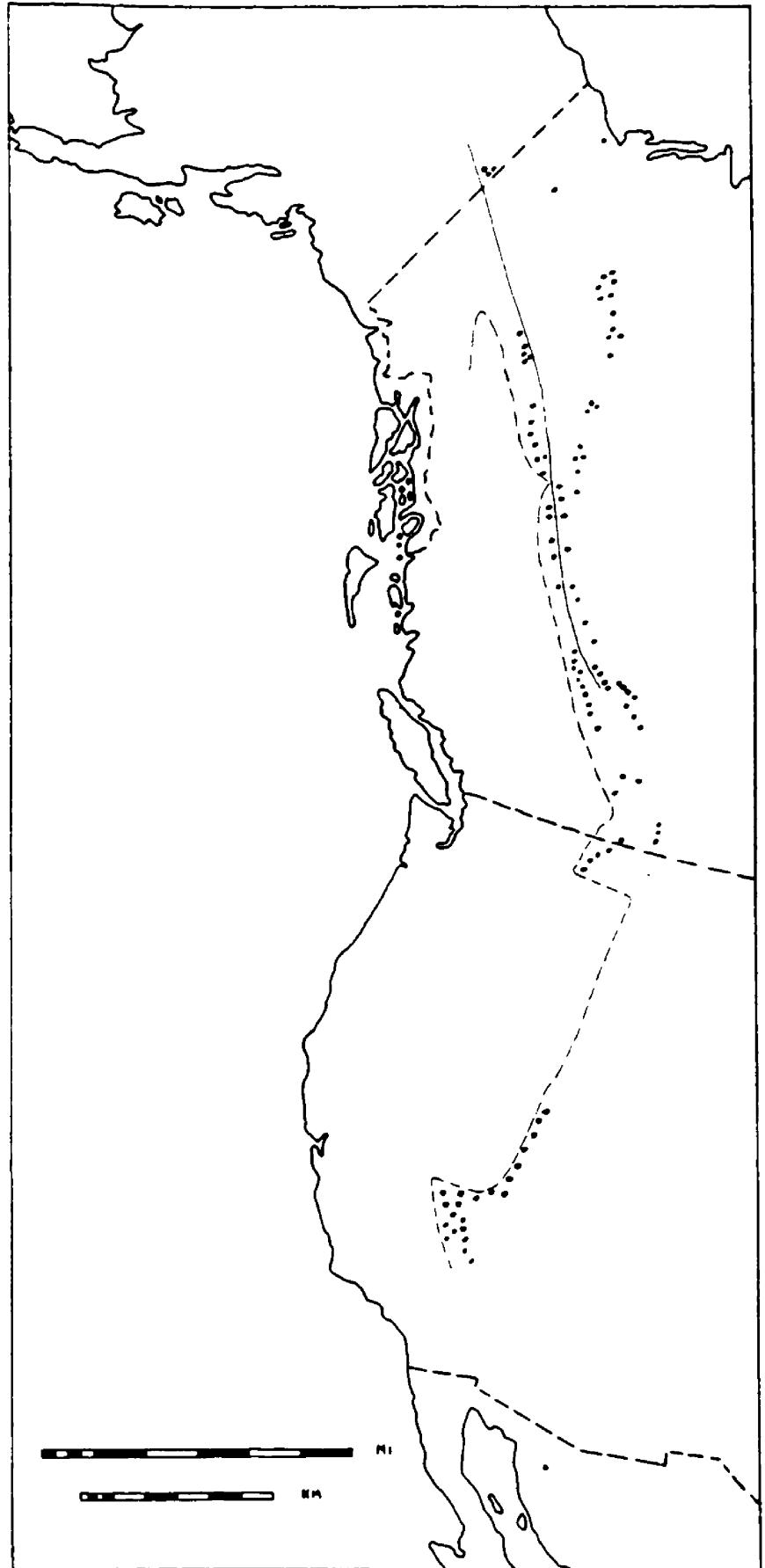
archeocyathid-bearing formations of the Cordillera are plotted in figures 25 and 26, respectively.

Archeocyathid-bearing formations of the Cordillera can be generally subdivided into three units. The basal unit is composed of fine-grained siliciclastic sediments with thin carbonate interbeds that grade upward into an overlying carbonate member in the Nevadella zone. Archeocyathid bioherms and fragments are locally common in the carbonate interbeds in the siliclastic intervals. The lower carbonate member contains abundant oolites, intraclasts, and archeocyathid bioherms. The amount of oolitic and intraclastic grainstone in this member increases toward the west suggesting oolitic shoals developed toward the seaward edge of the carbonate shelf (Rowland, 1981; Debrenne and Mansy, 1981; this study). The basal unit is represented by the lower siltstone and lower carbonate members of the Rosella Formation in the Cassiar Mountains.

The middle unit is a thin siliciclastic interval, at or near the Nevadella and Bonnia-Olenellus zone boundary, which represents the progradation of shallow, siliciclastically dominated, subtidal environments over the preexisting carbonate shelf. The siliciclastic interval is represented in the Cassiar Mountains by the upper siltstone member of the Rosella Formation.

The medial siliciclastic unit is conformably overlain by the third unit, a thick carbonate interval. This upper carbonate contains ooids

Figure 25. Archeocyathid localities of western North America (dots) plotted against the $Sr_{87}/Sr_{86} = .706$ isopleth (dashed line). Archeocyathid localities from Stelck and Hedinger (1975) and Stewart and Suczek (1977). Isotopic data from Monger and Price (1979), Kistler and Peterman (1978), and Armstrong et al. (1977). The solid line in northern Canada is the Tintina-Northern Rocky Mountain Trench fault system.



and intraclasts. However, they are not abundant; pisolites and oncolites are much more common. The decrease in the development of oolitic shoals and the increasing abundance of thick bedded fine-grained limestone suggests a deepening or widening of the carbonate platform during deposition of this member. The top of the upper carbonate is typically missing or not well exposed. Archeocyathid-bearing limestone encased in siltstone or shale lies above the upper carbonate member only in eastern California and western Nevada (Moore, 1976). The thick upper carbonate member is represented in the Rosella Formation by the upper carbonate member.

Sedimentary structures and faunal constituents in Lower Cambrian carbonates of western North America indicate they were deposited on a shallow carbonate shelf. Rowland (1981) and Moore (1976) proposed a depositional model for the Lower Cambrian Poleta Formation in eastern California and Nevada that closely resembles the depositional model synthesized in this study (fig. 27). These models include a carbonate shelf in the Nevadella zone dominated by oolitic shoals in its westernmost exposures. These oolitic shoals pass eastward into a shallow subtidal environments. Further east are siliciclastic rocks deposited in subtidal and intertidal environments (Moore, 1976). In the Cassiar Mountains intertidal sediments are not present in the Rosella Formation.

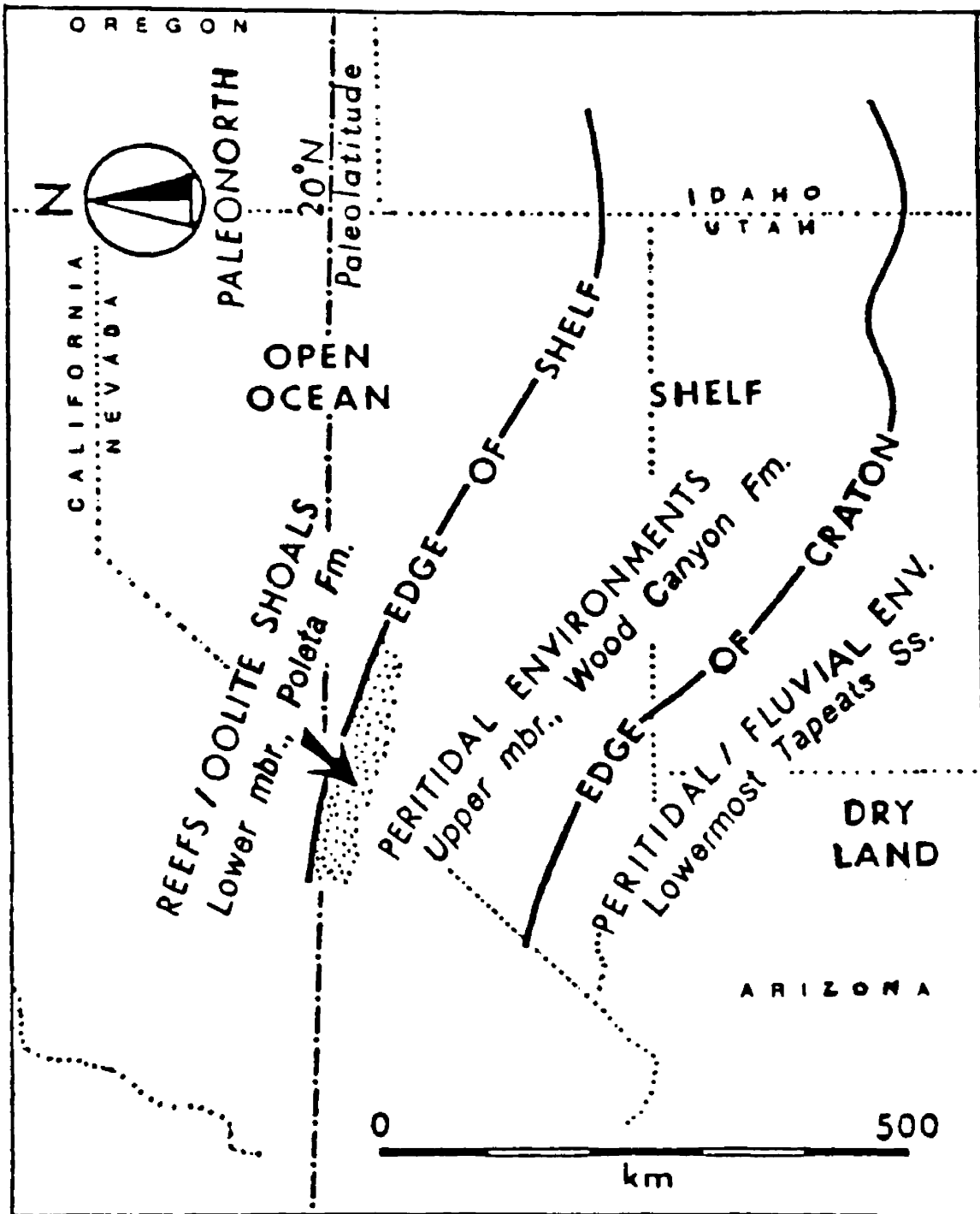


Figure 27.--Paleogeographic setting of the archaeocyathid reefs of the southern Great Basin. (from Rowland, 1981).

Debrenne and Mansy (1981) described lithostratigraphic sequences for Lower Cambrian rocks in the Omineca Mountains and northern Rocky Mountains of British Columbia which closely resemble the sequences in California and the Cassiar Mountains. However, they attributed the westward facies changes in these rocks to juxtaposition of the facies along the Northern Rocky Mountain Trench Fault (fig. 28). More recent work suggests the Omineca Mountains are structurally continuous with the northern Rocky Mountains (e.g. McDonough and Simony, 1989; Ross and Murphy, 1988; Price and Carmichael, 1986). Thus, the oolitic limestones in the Omineca Mountains are here interpreted to represent oolitic shoals which pass eastward into shallow water carbonate and fine grained siliciclastic sediments in the northern Rocky Mountains (fig. 29). The strong lithofacies similarities between the Cassiar Mountains, California, and northern British Columbia, and the common appearance of oolitic limestone from California to Alaska, suggests oolitic shoals developed toward the seaward edge of the carbonate shelf during the Nevadella zone. This shoal complex might have formed a continuous barrier along the entire extent of the miogeocline during this time.

REGIONAL HISTORY AND TECTONIC IMPLICATIONS

From the Late Proterozoic through the Early Paleozoic the western margin of North America was the site of passive margin sedimentation (Stewart and Suczek, 1977; Sloss, 1988) on a continental margin

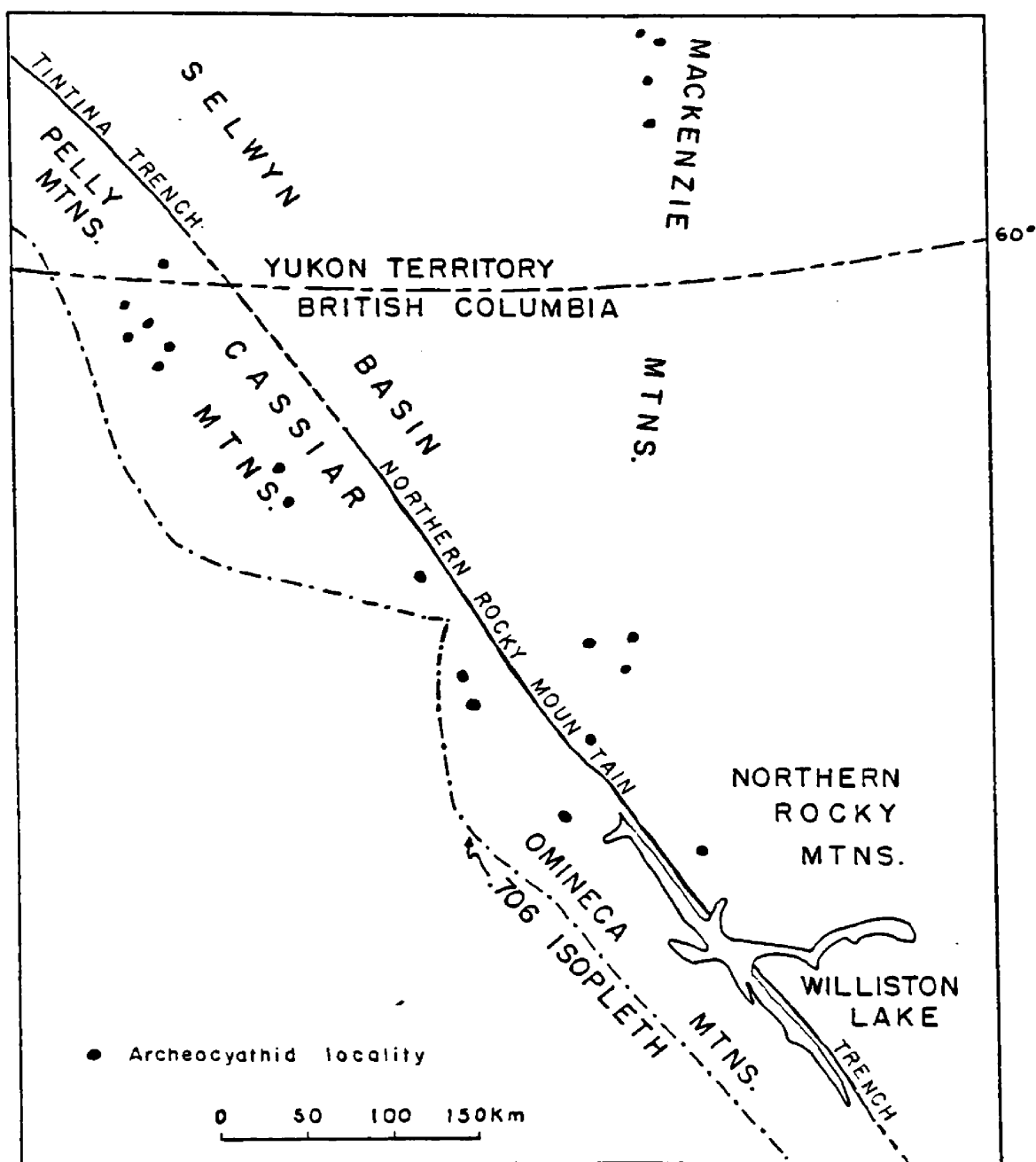


Figure 28. Map of archeocyathid occurrences in northern British Columbia and southern Yukon Territories (modified from Debrenne and Mansy, 1981).

