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SALTERELLA IN THE LOWER CAMBRIAN SHADY DOLOMITE OF SOUTHWESTERN VIRGINIA

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ABSTRACT. The Early Cambrian fossil *Salterella conulata* Clark has been found *in situ* at several places in Virginia. This species occurs near the top of the lower member of the Shady Dolomite about 152 m (500 ft) above the Antietam Quartzite, in the vicinity of Berryville. At Foster's Falls, it occurs about 252 to 260 m (825 to 850 ft) above the equivalent Erwin Quartzite. This species has also been found in subsurface drill cores at the nearby Austinville mining district. An undescribed new species of *Salterella* also occurs in a younger member of the Shady Dolomite at Austinville.

INTRODUCTION

Salterella is a small elongate conical fossil of uncertain affinities occurring in Lower Cambrian rocks. Yochelson (1970) redescribed *Salterella conulata* Clark and documented its occurrence in Lower Cambrian carbonates from Newfoundland southward. The species has potential as a stratigraphic marker within the Shady Dolomite of the southern Appalachians and lateral equivalents of the formation, but use of this fossil for that purpose has been limited in part because many of the occurrences reported are known from collections of uncertain stratigraphic position. Herein, the species is recorded from known intervals within the Shady. Further, not many workers are yet aware of *Salterella* or its potential usefulness. By noting new localities, we hope that others may find this fossil and test its utility in stratigraphic correlation. Fossils are not abundant in the Shady.

In redescribing the species, Yochelson (1970, p. B2-B3) commented upon the original collection of T. H. Clark at the Museum of Comparative Zoology, Harvard University, noting that the types were lost. Subsequently, Dr. Roger Thomas, assistant curator of invertebrate fossils at the museum, has relocated some specimens of the type lot that had been misplaced. These are catalogued as given in Clark (1924, explanation of pl. 2).

Examination of the original material in no way modifies the redescription given by Yochelson (1970, p. B3). Clark's specimens are in part differentially silicified; it is this feature that allowed for the logical deduction that the species was septate. The specimens are illustrated accurately by drawings (Clark, 1924, 1925). The holotype is under MCZ 2335, and the slab illustrated by Clark is present, though unnumbered. of the rest of the specimens, which were a series showing the apparent septate structure, are still missing. MCZ paratypes 2329, 2330, and 2333 are the specimens drawn for figures 1, 2, and 5 of Clark (1924, pl. 2; 1925, pl. 1). A glass vial marked 2334 (original of Clark's fig. 6) is present but broken open at the end so that the specimen may be presumed lost.

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PREVIOUS WORK IN SOUTHWESTERN VIRGINIA

Specimens of *Salterella conulata* which had been weathered free were collected in 1942 by R. L. Miller from the "Shady Umbarger Mine, Sugar Grove, Virginia", near Marion in Smyth County, Va. In discussing the occurrence of the species in Smyth County, Yochelson (1970, B9-B10) overlooked illustrations of nine specimens by Miller (1944, pl. 6A). In that work they were identified by Josiah Bridge as *S. acervulosa*, quite a different species.

Miller's specimens were all obtained near the bottom of a pit being mined for manganese ore. The specimens may have constituted a lag accumulation within a thick residium because Miller (1944, p. 21) reported a residual clay more than 60 m (200 ft) thick above the bedrock. However, at three places in Pennsylvania where *S. conulata* has been observed, specimens are also abundant: it may be that the hundreds of specimens obtained from the Umbarger mine could have come from only a few meters of strata. Unfortunately when the pit was reexamined in 1970, it had filled in completely, so this cannot be checked.

A few loose pieces of limestone in the vicinity of the pit are similar to the fossiliferous part of the Vintage Dolomite in eastern Pennsylvania, though much of the Vintage has similar lithology throughout its thickness. Miller (1944, p. 21) noted that in the general Glade Mountain mining area the Shady Dolomite is about 610 m (2000 ft) thick with a thin basal transition unit less than 15 m (50 ft) thick, the Patterson Limestone Member is about 260 m (850 ft) thick, and an overlying saccharoidal member is about 305 m (1000 ft) thick. He suggested (Miller, 1944, p. 22) that the specimens of *Salterella* "are almost surely derived from the Patterson Member of the Shady Dolomite and probably from its lowest part".

