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SKOLITHOS LINEARIS HALDEMAN FROM THE CARRARA FORMATION (CAMBRIAN) OF CALIFORNIA

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ABSTRACT—*Skolithos linearis* Haldeman is reported from the Carrara Formation of the Nopah Range, California. The trace is Middle Cambrian in age based on stratigraphic position. Paleobiology of the trace and possible inhabiting organism are discussed.

INTRODUCTION

DURING a field survey of the trace fossils of the Carrara Formation (Lower and Middle Cambrian) and lithologic equivalents, a float block containing 11 examples of the ichnospecies *Skolithos linearis* Haldeman was found. The float block was found in the Nopah Mountains, California (Figure 1), in the Jangle Limestone member (Middle Cambrian) of the Carrara Formation. Although the sample is from float it can be assigned to the uppermost unit in the Jangle Limestone based on its distinctive clean, siltstone lithology. The *Skolithos* burrows, are associated with sedimentary structures which are termed "disturbed zones," in vertical cross-section, and "sediment mounds," on the bedding plane. These features reveal some of the life habits of the organism that inhabited the *Skolithos* burrow.

Skolithos linearis is also known from two other localities in California, the Marble Mountains (unpublished data) and the White-Inyo Mountains (Alpert, 1975; Figure 1).

SYSTEMATIC PALEONTOLOGY

SKOLITHOS LINEARIS Haldeman, 1840
Figures 2A–F, 3

See: Alpert (1974) for synonymy of *Skolithos linearis* Haldeman.

Description.—Shaft diameter ranges from 3.5 to 4.5 mm. Cylindrical in cross-section. Shaft vertical to inclined (68°) with straight or slightly irregular walls. Wall distinct. Length 40 mm or more.

Discussion.—*Skolithos linearis* from the Nopah Mountains differ from *S. linearis* from the Marble Mountains and the White-Inyo Mountains by limited range of diameters (Alpert, 1974, 1975; Sundberg, unpublished data) and the lack of known curved specimens. Alpert (pers. commun., 1981) believes that the above differences between my specimens and specimens of *S. linearis* are not significant enough to warrant a new species. I am at present in agreement with Alpert's comments. *S. linearis* is similar to *S. verticalis* (Hall) but differs in the latter's smaller shaft diameter and being commonly curved (Alpert, 1974). *S. linearis* differs from *S. mag-*

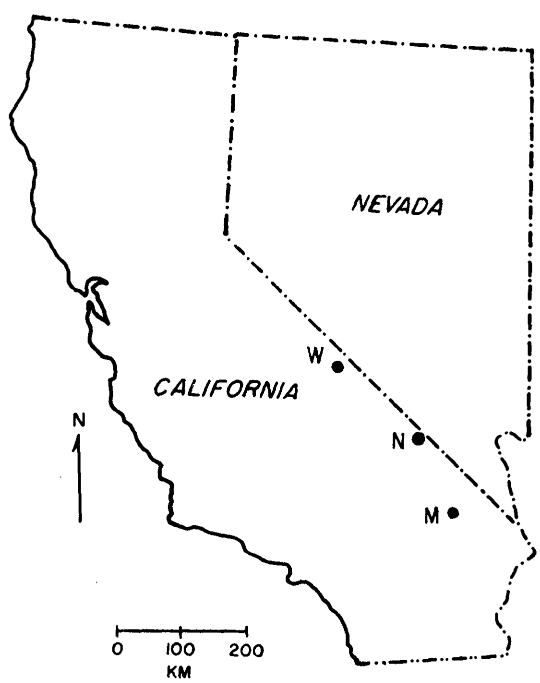

FIGURE *1*—Location map for the Nopah Mountains (N), White-Inyo Mountains (W) and the Marble Mountains (M), California, where *Skolithos linearis* is known to occur.

