The Brachiopod Genera *Hebertella, Dalmanella,* and *Heterorthina* from The Ordovician of Kentucky

GEOLOGICAL SURVEY PROFESSIONAL PAPER 1066-M

Prepared in cooperation with the Commonwealth of Kentucky, University of Kentucky, Kentucky Geological Survey

The Brachiopod Genera *Hebertella, Dalmanella,* and *Heterorthina* from The Ordovician of Kentucky

By LAURENCE G. WALKER

CONTRIBUTIONS TO THE ORDOVICIAN PALEONTOLOGY OF KENTUCKY AND NEARBY STATES

Edited by JOHN POJETA, JR.

GEOLOGICAL SURVEY PROFESSIONAL PAPER 1066-M

Prepared in cooperation with the Commonwealth of Kentucky, University of Kentucky, Kentucky Geological Survey

A taxonomic study of nine species and their stratigraphic distribution in the Lexington Limestone and younger Ordovician rocks

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON: 1982

UNITED STATES DEPARTMENT OF THE INTERIOR

JAMES G. WATT, *Secretary*

GEOLOGICAL SURVEY

Dallas L. Peck, *Director*

Library of Congress Cataloging in Publication Data

Walker, Laurence G. (Laurence Graves), 1937–
The brachiopod genera *Hebertella, Dalmanella,* and *Heterorthina* from the Ordovician of Kentucky.

(Contributions to the Ordovician paleontology of Kentucky and nearby states) (Geological Survey professional paper ; 1066–M)
"Prepared in cooperation with the Commonwealth of Kentucky, University of Kentucky, Kentucky Geological Survey."
Bibliography: p.
Supt. of Docs. no.: I 19.16:1066–M)
1. Hebertella. 2. Dalmanella. 3. Heterorthina. 4. Paleontology—Ordovician. 5. Paleontology—Kentucky. I. Title. II. Series. III. Series: Geological Survey professional paper ; 1066–M.
QE797.7W34 564'.8 82-600093
AACR2

**For sale by the Distribution Branch, U.S. Geological Survey,
604 South Pickett Street, Alexandria, VA 22304**

CONTENTS

ILLUSTRATIONS

[Plates follow references cited]

SYSTEM OF MEASUREMENT UNITS

The investigations underlying this series of reports were made over a period of years, and distances and stratigraphic measurements appear fairly uniformly in English units. Measurements of fossil specimens, on the other hand, follow the longstanding convention of appearing in metric units. Because of the dates of the investigations and the amount of resulting data, the English measurements have been retained. Conversions to metric units may be made by using the following conversion table:

To convert English unit:	To metric unit:	Multiply by:
Mile (mi)	Kilometer (km)	1.61
Foot (ft)	Meter (m)	.305
Inch (in.)	Centimeter (cm)	.394

CONTRIBUTIONS TO THE ORDOVICIAN PALEONTOLOGY OF KENTUCKY AND NEARBY STATES

THE BRACHIOPOD GENERA *HEBERTELLA*, *DALMANELLA*, AND *HETERORTHINA* FROM THE ORDOVICIAN OF KENTUCKY

By LAURENCE G. WALKER[1]

ABSTRACT

The orthid brachiopod genera *Hebertella, Dalmanella,* and *Heterorthina* are abundant in Middle and Upper Ordovician strata in Kentucky. Nine species are described: *Hebertella frankfortensis* Foerste; *H. parksensis* Foerste; *H. occidentalis* (Hall); *Dalmanella bassleri* Foerste; *D. fertilis* (Ulrich); *D. meeki* (Miller); *D. multisecta* (Meek); *D. sulcata* Cooper; and *Heterorthina macfarlani* Neuman. The species designations *Hebertella sinuata* (Hall), *H. subjugata* (Hall), and *H. latasulcata* Foerste are placed in synonymy with *H. occidentalis* (Hall). The stratigraphic distribution of each species is given.

Large collections of silicified specimens allowed the recognition of the considerable variability characteristic of most of the species. External morphology distinguishes species of *Hebertella,* whereas internal features are critical to recognition of species of *Dalmanella* and *Heterorthina.*

INTRODUCTION

Orthid brachiopods are abundant in Middle and Upper Ordovician rocks in central Kentucky and adjacent areas. A knowledge of their taxonomy and distribution is important for an understanding of the biostratigraphy of this reference area for the Upper Ordovician rocks of North America. The purpose of this paper is to describe the taxonomy and distribution of the common genera *Hebertella, Dalmanella,* and *Heterorthina,* to present interpretations regarding their evolution, and to assess their possible value in correlation. The other common orthid in this area is the genus *Platystrophia*; it was treated by Alberstadt (1979).

The study specimens were collected by staff members of the U.S. Geological Survey. Almost all collections were made in the Ordovician outcrop area of central Kentucky, although a few collections came from the adjacent States of Indiana, Ohio, and Tennessee.

[1]Hrubetz Oil Company, Lafayette, La.

Most collections are of silicified specimens, which were extracted from limestone by acid in the laboratories of the Geological Survey in Washington, D.C., and sent to me. Many collections from single beds contain scores or hundreds of well-preserved specimens. Good concepts of the orthid species were obtained from these large collections because infraspecific variability could be seen and evaluated. However, information on the geographic and stratigraphic distribution of species in the study area is limited. In general, collections were made from silicified beds, and no systematic sampling was done from thin intervals of all lithologies in a particular section. Silicified beds are so common that a good coverage of the Ordovician strata was obtained and the general stratigraphic ranges could be established. Significant gaps do exist, however, and the data and interpretations given herein concerning distribution and evolution are necessarily circumscribed. On the basis of the available information, nothing can be said regarding possible facies control of species.

Complex facies patterns exist in the Ordovician sequence in Kentucky. In determination of the stratigraphic ranges of species, I used the stratigraphic framework and correlations as interpreted by the U.S. Geological Survey staff (Black and others, 1965; Cressman and Karklins, 1970; Weir and Greene, 1965; Weir and others, 1965; Peck, 1966; Simmons and Oliver, 1967; Black and Cuppels, 1973; and Cressman, 1973). Pojeta (1979) has summarized the Ordovician stratigraphy of Kentucky and adjacent States.

ACKNOWLEDGMENTS

Financial assistance for this study was provided by two Faculty Research Grants at Memphis State University, Memphis, Tenn. I am grateful to the following

persons for the loan of type specimens: Thomas E. Bolton of the Geological Survey of Canada, Ottawa; Roger L. Batten of the American Museum of Natural History, New York; and Frederick J. Collier of the Smithsonian Institution, Washington, D.C. I especially appreciate the considerable aid and encouragement of the editor of this project, John Pojeta, Jr., of the U.S. Geological Survey, Washington, D.C.

SYSTEMATIC PALEONTOLOGY

Phylum BRACHIOPODA Dumeril
Class ARTICULATA Huxley
Order ORTHIDA Schuchert and Cooper
Superfamily ORTHACEA Woodward
Family PLECTORTHIDAE Schuchert and Levene

Genus HEBERTELLA Hall and Clarke, 1892

Type species.—*Orthis sinuata* Hall, 1847, p. 128, by original designation.

Description.—Adult shells 15 to 50 mm wide, 10 to 40 mm long; outline subquadrate to subelliptical; maximum width generally between hinge and midlength. Hinge straight, cardinal extremities generally rounded or angular but can be alate; pedicle valve interarea large, curved, apsacline, or rarely straight and catacline; brachial valve interarea smaller, curved, orthocline to apsacline, rarely anacline. Lateral profile unequally biconvex or convexo-concave; pedicle valve concave if beak erect and interarea near catacline; brachial valve strongly curved with maximum depth near or anterior to midlength; pedicle valve slightly curved in posterior part to flat or concave in anterior part, maximum depth within posterior one-third of valve. Anterior margin weakly to strongly uniplicate, brachial valve fold weak to strong, pedicle valve sulcus weak to strong. Ribs numerous, 14 to 20 developing from protegulal node, others developing lateral to beak on posterior edge of valve surface, tubulose and increasing in number by bifurcation.

Pedicle valve interior with prominent teeth, strong dental plates, and well-developed crural fossettes. Umbonal cavity deep, muscle scars obvious because of narrow marginal ridge or because deeply impressed; muscle field elongate cordate; adductor scars elongate suboval, borne on median double ridge; wide diductor scars subcrescentric, extending beyond adductor ridges but not enclosing adductor scars; pedicle adjustor muscle scars may be present at base and sides of dental plates. Pedicle callist present in thickened valves. Amount of secondary thickening variable, mainly around muscle field; wavy elevated lines commonly present in thickened areas on each side of muscle field.

Brachiophores and brachiophore bases convergent toward floor of brachial valve, curving toward midline near junction with prominent notothyrial platform. Curved fulcral plates forming floor of sockets. Cardinal process bladelike, may be slightly thickened along anteroventral edge; myophore thin, crenulated, located posterior to anteroventral edge of shaft, which extends higher as a thickened or bulblike structure. Median ridge extending anteriorly from notothyrial platform and ranging from slightly elevated to prominent, reaching as far forward as one-third length of valve. Muscle scars indistinguishable to faintly impressed on larger valves; posterior pair larger than anterior pair; scars subelliptical with long axes oriented about 30° to midline; median ridge commonly extending to within adductor-scar areas; laterally directed branches of median ridge may exist between posterior and anterior scars in larger valves. Radial elevated lines are generally marginal to socket area and posterior muscle scars in large valves.

Discussion.—The name *Hebertella* has been applied in the past to species of several genera, particularly *Plectorthis, Mimella, Glyptorthis, Eridorthis,* and *Austinella.* External similarities were the chief reason for this; generally, each of these genera is readily distinguished on the basis of internal structures. The last three genera were originally included in *Hebertella* by Hall and Clarke (1893) but were later separated by Foerste (1909a, 1914a).

The principal diagnostic features of *Hebertella* are its pedicle-valve muscle field, with the double adductor ridge, and the profile of the pedicle valve, which is only slightly convex or even flat to concave. *Plectorthis* is similar to *Hebertella* except for ventral interior structures and its more convex pedicle valve. Small *Hebertella* specimens are indistinguishable from *Plectorthis,* and the two genera are obviously closely related (Schuchert and Cooper, 1932).

Different species of *Hebertella* can be recognized on the basis of external morphology, especially the pattern of costae and costellae and the outline and maximum size of the shell. Internal morphology remains relatively constant among the various species, with only minor differences due to increased secondary material in larger valves. The species of *Hebertella* herein described are *H. frankfortensis* Foerste, *H. parksensis* Foerste, and *H. occidentalis* Hall. Infraspecific variation is common in *Hebertella,* as determined from the large collections from single beds that were available for this study. Confident taxonomic decisions can be made on the basis of collections of about 10 or more individuals, but one or a few isolated specimens can be difficult to identify. There is no one consistent key feature that is reliable. Shells smaller than about 5 mm are generally unidentifiable. Features of specific importance, namely bifurcation of costae and spacing of costae, appear within 5 to 15 mm of beak. In general, one needs several specimens more than 10 mm long to make a confident identification.

Hebertella occidentalis shows the greatest amount of intraspecific variation. Particularly important is its relation to *H. sinuata.* Both of these species were defined by Hall (1847), who noted the occurrence of the two together, including specimens intermediate between the typical forms. Foerste (1910) emphasized the apparent gradation. Similar observations were made in this study, and I consider all specimens that I have seen as belonging to a single variable species, *H. occidentalis,* the name having page priority (Hall, 1847). Collections of *Hebertella* from Richmondian strata are few, and perhaps future work will show that the separation of a second species is valid within that stratigraphic interval.

The collections studied do not include three species cited by earlier workers: *H. alveata* Foerste 1909; *H. latasulcata* Foerste 1914; and *H. subjugata* Hall 1847. These are all listed as valid species by Schuchert and Cooper (1932). I have seen the type specimens of these species. *Hebertella alveata* at the U.S. National Museum (USNM 78452, 87146, and 87158, a total of seven specimens) is characterized by a distinct and broad median depression on the brachial valve extending to the anterior margin; most specimens have alate cardinal extremities. Foerste (1909a) applied the name *H. alveata richmondensis* to similar forms having a less distinct median depression, narrower hingeline, and more convex brachial valve. He found this subspecies to be dominant over typical *H. alveata* at some horizons in beds of the Whitewater Formation. *H. alveata* occurs in the Liberty and Whitewater Formations of Ohio and Indiana. I consider *H. alveata* to be a distinct species, but none of the type specimens show interiors to confirm the generic identification. Collections in my study include only one sample from the Whitewater of Indiana, and this sample contains only *H. occidentalis.*

Hebertella latasulcata (USNM 78707, two pedicle valves) was described as a mutation by Foerste (1914b) rather than as a distinct species in the modern sense. It has a broader shallower sulcus, a rather flat pedicle valve with a lower interarea, and a slightly more elongate muscle field. These characteristics are well within the range of variation of *H. occidentalis,* and *H. latasulcata* is thus not recognized as a valid species herein.

Hebertella subjugata was described by Hall (1847) as being similar to *H. sinuata* and *H. occidentalis,* its principal distinguishing character being much finer costellae. The five type specimens at the American Museum of Natural History (AMNH 1342/1) include three articulated specimens having definitely finer costellae, but also a fourth articulated shell having costellae like *H. occidentalis.* Hall (1847, p. 130) noted that all three species, plus *Plaesiomys subquadrata* "are scarcely regarded as distinct, and are usually found mingled together in collections." In Hall and Clarke (1893), in which *Hebertella* was defined, *H. subjugata* was not included in the list of species belonging to *Hebertella* or in that belonging to any other genus. A question exists, therefore, as to the validity of this species, which could well be a variant within *H. occidentalis.*

Hebertella frankfortensis Foerste, 1909

Plate 4, figures 18–40

Orthis frankfortensis James, 1871, p. 10 (nom. nud.)
Hebertella frankfortensis Foerste, 1909b, p. 318–319, pl. 7, figs. 11a, b.

Description.—Adult shell small for genus, rarely wider than 25 mm; outline transverse subelliptical to subround; cardinal extremities rounded, rarely a right angle or alate; ventral interarea curved and apsacline, dorsal interarea curved and apsacline, rarely orthocline. Low fold on brachial valve and shallow sulcus on pedicle valve in specimens longer than about 5 mm; fold and sulcus may be strongly developed on valves longer than 15 mm. Costae coarse, generally nonbranching, ranging in number from 29 to 40 in valves shorter than 10 mm and from 34 to 55 in valves longer than 10 mm, number not closely corresponding to size; with size increase, costae developing at hinge lateral to beak area; costae per 5 mm across midline, 8 to 12 at 5 mm anterior to beak and 5 to 7 at 10 mm anterior to beak.

Pedicle valve interior with pronounced muscle scars; adductors on double ridge, not enclosed by wide diductor scars. Length-width ratio of scar field ranges from about 1:1 to 1:5, increasing during ontogeny.

