

## EDIACARAN FOSSILS FROM THE SOUTHWESTERN GREAT BASIN, UNITED STATES

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**ABSTRACT**—Ediacaran fossils from the southwestern Great Basin may help constrain regional Vendian-Cambrian biostratigraphy and provide biogeographic links between facies in this region and elsewhere. Locally, trace fossils suggest the Vendian-Cambrian boundary occurs within or below the upper third of the lower member of the Wood Canyon Formation. Ediacaran soft-bodied and tubular fossils, including the frondlike fossil *Swartpuntia* and tubular, mineralized or agglutinated fossils similar to *Archaieichnium*, *Cloudina*, *Corumbella*, and *Onuphionella* occur in the lowermost Wood Canyon Formation. Discoidal forms referred to *Nimbia* occur in both the lowermost Wood Canyon Formation and the underlying strata of the Stirling Quartzite. These fossils occur directly below Lower Cambrian trace fossils, including *Treptichnus pedum*, and confirm the persistence of the Ediacaran biota to near the base of the Cambrian. These faunas may also help strengthen previously proposed correlation schemes between the two main facies belts of the southwestern Great Basin (the Death Valley and White-Inyo facies), because a nearly identical Vendian-lowest Cambrian succession of faunas occurs in both regions. Lastly, lack of cosmopolitan Ediacaran faunas in these strata suggests a paleobiogeographic link between the southwestern U.S. and southern Africa in Vendian time.

### INTRODUCTION

**T**HE SOUTHWESTERN part of the Great Basin of the western United States is known for extensive exposures of Proterozoic strata (Stewart, 1970; Christie-Blick and Levy, 1989). However, this region generally lacks Ediacaran-type fossils. Furthermore, it has been difficult to pinpoint the Vendian-Cambrian boundary within sections in this region. In the Death Valley region, this difficulty stems from the lack of carbonate-dominated strata available for constructing chemostratigraphic profiles (Corsetti, 1993), the numerous regional disconformities (Corsetti and Kaufman, 1994), and the lack of fossils from the two units thought to straddle the boundary—the Wood Canyon Formation and the underlying Stirling Quartzite. Recent work has greatly improved our understanding of this interval (Horodyski, 1991; Corsetti, 1993, 1998; Horodyski et al., 1994; Runnegar et al., 1995; Runnegar, 1998), and our field research corroborates suggestions that the Vendian-Cambrian boundary lies within the lower member of the Wood Canyon Formation (hereafter lmWCF). Herein we document a new assemblage of Ediacaran-type fossils from immediately below the Vendian-Cambrian boundary, including soft-bodied fossils as well as four morphotypes of elongate tubelike fossils (Waggoner and Hagadorn, 1997; Hagadorn and Waggoner, 1998). This assemblage is of interest: because it helps constrain the position of the Precambrian-Cambrian boundary in the Death Valley facies of the southwestern Great Basin; because it provides additional correlation points between the major facies of the region (including the Death Valley, White-Inyo, and Caborca regions); and because it suggests larger-scale paleobiogeographic links between southwest Laurentia and Gondwanan cratons in latest Vendian time.

**Previous research.**—Langille (1974a, 1974b) documented conical calcareous fossils from the Funeral Mountains, California, from carbonates in the D member of the Stirling Quartzite. These fossils occur within a thinly-bedded, vuggy, dolomitic lag and may represent abraded specimens of the well-known mineralized form *Cloudina*. They also resemble the shelly fossil *Wyattia*, known from the upper Reed Dolomite in the Inyo Mountains (Taylor, 1966; Cloud and Nelson, 1966) and may indicate stratigraphic equivalence of these units (Stewart, 1970). Alternatively, they may represent a new genus (McMenamin, 1998), but are probably too poorly preserved to be confidently assigned to a particular genus.

Horodyski (1991) documented a nearly complete specimen of the ribbed, saclike fossil *Ernietta* from the Montgomery Mountains, Nevada. Further research confirmed that it came from the lowest of three parasequences within the lmWCF (Horodyski et al., 1994). *Phycodes pedum* (now *Treptichnus pedum*; see Jensen, 1997) was documented from the uppermost of these parasequence sets and suggests that the Precambrian-Cambrian boundary lies within or near the middle of the lmWCF in the Death Valley region (Horodyski et al., 1994).

