THE HELDERBERG GROUP OF PARTS OF WEST VIRGINIA AND VIRGINIA

By FRANK MCKIM SWARTZ[1]

INTRODUCTION

Although 90 years has elapsed since W. B. Rogers [2] first described the Paleozoic rocks of the Virginias, our knowledge of the more exact stratigraphic and paleontologic features of these beds is still relatively meager, at least when compared with the more extensive data gathered concerning the equivalent strata in the States to the north. The geologists concerned in the preparation of the folios of the Geologic Atlas covering this region [3] and of the State publications [4] have not, on the whole, been permitted time to make very detailed studies of these phases of their problems.

The present report is based on work done in the field during the summers of 1924 and 1925. Much of the laboratory work was completed and the report was originally written by the end of 1925. Several subsequent visits to Virginia have made possible some additions to the original manuscript; particularly with respect to the area south of the New River, which was visited with Charles K. Swartz during the summers of 1926, 1927, and 1928, in connection with a study of the Silurian deposits of that area.

The investigation was limited to a study of the development, in the Virginias, of the sediments that form the basal portion of the Devonian in this region and that constitute the Helderberg group, in the sense in which that term was used in the Maryland Geological Survey's report on the Lower Devonian. The strata concerned are here recognized as divisible into the Keyser, Coeymans, New Scotland, and Becraft limestones, named in ascending order. The relations of the Shriver chert have also been considered, as it seems to me probable that that formation is essentially equivalent to the Becraft limestone, at least as the Becraft is developed in Maryland and Virginia. The underlying Tonoloway limestone and the overlying Oriskany deposits were examined and roughly meas-

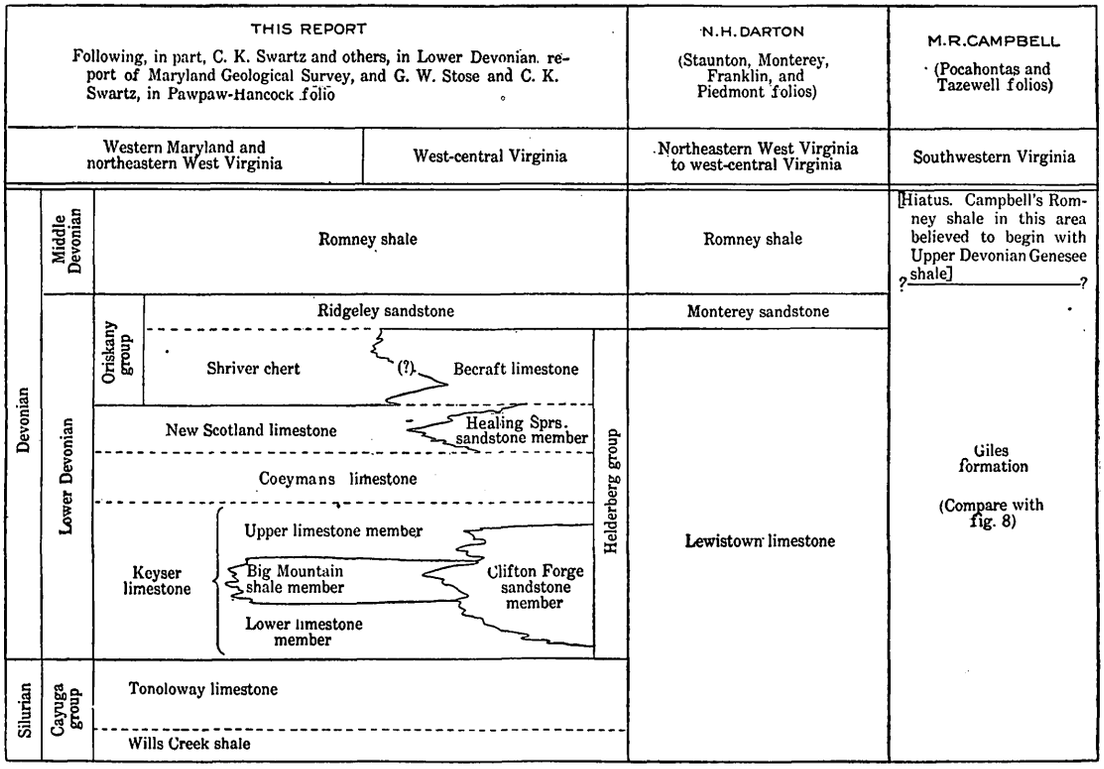

FIGURE 5.—Relations of Silurian and Devonian formations in western Maryland, northeastern West Virginia, and west-central and southwestern Virginia, as interpreted by F. M. Swartz

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[2] Rogers, W. B., Virginia State Geologist Rept. for 1837, reprint, pp. 195–203, New York, D. Appleton & Co., 1884.

[3] Darton, N. H., U. S. Geol. Survey Geol. Atlas, Folios 14, 28, 32, 61, 1895–1899. Campbell, M. R., idem, Folios 12, 26, 44, 59, 1894–1899.

[4] Virginia Geol. Survey Bull. 11A, 1909; Bull. 23, 1922. West Virginia Geol. Survey, Report on Pendleton County,

ured, as they are involved in delimiting the Helderberg in the several sections.

Figure 5 indicates the relations of the formations as I would interpret them and compares the grouping used here with that of Darton and Campbell in the folios of the Geologic Atlas.

The area covered by the investigation was of necessity limited to that in which the Helderberg group crops out. This group is brought to the surface, in the Virginias, at many points along the belt of mountain ranges lying between the Shenandoah Valley and its continuations, on the southeast, and the Allegheny Front, on the northwest. Southeast of this belt the Helderberg and even the underlying Silurian have been removed by erosion, except where they are preserved in the syncline of Massanutten and the associated mountains east of Woodstock. To the northwest the Helderberg beds pass beneath the nearly horizontal higher Devonian and Carboniferous beds, except where brought up locally, as by the Browns Mountain anticline, near Frost, W. Va. The general extent of the belt is indicated by the distribution of the sections visited, as shown in Figure 6.

After an examination of the section at Keyser, W. Va., described in the Maryland report,[5] the Helderberg strata were followed, with frequent sectioning, southward to Clifton Forge, Va., a distance of about 130 miles. Beyond this point it was difficult to obtain exposures, and no satisfactory sections were seen between the Clifton Forge area and Hollybrook, Va. Farther south sections near Wytheville, Saltville, and Big Stone Gap, Va., and Sneedsville, Tenn., were visited. At these localities the Keyser is definitely

