Some Silicified Middle Ordovician Brachiopods From Kentucky

GEOLOGICAL SURVEY PROFESSIONAL PAPER 583-A

Prepared in cooperation with the Kentucky Geological Survey

Some Silicified Middle Ordovician Brachiopods From Kentucky

By ROBERT B. NEUMAN

CONTRIBUTIONS TO THE ORDOVICIAN PALEONTOLOGY OF KENTUCKY

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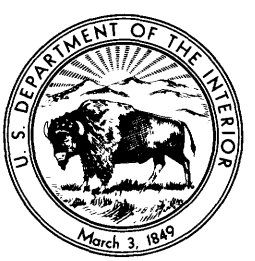
Descriptions of one strophomenid and four enteletacean brachiopods



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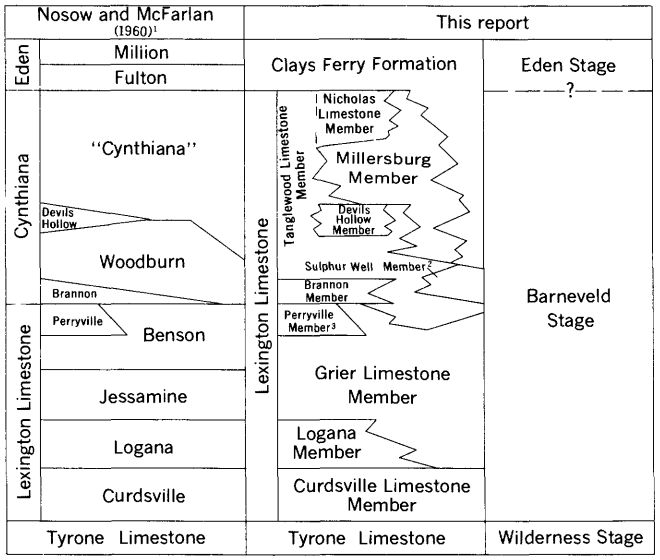

[1] Synthesized from Nosow and McFarlan (1960, figs. 3 and 14 and p. 37-42).
[2] Of McFarlan (1943).
[3] Includes Salvisa Bed.

FIGURE 1.—Divisions of the Lexington Limestone used currently by the U.S. Geological Survey compared with another classification of the same rocks. From Black, Cressman, and MacQuown (1965, p. C5); stage assignments added.

Heterorthina macfarlani occurs in the upper part of the Grier Limestone Member and its equivalents, and *Dalmanella bassleri* Foerste occurs in the upper part of beds still classed as Cynthiana along the Ohio River and in the immediately overlying Fulton Shale of earliest Eden age.

THE COLLECTIONS

The Lexington Limestone fossils described here were obtained from collections made by R. J. Ross, Jr., John Pojeta, Jr., E. L. Yochelson, and myself on several different occasions between 1962 and 1965. A special effort was made to obtain rock samples containing silicified fossils from measured sections. Where such rock was found, samples weighing 25–100 pounds were collected.

In concentrating on silicified material some advantages as well as disadvantages were anticipated. Advantages, considered paramount, included the considerations that well-silicified specimens would yield maximum information on morphology, the sampler's bias would be reduced, large numbers of collections and specimens could be handled efficiently, and such collections would yield stratigraphic information as well as information on growth and intraspecific variation of the fossils. Disadvantages resulted from the limited distribution of silicified specimens, both geographic and stratigraphic, and from the selectivity of the replacement. Thus, some intervals lacked silicified fossils, and some samples contained both silicified and nonsilicified forms. Furthermore, some species that have been reported as common or diagnostic in these rocks are poorly represented in these collections; *Heterorthis clytie* Hall is very rare, and no specimens of *Dinorthis ulrichi* Foerste and *Strophomena vicina* Foerste were found. However, because modern taxonomic discriminations are based on knowledge of morphology in detail not often or readily obtained from weathered-out or cracked-out specimens, the advantages of concentration on silicified brachiopods far outweighed the disadvantages.

Several species in addition to those reported on here are represented in the collections by a wide range of sizes and an abundance of specimens, and these specimens might later be informative for growth and variation studies. For example, the collections contain hundreds of specimens belonging to the genus *Zygospira*, some with silicified spires. This is the most common of the Lexington brachiopods, but such a wide range of sizes and other features is apparent that the specimens cannot be confidently assigned to existing species as these are now defined. Until these brachiopods are intensively studied, their taxonomy and stratigraphic utility should be considered as questionable.

PREPARATION

The samples were processed in the Washington and Denver laboratories of the U.S. Geological Survey. The procedure generally followed was:

1. Wash blocks to remove surface contamination, and dry.
2. Coat one side with Ambroid or other acid-resistant film.
3. Dissolve $CaCO_3$ completely by placing coated side down in commercial hydrochloric acid (1 part acid to 10 parts water). Remove $CaCl_2$ solution and replenish with acid as required to prevent buildup of $CaSO_4$.
4. Rinse residue to remove all salts and mud, and dry.

The fossils were then picked from the insoluble residue by a technician, first with the unaided eye, and then with the aid of a microscope.

CATALOGING AND DEPOSITORY

The collections have been assigned U.S. Geological Survey Cambro-Ordovician locality numbers (the CO catalog); those with a "D" prefix were first entered in the catalog in Denver, but most were entered in Washington, where all the collections are now stored.

All type specimens have been deposited in the collections of the U.S. National Museum in Washington and assigned USNM catalog numbers, as indicated at appropriate places in the descriptions that follow.