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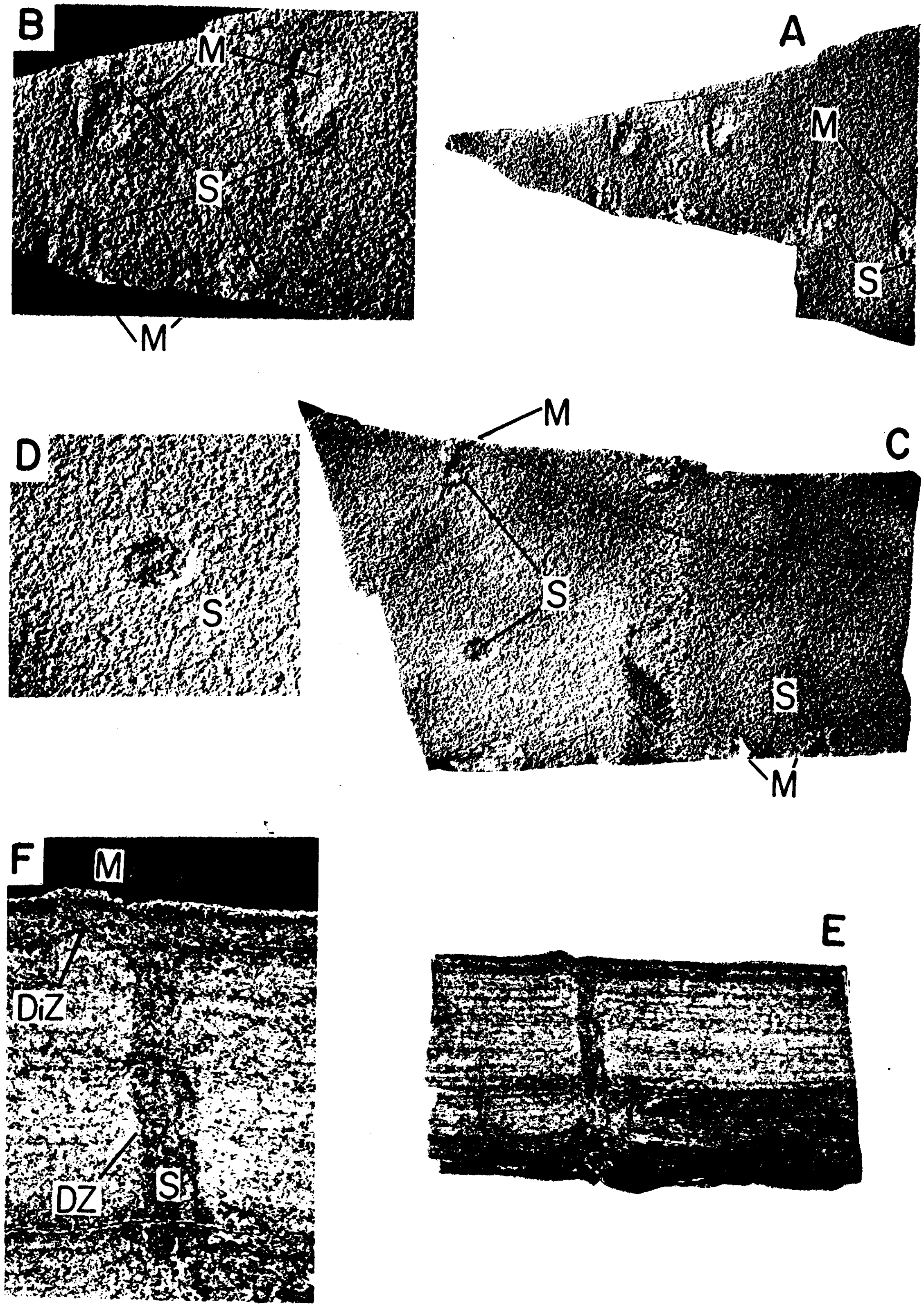
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nus Howell, *S. ingens* Howell, *S. annulatus* (Howell) and *S. bulbus* Alpert by the latter's larger diameters, the presence of annulations and/or bulbous expansions (Alpert, 1974, 1975).

The length of *Skolithos linearis* may be more than the stated 40 mm—the rock slab which contains the specimens is only 40 mm thick.

The presence of the disturbed zones next to the burrows (Figures 2E, F) and the sediment mounds (Figures 2A–C) are taken as secondary features of the burrows and not significant in determining the species. This non-significance is related to the type of sediment in which the burrow is present (i.e., laminated and cohesive sediments may show these two features but not massive fluid sediments). No other species of *Skolithos* are known to illustrate these sedimentological features.

Type specimens.—Hypotypes: University of California, Los Angeles, Department of Geology (UCLA), 59222, 59223, 59224.