Several subdivisions are recognized within the Shady Dolomite, but various authors have used different terminology for essentially the same units.

SALTERELLA CONULATA ON THE OUTCROP IN VIRGINIA

This species has now been found in place in two widely separated areas (fig. 1). The first is the extreme northern part of the state, near Berryville, Ashby Gap quadrangle, Clark County, Va. This area is about one-fifth of the distance along strike between Waynesboro, Pa., heretofore the most southerly outcrop occurrence and the Austinville region to be discussed below. A collection from West Virginia between Berryville and Waynesboro reported earlier (Yochelson, 1970, p. B9) is from a part of a quarry mined away, and its stratigraphic position is not known with any degree of reliability.

The fossils from the locality near Berryville were collected by Mr. W. E. Nunan, University of North Carolina, and kindly donated to the U.S. Geological Survey. They were obtained from a gray limestone interbedded with light-gray and black dolomite about 152 m (500 ft) above the top of the Antietam Sandstone and about 183 m (600 ft) below

TABLE 1

Stratigraphic terminology for the Shady Dolomite and adjacent formations in southwest Virginia

Butts (1940) Appalachian Valley	Brown and Weinberg 1968 Austinville area		Currier (1935) Austinville area	
Rome-Waynesboro Formation	Rome Formation		Rome Formation	
Shady-Tomstown Dolomite	Shady Dolomite	Carbide Member	Shady Dolomite	Ivanhoe Limestone Member
		Austinville Member		Saccharoidal Dolomite Member
		Ribbon Member		Patterson Limestone Member
Erwin Quartzite-Antietam Sandstone	Erwin Quartzite		Erwin Quartzite	

the base of the Waynesboro Formation. The upper 63 m (200 ft) of the Shady section is a very light gray saccharoidal dolomite in this area.

The fossil locality (USGS 7600-CO) is 6.8 km (4.2 miles), straight-line distance, southeast of the intersection of U. S. Highway 340 and Virginia 7 and 621, in a field on a hill 91 m (300 ft) north of Dog Creek, this hill being 1069 m (3500 ft) upstream from where Highway 521 crosses the creek. Representative specimens are illustrated in plate 2, E to H. The preservation is not quite so good as that of the other

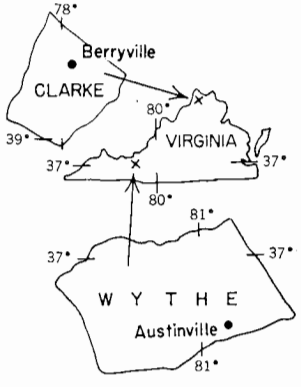


Fig. 1. Locality map showing general areas of *Salterella* occurrence in Clark and Wythe Counties, Va.

PLATE 1

Massive, light-gray banded limestone unit from which *Salterella* was collected, at railway cut, southwest of Fosters Falls, Va. Within the unit is a distinct white marker bed approximately 3 m (10 ft) above the base and 8 m (27 ft) below the top.

