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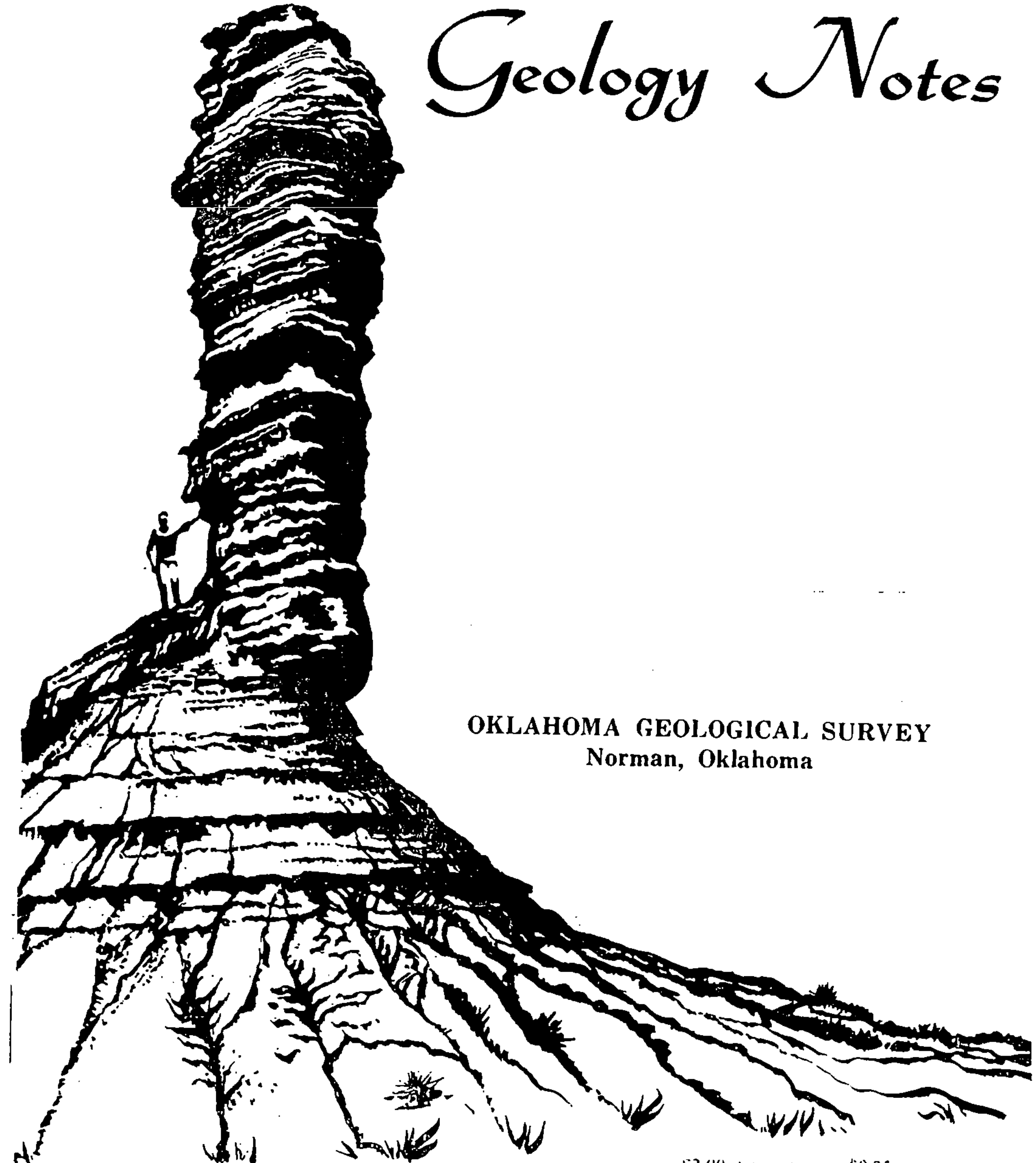

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New Records of the Scyphomedusan *Conostichus*

Carl C. Branson

Recently the genus *Conostichus* was reviewed and all known forms were described (Branson, 1960). Since that paper appeared several significant specimens have been received and it is now possible to establish a number of species.

Dr. George M. Wilson of the Illinois Geological Survey lent three huge specimens from the Finnie sandstone member, Abbott formation, McCormick group (nomenclature of December 1960). This member is the Delwood sandstone, Delwood formation, Tradewater group, of earlier nomenclature. The horizon is near that of the type locality of *Conostichus broadheadi*, the Savanna formation a few feet below the Bluejacket sandstone (Drywood formation of Missouri terminology). The three specimens are large, broad, layered sand casts, with cup-like depression on the upper surface. Measurements are:

	Width	*Height*
Specimen A	14.5 cm	8.0 cm
Specimen B	14.5 cm	9.0 cm
Specimen C	14.0 cm	7.0 cm

The specimens are the widest ones known. The base is a vague circular plate, and is succeeded by a wide layer upon which the other layers rest. The shape is unlike that of most specimens of *C. broadheadi.* Specimen B is figured (pl. II, figs. 8-9). The locality is SW¼ NW¼ NW¼ sec. 5, T. 11 S., R. 5 E., Pope County, Illinois.

Explanation of Plate I

Figure 1. *Lateral view of specimen of* Conostichus wycherlyi *(King), x1. Emporia formation, Lincoln County, Oklahoma. OU No. 321*

Figure 2. *Basal view of same specimen.*

Figure 3. *Lateral view of holotype of* Conostichus pulcher, *x1. Holdenville shale, Tulsa County, Oklahoma. OU No. 3222.*

Figure 4. *Basal view of same specimen.*

Figure 5. *Lateral view of holotype of* Conostichus arkansanus, *x1. Bloyd shale, Cleburne County, Arkansas. OU No. 3933*

Figure 6. *Basal view of same specimen.*

Figure 7. *Isolated basal disk of* Conostichus *sp. x1. Nellie Bly shale, Creek County, Oklahoma. OU No. 3239.*

Figure 8. *Basal view of specimen of* Conostichus ornatus *(?) Lesquereux, x1. Supposedly from Liverpool cyclothem, below Colchester coal, Spoon formation, Rock Island County, Illinois. Davenport Public Museum.*

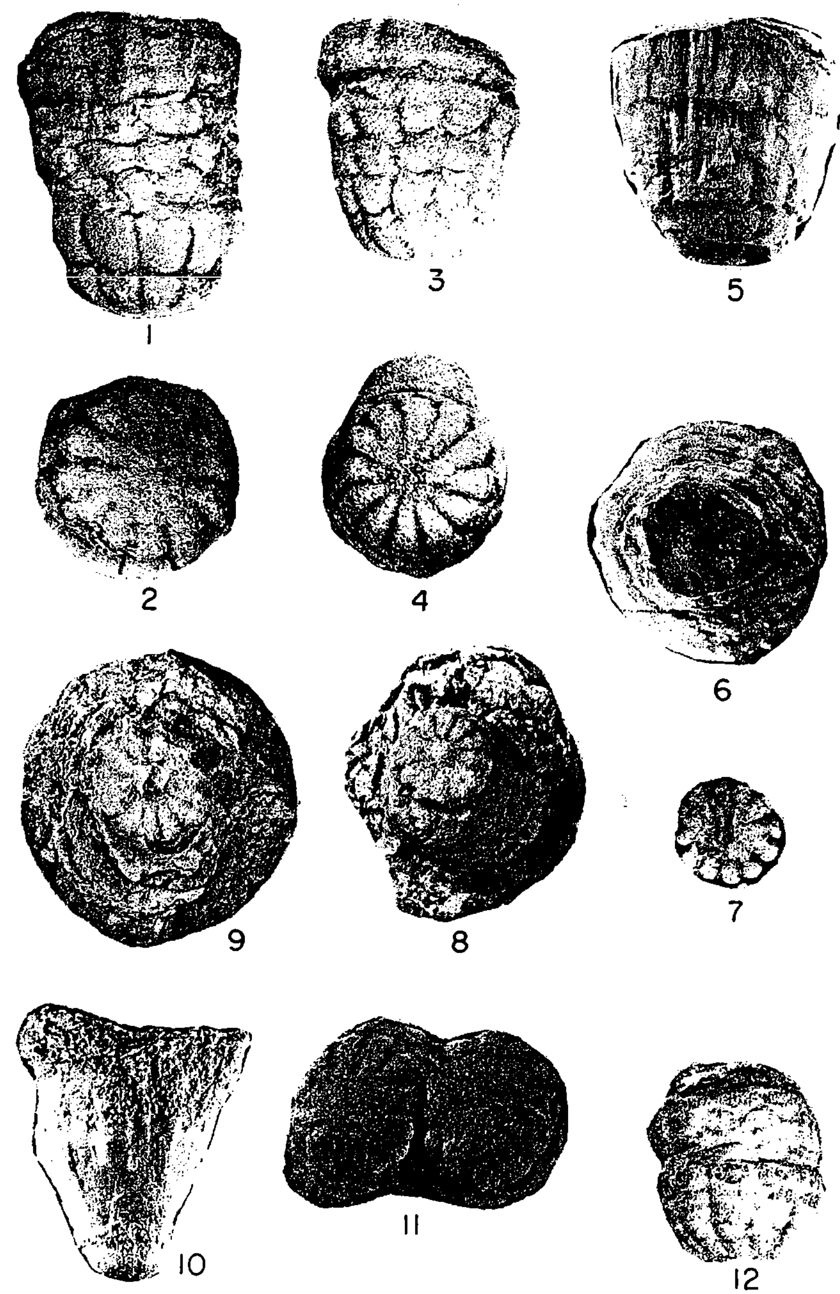
Figure 9. *Basal view of specimen of* Conostichus stouti *(?), x1. Pottsville. Jackson County, Ohio. Univ. of Cincinnati.*

Figure 10. *Lateral view of a coarse-grained specimen of* Conostichus *sp., x0.5. Seminole formation. Tulsa County, Oklahoma. OU No. 3918.*

Figure 11. *Two basal disks of* Conostichus quinni *(?), x1. Atoka formation, Washington County, Arkansas. OU No. 3927.*

Figure 12. *Lateral view of specimen of* Conostichus pulcher *(?), x1. Missouri series, Kansas City, Kansas. OU No. 353.*

(Figures 1-4, 7-9, 12 by Thomas W. Amsden; figures 5, 6, 10, 11 by Neville M. Curtis, Jr.)



Mr. Herald of the Davenport Public Museum lent two specimens from near that city. GPI no. 4148 is a basal disc of *Conostichus*. It is 2.4 cm in diameter. The specimen was collected by Dr. S. B. Bowman from the Pennsylvanian at Andalusia, Rock Island County, Illinois. The locality is a few miles from the type locality of *C. ornatus*, the genotype species, and the specimen may belong to that species (pl. II, fig. 3).

The second specimen is GPI 4149; a weathered disk 2.8 cm in diameter. The disk has a central button and a vague flange around the button. The twelve wedge-like segments are succeeded by a scalloped fringe. The specimen is not like any other one known. It was collected by The Reverend J. Gass, but the only locality given is "North Iowa", and no stratigraphic level is provided (pl. II, fig. 12).

Mr. Jack Hood has collected a second coarse-grained specimen like that described by me (1960, p. 202, paragraph 4) from the Seminole locality. The specimen consists largely of crinoidal debris. The disk is present, and is clearly of the symmetrical scalloped type with smoothly rounded margins (OU no. 3918). (pl. I, fig. 10).

Henbest (1960, p. 383, fig. 177, 1 A-C) recently illustrated a fluted cone of *Conostichus* from the part of the Woolsey shale member of the Bloyd shale above the Baldwin coal at a locality in Arkansas. The specimen occurred at the same level as those described here as *C. arkansanus*. Henbest also mentioned specimens from the Cane Hill member of the Hale formation.

A specimen from the Wetumka shale on the Thomas ranch, north center sec. 18, T. 3 N., R. 7 E., Pontotoc County, is in large part made up of shells of *Glabrocingulum grayvillense*.