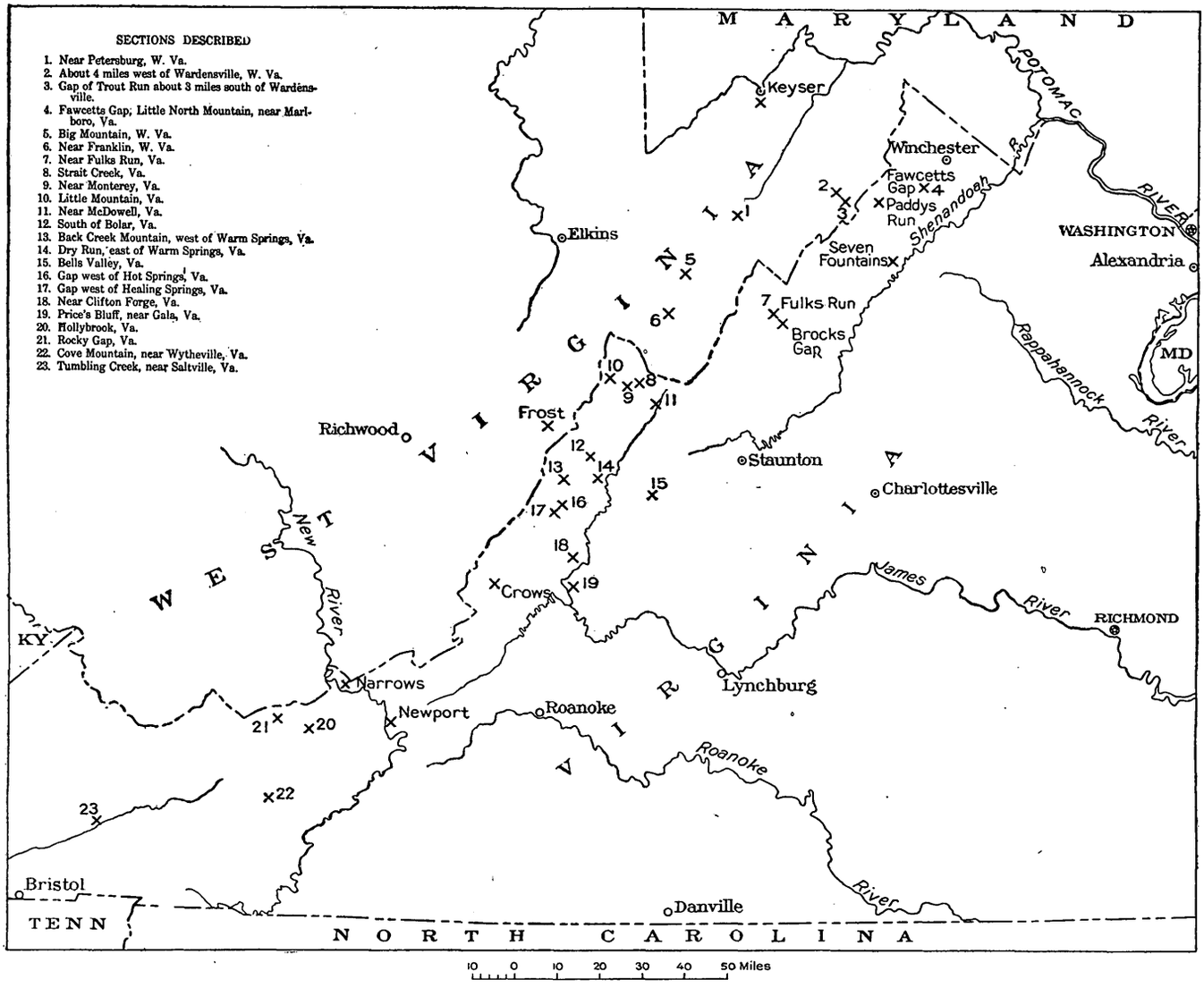

FIGURE 6.—Index map showing area in West Virginia and Virginia covered by investigation of Helderberg group

[5] Maryland Geol. Survey, Lower Devonian, p. 133, 1913.

absent, and there is some uncertainty as to the exact equivalency of the sandstones that form the basal portion of the Devonian.

KEYSER LIMESTONE

CHARACTER AND THICKNESS

At Keyser, W. Va., the type locality, the Keyser formation consists of a series of limestone beds 281 feet thick (see fig. 7), which are blue and very nodular below, more massive toward the middle, and rather shaly above. The upper portion resembles the Tonoloway somewhat in lithology and in the presence of *Tentaculites gyracanthus* and several ostracodes. The formation is underlain by the Tonoloway limestone, which is fine grained, thinly laminated, and sparingly fossiliferous—features which it was found to maintain, on the whole, at least as far south as Sneedsville, Tenn., where its lithology and fauna were identified. The Keyser is overlain by the Coeymans limestone, which is massive, crystalline, and highly crinoidal and carries characteristic fossils. This formation undergoes no essential lithologic changes as far south as Clifton Forge, Va., but its development farther south is questionable. The Keyser is thus limited, in much of the area investigated, by two well-defined formations.

At Petersburg, W. Va., the Keyser is 271 feet thick and consists of three well-defined members—an upper and a lower limestone and an intervening shale. The lower limestone is mostly heavy bedded and very nodular and aggregates 93 feet in thickness. The lowest beds, however, are somewhat shaly, and at 55 to 70 feet above the base there is a massive crinoidal and crystalline unit, overlain by a 13-foot concealed interval. The middle member is a calcareous shale, about 34 feet thick at Petersburg but thickening somewhat southward, replacing the upper beds of the underlying limestone, so that it finally rests upon the crystalline limestone noted above. This shale member is here named Big Mountain shale member, from exposures on Big Mountain, Pendleton County, W. Va. The upper limestone member carries massive and purer beds below, is more impure above, and is 144 feet thick. The three members described above are maintained southward to Warm Springs, Va.

As will be seen from Figure 7, there is little change in the thicknesses of these members, except as already noted for the shale, as far south as Bolar, Va. In the upper half of the upper limestone member there is, however, a well-marked variation from the impure phase seen at Keyser and Petersburg to a massive, purer, generally crystalline phase, well exhibited in the section west of Franklin, W. Va. The change in the character of the sediments is also reflected by changes in the fauna, including the disappearance of *Tentaculites gyracanthus* and of the ostracodes, seen at this horizon not only at Petersburg and Keyser, W. Va., but also northward through Maryland and Pennsylvania into the equivalent so-called Manlius limestone of New Jersey, which is considered by E. O. Ulrich and other geologists to be of Lower Devonian age and younger than the typical Manlius of New York; and the appearance of small varieties of *Camarotoechia altiplicata* and *Spirifer perlamellosus*, neither of which occurs below the Coeymans farther north.

Greater changes occur south of Bolar, Va. These include a marked thinning of the formation as a whole, the tonguing out of the Big Mountain shale member, the development of a heavy calcareous sandstone, seemingly equivalent to the lower half of the upper limestone member, the entire Big Mountain shale member, and the upper part of the lower limestone member. Thus in the section at Clifton Forge, Va., the lower limestone member is represented lithologically by only about 15 feet of somewhat sandy limestone, which retains the nodular character and the fauna of the lower Keyser as seen farther north; the Big Mountain shale member has disappeared as such; the bulk of the Keyser is formed by 66 feet of largely massive, unfossiliferous sandstone, here named the Clifton Forge sandstone member; and the overlying 34 feet of massive limestone seems to represent only the upper part of the upper limestone member as seen farther north.

The Keyser was not seen south of Gala, near Clifton Forge, Va. It is definitely absent in the sections near Saltville and Big Stone Gap, Va., where limestone of Tonoloway lithology and fauna was seen in contact with calcareous sandstones that are not older than the Coeymans. The Keyser is probably absent at Hollybrook and Rocky Gap also, although there are at those places concealed intervals of about 90 and 40 feet, respectively, between the exposures of the limestone of Tonoloway age and the Coeymans or younger beds. (See fig. 8.)

The Keyser also thins decidedly toward the eastern border of the belt of outcrop. Thus at Wardensville, W. Va., about 22 miles east of the Petersburg section, the entire interval between the Tonoloway and the Ridgeley sandstone is only 200 to 215 feet, as compared with 271 feet for the Keyser alone at Petersburg. The beds of the lower half of this interval are well exposed west of Wardensville, where the *Merista typa* subzone of the middle Keyser (No. 6, fig. 7) is 80 to 95 feet above the base. The higher beds are largely concealed in both of these sections, but the presence of considerable cherty material carrying some questionable New Scotland fossils, found loose about 160 feet above the base of the western section, indicates that the Keyser is possibly not over 150 feet thick here.