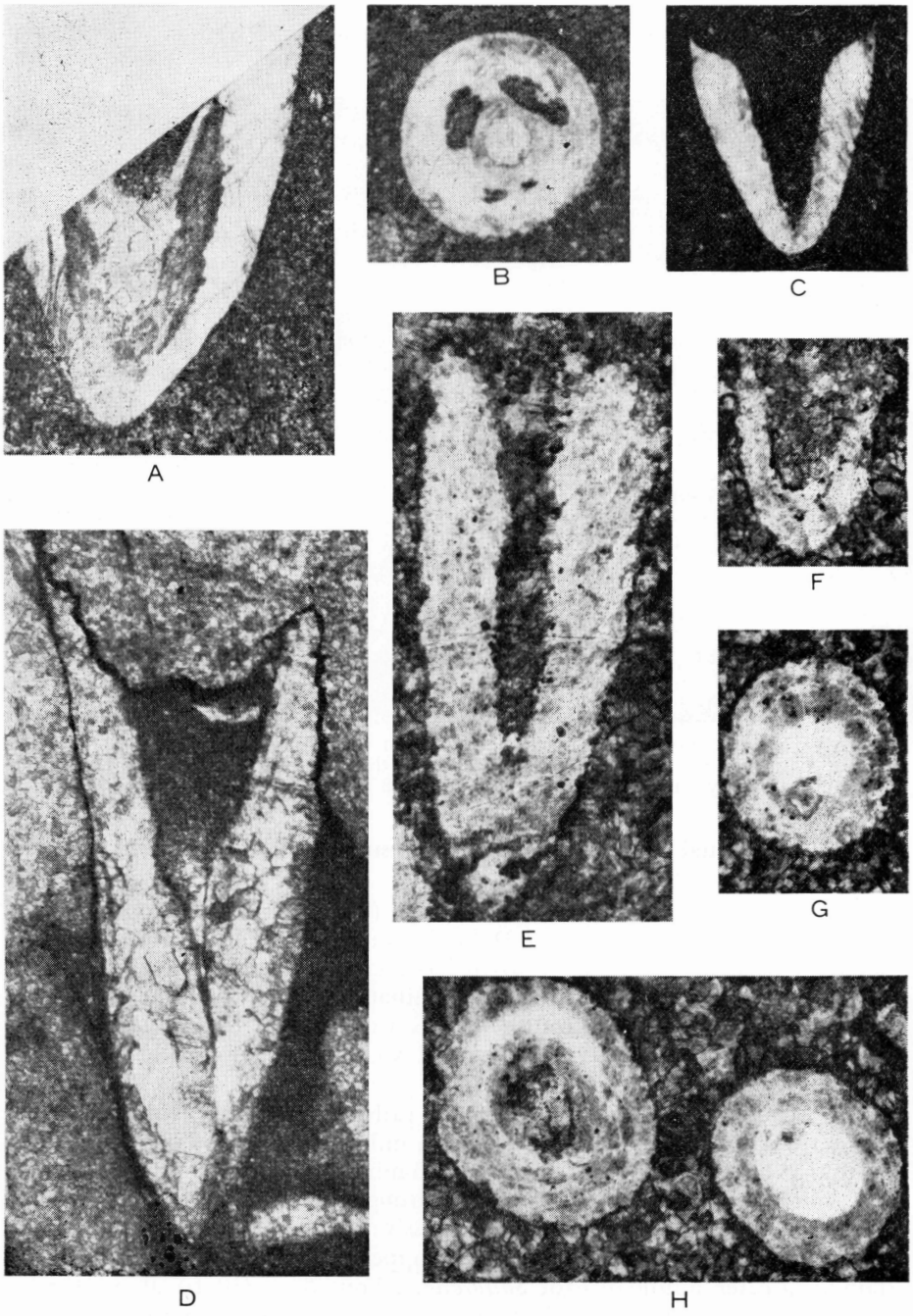
localities reported here; this may be the result of coarse recrystallization of the matrix.

The second area is more than 320 km (200 miles) to the southwest. A regional study of the Shady Dolomite in southwestern Virginia and adjacent parts of Tennessee by Byrd has included detailed measurement of stratigraphic sections as well as examination of hand specimens and thin sections. During the course of this work, *Salterella conulata* was found in only one unit, in the general vicinity of Austinville, Wythe County, Va.

Specimens were obtained along the railway cut of the Norfolk and Western Railroad, 0.3 km (one-fifth of a mile) southwest of the railroad station at Fosters Falls (Max Meadows, 15-minute quadrangle). Generally, the *Salterella* are scattered sparsely throughout the lower part of a medium-gray, argillaceous-streaked, massive bedded limestone (pl. 1) approximately 12 m (40 ft) thick. The upper part of the limestone contains a greater abundance of *Salterella*. About 3 m (10 ft) above the base of this unit is a very distinctive 0.3 m- (1 ft-) thick, white weathering, light-gray, coarsely crystalline dolomite interbedded within the limestone

Samples were collected immediately above the white marker bed (USGS 7598-CO). Some of the specimens are incomplete and broken, sug-

PLATE 2
Thin sections of *Salterella*



A. to C. *Salterella conulata* from the Shady Dolomite at USGS locality 7598-CO, near Fosters Falls, Va.; X15. The specimen in figure 1 is at the edge of a thin section and is incomplete. USNM 192,001-192-003. A and C are transverse sections. B is a cross section.

