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MIDDLE AND UPPER ORDOVICIAN BIOGENIC STRUCTURES AND PALEOENVIRONMENTS, SOUTHERN NEVADA[1]

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ABSTRACT: The Ordovician Eureka Quartzite–lowermost Ely Springs Dolomite sequence in the Arrow Canyon Range, southern Nevada, can be divided into five lithofacies, each with a characteristic set of physical and biogenic structures, fossils and lithologies. This succession of lithofacies reflects changes in depositional processes from those prevalent in modern shoreface zones (Eureka Quartzite) to those dominant in offshore environments (Ely Springs Dolomite). The lithofacies resulting from high energy depositional processes, such as those active in modern shoreface and shoal environments, are characterized by dwelling burrows (including *Skolithos*) and escape structures. Sediments deposited under more quiet water conditions have few physical sedimentary structures, are thoroughly bioturbated and contain the trace fossils *Chondrites* and *?Planolites*. Alternation of these lithofacies gives further indication that substrate and related factors control the distribution of organisms producing various biogenic structures.

INTRODUCTION

The Eureka Quartzite and lowermost Ely Springs Dolomite in southern Nevada comprise a Middle to Upper Ordovician sequence of quartzarenite and sandy dolomite. Moderately abundant and diverse biogenic and physical sedimentary structures in these rocks are exposed in the Arrow Canyon Range (Fig. 1). Although the local stratigraphy has been described in some detail (Carss, 1961; Langenheim et al., 1962) and the broad paleoenvironmental setting interpreted (Chamberlin, 1975; Chamberlin and Langenheim, 1976), detailed paleoecological analysis of the sequence has not been attempted. On the basis of both published stratigraphic data and detailed examination of the rocks, physical sedimentary structures and lebensspuren, this paper presents an integrated paleoenvironmental interpretation of these shallow water deposits, and discusses factors controlling the distribution of associated biogenic structures.

STRATIGRAPHY

In the Arrow Canyon Range, the Ordovician System includes three major rock units: The Pogonip Group, the Eureka Quartzite, and the Ely Springs Dolomite. The Pogonip Group has been studied by Hintze (1951), Nolan et al. (1956), Webb (1956, 1958), Stricker (1973), and Stricker and Carozzi (1973); in the Arrow Canyon Range it includes about 730 meters of limestone and dolomite (Langenheim et al., 1962). Webb (1958) considers the contact between the Pogonip Group and Eureka Quartzite to be disconformable throughout much of central Nevada.

As defined by Kirk (1933) the Eureka Quartzite is a white sandstone with associated sandy dolomite. At the Silica Quarry locality (Fig. 1) the quartzarenite is about 30 m thick. It is overlain by the Ely Springs Dolomite, consisting of 120 to 150 m of gray dolomite, including a basal sandy dolomite. The Ely Springs has been described by Westgate and Knopf (1932), Johnson and Hibbard (1957), Carss (1961), Langenheim et al. (1962), Byrd (1970) and others. Workers have disagreed on the placement of the Eureka–Ely Springs contact [top of lithofacies D on fig. 2 (Webb, 1956, p. 52); top of lithofacies B (Langenheim et al., 1962)] but have agreed that it is unconformable. I regard the lowermost dolomitic unit, a massive bed of dolomitic quartzarenite (lithofacies B, Fig. 2), as the base of the Ely Springs Dolomite and see no physical evidence of an unconformity between it and the under-

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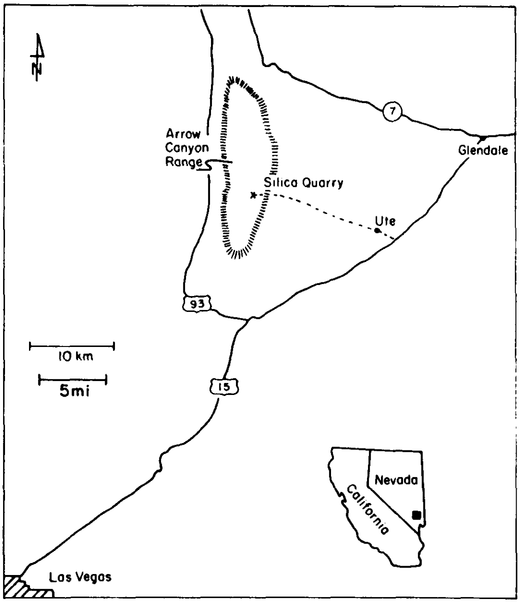

FIG. 1.—Silica Quarry locality on the east side of Arrow Canyon Range, Clark County, southern Nevada. The map reference is United States Geological Survey 15' topographic map series, Arrow Canyon Quadrangle, Nevada.