Brachiophores bladelike, grooved on interior face, brachiophore supports converging to meet valve floor on either side of the cardinal process. Low notothyrial platform having prominent anterior edge. Curved fulcral plates form floor of sockets. Cardinal process shaft thin, myophore usually crenulated, either small bulb or indistinguishable from shaft. Secondary thickening of cardinalia absent or minimum. Adductor muscle scars indistinguishable to faintly impressed on larger valves; all scars subelliptical, long axes oriented about 30° to midline. Low median ridge extending from notothyrial platform to between scars, faint ridge rarely present between the posterior margin and adductor scars.

Ontogeny.—Small valves are distinctly transverse, with acute cardinal angles. The cardinal angles change from acute to about right angle in valves 2 to 3 mm long and then to obtuse in valves longer than 4 mm. The ventral interarea is relatively high, and the teeth are large. In the brachial valve, the cardinalia are also large with respect to size of valve. Growth was allometric when length of valve is compared with either (1) width of valve, (2) interarea height, (3) tooth size, or (4) cardinalia size. Length increased at a proportionately greater rate than any of these four features.

In pedicle valves 2 to 4 mm long, the beak is erect, interarea slightly curved and high with large delthyrium, teeth large; valve transverse. A thin veneer of secondary material exists in the muscle area; costae prominent everywhere else on interior of valve. In valves about 5 mm long, outline of diductor muscle marks becomes evident. Very faint adductor ridge may be present at this size, but it usually is not evident in valves shorter than 8 mm. Diductor muscle marks are generally distinct in specimens larger than 6 mm because of thickening of secondary deposits around muscle-attachment area. As growth proceeded, the attachment area moved anteriorly and, to a lesser degree, anterolaterally, so that the muscle markings became progressively more elongate. A thin veneer of secondary material was deposited circumferentially about the muscle area at a valve length of about 7 to 10 mm, and the area of this veneer gradually enlarged during growth. This veneer may obscure the costae over an area as much as two-thirds of the valve length. As growth proceeded, addition of material took place at a greater rate at the anterior and anterolateral margins, so that the valve became less transverse. The development of the ventral sulcus is first evident in valves about 5 mm long by a distinct flattening of the anterior edge of the valve. A shallow depression may exist in valves 7 mm long. Thereafter, the development of the sulcus was variable. In some specimens, it remains a broad, very shallow depression; in others, it is an abrupt, relatively narrow depression. All variations within these extremes may exist within a collection from a single bed.

In the brachial valve, the cardinal process was bladelike in early growth, and diductor muscles were attached on sides of the process. As growth proceeded, the cardinal process increased in length, height, and slightly in width. The position of attachment of diductor muscles remained on the sides, in the more posterior part of the cardinal process. At a valve length of 4 to 5 mm, the anterior half of the process had become rather bulbous, the posterior part (diductor-muscle area) remaining very narrow. By this growth stage, the valve curvature is such that the cylinderlike part of the process is directed almost ventrally, and the flat muscle-attachment area is posterior to it. In valves larger than about 7 mm, the process has a cross section with the shape of a wide blade or a teardrop, both having crenulated sides. In the blade-shaped process, the bulbous part has been resorbed almost completely, and the muscle-attachment area has become enlarged. In the teardrop-shaped process, the bulbous part has been only partially resorbed. A bulbous process may be retained in valves as large as 15 mm. In larger valves, the front edge of the cardinal process extends anteroventrally, and a thin crenulated area of muscle attachment extends posteriorly to the valve floor. All variations in the cardinal process may be found in valves of all sizes in a collection from a single bed. Allometric growth existed in that all parts of the cardinalia are relatively large with respect to valve size in early growth as compared with later growth stages.

A very thin notothyrial platform is present in valves 2 mm long; it is thicker at the anterior edge, where a faint ridge of secondary material extends between the front edges of the brachiophore supports. As growth proceeded, this anterior edge became more prominent by being slightly thickened and by the impression of the posterior adductor muscles into it. In adult valves, the platform is thin and rather indistinct except for the anterior edge; the anterior edges of the brachiophore supports appear to curve sharply and converge to form the notothyrial platform. A medial ridge extends forward from the cardinal process area; it begins as a slight thickening in valves 3 to 5 mm long, and it may be prominent in adult valves where it extends to the anterior muscle marks.

Each socket is floored by a concave fulcral plate between the brachiophore and the hingeline. This plate was only slightly thickened during growth, and the space between it and the brachiophore support was not filled with secondary material to form a socket pad.

Convexity of the brachial valve increased throughout growth; in valves longer than 15 mm, the brachiophores project almost directly anteriorly. The fold is discernible as a broad deflection in the anterior commissure when valve length is 5 to 7 mm. The deflection gradually increased in magnitude during growth, but the fold remained very broad and had no definite flanks. In a few specimens having a valve length of 10 to 15 mm, the fold is narrower and slightly higher than the rest of the valve. Height of the fold is variable on larger specimens.

The midline of the brachial valve is flattened or slightly depressed in most specimens. This flat area or depression disappears at a distance of 7 to 10 mm from the beak. Many brachial valves have no flattened midline.

Discussion.—Infraspecific variation in *H. frankfortensis* can be seen in ventral muscle marks, branching of costae, and spacing of costae. The ratio of muscle-mark length to muscle-mark width in typical adult *H. frankfortensis* is about 1.3 to 1.4, with a maximum value of about 1.8. Some collections have an average muscle length–width ratio as great as 1.5, with a maximum of 2.4 for individual valves (as in USGS colln. 4883–CO).

Nonbifurcating costae are typical of most specimens of *H. frankfortensis*, but in some collections as many as 25 percent of the larger valves have at least one branching costa. The branching costae may be on

either the sides of the valves or on the anterior part. Bifurcation rarely takes place within 8 mm of the beak, and commonly it is present only beyond 12 mm, so only relatively large valves will have costellae. The branching of costae may have been related to the sensory apparatus of these brachiopods. If, as in some modern species, a sensory seta was located in the mantle edge in a position corresponding to a costa, then, as growth proceeded, the valve margin was lengthened and the setae became more widely spaced. The production of new setae would have been of value for greater sensory perception, and the branching of costae would reflect the increase in setae. However, there was no critical spacing of costae beyond which bifurcation would take place, because most large valves have costae that are more widely spaced than in those valves having branching costae.

The spacing of costae is also variable. Generally 9 to 11 costae are present in a space of 5 mm, measured across the midline at a distance of 5 mm from the beak. In some collections, most specimens have 11 or 12 costae per 5-mm interval. In any given collection in which most specimens have widely spaced costae, a few valves will have closely spaced costae. Similarly, closely spaced costae may be typical of a collection, but some valves will have widely spaced costae.

Mature specimens of *Hebertella frankfortensis* are readily distinguished from *H. parksensis* and *H. occidentalis.* The latter two species have numerous bifurcating costae, and, in *H. parksensis,* the costae and costellae are closely spaced, as contrasted with the widely spaced, generally nonbifurcating costae of *H. frankfortensis.* Also, *H. frankfortensis* has a smaller maximum size (generally less than 20 mm long) and less pronounced fold and sulcus. Cardinal extremities of *H. frankfortensis* are rarely a right angle or alate, as is common in the other two species. In specimens smaller than about 4 mm, the three species cannot be confidently distinguished because the valves are too small for the characteristic features to have developed.

Hebertella frankfortensis is possibly ancestral to *H. occidentalis.* Increased bifurcation of costae and an increase in size, accompanied by more pronounced development of fold and sinus, would have been the necessary evolutionary changes. However, there is no evidence for such evolution in collections from the study area. *H. parksensis* is unlikely to have descended from *H. frankfortensis,* considering the close packing of costellae and very early bifurcation of costae in *H. parksensis.*

Foerste (1909b) identified specimens collected in Ohio by Meek (1873) as *Hebertella frankfortensis.* These specimens had been identified by Meek as *H. borealis* Billings. The species *H. borealis* Billings, from Chazyan strata in Quebec, was placed in *Mimella* by Cooper (1956).

Stratigraphic distribution.—Hebertella frankfortensis ranges from the middle part of the Grier Limestone Member of the Lexington Limestone upward into the Millersburg Member of the Lexington in areas where the latter member is stratigraphically high (Franklin County). The species is abundant in the upper half of the Grier, and it is abundant in some beds at equivalent stratigraphic levels in other members. The lowest level at which collections of this species were made is about 100 ft below the top of the Grier in the Hunters Ferry Road section (Valley View Quadrangle), where the Grier is about 150 ft thick. USGS collection 5098–CO was made from float, and, if it were near the in-place level, it would be the lowest collection. Otherwise, all collections were made no lower than the middle of the Grier.

The species is abundant in the upper part of the Perryville Limestone Member of the Lexington Limestone, which is approximately equivalent to a stratigraphic level within the upper part of the Grier. It is present in the Sulphur Well, Brannon, and Tanglewood Limestone Members of the Lexington-Limestone, at levels below and above the Brannon Member. Where the Tanglewood is stratigraphically highest, in the Frankfort East and Switzer Quadrangles, *H. frankfortensis* is found in the lower part of the member.

The highest level of collection of this species is in the Millersburg Member in the Midway Quadrangle, above the lower part of the Tanglewood Limestone Member. This collection, USGS 7790–CO, consists of typical *H. frankfortensis* but does contain an unusually large brachial valve, length 19 mm, width 25 mm. The species was not collected from the Millersburg at any other location or from other units (Tanglewood Limestone Member of the Lexington and Clays Ferry Formation) at equivalent stratigraphic levels. The absence of specimens may be due to biased collecting.

No collections of *H. frankfortensis* were made from the lower part of the Clays Ferry Formation, but USGS collection 6909–CO is from the Point Pleasant Tongue of the Clays Ferry in the Falmouth Quadrangle, at a level approximately equivalent to the lower part of the Clays Ferry and uppermost part of the Grier or lower part of the Tanglewood Limestone Member of the Lexington.

Two types of infraspecific variation may be of stratigraphic value, at least within the area of study—the spacing and bifurcation of costae. Specimens of *H. frankfortensis* that are stratigraphically low typically have more widely spaced costae, generally 9, 10, or 11 costae per 5-mm interval, measured across the midline at 5 mm anterior to the beak. At a higher level are found specimens having more closely spaced costae, generally 11 or 12 per 5-mm interval. This level is in the uppermost part of the Grier Limestone Member

and several feet above the Grier, where the top of that unit is lower stratigraphically (as in the Salvisa Quadrangle). Similar specimens are found in the upper part of the Perryville Limestone Member, which is approximately at the same level. The closer spacing of the costae was not an evolutionary trend persistent in the area because *H. frankfortensis* specimens collected from still higher levels have the more widely spaced costae.

Bifurcation of costae becomes more pronounced in specimens collected from the uppermost part of the Grier in some sections. As many as 25 percent of sufficiently large specimens may have one to four bifurcating costae. This feature is best seen in the Valley View Quadrangle, where such collections (USGS 4185–CO, 4883–CO, 5096–CO) are found at the top of the Grier, a few feet above collections of specimens having the more closely spaced costae. In the Perryville Limestone Member, the highest collections (USGS 5016–CO, 6138–CO) contain specimens that have bifurcating costae but in lower proportion than those in the Valley View Quadrangle. These Perryville collections come from slightly higher levels than USGS 6915–CO and 6916–CO, which contain specimens having more closely spaced costae. The persistence of bifurcating costae at this general stratigraphic level is questionable because, in the Salvisa Quadrangle, the collections that span the upper part of the Grier and lower part of the Tanglewood contain only rare specimens that have bifurcating costae. Whether this variation is of evolutionary significance is difficult to test, because collections of this species above the Grier have few specimens of sufficient size. These collections would be expected to contain a higher proportion of valves having bifurcating costae, but this expectation is not confirmed by the available specimens. The highest collection of *H. frankfortensis*, USGS 7790–CO, from the Millersburg Member in the Midway Quadrangle, includes seven large valves, only one of which has a single bifurcating costa.

Hebertella occidentalis (Hall), 1847

Plate 5, figures 18–41

Orthis occidentalis Hall, 1847, p. 127–128, pl. 32a, figs. 2a–m, pl. 32b, figs. 1a–i.
Orthis sinuata Hall, 1847, p. 128–129, pl. 32b, figs. 2a–k, pl. 32c, figs. 21–s.
Orthis subjugata Hall, 1847, p. 129–130, pl. 32c, figs. 1a–n.
Hebertella latasulcata Foerste, 1914b, p. 131, pl. 3, figs. 7a, b.

Description.—Adult shell medium to large size, length generally 20 to 35 mm, width 25 to 40 mm. Cardinal extremities rounded to alate. Costae branching extensively, some branching originating within 6 mm of beak, most about 8 mm or more away from beak. Seven to 10 costae and costellae per 5 mm, counted across the midline, at 5 and 10 mm anterior to beak. Costellae are narrow near point of bifurcation, some enlarging to width of primary costae, others remaining narrower; no pattern to costellae size observed. Away from points of branching, intercostal spaces range in size from less than to greater than width of costellae. Costae are more widely spaced near midline of valve than on flanks because branching near midline begins farther from beak; wider spacing especially conspicuous within 10 to 15 mm of beak.

Pedicle-valve beak generally suberect with a slightly curved (orthocline) interarea. Lateral profile, gently convex near beak and flat to slightly concave toward anterior margin; valves having erect beaks may be concave from near beak area to anterior margin. Sulcus deep, originating about 7 to 10 mm from beak, rarely within 5 mm of erect beaks. Sulcus narrow, becoming deeper as valve grows, at lengths of 20 to 25 mm tending to deepen abruptly, causing sharp deflection in the anterior edge of valve. Rim of muscle marks thick; adductor double ridge prominent, elevated above diductor marks. Secondary thickening of valve common in larger specimens.

Brachial valve interarea strongly curved, apsacline. Cardinal process consisting of rodlike anterior part and bladelike posterior connection to floor of valve; tip of cardinal process rarely swollen. Adductor muscle field slightly discernible; low narrow median ridge extending to about one-third valve length; rarely, faint ridge between anterior and posterior scars; peripheral ridge absent. Fold beginning about 8 to 10 mm from beak, remaining narrow but relatively low as length increases. In some specimens larger than 20 mm, sharp deflections mark margins of fold, but crest of fold remains rounded; these individuals have exaggerated narrow sulcus in pedicle valve. Some specimens have narrow depression or flat area in midline of umbonal region; umbo remains smoothly convex in most specimens.

Distinguishing characteristics.—The branching costae and more prominent sulcus and fold distinguish *H. occidentalis* from *H. frankfortensis*, except in specimens too small for branching costae and development of the sulcus (shorter than about 5 mm). The coarser, more widely spaced costae and less erect beak of *H. occidentalis* make it distinctive from *H. parksensis*. Some variant specimens of *H. occidentalis* are indistinguishable from variant *H. parksensis*. Maximum size of *H. occidentalis* (as wide as 45 mm) is greater than that of *H. frankfortensis* and *H. parksensis*.