**Localities and stratigraphy.**—In the southwestern Great Basin, the Vendian-Cambrian boundary occurs within a 1 km-thick, northwestward-thickening siliciclastic-dominated succession of miogeoclinal sediments (Prave et al., 1991) that records the development of a passive margin along southwestern Laurentia (Stewart, 1982). Our research focuses on exposures of the Stirling Quartzite and overlying Wood Canyon Formation in the Funeral Mountains, Montgomery Mountains, Nopah Range, Resting Springs Range, and Spring Mountains of eastern California and western Nevada (Fig. 1; see Burchfiel et al., 1982 for a regional overview). In this region, the Stirling Quartzite is divided into five informal members (A through E) and the Wood Canyon Formation is divided into lower, middle, and upper members (Stewart, 1970). The upper Stirling is a medium to coarse quartz arenite that interfingers with, and is conformably overlain by, the lower member of the Wood Canyon Formation (Wertz, 1982). The lower and middle members of the Wood Canyon Formation record a shallow marine-continental braidplain transition (Diehl, 1979; Fedo and Cooper, 1990; Fedo and Prave, 1991), with the lower member recording a highstand systems tract consisting of three carbonate-capped parasequences (Prave et al., 1991; Horodyski et al., 1994; Runnegar et al., 1995). The uppermost parasequence is disconformably overlain by the fluvially-dominated terrestrial braidplain and braid-delta facies of the middle Wood Canyon Formation (Diehl, 1979; Fedo and Prave, 1991). The upper Wood Canyon represents a return to dominantly marine conditions (Fedo and Cooper, 1990), with abundant body and trace fossils typical of the Early Cambrian (Hunt, 1990; Fedo and Prave, 1991; Mount et al., 1991).

The oldest fossils documented here come from the uppermost Stirling Quartzite, from a locality in the Montgomery Mountains in southern Nye County, Nevada, near the ghost town of Johnnie (LACMNH loc. 17129). Most of our fossils have come from a