Explanation of Plate II

FIGURE 1. *Lateral view of holotype of* Conostichus quinni, *x1. Atoka formation. Franklin County, Arkansas. OU No. 3932.*

FIGURE 2. *Basal view of same specimen.*

FIGURE 3. *Isolated basal disk of* Conostichus ornatus *(?) x1. Spoon formation. Rock Island County, Illinois. Davenport Public Museum GPI No. 4148.*

FIGURE 4. *Holotype of* Conostichus prolifer, *suppressed as synonym of* C. broadheadi, *x0.5. Drywood formation, Vernon County, Missouri. USNM Paleobotany 6035.*

FIGURE 5. *Lateral view of holotype of* Conostichus broadheadi, *x0.5. Drywood formation, Vernon County, Missouri. USNM Paleobotany 10250.*

FIGURE 6. *Basal view of same specimen.*

FIGURE 7. *Lateral view of a metatype, x0.5. USNM Paleobotany 10251.*

FIGURE 8. *Lateral view of* Conostichus ornatus *(?), x0.25. Finnie sandstone, Abbott formation, Pope County, Illinois. Illinois Geol. Survey Coll.*

FIGURE 9. *Dorsal view of same specimen.*

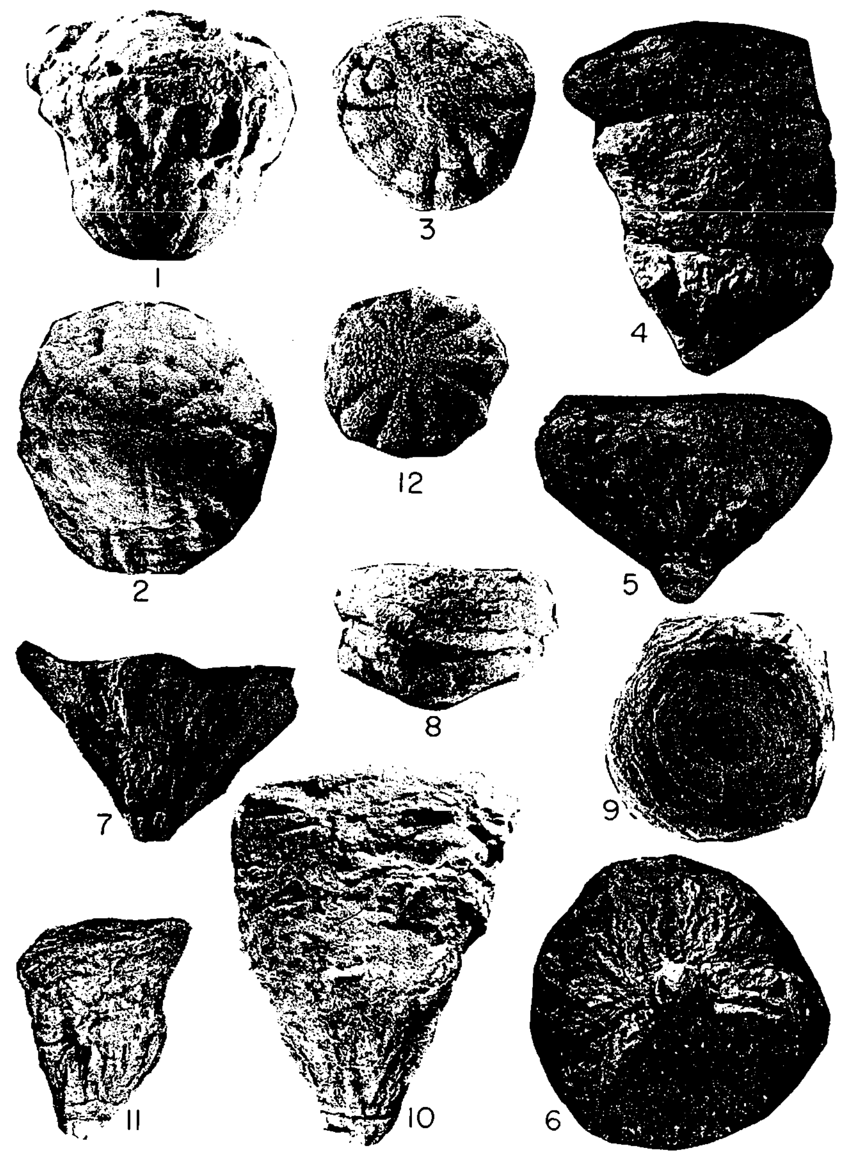
FIGURE 10. *Holotype of* Conostichus stouti, *x0.5. Pottsville series, Scioto County, Ohio. Ohio State Univ. Museum 10872a.*

FIGURE 11. *Holotype of* Conostichus hoodi, *x0.5. Holdenville shale, Tulsa County, Oklahoma. OU No. 3226.*

FIGURE 12. *Disk of* Conostichus *sp., x1. Unknown horizon and locality in Iowa. Davenport Public Museum GPI 4149.*

(Figures 4, 5, 6, 7 courtesy of U. S. National Museum; figures 1-3, 8, 9 by Neville M. Curtis, Jr.; figures 10, 11 by Thomas W. Amsden)

PLATE II



Mrs. Alva Ruskin collected two specimens from a farm one mile southeast of Red Bluff, which is two miles north of Floyd, White County, Arkansas. These are fluted cones.

Dr. James Quinn has sent 36 specimens from SW1/4 SE1/4 sec. 29, T. 11 N., R. 11 W., from near the new bridge near Higden, Cleburne County, Arkansas. They are in black Atoka shale. None is preserved in such a way as to show the character of the disk.

Conostichus is considered to be a member of the class Scyphozoa, subclass Scyphomedusae, order Coronatida. The genus clearly is a distinct family, here named Conostichidae. *Conostichus* is the adult form of a primitive type, now represented by the strobilation stage of coronatids. In modern forms the medusid produces planula larvae which are freed to attach themselves. At this stage the larva is a polyp, the hydrotuba, which has 16 tentacles (it is presumed that *Conostichus* had 12). Under adverse conditions the hydrotuba becomes segmented horizontally in the process called strobilation. The segmented body is called a scyphistoma. The segments are freed as ephyrae to become individual medusids. *Conostichus* lived embedded in the mud and the scyphistoma form was its adult condition. Presumably there was a reproductive stage to produce free-swimming medusids.

In *Conostichus* there is a basal disk and tiers of lappets. There is no evidence that ephyrae were developed and freed.

A sufficient record of the genus *Conostichus* has now accumulated to permit differentiation of species represented by specimens with the disk and form of lappets preserved. The following species are now distinguishable.

Conostichus stouti new species
Plate II, figure 10

The specimens figured by Stout (1956, figs. 1, 2) and by Branson (1960, pl. II, fig. 1) are here given the specific name *Conostichus stouti* in honor of Wilber Stout, former state geologist of Ohio. The holotype is Ohio State University Museum No. 10872a, the original of my figure 1 of 1960. The disk is nearly plane and the margin is slightly notched at the groove intersections.

Explanation of Plate III

Figure 1. *Basal view of paratype of* Conostichus hoodi, *x2. Holdenville shale, Tulsa County, Oklahoma. OU No. 3124.*

Figure 2. *Basal view of holotype of* Conostichus hoodi, *x2. Holdenville shale, Tulsa County, Oklahoma. OU No. 3226.*

Figure 3. *Basal disk of specimen of* Conostichus typicus *(?), x1. Barnsdall formation, Osage County, Oklahoma. OU No. 3621.*

Figure 4. *Lateral view of paratype of* Conostichus hoodi, *x2. Holdenville shale, Tulsa County, Oklahoma. OU No. 3223.*

Figure 5. *Lateral view of paratype of* Conostichus hoodi, *same specimen as figure 1, x2.*

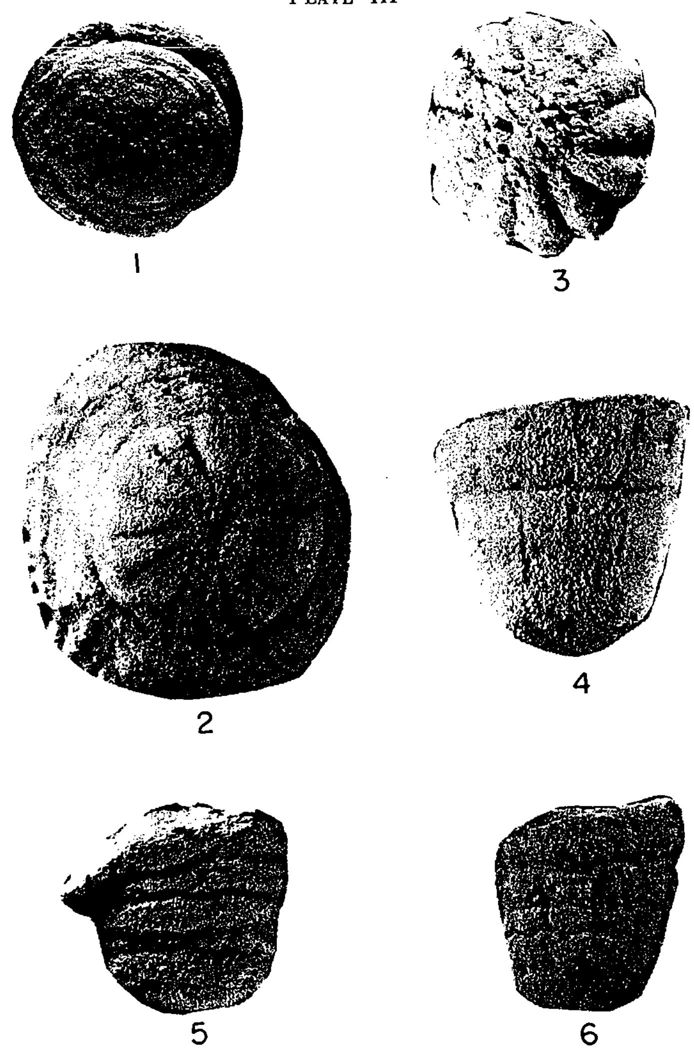
Figure 6. *Lateral view of paratype of* Conostichus pulcher, *x1. Holdenville shale, Tulsa County, Oklahoma. OU No. 3222-2.*

(Photographs by Neville M. Curtis, Jr.)

Conostichus hoodi new species
Plate II, figure 11; plate III, figures 2, 4, 5

The common species of *Conostichus* in the Holdenville formation is here named *C. hoodi* in honor of Mr. Jack Hood of Berryhill, Oklahoma, who found the localities and some of the better specimens. The species is distinguished by its small hemispherical disk and its short grooves. The holotype is OU No. 3226 (Branson, 1960, pl. II, fig. 6), and OU No. 3124 is a paratype.

Plate III



Conostichus pulcher new species
Plate I, figures 3, 4; plate III, figure 6

The Holdenville species with nearly flat base, base comparatively large, with four grooves (every third groove) extending nearly to the center, is here named *Conostichus pulcher*, from Latin pulcher, beautiful. Mr. Harrell Strimple and Mr. Hood collected the specimens. The holotype is OU No. 3222, figured as plate IV, figures 3-4 by me (1960).

Conostichus arkansanus new species
Plate I, figures 5-6

Dr. James Quinn of the University of Arkansas has sent me five specimens from the Bloyd shale (Woolsey member) at Greer's Ferry Dam, Heber Springs, Cleburne County, Arkansas. The specimens are of fine-grained sandstone with black shale coating. The black shale is slickensided. Each of the three specimens retains the basal disk, which is broadly rounded, has twelve short grooves dividing the surface of the border of the disk into twelve raised wedges, and has a central raised prominent base occupying the central third of the diameter. Above the disk four or five tiers of plate-like casts are preserved below the area in which the surface is that of a fluted cone. The three specimens have the following dimensions:

	Height (incomplete)	*Diameter*	*Diameter of disk*
Specimen A	4.7 cm	3.9 cm	2.2 cm
Specimen B	3.4 cm	3.6 cm	2.0 cm
Specimen C	2.6 cm	2.8 cm	1.9 cm

The form is certainly a distinct species from those previously known. The base is larger and the wedge segments shorter and higher than in known species.