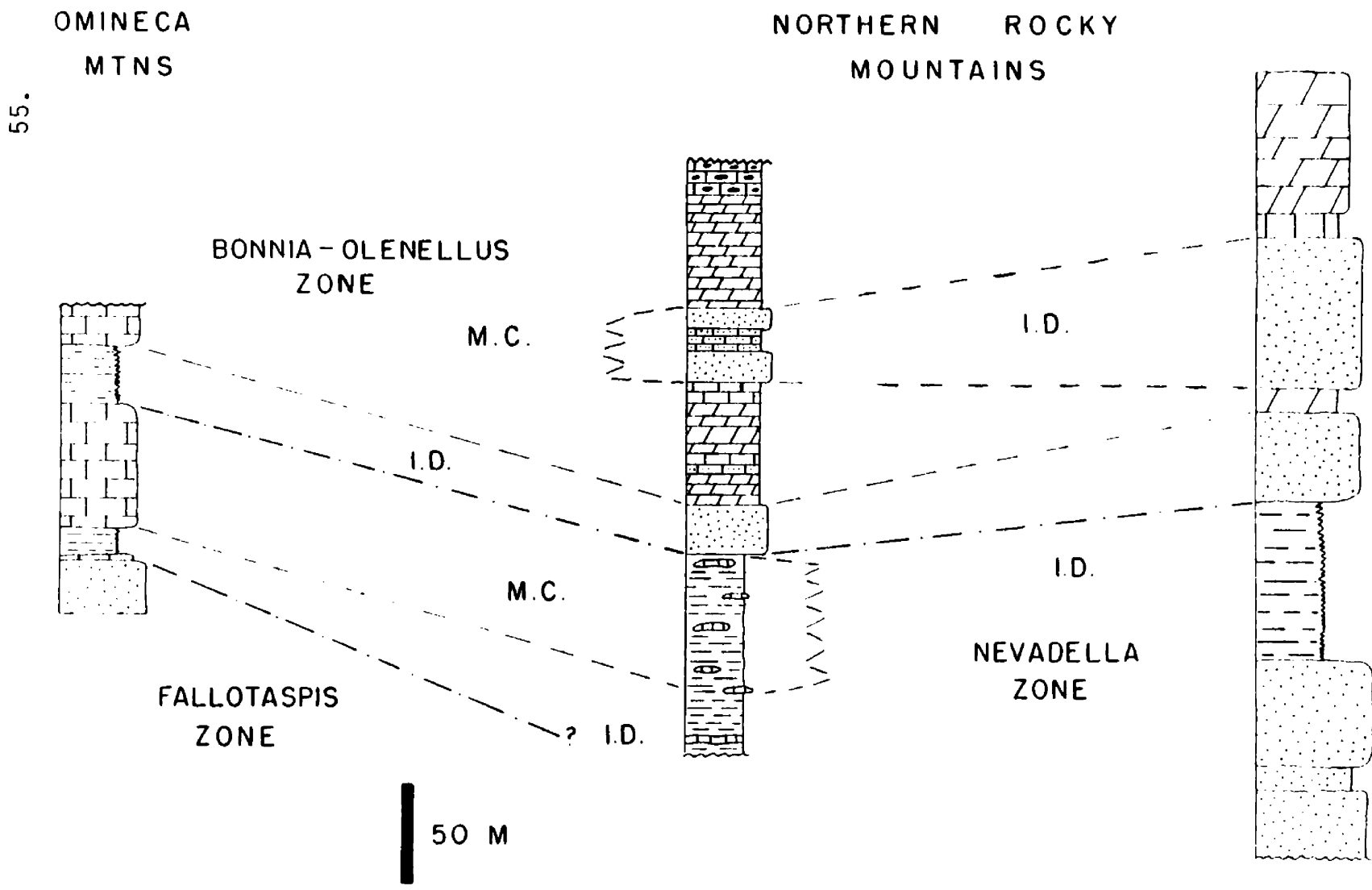


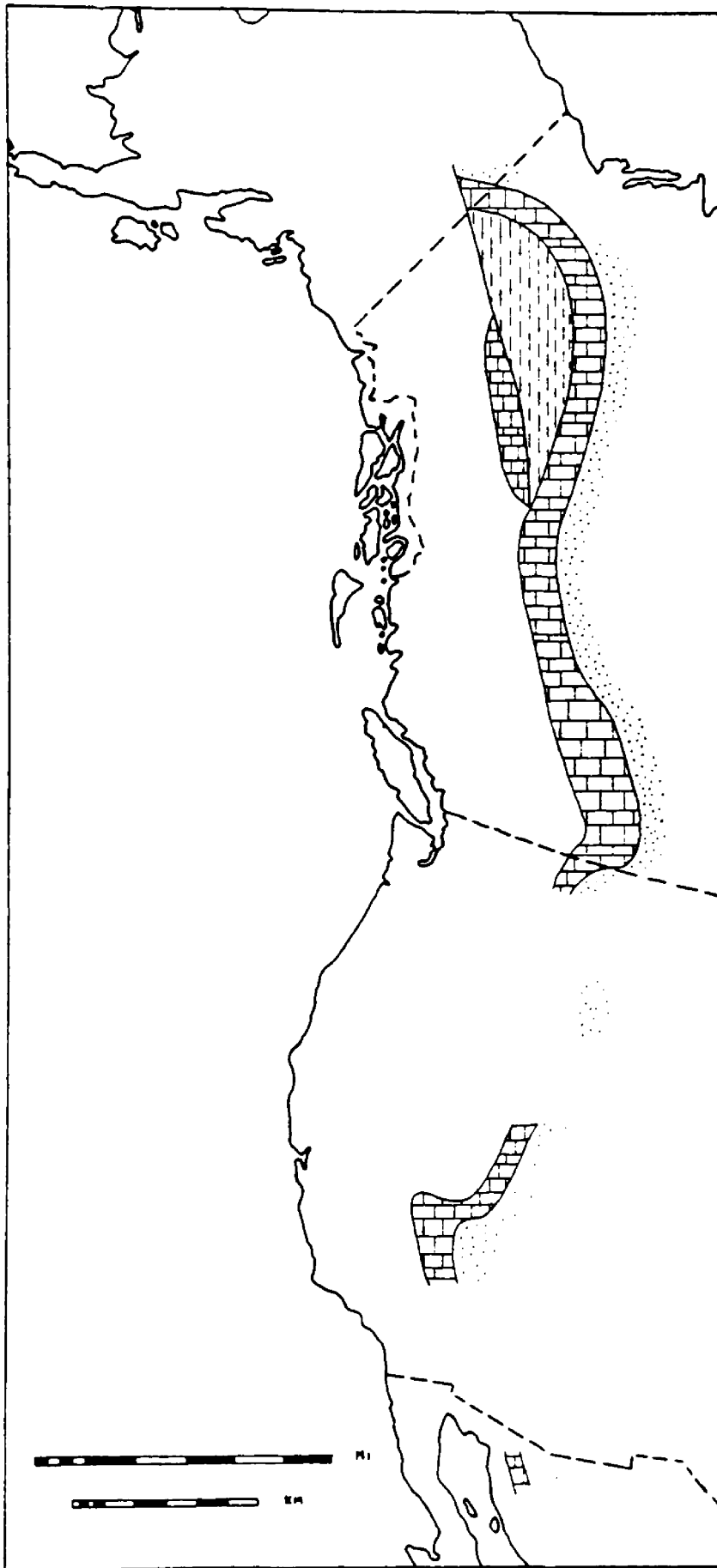
Figure 29. Stratigraphic sections of Lower Cambrian rocks along an E-W transect through the Northern Rocky Mountains and Omineca Mountains. Zone boundaries are marked by a dash-dot line, while depositional environment boundaries are delineated by a dashed line. M.C.= middle carbonate belt; I.D.= inner detrital belt. Data for sections from: Debrenne and Mansy (1981), Fritz (1972;1980b), and Mansy (1972;1976).

formed in an extensional regime (Devlin and Bond, 1988). Lower Cambrian miogeoclinal rocks of the Cordillera are divided into three parallel lithostratigraphic belts: the inner detrital, middle carbonate, and outer detrital (Palmer, 1960; Robison, 1960); which are mapped nearly continuously from Alaska to Mexico (fig. 30).

Paleomagnetic data infer that the western edge of North America paralleled the Equator, at approximately 10-15 degrees north latitude, during the Early Cambrian (Cowie et al, 1971). This orientation permitted the development of a continuous carbonate shelf, parallel to the Lower Cambrian shoreline. Archeocyathids, spongiomorphs that migrated into North America, by way of Siberia, during the Atdabanian stage were very abundant on this shelf (Rowland and Gangloff, 1988; text-figure 31).

In the Cordillera coarse-grained siliciclastic deposition during the Fallotaspis zone records the initiation of a world wide Early Cambrian transgression (Matthews and Cowie, 1979). Lower Cambrian limestone of the Nevadella and Bonnia-Olenellus zones delineate a shallow water carbonate shelf. The western edge of the carbonate shelf corresponds closely with the $Sr_{87}/Sr_{86} = .706$ isopleth for most of western North America (Armstrong et al., 1977; Kistler and Bateman, 1977; Monger and Price, 1979; see text-figure 25).

Between northern Nevada and northeastern Washington the entire Late-Proterozoic to Late Paleozoic assemblage of miogeoclinal rocks is






-  INNER DETRITAL BELT
-  MIDDLE CARBONATE BELT
-  OUTER DETRITAL BELT

Figure 30. Present day configuration of Lower Cambrian rocks of western North America.

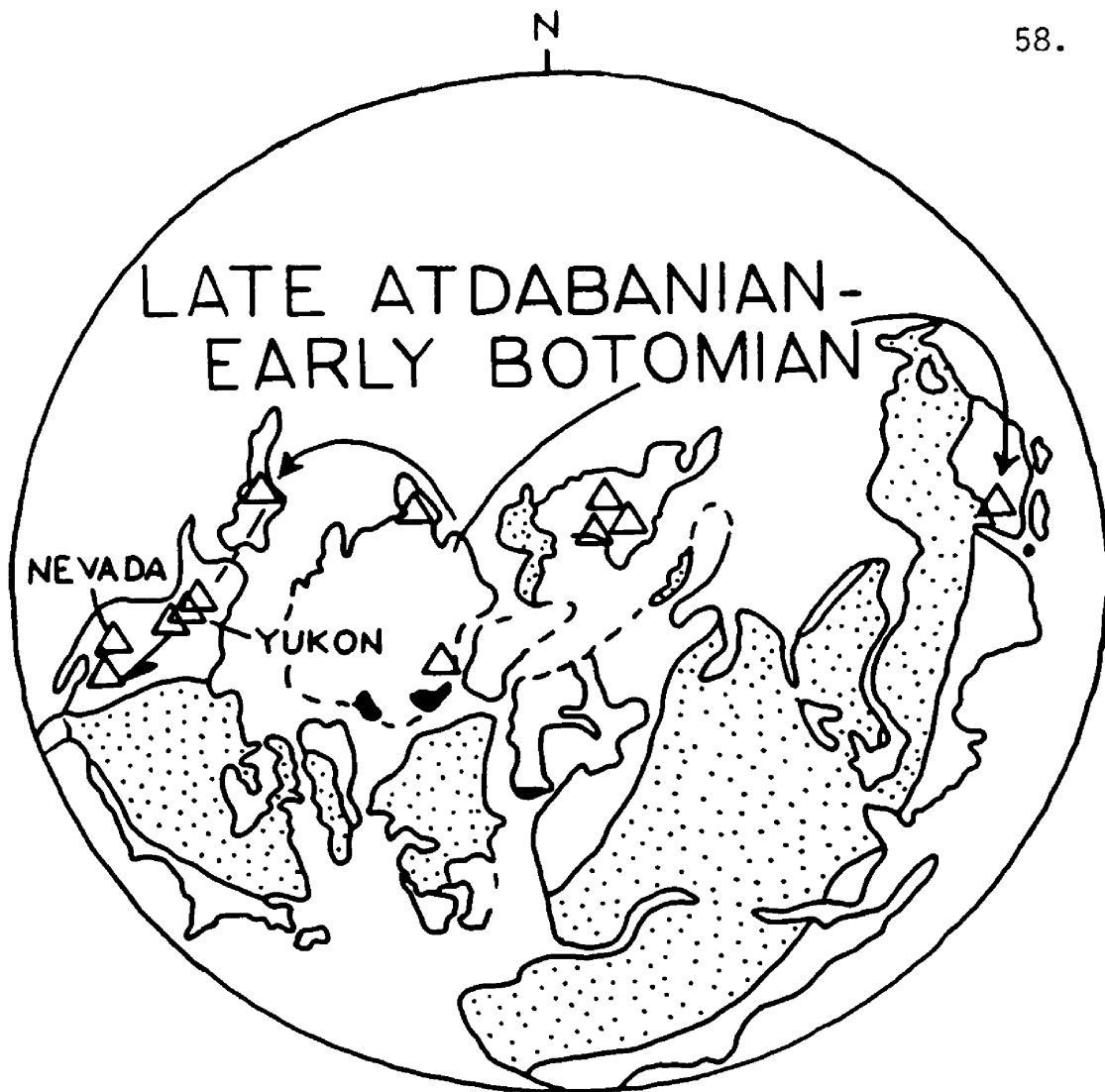


Figure 31. Proposed migration path of archeocyathids into western North America (from Rowland and Gangloff, 1988). Note gap from Nevada localities to northeastern Washington and southern British Columbia localities.

absent (Stewart and Suczek, 1977). Here, the allochthonous Jurassic Wallowa Terrane is juxtaposed against the Idaho Batholith along the Western Idaho Suture Zone (Hyndman et al., 1988; Strayer et al., in review). However, evidence of Late Proterozoic-Early Paleozoic miogeoclinal sedimentation is present in central and southern Idaho (McCandless, 1983; Fritz, 1975). Lower Cambrian quartzite and siltstone represent deposition in the inner detrital belt (Fritz, 1975), while sediments of the middle carbonate and outer detrital belts are missing. Also, westwardly thickening Middle Cambrian through Pennsylvanian miogeoclinal rocks, mostly innershelf siliciclastic sediments and shelf carbonate, are present in Idaho and western Montana (Peterson, 1988). This suggests that miogeoclinal deposition occurred outboard of central Idaho between the Late Proterozoic and Late Paleozoic.