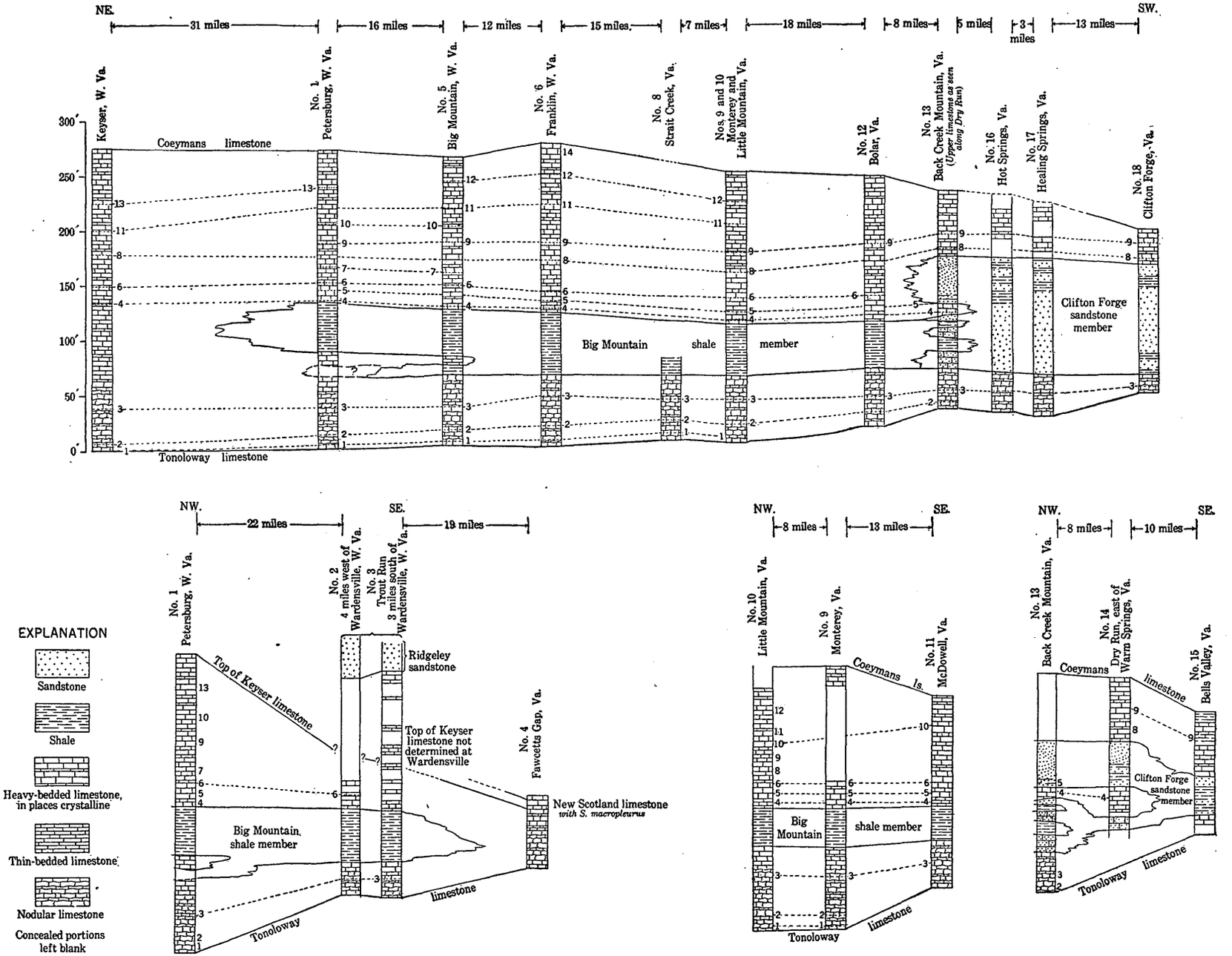

FIGURE 7.—Sections showing stratigraphy and faunal zones of the Keyser limestone from Keyser, W. Va., to Clifton Forge, Va., as interpreted by F. M. Swartz. Numbers at right of sections indicate the faunal zones and subzones. For forms characteristic of the faunal zones and subzones see table on page 32. (Section at Keyser, W. Va., after description in Maryland Geol. Survey, Lower Devonian, pp. 133–136, 1913)

The Keyser is comparatively thin throughout the mountains bordering the west side of the Shenandoah Valley, as far south as Bells Valley, Va. Thus at Fawcetts Gap, in Little North Mountain, about 8 miles southwest of Winchester, Va., the Keyser is only about 50 feet thick and is overlain by a massive limestone carrying *Spirifer macropleurus*, *Dalmanella perelegans*, and other New Scotland fossils. In this section the Keyser is composed entirely of limestones, which are chiefly nodular in the middle and lower portions. Fossils are rare. The Keyser can also be seen at Paddys Run, Va., where the lower beds carry *Chonetes jerseyensis* and *Uncinulus convexorus*. As the upper limits of the Keyser were not determined here, its thickness is uncertain. At Fulks Run, Va., the Keyser seems to be about 160 feet thick and is overlain by the New Scotland containing *Spirifer macropleurus*. *Merista typa* occurs in the middle of the Keyser at this locality, and *Chonetes jerseyensis* was observed near the base. The Big Mountain shale member is present at this locality, below the *Merista typa* zone. There is a concealed interval below the New Scotland, which may be occupied in part by the Coeymans, so that the exact thickness of the Keyser is uncertain, although it is in the neighborhood of 160 feet. The lower part of the Keyser was also seen at Brocks Gap, near by.

At Bells Valley, Va., east of the Warm Springs sections, the Keyser has a possible maximum thickness of 141 feet, of which the lower 34 feet is concealed and may belong with the Tonoloway. Fossils are rare here also, and those seen are of little aid in correlation. The sandstone and shale of the lower half of the formation are roughly equivalent to the Big Mountain shale and Clifton Forge sandstone members and, like the ripple-marked shale developed at the top of the Keyser, are indicative of shore conditions.

The most easterly occurrence of the Lower Devonian in the Virginias is found in the Massanutten Mountain syncline, where the upper Silurian and Lower Devonian limestones are well exposed in the vicinity of Seven Fountains, Va. The lower portions of these limestones are definitely of Wills Creek and Tonoloway age, but the relations of the upper portion are uncertain. Fossils are scarce, and the distinctive forms of the Helderberg of the more westerly sections are absent,

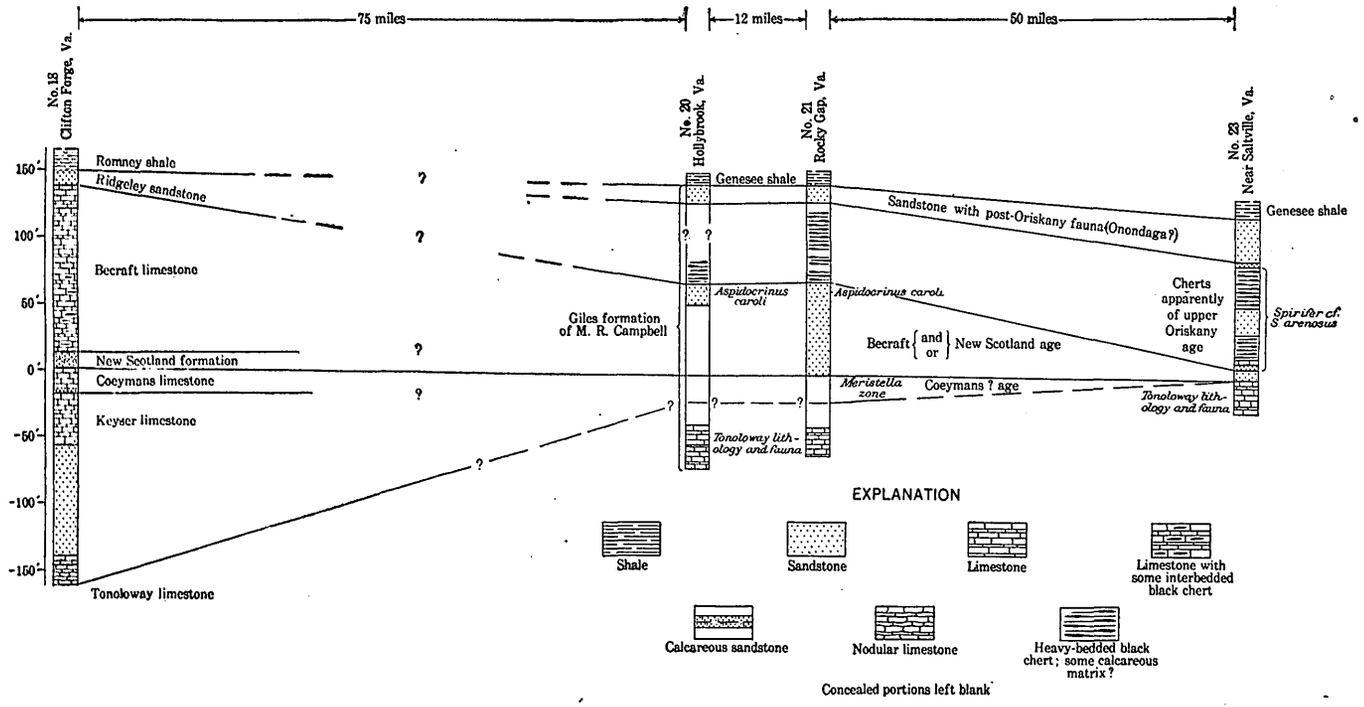

FIGURE 8.—Sections showing stratigraphy of the Helderberg group from Clifton Forge to Saltville, Va., as interpreted by F. M. Swartz. The limestone of Tonoloway age, the conglomerate of Helderberg age, the cherts of Oriskany (?) age, and the greenish post-Oriskany sandstone as seen at Hollybrook, Va., constitute what M. R. Campbell termed the Giles formation in folios of the Geologic Atlas

although lithologically these upper beds suggest the Helderberg rather than the Tonoloway. The Oriskany is apparently absent in this area. Further work will be required in this district before exact correlation can be attempted.

FAUNA

On the whole, the Keyser is abundantly fossiliferous, in the Virginias as in Maryland. A list of the fauna occurring in the Virginias will be found in the table on pages 35–37.

One of the most interesting features of the Keyser is the development of a considerable number of marked faunal zones, which can be traced for many miles. In this region, as in Maryland and Pennsylvania, two main zones can be recognized. The lower one is characterized by an abundance of *Chonetes jerseyensis*; the

upper one lacks that form and in the Maryland report was termed the *Favosites helderbergiae* zone, because of the abundance of the variety *praecedens* which it contains. Fourteen subzones, based on species of more restricted vertical range, can be recognized in the Virginias. Figure 7 and Table 1 show the occurrence of the subzones in the sections studied and their relations to the subzones established for Maryland and Pennsylvania.