Four specimens were collected by J. T. Vest, and these are catolog number OU 3933. One specimen was collected by E. F. Palmer of the U. S. Army Corps of Engineers (OU 3949). The specimen figured by Henbest (1960, fig. 177.1 B-C) is a fluted cone that probably belongs to the species. The specimen collected by J. T. Vest from the Bloyd shale in SW$\frac{1}{4}$ SE$\frac{1}{4}$ SE$\frac{1}{4}$ sec. 35, T. 11 N., R. 12 W., Van Buren County, Arkansas, is a fluted cone.

Conostichus quinni new species
Plate II, figures 1, 2

Dr. James Quinn of the University of Arkansas has donated to our collections the first well-preserved specimens of *Conostichus* from the Atoka. The holotype consists of the basal disk, two tiers of lappets, and the upper part is a fluted cone. The disk is depressed centrally, is broadly rounded, and is radially grooved. Four of the grooves, the first, third, seventh, and ninth, extend from the center of the disk to the scalloped margin. The three lateral grooves on each side are short, the grooves included between those that extend to the center are long and extend to points near the center. The disk is 2.2 cm in diameter.

The first tier of lappets consists of 12 rounded units each directly on a disk scallop, and they are marked off by deep vertical grooves. The

second tier of lappets is poorly preserved and passes into the fluted cone. The specimen is 3.6 cm high, 4 cm in diameter.

The holotype is OU No. 3932. Two specimens on one slab, also a gift of Dr. Quinn, show the disk well (OU No. 3927). The specimen was collected by Mr. Neumier, then a student at the University of Arkansas. It came from the Atoka in T. 14 N., R. 30 W., Washington County, Arkansas.

With the new material, specimens of *Conostichus* are now known from Oklahoma, Arkansas, Kansas, Missouri, Illinois, Indiana, Iowa, and Ohio, and have been observed or reported from Kentucky, New Mexico, Texas, and Bolivia. The genus is almost certainly present in sediments of the shelf-margin environment in Pennsylvanian rocks of many other areas.

The stratigraphic range is throughout the Pennsylvanian system. The occurrences are tabulated below with indication of the valid named species, of the unnamed forms with disk known (indicated as *C.* sp. *A*, *B*, *C*) and of fluted cones.

Virgil	*C. wycherlyi*	Disks, Emporia formation (Kan., Okla.)
	C. typicus	Disks. Plattsburg formation (Kan.). Barnsdall formation (Okla.)
	C. sp. C	Disked cones from shale below Birch Creek limestone (Okla.)
Missouri	*C. sp. B*	Disk and fluted cone from Nellie Bly shale (Okla.)
	C. sp.	Fluted cones from the Coffeyville formation (Okla.)
	C. sp. A	Disked cones from the Seminole formation (Okla.)
	C. hoodi	Holdenville shale, here figured (Okla.)
	C. pulcher	Holdenville shale, here figured (Okla.)
	C. sp.	Cones from the Nowata shale (Okla.)
	C. ornatus	Described by Lesquereux from Carbondale group (Ill.)
Des Moines	*C.* sp.	Here figured from Finnie sandstone (Ill.)
	C. broadheadi	Fluted cones described by Lesquereux from Savanna formation (Mo.)
	C. stouti	Figured by Stout from Pottsville beds (Ohio)
	C. sp.	Disks collected by Govett from Hartshorne formation (Okla.)
Atoka	*C. quinni*	Here figured from the Atoka formation (Ark.)
	C. arkansanus	Here figured from the Bloyd shale (Ark.)
Morrow	*C.* sp.	Reported from Cane Hill member of Hale fm. (Ark.)

Other Species

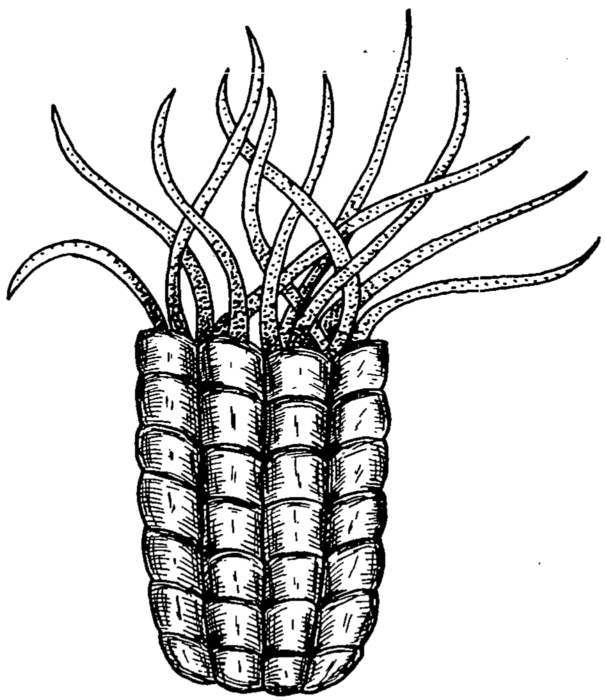
C. ulrichi (King), 1955 Reported from Devonian of Bolivia. Believed here to be Pennsylvanian.

C. prolifer Lesquereux, 1880 synonym of *C. broadheadi*

C. ? medusa Chadwick, 1918 not a *Conostichus*

C. ? polygonatus Chadwick, 1918 not a *Conostichus*

C. ? circulus Chadwick, 1918 not a *Conostichus*



TEXT-FIGURE 1. Conostichus *sp. Hypothetical reconstruction of living individual.*

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ANDESITE TUFF AND DACITE BASEMENT ROCKS OF NORTHEASTERN OKLAHOMA

WILLIAM E. HAM

Introduction

Dr. Louise Jordan has kindly called my attention to samples of basement rock from a well in Craig County, Oklahoma, that differ notably from the granitic rocks common in the basement complex of the region. A petrographic examination of excellent coarse cuttings from the Frankfort Oil Company No. 1 Van Ausdel, SE¼ NE¼ NW¼ sec. 31. T. 28 N., R. 20 E., showed that the basement rock beneath Upper Cambrian Arbuckle dolomite is andesite tuff, thus demonstrating for the first time the existence in northeastern Oklahoma of pyroclastic igneous rocks.

Further investigation of samples from other wells resulted in the discovery, in central and northern Craig County, of a basement rock volcanic field that consists of andesite tuff and dacite. Around the field are mainly pink micrographic granites as described in Ottawa County by Weidman (1932, p. 78), at Spavinaw in Mayes County by Merritt (1960), and mentioned in Osage County by Bass (1942, p. 356-357). The eastern and southern limits of the volcanic field are marked by the occurrence of micrographic granite at a depth of 1,769-1,946 feet in the 3-B Oil Company No. 1 Helmick, NW¼ NW¼ sec. 12, T. 26 N., R. 21 E., at the eastern border of Craig County, and by micrographic granite at a depth of 1,897-1,957 feet in the Lee Milligan No. 1 Lee, SE¼ SE¼ SE¼ sec. 17, T. 23 N., R. 19 E., near the center of the north line of Mayes County. The western limit of the field is not definitely established because basement-rock samples could not be obtained from Nowata County, and accordingly this part of the line, as drawn in figure 1, is hypothetical.

Neither the absoute nor the relative ages of granite and extrusive rocks have been determined. Both lie unconformably beneath Upper Cambrian (Franconian) sedimentary strata. Each was subaerially exposed and each contributed clastic material to the basal beds of the overlying sedimentary succession. Thus, although the basement rocks are clearly pre-Upper Cambrian, there is at present no information by which they can be directly correlated with the 500-550 m.y. igneous rocks of southern Oklahoma (Ham, Denison, and Merritt, 1960) or with the 1,450 m.y. rocks of southeastern Missouri (Davis, Tilton, Aldrich, and Wetherill, 1958, p. 180).

No well has been found thus far in northeastern Oklahoma from which the age of the extrusive series relative to granite can be deduced. Additional data must be obtained before it can be known whether the andesites have been intruded by near-surface micrographic granites. or conversely whether the granites have been emplaced, unroofed, and then covered by the extrusive rocks.

Except for the outcrop of four small granite hills at Spavinaw, Mayes County, all the basement rocks of northeastern Oklahoma are concealed

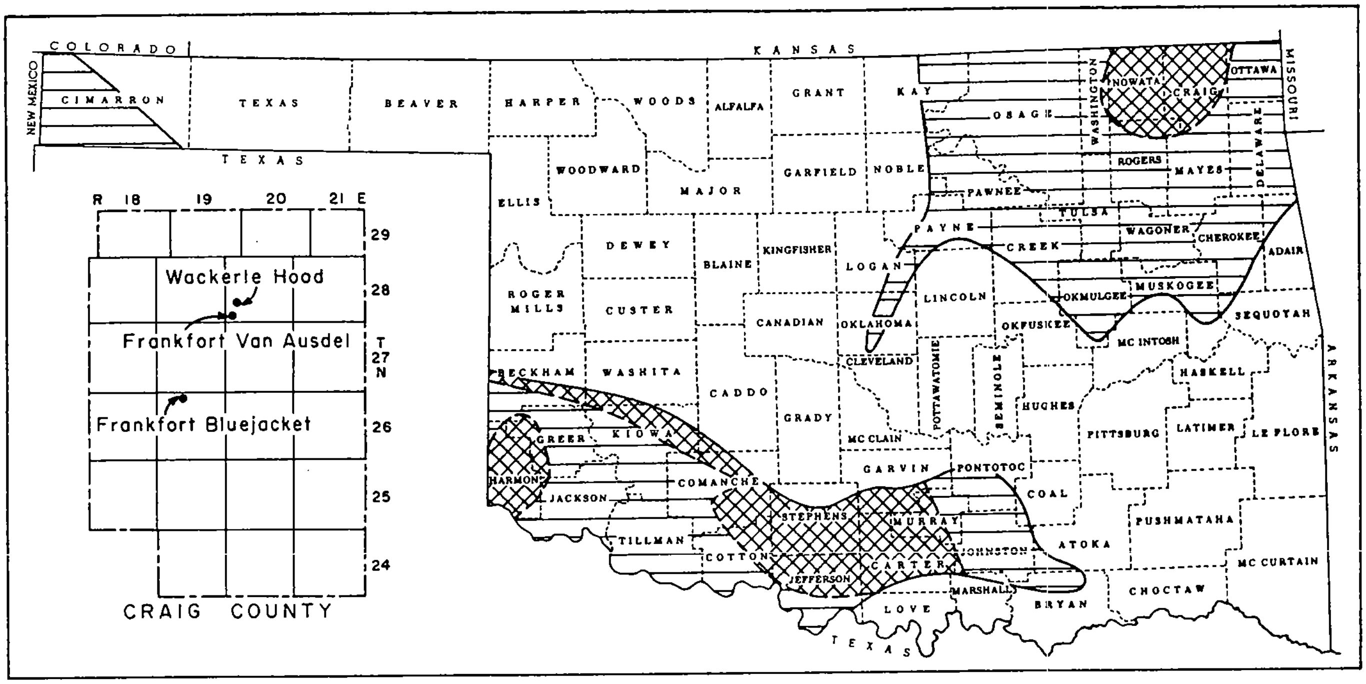


FIGURE 1. *Andesite tuff and dacite occurrences in Craig County compared with principal areas of extrusive basement rocks (cross-ruled) in Oklahoma. Other basement rocks are shown by horizontal ruling. Control wells lacking in blank region.*

TABLE I.—SUMMARY OF ANDESITE TUFF AND DACITE BASEMENT ROCKS IN CRAIG COUNTY, OKLAHOMA

Well	Frankfort Oil Co. No. 1 Van Ausdel	Wackerle Oil Co. No. 4 Hood	Frankfort Oil Co. No. 1 Bluejacket
Location	SE NE NW 31-28N-20E	SE SW SE 19-28N-20E	NW NW NW 4-26N-19E
Date Completed	January, 1955	December, 1954	January, 1955
Type of Samples	Coarse 5-foot rotary cuttings	Fine-grained cuttings, poor	Clean medium-coarse cuttings
Rock Overlying Basement	Cambrian Arbuckle	Cambrian Arbuckle	Cambrian sandstone Lamotte or Arbuckle
Basement Rocks			
Depth to top (feet)	1,692	1,493	2,102
Elevation of top (s.l.)	− 833	− 655	−1,267
Penetration	322	97	26
Character	Andesite tuff Dark gray to reddish-brown matrix containing poorly sorted crystal fragments of colorless andesine, brown hornblende, and magnetite. Tough and compact, partly silicified. No significant change throughout. Matrix composes 1/3 of rock and is made of welded and devitrified glass shards.	Andesite tuff Matrix is dark gray and greenish gray in upper part but brownish red in lower 35 feet. Contains poorly sorted subhedral to angular fragments of andesine and altered hornblende. The rock is mostly silicified.	Dacite Flesh-pink groundmass with phenocrysts 1 to 2 mm long of pink to milky white andesine and perthite, and of brilliant clear quartz. Much silicification. Flow-banded pilotaxitic groundmass makes up 2/3 of rock.

by a cover of Paleozoic sediments and can be investigated petrologically only by a study of cuttings and cores.