The truncation of Late Proterozoic-Late Paleozoic miogeoclinal rocks between northern Nevada and northeastern Washington corresponds to a distinctive bend in the $Sr_{87}/Sr_{86} = .706$ isopleth along the Western Idaho Suture Zone. The distortion of the $Sr_{87}/Sr_{86} = .706$ isopleth, the absence of Late Proterozoic through Late Paleozoic sediments west of the suture zone, and the truncation of Early Cambrian facies belts at the suture zone suggests the western edge of the miogeocline was tectonically displaced. No trace of these miogeoclinal sediments are found within eastwardly directed thrust

sheets of northern Idaho or western Montana (Hyndman et. al, 1988; Peterson, 1988). Thus, I suggest the western edge of the miogeocline was displaced by strike-slip faulting. Lund and Snee (1985) suggested that the suture zone between the Idaho Batholith and the Wallowa Terrane was the site of right lateral strike-slip faulting between 118-105 m.y.a.

In northern British Columbia and the Yukon Territories the Tintina-Northern Rocky Mountain Trench Fault system separates the Cassiar and Pelly Mountains from the Selwyn Basin and Mackenzie Mountains (see fig. 28). Here, two Late Proterozoic through Early Paleozoic assemblages of westward thickening miogeoclinal sediments are juxtaposed (Tempelman-Kluit, 1977). Right lateral displacement along the Tintina-Northern Rocky Mountain Trench Fault system is postulated for the emplacement of this slice of miogeoclinal rocks (Tempelman-Kluit, 1977,1979; Gabrielse, 1985). In the Selwyn Basin and Mackenzie Mountains, Lower Cambrian rocks of the Nevadella and Bonnia-Olenellus zones are interbedded quartzite, dolomite, and limestone that pass westward into dark platy limestone and black shale (Fritz, 1976; 1979; Fritz and Crimes, 1985). These Lower Cambrian rocks are interpreted to represent deposition in a deep water embayment or trough (Fritz, 1976; in press). The present configuration places the outer detrital belt sediments, deposited in the Selwyn Basin, against the shallow water carbonate platform

sediments of the Cassiar and Pelly Mountains (Read, 1980; Pope, 1989; text-figure 32).

Paleomagnetic data from the Cassiar Mountains suggests the Cassiar Platform has been translated northward up to 600 km since 105 m.y.a (Butler et al., 1988). Recent work in the southern Omineca Mountains of central British Columbia indicates that dextral displacement along the Northern Rocky Mountain Trench Fault is negligible in this area (McDonough and Simony, 1989; Ross and Murphy, 1988; Price and Carmichael, 1986), suggesting that the Omineca Mountains and the northern Rocky Mountains are a single geologic province on the western edge of cratonic North America. This geologic province consists of a westwardly thickening Late Proterozoic through Late Paleozoic miogeoclinai sequence that is truncated in the west along the Mesozoic Omineca Crystalline Belt, suggesting that northward displacement of the Cassiar Platform must have occurred on strike-slip faults outboard of the Omineca Mountains.

Southward repositioning of the Cassiar Platform 600 km, in accordance with the aforementioned paleomagnetic data of Butler et al.(1988), places it outboard of the Omineca and Northern Rocky Mountains (fig. 33). This restoration juxtaposes two westwardly facing carbonate shelves against one another. The paleogeography represented by the juxtaposition of two parallel oolitic shoal

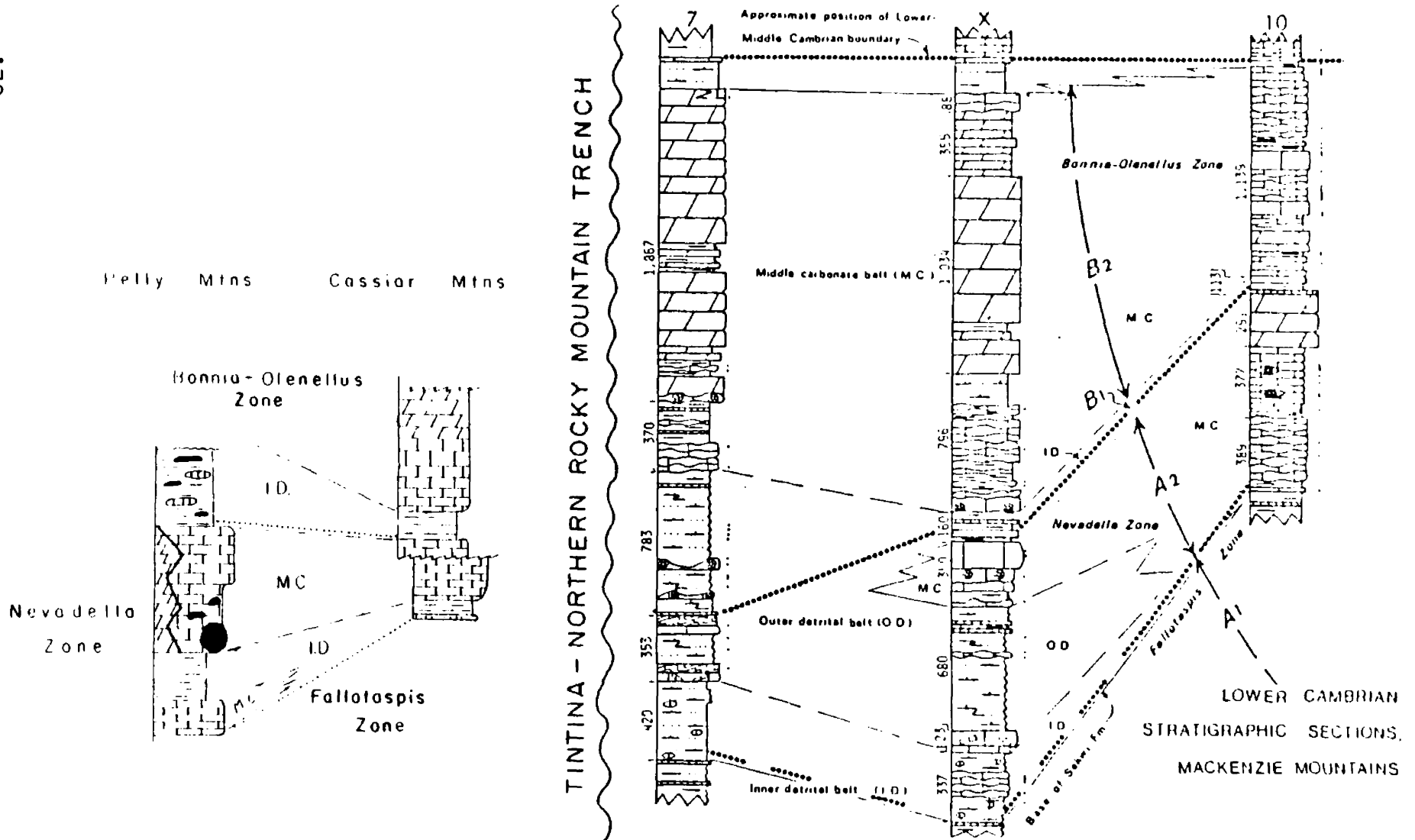
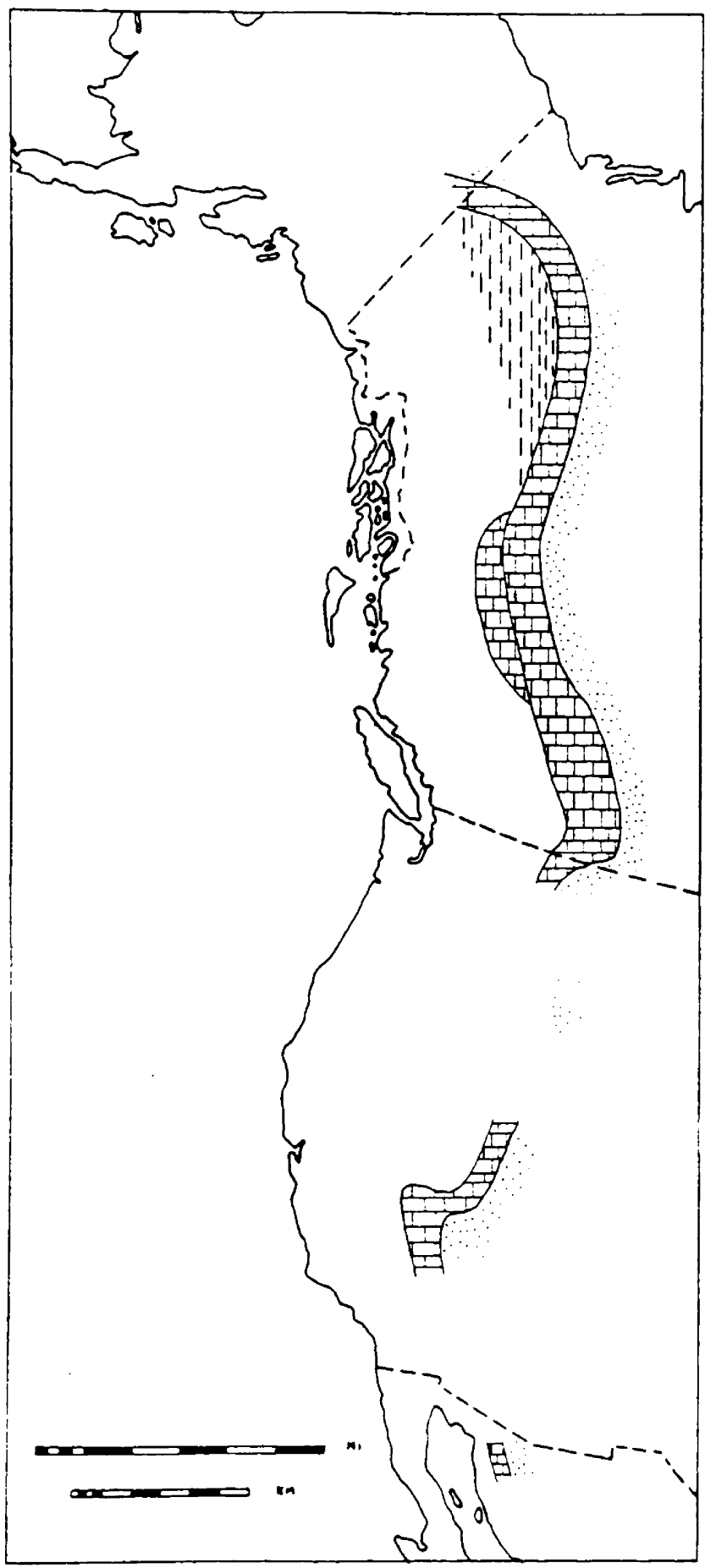


Figure 32. Stratigraphic sections of Lower Cambrian rocks along an E-W transect from the Mackenzie Mountains and Selwyn Basin to the Cassiar Platform. Data for the Mackenzie Mountains and Selwyn Basin from Fritz (1976). Data for the Cassiar Platform from Read (1980) and Pope (1989; this study). Zone boundaries are dotted lines and lithologic boundaries are dashed lines. All sections are drawn to the same vertical scale.