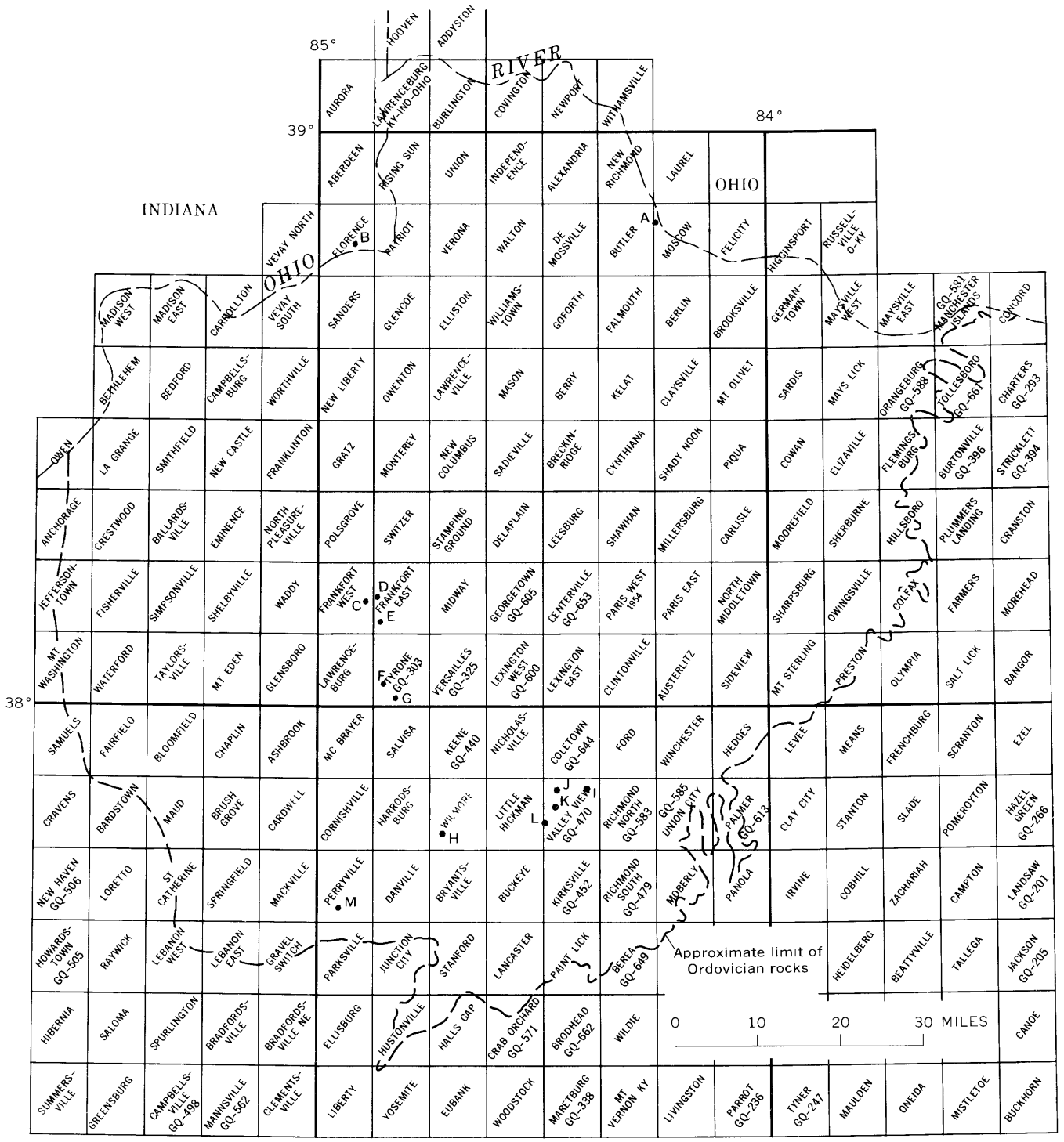

FIGURE 2.—Topographic quadrangles in central Kentucky, approximate limit of Ordovician rocks, and general location of localities from which fossils described in this report were obtained. Published geologic quadrangle maps are indicated by appropriate GQ numbers. A, Carnestown; B, Florence, Ind.; C, D1196–CO, 5073–CO, 5089–CO; D, 5093–CO; E, 4053–CO; F, 4865–CO, 5086–CO; G, 4077–CO, 4080–CO; H, 5080–CO; I, 4173–CO; J, 5096–CO; K, 4189–CO, 4191–CO, 4192–CO; L, 4879–CO, 4880–CO, 4883–O; M, 5015–O.

PALEONTOLOGY

ENTELETACEAN BRACHIOPODS

The superfamily name Enteletacea replaced the name Dalmanellacea on grounds of priority in the recent Brachiopoda volume of the "Treatise on Invertebrate Paleontology" (Williams and others, 1965, p. H328). The name Enteletacea is derived from a specialized Carboniferous genus, although the superfamily includes the older, more generalized forms; its application in this sense is new in the treatise volume and, as is mentioned there, ". . . may initially be inconvenient."

Under this superfamily are included the punctate orthoids which are common and often abundant in almost all Middle and Upper Ordovician fossiliferous rocks. As these brachiopods are relatively primitive and unspecialized, they look alike in many respects, both internally and externally. Most are small, thin, and rounded in outline, and their ventral valves are more convex than their dorsal valves, which may be nearly flat; shell surfaces are costellate. Internal structures are simple; ventral teeth are simple and small, and dental plates are short; muscle impressions are confined posteriorly and are tripartite. Dorsal cardinalia are somewhat more specialized, as shown in the various arrangements of the cardinal process, brachiophore supports, and the supporting structures of both.

Classification of these brachiopods at specific, generic, and suprageneric levels has had a long and complex history. A review of this history and the status of the members of the group would be inappropriate in this report. I have not yet fully appraised the nomenclatural changes that are new in the treatise and neither accept nor reject them here. Accordingly, the suprageneric categories used are limited to those required for an orderly arrangement of the descriptions that follow, and they are used informally.

ENTELETID BRACHIOPOD

Genus Pionodema Foerste, 1912

Pionodema rectimarginata new species

Plate 1, figures 1–13

Description.—Very small, wider than long, rotund, and inequivalved; ventral valve the deeper. Dorsal sulcus well developed in immature specimens and in posterior and medial parts of mature specimens, but disappears near front of old-age specimens whose anterior commissures are straight. Surface finely costellate; costellae rounded; some hollow; three or four per millimeter over the anterior half of mature shells, arise by branching and intercalation (branching interspaces).

Dorsal interior has moderately deep notothyrial cavity; brachiophore bases nearly parallel or converge slightly anteriorily, rise steeply from shell floor, and flare outward at their distal extremities where they join narrowly tapered, outward-flaring brachiophore processes. Fulcral plates well developed, forming deep sockets. Cardinal process shaft thin, rising from anterior end of notothyrial cavity to maximum height at posterior, where it supports a small crenulated myophore. Median ridge broad and low, extends to about midlength of valve. Adductor muscle scars not preserved.

Ventral interior has stout teeth supported by erect receding moderately divergent dental plates that rise from posterolateral margins of muscle field. Anterior margin of muscle field weakly impressed and probably cordate; diductor scars somewhat elevated above adductor track and apparently extend beyond it.

Measurements.—The measurements given here (in millimeters) are of the larger articulated specimens from four samples:

[All specimens paratypes except 155510, which is holotype]

USNM	USGS loc.	Length		Width		Thickness	Commissure
		Dorsal	Ventral	Hinge	Maximum		
155515	4879-CO	5.5	6.5	5.8	7.5	4.3	Straight.
155516	4879-CO	5.5	6.0	7.0	Incomplete	3.9	Do.
155510	4879-CO	4.5	5.5	5.0	6.5	3.3	Sulcate.
155517	4879-CO	3.5	4.2	5.5	6.0	2.5	Do.
155518	5096-CO	4.2	4.5	5.5	6.1	3.0	Do.
155519	4883-CO	5.5	6.0	5.5	6.5	3.3	Do.
155520	5098-CO	5.0	5.5	6.0	6.5	3.3	Do.

Discussion and comparison.—The species is erected from examination of 150 silicified specimens in the 10 collections from the Grier Limestone Member of the Lexington Limestone in central Kentucky listed below. The collections contain both articulated and disarticulated shells ranging in width from 2 to 7.5 mm. The largest specimens are about 5 mm long and have a maximum width of about 7 mm at midlength of the ventral valve; articulated specimens range from 2.5 to 4.3 mm in thickness. Of these large specimens, those 4 mm or more thick have straight anterior commissures, whereas those 3.5 or less thick are gently sulcate, and the sulcation of specimens smaller than 5 mm is even more pronounced. The thicker shells with straight commissures are therefore considered to be old-age specimens, and the thinner sulcate ones of the same height and width are considered to be mature. Small size thus seems to be characteristic of adults of this species.

P. rectimarginata is smaller than the three smallest species of the genus described by Cooper (1956), for which lengths of about 10 mm and widths of about 11 mm were given. Of these three species, *P. rectimar-*

ginata is most like *P. sulcata* Cooper, except in size, and is more evenly costellate than *P. conradi* Winchell and *P. miniscula* Willard.

Source of material and stratigraphic occurrence.—*Pionodema rectimarginata* is known from silicified specimens prepared from 10 samples taken from four places where it occurs in the middle part of the Lexington Limestone. The holotype and several paratypes were selected from a suite of about 50 specimens from the Grier Limestone Member 40–41 feet beneath the base of the overlying Tanglewood Limestone Member (41–42 ft above the base of exposure; loc. 4879–CO) in the roadside section about 500 ft northwest of Antioch Church, near the west margin of Valley View quadrangle, Jessamine County (Greene, 1966). A similar suite from 2 feet higher in the same section furnished other paratypes (loc. 4880–CO), and an additional paratype was selected from a smaller suite, 16 feet higher (loc. 4883–CO).

Paratypes were also selected from a suite of about 25 specimens from a float sample of the Grier (loc. 5098–CO), most probably from 40–45 feet beneath the base of the Tanglewood at the creekbed section beside Hunters Ferry Road, 1.35 miles northeast of the same Antioch Church; several specimens were found in outcrop samples at 31, 32, and 45 feet beneath the base of the Tanglewood in this section (locs. 4189–CO, 4191–CO, and 4192–CO, plotted as point O on the Valley View (Greene, 1966) geologic map). An additional measured paratype was selected from about 10 specimens from a sample of the Grier obtained beside an abandoned railroad bed (loc. 5096–CO), 0.3 mile southeast of the YMCA Camp in the northwest quarter of the Valley View quadrangle. A few specimens were also obtained from a sample (loc. 5015–CO) of the Salvisa Bed [1] of the Perryville Member in the Perryville quadrangle to the southwest, the sample was taken from 5 feet above the base of the unit in the roadside exposure on the east side of the Chaplin River, 0.4 mile south of the junction of U.S. Highways 150 and 68 in Perryville.