I am indebted to Dr. Jordan for obtaining the samples used in this investigation, and for her continued interest in the basement rocks of Oklahoma. Mr. Dan Strong, currently working on subsurface investigations in Craig and Mayes Counties for a Master's degree at The University of Oklahoma, supplied a list of basement-rock wells that proved to be most useful. Finally, my thanks are extended to the Oklahoma City office of Shell Oil Company for the generous loan of samples from the Wackerle No. 4 Hood well.

Extrusive Basement Rocks of Craig County

The volcanic field in Craig County is established by the three wells listed in table 1 and shown in figure 1. It consists of andesite tuff and closely related flows of dacite (quartz andesite), with a maximum drilled thickness of 322 feet in the Van Ausdel well. In none of the three wells has the base of the volcanic series been found, and its full thickness might be several thousand feet. Andesite tuffs. consisting of poorly sorted angular fragments of andesine, hornblende, and magnetite in a devitrified matrix of welded glass. are known as the basement rock in two wells. Flow-banded dacite, containing phenocrysts of andesine, perthite. and quartz in a pilotaxitic groundmass, occurs in a third well. The volcanic rocks are variously silicified and contain as alteration products small amounts of sericite, chlorite, epidote, and calcite.

Hornblende andesite tuffs.—The most complete knowledge of andesite tuff in northeastern Oklahoma is from the Frankfort No. 1 Van Ausdel, from which the largest cuttings, thickest penetration, and least altered samples were obtained. There is no significant change in character of

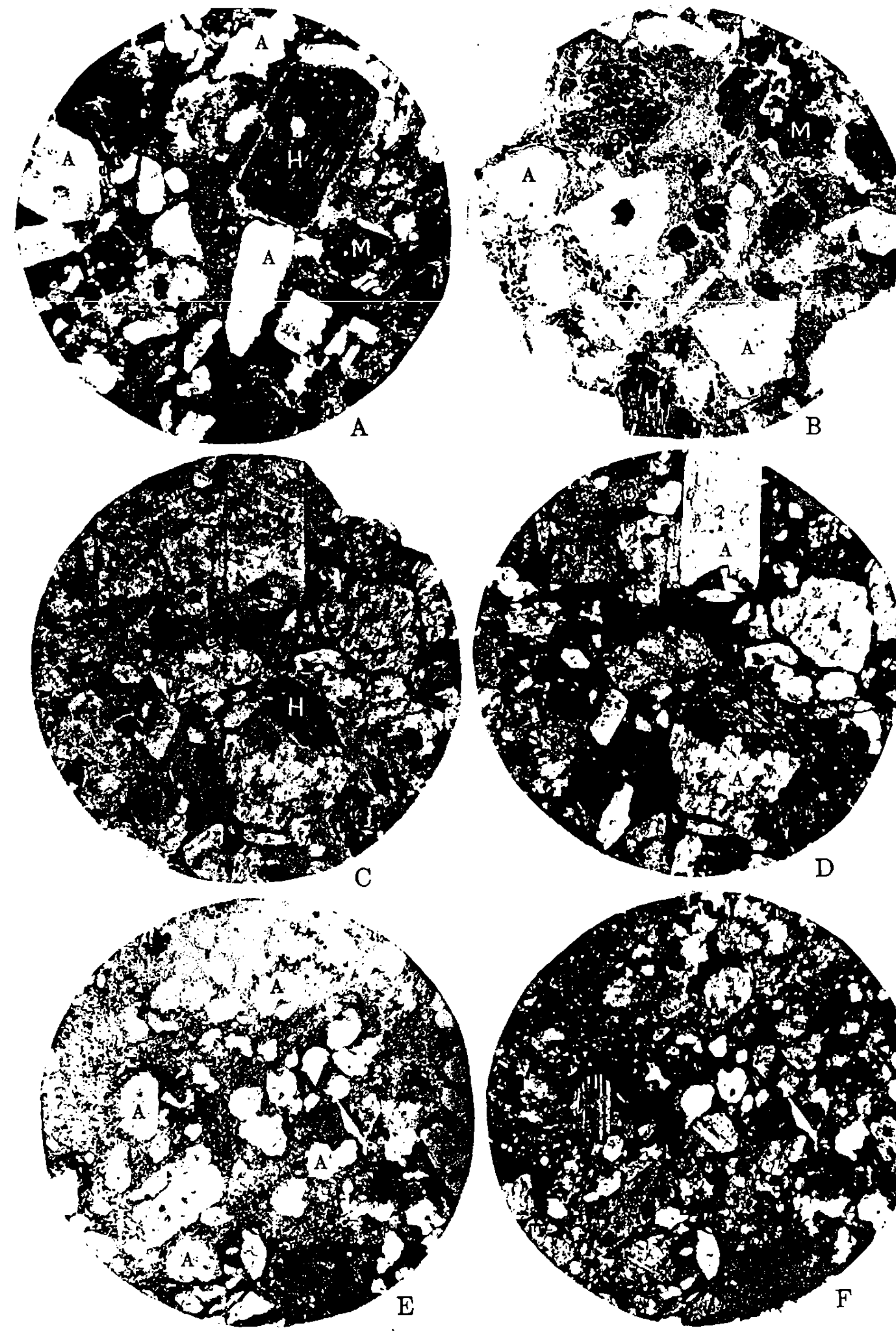
Explanation of Plate I

Photomicrographs of hornblende andesite tuff. Frankfort No. 1 Van Ausdel well, depth. 1.692-2,014 feet. All figures x15.

H. brown hornblende; A. plagioclase feldspar (An$_{38-48}$); M. magnetite.

- *A. Hornblende andesite tuff, 1,692-1.715 feet. plain light. Subhedral brown hornblende and angular to subhedral andesine are set in a devitrified glassy matrix. Feldspar grain at top is deeply embayed. The crystal grains are unsorted and range in diameter from 0.2 mm to 1.7 mm.*
- *B. Hornblende andesite tuff. 1.978-2,014 feet, plain light. Hornblende, plagioclase, and magnetite are surrounded by banded devitrified glass that is stained red by the introduction of hematite dust. Feldspar grain at right is notably angular. Note absence of fluxion structure and of the development of feldspar crystals in two distinct generations.*
- *C. Hornblende andesite tuff, 1,978-2,014 feet, plain light. Unsorted grains of angular to subhedral andesine and brown hornblende lie in a matrix of contorted devitrified glass.*
- *D. Same as C, crossed nicols.*
- *E. Silicified andesite tuff, 1,692-1,715 feet, plain light. Subrounded to angular grains of andesine, mostly of medium and coarse sand size, and averaging about 0.4 mm in diameter, are surrounded by a matrix of devitrified glass shards. Matrix of light-colored area at top is extensively silicified.*
- *F. Same as E, crossed nicols.*

PLATE I



the samples throughout the 322 feet of drilled thickness, and it therefore seems probable that a much thicker sequence was originally present at this locality. An unknown thickness has been removed from the top by erosion during the period of exposure before the volcanic rocks were covered unconformably by marine strata of Late Cambrian age. The overlying slightly glauconitic dolomite of the Arbuckle group is surprisingly free from tuffaceous detritus, however, and accordingly it can be inferred that the Van Ausdel well is at or near the cleanly swept crest of a buried basement-rock hill.

The typical rock in the Van Ausdel well is dark-gray to nearly black felsite containing light-colored grains of plagioclase as much as 2.5 mm long. As seen in cuttings the rock has a porphyritic appearance but as determined from a study of six thin sections it is a tuff composed of broken crystal grains set in a matrix of devitrified glass. Pilotaxitic and fluxion fabrics are absent, and there is a continuous gradation in size of grains from 0.2 to 2.5 mm. The rock is about two-thirds crystal fragments and one-third devitrified glassy matrix, and would be classified in its original state as a vitric crystal tuff.

Angular to subhedral grains of andesine (An_{38-48})* predominate, making up 40 to 50 percent of the rock (pl. I). Each grain is a subhedral phenocryst or a broken fragment of one, and the plagioclase zonal growth common in surface flows is absent. About 20 percent of the grains are unaltered, but the remainder are replaced in various stages by sericite, epidote, quartz, pyrite, chlorite, and zoisite. Sericite and epidote are the most abundant alteration products, and carbonates do

*Determined by extinction angles and by indices of refraction of powdered grains in immersion oils.

Explanation of Plate II

Photomicrographs of dacite and andesite tuff from Craig County, x1.5. P, perthite; A, andesine; Q, quartz.

A-D. *Dacite from Frankfort No. 1 Bluejacket well, depth 2,102-2,128 feet.*

A. *Quartz and feldspar phenocrysts in a flow-banded silicified groundmass, crossed nicols. Tiny phenocrysts in groundmass show a vaguely defined pilotaxitic fabric.*

B. *Flow banding of groundmass around a large phenocryst of perthite. The much-altered perthite occurs as a crystal 2 mm long and is typical of first-generation feldspar in the dacite. Crossed nicols.*

C. *Corrosion and deep embayment of andesine phenocryst in partly silicified groundmass. Crossed nicols.*

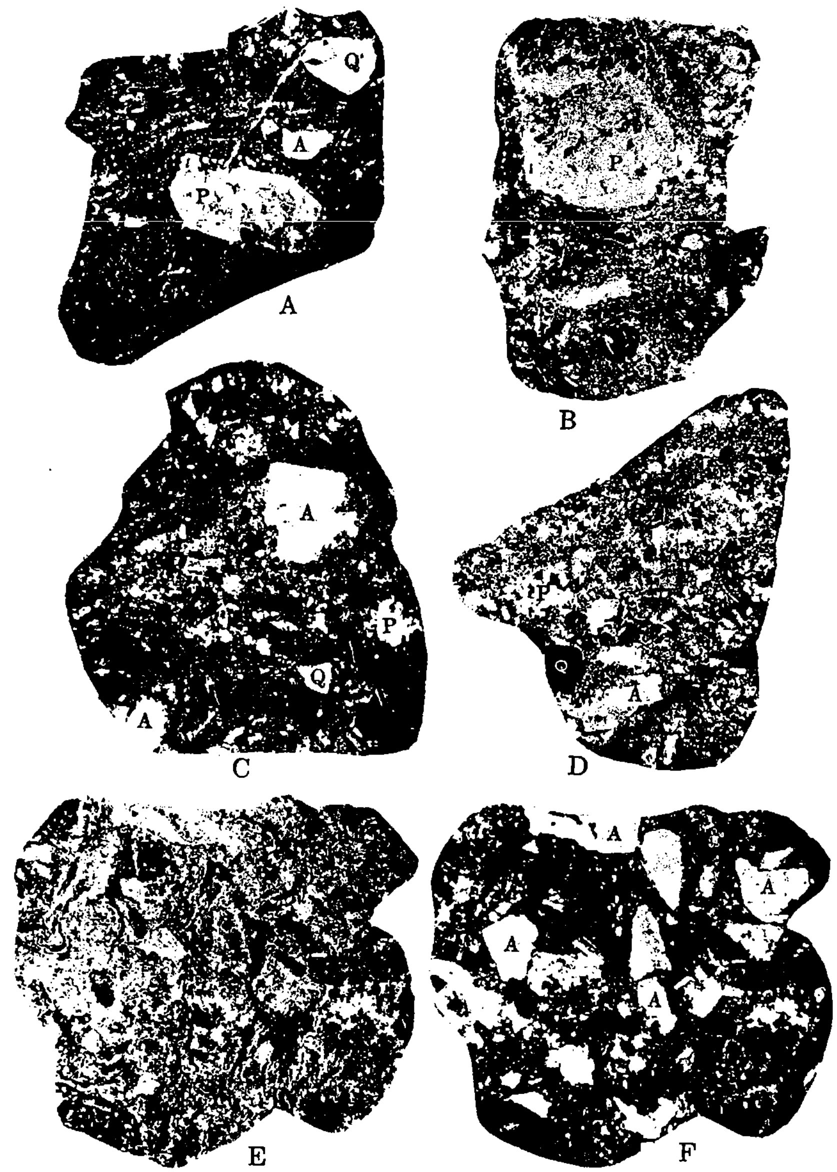
D. *Small phenocrysts of subhedral feldspar and euhedral quartz in an extensively silicified groundmass. Crossed nicols.*