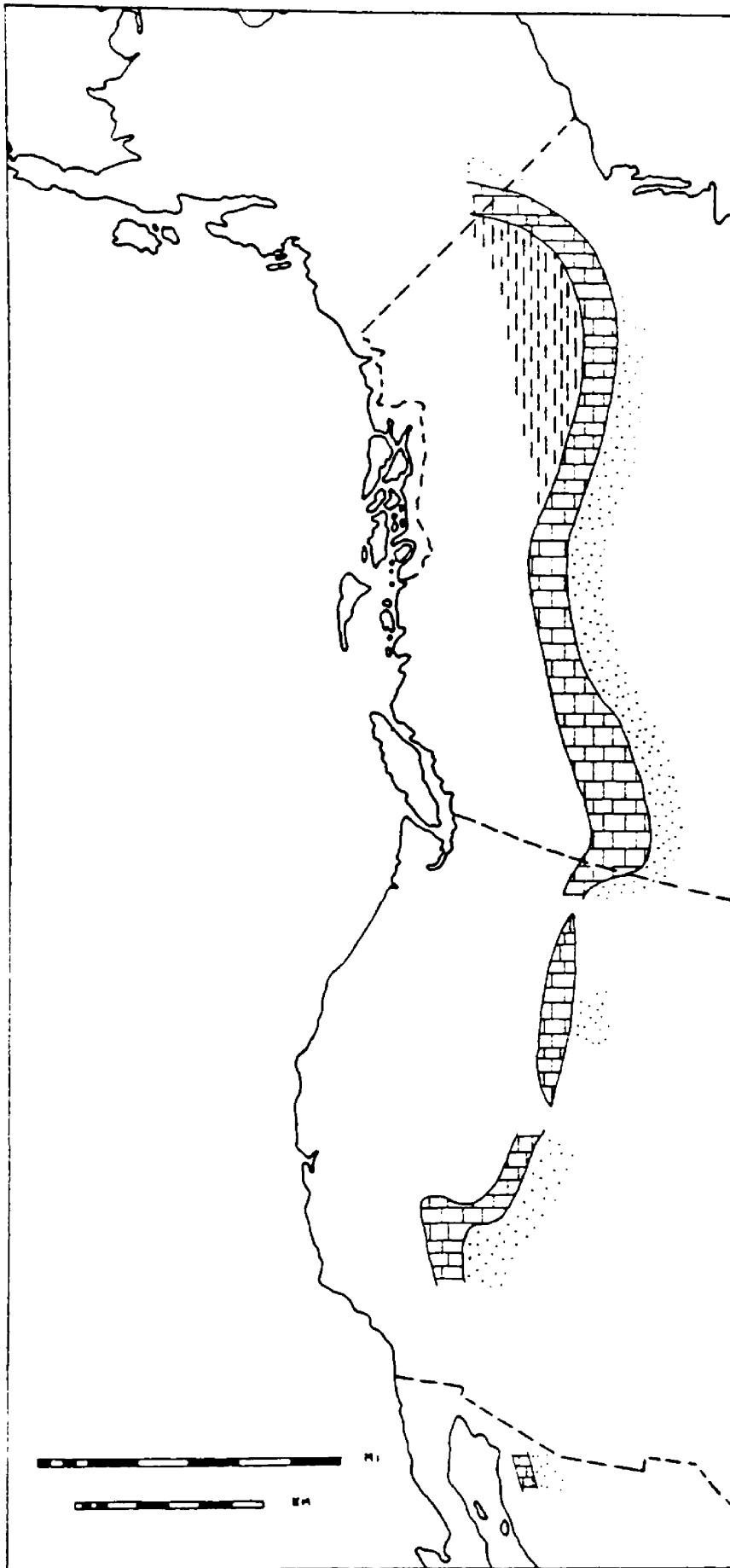
-  INNER DETRITAL BELT
-  MIDDLE CARBONATE BELT
-  OUTER DETRITAL BELT

Figure 33. Repositioned Cassiar Platform, 600 km to the south, in accordance with paleomagnetic data of Butler et al. (1988).

complexes with an intervening siliciclastic environment with no eastern source area is difficult to explain. This restoration also produces a middle carbonate belt twice the width of any other place in the Cordillera while moving the western edge of continental crust outboard of its present position in the Omineca Mountains, producing an uncharacteristic bulge in the otherwise straight Omineca Crystalline Belt. Similarly, southward re-positioning of the Cassiar Platform to any location in the Cordillera, except between northern Nevada and northeastern Washington, produces the same unexplainable problems.

I suggest the paleomagnetic data of the Cassiar Platform (Butler et al., 1988) represents only part of the tectonic history of this allochthonous block, and that miogeoclinal sedimentary rocks in the Cassiar-Pelly Mountains were originally deposited between northern Nevada and northeastern Washington (fig. 34), on a segment of continental crust which has been severed from the craton and translated northward 1600 to 1800 km. Reconstruction of the North American continental margin as depicted in figure 34 solves many problems: 1) it restores the continuity of the Late Proterozoic-Early Paleozoic passive margin, reconstructing the three parallel lithostratigraphic depositional belts of the Lower Cambrian; 2) it restores the proposed migration path for archeocyathid colonization of western North America (Rowland and Gangloff, 1988); 3) it restores






-  INNER DETRITAL BELT
-  MIDDLE CARBONATE BELT
-  OUTER DETRITAL BELT

Figure 34. Proposed reconstruction of the Early Cambrian continental margin.

the $Sr_{87}/Sr_{86} = .706$ isopleth to a simpler configuration characteristic of a continental margin dominated by passive margin sedimentation.

CONCLUSIONS

Lower Cambrian rocks of the Rosella Formation were deposited in a shallow subtidal environment. These rocks record a marine transgression which is punctuated by a regressional event near the base of the Bonnia-Olenellus zone. Interbedded limestone and fine grained siliciclastic units represent the development of carbonate shelf that passed shoreward into shallow subtidal environments. The carbonate shelf of the Nevadella zone is characterized by an oolitic shoal complex along its western edge, that passes eastwardly into shallow subtidal carbonate containing archeocyathid bioherms. The carbonate shelf of the Bonnia-Olenellus zone contains evidence of oolitic shoals, but large shoal complexes did not develop.

The stratigraphy of the Rosella Formation is similar to other archeocyathid bearing formations of the Cordillera. Lower Cambrian Formations record a transgression in the Faliotaspis and Nevadella zones that was interrupted near the base of the Bonnia-Olenellus zone by a continent wide regressional event. The regression was then followed by the continuation of the Early Cambrian transgression.

The Cassiar Platform is an allochthonous slice of miogeoclinal rocks, originally deposited near Idaho, which was severed from North America between 118-105 m.y.a. Dextral strike slip displacement along

the Western Idaho Suture Zone and other poorly constrained faults in British Columbia transported this miogeoclinal slice northward approximately 1300 km. Dextral strike-slip displacement on the Tintina-Northern Rocky Mountain Trench Fault system is postulated for movement, up to 600 km since 105 m.y.a, and emplacement of this terrane to its present position.

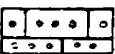
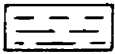
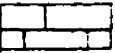
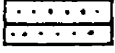
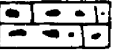
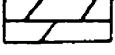
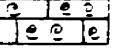
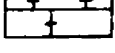
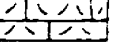
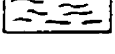
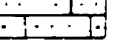

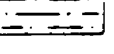

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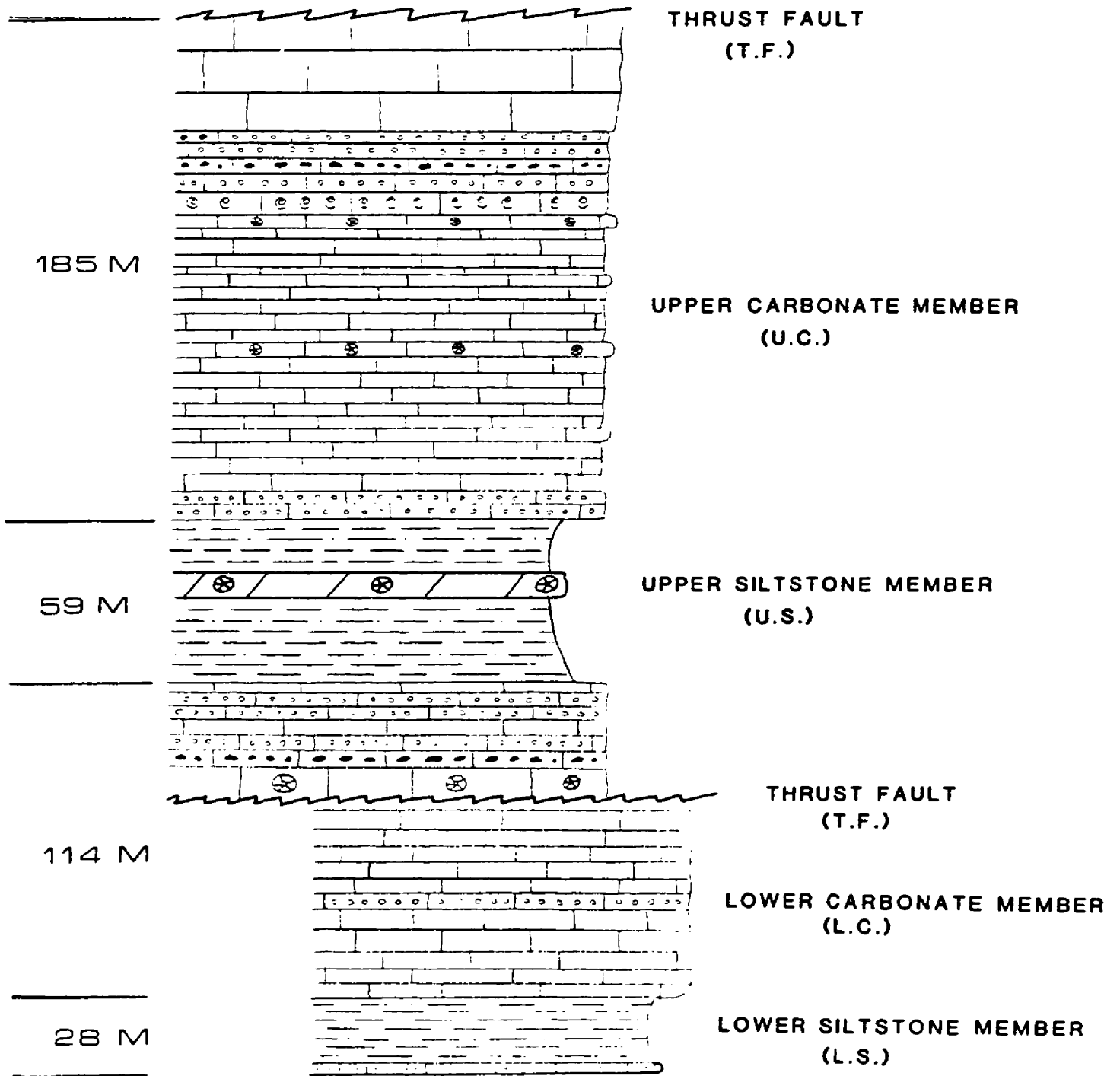
APPENDICES

I. Measured Sections

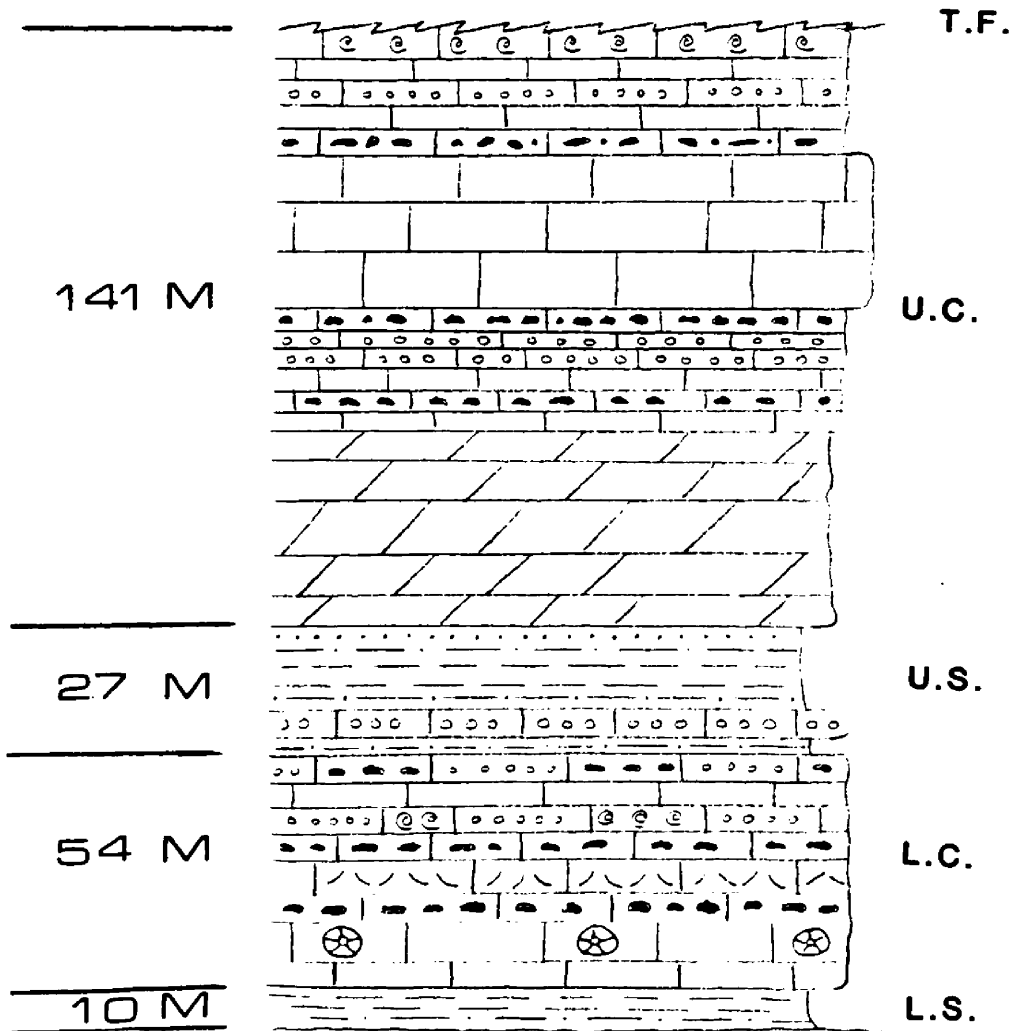
Eight measured sections of the Rosella Formation in the Cassiar Mountains are presented here with a legend. A generalized correlation diagram demonstrating relationships between the sections is also presented.

	oolitic limestone		shale
	micritic, pelletal(?) limestone		quartzite
	intraclastic limestone		dolomite
	pisolitic, oncolitic limestone		marble
	cross bedded limestone		phyllite
	sandy limestone		archeocyathids
	siltstone		brachiopods