Ontogeny.—The development of specimens of *H. occidentalis* is similar to that of *H. frankfortensis* except for the specific characteristics. To a length of 5 to 8 mm, the species are indistinguishable; beyond that length, the costae of *H. occidentalis* bifurcate, and the sulcus is more pronounced. Also, in small pedicle valves, the beak of *H. occidentalis* is higher.

After a valve length of 10 to 15 mm is reached, secondary material is added to the pedicle-valve interior. In large valves, the internal thickening is very pronounced, and the muscle marks deeply imbedded. Very little thickening of cardinalia or the floor of the brachial valve takes place.

Discussion.—*Hebertella occidentalis* and *H. sinuata* are herein regarded as synonyms. Hall (1847) recognized the species *Orthis occidentalis* and *O. sinuata* from the Upper Ordovician of the Ohio Valley region. *Orthis sinuata* was used as the type species of *Hebertella* as defined by Hall and Clarke (1893). The two taxa have always been recognized as being similar, and Hall (1847, p. 130) said that they (along with *H. subjugata*) "are usually found mingled together in collections." Meek (1873) stated that the two species are connected by intermediate forms and, thus, probably represent only varieties of the same species. Cumings (1908, p. 907) found that there was a "perfectly graded series of intermediate forms" between the two taxa, and he considered *H. sinuata* to be a variety of *H. occidentalis.* He reported that *H. occidentalis* var. *sinuata* ranged from the Lorraine Shale (Edenian-Maysvillian) into the Liberty Formation (upper Richmondian) and was present also in the Elkhorn Formation (uppermost Richmondian); *H. occidentalis* was found in the upper part of the Liberty and the Whitewater Formations (upper Richmondian). Foerste (1910, p. 53) considered the two to be separate species, although he noted that "at the same locality all the intermediate stages are almost certain to be found." Schuchert and Cooper (1932) listed *H. occidentalis* and *H. occidentalis sinuata* among species of *Hebertella.* Later, Howe (1966) found that considerable overlap existed in the supposedly diagnostic features of *H. occidentalis* and *H. sinuta,* on the basis of his study of large collections in the U.S. National Museum.

My investigation of large collections also showed that intermediate forms exist between "typical" *H. occidentalis* and *H. sinuata* and that all types may occur together. The two features generally used to distinguish the taxa are (1) a median depression in the umbonal region of the brachial valve of *H. occidentalis* and (2) the coarser, more widely spaced costae of *H. sinuata.* Any large collection is likely to contain some brachial valves that have a median depression and some that do not; the coarseness and spacing of costae is not consistent with either type of valve. The conclusion is that we are dealing with one variable species and that it should bear the name *Hebertella occidentalis,* which has page priority. Perhaps a study of Richmondian specimens in Ohio and Indiana would show that a subspecies *H. occidentalis sinuata* could be consistently recognized. I have seen three large Richmondian collections from Indiana, but they consist of the variable *H. occidentalis* as found in Kentucky.

Hebertella subjugata (Hall) 1847 is also probably a variant morphologic type within *H. occidentalis.* Hall (1847) gave *H. subjugata* several distinguishing characteristics, the main one being much finer costae than those of *H. occidentalis.* However, all these features can be found in variable *H. occidentalis.* Of the five type specimens of *H. subjugata* (AMNH. 1342/1), three specimens do have fine costae and costellae, as in *H. parksensis.* The other two specimens have coarse costae, as in *H. occidentalis.* I have seen some specimens that have fine costae in large collections of *H. occidentalis,* and I think that all Hall's specimens do fall within the range of variation of that species. As stated above, Hall usually found *H. subjugata* together with *H. occidentalis* and *H. sinuata.* Three USGS collections (7319–CO, 7321–CO, 7322–CO) from the Millersburg Member of the Lexington Limestone in the Winchester Quadrangle (Maple Street Section) include specimens that have fine costae. Although they are similar to *H. subjugata,* I consider them to be variant *H. occidentalis.*

Perhaps Hall and Clarke (1893) did not consider *H. subjugata* to be a valid species because they did not list it with other *Hebertella* species. Also, a catalog of AMNH type specimens (Whitfield and Hovey, 1898) listed the five type specimens as *H. occidentalis,* with the remarks "as types of *Orthis subjugata.*"

Stratigraphic distribution.—The collection (USGS D–1172–CO) containing the oldest *H. occidentalis* was found in the Clays Ferry Formation in the Ford Quadrangle, about 25 ft above the Tanglewood Limestone Member of the Lexington Limestone. This part of the Clays Ferry intertongues with the Millersburg Member of the Lexington and the upper tongue of the Tanglewood, and the level of collection is perhaps slightly lower than that of *H. occidentalis* collections from the Millersburg in adjacent quadrangles. The lowermost Millersburg *H. occidentalis* is found about 10 ft below the Strodes Creek Member of the Lexington, a persistent unit that extends north from the Winchester Quadrangle.

Considering the uncertainty of correlation based on mapping, the lower part of the range of *H. occidentalis* may overlap with the upper range of *H. parksensis.* However, in any given section where the two species are present, *H. occidentalis* always is found above *H. parksensis.* USGS collection D–1172–CO does contain one finely costellate pedicle valve that could be *H. parksensis.* Nowhere else were the two species found together.

The lowest level of *H. occidentalis* is approximately equivalent to the highest level of *H. frankfortensis* (USGS colln. 7790–CO) from the Millersburg Member in the Midway Quadrangle. An unusual occurrence of two apparent *H. occidentalis* brachial valves is in

USGS collection 6138–CO, which contains scores of *H. frankfortensis* specimens. These are from the Perryville Limestone Member of the Lexington Limestone in the Bryantsville Quadrangle. This unit is much lower than the lowest known *H. occidentalis*, in the Ford Quadrangle, and large collections in intervening strata contain only *H. frankfortensis* or *H. parksensis*. Possibly the valves are very aberrant *H. frankfortensis* specimens, although they are quite distinct and are like most *H. occidentalis* specimens. An unlikely explanation is that the sample was contaminated. Finally, these valves may be true *H. occidentalis* that occur much lower than other known *H. occidentalis*.

Hebertella occidentalis is present in all the formations that overlie the Lexington Limestone, from Edenian to Richmondian strata. It is common to abundant in most of this stratigraphic interval. The youngest collections come from the Preachersville Member of the Drakes Formation in the Hedges Quadrangle in central Kentucky. In northern Kentucky where the Preachersville Member is present, the highest collections are from the upper part of the Bull Fork Formation, about 20 ft below the Preachersville. The collections made from Richmondian rocks in Indiana and Ohio (USGS 6139–CO to 6141–CO, 7833–CO, 7834–CO) are probably about the same age as the highest collections in northern Kentucky.

Despite the long stratigraphic range of the species, no evolutionary trends or consistent morphologic differences from level to level were found. Variations within the species appear to have no correlation with stratigraphy.

Hebertella parksensis Foerste, 1909

Plate 5, figures 1–17

Herbertella maria-parksensis Foerste, 1909b, p. 319, pl. 7, figs. 6a, b.

Description.—Adult shell medium sized for genus, generally 15 to 25 mm long and 10 to 33 mm wide. Cardinal extremities rounded to alate. Costae bifurcate extensively, branching originating mainly beyond 4 mm from beak. Usually 11 to 13 (maximum 17) costae and costellae per 5 mm, counted across the midline, at 5 and 10 mm anterior to beak. Costellae uniform in size and generally closely spaced, especially within 10 mm of beak.

Pedicle-valve beak generally suberect with slightly curved interarea; beak erect with flat orthocline interarea in a minority of valves. Valve gently convex near beak and almost flat toward anterior margin; beak erect in nearly flat valves. Sulcus conspicuous, originating about 4 to 7 mm from suberect beaks, within 3 mm of erect beaks. Narrow sulcus becoming deeper as valve grows; anterior edge of valve commonly sharply deflected in specimens longer than 10 mm; sulcus shallow in some adult specimens. Interior of valve has pronounced muscle marks with elevated rim so that many specimens have almost a muscle platform; adductor double ridge well elevated above diductor marks; radiating ridges and grooves may be present in diductor marks.

Brachial valve interarea strongly curved, apsacline; notothyrium large. Adductor muscle field slightly discernible; median ridge generally very low and narrow; rarely, a faint ridge between anterior and posterior scars; no peripheral ridge. Brachial valve fold originating beyond 8 mm from beak; generally narrow and low, although sharp deflection may exist in anterior edge of valve and corresponding sulcus may be deep.

Ontogeny.—The growth of specimens of *H. parksensis* was similar to that of specimens of *H. frankfortensis* except for the specific characteristics. Costae are more closely crowded in the beak area, and costellae appear as near as 3 to 6 mm from the beak. Ventral sulcus first appears at 3 to 7 mm from the beak and commonly is a sharp deflection in valves 10 to 15 mm long. When a valve length of 8 to 10 mm was reached, the rim around the ventral muscle rapidly developed, so that the rim rises well above the valve floor in valves more than 10 mm long.

Distinguishing characteristics.—The closely spaced costae and costellae are the most reliable character. For any given size valve, the sulcus of *H. parksensis* is generally more pronounced than those in *H. frankfortensis* and *H. occidentalis* and the ventral muscle-mark rim is more pronounced; the muscle marks may even be elevated in *H. parksensis*.

Discussion.—Foerste (1909b) originally used the name *H. maria-parksensis*, but he considered it to be a distinct species, and in the same article and in later publications he referred to the species as *H. parksensis*. Bassler (1915) and Schuchert and Cooper (1932) continued usage of *H. maria-parkensis* [sic]. I consider *H. parksensis* to be more appropriate because it fits the rules of zoological nomenclature for a distinct species. The spelling *H. parksensis* is correct, as the name is derived from Parks Hill, Ky., although the spelling *H. parkensis* has commonly been used.

Hebertella parksensis from Kentucky and *H. maria* (Billings), from Richmondian strata on Anticosti Island, southeastern Canada, are indeed similar. Foerste (1909b, p. 319) based his comparison on figured specimens of *H. maria* and stated that *H. parksensis* is larger and the pedicle valve is "much more convex toward the beak." I have examined the type specimens of *H. maria* belonging to the Geological Survey of Canada (syntypes: GSC 2271, 2271a, 2271b, 2271c; hypotypes: GSC 29599, 29618; also two nontype specimens). Most are smaller than typical *H. parksensis*, but one is large (18 mm long, 23 mm wide). Pedicle-valve convexity is slightly less in *H. maria*. The lateral edges and cardinal

extremities of *H. maria* valves are distinctly rounded, whereas, in any collection of *H. parksensis*, many valves will have straight lateral edges and even alate cardinal extremities, in addition to valves having rounded lateral edges. Spacing and bifurcation of costae and costellae are similar, except for specimen GSC 2271b, which has more widely spaced and fewer branching costae. Other external characteristics are similar. All the reference specimens of *H. maria* are articulated, so no internal features are known. Larger collections of *H. maria* should be examined before judgment is passed on the significance of the differences cited.

Stratigraphic distribution.—Hebertella parksensis seems to be confined to the upper part of the Lexington Limestone and to parts of the Clays Ferry Formation and the Point Pleasant Tongue of that unit that are stratigraphically equivalent to the upper part of the Lexington. The lowest collection, USGS 7792–CO, is from the top of the Grier Limestone Member of the Lexington in the Ford Quadrangle; no other collections come from the Grier. USGS collection 6146–CO comes from the Point Pleasant Tongue in the Felicity Quadrangle, Clermont County, Ohio. The Point Pleasant is equivalent to the lower part of the Clays Ferry in central Kentucky (Cressman and Karklins, 1970).

All 23 other collections of *H. parksensis* come from a stratigraphic interval about 30 ft thick. This interval spans part of the lower and the whole middle part of the Millersburg Member of the Lexington and the interbedded lower and upper tongues of the Clays Ferry Formation, as these are exposed in the more eastern quadrangles (Cynthiana Quadrangle south to Winchester Quadrangle, also Sadieville Quadrangle). A regional facies framework diagram was given by Black and Cuppels (1973). The highest level of collection is apparently the upper tongue of the Clays Ferry, from which USGS 6143–CO was obtained in the Cynthiana Quadrangle. The Strodes Creek Member of the Lexington is a stratigraphic marker from the Cynthiana to the Winchester Quadrangles (Black and Cuppels, 1973). The highest *H. parksensis* occurs about 14 to 20 ft below the Strodes Creek (example is USGS colln. 7333–CO in Strodes Creek type section). *Hebertella occidentalis* is found between the highest *H. parksensis* and the Strodes Creek, as well as higher in the section.

No collections of *H. parksensis* come from the Tanglewood Limestone Member of the Lexington, which intertongues with the Millersburg and Clays Ferry and which also underlies the Millersburg. Silicification is very limited in the Tanglewood; probably the restricted distribution of collections of *H. parksensis* is due to collecting bias.

The oldest *H. parksensis* is found in the top of the Grier Limestone Member, so the stratigraphic ranges of this species and *H. frankfortensis* overlap, although the two species are rarely found together. USGS collection 6143–CO, probably the youngest of *H. parksensis*, contains three *H. frankfortensis* valves. This is approximately the same stratigraphic level as USGS 7790–CO, the highest *H. frankfortensis*, from the Millersburg Member in the Midway Quadrangle. Several other collections of *H. parksensis* contain possible *H. frankfortensis*, but the differentiation of young specimens of *H. frankfortensis* from those of *Plectorthis* is very difficult.

Superfamily ENTELETACEA Waagen
Family DALMANELLIDAE Schuchert

The analysis of dalmanellids by Williams and Wright (1963) is the basis for the taxonomy used in this report. Neuman (1967) used the same basis in a study of some of the taxa described herein. Before Williams and Wright's article, the taxonomy of dalmanellids was confusing and unsatisfactory, principally because of the considerable infraspecific variation characteristics of dalmanellids. Some investigators chose such variable features as characters for discrimination of genera and species.

Genus DALMANELLA Hall and Clark, 1892

Type species.—Orthis testudinaria Dalman, 1828, p. 115, by original designation.

Description.—Outline subcircular to transversely subelliptical to subrectangular; profile ventribiconvex to almost planoconvex; variably developed dorsal sulcus. Coarsely to finely fascicostellate, costae and costellae on lateral slopes are curved; median costa present in dorsal valve of some species; prominent growth lines variably developed, irregularly spaced where present, minute growth lines (fila) between costellae are present in some species. Maximum length 20 to 25 mm, maximum width 25 to 30 mm, maximum convexity about 8 mm. Ventral muscle field cordate to bilobed, submedian diductor lobes usually extending beyond adductor, generally confined to posterior half of valve; posterolateral edges of field bounded by small ridges extending from dental plates; length and width of field quite variable. Cardinal process bilobed, undifferentiated, commonly thickened with secondary material; shaft rising from notothyrial platform merging with median ridge extending to about midlength of valve. Brachiophore bases either convergent onto median ridge or subparallel down to edges of ridge; secondary thickening around brachiophore bases. Tiny rodlike brachiophore processes, rarely preserved, extend from tips of brachiophores, length about one-third to one-half that of brachiophores; processes curving anteriorly from tip of brachiophores. Dorsal adductor

field quadripartite, elongately suboval, may extend to midlength; posterior edge may be imbedded in secondary material around cardinalia and median ridge. Secondary deposits in valve interiors range from nil to relatively thick, with imbedded muscle marks; thickening generally less in ventral valve.