E-F. *Andesite tuff from Wackerle No. 4 Hood well, depth 1,493-1,517 feet.*

E. *Hornblende andesite tuff, showing convolute banding of matrix around broken grains. Hornblende grain at lower left is converted into chlorite. Plain light.*

F. *Same as E, crossed nicols. Poorly sorted angular grains of andesine lie in a matrix of devitrified glass shards. Silicification of the andesite tuff is much less pronounced than in the dacite.*

Plate II



not occur. The distinguishing characters of the plagioclase grains are the lack of euhedral phenocrysts, absence of phenocrysts in two generations, poor sorting and angularity of the particles, and the absence of a preferred-orientation fabric.

Prismatic crystals and subhedral grains of brown hornblende, some containing inclusions of plagioclase and apatite, make up about 10 percent of the tuff beds. Most of the hornblende grains are unaltered. The third most abundant constituent is magnetite, which occurs as grains generally about 0.5 mm in diameter. Much smaller magnetite grains are scattered or arranged in contorted layers within the devitrified matrix. They compose about eight percent of the rock.

Surrounding the crystal grains is a nearly isotropic field of dark-brown devitrified glass. It is partly replaced by fine-grained aggregates of quartz, together with epidote and a little chlorite. It contains no plagioclase laths of a late generation. Above all it is characterized by the development of contorted lines, in part wrapping around crystal grains, abutting against them, or arranged in irregular concentric bands (fig. 2).

This distinctive fabric does not conform to the normal type of banding developed in layered flows, as it is much too irregular and lacks the property of a preferred flow direction. Because the crystal grains within it are mostly unsorted and angular, and therefore like the ejected fragments of a volcanic explosion, it is reasonable to believe that the embedding material originally was a matrix of glass shards. Inasmuch as no trace of shard outlines has been preserved, the matrix probably has been changed by welding shortly after deposition of the tuff beds. By means of the welding process the glassy shards were rearranged into a compact glass, and, at the same time, welding bands were developed by irregular accommodation around the enclosed grains. According to Smith (1960, p. 151), crinkling or crenulations around crystal or rock fragments are common in most welded tuffs.

Except for one small grain of micrographic granite and one angular piece of quartz, rock fragments have not been observed in the tuff from Oklahoma. Glassy fragments, some of them containing phenocrysts, presumably were present at the time the rock was formed, but like the shards their outlines have been lost by consolidation and devitrification.

Pronounced corrosion of some of the feldspars (pl. IIA, D) probably was effected during the welding stage. Silicification, devitrification, and the hydrothermal formation of epidote and sericite belong to the same or to a slightly later stage, all of it preceding the inundation of the tuff beds by the Late Cambrian sea.

Andesite tuff also occurs as the basement rock under Cambrian Arbuckle dolomite in the Wackerle No. 4 Hood, 1.5 miles north-northeast of the Van Ausdel well. In the Hood well: (a) the feldspar grains are more intensely sericitized, (b) the matrix is more silicified, (c) the hornblende is completely altered to chlorite, and (d) calcite has been introduced in addition to the normal alteration products. Nevertheless, rocks from the two wells are almost identical in mineral composition and fabric, and both doubtless are parts of the same volcanic series. The dark-brown irregularly contorted matrix of devitrified glass, comprising about 35 percent of the rock, surrounds angular and strongly corroded

FIGURE 2. *Photomicrograph of hornblende andesite tuff from the Frankfort No. 1 Van Ausdel, depth 1.715-1,815 feet, showing banding of devitrified matrix around fragments of andesine (A), brown hornblende (H), and magnetite (M). The matrix is interpreted as having been composed originally of glass shards of a hot ash flow, the shards being welded together with destruction of the vitroclastic fabric, and with the consequent development of irregularly contorted welding bands. No silicification except in light-colored area at upper left corner. Plain light, x30.*

cystals of andesine (An_{33-36}), chloritized amphibole (brown hornblende?), and magnetite. The fragmental grains range in diameter from 0.2 to 1.5 mm, averaging about 0.5 mm, and are poorly sorted (pl. IIE, F). As a result of extensive but variable silicification, the color as seen in cuttings is dark gray, light gray, or brownish red.

First recognition of the andesitic nature of the basement rock in the Wackerle No. 4 Hood was by Farquhar (1957), although the location given (cutlines for plate 8, p. 102) as sec. 19, T. 28 N., R. 19 E., Craig County, Oklahoma, is a typographical error.* According to Farquhar (p. 97),

> A much altered rock resembling a hornblende andesite occurs in the Precambrian subsurface of Craig County, Oklahoma, only a few miles south of the Kansas line. This may represent a local extrusive flow, but the evidence is confined to samples from a single well. A slide of this material shows a brecciated rock containing a much-corroded dark mineral, probably hornblende, and andesine feldspar. The brecciation may have been caused by explosive activity during the crystallization stage. Former voids in the rock are filled with quartz, mosaically arranged.

He further states (p. 102) that it is andesitic breccia (?) containing brecciated and altered andesine.

*Mr. Dan Merriam of the Kansas Geological Survey has kindly confirmed the identity of the well in question as the Wackerle No. 4 Hood, in sec. 19, T. 28 N., R. 20 E.

Because of the altered condition of samples from the Hood well, the interpretations of Farquhar are reasonable, but the much better samples and greater depth of penetration in the Van Ausdel well give evidence that the rock is a welded tuff rather than a breccia. My examination of eight thin sections shows no brecciation in the sense that the andesite has been broken in situ during crystallization. Instead, the crystal grains are separated and piled together randomly, as if they had been broken by explosive violence and transported to a new depositional site. Furthermore the contorted lines of the matrix are better explained as originating through the welding of glassy shards of a hot ash flow.

It is most interesting that extrusive and pyroclastic rocks have not been found in the basement complex of Kansas (Farquhar, 1957, p. 59).

Dacite.—Twenty-six feet of flesh-pink dacite, appearing in cuttings much like normal rhyolite, was drilled in the Frankfort No. 1 Bluejacket. It is eight miles southwest of the Van Ausdel well, and establishes the length of the volcanic field to be at least nine miles. The dacite of the Bluejacket well is unconformably overlain by slightly glauconitic poorly sorted Upper Cambrian sandstone (Lamotte?), the basal 15 feet of which shows a downward-increasing content of pink feldspar and coarse grains of quartz sand. The basement rock contains pink to milky white phenocrysts of feldspar, along with phenocrysts of clear glassy quartz, embedded in a tough pink groundmass.

In thin section the feldspar is seen to be andesine (An_{34-38}) and perthite, which occur in two generations and make up 30 percent of the rock. The earlier generation is mainly perthite, occurring as a highly irregular intergrowth of potash feldspar (sanidine?) and plagioclase. Subhedral crystals of the perthite are 1.5 to 2.0 mm long (pl. IIA, B). Many of them are clouded with alteration products, mainly sericite, chlorite, and calcite. Some of the early andesine phenocrysts are deeply corroded (pl. IIC). The later generation is dominantly andesine, and it occurs in the groundmass as subhedral phenocrysts about 0.4 mm long. Quartz is present in euhedral to corroded phenocrysts 0.3 to 0.7 mm in diameter, making up about seven percent of the rock.

In addition to its content of perthite and quartz, the dacite differs from the andesite tuffs in shape and arrangement of grains, and in the amount and character of the enclosing groundmass. Dacite from the Bluejacket well contains 60 to 65 percent cryptocrystalline pink groundmass, with sparse chlorite, carbonate, biotite, magnetite, and apatite. The groundmass has a pilotaxitic fabric and linear flow banding (pl. IIA); and the introduction of much fine-grained quartz, partly along the flow lines, accentuates and preserves this structure. The rock lacks the features of a breccia or tuff and is interpreted as an extrusive flow. Probably on a regional scale it is interbedded with andesite tuff and constitutes an essential part of the northeastern Oklahoma volcanic field.

Summary and Conclusions

Extrusive basement rocks at least 322 feet thick are described from wells in central and northern Craig County. They consist of welded andesite tuffs and dacite flows that probably were derived from volcanic eruptions and were spread in considerable thickness over a wide area.

From scattered well control the volcanic field can be inferred to cover most of Craig County and perhaps much of Nowata County, or a total area of approximately 1,000 square miles. The original thickness cannot be measured, as the base has not been drilled and the top is everywhere eroded under Upper Cambrian marine strata. If, however, the uppermost andesite beds in the Van Ausdel well are densely welded tuffs, as seems probable, it can be inferred from the diagrams of Smith (1960, pl. 20) that not less than 200 to 400 feet has been removed by erosion from the top of the volcanic sequence, making an original thickness at this site of at least 500 to 700 feet.

In the present state of knowledge, the relations of the northeastern Oklahoma volcanic field to other volcanic basement rocks cannot be established. As shown in figure 1, an extensive tract of rhyolite, rhyolite tuff, andesite, and spilitic basalt is known from southern Oklahoma (Ham, Denison, and Merritt, 1960; Denison, 1959). Perhaps the rocks of the two areas are time equivalents, but it is equally possible that the welded andesite tuffs are more closely related to the rhyolitic rocks of southeastern Missouri. From the descriptions of Farquhar (1957) it appears likely that no equivalent rocks are present in Kansas.

The first approach to a solution of the problem of correlation is the determination of the absolute age of the Spavinaw granite, presumably by isotopic studies of its zircon. The expected age would be 550, 1,000, or 1,400 m.y. The volcanic rocks of Craig County can not have an age markedly different from that of the Spavinaw granite and still be so closely associated with it in space, in freedom from metamorphic effects, and in general petrologic similarity. The two rock groups are, in fact, probably related to the same magma and are essentially contemporaneous.

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Nymphaeoblastus, A MISSISSIPPIAN BLASTOID FROM JAPAN

ROBERT O. FAY

The genus *Nymphaeoblastus* von Peetz, 1907, has been previously recorded as occurring in Tournaisian-Viséan rocks of Russia by Yakovlev (1926, 1941, 1956) and von Peetz (1907). This fissiculate blastoid is elongate subellipsoidal, with 4 long deltoids and, on the anal side, an elongate anal opening between a short epideltoid and a long hypodeltoid, with 10-15 or more short slits across the radiodeltoid sutures on either side of each ambulacrum, with linear elongate ambulacra that extend to the concave aboral surface, and lancet plate exposed the medial one-third of its width almost to the aboral end.

In 1951 and 1952, Minato mentioned and figured some blastoids from Mississippian rocks of the Kitakami Massif, northeast Honshu, Japan, being the first known record of Blastoidea from Japan. The species was not named. The specimens were sent to Dr. Gerhard Regnéll, Lund, Sweden, and to Dr. Lewis Cline, University of Wisconsin, for identification and publication but pressing duties prevented preparation of manuscript, and the specimens were sent to Fay at The University of Oklahoma. The specimens belong to the Geology Department of Hokkaido University, Sapporo, Japan, where they will remain on deposit.