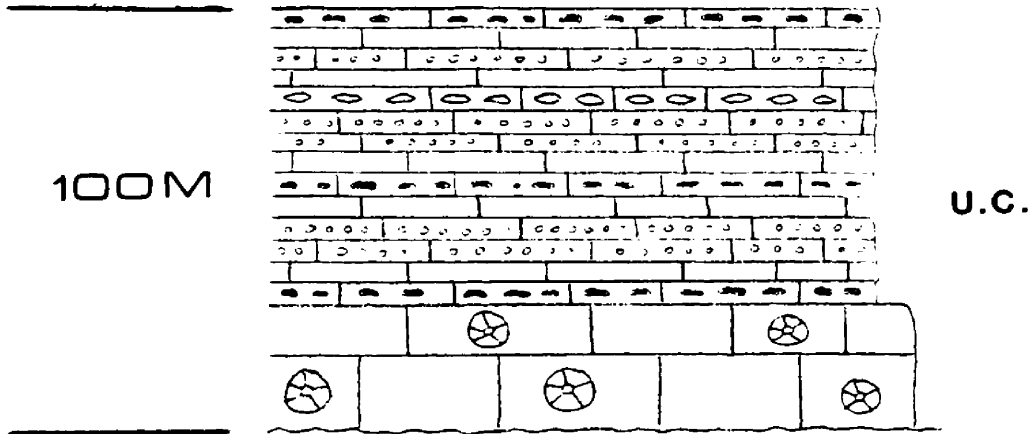
Section 1



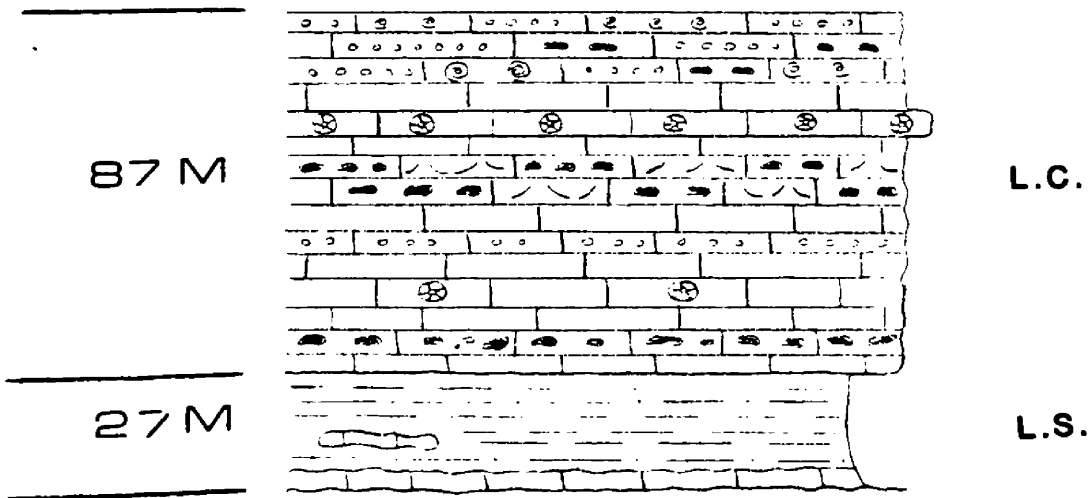
Section 2



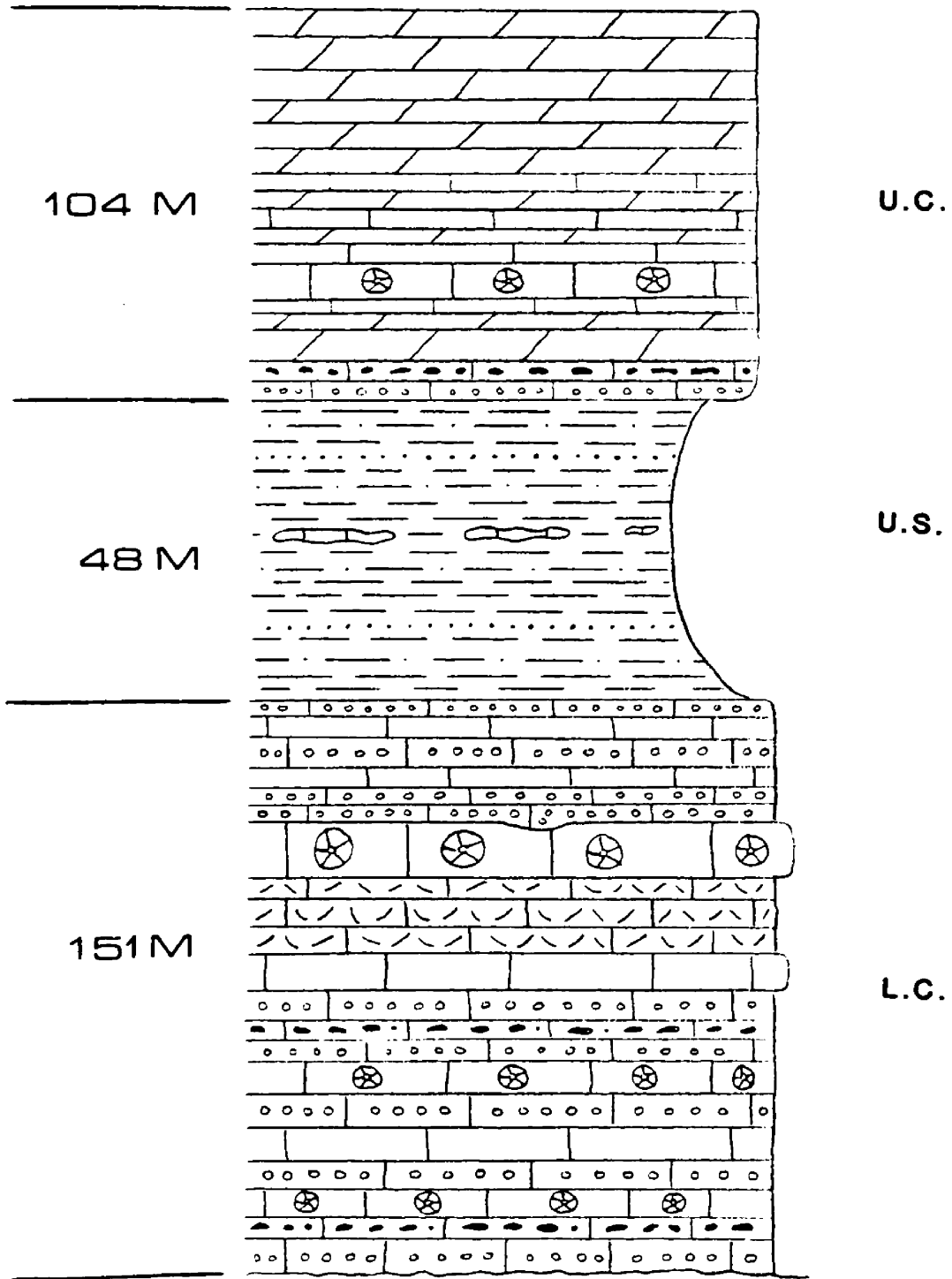
Section 4



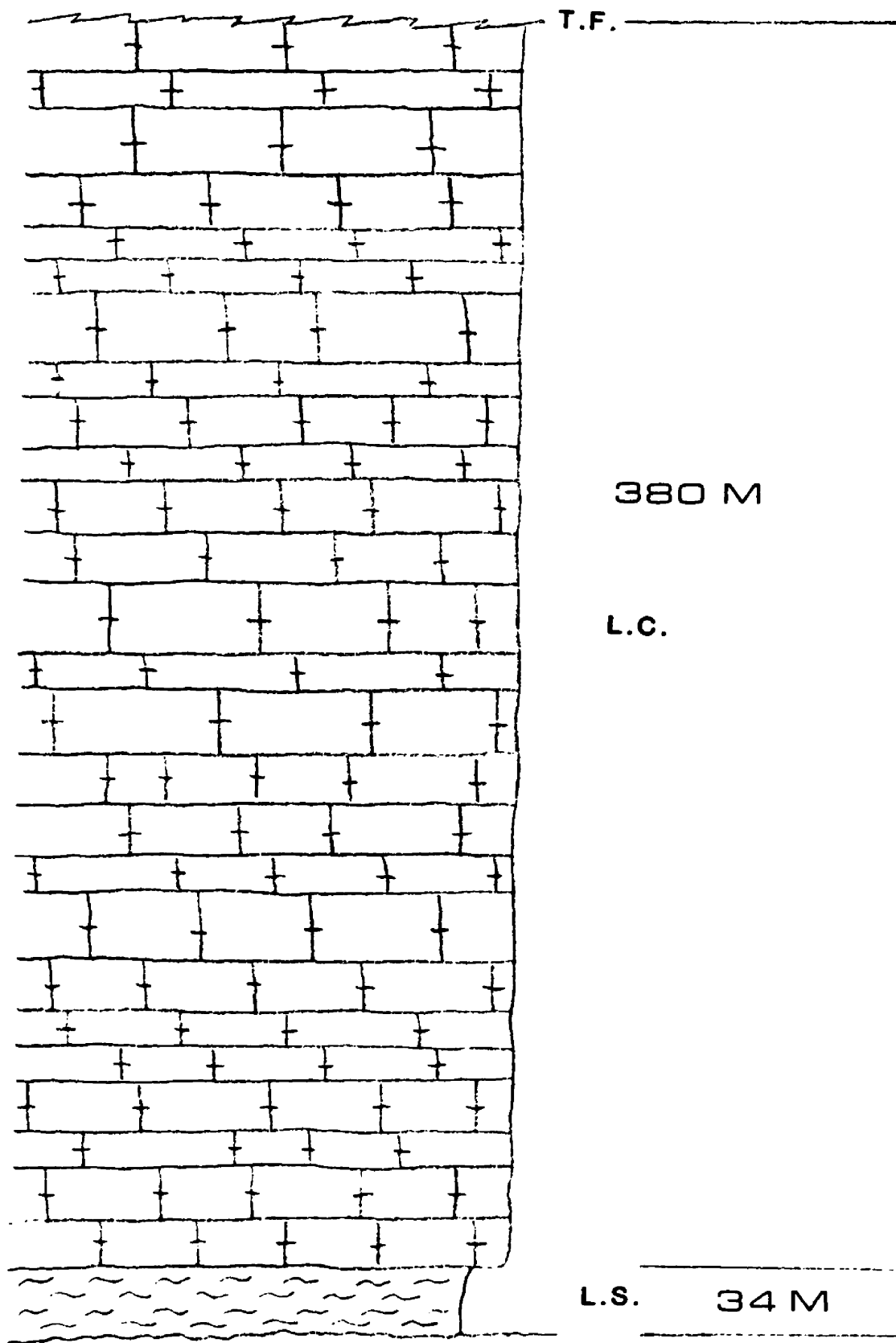
Section 3



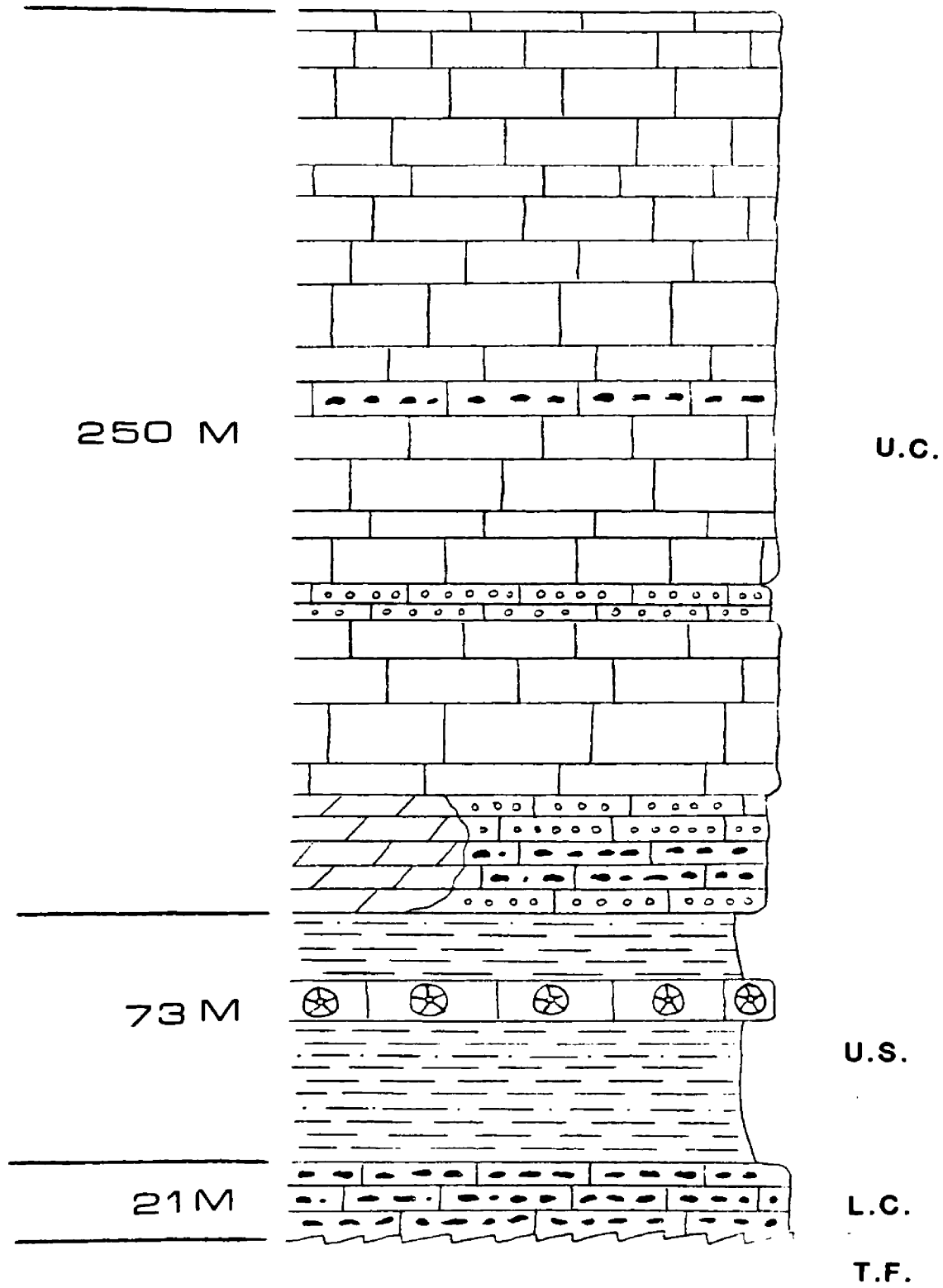
Section 5



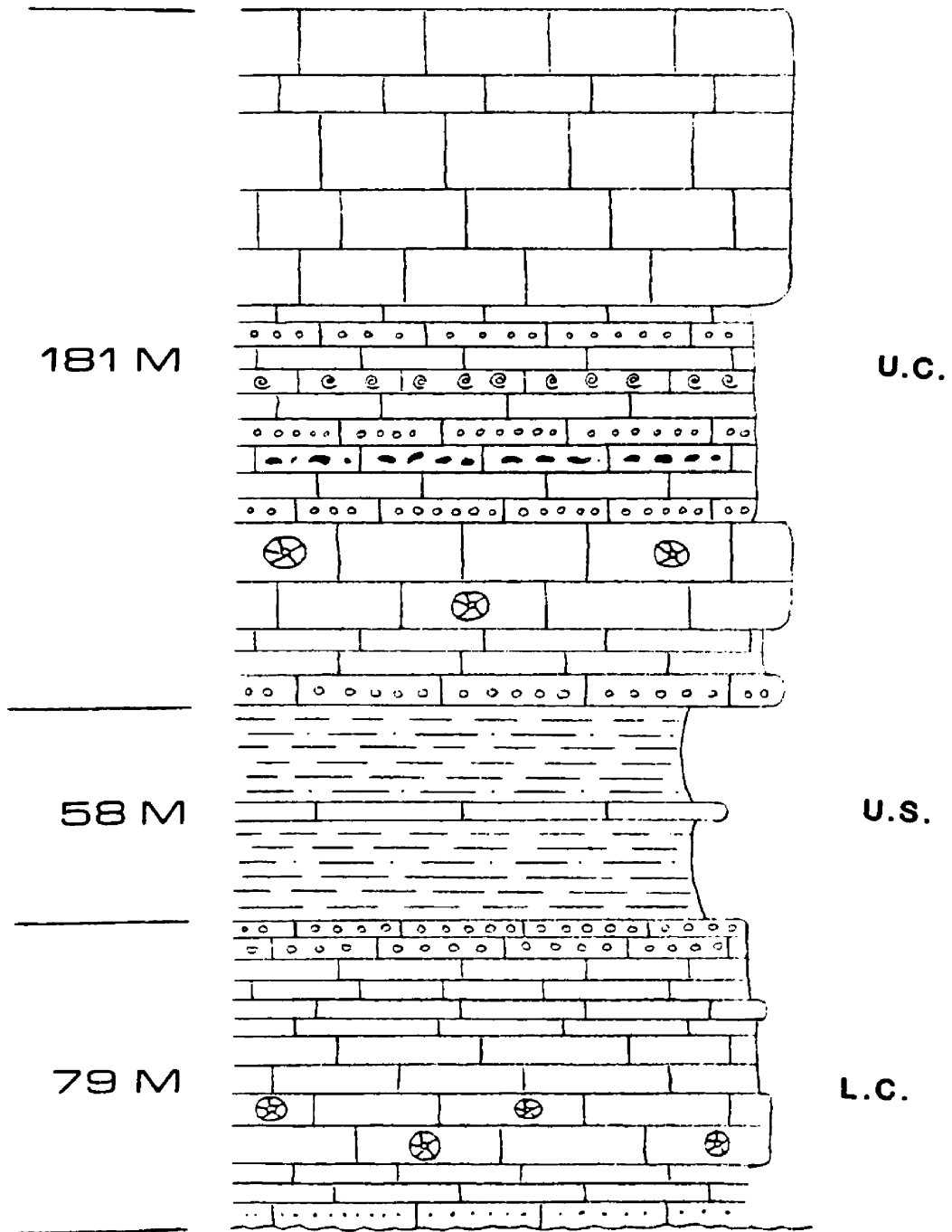
Section 6

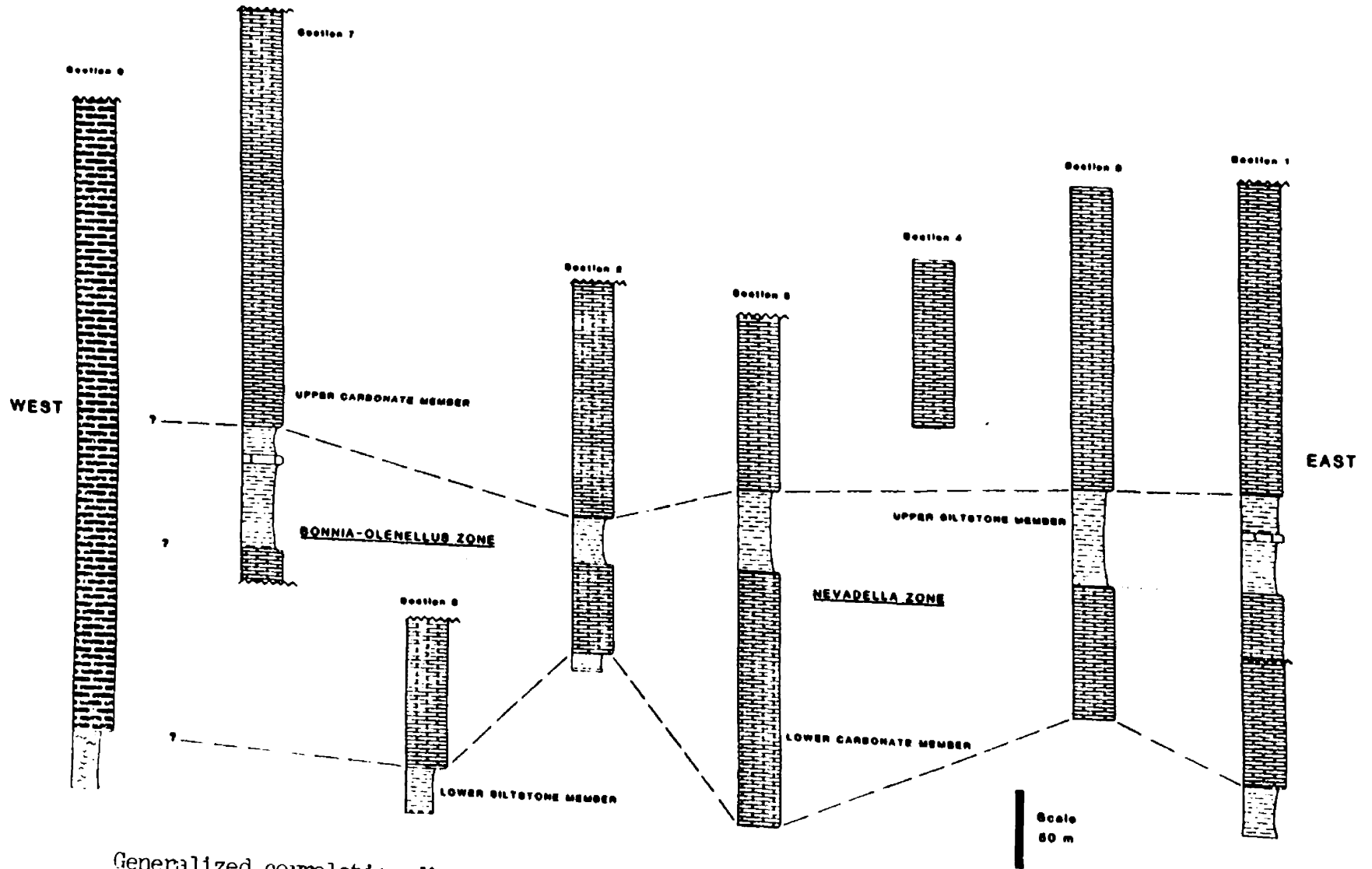


Section 7



Section 8





Generalized correlation diagram of stratigraphic sections for the Rosella Fm.

LOCATION OF STRATIGRAPHIC SECTIONS

SECTION	LATITUDE	LONGITUDE	MAP SHEET
1 (Lower)	59 16 50	129 12 55	104P/6
1 (Upper)	59 16 38	129 10 55	104P/6
2	59 25 48	129 30 05	104P/5
3	59 26 40	129 31 10	104P/5
4	59 44 20	129 38 03	104P/12
5	59 26 54	129 25 48	104P/6
6	59 15 39	129 50 05	104P/5
7	59 28 28	129 34 12	104P/5
8	59 50 57	129 35 46	104P/13

II. Petrography

Over 180 thin sections of the Rosella Formation were examined for this study. Approximately half of the slides are stained with amaranth red. In the stained slides calcite stains red, while dolomite and quartz are clear.

Microcrystalline sparry calcite pervades numerous samples and is particularly abundant in the pelletal wackestones of the upper carbonate member. This microspar is interpreted to represent the neomorphism of micron sized lime mud to microspar.