Discussion.—Dalmanella was recognized principally on the basis of the cardinalia that are different from those of *Heterorthina*, the only other dalmanellid found in this study. The name *Onniella* has been used by other workers (Cooper, 1956; Hall, 1962) for species placed in *Dalmanella* in this report, but, according to Williams and Wright (1963), that genus has brachiophore bases that diverge toward the valve floor. No Kentucky specimens show such features, except for *Heterorthina*, which is otherwise different from *Onniella*.

Variation in the cardinalia is produced by secondary deposits that form brachiophore bases (supports), ancillary struts, and thickening around the cardinal process. The brachiophores are bladelike structures, subtrigonal in side view, that stand erect and are directed anteroventrally. In very young specimens, the outer faces of the brachiophores formed the inner edges of the sockets. As the individual grew, deposits were added to the dorsal edges and lower inner faces of the brachiophores to form the brachiophore bases (supports) and ancillary struts. In *Dalmanella*, the brachiophore bases are (1) convergent to the median ridge, which extends forward from the notothyrial platform, or (2) they extend straight down to the valve floor and thus are subparallel. In (2), secondary deposits connect the inner faces of the brachiophore bases and the median ridge. Gradations between (1) and (2) can be found within a single species, but most specimens of one species will have either distinctly convergent or subparallel brachiophore bases. The presence of fulcral plates is likewise variable within a species, but plates are far more prevalent in species that have convergent brachiophore bases.

Dalmanella sulcata and *D. bassleri* have convergent brachiophore bases. In both species, the brachiophores and bases in very small specimens are subparallel, and they bound the sockets. As the individuals grew, more material was added to the dorsal edges in an anteromedian direction, so that the main supports of the brachiophores are convergent to the median ridge. In *D. sulcata*, material was also added in an anterolateral direction, so that a wall-like structure extended forward and continued to bound the sockets. The outer face of this structure may be inclined toward the hingeline, and, in some specimens, the lower part of the structure is slightly curved outward. Generally, this structure merges into the valve, the socket being adjacent. In some specimens, distinct fulcral plates are present; the space between them and the valve floor may be filled with secondary deposits to form a socket pad. The support joining the median ridge extends farther forward than the structure that bounds the socket, and this support forms the ceiling of a cavity that forms between the two structures and the valve floor; this cavity is filled with secondary deposits in some adults. In *D. bassleri*, distinct curved fulcral plates bound and floor the sockets; part of the cavity beneath the fulcral plate may be filled with secondary material to form a socket pad.

The development of brachiophore supports in *D. sulcata* is significant when compared with that of *Heterorthina macfarlani*. In *H. macfarlani*, the original brachiophore and base structure is similar to that of *D. sulcata*. However, as growth proceeded, the main development of the bases was in an anterolateral direction, and these structures continued to bound the sockets; thus, the main brachiophore supports are thick bladelike structures that slope slightly posteriorly and so are divergent in a dorsal direction. Also, secondary material was added at a slower rate between the lower inner face of the brachiophore supports and the median ridge to form ancillary struts, which are analogous to the main brachiophore supports in *Dalmanella sulcata*. A cavity formed between the struts, the brachiophore supports, and the floor of the valve; in adults, this cavity may be filled.

Subparallel brachiophore supports are characteristic of *Dalmanella fertilis, D. multisecta*, and *D. meeki*. Commonly, massive secondary deposits (ancillary struts?) join the brachiophore bases and the median ridge, and fulcral plates are rare because the brachiophore bases bound the sockets. Therefore, unlike cardinalia development in *D. sulcata* and *D. bassleri*, the main growth of the brachiophore bases was in an anterolateral direction, and the secondary material between the bases and the median ridge is not the main support of the brachiophores. A cavity is never found under the brachiophore supports, rather a buttress above the posterior edges of the muscle marks.

Secondary thickening of the cardinal process, especially the shaft, takes place in all species of *Dalmanella*. In some species, extensive thickening is confined to relatively few large specimens, as in *D. sulcata* and *D. bassleri*, but, in other species, it started early and can form a large mass between the brachiophores, as in *D. meeki*.

The ventral musculature can also be quite variable within a single species of *Dalmanella*. The outline of the muscle field ranges from cordate, where the diductor marks are only slightly longer than the adductors, to elongate bilobed, where the diductor marks extend well beyond the adductor marks but do not enclose them.

Dalmanella bassleri Foerste, 1909

Plate 2, figures 15–28

Dalmanella bassleri Foerste, 1909a, p. 215–216.
Onniella bassleri (Foerste), Hall, 1962, p. 144–145, pl. 20, figs. 41, 42.
Dalmanella bassleri Foerste, Neuman, 1967, p. 6, figs. 35–44.

Diagnosis.—Large size for genus, as much as 22 mm long and 27 mm wide, subrectangular to transversely subelliptical, valves becoming more subelliptical as they grow; ventral valve subcarinate, medium convex, 4 or 5 mm depth in largest specimens; dorsal valve almost flat to slightly convex, as much as 2 mm in depth; both valves more convex in early growth stages, become flatter as they grow; distinct dorsal sulcus present in small to medium specimens, shallowing and disappearing anteriorly in large specimens; both valves thin compared with other *Dalmanella* species. Six to 9 costae and costellae, rarely 10, within 2-mm interval measured 5 mm anterior to dorsal umbo. Prominent growth lines generally not present; fila absent. Ventral muscle field cordate to bilobed, relatively widely splayed in some specimens, generally confined to posterior one-third of valve. Cardinalia relatively small compared with valve size, especially in large specimens; brachiophore bases convergent to median ridge, fulcral plates present in small to large specimens, socket pad may form by secondary deposits in large valves; secondary deposits thicken cardinal process and brachiophore bases in some large specimens. Dorsal adductor muscle marks generally poorly defined except in some larger specimens; very little secondary thickening of valve floor.

Discussion.—The most diagnostic features are the large size, low convexity, small cardinalia with convergent brachiophore supports and with fulcral plates, and distinctly thin valves and delicate appearance of most specimens. The cardinalia are similar to those of *Dalmanella sulcata* but are relatively larger in *D. sulcata* and generally lack fulcral plates; *D. sulcata* is smaller in overall size. Specimens of *D. bassleri,* which have flatter dorsal valves, are similar externally to *Heterorthina macfarlani,* but the cardinalia are different.

Type specimens and others identified by Foerste were described by Neuman (1967), who did not have the collections of specimens used in my study. Foerste's specimens came from the "Cynthiana Formation" adjacent to the Ohio River. Hall (1962) described a small number of specimens from the overlying Edenian "Fulton" beds in the Cincinnati area. The species also occurs in the basal part of the Martinsburg Formation in southwest Virginia (Walker, 1967, identified as *D.* cf. *bassleri*).

Stratigraphic distribution.—Collections of *Dalmanella bassleri* are few. The species is apparently confined to the stratigraphic interval that contains the Point Pleasant Tongue of the Clays Ferry Formation, the lower part of the Kope Formation, and equivalent parts of the main body of the Clays Ferry Formation and the Lexington Limestone (above the Grier Limestone Member). USGS collection 6909–CO is from the lower 20 ft of the Point Pleasant Tongue, and collection 7824–CO is from the upper 25 ft of that unit. The Point Pleasant corresponds to the strata of the so-called Cynthiana Formation from which Foerste (1909a) collected his specimens. Probable *D. bassleri* are found in the Kope Formation (USGS colln. 6910–CO) about 66 ft above the Point Pleasant; the lower part of the Kope corresponds to Hall's (1962) "Fulton" beds. The species was questionably identified in the lower part of the Tanglewood Limestone Member of the Lexington Limestone in the Monterey Quadrangle (USGS colln. 7823–CO), at a level approximately equivalent to lower middle parts of the Point Pleasant Tongue. The relatively few collections from the upper part of the Lexington Limestone and the Clays Ferry Formation may account for the apparent scarcity of *D. bassleri* in these units.

Dalmanella fertilis (Ulrich) 1909

Plate 1, figures 1–24

Orthis (Dalmanella) fertilis Ulrich *in* Bassler, 1909, p. 182, pl. 24, fig. 5.
Onniella fertilis (Ulrich) Cooper, 1956, p. 954–955, pl. 157, figs. 1–3; pl. 157, figs. 5, 6; pl. 159, figs. 21–37.

Description.—Medium size, length generally less than 16 mm; subcircular to slightly transverse outline; cardinal extremities generally rounded; ventral valve has low to medium convexity, subcarinate to gently rounded in posterior view; dorsal valve almost flat, dorsal sulcus present in some specimens. Seven or 8 costae and costellae, rarely 6 in 2-mm interval measured 5 mm anterior to dorsal umbo. Prominent growth lines present or absent, fila present. Ventral muscle field cordate to bilobed, generally no longer than one-third of valve, rarely extending to midlength and beyond. Brachiophore bases may form buttresses above posterior adductor marks; thick socket pads may be present, distinct fulcral plates occurring only in some young specimens; thickening of cardinal process variable; adductor muscle marks impressed in secondary material, commonly thickening valve interior.

Discussion.—The best features for identification are the cardinalia, although the subcircular, flat, generally nonsulcate dorsal valve is usually a reliable guide.

Dalmanella fertilis is widespread in Middle Ordovician rocks in the Eastern United States. I have seen collections of James Hall's *"Dalmanella testudinaria"* from the Trenton Group of New York, which include specimens used in descriptions and figures in the

"Paleontology of New York," volumes 1 and 8: the collections from Lowville, N.Y. (AMNH 690/3), consist of *D. fertilis*. Specimens used for the drawings in volume 8, plate 5B, figures 38 and 39 are in these collections. The collections from Middleville, N.Y. (AMNH 690/1), probably include different species. A slab bearing this collection number has on it specimens of *D. fertilis*, and a pedicle valve interior was used for figure 38, plate 5B, in volume 1.

Stratigraphic distribution.—*Dalmanella fertilis* is common to abundant throughout the Curdsville Limestone Member of the Lexington Limestone. The species was not collected from any other unit, with the possible exception of USGS collection 4124-CO, which was made early in the collecting program and which was thought to be from the Logana Member of the Lexington Limestone.

Dalmanella meeki (Miller) 1875

Plate 3, figures 20–30

Orthis emacerata Hall (partim) Meek, 1873, p. 109, figs, 1a–c, 2a–g.
Orthis meeki Miller, 1875, p. 20.
Dalmanella meeki (Miller), Foerste, 1909a, p. 218, pl. 4, figs. 16a, b.
Onniella meeki (Miller), Hall, 1962, p. 145–148, pl. 19, figs. 1–24, pl. 20, figs. 1–10.

Description.—Like *Dalmanella multisecta*, except for the following: medium to large size, generally less than 18 mm long, 22 mm wide; outline subcircular to transverse. Dorsal valve commonly more convex and sulcate. Cardinalia extremely thickened in mature specimens, cardinal process greatly inflated and filling space between brachiophore bases.

Discussion.—My study was based on only six collections, totaling 39 specimens, most of which showed only exteriors. Hall (1962) gave a description and many illustrations based on a large number of specimens. He provided a complete synonomy and a review of the complex nomenclatural history of the species.

As discussed under *Dalmanella multisecta*, that species and *D. meeki* are similar. Definite distinction generally can be made only if collections happen to include specimens larger than about 14 mm, with very thickened cardinalia, or transverse specimens of *D. meeki*. Foerste (1909a, p. 219) quoted Miller (1875, p. 23) that (1) *D. multisecta* was found as high as 250 ft above low-water mark at Cincinnati, Ohio (in the "Fairmount"), and *D. meeki* was found from that level upward and (2) "It would be impossible to determine where one form begins and the other ends, as they clearly intermingle, and leave the constantly recurring impression that they are not specifically distinct."

Stratigraphic distribution.—Collections of *D. meeki* used herein come from the Bull Fork Formation, 23 to 111 ft above the base of the unit, at the County Line Section in the Orangeburg and Maysville East Quadrangles. The Bull Fork is mainly Richmondian in age (Peck, 1966), and the collections would correspond to Hall's (1962) designation of *D. meeki* as being of Richmondian Age. However, earlier workers, including Foerste (1909a), thought that *D. meeki* occurred as low as the "Fairmount" (equivalent to part of the Fairview Formation of Peck, 1966), which is Maysvillian in age. Hall (1962) gave the range of *D. multisecta* as Edenian-Maysvillian and that of *D. meeki* as Richmondian, without discussing the reasons for his disagreement with earlier workers. Only a thorough study of taxonomy and stratigraphic distribution based on many collections can resolve the problem.

Dalmanella multisecta (Meek), 1873

Plate 3, figures 1–19

Orthis multisecta James, 1871, p. 10 (nomen nudum).
Orthis emacerata var. *multisecta* Meek, 1873, p. 112, pl. 8, fig. 3.
Orthis multisecta James, Miller, 1875, p. 22.
Onniella multisecta (Meek) Hall, 1962, p. 148–150, pl. 20, figs. 11–13.

Description.—Small to medium size, generally less than 14 mm long; outline commonly subcircular, may be transversely subelliptical, especially in smaller specimens. Ventral valve subcarinate with medium convexity for its size, as deep as 3 mm. Dorsal valve slightly convex to almost flat in larger specimens; distinct dorsal sulcus present, shallowing anteriorly and may be indistinct at front margins of some larger valves. Median costa present on dorsal valve; 6 to 9 costae and costellae, but generally 7 to 8, per 2 mm, measured 5 mm anterior to dorsal umbo; fila present.

Ventral valve teeth large; muscle field generally distinctly bilobed with wide adductor track, length about one-third valve length, width variable; thickening of valve interior common, hence muscle field generally impressed, pallial markings may be faintly visible.

Stout brachiophore bases subparallel to valve floor slightly convergent in early growth; in mature specimens, the bases curving laterally, as seen in plan view; bases thickened with secondary material, especially on inner faces, forming buttress above posterior muscle marks. Bases bound inner side of wide sockets; thick socket pads develop in early growth. Cardinal process shaft thin in small valves, flat and wide in medium to large valves because of secondary thickening, furrows present in either side of widened shaft; myophore bilobed, sessile, prominent but not excessively enlarged as other parts of cardinalia. Adductor muscle marks generally well defined, posterior marks deeply impressed in secondary material around cardinalia; outline of each muscle mark smooth, posterior marks subtrigonal; outline of field transversely subcircular; anterior margin of field generally at midlength of valve or slightly beyond.