There are three known species of *Nymphaeoblastus*: (1) *N. anossofi* Yakovlev 1926 (10-15 hydrospire slits, round in top view, no depression in middle of deltoid plates, small size), (2) *N. miljukovi* von Peetz 1907 (type species, 10-15 hydrospire slits, lobed in top view, with a longitudinal depression in middle of each deltoid plate, small size), and (3) *N. kasakhstanensis* Yakovlev 1941 (more than 15 hydrospire slits, large size). The first two species occur in Tournaisian rocks and the latter one occurs in Viséan rocks of Russia. The Japanese blastoids appear to belong to one species, indistinguishable from *Nymphaeoblastus anossofi*, and therefore this name is here applied to these representatives.

EXPLANATION OF PLATE I

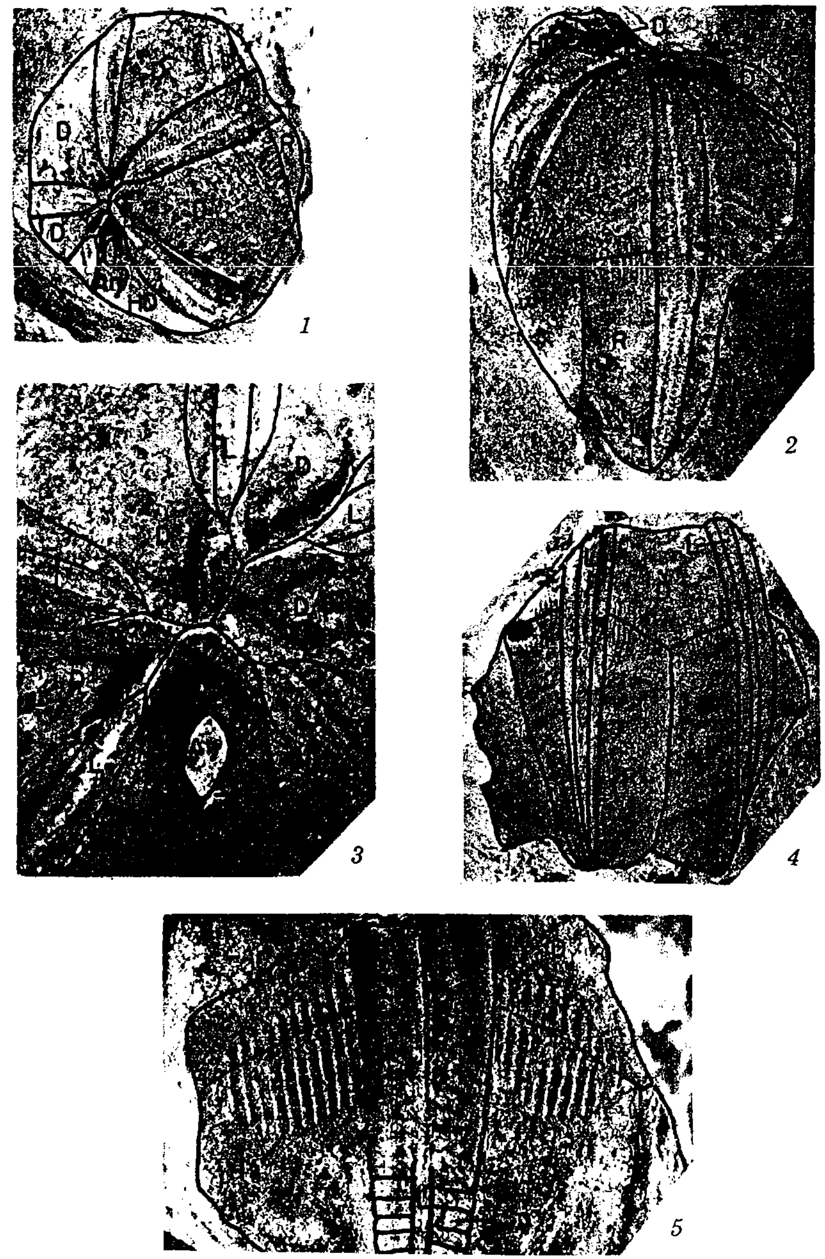
Nymphaeoblastus anossofi *Yakovlev, 1926, from D_n zone, Jumonji stage, Arisu series (upper Tournaisian), Mississippian system, Kesen-gun, Iwate Prefecture, northeast Honshu, Japan. Types are on deposit at Hokkaido Univerity, Sapporo, Japan.*

FIGURES 1, 2. *Oral and (E) ambulacral views of an external mold, x2.0, from Kozubo, Yokota-mura. No. 16001.*

FIGURE 3. *Oral view of summit of an external mold, x6.0, from Jumonji, Simoarisu-mura, No. 16001.*

FIGURES 4, 5. *Side views of two specimens (fragmentary) showing shape of radial plates and details of the hydrospire slits, x2.3 and x6.0 respectively, from Jumonji, Simoarisu-mura, No. 16191.*

An—anal opening | *Hs—hydrospire slits*
D—deltoid plate | *L—lancet plate*
ED—epideltoid plate | *R—radial plate*
HD—hypodeltoid plate | *Sp—side plate*



The description is based principally upon characteristics of one specimen (16001) supplemented by those of the other figured specimens (16191 and 16010).

Nymphaeoblastus anossofi Yakovlev, 1926

Plate 1, figures 1-5

Theca elongate subellipsoidal, 33 mm long by 21 mm wide, with concave base. Basal plates destroyed but in one specimen the shape of the basi-radial suture indicates that the basalia is about 8 mm wide, confined to the basal concavity. Radials about as long as deltoids, each subpentagonal, 19 mm long by 13 mm wide, with long, narrow, shallow sinus extending to basal concavity.

Deltoids 4, elongate lancet-shaped, extending to periphery, each 15 mm long by 9 mm wide, with approximately 12 hydrospire slits on each side of an ambulacrum, extending onto adjacent radial limbs. The longest hydrospire slits, adjacent to ambulacral margins, are 5 mm long in each of the 10 hydrospire fields, decreasing in size toward the interradial suture; thus the hydrospire slits are short, and confined to the peripheral area. On the anal side there are two deltoid plates, an adoral epideltoid and a long aboral hypodeltoid, with a small elliptical anal opening between, confined to the summit. In one specimen there are several hydrospire slits preserved on the anal side which appear to be excavated in the hypodeltoid; a condition unknown in the Blastoidea. In all known specimens of blastoids, the hypodeltoid is not infolded into hydrospires; thus one might suspect that other anal plates may be present or that slits are actually absent on the anal side. Published accounts indicate that there are hydrospire fields on the anal side, and one specimen (16010) has what appears to be 2 slits preserved on the anal side (the remainder of the specimen is destroyed). The Russian and Japanese specimens are poorly preserved molds and it is quite possible that the epideltoid extends in a horseshoe shape along the ambulacral margins to the radial limbs, with the hydrospire slits excavated in the epideltoid limbs.

Ambulacra 5, linear, each 35 mm long by 4 mm wide, with greatest width near periphery; lancet exposed along middle one-third of its width almost the entire length of the ambulacrum; with 20 side plates in 10 mm length of an ambulacrum. Each ambulacrum is curved aborally to the basal concavity, and adorally each ends about 2 mm from the oral opening.

The surfaces of the plates appear to be ornamented wth large granules aligned along growth lines, forming pronounced chevrons on the deltoid plates. The chevrons are parallel to the radiodeltoid suture, forming a 130 degree angle, with center at intersection of interradial suture with radiodeltoid suture.

Occurrence.—The described specimens occur as molds in tuff, D_0 zone, Jumonji stage, Arisu series, Mississippian system; from Kozubo, Yokota-mura (16001); Nasirosawas, Jumonji, Simoarisu-mura (16056); Kozubo, Setamai-mach (16057); Hinozuti, Simoarisu-mura (16169); Jumonji, Simoarisu-mura (16010, 16191); all from the Kitakami Massif, Kesen-gun, Iwate Prefecture, northeast Honshu, Japan. The D_0 zone is correlated with the C_1 Avonian of England, upper Tournaisian of Belgium, and Osagean of the United States, according to Minato (1960) and Moore (1948).

Types.—Plesiotypes, 16001, 16056, 16057, 16010, 16169, 16191, Department of Geology and Mineralogy, Hokkaido Imperial University, Sapporo, Japan. The specimens were collected by Professor Doctor Masao Minato.

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A Color-Marked Devonian Blastoid

Irving G. Reimann

Paleozoic fossils retaining indications of their original color pattern are rare. Among these older fossils, color markings have been most frequently noted in cephalopods and brachiopods. They occur less commonly on gastropods, pelecypods, and trilobites. The writer knows of only one Paleozoic echinoderm, a crinoid, which has been described (Bather, 1892) as preserving evidence of a color pattern. This crinoid, *Cyathocrinus acutitulus* Bather, has dark spots on the arms which, Bather declared, "may possibly be the relic of some original coloring, since similar ornament is found on recent forms."

Living echinoderms display a great diversity of colors and patterns (H. L. Clark, 1921, 1938; A. H. Clark, 1921), and it is presumed that their early predecessors may also have displayed vivid spots and bands of color.

As pointed out by Reimann (1945), the appearance of a color pattern may be simulated by light refraction in fibrous and fibro-lamellar substances, unequal staining by mineral solutions of shells of heterogeneous texture or substance, and by dark matrix showing through thinner portions of translucent shells. None of these alternative explanations appears to account for the striking banding of specimens of the blastoid, *Pentremitidea alveata,* described below. The specimens consist of dense calcite, the test substance is homogeneous both on the surface, where the markings are confined, and beneath it. The test is much too thick and opaque to show the effect of any internal plications on the plates.

The group of melanin pigments which is responsible for dark coloring in the vertebrates, and is known to cause dark coloring of numerous mollusk shells (Oppenheim, 1918), is insoluble in water, alcohol, and ether, and resists rather strong acids. If a melanin pigment were responsible for the dark colors of blastoids, its traces may remain in favorably preserved fossil material. The brown color of the stripes on the blastoid under discussion is consistent with this suggestion.

Concerning living crinoids, Clark stated (A. H. Clark, 1921) that "the coloring matter of crinoids is freely soluble in fresh water and in alcohol . . . many may be partially decolorized in a stream of fresh water while still alive." Whether or not salt water affects the permanence of the color is not stated. This is negative evidence, however, and it is not known whether the pigments of Paleozoic blastoids were the same as or different from those of living crinoids. Bather's color-marked crinoid seems to suggest that a permanent pigment may have occurred in that group.

The surface of the most strongly color-marked specimen of *Pentremitidea alveata* is pitted with almost microscopic borings of a *Cliona*-like sponge. These borings are filled with reddish material, quite certainly iron oxide. These borings are closely spaced over some parts of the specimen, shallowly penetrating both stripes and interspaces. No relationship whatsoever is apparent between the color pattern and the borings, and it may be safely stated that, if iron staining were the cause of the color marks, the staining should be most evident near, or at, places where iron oxide fills the sponge borings. All of the specimens of *Pentremitidea alveata* bear superficial iron oxide stains. These are different from the supposed color bands, and are not arranged in any regular pattern.

The color bands cannot be ascribed to symmetrical longitudinal sponge, annelid, or other borings which penetrate the shell beneath the markings, creating the illusion of dark coloration. Vertical sections of the test visible at places where parts of the test have been removed by weathering or by adherence to the rock matrix show no such burrows, and the color is seen to be confined to the thin surface layer.