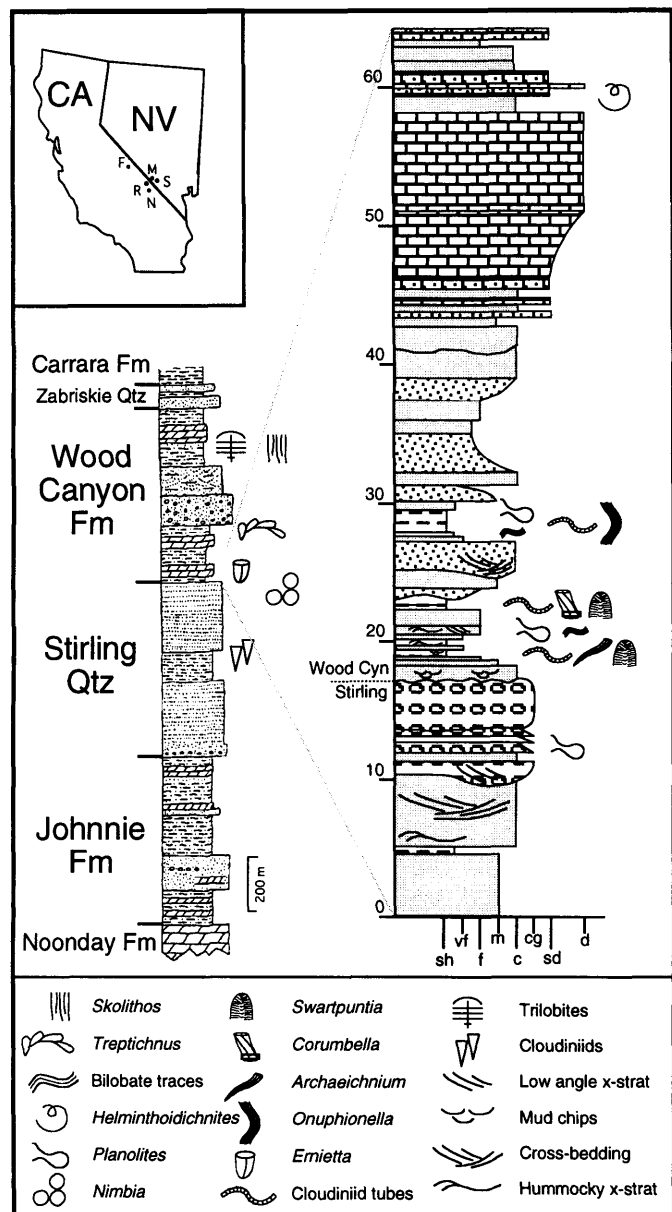


FIGURE 1—Generalized regional stratigraphy, modified from Prave et al. (1991), with composite measured section indicating principal fossiliferous horizons. Lithologies indicated as follows: sh = shale; vf-f-c = very fine-fine-coarse sandstone; cg = coarse-pebbly sandstone and conglomerate; sd = sandy dolostone; d = dolostone. Localities (inset) include the Montgomery Mountains (M; LACMNH locs. 17129, 17130), Nopah Range (N; LACMNH locs. 17132, 17133), and Spring Mountains (S; LACMNH loc. 17131). Additional material has been observed in the Resting Springs Range (R) and the Funeral Mountains (F; Langille, 1974a, 1974b).

single locality in the ImWCF, also located in the Montgomery Mountains not far from Johnnie (LACMNH loc. 17130). Additional localities are in the southern Nopah Range, in southern Inyo County, California (LACMNH locs. 17132, 17133). A few fossils have been found in the ImWCF in the Spring Mountains, across Pahrump Valley from the Montgomery Mountains (LACMNH loc. 17131). The Cambrian trace fossil *Treptichnus pedum* was collected from a locality in the Montgomery Mountains (LACMNH loc. 17134) in the ImWCF, but stratigraphically

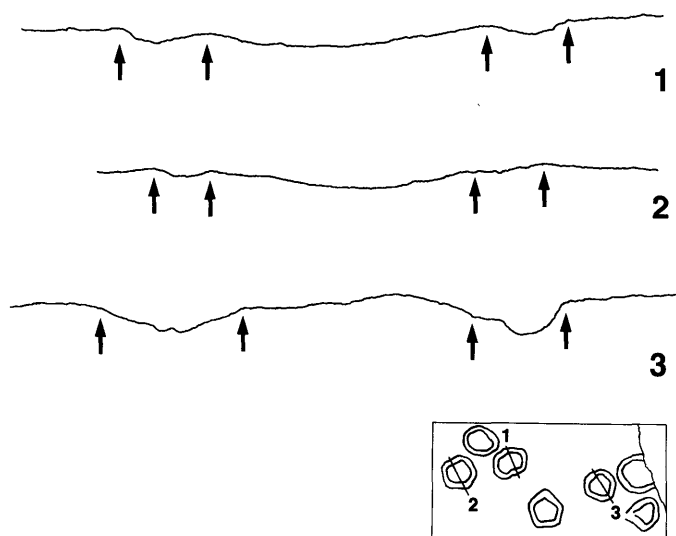


FIGURE 2—Outlines of cross-sections through plaster casts of three individuals of *Nimbria* sp. from the Stirling Quartzite, Montgomery Mountains, near Johnnie, Nye County, Nevada (LACMNH loc. 17129),  $\times 1$ . Arrows indicate boundaries of the depressed rims. Inset diagram shows location of sections on fossil-bearing slab (compare fig. 3.1).

higher than locality 17130. We have visited other localities in the ImWCF in the Funeral Mountains, Resting Spring Mountains, and northern Nopah Range, all in Inyo County, California. Some of these sites have yielded tubular fossils and trace fossils, but these do not affect our systematic descriptions and are not described here. Detailed locality information is given in the Appendix.