Discussion.—The diagnostic features of *Dalmanella multisecta* are the combination of relatively small size and the stout subparallel brachiophore bases and wide sockets to accommodate the large teeth. This species is most similar to *D. meeki,* which has a slightly larger maximum size, more massive cardinalia, and, in some specimens, a more transverse outline and a more convex and more sulcate dorsal valve. Many specimens of the two species would be indistinguishable.

Dalmanella fertilis is also similar to *D. multisecta,* but *D. fertilis* has generally less massive cardinalia with straight brachiophore bases and smaller sockets, and its dorsal valve is generally flatter and less sulcate. Some specimens of the two species would be indistinguishable, especially externally.

Dalmanella multisecta is well separated stratigraphically from *D. fertilis,* which is older. *D. meeki* (Richmondian) apparently stratigraphically succeeds *D. multisecta* (Edenian-Maysvillian), according to Hall (1962). Better and more extensive collections than were available for this study would probably show evolutionary gradation between the two species. My description of *D. multisecta* was based on 8 collections, only 3 of which had more than 12 specimens.

Stratigraphic distribution.—*Dalmanella multisecta* was present in seven collections from the Kope Formation, ranging from the lower 20 ft to 212 ft above the base of the Kope (USGS collns. D–1314–CO, D–1315–CO, 7979–CO through 7981–CO). The species was also found in collection D–1363–CO, from the lower 37 ft of the Calloway Creek Limestone. The stratigraphic range for these collections is Edenian-Maysvillian.

Dalmanella sulcata Cooper, 1956

Plate 1, figures 25–38; plate 2, figures 1–14

Dalmanella sulcata Cooper, 1956, p. 951–952, pl. 161, figs. 1–16; Neuman, 1967, p. 8–10, pl. 1, figs. 14–34.

Diagnosis.—Medium size, length generally less than 16 mm; subcircular to subrectangular to slightly transversely elliptical in outline; ventral valve medium to highly convex for the genus (as much as 6 mm); dorsal valve slightly convex (as much as 2 mm); distinct dorsal sulcus generally present, as much as 1 mm deep; ventral valve subcarinate to gently rounded in posterior view. Seven to 9 costae and costellae, rarely 6 or 10, in 2-mm interval, measured 5 mm anterior to dorsal umbo; fila absent, prominent growth lines may be present. Ventral muscle field usually bilobed but may be cordate, extending to about midlength. Brachiophore processes convergent to median ridge and notothyrial platform; sockets generally bounded by posterolateral faces of brachiophore bases and floored by socket pads, fulcral plates present in some specimens; secondary deposits thicken brachiophore bases and cardinal process, especially shaft, in gerontic specimens. Very little secondary material on floor of valve, adductor muscle marks impressed in secondary material in some mature specimens; juvenile parts of posterior marks floor cavities beneath brachiophore bases, cavity may be filled by secondary deposits.

Discussion.—An extensive description of *D. sulcata* was given by Neuman (1967). His analysis was based on most of the specimens that were used for my study.

The most diagnostic features are the slightly convex sulcate dorsal valve and the distinctly convergent brachiophore bases and associated socket pads. Infraspecific variation occurs in (1) curvature of ventral valve, varying from subcarinate to gently rounded, (2) outline of shell, and (3) alteration of dorsal interior because of the addition of secondary deposits, the most significant variation. In some collections (such as USGS 4051–CO and 5070–CO), secondary deposits thicken the cardinal process, brachiophore bases, and socket pads, and they fill the cavity beneath the brachiophore bases. Also, dorsal muscle marks may be impressed in immature as well as in mature specimens. Such altered cardinalia resemble those of *D. fertilis* and even *Heterorthina macfarlani,* in which the main brachiophore bases are divergent to the valve floor.

Stratigraphic distribution.—*Dalmanella sulcata* occurs principally in the Logana Member of the Lexington Limestone, and its presence is characteristic of that stratigraphic level. It is found in the lower part of the Grier Limestone Member of the Lexington (in USGS colln. 5080–CO, Wilmore Quadrangle, and possibly in D–1197–CO, Frankfort East Quadrangle) at levels equivalent to the Logana elsewhere. The species was questionably identified in USGS collection 5023–CO from the top of the Curdsville Limestone Member of the Lexington in the Keene Quadrangle, in association with *Dalmanella fertilis. Dalmanella sulcata* is also present in collection 5085–CO, which came from a piece of float identified as Curdsville, at the Kentucky Utilities Plant Section in the Tyrone Quadrangle.

The species is known from the lower part of the Hermitage Formation in central Tennessee (Cooper, 1956) and from the Martinsburg Formation in Virginia (Walker, 1967, referred to as *D. bassleri*). Probably it occurs elsewhere but has been misidentified.

Genus HETERORTHINA Bancroft 1928

Type species.—*H. praeculta* Bancroft, by original designation.

Discussion.—The most diagnostic feature of *Heterorthina* in the Kentucky area is the divergence of the brachiophore bases relative to their tops (described in the discussion of *Dalmanella*). Williams and Wright (1963) and Wright (*in* Williams and others, 1965)

described the genus as being similar to *Onniella* but stated that *Heterorthina* has a more convex pedicle valve, a subplanar brachial valve, and more splayed ventral diductor scars. *Heterorthina macfarlani* is the only species of the genus that I have seen.

Heterorthina macfarlani Neuman, 1967

Plate 3, figures 31–35; plate 4, figures 1–17

Heterorthina macfarlani Neuman, 1967, p. 10–12, pl. 2, figs. 1–19.

Diagnosis.—Large dalmanellid, as much as 21 mm long and 25 mm wide; transversely subelliptical in outline, cardinal extremities rounded except in some smaller specimens, anterolateral margins always rounded. Ventral valve moderately convex, as much as 6 mm deep, subcarinate to gently rounded in posterior view, low fold present in some valves as much as 12 to 15 mm long. Dorsal valve nearly flat but ranges from slightly convex through flat to resupinate; sulcus generally present in early growth stages, gradually shallowing and disappearing in specimens more than about 12 to 15 mm long; smaller specimens commonly have sulcate anterior margin. Seven to 9 costae and costellae, rarely 10, per 2-mm interval measured 5 mm anterior to dorsal umbo. Growth lines present or absent; where present, irregularly spaced and more prominent near margins of medium to large shells; fila absent.

Ventral muscle field wide, with widely flaring dental plates enclosing posterior one-third of field; outline of field varying from almost cordate with adductor mark narrow, to more common bilobed shape with adductor track wide and one-half to three-fourths length of diductor marks; diductor marks extending from one-third to midlength of valve.

Brachiophores with spikelike processes (rarely preserved) and with bases greatly divergent relative to their tops, so outer faces bound sockets, visible in plan view. Struts connect inner faces of brachiophore bases to median ridge and form notothyrial platform from which cardinal process rises; struts may be subparallel to valve floor or may slope inward toward midline of valve; platform elevated, cavity under struts on either side of median ridge, may be filled in larger specimens; short plates may be present under struts. Cardinal process shaft thin and myophore bulbous in very small specimens; myophore enlarged and distinctly bilobed in valves 8-10 mm long; shaft deeply cleft and greatly thickened during growth, occupying most of space between brachiophore supports, commonly wider than myophore in large valves. Median ridge broad, commonly with shallow median cleavage continuous with that of shaft of cardinal process. Adductor muscle marks preserved in some medium to large valves with secondary material thickening valve interior; marks extend from one-third to midlength of valve; anterior marks quadripartite to almost elliptical, posterior marks triangular and about equal in size to anterior marks.

Discussion.—Neuman (1967) provided a description and a detailed discussion of the ontogeny of *Heterorthina macfarlani,* and our analyses agree closely.

The cardinalia are the only features consistently reliable for differentiating *Heterorthina macfarlani* from species of Dalmanella. The large *D. bassleri* is most similar to *Heterorthina macfarlani,* but generally its ventral valve is less convex, more carinate, and has flatter posterolateral slopes. The ventral muscle field is not as wide, and the dorsal valve is slightly more convex, especially in smaller specimens. However, many specimens in both species are indistinguishable externally. As Neuman (1967) pointed out, *H. macfarlani* has been misidentified as *Dalmanella* (or *Onniella*) bassleri by others. Small to medium specimens of *H. macfarlani* can be similar externally to other smaller species of *Dalmanella.* Obviously, the two genera are closely related.

Even the cardinalia of some specimens of *H. macfarlani* can resemble *D. sulcata,* depending on the development of the struts that form the notothyrial platform of *Heterorthina.* If the struts are inclined downward to the valve midline and are built far forward relative to the brachiophore bases, the struts look like the convergent brachiophore supports and the brachiophore bases, like the structure that forms the socket margin in *D. sulcata.* However, confusion of the two species is not likely except for collections of few, poorly preserved specimens.

Stratigraphic distribution.—*Heterorthina macfarlani* occurs only within the Grier Limestone Member of the Lexington Limestone. It is apparently confined to the middle and upper part of the member, although it is rare or absent in the highest part of the Grier. Neuman (1967) stated that the species is confined to about one-fourth of the thickness of the Grier upward from about the middle of the member.

LOCALITY REGISTER

This locality register supplements those published by Pojeta (1979) and Parsley (1981) in Chapters A and K, respectively, of this series. The details of the numbering and the methods of notation are in Pojeta (1979). Only localities not mentioned in Chapters A and K are included here; therefore, refer to either Chapter A or K for any locality numbers used herein that are not listed in this register.

Collection number----------**4051-CO.**
Geographic location --------The same as for 5072-CO.
Coordinates Do.

Formation ----------Logana Member, Lexington Limestone.
Stratigraphic position-------48 ft above Tyrone Limestone-Lexington Limestone contact.
Silicified ----------Yes.
Quadrangle name ----------Frankfort East, Ky.
Section name----------Frankfort East B.
Section number----------87.

Collection number----------**4056–CO.**
Geographic location --------Quarry on east side of U.S. Route 27, 3.1 mi south of Bryantsville, Ky., 0.5 mi south of Burdette Knob. Stop 14, Nosow and McFarlan (1960).
Coordinates----------384 mm east, 242 mm north.
Formation ----------Cornishville Bed(?), Perryville Limestone Member, Lexington Limestone.
Silicified ----------Yes.
Quadrangle name ----------Bryantsville, Ky.
Section name----------Burdett Knob.

Collection number----------**4074–CO*.**
Geographic location --------The same as for 4072–CO.
Coordinates Do.
Formation ----------Grier Limestone Member, Lexington Limestone.
Stratigraphic position-------144 ft above the base of the Curdsville Limestone Member, Lexington Limestone.
Quadrangle name ----------Tyrone, Ky.
Section name----------Tyrone A.
Section number----------89.

Collection number----------**4177–CO*.**
Geographic location --------Section at crossing of Kentucky Route 169 and headwaters of Marble Creek.
Coordinates----------168 mm east, 573 mm north.
Formation ----------Curdsville Limestone Member, Lexington Limestone.
Stratigraphic Position -----19.4 ft above Tyrone Limestone-Curdsville Limestone Member contact.
Silicified ----------Yes.
Quadrangle name ----------Valley View, Ky.
Section name----------Marble Creek.

Collection number----------**4185–CO*.**
Geographic location --------The same as for 4178–CO.
Coordinates Do.
Formation ----------Grier Limestone Member, Lexington Limestone.
Stratigraphic position-------136 ft above the base of the section.
Silicified ----------Yes.
Quadrangle name ----------Valley View, Ky.
Section name----------Valley View B (Hunters Ferry Rd.).
Section number----------34.

Collection number----------**4883–CO*.**
Geographic location --------The same as for 4871–CO.
Coordinates Do.
Formation ----------Grier Limestone Member, Lexington Limestone.
Stratigraphic position-------60 ft above the base of the section.
Silicified ----------Yes (75 lbs).
Quadrangle name ----------Valley View, Ky.
Section name----------Valley View C (Antioch Church Rd.).
Section number----------180.

Collection number----------**5070–CO*.**
Geographic location --------200 ft north of 5069–CO.
Coordinates Do.
Formation ----------Upper part of the Logana Member, Lexington Limestone.
Quadrangle name ----------Frankfort East, Ky.
Section name----------Old Taylor.

Collection number----------**5085–CO.**
Geographic location --------The same as for 5081–CO.
Coordinates Do.
Formation ----------Curdsville Limestone Member, Lexington Limestone.
Stratigraphic position-------16 ft above Tyrone Limestone-Curdsville Limestone Member contact.
Silicified ----------Yes (2 lbs).
Quadrangle name ----------Tyrone, Ky.
Section name----------Tyrone C (Kentucky Utilities Plant).
Section number----------174.

Collection number----------**5098–CO.**
Geographic location --------The same as for 4178–CO.
Coordinates Do.
Formation ----------Grier Limestone Member, Lexington Limestone.
Stratigraphic position-------40–45 ft above base of section.
Silicified ----------Yes (15 lbs).
Quadrangle name ----------Valley View, Ky.
Section name----------Valley View B (Hunters Ferry Rd.).
Section number----------34.

Collection number----------**6910–CO*.**
Geographic location --------The same as for 6909–CO.
Coordinates Do.
Formation ----------Kope Formation.
Stratigraphic position-------66 ft above the Point Pleasant Tongue, Clays Ferry Formation—Kope Formation contact.
Quadrangle name ----------Falmouth, Ky.
Section name----------Falmouth A.
Section number----------195

Collection number----------**7833–CO.**
Geographic location --------Roadcut near intersection of Bull Fork Rd. and Righthand Fork Creek, west of Hamburg, Ind.
Coordinates----------322 mm east, 36 mm north.
Formation ----------Lower part of the Saluda Formation.
Silicified ----------Yes (11 lbs).
Quadrangle name ----------Clarksburg, Ind.
Section name----------Hamburg.

Collection number----------**7979–CO.**
Geographic location --------The same as for 7978–CO.
Coordinates Do.
Formation ----------Kope Formation.
Stratigraphic position-------Collected through lower 20 ft of Kope Formation.
Quadrangle name ----------Demossville, Ky.
Section name----------Moffett Road.

Collection number----------**7980-CO.**
Geographic location --------The same as for 7978-CO.
Coordinates Do.
Formation ----------Kope Formation.
Stratigraphic position-------130 ft above Point Pleasant Tongue, Clays Ferry Formation-Kope Formation contact.
Quadrangle name ----------Demossville, Ky.
Section name----------Moffett Road.

Collection number----------**7981-CO.**
Geographic location --------The same as for 7978-CO.
Coordinates Do.
Formation ----------Kope Formation.
Stratigraphic position-------212 ft above Point Pleasant Tongue, Clays Ferry Formation-Kope Formation contact.
Quadrangle name ----------Demossville, Ky.
Section name----------Moffett Road.