At both the Perryville and the Antioch Church localities, *Pionodema rectimarginata* occurs with *Pionomena recens*, described on page A12. Here and elsewhere, *P. rectimarginata* is associated with the more common Lexington brachiopods *Hebertella frankfortensis* Foerste, *Rafinesquina trentonensis* Conrad, and *Zygospira* sp.

DALMANELLID BRACHIOPODS

Only three of the genera included in the family Dalmanellidae in the treatise (Williams and others, 1965, p. H330–H336) are here considered: *Dalmanella*, *Onniella*, and *Heterorthina*. The classification of these and other genera in this group of brachiopods has had a long and complex history, and the criteria by which they are identified and distinguished are still poorly understood. The generic diagnoses in the treatise and the earlier review of the "*Orthis testudinaria* Dalman" group of brachiopods by Williams and Wright (1963) offer some promise of stabilizing these generic concepts.

The presence or absence of fulcral plates had been considered to be of prime taxonomic importance (Schuchert and Cooper, 1932, p. 121; Opik, 1933, p. 15; Cooper, 1956, p. 947, 953; Hall, 1962, p. 141–142). Cooper (1956, p. 948–949), in discussing *Dalmanella costellata*, commented on the great variation of its brachial structures, including the fulcral plates. Williams and Wright (1963, p. 6) found these plates in only three of six small specimens of *D. wattsi* (Bancroft), and the plates are present in a minority of specimens in some populations of *D. sulcata* Cooper from Kentucky which were studied for this report. Thus, the presence or absence of fulcral plates in this genus seems to have no taxonomic significance whatever.

Attitudes of the brachiophores, emphasized by Williams and Wright (1963, p. 4–11, fig. 10, p. 25), are more persistent within populations and seem crucial in discriminating these genera. Williams and Wright described the attitudes in terms of angles subtended by the brachiophores and contrasted the angle at the base (at the floor of the valve) with that at the top. In those whose tops subtend a greater angle than their bases, the brachiophores flare upward and outward and present their inner surfaces in plan view; Williams and Wright (1963, p. 27) characterized the brachiophores of *Dalmanella* as of this kind. In those whose tops subtend a smaller angle than their bases, the brachiophores converge upward so that their inner surfaces are concealed but their outer surfaces that face posterolaterally are presented in plan view. Of the genera under consideration, Williams and Wright (1963, p. 28) found the brachiophores of *Onniella* and *Heterorthina* to be of this kind; these two genera were differentiated by them by the convexity of their dorsal valves, the former convex, the latter subplanar.

On the basis of these criteria and others, the Lexington Limestone contains one species of *Heterorthina*—*H. macfarlani* n. sp.—and two species of *Dalmanella* that are very similar to each other—*D. fertilis* Bassler and *D. sulcata* Cooper. The exceptionally large species *D. bassleri* Foerste, with which *H. macfarlani* had been confused, seems to occur only in the upper "Cynthiana" and in the overlying Fulton Shale along the Ohio River. No brachiopods from these rocks are assigned to *On-*

[1] The Salvisa Member of Miller (1913) is herein adopted for use by the U.S. Geological Survey as the Salvisa Bed of the Perryville Member of the Lexington Limestone.

niella, as none are known that fit the description of this genus as given by Williams and Wright (1963, p. 28–29; Williams and others, 1965, p. H336).

Genus Dalmanella Hall and Clarke, 1892

Dalmanella bassleri Foerste, 1909

Plate 1, figures 35–44

Dalmanella bassleri Foerste, 1909, p. 215 (not figured).
Onniella bassleri (Foerste), Hall, 1962, p. 144–145, pl. 20, figs. 41, 42.
non Dalmanella bassleri Foerste, McFarlan, 1932, p. 70, pl. 2, figs. 1–3 (fide Hall, 1962, p. 144).

Description.—Exceptionally large biconvex inequivalved shells; ventral valve the deeper and bears low fold; dorsal valve has low but distinct convexity and bears shallow sulcus. Anterior commissure sulcate. Outline rounded and wider than long; maximum width at midlength; cardinal extremities obtuse and rounded. Ornament uniformly costellate; costellae branch so that two or three per millimeter are present at 5 mm or more length. Costellae of posterolateral slopes arcuate, the posteriormost curving to intersect posterior margin at a small acute angle.

Dorsal interior has sessile notothyrial platform; brachiophores stout, their tops subtending a larger angle than their bases. Fulcral plates lacking. Cardinal process prominently bilobed; shaft short and cleft and tapers anteriorly to terminate at anterior edge of notothyrial platform. Median ridge low and broad and confined to posterior third of shell floor. Posterior adductor muscle impressions oval, about a third longer than wide, and better marked than anterior impressions, which are poorly defined.

Ventral interior has short divergent dental plates that extend only a short distance along shell floor. Diductor muscle impressions confined to posterior third of shell; anterior terminations rounded and extend beyond adductor impression, which is poorly defined.

Type specimen.—A type specimen of *D. bassleri* was not designated by Foerste in his original description of the species, nor was this lack mentioned by Hall (1962). The U.S. National Museum collections contain two incomplete specimens—a dorsal and a ventral valve, both numbered 87,148—labeled as cotypes of *Dalmanella bassleri* with a pencilled note on the label: "Foerste says big specimens are types. C. B. [Charles Butts] Apr. 9, 1934." The locality given on the accompanying labels is: "Trenton—*Strophomena vicina* Zone, Carnestown, Kentucky" (Moscow 7½-minute quadrangle) and "5–20 ft. above Ohio River." As Foerste's (1909, p. 215) description is apparently based on specimens from Carnestown (spelled Carntown on the topographic map), and the most distinctive feature of the species is its size, the larger of the two specimens, the ventral valve, is here designated the lectotype; the accompanying dorsal valve is, thus, a paratype. Photographs of both specimens are published for the first time in this report (pl. 1, figs. 35–36). Measurements of these specimens, in millimeters, are given below; inasmuch as the specimens are incomplete, dimensions of the preserved shell are given, followed where appropriate by estimates of these dimensions (in parentheses) of the complete shell.

USNM	Length	Width		Depth
		Hinge	Maximum	
87148a (ventral valve—lectotype)	21.5	24	26.5(28)	4.5
155521 (dorsal valve—paratype)	15	18	19 (21)	1.5

Florence, Ind., specimens.—The National Museum collections also contain several specimens (84420) identified by Foerste as *Dalmanella bassleri* from "opposite Warsaw, Ky. on Indiana side of Ohio River," (Florence 7½-minute quadrangle) according to the label. This is one of the five localities noted for the species by Foerste (1909, p. 215), who further identified the site as "east of Florence, Indiana." This collection contains several calcite and partly decalcified specimens in calcareous siltstone and silicified specimens in a single piece of argillaceous limestone about 2 inches in diameter. The limestone block was dissolved to free the silicified specimens, and some calcite specimens were dissolved to expose their internal structures cast in the siltstone.

These specimens are better preserved than those from Carnestown. Although somewhat smaller than the Carnestown specimens, the Florence specimens are generally larger than those of measured populations of *D. emacerata* (Hall) of Eden age (Hall, 1962, p. 153) and *D. meeki* (Miller) of Richmond age (Hall, 1962, p. 148). Photographs of both silicified and decalcified specimens are given on plate 1 (figs. 37–44), and measurements, in millimeters, of both types of specimens given in the following table.