D. *Salterella conulata* Clark from the Shady Dolomite at USGS locality 7077-CO, cored at Austinville, Va.; X15. USNM 192,004.

E. to H. *Salterella conulata* Clark from the Shady Dolomite at USGS locality 7600-CO, near Berryville, Va.; X15. USNM 192,005, 192,006. E and F are transverse sections; G and H are cross sections.

gesting transport; thin sections of several individuals are shown in plate 2, A to C. The fossils are in limestone clasts created by intense stylolitic solution which concentrated insoluble material between the clasts so that the rock superficially resembles a breccia formed by transport. The original rock type, prior to diagenesis, was a biopelmicrite.

Samples collected from the top of this unit (USGS 7599-CO) contain more numerous specimens of *Salterella* in a medium-gray argillaceous biopelmicrite. The lithology is identical with that of the underlying fossiliferous clasts except that the clasts appear to have been more extensively recrystallized. Representative specimens are illustrated in plate 3, E to I. These specimens are superior in preservation to those at Berryville.

The base of the *Salterella*-bearing biopelmicrite unit is approximately 249 m (816 ft) stratigraphically above the contact with the underlying Erwin Quartzite exposed in the New River and near the railroad station. Samples collected above the white marker bed (USGS 7598-CO) are 252 m (826 ft) above the Erwin, and the samples collected from the top of unit (USGS 7599-CO) are 260 m (850 ft) above the Erwin. This unit appears to be normally imbedded with the Patterson Limestone Member; the underlying bed is a ribbon-laminated, light- to dark-gray, medium- to coarsely-crystalline dolomite, and the overlying bed is a zebra-mottled, light- to dark-gray, medium- to coarsely-crystalline dolomite.