Collection number----------**7983-CO.**
Geographic location --------The same as for 7823-CO.
Coordinates Do.
Formation ----------Clays Ferry and Kope Formations, undivided.
Stratigraphic position-------Just above lowest occurrence of *Sowerbyella rugosa.*
Quadrangle name ----------Monterey, Ky.

Collection number----------**D-1197-CO*.**
Geographic location --------The same as for D-1196-CO.
Coordinates Do.
Formation ----------Grier Limestone Member, Lexington Limestone.
Stratigraphic position-------52 ft above the top of Tyrone Limestone.
Quadrangle name ----------Frankfort East, Ky.
Section name----------Frankfort East A.
Section number----------86.

Collection number----------**D-1249-CO*.**
Geographic location --------The same as for D-1239-CO.
Coordinates Do.
Formation ----------Bull Fork Formation.
Stratigraphic position-------43 ft above base of Bull Fork Formation.
Quadrangle name ----------Orangeburg, Ky.
Section name----------County Line.

Collection number----------**D-1315-CO*.**
Geographic location --------The same as for D-1314-CO.
Coordinates Do.
Formation ----------Fairview Formation.
Stratigraphic position-------51 ft above the base of the section.
Quadrangle name ----------Maysville East, Ohio-Kentucky.
Section name----------Sleepy Hollow.

Collection number----------**D-1363-CO*.**
Geographic location --------The same as for D-1365-CO.
Coordinates Do.
Formation ----------Calloway Creek Limestone.
Stratigraphic position-------Collected through the lower 37 ft of the Calloway Creek Limestone.
Quadrangle name ----------Richmond North, Ky.
Section name----------Type section of the Calloway Creek Limestone.

REFERENCES CITED

Alberstadt, L. P., 1979, The brachiopod genus *Platystrophia*: U.S. Geological Survey Professional Paper 1066-B, 20 p., 7 pls.

Bancroft, B. B., 1928, On the notational representation of the rib system in Orthacea: Manchester Literary and Philosophical Society Memoirs and Proceedings, v. 72, p. 53-90.

Bassler, R. S., 1909, The cement resources of Virginia west of the Blue Ridge: Virginia Geological Survey Bulletin 2A, 309 p.

—— 1915, Bibliographic index of American Ordovician and Silurian fossils: U.S. National Museum Bulletin 92, 2 v.: 1521 p.

Black, D. F. B., Cressman, E. R., and MacQuown, W. C., Jr., 1965, The Lexington Limestone (Middle Ordovician) of central Kentucky: U.S. Geological Survey Bulletin 1224-C, 29 p.

Black, D. F. B., and Cuppels, N. P., 1973, Strodes Creek Member (Upper Ordovician)—A new map unit in the Lexington Limestone of north-central Kentucky: U.S. Geological Survey Bulletin 1372-C, p. C1-C16.

Cooper, G. A., 1956, Chazyan and related brachiopods: Smithsonian Miscellaneous Collections, v. 127, pt. 1 (text), p. 1-1024; pt. 2 (plates), p. 1025-1045, 269 pls.

Cressman, E. R., 1973, Lithostratigraphy and depositional environments of the Lexington Limestone (Ordovician) of central Kentucky: U.S. Geological Survey Professional Paper 768, 61 p.

Cressman, E. R., and Karklins, O. L., 1970, Field Trip No. 2, Lithology and fauna of the Lexington Limestone (Ordovician) of central Kentucky, *in* Geological Society of America, Southeastern Section, Guidebook for Field Trips—18th Annual Meeting, Lexington, Ky., 1970: Lexington, Ky., Kentucky Geological Survey, p. 17-28.

Cumings, E. R., 1908, The stratigraphy and paleontology of the Cincinnati series of Indiana: Indiana Department of Geology and Natural Resources, Annual Report 32, p. 607-1189.

Dalman, J. W., 1828, Uppställning och beskrifning af de i Sverige funne Terebratuliter: Kongl. Svenska Vetenskaps Akademiens Handlingar for 1827, p. 85-155, pls. 1-6.

Foerste, A. F., 1909a, Preliminary notes on Cincinnatian fossils: Denison University Scientific Laboratories Bulletin, v. 14, p. 208-232.

—— 1909b, Preliminary notes on Cincinnatian and Lexington fossils: Denison University Scientific Laboratories Bulletin, v. 14, p. 289-334.

—— 1910, Preliminary notes on Cincinnatian and Lexington fossils of Ohio, Indiana, Kentucky, and Tennessee: Denison University Scientific Laboratories Bulletin, v. 16 p. 17-100.

—— 1914a, Notes on the Lorraine faunas of New York and the Province of Quebec: Denison University Scientific Laboratories Bulletin, v. 17, p. 247-340.

—— 1914b, The Rogers Gap fauna of central Kentucky: Cincinnati Society of Natural History Journal, v. 21, p. 109-156.

Hall, D. D., 1962, Dalmanellidae of the Cincinnatian: Palaeontographica Americana, v. 4, no. 29, p. 131-165.

Hall, James, 1847, Descriptions of the organic remains of the lower division of the New York system: Paleontology of New York, v. 1, 338 p.

Hall, James, and Clarke, J. M., 1893, An introduction to the study of the genera of Paleozoic Brachiopoda: New York Geological Survey, Paleontology of New York, v. 8, pt. 1, 367 p. [1892].

Howe, H. J., 1966, Orthacea from the Montoya Group (Ordovician) of Trans-Pecos Texas: Journal of Paleontology, v. 40, no. 2, p. 241-257.

James, U. P., 1871, Catalogue of Lower Silurian fossils, Cincinnati Group: Cincinnati, Ohio, 14 p.

Meek, F. B., 1873, Description of invertebrate fossils of the Silurian and Devonian systems: Ohio Geological Survey, v. 1, Geology and paleontology, pt. 2, Paleontology, p. 1-243.

Miller, S. A., 1875, Monograph of the class Brachiopoda of the Cincinnati Group: Cincinnati Quarterly Journal of Science, v. 2, p. 6–62.

Neuman, R. B., 1967, Some silicified Middle Ordovician brachiopods from Kentucky: U.S. Geological Survey Professional Paper 583–A, p. A1–A14.

Nosow, Edmund, and McFarlan, A. C., 1960, Geology of the central Bluegrass area [Guidebook]—Geological Society of America, Southeastern Section, Field Trip [No. 1]: Lexington, Ky., Kentucky Geological Survey, 54 p.

Parsley, R. L., 1981, Echinoderms from Middle and Upper Ordovician rocks of Kentucky: U.S. Geological Survey Professional Paper 1066–K, p. K1–K9.

Peck, J. H., 1966, Upper Ordovician formations in the Maysville area, Kentucky: U.S. Geological Survey Bulletin 1244–B, p. B1–B30.

Pojeta, John, Jr., 1979, The Ordovician paleontology of Kentucky and nearby States—Introduction: U.S. Geological Survey Professional Paper 1066–A, 48 p.

Schuchert, Charles, and Cooper, G. A., 1932, Brachiopod genera of the suborders Orthoidea and Pentameroidea: Peabody Museum of Natural History Memoirs, v. 4, pt. 1, 270 p.

Simmons, G. C., and Oliver, W. A., Jr., 1967, Otter Creek coral bed and its fauna, east-central Kentucky: U.S. Geological Survey Bulletin 1244–F, p. F1–F13.

Walker, L. G., 1967, Stratigraphy of the Ordovician Martinsburg Formation in southwestern Virginia: Cambridge, Mass., Harvard University, Ph.D. dissertation, 147 p.

Weir, G. W., and Greene, R. C., 1965, Clays Ferry Formation (Ordovician)—A new map unit in south-central Kentucky: U.S. Geological Survey Bulletin 1244–B, p. B1–B18.

Weir, G. W., Greene, R. C., and Simmons, G. C., 1965, Calloway Creek Limestone and Ashlock and Drakes Formations (Upper Ordovician) in south-central Kentucky: U.S. Geological Survey Bulletin 1224–D, p. D1–D36.

Whitfield, R. P., and Hovey, E. O., 1898, Catalogue of the type and figured specimens in the paleontological collection of the geological department, American Museum of Natural History: American Museum of Natural History Bulletin 11, 500 p.

Williams, Alwyn, and Wright, A. D., 1963, The classification of the *"Orthis testudinaria* Dalman" group of brachiopods: Journal of Paleontology, v. 37, no. 1, p. 1–32.

Williams, Alwyn, and others, 1965, Brachiopoda, Pt. H *of* Moore, R. C., ed., Treatise on invertebrate paleontology: New York and Lawrence, Kans., Geological Society of America and University of Kansas Press, 2 v., 927 p.

PLATES 1–5

Contact photographs of the plates in this report are available, at cost, from the U.S. Geological Survey Library, Federal Center, Denver, CO 80225.

PLATE 1

FIGURES 1–24. *Dalmanella fertilis* (Ulrich), 1909 (p. 11).

1–4. Ventral valve; exterior, interior, posterior, and side views, × 2. USGS loc. 4177–CO, Curdsville Limestone Member, Lexington Limestone. USNM 258406.

5. Ventral exterior, × 2. USGS loc. 4124–CO, Logana Member(?), Lexington Limestone. USNM 258407.

6. Ventral exterior, × 2. USGS loc. 4124–CO, Logana Member(?), Lexington Limestone. USNM 258409.

7. Interior of small ventral valve, × 4. USGS loc. 5069–CO, Curdsville Limestone Member, Lexington Limestone. USNM 258410.

8. Ventral interior, × 2. USGS loc. 4124–CO, Logana Member(?), Lexington Limestone. USNM 258411.

9. Ventral interior, × 2. USGS loc. 5022–CO, Curdsville Limestone Member, Lexington Limestone. USNM 258412.

10. Dorsal exterior, × 2. USGS loc. 4124–CO, Logana Member(?), Lexington Limestone. USNM 258413.

11, 12. Dorsal interior; cardinalia thickened by secondary deposits; ventral and anterior views, × 2. USGS loc. 4124–CO, Logana Member(?), Lexington Limestone. USNM 258414.

13, 14. Dorsal interior; cardinalia thickened by secondary deposits; ventral and anterior views, × 2. USGS loc. 5022–CO, Curdsville Limestone Member, Lexington Limestone. USNM 258415.

15, 16. Very small ventral valve; exterior and interior views, × 8. USGS loc. 5069–CO, Curdsville Limestone Member, Lexington Limestone. USNM 258416.

17. Small dorsal valve with fulcral plate; anterolateral view, × 8. USGS loc. 5069–CO, Curdsville Limestone Member, Lexington Limestone. USNM 258417.

18–21. Very small dorsal valve; exterior, interior, anterior, and anterolateral views, × 8. USGS loc. 5069–CO, Curdsville Limestone Member, Lexington Limestone. USNM 258418.

22–24. Medium-sized dorsal valve; interior, anterior, and anterolateral views, × 4. USGS loc. 5069–CO, Curdsville Limestone Member, Lexington Limestone. USNM 258419.

FIGURES 25–38. *Dalmanella sulcata* Cooper, 1956 (p. 13).

25–27. Very small dorsal valve; ventral, anterior, and anterolateral views, × 6. USGS loc. 5073–CO, Logana Member, Lexington Limestone. USNM 258420.

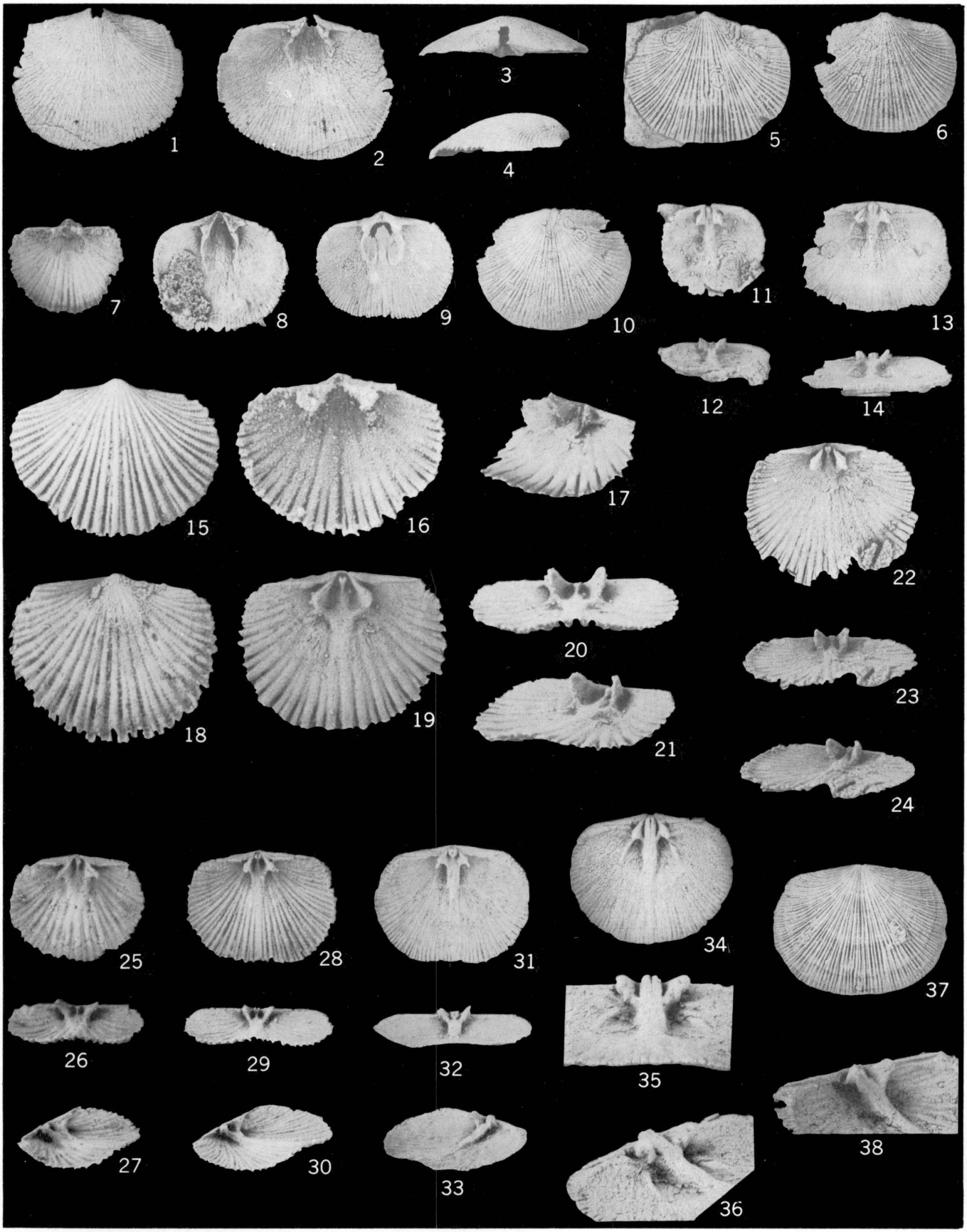
28–30. Small dorsal valve; ventral, anterior, and anterolateral views, × 4. USGS loc. 5073–CO, Logana Member, Lexington Limestone. USNM 258421.