[Number in parentheses is estimated width of complete specimen]

USNM	Length	Width		Thickness or depth
		Hinge	Maximum	
155523 (articulated, silicified)	16 (ventral), 15 (dorsal)	16	20.5	6
155548 (dorsal, silicified)	15	13	18	
155549 (ventral, silicified)	17	7(15)	19 (24)	4
155522 (dorsal, decalcified)	16	15	19	1.5
155524 (ventral, decalcified)	20	13(15)	22.5(26)	5

Comparison.—*D. bassleri* is characterized by the large size attained by some specimens. Of the species in the Cincinnati region, it is most similar to *D. meeki* (Miller). However, comparison of length and width measurements made by Hall (1962, p. 148) of 23 specimens of *D. meeki* with measurements of 5 specimens from Foerste's collections and 2 from Hall's (p. 145) collections shows that although there is some overlap, most specimens identified as *D. bassleri* are larger than specimens of *D. meeki* (fig. 3).

Discussion.—*D. bassleri* is redescribed here to establish its identity and to distinguish it clearly from other brachiopods erroneously identified as *D. bassleri*, particularly from those here included in *Heterorthina macfarlani* n. sp., described on page A10. *H. macfarlani* is also an exceptionally large dalmanelloid, but its internal structures are distinctive, and it has a much thinner shell and a nearly flat dorsal valve that lacks a conspicuous sulcus like that of *D. bassleri*.

Occurrence.—Little is known about the occurrence and distribution of *D. bassleri*. The only specimens assigned to the species with confidence are those in the collections described here and in the collections described by Hall (1962, p. 144–145). Of the other occurrences listed by Foerste (1909, p. 215), that of the "Wilmore bed" of Kentucky is probably in error; certainly the single specimen in the National Museum collection so labeled is misidentified. However, the National Museum collections contain no specimens from the other three localities given by Foerste—South Moscow, Butler, and Parks Hill. No specimens of *D. bassleri* have been obtained from recent U.S. Geological Survey Middle Ordovician collections from Kentucky. Thus, little is known about the occurrence and stratigraphic range of *D. bassleri*, but it seems to occur in the beds Foerste assigned to the Cynthiana Formation adjacent to the Ohio River and, according to Hall (1962, p. 145), in the overlying basal (Fulton) beds of the Economy Member of the Latonia Formation (as classed by Caster and others, 1955, p. 12).

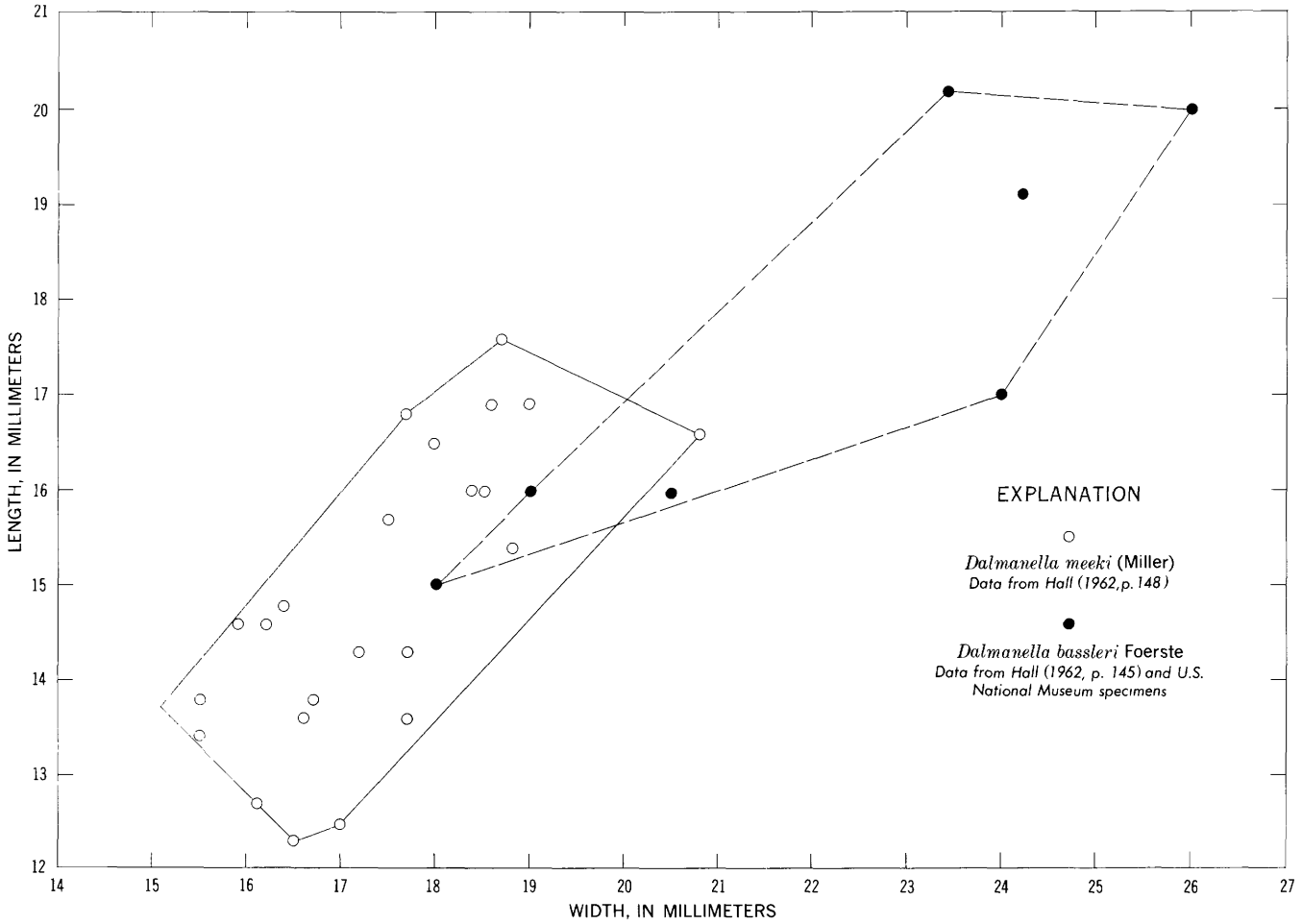

FIGURE 3.—Length and width of specimens of *Dalmanella meeki* (Miller) and *D. bassleri* Foerste.

Dalmanella sulcata Cooper, 1956

Plate 1, figures 14–34

Dalmanella sulcata Cooper, 1956, p. 951–952, pl. 161, figs. 1–16.

Description.—Reexamination of the topotypes and other types in the National Museum collections together with the Kentucky specimens indicates that both internal and external features of this species are highly variable. The following redescription is an emendation of Cooper's made largely to accommodate this range of variation.

Subrectangular to transversely elliptical in outline, wider than long and widest near middle; hinge width about two-thirds maximum width. Sides gently rounded to nearly straight; cardinal extremities obtuse and narrowly rounded; anterior margin strongly rounded. Dorsal sulcus and corresponding ventral fold narrow and well defined in posterior half of shell, but their persistence to anterior is variable, so that anterior commissure ranges from sulcate to nearly straight (fig. 4). Surface costellate (ramicostellate); costellae branch so that they are of nearly uniform density (two or three per millimeter) over entire shell; costellae of lateral slopes arcuate, those in the posterior region curving to intersect the posterior margin at a small angle. Growth lines prominent at irregular intervals; concentrated at anterior margin where some project as short growth lamellae.

Ventral valve deeper than dorsal valve, gently convex in lateral profile; maximum convexity at the umbo.

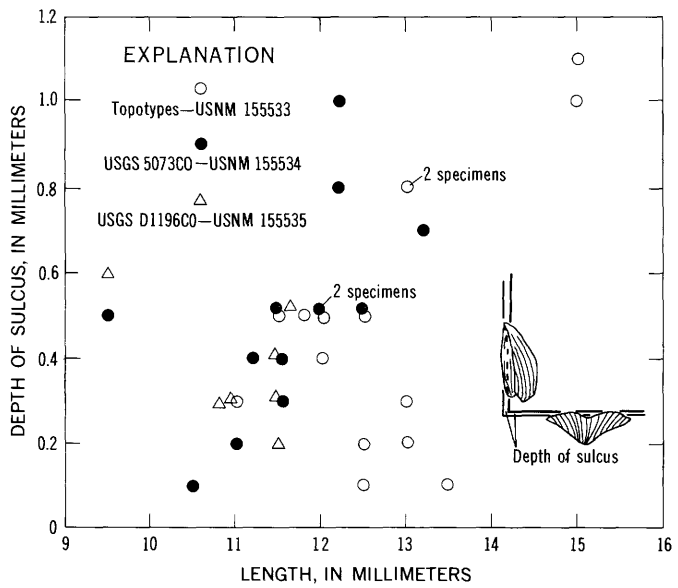

FIGURE 4.—Depth of dorsal sulcus plotted against length of shell for three populations of *Dalmanella sulcata* Cooper. Measurement obtained by viewing along anterior slope of a dorsal valve oriented so that it is in line with anterior commissure as shown in sketch.