Occurrence.—*S. linearis* was found in a float block which, because of its lithology and occurrence on the slope, can be assigned to a siltstone layer in the upper Jangle Limestone member of the Carrara Formation. UCLA Loc. 6938, Emigrant Pass, southern Nopah Range, Inyo County, California.

Age.—No associated fossils were found with *S. linearis* but the Jangle Limestone in other areas contain faunas diagnostic of the upper *Albertella* and lower *Glossopleura* Biozones (Palmer and Halley, 1979). The siltstone horizon from which the fossils came is in the uppermost part of the Jangle Limestone and may be lower *Glossopleura* Biochron in age.

PALEOBIOLOGY

Skolithos linearis is unique in the preservation of sediment mounds (disturbed zones in cross-section) associated with it. Although these features are not part of the burrow itself, they reveal some life habits of the species which created the burrow. The mound is a pile of sediment directly associated with the burrow and is also present on only one side of the burrow (Figures 2A–D). On the rock slab found, there is no apparent preferred orientation of the mounds (Figures 2A, B). On most of the burrows, the mounds overlap onto the burrow opening, but on others these mounds do not overlap or are not present. In cross-section the sediment mound is represented by the disturbed zone. The disturbed zone is a zone adjacent to the burrow in which laminations are not present or bowed upwards (Figures 2E, F; 3). A small zone of distortion is present around the burrow, but the larger disturbed zone when present, is only on one side (Figure 3).

The interpretation placed upon these mounds of sediment and the disturbed zone

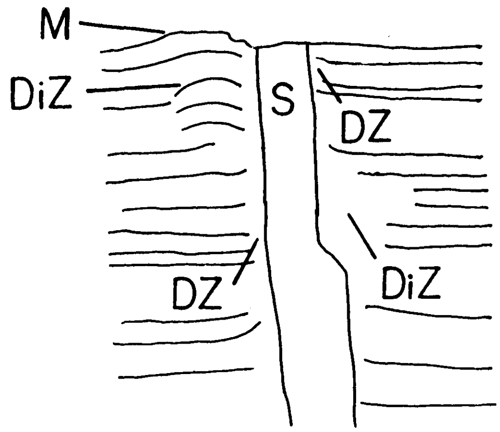

FIGURE 3—Schematic drawing of the cross-section of *Skolithos linearis* showing: S = shaft, DZ = distorted zone, and DiZ = disturbed zone. Same specimen as in Figures 2E, F.

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FIGURE 2—*Skolithos linearis* Haldeman, Carrara Formation, Nopah Mountains, California. UCLA Loc. 6938. Specimens in Figures *A–D* are coated with ammonium chloride sublimate. S = shaft, M = sediment mound, DiZ = disturbed zone, DZ = distorted zone. UCLA = University of California, Los Angeles, Geology Department. *A*, top surface of hypotype UCLA 59222, ×1. *B*, enlargement of a portion of *A*, showing burrow features. Note the sediment mound (M) overlapping shaft (S) in upper right corner specimen, ×2. *C*, top surface of hypotype UCLA 59223, ×1. *D*, enlargement of a portion of *C* showing shaft (S) without sediment mound, ×2. *E*, cross-section of hypotype UCLA 59224, ×1. *F*, enlargement of a part of *E*, showing burrow features, ×2.5. See Figure 3 for schematic drawing.