31–33. Dorsal valve; ventral, anterior, and anterolateral views, × 2. USGS loc. 5073–CO, Logana Member, Lexington Limestone. USNM 258422.

34–36. Large dorsal valve with thickened cardinalia. Ventral view, × 2; anterior and anterolateral views, × 4. USGS loc. D–1196–CO, Logana Member, Lexington Limestone. USNM 258423.

37. Dorsal exterior, × 2. USGS loc. D–1196–CO, Logana Member, Lexington Limestone. USNM 258424.

38. Cardinalia with fulcral plates; anterolateral view, × 4. USGS loc. 5073–CO, Logana Member, Lexington Limestone. USNM 258425.


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38

DALMANELLA

PLATE 2

FIGURES 1–14. *Dalmanella sulcata* Cooper, 1956 (p. 13).

1, 2. Small ventral valve; exterior and interior, × 4. USGS loc. 5073–CO, Logana Member, Lexington Limestone. USNM 258426.

3, 4. Ventral valve; exterior and interior, × 2. USGS loc. 5073–CO, Logana Member, Lexington Limestone. USNM 258427.

5. Ventral interior, × 2. Compare muscle marks with those in specimens shown in figures 2, 4, and 12. USGS loc. 5092–CO, Logana Member, Lexington Limestone. USNM 258428.

6–10. Articulated specimen; ventral, dorsal, side, posterior, and anterior views × 2. USGS loc. 5092–CO, Logana Member, Lexington Limestone. USNM 258429.

11–14. Ventral valve; exterior, interior, side, and posterior views, × 2. Note relatively short hingeline. USGS loc. 4051–CO, Logana Member, Lexington Limestone. USNM 258430.

FIGURES 15–28. *Dalmanella bassleri* Foerste, 1909 (p. 11).

15, 16. Dorsal valve; exterior and interior, × 2. USGS loc. 7824–CO, Point Pleasant Tongue, Clays Ferry Formation. USNM 258431.

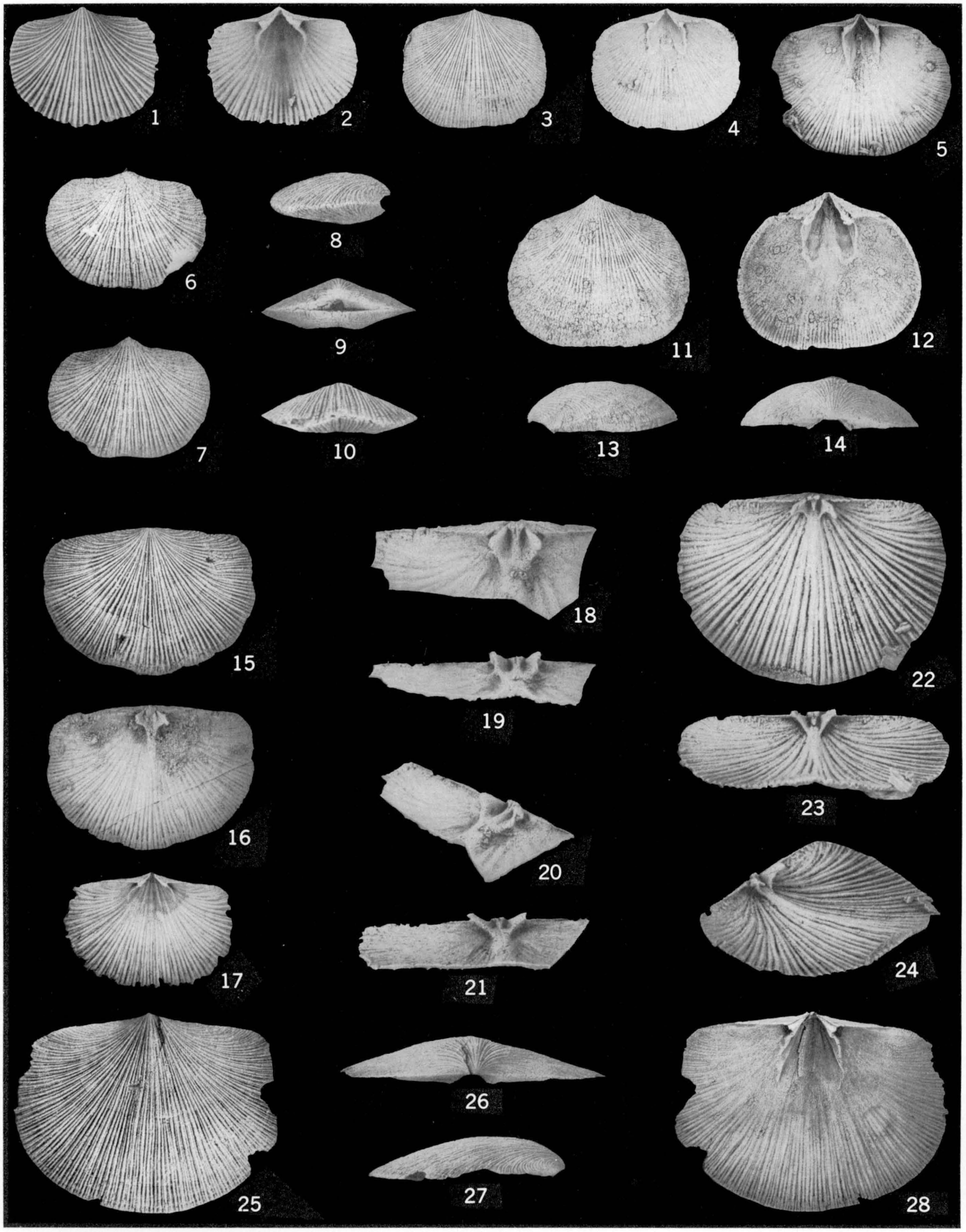
17. Small ventral interior, × 2. USGS loc. 7824–CO, Point Pleasant Tongue, Clays Ferry Formation. USNM 258432.

18–20. Fragment of dorsal valve showing cardinalia; ventral, anterior, and anterolateral views, × 4. USGS loc. 7824–CO, Point Pleasant Tongue, Clays Ferry Formation. USNM 258433.

21. Fragment of dorsal valve showing cardinalia; anterior view, × 4. Compare angle between brachiophore bases with those in specimens shown in figures 19 and 23. USGS loc. 7824–CO, Point Pleasant Tongue, Clays Ferry Formation. USNM 258434.

22–24. Smaller dorsal valve; ventral, anterior, and anterolateral views, × 4. USGS loc. 6146–CO, Point Pleasant Tongue, Clays Ferry Formation. USNM 258435.

25–28. Ventral valve; exterior, posterior, side, and interior views, × 2. USGS loc. 7824–CO, Point Pleasant Tongue, Clays Ferry Formation. USNM 258436.



DALMANELLA

PLATE 3

FIGURES 1–19. *Dalmanella multisecta* (Meek), 1873 (p. 12).

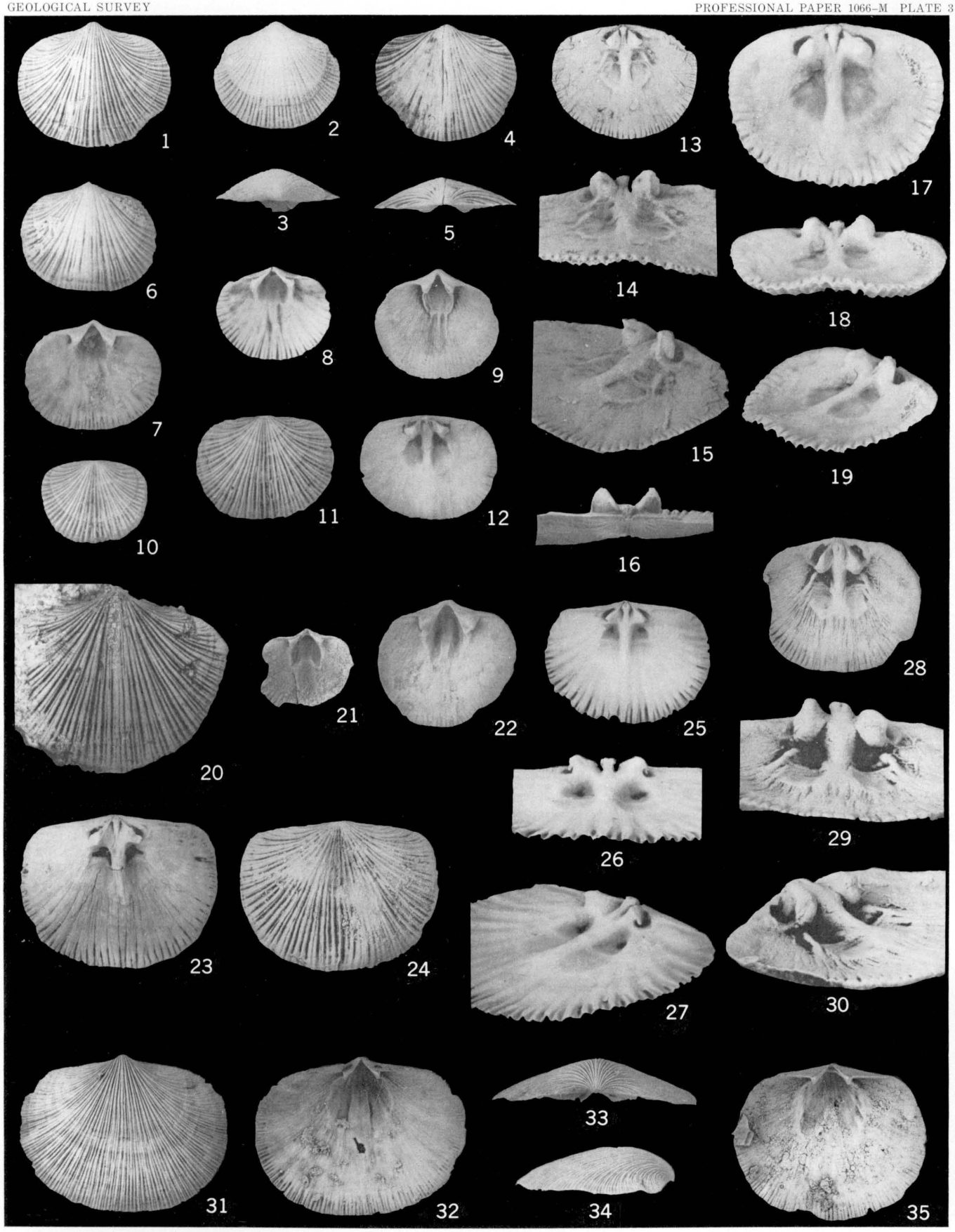
1. Ventral exterior, × 2. USGS loc. 7979–CO, lower part of the Kope Formation. USNM 258437.
2, 3. Ventral valve; ventral and dorsal views, × 2. Compare curvature of valve with that shown in figure 5; USGS loc. 7983–CO, Kope Formation. USNM 258438.
4, 5. Ventral valve; ventral and dorsal views, × 2. USGS loc. 7981–CO, upper part of the Kope Formation. USNM 258439.
6, 7. Ventral valve; exterior and interior views, × 2. USGS loc. uncertain. USNM 258440.
8. Ventral interior, × 2. Compare muscle mark with that of specimen shown in figure 9. USGS loc. 7981–CO, upper part of the Kope Formation. USNM 258441.
9. Ventral interior, × 2. USGS loc. 7983–CO, Kope Formation. USNM 258442.
10. Dorsal exterior, × 2. Figures 17–19 show interior views of this valve. USGS loc. 7981–CO, upper part of the Kope Formation. USNM 258443.
11, 12. Dorsal valve; exterior and interior views, × 2. USGS loc. 7981–CO, upper part of the Kope Formation. USNM 258444.
13–16. Dorsal valve; ventral view, × 2; anterior, anterolateral, and posterior views, × 4. USGS loc. 7981–CO, upper part of the Kope Formation. USNM 258445.
17–19. Dorsal valve; ventral, anterior, and anterolateral views, × 4. Thick secondary deposits. Figure 10 shows the exterior of this valve. USGS loc. 7981–CO, upper part of the Kope Formation. USNM 258443.

FIGURES 20–30. *Dalmanella meeki* (Miller), 1875 (p. 12).

20. Ventral exterior, × 2. USGS loc. D–1244–CO, Bull Fork Formation. USNM 258447.
21. Small ventral interior, × 2. USGS loc. D–1255–CO, Bull Fork Formation. USNM 258448.
22. Ventral interior, × 2. USGS loc. D–1249–CO, Bull Fork Formation. USNM 258449.
23, 24. Dorsal valve; interior and exterior views, × 2. USGS loc. D–1244–CO, Bull Fork Formation. USNM 258450.
25–27. Dorsal valve; ventral view, × 2; anterior and anterolateral views, × 4. USGS loc. D–1256–CO, Bull Fork Formation. USNM 258451.
28–30. Dorsal valve; ventral view, × 2; anterior and anterolateral views, × 4. Very thick secondary deposits. USGS loc. D–1251–CO, Bull Fork Formation. USNM 258452.

FIGURES 31–35. *Heterorthina macfarlani* Neuman, 1967 (p. 14).

31–34. Ventral valve; exterior, interior, posterior, and side views, × 2. USGS loc. 5093–CO, Macedonia Bed, Grier Limestone Member, Lexington Limestone. USNM 258453.
35. Ventral interior, × 2. USGS loc. 5093–CO, Macedonia Bed, Grier Limestone Member, Lexington Limestone. USNM 258454.



DALMANELLA AND *HETERORTHINA*

PLATE 4

FIGURES 1–17. *Heterorthina macfarlani* Neuman, 1967 (p. 14).

1–3. Interior of a very small dorsal valve; ventral, anterior, and anterolateral views, × 12. USGS loc. 5093–CO, Macedonia Bed, Grier Limestone Member, Lexington Limestone. USNM 258455.

4–6. Interior of a small dorsal valve; ventral view × 4; anterior and anterolateral views, × 8. USGS loc. 5093–CO, Macedonia Bed, Grier Limestone Member, Lexington Limestone. USNM 258456.

7–9. Interior of a medium-sized dorsal valve; ventral, anterior, and anterolateral views, × 4. USGS loc. 5093–CO, Macedonia Bed, Grier Limestone Member, Lexington Limestone. USNM 258457.

10. Interior of a large dorsal valve, × 2. USGS loc. 4852–CO, Grier Limestone Member, Lexington Limestone. USNM 258458.

11–13. Cardinalia of a large specimen; ventral, anterior, and anterolateral views, × 4. USGS loc. 5093–CO, Macedonia Bed, Grier Limestone Member, Lexington Limestone. USNM 258459.