#### SYSTEMATIC PALEONTOLOGY

All figured specimens have been curated in the Los Angeles County Museum of Natural History (LACMNH). Casts of some figured specimens, as well as some unfigured topotype material, have been deposited in the University of California Museum of Paleontology (UCMP; curation pending) and in the University of Central Arkansas paleontological collections (UCA).

#### Genus NIMBIA Fedonkin, 1980

Figure 2, 3.1–3.3

*Type species.*—*Nimbria oclusa* Fedonkin, 1980, p. 8, pl. 1, figs. 1, 2.

*Diagnosis.*—(Translated and abridged from Fedonkin, 1985) Flat, discoidal, circular to oval organisms preserved in positive hyporelief. Peripheral part forms a single thick marginal rim. Central portion within the rim is usually smooth and featureless but may have a central tubercle.

*Description.*—Large, ring-shaped structures about 60 mm in diameter, preserved in negative epirelief, consisting of a sunken rim about 10 mm thick with slightly raised edges. Center is typically either slightly sunken or slightly raised (Fig. 2).

*Material and occurrence.*—Member E, Stirling Quartzite, Montgomery Mountains, Nye County, Nevada (LACMNH loc. 17129): Seven specimens on upper surface of one block of quartzite. Originals could not be collected, but casts made from molds have been curated as LACMNH specimens 12790 and 12791.

*Discussion.*—Identification of circular “medusoid” fossils is problematic owing to the abundance of circular dubiofossils during this interval (Cloud, 1960, 1968, personal observations). Although these specimens could be abiogenic sedimentary features, they do not resemble any abiogenic features that we have

seen in this interval. The specimens could not be sectioned, but field inspection of partial specimens along broken slab edges showed no concretion, load, gas escape, or injection features (Fig. 3.3). The apparent distortion visible in some of the specimens suggests that they represent flexible objects (Fig. 3.2). Their consistent morphology and size suggests that they are body fossils which are morphologically similar to the Ediacaran "medusoid" *Nimbia occlusa* (Fedonkin, 1985; BW, personal observations). The only major difference is that the Stirling Quartzite fossils are roughly twice the diameter of typical *N. occlusa*. Raised or sunken centers or central markings, somewhat similar to those seen in our specimens, are sometimes seen in *N. occlusa*.

Genus NIMBIA? Fedonkin 1980  
Figure 3.4

*Description.*—Specimen preserved in convex relief, 30 mm in diameter, with much thinner rim (2 mm in thickness) and indistinct central depression.

*Material and occurrence.*—One specimen (LACMNH 12792). Collected from float in the lower Wood Canyon Formation, southern Nopah Range, Inyo County, California (LACMNH loc. 17133)

*Discussion.*—A single specimen (LACMNH 12792; Fig. 3.4) is smaller than the Stirling Quartzite specimens and has a much narrower rim, and is preserved in positive relief. Because it was not collected in situ, it is not certain whether it preserved in epirelief or hyporelief. The specimen somewhat resembles a looping trace fossil such as *Gordia*, *Helminthoidichnites*, or *Circulichnis*. However, we tentatively refer it to *Nimbia* because of its apparently complete rim and a possible central marking. It falls within the observed size and shape range of *N. occlusa* (Fedonkin, 1985; BW, personal observations).

Genus SWARTPUNTIA Narbonne, Saylor, and Grotzinger, 1997

*Type species.*—*Swartpuntia germsi* Narbonne, Saylor, and Grotzinger, 1997.

*Diagnosis.*—(Modified from Narbonne et al. 1997, p. 959). Ovate, leaf-shaped frond showing unipolar organization. At least three petaloids attached longitudinally to a transversely segmented central stalk; each petaloid a quilted sheet of 2–3 mm-wide segments, with both the length of individual segments and their angle of branching from the central stalk decreasing distally.