Coarse-grained sparry calcite is common in many of the samples. Much of the sparry calcite in grainstone beds is interpreted to represent cementation of well sorted carbonate sand grains, where micron sized lime mud was by-passed through the system. In a few slides sparry calcite is tangentially oriented around coarse grains (fig. 35). This texture suggests cementation in the marine phreatic zone (Bathurst, 1975).

Dolomite has replaced limestone in many of the samples. Tan to orange coarse- to very- coarse crystalline dolomite rhombs are easily identified in hand sample. In thin section, dolomite crystals are euhedral and range in size from a few microns to 1 cm (fig. 36). In some thin sections dolomite has preferentially replaced oolites, intraclasts, or biological fragments (fig. 37). The amount of replacement by dolomite increases toward the top of the Rosella

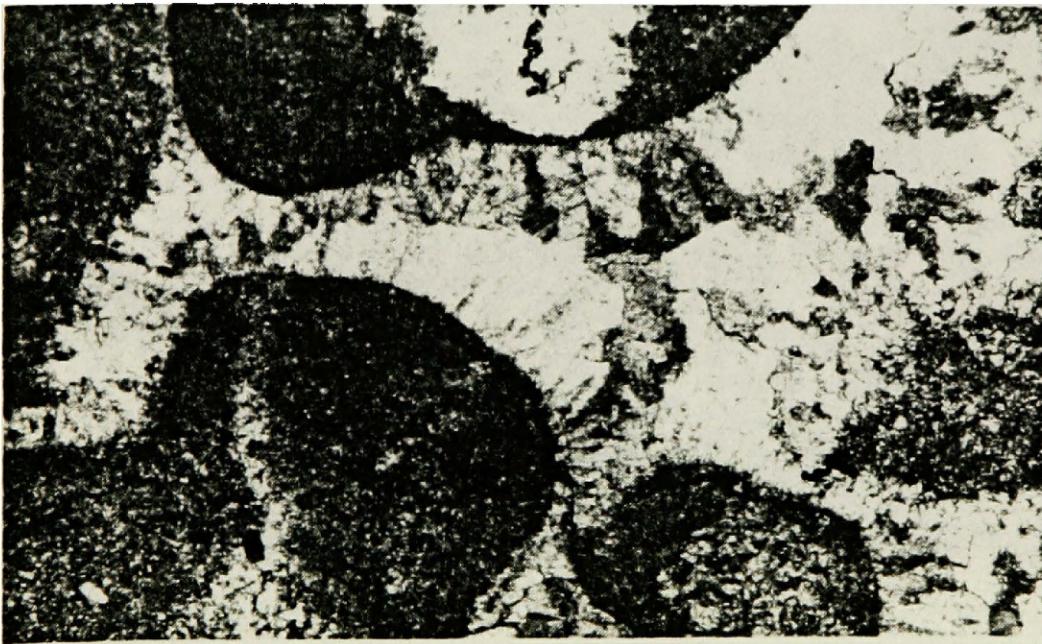


Figure 35. Photomicrograph of radially oriented sparry calcite around intraclasts (sample 4-10). The field of view is 7 mm.

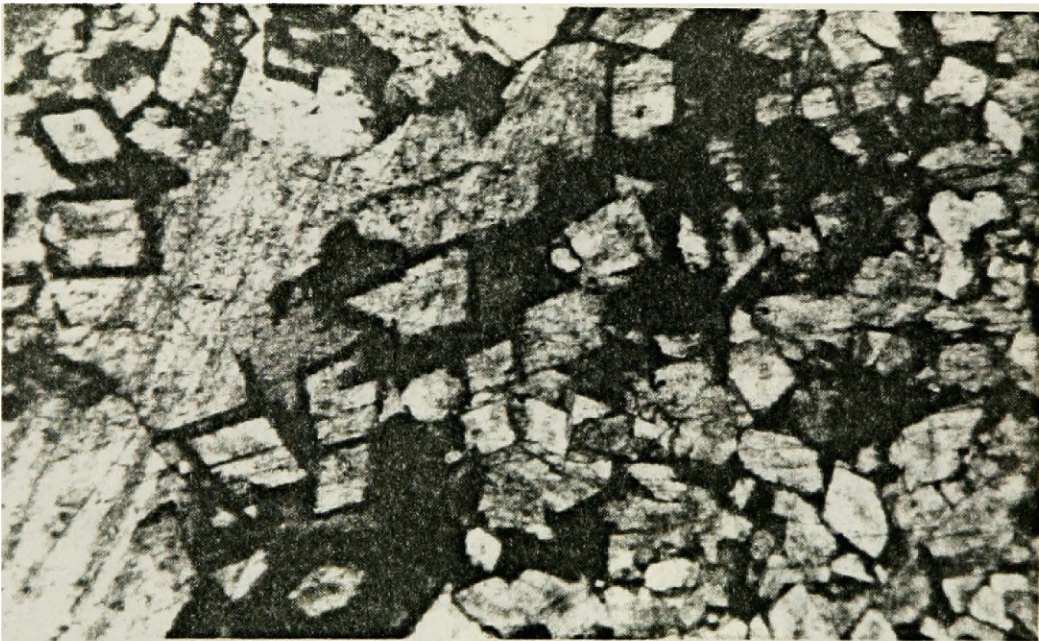


Figure 36. Photomicrograph of fine dolomite rhombs (sample 4-7). The field of view is 2 mm.