TABLE 1.—*Faunal zones and subzones of the Keyser limestone*

Pennsylvania	Maryland	West Virginia-Virginia
Favosites helderbergiae var. praecedens zone		
17. *Leperditia* subzone.	14. *Leperditia* subzone. 13. *Stromatopora* reef.	14. *Spirifer vanuxemi* var. *prognosticus* and *Whitfieldella prosseri* subzone. 13. *Tentaculites* subzone. 12. *Camarotoechia* cf. *C. altiplicata* and *Nucleospira ventricosa* subzone.
16. *Tentaculites* subzone. 15. *Stromatopora* reef. 14. *Rensselaeria mutabilis* subzone.	12. *Tentaculites* subzone. 11. Lower *Stromatopora* reef. 10. *Rensselaeria mutabilis* subzone.	11. *Rensselacria mutabilis* subzone.
13. *Pholidops ovata* subzone. 12. Lower *Leperditia* subzone. 11. Coral subzone B. 10. *Spirifer vanuxemi* var. subzone.	9. Keyser coral reef.	10. *Meristella praenuntia* subzone. 9. Petersburg *Stromatopora* reef. 8. Coral subzone, with *Cladopora rectilineata*.
Chonetes jerseyensis zone		
9. *Calymene camerata* subzone. 8. Bryozoan subzone.	8. Bryozoan subzone.	7. Bryozoan subzone. 6. *Merista typa* subzone. 5. *Camarotoechia gigantea* subzone.
7. *Gypidula coeymanensis* var. subzone.	7. *Gypidula coeymanensis* var. subzone.	4. *Gypidula coeymanensis* var. subzone.
6. *Dalmanella clarki* subzone. 5. *Spirifer modestus* subzone. 4. *Stromatopora* subzone. 3. Coral subzone A.	6. Cystid-*Spirifer* subzone. 5. Rawlings *Stromatopora* reef. 4. *Cladopora rectilineata* subzone.	3. *Stenochisma deckerensis*, *Spirifer modestus*, *Uncinulus convexorus*, and *Nucleospira swartzi* subzone.
2. *Rhynchospira* subzone.	2, 3. *Rhynchospira* subzones.	2. *Cyphotrypa corrugata* and *Stropheodonta bipartita* subzones (with *Rhynchospira globosa*?).
1. *Camarotoechia lamellata* subzone.	1. Warrior Mountain coral reef.	1. *Whitfieldella minuta* subzone.

1. *Whitfieldella minuta* subzone: In the somewhat shaly beds that occur at the base of the lower limestone member in a number of the sections, *Whitfieldella minuta* and *Camarotoechia litchfieldensis* occur in considerable abundance. *Whitfieldella minuta*, which occurs at the base of the Keyser at Keyser, W. Va., the type locality of the formation, seems to be restricted to this horizon. Chaetetoid Bryozoa are also prominent; and at this horizon at Petersburg were found some favositid corals, which suggest equivalency with the coral subzone at the base of the Keyser at Warrior Mountain, Md.

2. *Cyphotrypa corrugata*, etc., subzone: In the lower part of the Keyser *Cyphotrypa corrugata* and *Stropheodonta bipartita* have a nearly equivalent range, occurring not only in the *Whitfieldella minuta* subzone but continuing well up to the middle of the lower limestone member and overlapping the range of the species noted in the succeeding subzone. Both of these fossils are common but are rarely profuse. Some poorly preserved material found just above the *Whitfieldella minuta* subzone has been referred with some doubt to *Rhynchospira globosa* and suggests that this is essentially the horizon of the *Rhynchospira* zones noted farther north.

3. *Stenochisma deckerensis*, *Uncinulus convexorus*, etc., subzone: The nodular limestones of the lower limestone member of the Keyser contain a fauna which seems to be essentially a unit, although it is subject to facies development. Thus in the more shaly portions of the nodular limestone in the Petersburg, Big Mountain, Monterey, and Little Mountain sections *Stenochisma deckerensis* and *Uncinulus convexorus* occur in profusion, with an abundance of *Atrypa reticularis* and *Chonetes jerseyensis; Spirifer modestus*, *S. modestus* var. *plicatus*, and *Nucleospira swartzi* are rare in these beds at Petersburg and Monterey, although they are common to abundant at Big Mountain and Little Mountain. In the Strait Creek section this nodular limestone is highly argillaceous and contains an abundance of *Spirifer modestus*, *S. modestus* var. *plicatus*, *Atrypa reticularis*, *Chonetes jerseyensis*, *Nucleospira swartzi*, and *Dalmanella concinna*, but *Stenochisma deckerensis* and *Uncinulus convexorus* are comparatively rare, although the horizon seems to be exactly that at which these two species are abundant in the sections first mentioned. At Franklin, W. Va., and McDowell, Bolar, and Warm Springs, Va., the equivalent beds are more massive, the nodular character being less conspicuous

or even lacking, and although most of the above-named fossils were found, they occur much more sparingly. *Stenochisma deckerensis, Uncinulus convexorus, Chonetes jerseyensis,* and *Nucleospira swartzi* were also found in the thinning, still nodular remnant of the lower limestone member of the Keyser at Clifton Forge. *Uncinulus convexorus* is extraordinarily profuse in this limestone in the section south of Wardensville, where the other forms are rare or lacking. It should be noted that this is one of the two horizons in the Helderberg group at which *Atrypa reticularis* is abundant; the other one occurs at and above the *Gypidula* zone of the middle Keyser. Similar zones of abundance of *Atrypa reticularis* seem to be present in the Keyser of Maryland. It would be interesting to know what conditions permitted this species to flourish during the times represented by these two horizons, and what changes caused it to be practically excluded from the Maryland-Virginia area during the remainder of Keyser time. The *Stenochisma deckerensis,* etc., subzone is of considerable importance as a guide zone, because it is usually well developed in the sections from Maryland to Clifton Forge, Va., and can, indeed, be traced through Maryland into central Pennsylvania. *Stenochisma deckerensis, Uncinulus convexorus, Spirifer modestus,* and *Nucleospira swartzi* all seem to be restricted to these nodular limestones of the lower Keyser. There is, however, a very similar nodular limestone at about the middle of the underlying Tonoloway in the vicinity of Monterey, McDowell, and Bells Valley, Va., and this bed also contains an abundance of *Atrypa reticularis* and an *Uncinulus* that differs from *U. convexorus* only in its slightly finer ribbing. Owing to this lithologic and faunal resemblance these nodular beds might be confused, but the Tonoloway zone can readily be distinguished by an investigation of the stratigraphic succession, as well as by the absence of other fossils characteristic of the lower Keyser.

4. *Gypidula coeymanensis* var. subzone: One of the most striking faunal zones of the Keyser is that at about the middle of the formation, characterized by a *Gypidula* forerunning the *G. coeymanensis* of the over-lying Coeymans limestone. The zone can be traced from central Pennsylvania to Warm Springs, Va., and seems to occupy everywhere the same stratigraphic position; moreover, the fossil is both very abundant and greatly restricted in vertical range. The ventral valve tends to stand out on weathered surfaces and is readily recognized. The zone disappears south of Warm Springs, owing to the introduction of the shore conditions represented by the Clifton Forge sandstone member.

In Maryland and Pennsylvania the Gypidulas of this zone have been referred to the variety *prognosticus,* the separation resting largely upon the smaller size. In the Virginias, particularly in the vicinity of Monterey, the individuals of this horizon become larger, some reaching lengths of 35 millimeters, and can hardly be differentiated from the Coeymans material. However, in view of some differences in the plications, I have referred these large specimens to the new variety *similis.*

5. *Camarotoechia gigantea* subzone: The species *Camarotoechia gigantea,* which fails to the north, being relatively rare even in Maryland, has a profuse but stratigraphically restricted development in the Virginias, occurring only in and a few feet above the *Gypidula* zone, from Petersburg, W. Va., to Warm Springs, Va. This horizon is also that of the higher of the two zones in which *Atrypa reticularis* is abundant, as noted in the description of the *Stenochisma deckerensis* zone. *Atrypa reticularis,* however, ranges somewhat higher than *Camarotoechia gigantea.*

6. *Merista typa* subzone: *Merista typa* occurs 5 to 10 feet above the *Gypidula* zone in the Petersburg section, but ranges downward and mingles with both *C. gigantea* and *G. coeymanensis* farther south. It also occurs at this horizon in several of the sections of Maryland and Pennsylvania. The zone was not found south of Bolar, Va. *Chonetes jerseyensis* is of common occurrence at this horizon.

7. Bryozoan subzone: Above the *Merista typa* subzone in the Petersburg and Big Mountain sections was noted a bryozoan subzone, which would seem to correspond with that occurring near the top of the *Chonetes jerseyensis* zone in Maryland and Pennsylvania. No specific determinations were made, however, and the correlation is open to some question.