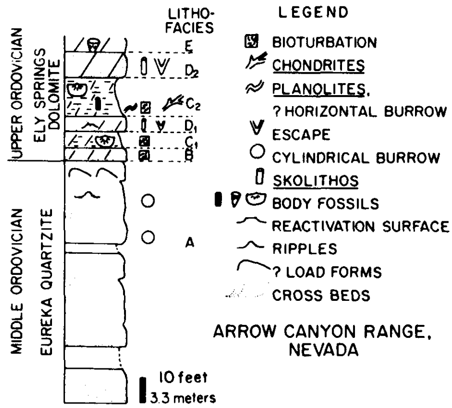

FIG. 2.—Generalized stratigraphic column of the Eureka Quartzite-lowermost Ely Springs Dolomite exposed at the Silica Quarry locality.

lying Eureka Quartzite (Miller, 1975a); Chamberlin and Langenheim (1976) concur with this interpretation. Working farther north, Byrd (1970) also came to the same conclusion.

Age relations of the units, based largely on faunal evidence, are not clear. Webb (1958, Fig. 6) indicated that the Eureka Quartzite is middle to late Trentonian, with the upper portions possibly being Edenian. Corals collected by C. A. Nelson from the Eureka Quartzite at Cortez, Nevada, although poorly preserved, were judged by W. A. Oliver, Jr. (1958, personal communication to C. A. Nelson) to be post-early Trentonian but pre-Richmondian. Although the brachiopods occurring in the lowermost Ely Springs Dolomite are generally considered to be Richmondian (Kettenring, 1975), Langenheim et al. (1962, p. 599) suggest that they may be Edenian. Carss (1961, p. 20) interpreted the conodont fauna as early Maysvillian, but Chamberlin (1975) indicated that some of the elements belong to Sweet et al.'s (1971, Fig. 1) fauna No. 10 (Edenian and pre-Edenian) although most are included in fauna No. 11 (late Edenian to Maysvillian). Given that the Eureka Quartzite has been interpreted as deposited partly in the Edenian as well as in the middle to late Trentonian, and that the Ely Springs Dolomite fauna is probably late Edenian to early Maysvillian, the age relations as presently understood do not necessarily indicate a significant depositional hiatus. In light of the lack of physical evidence to the contrary, it is reasonable to interpret the Eureka-Ely Springs sequence in the Arrow Canyon Range as representing continuous, or nearly continuous, deposition.

Silica Quarry Section

The Eureka Quartzite-Ely Springs Dolomite sequence at the Silica Quarry is here divided into five lithofacies labelled A through E in Fig. 2. Lithologies, sedimentary structures and fossil contents are summarized in Table 1. Grain size data were obtained from thin sections by counting 100 grid points. Carbonate was determined to be dolomite by staining according to the method of Katz and Friedman (1965).

Lithofacies A.—The Eureka Quartzite (lithofacies A) is quartzarenite composed entirely of quartz grains cemented by silica overgrowths. Physical sedimentary structures include widespread, although not ubiquitous, high angle cross-bedding (15 to 20 degrees) and rare rippled surfaces. Bed thicknesses range from 20 cm to over 100 cm. Near the top of the unit large laminated domed structures occur in a zone about 1.5 m thick. They range from 17 to 125 cm across and from 16 to 33 cm high;

TABLE 1.—*Lithologic and faunal characteristics of lithofacies A through E of the Eureka Quartzite-lowermost Ely Springs Dolomite sequence and their environmental interpretation*