Anterior profile variable, ranging from broadly triangular for specimens with more carinate and persistent fold to broadly domed for specimens whose fold is not persistent. Beak low, incurved; umbo carinate. Anterior prolongation of carina variable; ranges from those whose fold persists from beak to anterior margin to those whose fold disappears beyond midlength. Interarea moderately long, curved, and apsacline.

Dorsal valve gently convex in lateral profile; anterior third somewhat flattened. Anterior profile bilobate; depression between lobes varies in depth and width. Umbo conspicuously sulcate; narrow sulcus persists and becomes wider and deeper toward anterior margin of some specimens but disappears toward anterior margins of others. Interarea curved, anacline; length about one-third of that of ventral interarea.

Ventral interior has small teeth supported by flaring dental plates that thicken anteriorly to enclose posterior sides of muscle field. Muscle field extends to about midlength of shell floor. Diductor scars elongate, occupying about three-fourths of field at its midlength and extending beyond adductor scar to narrowly rounded anterior termination.

Dorsal interior has bladelike divergent brachiophore supports rising from slightly elevated notothyrial platform; bases of brachiophore supports subtend smaller angle than do tops. In a few well-preserved specimens, supports merge anteroventrally with slender tapering rodlike brachiophore processes at anterior tip of blade, and these processes are as much as a third the length of supports. Sockets undefined in most specimens, but in some are floored with pad of shell that fills apex of angle between the posterolateral face of brachiophore base and posterior wall of valve. In a few specimens, fulcral plates connect posterolateral faces of the brachiophore bases to posterior wall. Cardinal process has bilobed crenulated myophore occupying most of notothyrium and projects beyond the interarea. Shaft normally short, slender, not cleft, and confined to notothyrial platform; in gerontic specimens, shaft is thickened and cleft and merges with median ridge. Median ridge low and broad, extends to about midlength of shell. Adductor muscle scars not seen.

Ontogeny.—Immature specimens 2 mm long were obtained from collection D1196–CO, and some 3 mm long from collection 5073–CO. Ventral valves of this size are not different in any essential from larger specimens, but significant changes can be seen in progressively larger dorsal valves.

In the smallest shells, 2–3 mm wide, the brachiophore supports rise directly from the shell floor; no notothyrial platform or median ridge is present, and no fulcral plates are seen. The shaft of the cardinal process is thin,

and although preservation is too imperfect to be certain, the bilobed myophore appears to be present at this stage, elevated above the floor of the shell.

Shells about 5 mm wide and 4 mm long have an elevated notothyrial platform formed by thickened shell between the brachiophore supports, and the median ridge is present in adult form. At this stage the posterior edge of the myophore is ankylosed to the shell floor at the apex of the notothyrium, but its anterior edge remains elevated on the shaft. One specimen out of about 10 at this stage has fulcral plates.

Shells wider than 5 mm have adult characteristics; the most notable progressive change beyond this stage is the addition of shell material around the cardinal process. In shells 5–10 mm wide the shaft and myophore are well differentiated; in many shells wider than 10 mm the shaft becomes swollen and cleft, some have a cross section like that of the myophore, and the cleft shaft extends beyond the notothyrial platform where it merges with the median ridge.

Discussion and comparison.—Most specimens of *D. sulcata* from Kentucky, like most of Cooper's from Tennessee, are characterized by their strongly sulcate anterior profile. Internally the Tennessee and Kentucky specimens are identical. However, it should be noted that although Cooper (1956, p. 947) inferred the presence of fulcral plates in this species from its taxonomy, none of the type specimens have these plates. Williams and Wright (1963, p. 8) observed that these plates occurred only in specimens of this species longer than 5 mm, but the context of their remarks indicates that fulcral plates are exceptional in adult shells, as the present study indicates.

Cooper (1956, p. 952) described the brachiophores of this species as "united to median septum," an apparent error as no specimens have a median septum. As stated in the species discription, the brachiophores of young specimens rise directly from the shell floor; a notothyrial platform is developed in larger specimens by thickening of the shell between the brachiophore bases, and a low median ridge projects directly from the platform, but there is no true median septum at any stage.

Two other sulcate species described by Cooper (1956) are very similar to *D. sulcata* but smaller: *D. crassicostellata* and *Onniella? planoconvexa*, which occur together at a single locality in the lower part of the Hermitage Formation in western Tennessee. Large collections of these species from their type locality and from points between it and the type locality of *D. sulcata* should be studied to determine their degree of distinctness.

D. sulcata is readily distinguished from *D. fertilis* Ulrich; the dorsal valve of the latter is distinctly less convex than that of *D. sulcata*, and it lacks the sulcus that characterizes most specimens of *D. sulcata*. *D. fertilis* is confined to the Curdsville Limestone Member of the Lexington Limestone in Kentucky. Although the recent collections add little to the knowledge of *D. fertilis* (Cooper, 1956, p. 954–955), they do demonstrate that *D. fertilis* and *D. sulcata* can be differentiated by their shapes if adequate samples are studied. Some identifications in recently published Geological Survey quadrangle maps were made before these differences were fully appreciated; restudy of all Logana Member collections indicates that the *Dalmanella* in this member is *D. sulcata*, not *D. fertilis*.

Source of material and stratigraphic occurrence.—The species description is based on examinations of type specimens from Tennessee and of silicified specimens recently collected from seven localities in Kentucky. The type lot consists of the holotype (USNM 117365a), 11 paratypes selected by Cooper, and about 200 topotypes collected by Cooper from the basal part of the Hermitage Formation at a locality given as "east side of U.S. Highways and 70S–41, 4.2 miles southeast of Nashville, Tenn." Cooper, 1956, p. 1167). Kentucky specimens, all from the Logana Member of the Lexington Limestone, are from U.S. Geological Survey collections as follows: Locs. D1196–CO, 5073–CO, and 5089–CO—Interstate Highway 64 south of Frankfort, just east of Kentucky River Bridge, Frankfort East quadrangle (interstate highway not shown on 1959 edition of map), Franklin County; loc. 4053–CO—small tributary to Glenns Creek north of Old Crow Distillery, Frankfort East quadrangle, Woodford County; loc. 4080–CO—Shryock Ferry Road (N of geologic map, Cressman, 1964), Woodford County; locs. 4865–CO and 5086–CO—half a mile east of Kentucky Utilities Corp. power plant north of Blackburn Memorial Bridge (U.S. Highway 62), Tyrone quadrangle, Woodford County; loc. 4173–CO—Kentucky Highway 169 just east of Marble Creek, Valley View quadrangle (P of geologic map, Greene, 1966), Jessamine County; and loc. 5080–CO—Southern Railroad cut 1.2 miles west of Herrington Lake spillway, Mercer County. Of these, locs. D1196–CO and 5073–CO yielded the most numerous and best preserved specimens having a wide range of sizes; loc. 5073–CO yielded more than 1,000 specimens.

All but two of Cooper's specimens are silicified, only eight are disarticulated to show their internal structures, and none are smaller than 5 mm in length. All the Kentucky specimens are silicified, and most are disarticulated. Thus, the range of variation of external features for comparable numbers of both Tennessee and Kentucky specimens could be determined and compared,

but the Kentucky specimens offer far more opportunity to observe internal structures and immature forms.

The species is known to occur in the lower part of the Hermitage Formation in central Tennessee and in the Logana Member of the Lexington Limestone in central Kentucky, where it appears to be the only *Dalmanella* present.