The presence of a color-banded fossil in a fauna in which such a phenomenon has not been reported is not to be entirely unexpected. Many color markings are so faint as to be overlooked unless specifically sought. In other instances they have probably been mistaken for staining derived from the matrix. The discovery of one well-marked specimen or species in a fauna has no doubt more than once led to more careful inspection of specimens, and the finding of additional and corroborative material. As pointed out by Foerste (1930), "to judge from occurrences elsewhere, e v e n where color-marked species are unusually frequent, the number of specimens of any species actually retaining color markings forms only a small part of the total number of specimens of that

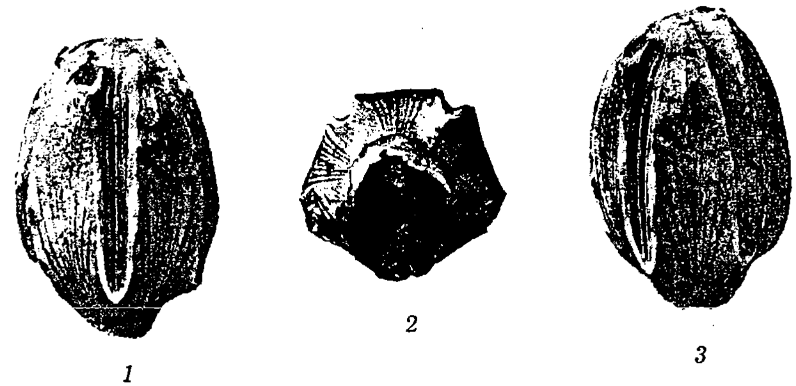

PLATE I

Pentremitidea alveata *Reimann, 1945, x2.0, showing color markings*
Specimen No. 37,808

FIGURE 1. *(E) ambulacral view*
FIGURE 2. *Aboral view with (B) ambulacrum toward bottom of page.*
FIGURE 3. *(D-E) interambulacral view.*
(Photographs by A. K. Miller)

species occurring at the same horizon." It is thus evident that, even under the most favorable conditions, where certain species retain the original color pattern, the majority of specimens of these species will have lost it. It is the more remarkable then that, of the seven known specimens of the species under consideration, four show color patterns, one with exceptional vividity, and three faintly.

Description of Specimens

Pentremitidea alveata Reimann, 1945

Plate I, figures 1-3; plate II

Pentremitidea alveata, Reimann. Buffalo Soc. Nat. Sciences, Bull., vol. 19, no. 2, p. 32, 33, plate 6, fig. 19, 1945.

The specimen shown retains the color bands in all interradii. The lower two-thirds of the right anterior and right posterior interradii have been destroyed by weathering, but in the remaining portion bands are seen to reach almost to the apex of the area. The color bands of the left anterior interradius are strongest in the lower half of the area, and become weaker toward the damaged apex. The same is true of the left posterior and the posterior interradii. On the radials, the bands coincide with the crests of low weak undulations of the surface of the plates. These undulations parallel the lines of growth. The bands are lacking on the shoulders, but appear faintly on the lowest part of the radials, parallel to the radiobasal sutures as horizontal continuations of the stronger lines of the radial limbs. Two color bands show on the upper part of the basals, parallel to the radiobasal suture. The color bands are approximately 0.1 mm wide. The width of the interspaces between the color bands varies on the radials, the bands being

Plate II

Pentremitidea alveata *Reimann, 1945, x13.0. Enlarged (D-E) interambulacral view of specimen 37,808, showing color markings.*
(Photograph by R. O. Fay)

close together on the lower portion and diverging adorally. The bands are crowded near the interradial suture toward the bottom of the area, and adorally approach and at places touch the ambulacral edges of the radials.

Three other specimens show faint traces of identical markings, one is a badly crushed fragmentary specimen, another is the most complete average individual of the species thus far seen, and the third is an obese gerontic individual. The excellent condition of the latter specimens enables us to add a few details to our knowledge of the species.

Pentremitidea alveata was originally described from crushed and broken specimens. The new material confirms that the proportions and outline are similar to those of *P. filosa* Whiteaves, but *P. alveata* is twice as large as that species. *P. alveata* differs from *P. filosa* principally in having saddle-like deltoid crests and much narrower spiracle margins. The hypodeltoid of *P. alveata* is longer and narrower distally and shorter and wider proximally than that of *P. filosa*. Further distinguishing characters of *P. alveata* are the increase in coarseness of the striae of the radials adorally, and the strongly reflected ambulacral edges of the radials, as pointed out in the original description. *P. alveata* is not to be confused with gerontic individuals of *P. filosa*, as the only seven specimens of the former, all from one horizon and locality, are all of similar size; smaller specimens which might be confused with *P. filosa* have not been found in association with *P. alveata*. Gerontic specimens of most blastoids are not necessarily much taller than fully mature specimens, but in most cases they are increasingly obese, or rotund. This is definitely true of both *P. filosa* and *P. alveata*.

Repository.—Plesiotypes—37,808 (figured) and 37,809 (unfigured), University of Michigan Museum of Paleontology.

Horizon and Locality.—All of the specimens of *P. alveata* known to the writer were collected by Charles Southworth from the Upper Widder beds of the Middle Devonian Hamilton group, at Jim Bell's "quarry," Thedford, Ontario.

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An Unusual *Agassizocrinus*

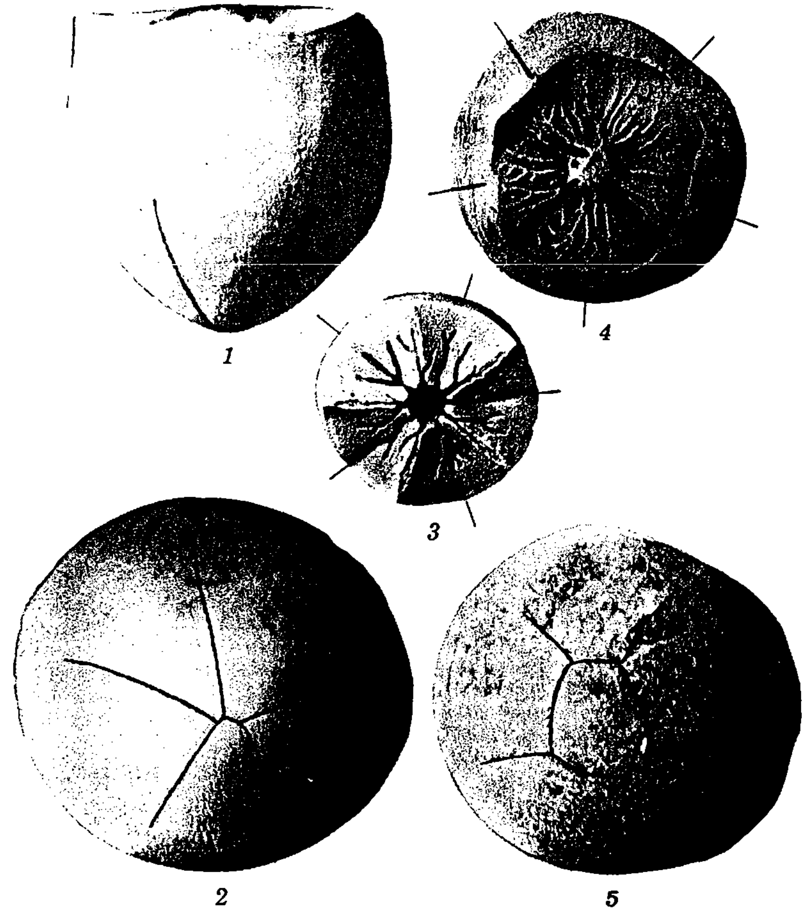
Harrell L. Strimple

Four specimens, which are infrabasal cones of *Agassizocrinus*, were collected by W. E. Ham on May 6, 1952, in the lower part of the Goddard formation (Mississippian) about 90 to 150 feet above the base. The location is given as NE¼ SE¼ SE¼ sec. 18, T. 3 S., R. 4 E., on Oil Creek on the Goddard Ranch. They are numbered 3919 in the Paleontological Collections of The University of Oklahoma. The specimens are unique in three respects; the sutures are visible although fusion has obviously taken place; one specimen shows a supernumerary infrabasal plate at the base of the cone; and all specimens possess exposed canal systems in the top of the cone.

The largest specimen has a height of 14.7 mm, maximum width of 15.3 mm, minimum width of 14.2 mm and it has a distinctive outline when viewed from the side. The cone expands rather rapidly to attain its full width jut below the mid-height of the cone. Above this level the lateral sides rise evenly and even curve inward imperceptably to the distal edges. The other three cones expand rather rapidly for a short distance, thereafter continuing to expand gently to the distal edges. The smallest specimen has a height of 9.3 mm, maximum width 12.7 mm, and minimum width of 11.9 mm. The maximum height of the cone is in mid-portion of the upper face due to the slight upward rise of the ridges that mark the interbasal positions. The cones are slightly elliptical, as reflected by the maximum and minimum widths.

Interinfrabasal sutures are best shown by the largest specimen. The sutures are faint in upper portions but may be followed to the distal edge of the cone by using reflected light on the shallow indentures. There is some slight difference in the sizes of the plates. One is larger than the average and one is smaller than the average. Differences are accentuated at the base of the cone as shown by figure 2. In the same figure, it is seen that the proximal tips of two of the infrabasals do not quite reach the central point of meeting. Moore and Plummer (1938) studied the different orientation of crystalline calcite composing each plate of infrabasal cones of *Paragassizocrinus magnus* (Moore and Plummer, 1938) and *P. caliculus* (Moore and Plummer, 1938) from Morrowan beds of Arkansas and Oklahoma. Their text-figure 11 applies to *P. magnus* and shows an asymmetry of the plates in their upper portions quite unlike the present form, but in the lower part the pattern is comparable to the form under consideration. The meeting of plates at the base of *P. magnus* is an even juncture.

The cone that possesses a supernumerary infrabasal plate (fig. 2) is smaller than the largest specimen but is not the smallest of the group. It is not juvenile. I would consider the specimen to be abnormal except that I am aware of similar occurrences in *Agassizocrinus patulus* Strimple, 1951. The structure escaped my attention when I described the species but in material subsequently collected from the type locality, consisting mainly of infrabasal cones, attention was drawn to the common presence of a minute, well-defined cavity at the base of the cones. Under



Figures 1-3 Agassizocrinus *sp., largest observed specimen. OU 3919.*
1. *Side view, approximately x3.*
2. *Basal view, approximately x3.*
3. *View of summit, x2, position of infrabasal sutures shown by drawn lines.*

Figures 4, 5. Agassizocrinus *sp., specimen with supernumerary infrabasal plate, OU 3919.*
4. *Plastolene squeeze of the summit, x2, position of infrabasal sutures shown by drawn lines.*
5. *Basal view, approximately x3.*

magnification, the cavities are seen to have a pentagonal outline. Unfortunately I do not have any specimens at hand to figure at this time. The supernumerary plate is pentagonal and elongate. The greatest length (4.1 mm) is at right angles to the long axis of the cone. It is of some interest to note that the sutures between infrabasals are also visible to a degree in *A. patulus,* which is also a Chesterian species.

The canal system preserved in the top of the cone is a truly rare occurrence among fossil crinoids. A view is afforded of the largest specimen by the unretouched photograph (fig. 3). The apparent positions of the interinfrabasal sutures are shown by lines drawn outside the photograph. The interbasal canals follow the ridges and extend closer to the outer surface of the cone. I believe that they join with canals interposed between the basals and pass on to the radial plates. The next longest canals are in position to reach the center of the lower apex of the basals and likely join an internal canal in the basal plates. It is possible that some of the next longest canals join with canals that may be on the inner walls of the basals. This is of course pure conjecture; however, there is no reason to doubt that the canals did serve the main axial nerve cords, which are part of the sensomotor nervous system of the cup. Strimple and Blythe (1960) described a closed canal system for *Paragassizocrinus atoka* Strimple and Blythe which is much simpler than the present system but is fundamentally comparable. Teichert (1949) described a more complex, open canal system for *Calceolispongia,* which he ascribed to the nervous system. Sieverts (1927) described a complex canal system for *Marsupites* as a nerve system. There are enough points of similarity in the systems of the few examples known to regard the presently considered system as being of the same nature. As pointed out by Teichert (1949, p. 17) these should not be confused with systems of radial ridges on the inner surface of some crinoid plates, which may or may not represent nerve-canal systems.