8. Coral subzone, with *Cladopora rectilineata:* In the section at Franklin, W. Va., *Cladopora rectilineata* occurs in profusion some distance above the *Merista typa* subzone, thus paralleling the occurrence noted by Reeside in Pennsylvania, at about the same horizon. This zone was also seen at Monterey and Little Mountain, Va. At Little Mountain *C. rectilineata* is accompanied by an abundance of *Aulopora schohariae, Striatopora bella,* and a number of other corals. *Cladopora rectilineata* is also abundant in the upper limestone member of the Keyser in the Clifton Forge and Gala sections. It is impossible to say whether this occurrence should be correlated exactly with that in the Franklin-Monterey area. In Maryland *C. rectilineata* seems to be restricted to the lower part of the Keyser, but it occurs in both the lower and upper parts in Pennsylvania.

9. Petersburg *Stromatopora* reef: The *Stromatopora* reef that is developed at about the middle of the upper limestone member of the Keyser in the Petersburg section seems to be paralleled by similar occurrences in most of the other sections southward to Bolar, Va. The reefs in the upper limestones of the Bells Valley and Clifton Forge sections may also be placed here tentatively, but the exact correlation can not be regarded as certain. The presence of *Rensselaeria mutabilis* above this reef in the Big Mountain, Franklin, and Little Mountain sections indicates that this reef

is below the lower of the two reefs noted at Corriganville, in the Maryland area, which lies above the *R. mutabilis* zone.

10. *Meristella praenuntia* subzone: The work done in Maryland has shown that *Meristella praenuntia* ranges through a considerable distance, stratigraphically, in the upper part of the Keyser of that State. In the Virginias, however, it was found only between the *Stromatopora* reef described above and the overlying *Rensselaeria mutabilis* subzone. As it occurs at this horizon in considerable abundance and in a number of the sections, it will be assigned to this zonal position, for the Virginias.

11. *Rensselaeria mutabilis* subzone: *Rensselaeria mutabilis* has been shown to have a very definite stratigraphic position in the upper part of the Keyser of Maryland and Pennsylvania, and it occurs at the same horizon in the Big Mountain, Franklin, and Little Mountain sections.

12. *Camarotoechia* cf. *C. altiplicata* and *Nucleospira ventricosa* subzone: With the change from the more shaly limestones of the upper part of the Keyser of Maryland to the purer and more massive beds that are developed at that horizon around Franklin and to the south, *Camarotoechia altiplicata* and *Nucleospira ventricosa*, both of which are present in the Coeymans and New Scotland, range downward into the upper part of the Keyser, where they occur in and above the *Rensselaeria mutabilis* subzone. Although common and rather persistent, the species are rarely abundant. The zone is also occupied commonly by *Schuchertella prolifica*, several species of bryozoans, and some corals. Other forms are of rare occurrence. The Camarotoechias here referred to *C. altiplicata* are somewhat smaller than the typical material but are otherwise similar.

13. *Tentaculites gyracanthus* subzone: The *Tentaculites* subzone that is so characteristic of the upper part of the Keyser in Pennsylvania and Maryland was observed in the Virginias only in the section at Petersburg, W. Va., although it was searched for carefully elsewhere. Its disappearance to the south is concomitant with the development of the more massive and purer limestones of the upper limestone member.

14. *Spirifer vanuxemi* var. *prognosticus* subzone: *Spirifer vanuxemi* var. *prognosticus* occurs in abundance in a zone at the very top of the Keyser in the section at Franklin, W. Va., together with *Whitfieldella prosseri* and *Schuchertella prolifica*. As its appearance at this horizon seems to correspond to its occurrence in Maryland [6] it is noted here as marking a faunal subzone. Although no similar occurrence was observed elsewhere in the Virginias, the subzone is of interest, because it perhaps represents a higher horizon in the Keyser than is found in most of the sections. This conclusion is also suggested by the exceptional thickness of the upper limestone member of the Keyser, which is greater in the Franklin section than in the other sections studied. The absence of the zone elsewhere might be due to the presence of the minor hiatus that has generally been thought to mark the Keyser-Coeymans contact.

Kloedenia smocki, the one ostracode found in the Keyser in the Virginias, was discovered about 30 feet beneath the top of the Keyser in the Big Mountain section. Its presence there is of interest in that the horizon seems to correspond to the so-called Manlius of the New Jersey section, from which *K. smocki* was originally described by Weller.

A complete list of the Keyser fauna is given in the following table:

[6] Maryland Geol. Survey, Lower Devonian, p. 404, 1913.

TABLE 2.—*Distribution of the fauna of the Keyser limestone of West Virginia and Virginia*

[Note.—"r" represents a very closely related species]

	West Virginia-Virginia				Maryland-Pennsylvania				New Jersey				Eastern New York				Western New York		
	Keyser limestone					Keyser limestone													
	Chonetes jerseyensis zone																		
	Lower limestone and Big Mountain shale members	Base of upper limestone member	Favosites zone	Coeymans to Becraft limestones	Tonoloway limestone	Chonetes jerseyensis zone	Favosites zone	Coeymans to Becraft limestones	Decker limestone	Rondout limestone	So-called Manlius limestone	Coeymans to Becraft limestones	Cobleskill limestone	Rondout limestone	So-called Manlius limestone	Coeymans to Becraft limestones	Cobleskill limestone	Rondout limestone	Manlius limestone
COELENTERATA																			
1. Cyathophyllum radiculum Rominger			X				X												
2. Striatopora bella C. K. Swartz			X					X											
3. Favosites cf. F. helderbergiae var. praecedens Schuchert			X				X												
4. Cladopora rectilineata Simpson			X			X	X		X				X						
5. Aulopora schohariae Hall			X				X	X								X			
6. Aulopora schucherti C. K. Swartz			X			X	?	X											
7. Stromatoporoidea undetermined			X	a															
Favosites zone			6			2	5	3	1				1			1			
ECHINODERMATA																			
8. Jaekelocystis hartleyi Schuchert	X					X													
9. Mariacrinus sp			X																
Lower Keyser	1					1													
Favosites zone			1																
BRYOZOA																			
10. Cyphotrypa corrugata (Weller)	X					X			X										
11. Orthopora rhombifera (Hall)	X					X	X	X								X			
12. Bryozoa undetermined	X		X																
Lower Keyser	2					2	1	1	1							1			
BRACHIOPODA																			
13. Dalmanella concinna (Hall)	X		X			X	X												
14. Rhipidomella emarginata (Hall)	X					X													
15. Leptaena rhomboidalis (Wilckens)	X	X	X	X		X	X	X	X			X	X			X	X		
16. Stropheodonta bipartita (Hall)	X				X	X			X				X				X		
17. Stropheodonta cf. S. planulata (Hall)		X		X				X								X			
18. Strophonella keyserensis C. K. Swartz		X				X													
19. Schuchertella deckerensis (Weller)	X					X			X										
20. Schuchertella sinuata (Hall and Clarke)	X					X													

TABLE 2.—*Distribution of the fauna of the Keyser limestone of West Virginia and Virginia*—Continued

	West Virginia-Virginia				Maryland-Pennsylvania				New Jersey				Eastern New York				Western New York		
	Keyser limestone					Keyser limestone													
	Chonetes jerseyensis zone																		
	Lower limestone and Big Mountain shale members	Base of upper limestone member	Favosites zone	Coeymans to Becraft limestones	Tonoloway limestone	Chonetes jerseyensis zone	Favosites zone	Coeymans to Becraft limestones	Decker limestone	Rondout limestone	So-called Manlius limestone	Coeymans to Becraft limestones	Cobleskill limestone	Rondout limestone	So-called Manlius limestone	Coeymans to Becraft limestones	Cobleskill limestone	Rondout limestone	Manlius limestone
BRACHIOPODA—continued																			
21. Schuchertella prolifica Schuchert		X	X				X												
22. Chonetes jerseyensis Weller	X	X				X			X				X				X		
23. Gypidula coeymanensis var. prognostica Maynard		X				X													
24. Gypidula coeymanensis var. similis F. M. Swartz, n. var		X		r		r		r				r				r			
25. Stenochisma deckerensis (Weller)	X					X			X										
26. Camarotoechia litchfieldensis (Schuchert)	X				X	X													
27. Camarotoechia gigantea Maynard		X				X													
28. Camarotoechia gigantea var. gigas F. M. Swartz, n. var		X																	
29. Camarotoechia cf. C. altiplicata (Hall)			X					X								X			
30. Uncinulus convexorus Maynard	X					X													
31. Uncinulus gordoni Maynard			X			X	X	?											
32. Uncinulus nucleolatus (Hall)			X			X	X					X				X			
33. Uncinulus angulatus Maynard			X			X													
34. Rensselaeria mutabilis (Hall)			X				X	X								X			
35. Atrypa reticularis (Linné)	X	X				X		X	X			X	X			X	X		
36. Spirifer modestus Hall	X					X													
37. Spirifer modestus var. plicatus Maynard	X					X													
38. Spirifer octocostatus (Hall)	X					X										X			
39. Spirifer vanuxemi var. prognosticus Schuchert			X			X	X												
40. Spirifer perlamellosus var. praenuntius F. M. Swartz, n. var			X																
41. Cyrtina dalmani (Hall)			X													X			
42. Rhynchospira globosa (Hall)	X				X	X		X								X			
43. Rhynchospira formosa (Hall)	X					X			X			X				X			
44. Nucleospira swartzi Maynard	X					X													
45. Nucleospira ventricosa (Hall)			X			?	?	X				X				X			
46. Whitfieldella minuta Maynard	X					X													
47. Whitfieldella? prosseri Grabau			X				X												
48. Meristella praenuntia Schuchert and Maynard			X				X												
49. Meristella nasutaformis F. M. Swartz, n. sp			X																
50. Merista typa (Hall)		X				X													
Lower limestone and Big Mountain shale [a]	16	1	1		3	16	1	1	5			1	2			1	2		
Base of upper limestone [a]	1	9	1	2		6	1	2	1			1	1			2			
Favosites zone [a]	1	1	14	1		5	8	6				2				5			