Genus Heterorthina Bancroft, 1928

Heterorthina macfarlani new species

Plate 2, figures 1–19

Name.—This species is named for Prof. Arthur C. McFarlan, longtime Head of the Department of Geology, University of Kentucky, and former Director of the Kentucky Geological Survey. The name is spelled in accordance with Recommendation III–21(a) of appendix D of the International Code of Zoological Nomenclature (Stoll and others, 1964).

Description.—Large, generally planoconvex, wider than long, subelliptical in outline, and widest at midlength; cardinal extremities rounded. Dorsal valve nearly flat but ranging from slightly convex through flat to resupinate. Dorsal interarea very short, slightly curved, and anacline; umbo low; sulcus deepest at about 3 mm shell length and gradually flattens beyond, so that shells longer than about 15 mm have straight anterior commissure. Ventral valve moderately convex; maximum convexity in posterior region. Ventral interarea two to three times longer than dorsal interarea, gently curved, and apsacline. Beak slightly incurved; umbo high, passes forward into low fold that persists for about 15 mm, beyond which shell is uniformly arched in anterior profile. Shell surface costellate (ramicostellate), rounded costellae branch and are of nearly uniform density (2 or 3 per millimeter) over shell surface. Costellae of lateral slopes arcuate; those in posterior region curve to intersect posterior margin at about 45°. Growth lines present on some specimens, absent from others; where present, spaced at irregular intervals, most prominent near front of large shells.

Dorsal interior has triangular brachiophore supports surmounted by spike-shaped brachiophore processes (rarely preserved). Triangular shape of brachiophore supports is as follows: Obtuse angle (about 120°) at anterior end on valve floor; acute angle (about 20°) at posterior end; intermediate angle (about 40°) at anterior end above valve floor. Angle subtended between plates at shell floor is about 90° (80°–95°), whereas angle is about 70° (60°–75°) at top of plates. Thus plates slope posterolaterally and converge upward so that their outer faces are visible in plan view but their inner faces are concealed. Posterior ends of plates laid along margins of notothyrium. Brachiophore processes project from free upper anterior angle of supporting plates in line with their upper edges. Junction between supporting plates and processes defined by marked thinning of shell substance. Length of brachiophore processes about equal to that of supporting plates. Sockets poorly defined; fulcral plates lacking. Notothyrial platform elevated; anterior edge lifted above shell floor and supported at lateral margins by pair of short plates. Cardinal process has broad deeply cleft shaft that occupies nearly full width of notothyrial platform; myophore large, crenulated, and biolobed; projects slightly beyond interarea. Median ridge broad, commonly has shallow median cleavage continuous with that of shaft of cardinal process; ridge extends about one-third length of shell. Adductor muscle scars, preserved in only a few large specimens, are quadripartite; anterior pair subquadrate and about equal in area to triangular posterior pair. Pallial marks not preserved.

Ventral interior has stout curved triangular teeth supported by short advancing widely flaring dental plates that enclose posterior half of muscle field. Muscle impressions variable; outline of entire field ranges from cordate where adductor track is narrow to divergently bilobed where adductor track is wide. Diductor scars have rounded anterior ends extending beyond adductor track almost to midlength of valve. Adductor track about three-fourths length of diductors and slightly depressed below them in some specimens, but slightly elevated above them in others; relative width of track variable, ranges from 10 percent to 25 percent of total width of muscle field. Adjustor scars variable, well developed in some specimens and obscure in others of similar size; where well developed, are about half the length and width of adjacent diductor and separated from it by a low ridge. Pedicle callist at apex of delthyrial cavity. Preservation of pallial marks inadequate for description.

Ontogeny—Ontogenetic changes were observed in specimens ranging from 2 to 20 mm in length, mostly from locality 5093–CO. These changes were most apparent in the dorsal cardinalia. Few significant changes were observed in the ventral valve; the pedicle callist was seen only in shells 6 mm or more long, and muscle impressions were visible only in specimens longer than 15 mm. A low sulcus extends the full length of dorsal valves less than 8 mm long and is complemented by a low ventral fold, so that such small specimens have an anterior commissure that is gently sulcate. The costellae of shells less than 3.5 mm long (Pl. 2, fig. 12) are nearly straight and are radially disposed; they do not curve

backward to meet the posterior margin as they do in larger specimens.

In the smallest specimens preserving dorsal cardinalia (about 2 mm long), the brachiophore supports rise vertically from the shell floor and diverge anteriorly (Pl. 2, figs. 14, 15). Brachiophore processes are present, but they are not differentiated from their supports by shell constriction as they are in larger shells. The notothyrial platform is not thickened at this stage, although its lateral margins are defined by the bases of the brachiophore supports. The shaft of the cardinal process is a short thin blade. The myophore, imperfectly preserved in these specimens, is elevated above the notothyrial platform at its posterior end; the myophore is probably bilobed, the whole structure forming a Y in anterior view.

Shells about 4 mm long (pl. 2, figs. 16, 17) have brachiophore supports of characteristic adult shape and posterolateral slope; presumably, the brachiophore processes are well differentiated from their supports at this stage, but none of the processes are preserved. The thickened shell between the brachiophores defines the notothyrial platform of shells of this size, but its anterior edge is not lifted as it is in larger ones. A median ridge is present at this stage, but it lacks cleavage. The cardinal process retains its juvenile form: the anterior end of the myophore is elevated above the floor of the notothyrial platform on a thin shaft. In shells only slightly larger (pl. 2, figs. 18, 19), the base of the myophore is ankylosed to the notothyrial platform.

The adult form of the cardinal process having a cleft shaft and a sessile myophore appears in some, but not all, shells 8–10 mm long, and it is a persistent feature in those more than 10 mm long.

Gerontism is manifest in incomplete dorsal valves that were probably more than 20 mm long, especially in the depth of impression of the adductor muscle scars and in the swollen cardinal process (pl. 2, fig. 5). The cleft shaft nearly fills the notothyrial platform; the myophore is proportionally smaller, so that in these large shells the cross section is less than that of the shaft, and the shaft tapers posteriorly. Anteriorly, the shaft merges without contrast with the median ridge which is cleft at its posterior end.

Measurements.—The mesaurements given here (in millimeters) are of common large-sized specimens which have been judged to be adults. As indicated in the preceeding paragraphs, immature specimens are as little as 2 mm long, and gerontic specimens are about 20 mm long.

[All specimens paratypes except 155536, which is holotype]

USNM	USGS loc.	Length	Width		Depth
			Hinge	Maximum	
Dorsal valves					
155536	5089-CO	14.5	12	18.5	----
155550	5089-CO	19.5	11	25	----
155540	5089-CO	9	7	12	----
155551	5089-CO	16.5	11	20	----
155552	5089-CO	16	11.5	20.5	----
155538	4077-CO	16	11.5	21.5	----
Ventral valves					
155553	5089-CO	18	12	22	5
155554	5089-CO	17	15	21	3.5
155555	5089-CO	17.5	10	20.5	4
155556	5089-CO	14.5	11	18	4
155537	5089-CO	14	9	16.5	3.5
155541	5093-CO	17.5	13.5	21	4.5

Discussion and comparison.—The shells described here as *Heterorthina macfarlani* have heretofore been identified as *Dalmanella* (or *Onniella*) *bassleri* by others (Foerste, 1909, p. 215: ". . . in the Wilmore bed, belonging to the so-called Trenton of Kentucky"; McFarlan and White, 1948, p. 1634, as "*Dalmanella bassleri* (*D. fertilis*)," repeated by Nosow and McFarlan, 1960, p. 39), and as *Heterorthina* sp. (=*Dalmanella bassleri*) by myself (in Cressman, 1964). A comparison of the foregoing descriptions of typical *D. bassleri* and *Heterorthina macfarlani* indicates the generic distinctness of the two forms. The two are alike in being exceptionally large dalmanelloids, but they are subtly distinctive in their external form and clearly distinctive in their dorsal cardinalia.

The cardinalia of *H. fairmontensis* (Foerste), a fossil of Maysville age (pl. 2, fig. 20), are like those of *H. macfarlani*, indicating close relations between the species. *H. fairmontensis* is somewhat differently shaped, however, being wider and more triangular and its maximum width is closer to the hinge line.