Figure 4 is a plastolene squeeze of the slightly more complex canal system found in the specimen with the supernumerary plate (fig. 5). I can offer no explanation of the more numerous canals and branches of main canals. Unfortunately it has not been possible to obtain a squeeze that shows the entire morphology of the central cavity because of a slight overhang. The edges of the cavity are uneven but the opening has a mean width of about 2.6 mm and it has a depth of 3.5 mm. All canals converge into five chambers in the lower walls of the cavity and are radial in position. The nature of the relatively small cavity would be obscure unless compared with some living crinoid wherein the proximal end of the plexiform gland, as well as the axial canal and blood vascular system, occupies a small chamber in the bottom of the dorsal cup (see P. H. Carpenter, 1884, pl. 62).

The outer surface of the largest cone has a frosted appearance under low magnification. There is no species known to me with a cone shaped like that of the large specimen. *Paragassizocrinus* is restricted to the Pennsylvanian at this time so the presently considered form is listed as *Agassizocrinus* sp.

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Productoidea in Oklahoma

Carl C. Branson

The long-awaited Muir-Wood and Cooper memoir on the productoid brachiopods reached here on November 15, 1960. The nomenclatorial impact will be overwhelming everywhere, and it is here reviewed as it affects Oklahoma fossils. The oldest productoid is *Spinulicosta* of the Lower Devonian, but the oldest productoids that have earlier been reported from Oklahoma are *Productella hirsutiformis* from the Woodford shale (Morgan, 1924, p. 47) and *P. concentrica* Hall (Morgan, 1924, p. 46). Both the identifications and the stratigraphy are suspect. Muir-Wood and Cooper divide the Suborder Productoidea into two superfamilies and 19 families. The superfamily Strophalosiacea is represented in Oklahoma only by the genus *Planispira* Stehli, reported from the Red Eagle limestone of Osage County, Oklahoma.

Superfamily Productacea
Family Productellidae

The new genus *Quadratia* is erected upon the type species *Productus hirsutiformis* Walcott, 1884. The species has been reported from the Bayou Manard member of the Moorefield formation in northeastern Oklahoma (Huffman, 1958, p. 52) and from the Ahloso member of the Caney shale (Girty, 1909, p. 24). Oklahoma specimens are figured by Muir-Wood and Cooper from Moorefield limestone in SW¼ NW¼ sec. 21, T. 15 N., R. 20 E., Muskogee County (pl. 39, figs. 1-5), from the same unit in S½ NW¼ sec. 21, T. 15 N., R. 20 E., Muskogee County (pl. 39, figs. 7-8), and from the Moorefield in sec. 19, T. 15 N., R. 20 E., Muskogee County (pl. 39, fig. 9).

Family Leioproductidae

Semicostella is established on *Avonia oklahomensis* Snider, 1915, from the Bayou Manard member of the Moorefield formation. The figured types are from center east line sec. 20, T. 15 N., R. 20 E., Muskogee

County (pl. 62, figs. 1-4, 9-12) and from NW¼ sec. 18, T. 15 N., R. 21 E., Cherokee County (pl. 62, figs. 5-7).

Setigerites setiger (Hall) is recorded as from Oklahoma, presumably from the Moorefield as reported by Sutton in 1942 (as *Buxtonia setigera*).

Family Marginiferidae

Marginifera splendens (Norwood and Pratten), 1855, and *M. haydenensis* Girty, 1908, are referred to *Kozlowskia*, and Oklahoma occurrences are noted, the latter species figured from the Pumpkin Creek limestone, sec. 32, T. 3 S., R. 4 E., Johnston County (pl. 63, fig. 12).

Chonetella dunbari Newell, 1934, from the Missourian near Wann, Nowata County, is tentatively removed from that Permian genus.

The new genus *Inflatia* includes *Productus cherokeensis* Drake, 1898, described from the Moorefield five miles southeast of Adair, Mayes County, and *P. adairensis* Drake, 1898, described from the Ordnance Plant member of the Moorefield formation (see Huffman, 1958, p. 60). The figured specimens of the genotype, *Inflatia inflata* (McChesney), 1860, are from the Fayetteville shale in NE¼ sec. 7, T. 22 N., R. 20 E., Mayes County (pl. 55, figs. 1-15).

Muir-Wood and Cooper set up the genus *Rudinia* with *Productus muricatus* Norwood and Pratten, 1855=*Marginifera muricatina* Dunbar and Condra, 1932, as genotype (p. 229-230). While the book was in press Hoare (1960, p. 226) described the genus under the name *Desmoinesia* with the same type species. *Rudinia* is a junior objective synonym and is therefore invalid (see Muir-Wood and Cooper, addendum, p. 431). *Desmoinesia muricatina* occurs in the Cabaniss and Marmaton groups of Oklahoma, Muir-Wood and Cooper refer the Krebs species *Marginifera missouriensis* Girty, 1915, to *Rudinia*, and this widespread Oklahoma form is thus referred by them to *Desmoinesia*. Muir-Wood and Cooper figure *D. muricatina* from the Wetumka of the north center sec. 18, T. 3 N., R. 7 E., Pontotoc County (pl. 64, figs. 11-16, 18) and from the Senora in Dewar, Okmulgee County (pl. 64, figs. 17, 19-25).

Family Productidae

The genus *Diaphragmus* Girty, 1910, is again left distinct from *Productus* sensu strictu. The genus is represented in Oklahoma by *D. cestriensis* (Worthen), 1860, in the three Chester formations of the northeastern part of the State (Hindsville, Fayetteville, Pitkin), and in the Bayou Manard member of the Moorefield, and *D. fasciculatus* (McChesney), 1860, is listed from the Bayou Manard, Hindsville, and Fayetteville (Huffman, 1958, p. 53-73). It would seem probable that *D. centriensis* is the Chester species, *D. fasciculatus* the Meramec species. Figured specimens of *D. cestriensis* are from the lower part of the Fayetteville in SW¼ sec. 21, T. 15 N., R. 20 E., Muskogee County (pl. 73, figs. 1-6, 13, 17), and from the Fayetteville in sec. 20, T. 15 N., R. 20, E., Muskogee County (pl. 73, fig. 12; text fig. 3 D).

Family Echinoconchidae

The new genus *Echinaria* is founded upon *Productus semipunctatus* Shepard, 1838, and the Oklahoma Pennsylvanian forms are thus removed from the genus *Echinoconchus*. *Echinaria semipunctatus* has been listed

from the Atoka of eastern Oklahoma (Huffman, 1958, p. 86). *E. alternatus* is listed by Huffman (1958, p. 47) from the Short Creek oolite member of the Keokuk formation, and the subspecies *E. semipunctatus knighti* Dunbar and Condra, 1932, has been reported from the Altamont limestone of Nowata County and from the Deese group of the Criner Hills region.

Pulchratia, a new genus founded upon *Productus symmetricus* McChesney, 1860, has been listed from several Middle and Upper Pennsylvanian formations. *P. symmetrica* (McChesney), 1860, is figured from the Brownville of NE¼ NW¼ sec. 10, T. 24 N., R. 6 E., Osage County (pl. 87, fig. 11).

Family Buxtoniidae

The new genus *Flexaria* is erected for the group of species of the *Productus arkansanus* Girty, 1910, type. *F. arkansana* occurs in the Pitkin, Fayetteville, and Hindsville and in the Bayou Manard member of the Moorefield, and *F. multilirata* (Girty) in the Lindsey Bridge member of the Moorefield (Huffman, 1958, p. 53-73). Specimens of *F. arkansana* from the Fayetteville in SE¼ NE¼ sec. 7, T. 22 N., R. 20 E., Mayes County, are figured (pl. 78, fig. 9-18 and pl. 123, figs. 18-21).

Unassigned specimens of *Buxtonia* are figured from the Fayetteville of Mayes County, SE¼ NE¼ sec. 7, T. 22 N., R. 20 E., (pl. 74, figs. 1-4), and of Craig County, NE¼ sec. 11, T. 25 N., R. 21 E. (pl. 74, figs. 5-7).

The genus *Protoniella* Bell, 1929, is expanded to include doubtfully the species *Productus welleri* Mather, 1915, from the Hale and Bloyd of Oklahoma, listed by Huffman (1958, p. 79, 83).

Family Dictyoclostidae

The species *Productus coloradoensis* Girty, 1915, and *P. hermosanus* Girty, 1903, are left in the incompletely known genus *Antiquatonia*. These species are widely identified in Oklahoma. The Morrow species *Productus morrowensis* Mather, 1915, of the Hale and Bloyd is also left in *Antiquatonia*. The genus remains a broad one, ranging from Chesterian to Leonardian in age.

Auloprotonia is founded upon *A. aulacophora* new name, for *Dictyoclostus crawfordsvillensis* of Sutton, not Weller (1942, pl. 71, figs. 1-2) of the Moorefiield of Bayou Manard (text fig. 4 A; pl. 97, figs. 1-10, pl. 98, figs. 1-5) All of the figured specimens came from the NW¼ sec. 18, T. 15 N., R. 21 E., Cherokee County. Huffman reported the species from the Keokuk (1958, p. 46) and *A. manardensis* (Sutton) from the Bayou Manard member of the Moorefield (1958, p. 53). He did not certainly recognize *A. fosteri* (Sutton), 1942, another Moorefield species; but doubtfully listed it from the Bayou Manard (1958, p. 53).

Reticulatia is founded upon *Productus huecoensis* King, 1931, into which *Dictyoclostus americanus* of Dunbar and Condra, 1932 (not *Productus americanus* Swallow) is merged. The species is reported from the Brownville limestone (Virgilian) and Red Eagle limestone (Lyonian) of Oklahoma. Brownville specimens from NE¼ NW¼ sec. 10, T. 24 N., R. 6 E., Pawnee County (sic) =Osage County, are figured (pl. 104, figs. 1-4).

Family Linoproductidae

The redefined genus *Linoproductus* is left with the following Oklahoma species:

L. insinuatus (Girty), 1911, of the Wewoka formation; and also reported from the Fort Scott.

L. prattenianus (Norwood and Pratten), 1855, listed by authors from many Oklahoma localities.

L. oklahomae Dunbar and Condra, 1942. Figured from the Okesa sandstone near Barnsdall, Osage County (pl. 111, figs. 1-2).

L. cf. *L. cora* (d'Orbigny), 1842, from the Red Eagle limestone, NW¼ SE¼ sec. 25, T. 26, N., R. 5 E., Osage County (pl. 111, figs. 10-14).

The genus *Marginirugus* Sutton occurs as *M. magnus* (Meek and Worthen), 1862, in the Short Creek oolite (Huffman, 1958, p. 47).

The new genus *Ovatia* is established with the new species *O. elongata* as genotype. The holotype specimen is from the lower part of the Fayetteville formation from east of Ft. Gibson in Muskogee County (p. 312-314; pl. 114, figs. 1, 3-4). Another specimen from that locality is figure 2, the original of figure 6 is from nearby, the original of figure 8 is from southeast of Adair in Mayes County, and the original of figure 12 is from the Moorefield formation of Muskogee County. The specific name *Productus ovatus* Hall, 1858, is preoccupied by *P. ovatus* Pander, 1830, but Muir-Wood and Cooper did not replace the homonym because the type specimen is lost and because *P. pileiformis* McChesney, 1860, and *P. laevicostus* White, 1861, may be names for the same species.

Ovatia elongata (as *P. ovatus*) was reported by Huffman (1958) from the Bayou Manard member of the Moorefield formation (p. 53), from the Ordnance Plant member (p. 60), from the Hindsville formation (p. 65), from the Fayetteville formation (p. 70), from the Pitkin limestone (p. 74), and from the Hale formation (p. 79).

Such genera as *Productus, Dictyoclostus, Marginifera*, and *Pustula*, the names of which have long been familiar in Oklahoma, do not occur in the State.

The book is "Morphology, classification and life habits of the Productoidea (Brachiopoda)," by Helen Muir-Wood and G. Arthur Cooper, Geological Society of America, Memoir 81, 447 pages, 135 plates, 8 figures. The book is dated October 31, 1960. The price is $12.75. It is well worth the money, for it is a paleontological classic.

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