14. Dorsal exterior, × 2. USGS loc. 4852–CO, Grier Limestone Member, Lexington Limestone. USNM 258460.

15. Ventral interior, × 2. USGS loc. 5093–CO, Macedonia Bed, Grier Limestone Member, Lexington Limestone. USNM 258461.

16–17. Ventral valve; exterior and interior views, × 2. USGS loc. 5093–CO, Macedonia Bed, Grier Limestone Member, Lexington Limestone. USNM 258462.

FIGURES 18–40. *Hebertella frankfortensis* Foerste, 1909 (p. 3).

18, 19. Exterior and interior of a very small ventral valve, × 4. USGS loc. 5016–CO, Cornishville Bed, Perryville Limestone Member, Lexington Limestone. USNM 258463.

20. Interior of a small ventral valve, × 4. USGS loc. 4883–CO, Grier Limestone Member, Lexington Limestone. USNM 258464.

21. Interior of a very small dorsal valve, × 4. USGS loc. 5016–CO, Cornishville Bed, Perryville Limestone Member, Lexington Limestone. USNM 258465.

22, 23. Exterior and interior of a ventral valve. × 1. USGS loc. 4056–CO, Cornishville Bed(?), Perryville Limestone Member, Lexington Limestone. USNM 258466.

24. Ventral interior, × 1. USGS loc. 4883–CO, Grier Limestone Member, Lexington Limestone. USNM 258467.

25. Exterior of ventral valve with closely spaced costae, × 1. USGS loc. 4074–CO, Grier Limestone Member, Lexington Limestone. USNM 258468.

26. Exterior of dorsal valve with closely spaced costae, × 1. USGS loc. 4928–CO, Grier Limestone Member, Lexington Limestone. USNM 258469.

27. Dorsal valve with very low fold; anterior view, × 1. USGS loc. 4883–CO, Grier Limestone Member, Lexington Limestone. USNM 258470.

28. Dorsal valve with fold; anterior view, × 1. USGS loc. 4883–CO, Grier Limestone Member, Lexington Limestone. USNM 258471.

29–33. Articulated specimen; ventral exterior, dorsal exterior, posterior, anterior, and lateral views, × 1. USGS loc. 5016–CO, Cornishville Bed, Perryville Limestone Member, Lexington Limestone. USNM 258472.

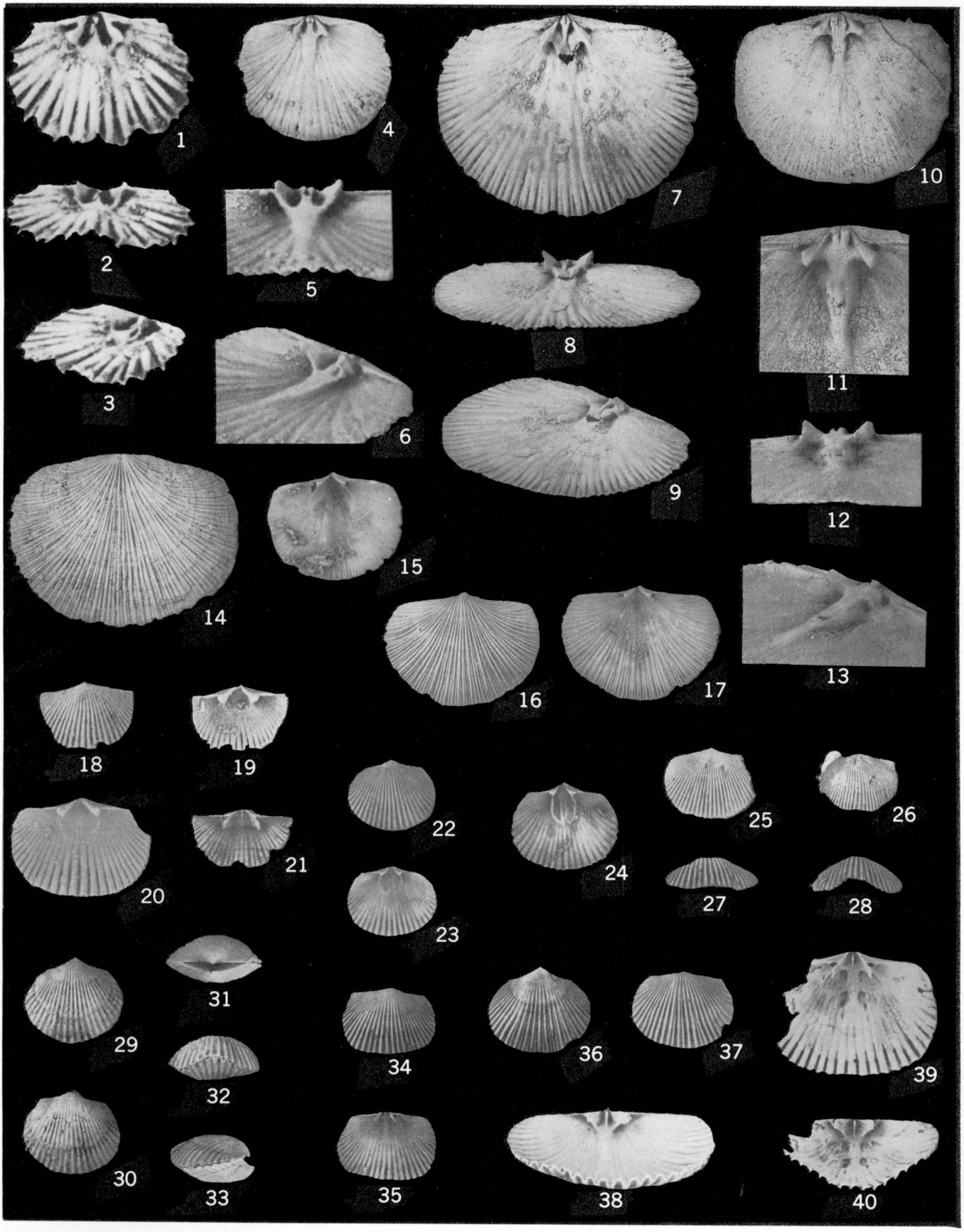
34, 35. Exterior and interior of dorsal valve, × 1. USGS loc. 4883–CO, Grier Limestone Member, Lexington Limestone. USNM 258473.

36. Ventral exterior, bifurcating costae, × 1. USGS loc. 4883–CO, Grier Limestone Member, Lexington Limestone. USNM 258474.

37. Dorsal exterior, bifurcating costae, × 1. USGS loc. 4883–CO, Grier Limestone Member, Lexington Limestone. USNM 258475.

38. Dorsal interior; anterior view, × 2. USGS loc. 4883–CO, Grier Limestone Member, Lexington Limestone. USNM 258476.

39, 40. Dorsal interior; ventral and anterior views, × 2. USGS loc. 4056–CO, Cornishville Bed(?), Perryville Limestone Member, Lexington Limestone. USNM 258477.



HETERORTHINA AND *HEBERTELLA*

PLATE 5

FIGURES 1–17. *Hebertella parksensis* Foerste, 1909 (p. 8).

1, 2. Exterior and interior of a very small ventral valve, × 4. USGS loc. 7812–CO, Clays Ferry Formation. USNM 258478.

3–5. Small dorsal valve; exterior view, ventral and anterior views of the interior, × 4. USGS loc. 7349–CO, tongue of Clays Ferry Formation. USNM 258479.

6. Dorsal interior; anterior view, × 1. USGS loc. 7353–CO, Millersburg Member, Lexington Limestone. USNM 258480.

7, 8. Exterior and interior of dorsal valve, × 1. USGS loc. 7353–CO, Millersburg Member, Lexington Limestone. USNM 258481.

9, 10. Exterior and interior of ventral valve, × 1. USGS loc. 7350–CO, Millersburg Member, Lexington Limestone. USNM 258482.

11. Interior of small ventral valve, × 1. USGS loc. 7348–CO, tongue of Clays Ferry Formation. USNM 258483.

12. Articulated specimen with unusually convex valve flanks, anterior view, × 1. Collected by A. F. Foerste, Parks Hill, Nicholas County, Ky.; Millersburg Member, Lexington Limestone of current usage. Topotype specimen, USNM 258446.

13–15. Articulated specimen; ventral exterior, dorsal exterior, and lateral views, × 1. Parks Hill, Nicholas County, Ky.; Millersburg Member, Lexington Limestone of current usage. Syntype specimen, USNM 87054.

16. Articulated specimen; anterior view, × 1. Collected by A. F. Foerste, Parks Hill, Nicholas County, Ky.; Millersburg Member, Lexington Limestone of current usage. Topotype specimen, USNM 84089.

17. Dorsal interior; anterior view, × 2. USGS loc. 7353–CO, Millersburg Member, Lexington Limestone. USNM 258484.

FIGURES 18–41. *Hebertella occidentalis* (Hall), 1847 (p. 6).

18, 19. Exterior and interior of very small ventral valve, × 6. USGS loc. 6409–CO, Calloway Creek Limestone. USNM 258485.

20, 21. Exterior and interior of very small dorsal valve, × 6. USGS loc. 6409–CO, Calloway Creek Limestone. USNM 258486.

22, 23. Exterior and interior of small ventral valve, × 2. USGS loc. 6409–CO, Calloway Creek Limestone. USNM 258487.

24, 25. Exterior and interior of dorsal valve, × 2. USGS loc. 6409–CO, Calloway Creek Limestone. USNM 258488.

26. Dorsal exterior, × 1. USGS loc. 6139–CO, upper part of the Dillsboro Formation. USNM 258489.

27. Dorsal exterior; compare spacing of costae with specimen in fig. 26; × 1. USGS loc. 6139–CO, upper part of the Dillsboro Formation. USNM 258490.

28. Dorsal exterior with sulcus, × 1. Same specimen as shown in fig. 32. USGS loc. 6139–CO, upper part of the Dillsboro Formation. USNM 258491.

29. Ventral exterior, × 1. USGS loc. 6139–CO, upper part of the Dillsboro Formation, USNM 258492.

30. Dorsal exterior, closely packed costae and costellae, × 1. USGS loc. 6139–CO, upper part of the Dillsboro Formation. USNM 258493.

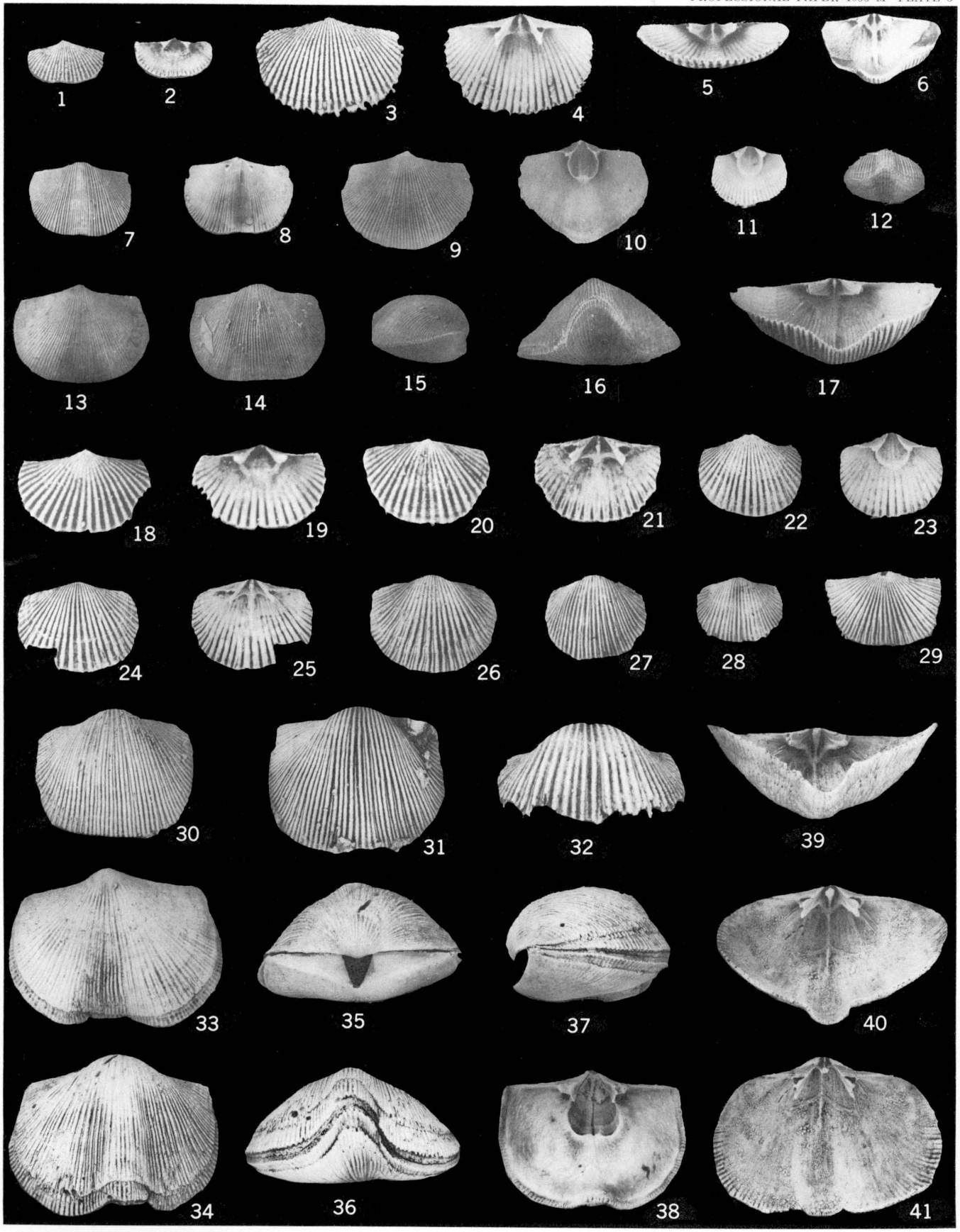
31. Dorsal exterior, × 1. USGS loc. 6139–CO, upper part of the Dillsboro Formation. USNM 258494.

32. Dorsal exterior with sulcus; anterior view; same specimen as fig. 28; × 2. USGS loc. 6139–CO, upper part of the Dillsboro Formation. USNM 258491.

33–37. Articulated specimen; ventral exterior, dorsal exterior, posterior, anterior, and lateral views, × 1. USGS loc. 4556–CO, Back Bed, Tate Member, Ashlock Formation. USNM 258496.

38. Ventral interior, × 1. USGS loc. 4556–CO, Back Bed, Tate Member, Ashlock Formation. USNM 258497.

39–41. Dorsal interior; anterior, oblique anterior, and ventral views, × 1. USGS loc. 4556–CO, Back Bed, Tate Member, Ashlock Formation. USNM 258498.


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
39
33
35
37
40
34
36
38
41

HEBERTELLA