MOLLUSCA																			
51. Actinopteria cf. A. reticulata Weller			×			×			×										
52. Cypricardinia lamellosa Hall		×				×										×			
53. Straparollus welleri F. M. Swartz, n. name	×								×										
54. Tentaculites gyracanthus (Eaton)			×		×	×	×				×				×				×
55. Orthoceras cf. O. rigidum Hall	×						×									×			
Lower Keyser	2	1				1	1		1							2			
Favosites zone			2		1	2	2		1		1				1				1
ARTHROPODA																			
56. Proetus protuberans Hall	×					×		×				×				×			
57. Calymene camerata Conrad	×				×	×			×				×				×		
58. Kloedenia smocki (Weller)			×								×								
Lower Keyser	2				1	2		1	1			1	1			1	1		
Favosites zone			1								1								

[a] Atrypa reticularis and Leptaena rhomboidalis are excluded from this analysis.

CORRELATION

The essential continuity of the Keyser as a more or less definite lithologic unit from Maryland southward to Clifton Forge, Va., has already been demonstrated. The continuation of the series of faunal subzones, as shown in Figure 7 and Table 1, into the Keyser of Maryland and Pennsylvania is of even greater importance in the more exact correlation in time of the several horizons at which these subzones occur. The relationships of the fauna as a whole are given in Table 2 and the following analysis. *Atrypa reticularis* and *Leptaena rhomboidalis* are excluded from this and other analyses in this paper, because of their great stratigraphic range.

		Per cent
Species occurring in the Keyser limestone of West Virginia and Virginia	54	100
Previously described	49	91
Occurring in the Keyser of Maryland and Pennsylvania	43	82
Restricted to the Keyser in Maryland and Pennsylvania	27	54
Occurring in the Decker limestone to so-called Manlius limestone of New Jersey	14	27
Occurring in the Tonoloway limestone of Maryland	6	12
Occurring in the Coeymans to Becraft limestone of Maryland, etc	16	32
Occurring in the Coeymans to Becraft limestone of Maryland, etc., but not in the Keyser of Maryland	4	8
Forms very closely related to species occurring in the Coeymans to Becraft limestones of Maryland, etc., but without counterpart in the Keyser of Maryland	1	2

The large number of species common to the Keyser of the Virginias and that of Maryland and Pennsylvania and particularly the fact that the same species are generally the abundant ones in both areas indicate that the two areas were parts of one and the same depositional basin during Keyser time. The faunal zones recognized in these districts, as compared in Table 1, also show that the upper and lower limits of the Keyser are essentially of the same age from central Pennsylvania to west-central Virginia.

Ulrich,[7] C. K. Swartz,[8] and Reeside [9] have concluded that the interval from the Decker to the so-called Manlius of the New Jersey section, as described by Weller,[10] is the essential equivalent of the Keyser of the central Appalachian area. There is some uncertainty, at least in the minds of Swartz and Reeside, as to the relationships of the Keyser and also of the Decker, Rondout, and so-called Manlius of New Jersey to the Cobleskill, Rondout, and Manlius of New York. For further discussion the reader is referred to the Maryland Lower Devonian report.

[7] Ulrich, E. O., U. S. Geol. Survey Geol. Atlas, Pawpaw-Hancock folio (No. 179), p. 8 (notes on lowest and second faunal zones of the Helderberg limestone), 1912.

[8] Swartz, C. K., Maryland Geol. Survey, Lower Devonian, pp. 105–117, 1913.

[9] Reeside, J. B., jr., The Helderberg limestone of central Pennsylvania: U. S. Geol. Survey Prof. Paper 108, pp. 193–197, 1917.

[10] Weller, Stuart, Paleontology of New Jersey, vol. 3, pp. 62–80, 1903.

An interesting point in the comparison of the Keyser and the New Jersey formations, seemingly unnoted before, is the similarity in position of the *Gypidula coeymanensis* var. *prognostica* subzone of the middle Keyser, and the *Gypidula* (*"Pentamerus"*) *circularis* zone in the Decker. Both zones are near the top of the range of *Chonetes jerseyensis* in their respective sections. The general variability of the Gypidulas of the middle Keyser has been noted; in the Virginias they are large and comparable in size, at least, to the typical material; at the same horizon in Maryland and Pennsylvania the Gypidulas have been separated as the variety *prognostica*, chiefly because of their smaller size. With these facts in mind it seems possible, if not probable, that the *Gypidula circularis* of the Decker is the stunted counterpart of the Gypidulas of the Middle Keyser to the southwest. Evidence suggesting less favorable environment to the north is found in the changes going on in the fauna as a whole, which led Reeside [11] to conclude that the Keyser of Maryland, Pennsylvania, and New Jersey was "laid down in a basin which was connected with the open sea in the Maryland region and was progressively restricted northward and eastward to New Jersey."

Dunbar [12] has recently shown that the basal Devonian beds of western Tennessee, composed of the Rockhouse shale and the lower portion of the overlying Olive Hill formation, are perhaps of Keyser age. This view is suggested because the faunas of the Olive Hill, as a whole, and of the succeeding Birdsong shale are very definitely Coeymans and New Scotland, respectively, whereas there is no indication of a break of any magnitude between the Rockhouse and the Olive Hill which might make the former pre-Keyser. The fauna of the Rockhouse is too poor to give direct evidence of the age of the formation. It is an interesting hypothesis that the deposition of the Rockhouse shale resulted from the same crustal movements that caused the Virginia area to be flooded by sand and mud during the deposition of the Clifton Forge sandstone and Big Mountain shale members of the Keyser. The generally clearer water deposits of the Olive Hill might then be equivalent to both the upper Keyser and Coeymans limestones of the Virginias.

COEYMANS LIMESTONE

CHARACTER AND THICKNESS

The Coeymans of West Virginia and Virginia (see fig. 9) is in general a well-defined lithologic unit, consisting, as in Maryland, of very massive, crystalline, highly crinoidal limestone as far south as Clifton Forge, Va. It is separated from the underlying Keyser by a fairly sharp contact, the basal portion of the Coeymans

[11] Reeside, J. B., jr., op. cit., p. 204.

[12] Dunbar, C. O., Stratigraphy and correlation of the Devonian of western Tennessee: Tennessee Geol. Survey Bull. 21, pp. 40–42, 54, 1919.

being somewhat sandy, particularly toward the south. The passage into the overlying New Scotland is transitional where that formation is a cherty limestone; but south of Monterey, where at least the lower portion of the New Scotland is highly arenaceous, the contact as here drawn becomes clear cut. At Bells Valley, Va., however, the New Scotland and Coeymans combine to form a massive limestone, which is highly crinoidal throughout, with diagnostic New Scotland fossils, including *Spirifer macropleurus*, restricted to the upper 20 feet. Only 4 miles to the north, along the same line of outcrop, at Craigsville, the *Spirifer macropleurus* zone is again cherty.

At Fawcetts Gap, in Little North Mountain, near Winchester, Va., the Coeymans is possibly absent. were observed in some weathered cherty fragments in the otherwise concealed interval just beneath the supposedly New Scotland sandstones; and this zone is possibly equivalent to the *Meristella arcuata* zone at the top of the Coeymans in the Clifton Forge area.