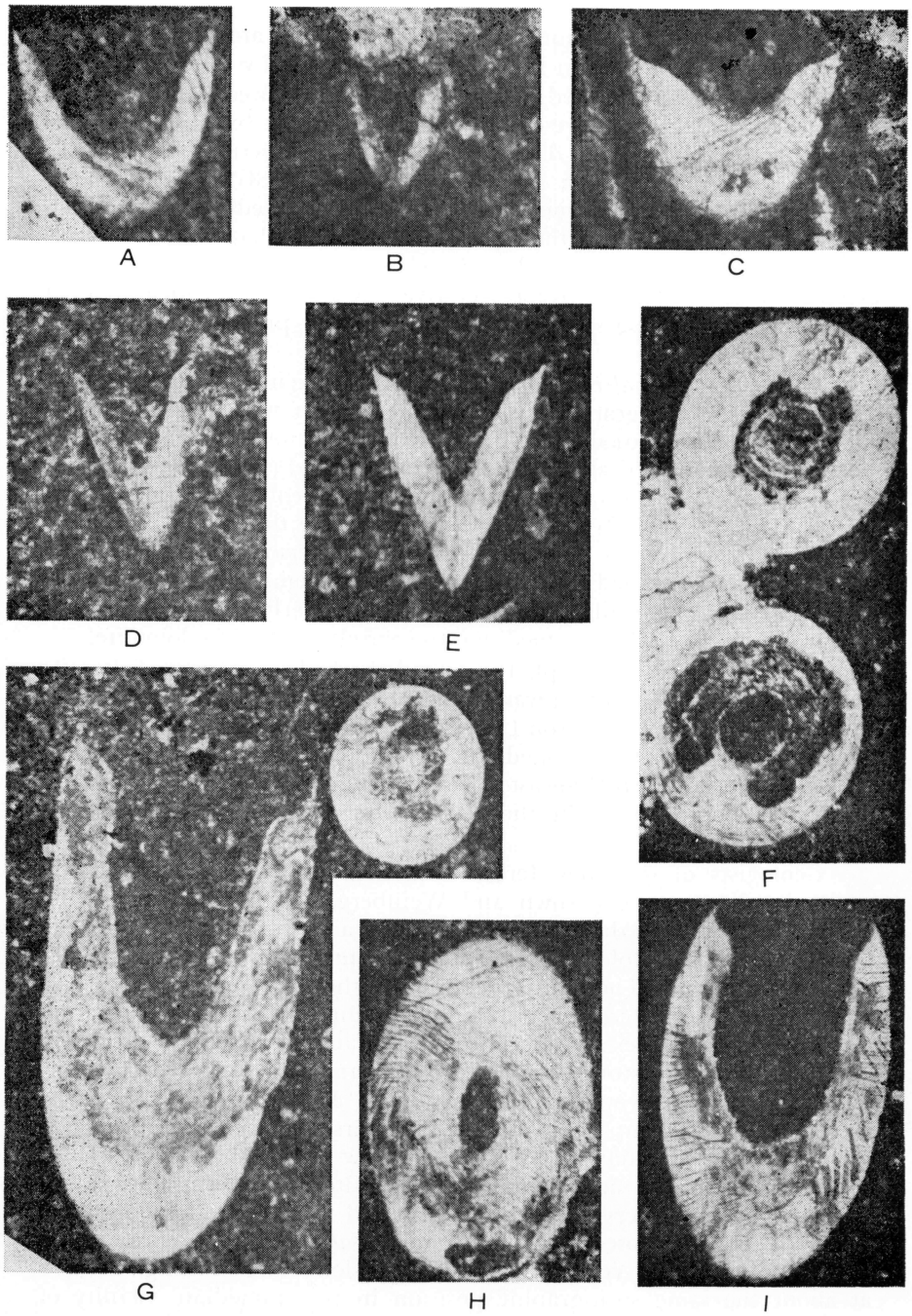
Stose and Jonas (1938, pl. 1) mapped the beds containing *Salterella* as Kinzers Formation, which was thought by them to have been brought into contact with the Patterson Limestone Member of the Shady Dolomite by a thrust fault. They applied the terminology used by them for the Lower Cambrian near Lancaster, Pa., because of lithologic similarity and an obvious change in the Shady from dolomite to fossiliferous limestone.

Geologists of the New Jersey Zinc Company have more recently mapped this sequence (Brown and Weinberg, 1968). They traced the Erwin Quartzite and the "Ribbon Member" and the "Austinville Member" of the Shady Dolomite (see table 1) southwest from Fosters Falls, along the railroad. Their interpretation of the stratigraphy appears to be correct, as the *Salterella*-bearing units are interbedded with the Patterson Member, and there is no major thrust fault disrupting the section. The Patterson Limestone Member, in the terminology used by the Virginia Geological Survey, is equivalent to the "Ribbon Member" used by the New Jersey Company geologists. The first *Salterella* occurrence is therefore approximately 52 m (170 ft) below the "Ribbon-Austinville" contact (or Patterson-saccharoidal contact of alternative terminology), but this stratigraphic interval must be interpreted from maps, for only 14 m (47 ft) of beds is exposed above the younger *Salterella* occurrence.

Examination by Yochelson of outcrops along Virginia Highway 619 at about the same stratigraphic position in the immediate vicinity of Austinville produced many isolated echinoderm fragments but no *Salterella*. *Salterella* was reported from surface exposures (Stose and Jonas,

PLATE 3

Thin sections of *Salterella*



A. to D. *Salterella* sp. from the Shady Dolomite at USGS locality 7078-CO, underground at Austinville, Va.; X20. USNM 192,007-192,009.

E. to I. *Salterella conulata* Clark from the Shady Dolomite at USGS locality 7599-CO, near Fosters Falls, Va.; X15, USNM 192,010-192,012. E and I are transverse sections; F and H are cross sections; G gives both orientations.

1938) in this region, though the collections, if any, upon which such a report was based cannot be located in collections of the U. S. Geological Survey.