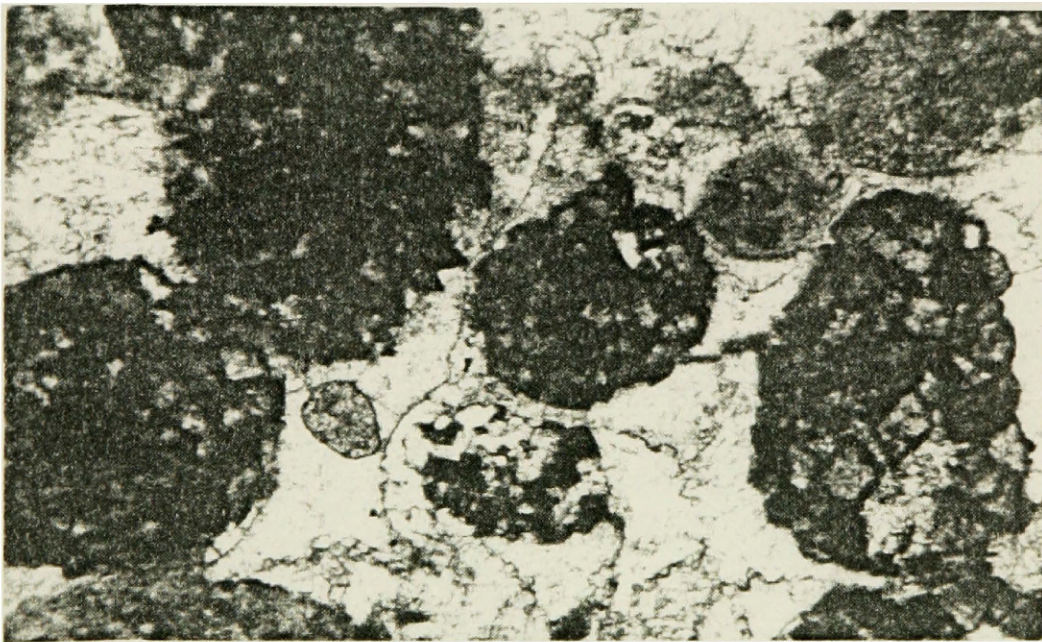


Figure 37. Photomicrograph showing preferential replacement of oolites by dolomite (sample 4-7). The field of view is 7 mm.

Formation and is very evident in the upper carbonate member.

Dolomite replacement of limestone cuts across primary bedding.

Secondary quartz is locally common in both carbonate members.

The fine- to medium-grained quartz crystals are euhedral, cut across grain boundaries, contain numerous carbonate inclusions, and commonly display extinction angles of up to 10 degrees (fig. 38).

These relationships indicate the quartz is authigenic. X-ray diffraction analysis of sample 8-10 confirms quartz is the abundant authigenic mineral in this specimen.

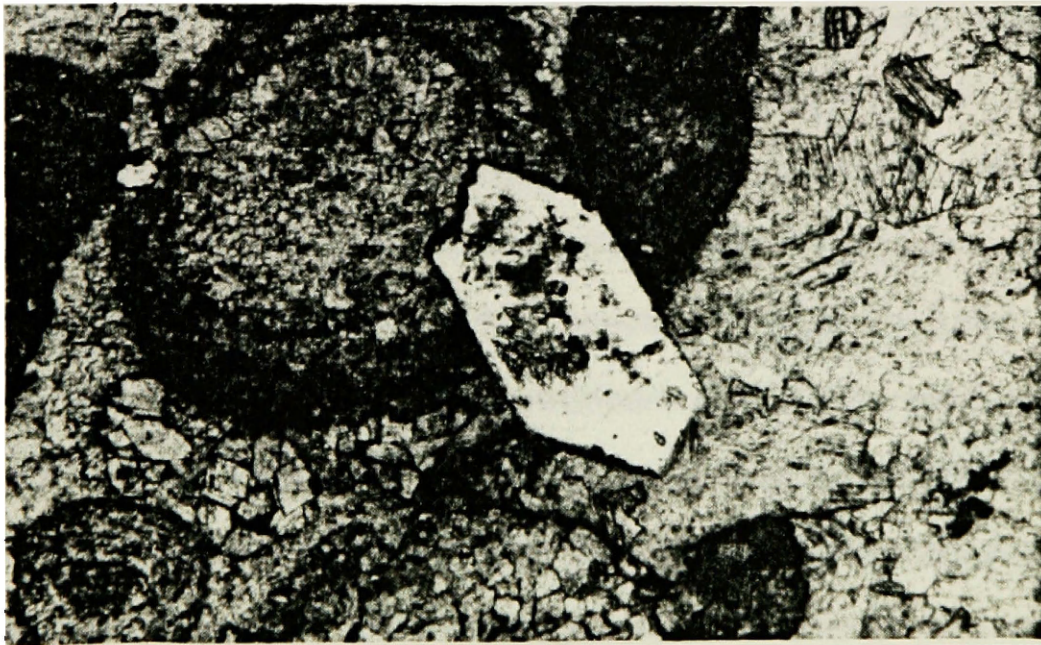
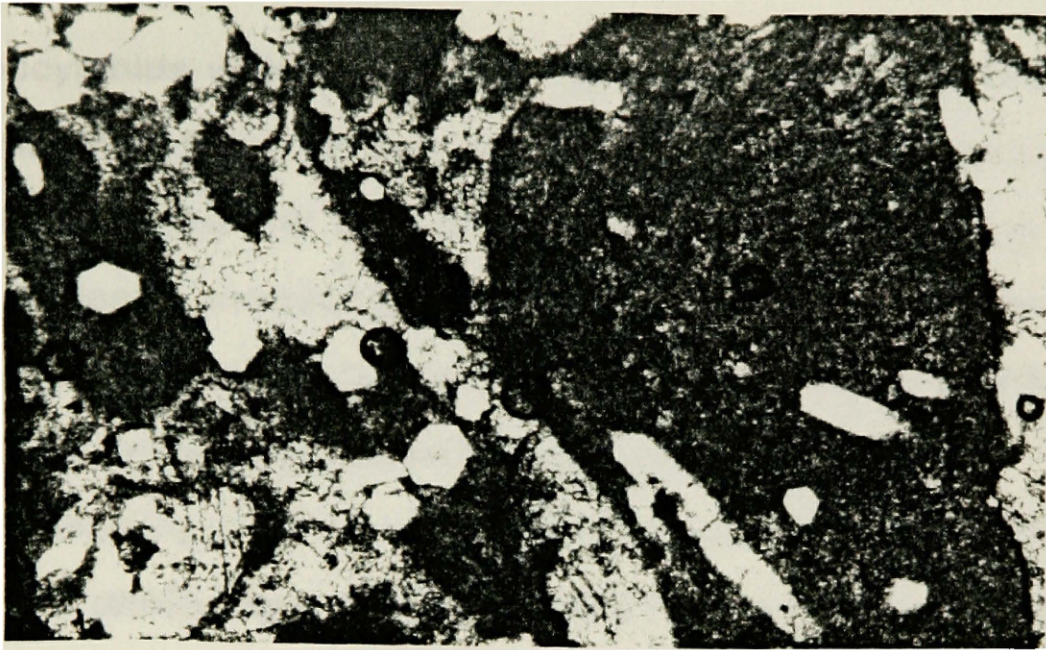


Figure 38. Photomicrographs of authigenic quartz crystals.

- A. Sample 8-10, field of view is 7 mm.
- B. Sample 2-1. field of view is 2 mm.

II. Faunal Constituents

Archeocyathids

Archeocyathids were a unique group of benthic shallow marine organisms (Morgan, 1976) that constructed skeletons of calcium carbonate (Rowland and Gangloff, 1988) and lived only during the Cambrian. Recent morphological studies of archeocyathids suggests they are spongiomorphs (Savarese and Rowland, 1988). Rowland and Savarese (in press) suggest archeocyathids contained photosynthesizing algal or cyanobacterial symbionts, thus confining them to the photic zone. Archeocyathids vary in shape from cuplike discoid forms to stick like branching forms (fig. 39). Archeocyathids are separated into two groups, Regulares and Irregulares, based on ontogeny and microstructures (Hill, 1972). Protopharetra sp., an Irregulare archeocyathid with a branching stick-like form is the most abundant species in the bioherms which developed leeward of the oolitic shoals in the lower carbonate member. Large, colonial, Regulare archeocyathids are most common in the bioherms and biostromes that developed in the lagoonal settings (Gangloff, pers. comm., 1989). This stratigraphic relationship suggests Regulare and Irregulare archeocyathids were ecologically constrained and can thus be used to determine paleogeographic position within a section. Roland Gangloff, of the University of Alaska, is currently identifying the archeocyathids collected during this study.

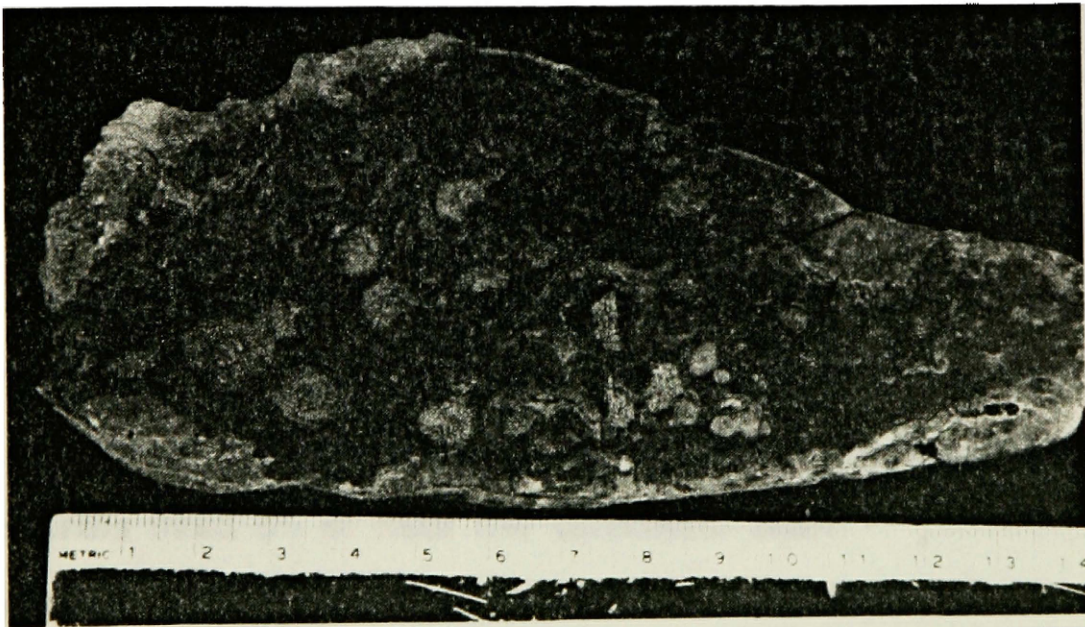
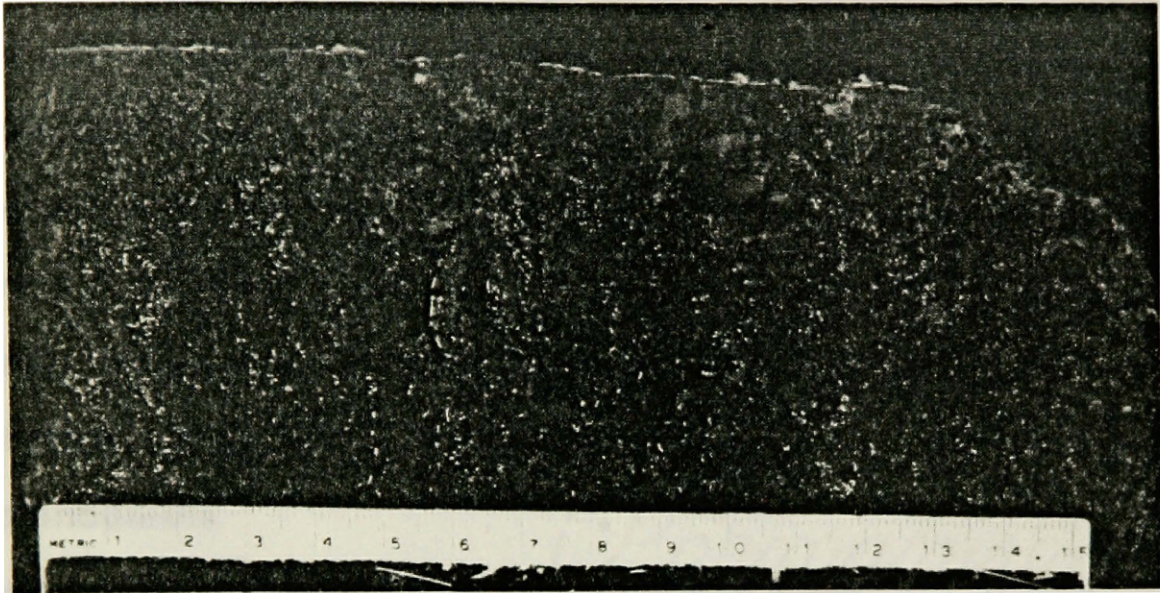


Figure 39. Hand specimens containing archeocyathids.
A. Protopharetra sp. a branching Irregulare, from section 5.
B. Unidentified species from section 4.

Trilobites

Trilobite fragments are common in the fine-grained siliciclastic lower and upper siltstone members. The carbonate members contain abundant trilobite fragments in bioclastic wackestone, archeocyathid bioherms, and in the cores of intraclasts. Whole trilobite specimens are rare in the Rosella Formation. Most trilobites are considered deposit feeders, though some have recently been interpreted as carnivores (Conway Morris, 1986).

Echinoderms

Echinoderm fragments and disarticulated plates are locally abundant in all the members of the Rosella Formation (fig. 40). No whole echinoderm specimens were found in the study area, thus identification of the echinoderms was not attempted. Cambrian echinoderms lived gregariously as stalked suspension feeders or low-level, epifaunal suspension feeders along the flanks of carbonate platforms (Sprinkle, 1976). The abundant echinoderm fragments in the lower and upper carbonate members suggests a large population of echinoderms lived on or near the carbonate shelf.