FAUNA AND CORRELATION

The Coeymans is in general abundantly fossiliferous. *Gypidula coeymanensis*, the most diagnostic form of this horizon, although profuse at Petersburg, W. Va., was found only after search in the sections from Petersburg to Hot Springs, Va., and seems to be entirely absent in the Coeymans at Bells Valley, Dry Run, and Clifton Forge. The specimens from the Coeymans in the Virginias are generally smaller than

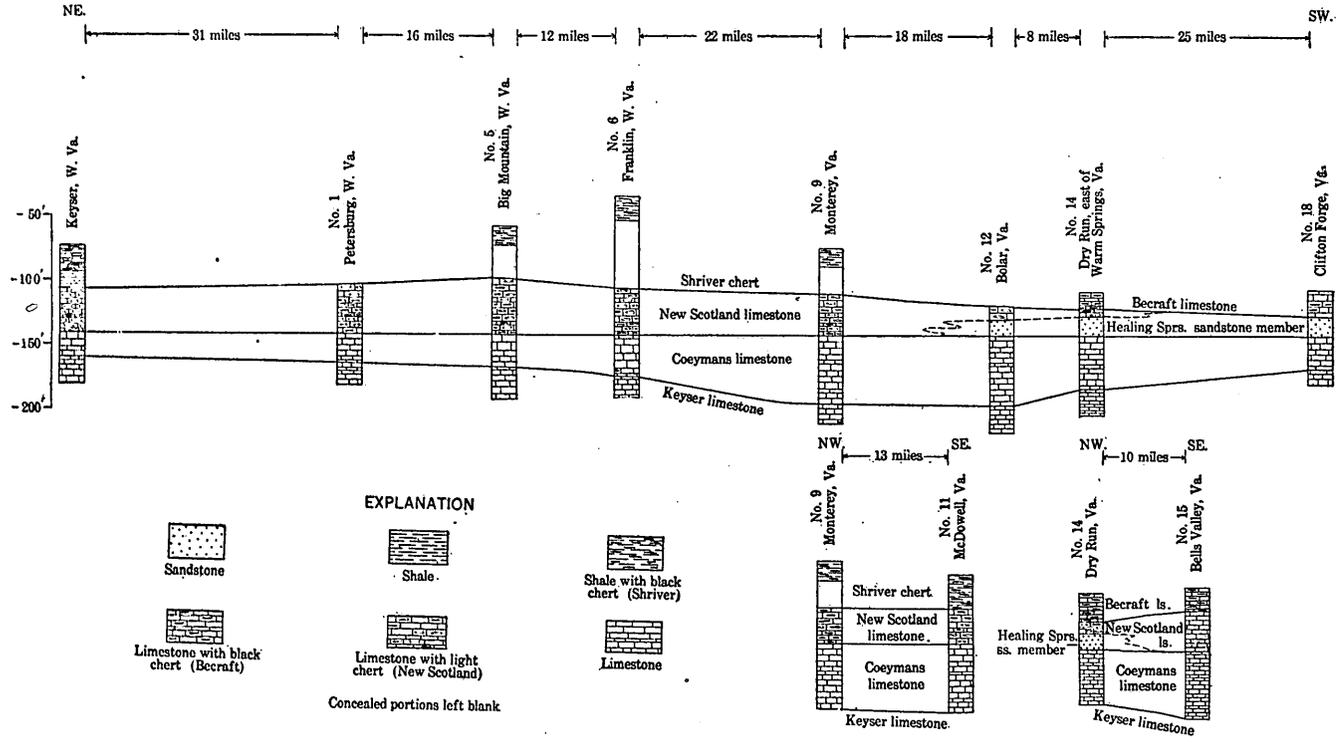

FIGURE 9.—Sections showing stratigraphy of the Coeymans and New Scotland limestones from Keyser, W. Va., to Clifton Forge, Va., as interpreted by F. M. Swartz. (Section at Keyser after description in Maryland Geol. Survey, Lower Devonian, p. 167, 1913)

At least, faunal evidence of its presence is lacking, although analogy with the Bells Valley section might suggest Coeymans age for the lower few feet of the crinoidal limestone, which in its upper portion contains *Spirifer macropleurus*. Because of concealment of the interval, no data concerning the Coeymans were available at Wardensville, W. Va., and Fulks Run, Va.

The Coeymans seems to disappear in southwestern Virginia, as the calcareous sandstones in contact with the limestone of Tonoloway age at the sections near Saltville and Big Stone Gap are most probably of New Scotland age or even younger, although the faunal evidence observed is not altogether conclusive. At Rocky Gap, however, abundant casts of *Meristella* the material from New York and New Jersey and even from Maryland. Thus in the Virginias the Gypidulas of the middle Keyser are both larger and much more abundant than those of the Coeymans itself.

A very useful zone in the Monterey-Clifton Forge area is found at the top of the Coeymans, where *Meristella arcuata* occurs in considerable abundance, together with *Rhipidomella oblata* and, less commonly, *Uncinulus abruptus*. This zone is just beneath the sandy beds placed at the base of the New Scotland in the Bolar, Dry Run, Clifton Forge, and Gala sections and beneath the range of *Spirifer macropleurus* and *Dalmanella perelegans* in the Monterey and Bells Valley sections. The occurrence of this zone about 50 feet above the base of the crinoidal

limestone in the Monterey and Bells Valley sections is one of the chief reasons for considering the lower two-thirds of that unit Coeymans in age, rather than referring the whole of it to the New Scotland.

The following analysis shows the general relationships of the fauna; details of distribution are given in Table 3.

		Per cent
Species occurring in the Coeymans limestone of West Virginia and Virginia	18	100
Previously described	16	89
Occurring in the Coeymans of Maryland, New Jersey, and New York	11	68
Occurring in the New Scotland limestone of Maryland, etc	14	87
Occurring in the New Scotland of Maryland, etc., but not reported from the Coeymans or below	4	23
Occurring in the Keyser limestone (including two closely related forms)	4	23

These figures would seem to indicate a closer relationship to the fauna of the New Scotland of the Northern States than to that of the Coeymans. That the fauna and the beds containing it are Coeymans is shown by the presence of *Gypidula coeymanensis*, the most diagnostic species of the formation, and by the absence of *Spirifer macropleurus* and other characteristic fossils of the New Scotland, which appear in the overlying beds. Again, only one of the four species not noted from the Coeymans or lower horizons farther north—namely, *Meristella arcuata*—is at all abundant, and in some of the sections in the Virginias this form ranges well down into the Coeymans, occurring with *Gypidula coeymanensis* in the Big Mountain section. Of the other three, *Platyceras gibbosum* is represented only by two specimens and should not be considered decisive; and *Uncinulus abruptus* and *Camarotoechia campbellana* occur, in the Coeymans, only in the topmost beds, in the *Meristella arcuata* zone of the Monterey-Clifton Forge area, where they are not very common. This zone is placed in the Coeymans because it is below the range of *Spirifer macropleurus* in the sections where that form occurs, and particularly because it seems most logical to draw the New Scotland-Coeymans contact at the base of the Healing Springs sandstone member in the Bolar, Dry Run, and Clifton Forge sections. The zone seems, however, to be above the range of *Gypidula coeymanensis* and might well be considered equivalent to the beds included at the base of the New Scotland in Maryland, which are below the range of *Spirifer macropleurus*. The difference in usage is, of course, a reflection of the changes in lithology in the Clifton Forge area.

The close agreements between the faunas of the Olive Hill formation and the Birdsong shale of western Tennessee and those of the Coeymans and New Scotland of the Appalachian Basin, respectively, as recently reported by Dunbar,[13] indicate an open seaway between the two areas during the time of deposition of those formations. The middle of this passageway was probably in West Virginia and Kentucky, some distance west of Clifton Forge, Hollybrook, and Big Stone Gap, as shore and land conditions seem to be indicated in these localities.

NEW SCOTLAND LIMESTONE

CHARACTER AND THICKNESS

No essential changes in lithology, fauna, or thickness were noted in the cherty phase of the New Scotland from Keyser, W. Va., to Monterey, Va. (See fig. 9.) Throughout this area the formation is a cherty limestone, generally massive, and usually well exposed. Here, as in Maryland, the cherts are always white or at least light colored, even when quite fresh. The beds immediately overlying the cherty limestone are generally concealed and covered by débris; consequently there is some uncertainty as to the extent to which the shaly phase of the upper part of the New Scotland of western Maryland, so classed because of its contained fauna, is developed in the area studied. At Monterey and to the north the upper boundary of the New Scotland has everywhere been placed at the top of the exposed cherty limestone. Whether a portion of the overlying beds should be included in the formation must remain a problem for further investigation. At McDowell, however, and where the Becraft limestone is developed, the shaly phase is definitely absent.

To the east, at Fawcetts Gap, near Winchester, Va., the New Scotland is represented by a crinoidal limestone carrying *Spirifer macropleurus*. A somewhat similar occurrence is found at Bells Valley, Va., where *S. macropleurus* and other New Scotland fossils occur in the upper 20 feet of a very massive crinoidal limestone 78 feet thick. As noted in the discussion of the Coeymans limestone, the lower 50 feet or so of this limestone is apparently of Coeymans age. At Fulks Run, about halfway between Fawcetts Gap and Bells Valley and nearly along the strike line between them, the New Scotland is again a cherty limestone; and the *Spirifer macropleurus* zone is cherty at Craigsville, only about 4 miles north of Bells Valley, and along the same belt of outcrop.