The ribboned dolomites and limestones of Tennessee and in all areas of Virginia studied by Byrd appear to have been deposited in a tidal-flat environment. Light-gray laminae are considered to represent a marine influx of carbonate mud, often pelleted, across a tidal flat. The dark, often stylolitic, layers may represent periods of algal entrapment of silt and clay from a terriginous influx. The clay and organic residue may have facilitated the formation of stylolites and the selective dolomization of the dark layers. Thus, the biopelmicrite is interpreted as a slightly deeper shallow subtidal facies interbedded with the tidal-flat facies of ribboned dolomites and limestones.

Salterella conulata was previously reported to have a range of at least 30 m (100 ft) through the upper part of the Vintage Dolomite at Thomasville, Pa. (Yochelson, 1970); the term Vintage as it was used in Austinville is not necessarily precisely correlative. The new stratigraphic information from Berryville and Austinville indicate that the range probably should be extended downward another 30 m or so. The data suggest that even with a range of several hundred meters this fossil is a good marker to the upper half of the Patterson Limestone Member and supplies a means of biological correlation from one region to another.

SALTERELLA IN THE SUBSURFACE

A detailed stratigraphy has been worked out in the vicinity of the Austinville-Ivanhoe mine by geologists of the New Jersey Zinc Company. Local stratigraphic names are used for subdivisions with the Shady Dolomite; these names were established for internal company use 5 years before the publication by Currier (1935, p. 19-30) which introduced a different terminology. This company terminology (Brown and Weinberg, 1968, p. 172) and that used by others are shown in table 1.

Mining in the Austinville-Ivanhoe district is based on an extensive program of core drilling to insure ore grade and reserves. The diamond-drilled cores are about 5 cm in diameter and adequate for logging the lithology. After standard core logging, *Salterella* was noticed in one piece of core taken from the "Ribbon Member". At this time it can only be determined that the core is from within the upper 61 m (200 ft) of the "Ribbon Member" (USGS 707-CO). Within this core, *Salterella conulata* occurs in a solution breccia comparable to those in the Patterson Limestone Member at Fosters Falls which yielded this species. The only specimen available is illustrated in plate 2-D.

Additional core drilling on Austinville mine sections 32 and 64, respectively 48 and 97 m (1600 and 3200 ft) southwest of the main shaft, indicated that *Salterella conulata* is locally confined to a zone 18 to 61 m (60-200 ft) below the upper contact of the "Ribbon Member", with its more common occurrence being limited to 18 to 34 m (60-110 ft) below that contact. As the "Ribbon Member" is about 320 m (1050 ft)

thick locally, it would appear that the surface and subsurface occurrences are from the same interval. It is hoped that additional finds of this species in cores from known intervals will more firmly fix the range of species below the "Ribbon-Austinville" contact.

In addition, another species of *Salterella* has been found in an underground drift (USGS 7078-CO) cutting the "Austinville Member". The locality is approximately 61 m (200 ft) above the contact with the "Ribbon Member" in the 11th level, 91 crosscut, of the Austinville mine, 579 m (1900 ft) southeast of the Austinville baseline (approx 1460 m (4800 ft) N 60° E from the Van Mater Shaft). Thin sections of specimens are shown in plate 3, A to D. This species is smaller, more rapidly expanding, and has a more pointed apex than *S. conulata*. It is sparse in occurrence in the small hand specimen in which it is found. Examinations of several cores from this part of the section did not yield additional specimens. More material is needed both to establish better the characters of this form and to delineate its range.

These specimens are probably conspecific with an undescribed form known from Thomasville, Pa. (Yochelson, Taylor, and Cloos, 1968). That species has been found immediately above the highest occurrence of *S. conulata* in that area (Yochelson, 1970, p. B8). The specimens from Austinville are in a light-gray aphanitic limestone and are associated with archaeocyathids, whereas those from Thomasville are in a dark limestone associated with numerous echinoderm fragments. Should the specimens from these two areas prove conspecific, it will help document a facies change within the upper part of the Shady Dolomite. Although the "Austinville Member" and the unnamed rocks at Thomasville are dissimilar, they may have been deposited as lateral facies of the "saccharoidal dolomite member". Both are fossiliferous marine limestones, which could have fringed tidal flats or lagoonal areas in which dolomites were formed.

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