Comparison of immature specimens of *H. macfarlani* and *D. sulcata* shows that although the cardinal process develops in the same manner in both, the slope of their brachiophore supports remains distinctive through the smallest sizes observed. Thus, although the two genera represented by these species are obviously closely related, they retain their distinctive characteristics throughout the range of sizes available for study.

Source of material and stratigraphic occurrence.—The holotype and most of the paratypes were selected from about 250 silicified specimens prepared from the Macedonia Bed of the Grier Limestone Member of the Lexington Limestone in cuts on the south side of the westbound lane of Interstate Highway 64, just east of

Stoll, N. R. (chm.), and others, 1964, International code of zoological nomenclature adopted by the 15th International Congress of Zoology: 2d ed., London, Internat. Trust Zool. Nomenclature, 176 p.

Williams, Alwyn, 1962, The Barr and lower Ardmillian series (Caradoc) of the Girvan district, south-west Ayrshire, with descriptions of the Brachiopoda: Geol. Soc. London Mem. 3, 267 p.

Williams, Alwyn, and Wright, A. D., 1963, The classification of the "*Orthis testudinaria* Dalman" group of brachiopods: Jour. Paleontology, v. 37, p. 1–32.

Williams, Alwyn, and others, 1965, Brachiopoda, Part H *of* Moore, R. C., ed., Treatise on invertebrate paleontology: New York, and Lawrence, Kans., Geol. Soc. America and Univ. Kansas Press, 2 v., 927 p.

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PLATES 1 and 2

PLATE 1

FIGURES 1–13. *Pionodema rectimarginata* n. sp. (p. A4).

1–5. Holotype; a coarsely silicified articulated specimen; ventral, dorsal, posterior, anterior, and right-side views, × 4; USNM 155510; USGS Loc. 4879–CO.

6, 7. Paratype; a large well-preserved dorsal valve; exterior and interior views, × 4; USNM 155511; USGS Loc. 4879–CO.

8, 9. Paratype; a large well-preserved ventral valve; exterior view showing hollow costellae, and interior view, × 4; USNM 155512; USGS Loc. 4880–CO.

10. Ventral interior with a considerably larger muscle scar than that shown in fig. 9, × 4; this specimen, from USGS Loc. 4880–CO, was lost after photography.

11. Paratype; interior of small dorsal valve with right-hand brachiophore process preserved, × 4; USNM 155513; USGS Loc. 4880–CO.

12, 13. Paratype; a large dorsal valve, exterior and interior views, × 4; USNM 155514; USGS Loc. 4880–CO.

14–34. *Dalmanella sulcata* Cooper (p. A8).

14, 15, 19. Dorsal valve, exterior, interior, and anterior views, × 2; USNM 155525; USGS Loc. 5073–CO.

16, 17. Ventral valve, exterior and interior views, × 2; USNM 155526; USGS 5073–CO.

18. Immature dorsal valve, × 5; note that the brachiophore supports rise directly from the shell floor; USNM 155527; USGS Loc. 5073–CO.

20–23. Nearly complete articulated shell, posterior, anterior, ventral, and dorsal views, × 2; USNM 155528; USGS Loc. 5073–CO.

24–26. Holotype; ventral, dorsal, and anterior views, × 2; USNM 117365a.

27, 28. Anterior views of two other specimens from collection from which types were selected to show maximum and minimum sulcation of anterior margin, × 2; USNM 155529 and 155530.

29, 30. Dorsal interior; posterior (× 4) and plan (× 2) views, showing brachiophore processes; USNM 155531; USGS Loc. 5073–CO.

31. Dorsal interior, oblique view of specimen showing well-developed fulcral plates × 3; USNM 155587; USGS Loc. D1196–CO.

32–34. Immature dorsal valve; posterior (× 8) and plan (× 6) views, and oblique anterior view of cardinalia (× 15) to show bilobed myophore elevated on shaft; USNM 155532; USGS Loc. 5073–CO.

35–44. *Dalmanella bassleri* Foerste (p. A6).

35. Paratype; dorsal interior, × 2; labelled "Carnestown, Ky., 5–20 ft. above Ohio River." Foerste collection, USNM 155521.

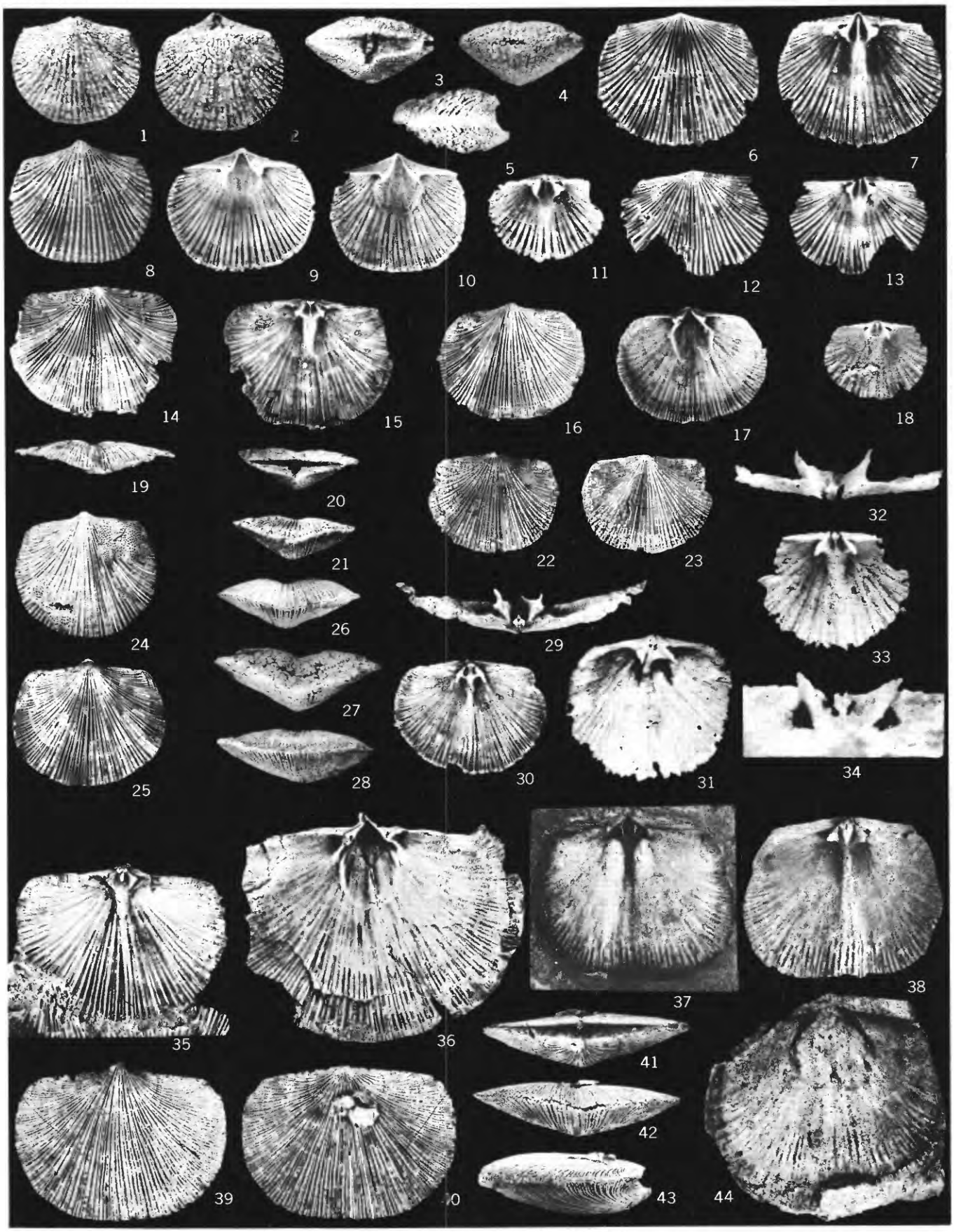
36. Lectotype; ventral interior, × 2; same label as fig. 35; USNM 87148.