SWARTPUNTIA cf. GERMSI Narbonne, Saylor,  
and Grotzinger, 1997  
Figure 4.1–4.3

*Description.*—Frondose organism with segmented central rachis. The most complete specimen has a spindle-shaped central rachis 85 mm long and 11 mm at its widest point, divided into segments 7 to 8 mm long (seven are clearly visible). The rachis is surrounded by a flat, ovate frond with fine parallel striae about 1 mm apart, radiating from the axis at approximately 45 degrees. Examination of the edge suggests that at least two petaloids were present on the rachis, and were superimposed on each other at burial. Estimated total width about 90 mm; estimated total length more than 100 mm.

*Material and occurrence.*—One near-complete specimen (LACMNH 12793); several poorly preserved fragments (not figured). Lower Wood Canyon Formation, Montgomery Mountains, Nye County, Nevada (LACMNH loc. 17130)

*Discussion.*—The most complete specimen of *Swartpuntia* is preserved in epirelief in sandy siltstones just above the Wood Canyon Formation–Stirling Quartzite contact. Although the specimen is incomplete and we have not identified the presence of

a basal stalk, it is nearly identical in all observable characters to the type species, *S. germsi*.

Genus cf. ARCHAIECHNIUM Glaessner, 1963

*Type species.*—*Archaeichnium haughtoni* Glaessner, 1963.

*Diagnosis.*—Cylindrical or conical tubular fossils, round in cross section, 1–5 mm in diameter. Walls of agglutinated sand grains, often showing fine longitudinal lineations; tubes somewhat flexible in life.

cf. ARCHAIECHNIUM sp.  
Figure 3.5, 3.6

*Description.*—Conical tube, tapering from a maximum diameter of 5 mm to a minimum diameter of 3 mm; longest specimen fragment is 29 mm. Longitudinal fracturing of specimen allows wall structure to be examined: wall composed of agglutinated sediment grains of approximately the same grain size as the surrounding matrix. No sharp separation present between wall and surrounding matrix. Weak transverse annulations visible, spaced irregularly but approximately 1 mm apart. Faint, fine longitudinal striations also visible, creating "cross-hatched" effect on surface. Several angular bends along length resemble buckling.

*Material.*—One specimen of an external mold (LACMNH 12794).

*Occurrence.*—Lower Wood Canyon Formation, Montgomery Mountains, Nye County, Nevada (LACMNH loc. 17130).

*Discussion.*—Although only one specimen has been found thus far, the specimen is distinct from all other tubular fossils known from the lowest Wood Canyon Formation. It differs from typical cloudiniids, and from all other tubular fossils described in this paper, in several ways: the wall is agglutinated; the shape is much more conical; the transverse ornament is weak and unevenly spaced; fine longitudinal ridges as well as transverse ridges are present; and the "buckling" suggests that the fossil was flexible rather than strongly mineralized. Although it is possible that this specimen represents a lined burrow, the buckling and slight conical taper are atypical of most trace fossils from this region. This fossil is similar in morphology and size to the agglutinated tube *Archaeichnium haughtoni*, known only from the late Proterozoic of Namibia (Glaessner, 1963, 1978). It differs in possessing fine transverse ornamentation (although this is also occasionally seen in *A. haughtoni*); its longitudinal striae are also much weaker than is typical for the type material. However, since *A. haughtoni* is quite variable (Glaessner, 1978), we prefer not to place our specimen in a species. Further material must be collected to make a firm taxonomic determination.

Genus cf. CLOUDINA Germs, 1972

*Type species.*—*Cloudina hartmannae* Germs, 1972.

*Diagnosis.*—Calcareous tubes, nearly round in cross section, typically curving or sinuous, with cone-in-cone wall structure in longitudinal section. Outer wall bears annular ridges and depressions, inner wall nearly smooth. Ends open.

cf. CLOUDINA sp.  
Figures 3.7–3.10, 5.1–5.3

*Description.*—Narrow, straight or slightly curved, almost cylindrical tubes with minor or no tapering, terminating abruptly. Diameter between 1 and 3 mm; maximum observed length about 35 mm. Both annulated and smooth tubes present. High relief suggests tubes were originally mineralized.

*Material.*—About fifty specimens; figured specimens LACMNH 12795, 12796, 12797, 12798, 12799, 12800, 12801.

*Occurrence.*—Lower Wood Canyon Formation, Montgomery