Lithofacies	Lithology	Physical Sedimentary Structures	Biogenic Structures	Fossils	Modern Environment with Similar Depositional Processes
E	Medium crystalline fossiliferous dolomite	None	None	Rugose corals	Offshore
D	Fine sandstone: dolomite quartzarenite	Cross-bedding, large and small scale, including rare herring-bone cross-lamination Parallel lamination Reactivation surfaces	*Skolithos*, Escape structures, Bioturbated texture	None	Shoal, partially tidally dominated
C: C_2	Silty finely crystalline dolomite	Parallel lamination (rare)	*Chondrites*, *?Planolites*, Horizontal burrow Bioturbated texture	Brachiopods, crinoids	Offshore
C: C_1	Very fine sandstone dolomitic quartzarenite Silty finely crystalline dolomite	Parallel lamination	Bioturbated texture	Crinoids, brachiopods (rare)	
B	Fine sandstone: dolomitic siliceous quartzarenite	None	Bioturbated texture, ?Arthropod burrows	None	Lower shoreface
A	Fine sandstone: siliceous quartzarenite	Cross-bedding, including rare trough cross beds Load structures Ripple marks (rare)	Cylindrical burrows	None	Shoreface

the laminae range from about 2 to 10 mm in thickness. These dome-shaped structures are interpreted as load forms, for they closely resemble the load structures produced experimentally by Anketell et al. (1970) (Miller, 1975b).

Lithofacies B.—This lithofacies occurs at the base of the Ely Springs Dolomite where it is represented by a single 1.3-m thick bed of highly bioturbated dolomitic quartzarenite. The upper surface of this bed is covered with elongate nodules of predominately silica-cemented quartzarenite which may be arthropod burrows.

Lithofacies C.—The reddish brown, thinly bedded silty to sandy dolomite comprising lithofacies C is exposed only in a small road-cut. Although physical sedimentary structures are generally obliterated by bioturbation, some parallel laminae are preserved. Lithofacies C occurs twice in the vertical section. In the upper of the two occurrences, designated sublithofacies C_2 in Fig. 2, the rock consists of silty dolomite with layers of abundant well-preserved brachiopods (*Strophomena, Diceromyonia, Platystrophia*; Carss, 1961; Kettenring, 1975) and crinoids which show little evidence of transportation. The terrigenous fraction in rocks of sublithofacies C_1 is coarser grained near the base, becoming finer upwards. Fossils are less abundant than in sublithofacies C_2, and include only crinoid plates and one brachiopod genus. Bioturbation has been less intense and horizontal laminations are more abundant.

Lithofacies D.—Both large and small scale cross-bedding as defined by Reinecke and Singh (1973, p. 85) are common in the dolomitic sandstone of lithofacies D, as are horizontal laminations of diverse thicknesses and beds of disturbed sediment (Fig. 3a). Reactivation surfaces as described by Klein (1970) and small scale herringbone cross-lamination are present but rare.

Only at the Silica Quarry are there two distinct occurrences of lithofacies D within the vertical sequence. Elsewhere in the immediate area (within a 1.6-km radius of the Silica Quarry) the thickness of the lithofacies does not exceed 3 to 6 m; five kilometers to the southwest the strongly cross-bedded sandy dolomite is not present.

Lithofacies E.—Comprising the upper portion of the lowermost Ely Springs Dolomite, lithofacies E is gray, recrystallized dolomite with a small amount of very fine-grained insoluable residue. Undisturbed rugose corals are present and fragments of other recrystallized fossils can be seen in thin section.

FIG. 3.—Rock representative of lithofacies D showing bioturbated texture (top), parallel lamination, and large scale cross-bedding (× 6).

BIOGENIC STRUCTURES

Lithofacies A

Cylindrical burrows 7 to 14 mm in diameter (Fig. 4a) are locally abundant on bedding surfaces. Round or elliptical areas 5 to 14 mm in longest dimension, which are also burrows, occur on weathered vertical and bedding surfaces. These are generally not discernable on unweathered surfaces because of the homogeneity of the quartzarenite, but are visible in radiographs of thin slices of the rock.

The cylindrical burrows resemble *Skolithos*, which are considered to be the dwelling burrows of sedentary suspension feeding organisms such as phoronids and some polychaetes (Fenton and Fenton, 1934; Osgood, 1970).

Lithofacies B

Any lamination originally present in lithofacies B has been obliterated by burrowing activity, the entire unit having a bioturbated texture.