37. Dorsal interior, × 2; cast of decalcified specimen in siltstone, labelled "Trenton (top), opposite Warsaw, Ky. on Ind. side of Ohio River." Foerste collection, USNM 155522.

38. Rubber replica made from cast of fig. 37; note the outward flaring brachiophore supports and the short shaft of the cardinal process in this specimen and in fig. 35.

39–43. A complete silicified specimen; dorsal, ventral, posterior, anterior, and side views, × 2; same label as fig. 37; USNM 155523.

44. Ventral interior, × 2; cast of decalcified specimen; note the cordate muscle field with a narrow, slightly elevated adductor track; same label as fig. 37; USNM 155524.



PIONODEMA AND *DALMANELLA*

PLATE 2

FIGURES 1–19. *Heterorthina macfarlani* n. sp. (p. A10).

1, 2. Holotype; dorsal valve, exterior and interior views, × 2; USNM 155536; USGS Loc. 5089–CO.

3, 4. Paratype; ventral valve, exterior and interior views, × 2; note the variation of musculature in the four specimens on the right-hand side of this plate, especially the differences in width of the adductor tracks and the adjustor scars; USNM 155537; USGS Loc. 5089–CO.

5, 6. Paratypes; interiors of large dorsal valves, showing adductor scars, × 2; note the differences in outline of the scars; USNM 155538; USGS Loc. 5089–CO; USNM 155539; USGS Loc. 4077–CO.

7, 8. Paratype; dorsal valve, posterior view × 4, plan view × 5, showing brachiophore processes; in fig. 8 a disc of black paper was inserted on the floor of the valve as a background for the processes; USNM 155540; USGS Loc. 5089–CO.

9–11. Paratypes; ventral valves, × 2, to show range of variation of musculature; USNM 155541; USNM 155542; USGS Loc. 5093; USNM 155543; USGS Loc. 5089–CO.

12, 13. Paratype; exterior and interior views of immature ventral valve, × 5; note that at this stage the costellae do not intersect the posterior margin; USNM 155544; USGS Loc. 5093–CO.

14, 15. Paratype; interior of immature dorsal valve, plan view × 8, oblique anterior view of cardinalia × 30; note the upward converging brachiophore supports and the bilobed myophore elevated on shaft; USNM 155545; USGS Loc. 5093–CO.

16, 17. Paratype; interior of a somewhat larger immature dorsal valve, plan view × 6, oblique view of cardinalia × 15; note that the median ridge is developed at this stage, and that the myophore is nearly ankylosed to the floor of the notothyrial platform; USNM 155546; USGS Loc. 5093–CO.

18, 19. Paratype; interior of a small dorsal valve, plan view × 6, oblique view of cardinalia × 15, showing early mature development of myophore ankylosed to notothyrial platform; note plates supporting notothyrial platform; USNM 155581; USGS Loc. 5093–CO.

20. *Heterorthina fairmontensis* Foerste, dorsal interior, × 2, shown for comparison with *H. macfarlani;* from Ulrich collection labelled: "Maysville (Bellevue), Hamilton, Ohio." USNM collection 48710a, spec. 155547.

21–36. *Pionomena recens* n. sp. (p. A12).

21, 22. Paratype; exterior and interior of a nearly complete ventral valve, × 2; USNM 155557; USGS Loc. 4880–CO.

23–25. Holotype; exterior and interior views of a nearly complete dorsal valve, × 3, and enlargement of cardinalia, approximately × 10, showing the unsupported curled plate that forms the sockets and supports the bilobed cardinal process; note that the posterior faces of the cardinal process lobes are notched; USNM 155558; USGS Loc. 5015–CO.

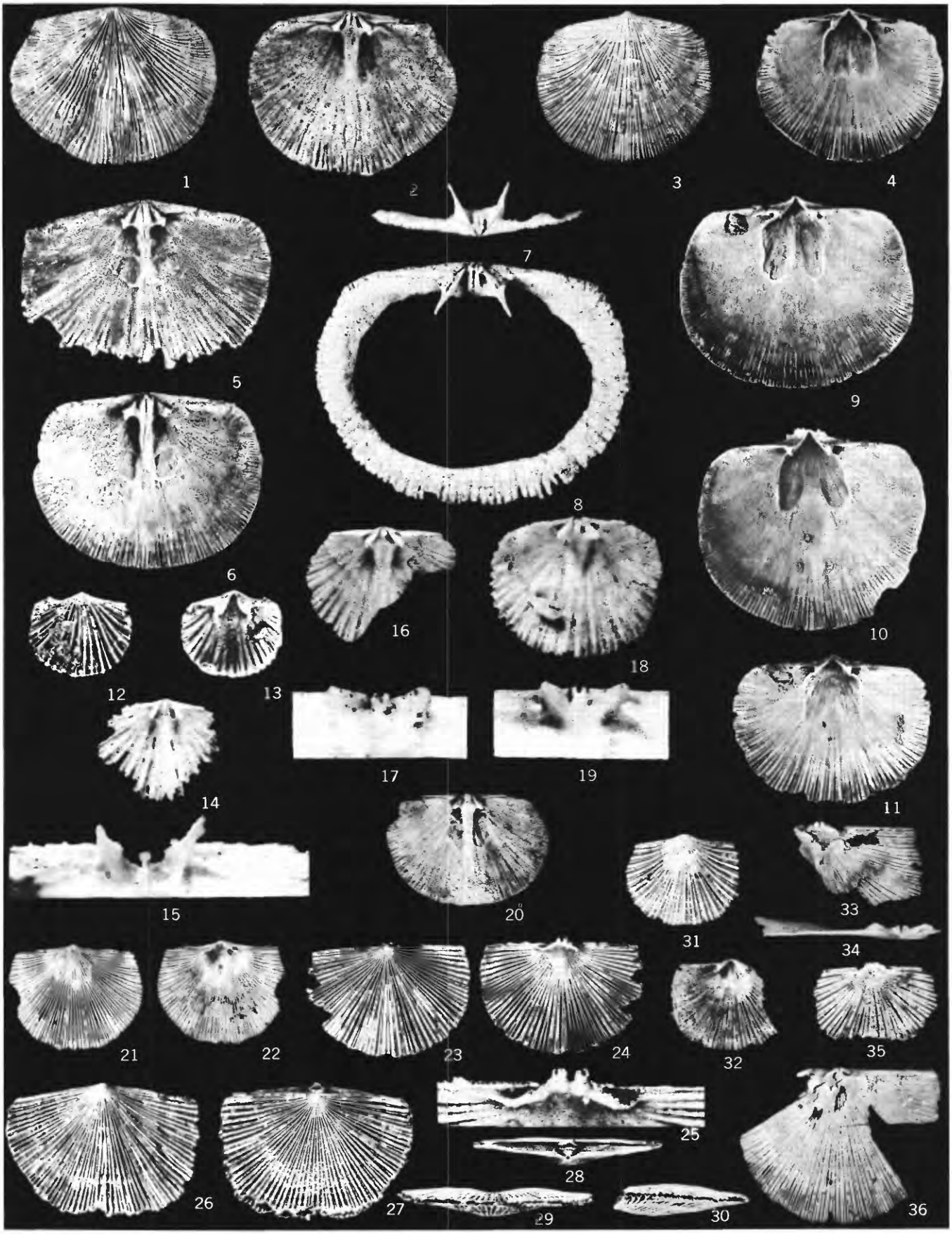
26–30. Paratype; an articulated, nearly complete specimen; ventral, dorsal, posterior, anterior, and side views, × 3; USNM 155559; USGS Loc. 5015–CO.

31, 32. Paratype; immature ventral valve, exterior and interior views, × 5; a part of the specimen was broken off during photography; USNM 155575; USGS Loc. 4880–CO.

33, 34. Paratype; partly preserved dorsal valve, interior view, × 2; USNM 155576; USGS Loc. 4880–CO.

35. Paratype; immature dorsal valve, interior view, × 5; USNM 155577; USGS Loc. 4880–CO.

36. Paratype; incomplete dorsal valve, interior view, × 2, the largest specimen seen; USNM 155578; USGS Loc. 4880–CO.



HETERORTHINA AND *PIONOMENA*