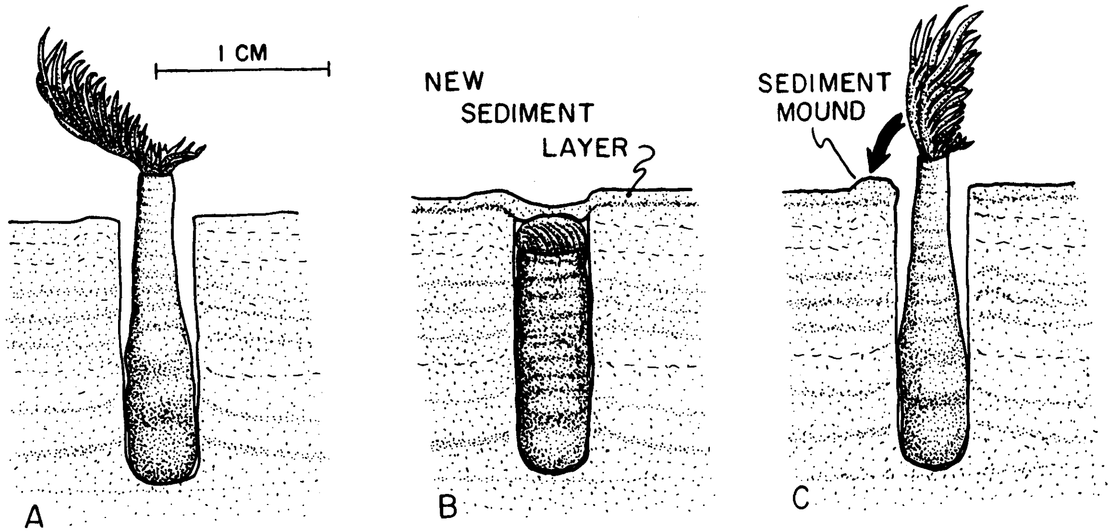

FIGURE 4—Reconstructions of the hypothetical organism inhabiting *Skolithos linearis*. *A*, organism during low turbidity conditions with tentacles full extended to gather food. *B*, position of organism during time of high turbidity of sedimentation with tentacles folded inwards. *C*, the organism emerging and unfolding its tentacles at the end of a high sedimentation period. The arrow indicates the direction of sediment movement of the tentacles to form the sediment mound. Reconstructions based on sedimentary features found in and near *S. linearis* and life habits of phoronids (Hyman, 1959).

(cross-sections of mounds) is as a sediment plug of the burrow, discarded by the animal living within the burrow. It is possible that the mounds represent fecal material extruded by the animal, but the lack of organic matter and its coarse grained nature suggests that it is not fecal in origin. It is also possible that the mounds represent plugs of sediment pushed out of an escape structure by an organism, but both the slow accumulation of sediments, as indicated by laminated sediments and the lack of horizontal or other trace fossils suggest the burrows were dwelling structures.

The distortion zone around the burrow is interpreted as the results of the organism's vertical movement in its burrow, perhaps during the process of removing the sediment plug.

The organism itself was probably a suspension feeder of some type. The suspension feeding habit is suggested primarily by the vertical nature of the shafts and the lack of mud and organic detritus in the sediments. The exact type of organism is unknown. Fenton and Fenton (1934) have suggested that *Skolithos* was a dwelling tube for a representative of Phoronidea, but Osgood (1975) pointed out that modern polychaetes have similar burrows. It is also possible that *Skolithos* is a dwelling tube for some unknown taxon of Middle Cambrian worm.

The "horseshoe" tentacle arrangement of recent phoronids is used in the following reconstruction because of its more primitive nature (Hyman, 1959) and because the dorsally distributed nature would produce a sediment mound on only one side of the burrow. Figure 4A illustrates the life position of a hypothetical worm during non- or slow sedimentation rate. Being a suspension feeder it probably had extendable tentacles, or a similar structure, for filtering out plankton. During times of high turbidity and sedimentation, the worm retracted into its burrow (Figure 4B). Both phoronids and polychaetes live unattached in their burrows (Hyman, 1959; Tasch, 1980) and retract vertically into their burrows by contraction of the body. Phoronids during retraction fold their tentacles inward (Hyman, 1959) which would create a plug in the tube to keep sediment out. When quiescent or periods of lower turbidity occurred the organism would emerge from its burrow. While emerging and unfolding its tentacles, the sediment, which filled the top of the burrow, would be lifted up and thrown backwards (dorsally) off the organism, forming the sediment mound (Figure 4C).

ECOLOGY

The environment in which *Skolithos linearis* existed was probably shallow subtidal. *S. linearis* was found in a clean siltstone closely associated with the lime-mudstone lithofacies of Palmer and Halley (1979). They interpret this lithofacies to be subtidal on the cratonward side of an algal barrier bar. The lime-mudstone and algal lithofacies are part of the Middle Carbonate Belt of Palmer (1960). The siltstone unit in the Jangle Limestone and other terrigenous units in the Carrara are part of Palmer's Inner Detrital Belt.

The occurrence of the burrow in the clean siltstone indicates that the organism existed in relatively clear, well aerated waters. Water movement was minimal as indicated by the laminated sediments. Periods of higher water energy are indicated by ripple marks also in the siltstone. Higher energy sedimentary features are not present, and thus the sediments were probably laid down below normal wave base.

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