Hyalolithids

Hyalolithid shells (fig. 41) are common in the thin limestone beds within the lower and upper siltstone members. Hyalolithids were mobile deposit feeders, active in shallow subtidal environments (Rowland and Gangloff, 1988)

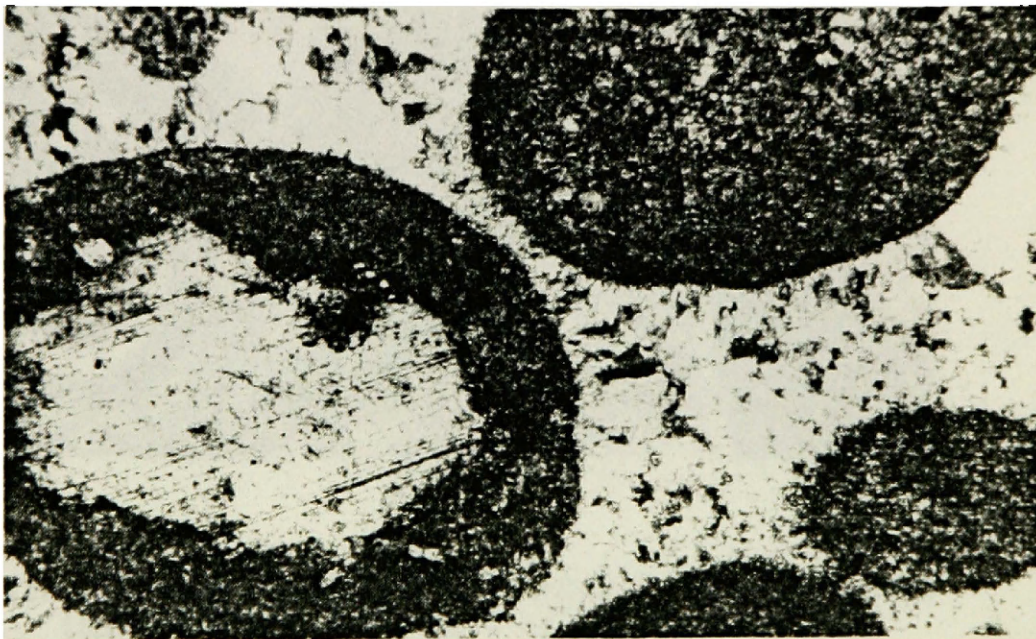


Figure 40. Photomicrographs of echinoderm plates in intraclastic grainstone.

A. Sample 1-2, field of view is 7 mm.

B. Sample 4-10, field of view is 7 mm.

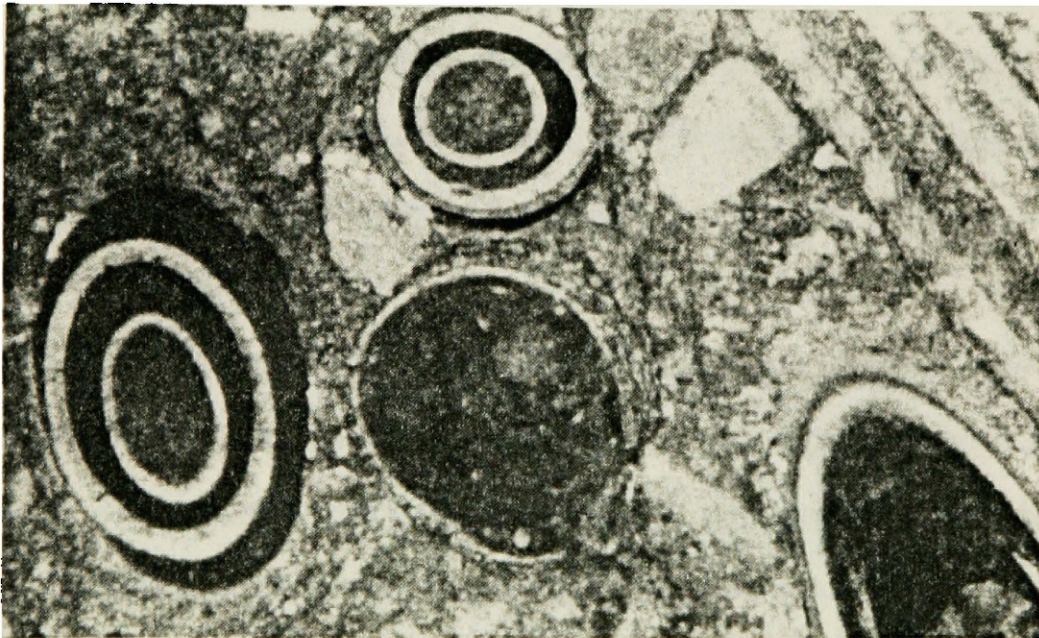


Figure 41. Photomicrograph of hyolithid in cross section (sample 1-2). The field of view is 7 mm.

Algae

Renalcis and Epiphyton are locally common within the archeocyathid bioherms. Fragments of Renalcis are rare in samples of the oolitic grainstone (fig. 42). Filamentous algal (?) fragments are present in the oolitic grainstone facies of both the lower and upper carbonate members (fig. 43). These fragments are bilaterally symmetrical in longitudinal section and are circular in cross section. The longitudinal sections display segmentation perpendicular to the cell walls. These algal fragments resemble filamentous fossils from an unnamed Lower Cambrian limestone in the Tindir Group of southeastern Alaska (Allison, 1988). The presence of algal fragments in these sediments indicates deposition in the photic zone.

Articulate Brachiopods

Whole Articulate brachiopods (fig. 44) are common in the packstone beds near the top of the upper carbonate member of section 4. Thin sections of the brachiopod packstone display well defined punctae. Articulate brachiopod fragments are also common in the archeocyathid bioherms. The brachiopods are not identified in this study. Articulate brachiopods lived in clear water and survived by filter feeding (Rudwick, 1970).



Figure 42. Photomicrograph of Epiphyton algal fragment in oolitic grainstone (sample 3-4). The field of view is 2 mm.

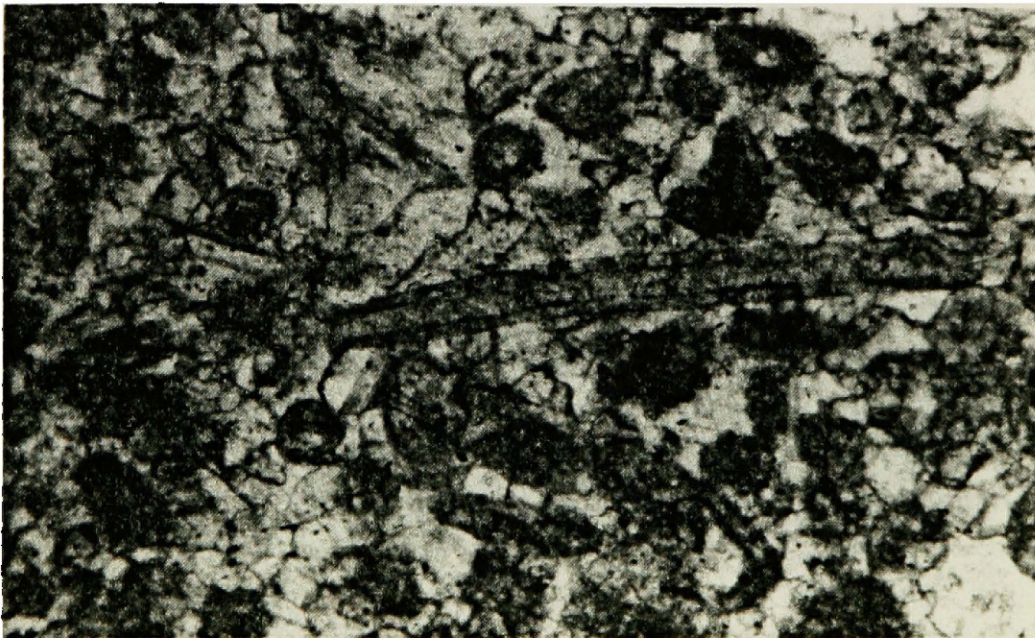
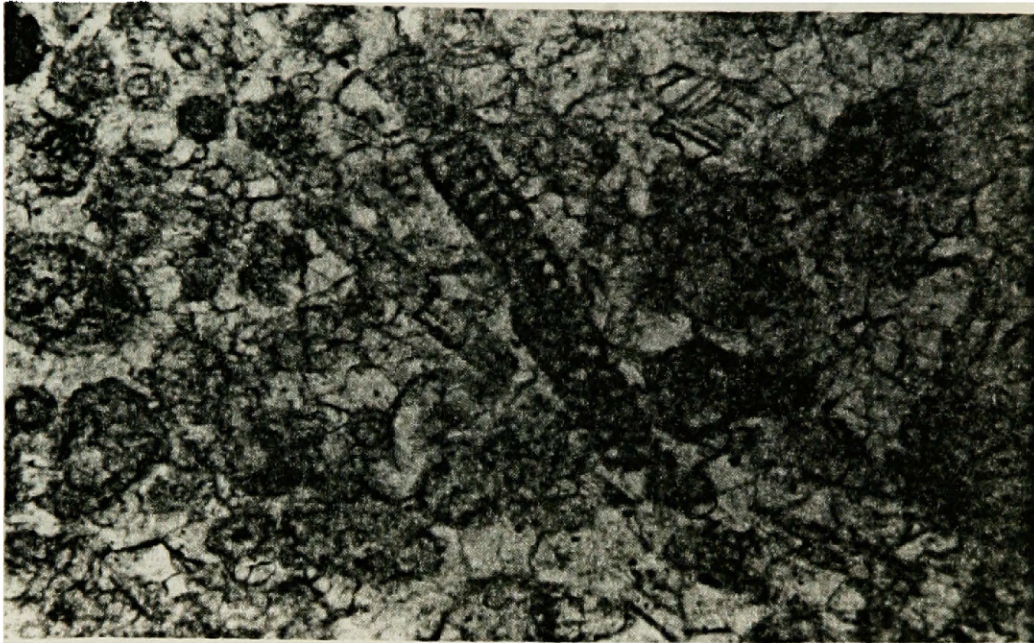


Figure 43. Photomicrographs of filamentous algae (sample 2-11).
A. Longitudinal slice displaying well defined inner cellular structure, field of view is .5 mm.
B. Longitudinal slice with no inner structures defined, cross-sectional slices are dark rounded structures; field of view is .5 mm.

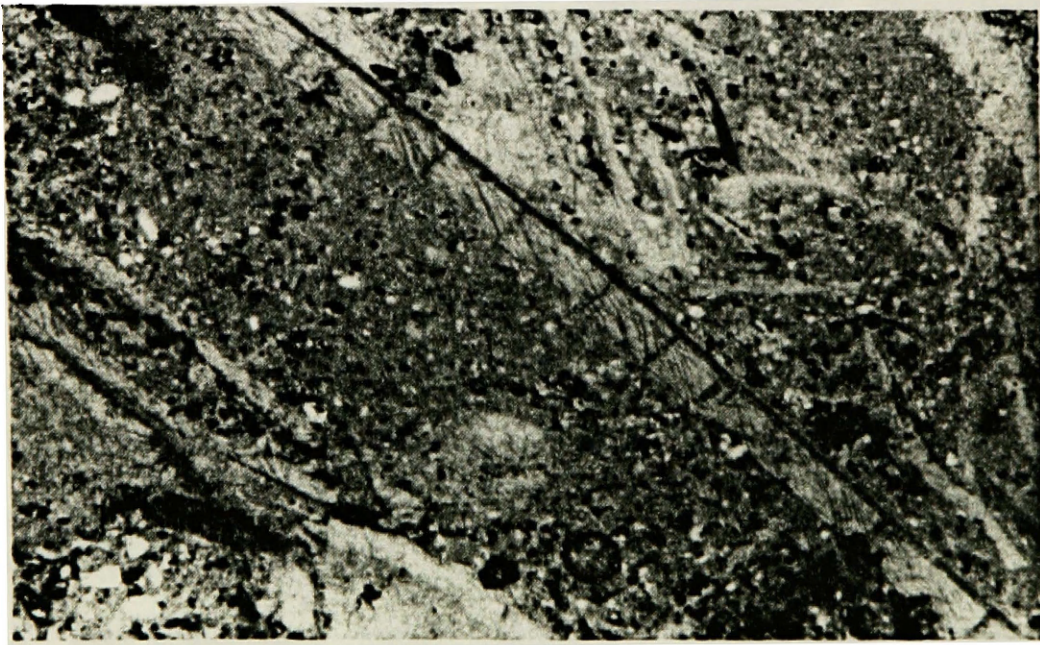
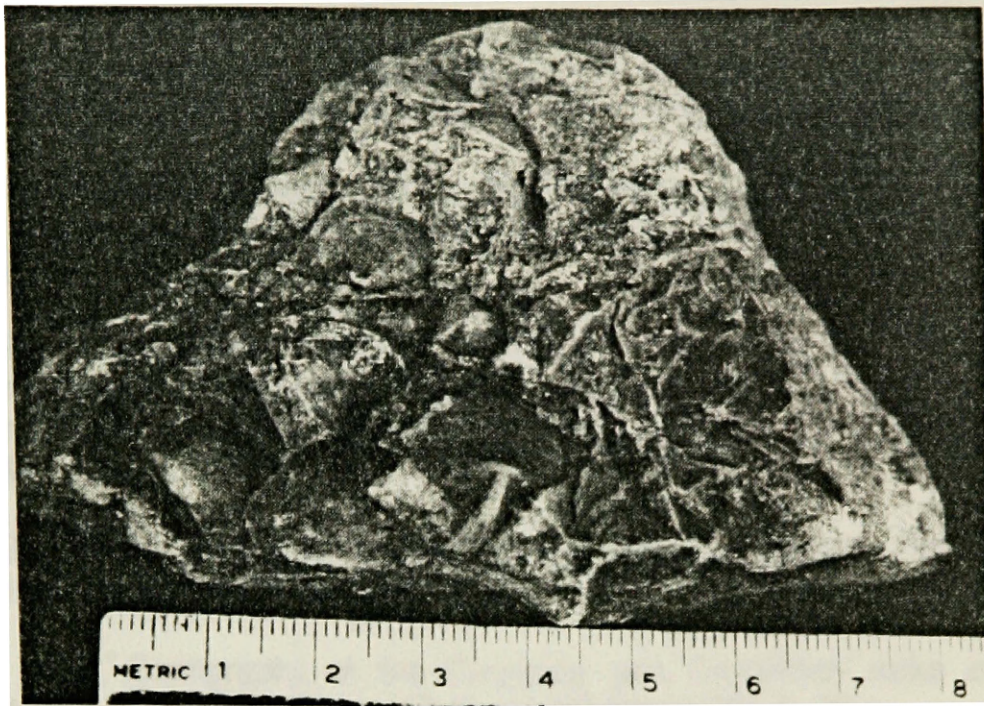


Figure 44. Articulate brachiopods.

- A. Hand specimen of brachiopod packstone (sample 4-12).
- B. Photomicrograph of brachiopod shell displaying well defined punctae (sample 5-8), field of view is 7 mm.

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