As has been stated in the description of the Keyser, it has not been found feasible to correlate definitely the supposedly Lower Devonian limestones of the Seven Fountains section, in the Massanutten Mountain syncline, with the Helderberg. At least, no beds carrying the diagnostic New Scotland or other Helderberg faunas were observed in this section, and the lithologic sequence is not sufficiently similar to that of

[13] Dunbar, C. O., op. cit., pp. 54, 62–65.

the more western sections to permit confident correlation.

South of Monterey, Va., the New Scotland becomes highly arenaceous in its lower half, as at Bolar and Dry Run, and finally the calcareous sandstone (in part arenaceous limestone) entirely replaces the cherty limestone, forming what is here named the Healing Springs sandstone member. This sandstone contains some fossils in the sections west of Healing Springs and Warm Springs, including a few fragments of *Spirifer macropleurus*, but it seems to be quite unfossiliferous at Clifton Forge and Gala.

The New Scotland may be represented in the sandstones below the dark siliceous cherty beds of the Hollybrook, Rocky Gap, and Saltville sections. As stated in the descriptions of the Coeymans, a *Meristella* zone, possibly representing the *M. arcuata* of the upper Coeymans, was found just beneath these sandstones at Rocky Gap. The overlying dark cherts are unfossiliferous at Hollybrook and Cove Mountain, where they were first studied, and I then considered them definitely representative of the Shriver chert, although that formation had been last seen just west of Covington, about 70 miles to the north. Beds of upper Oriskany or Ridgeley age were thought to be entirely absent, as the Ridgeley is only a few feet thick near Clifton Forge, and the chert in the Hollybrook and Cove Mountains area is overlain by a thin sandstone carrying an Onondaga fauna. Study of the section on Tumbling Creek, 6 miles southwest of Saltville, cast a somewhat different light upon the subject, as the apparently equivalent cherts and some associated sandstones seen there carry *Diaphorastoma ventricosum*, *Ambocoelia umbonata* and a *Spirifer* which is essentially *S. arenosus*, although it differs slightly in its general aspect from the typical material of the Ridgeley sandstone farther north. Because of the pronounced flattening of its ribs it is here named *Spirifer arenosus* var. *planicostatus*. The presence of these fossils indicates late Oriskany age for the chert and associated beds containing them and suggest relationship to the Harriman chert of western Tennessee. Other upper Oriskany species, such as *Rensselaeria marylandica* and *Spirifer murchisoni* of the Ridgeley sandstone, were not observed. Charles Butts has referred a similar but unfossiliferous chert formation occurring near Gate City, Va., to the Onondaga, as there seemed to be no adequate reason for separating it from the overlying beds that carry an Onondaga fauna. The presence of *Ambocoelia umbonata* gives something of a Middle Devonian cast to the fauna of the chert at Tumbling Creek, but it seems best to regard the chert as being of late Oriskany age, though possibly with deposition continuous into the overlying Onondaga deposits.

At the Tumbling Creek section the lowest beds containing *S. arenosus* var. *planicostatus* are underlain by about 7 feet of calcareous sandstone in which was observed a *Rhipidomella* suggestive of *R. oblata* and a large *Dalmanella* that should probably be referred to *D. perelegans*. This sandstone should probably be correlated with the Becraft limestone, or possibly with the New Scotland. It is underlain in turn by the limestone of Tonoloway age.

Comparison of the sections at Hollybrook and Rocky Gap with that at Tumbling Creek strongly suggests that the chert of the Hollybrook-Rocky Gap area should be correlated with that seen at Tumbling Creek and should thus be considered younger than the Shriver chert of the sections farther north. At Hollybrook and Rocky Gap the chert is underlain by about 60 feet of calcareous sandstone, the upper part of which is somewhat conglomeratic, and contains at both localities a profusion of the empty molds of a cuplike crinoid fossil. Charles Butts, of the United States Geological Survey, examined a specimen of the crinoid and immediately referred it to *Aspidocrinus*, suggesting comparison with *A. scutelliformis* Hall, of the New York Becraft. Edwin Kirk agreed to the generic reference but thought it was not the species mentioned. It is here named *Aspidocrinus caroli*. The lower portion of the sandstone contains a few poorly preserved fossils, including a *Spirifer* close to *S. cyclopterus*. One fragmental cast is suggestive of *Trematospira equistriata*. The sandstone may be considered roughly equivalent to the Becraft and New Scotland limestones, although the fauna is a poor one for the purpose of correlation.

The similar calcareous sandstone that forms the basal portion of the Devonian in the vicinity of Big Stone Gap has been referred to the New Scotland by Ulrich, although no faunal lists accompanied Ulrich's published section.[14] The fauna, so far as I observed it during a short visit, is not distinctively New Scotland; that of the upper beds is in fact suggestive of the Onondaga. Further work must be done before the correlation of this sandstone can be considered assured

FAUNA AND CORRELATION

North of Healing Springs, Va., the beds assigned to the New Scotland carry *Spirifer macropleurus* and other characteristic New Scotland fossils. These are only sparingly present in the Healing Springs sandstone member but are generally profuse where the New Scotland consists of the cherty limestone. *Streptelasma strictum*, *Dalmanella perelegans*, and *Meristella arcuata* are generally very abundant.

[14] Ulrich, E. O., in Eby, J. B., The geology and mineral resources of Wise County, Va.: Virginia Geol. Survey Bull. 24, p. 40, 1923.

The New Scotland age of this fauna is shown by the following relationships:

		Per cent
Species occurring in the New Scotland limestone of West Virginia and Virginia	16	100
Previously described	16	100
Occurring in the New Scotland of Maryland, New Jersey, and New York	15	94
Occurring in the Coeymans limestone of Maryland, etc	6	38
Occurring in the Becraft limestone of Maryland, etc	11	68
Occurring in the Becraft of Maryland, etc., but not in the New Scotland	1	6
Restricted to the New Scotland in Maryland, etc	4	25

Further details of the distribution of the fauna are given in Table 3.

BECRAFT LIMESTONE

CHARACTER AND THICKNESS

At Clifton Forge, Gala, Healing Springs, Dry Run, and Bells Valley, Va., the interval between the New Scotland formation and the Ridgeley sandstone is occupied by a limestone 100 to 120 feet thick, with much interbedded black chert, chiefly in the lower and middle parts. (See fig. 10.) The upper chert-free beds are also present on Back Creek Mountain, along the road from Warm Springs to Driscol. The stratigraphic position of the limestone and more particularly the presence in it of *Spirifer concinnus*, *Rhipidomella assimilis*, and certain other fossils indicate general equivalency to the Becraft limestone of southeastern New York, New Jersey, and central Maryland. This limestone is also present farther north in Virginia, where it was seen at Fawcetts Gap, near Winchester; and it has been reported to occur in the vicinity of Cherry Run, W. Va.,[15] along the same general belt of outcrop.

FAUNA AND CORRELATION

The relationships of the fauna collected from this limestone in the Clifton Forge area are given in detail in Table 3 and are summed up in the following analysis:

		Per cent
Determined species occurring in the Becraft limestone of west-central Virginia	25	100
Previously described	24	96
Occurring in the Becraft limestone of Maryland, New Jersey, and New York	18	72
Occurring in the New Scotland limestone of Maryland, etc	14	56
Occurring in the New Scotland limestone of Maryland, etc., but not in the Becraft limestone of those States	1	4
Occurring in the Ridgeley sandstone of Maryland and the Oriskany sandstone of New Jersey and New York	9	36
Occurring in the above-mentioned sandstones but not previously reported from lower beds	3	12
Occurring in the Shriver chert of Maryland	2	8
Restricted to the Becraft limestone, at least in Maryland	3	12

[15] Maryland Geol. Survey, Lower Devonian, p. 179, 1913.

The large percentage of New Scotland survivors, together with the absence of such typical New Scotland forms as *Spirifer macropleurus* and *Spirifer perlamellosus*, is in itself very characteristic of the Becraft; particularly as these characteristic New Scotland species are found in the underlying beds. Of the New Scotland survivors, *Streptelasma strictum*, *Edriocrinus pocilliformis*, and *Uncinulus abruptus* are prominent in the lower part of the Virginian Becraft but do not appear to range higher. The two specimens of *Phacops logani* were also found in these lower beds, as were the fragmental Rensselaerias referred to *R. aequiradiata*, a species of the New York Becraft. On the other hand, *Schuchertella woolworthana* ranges throughout the Becraft, as do the new arrivals, *Rhipidomella assimilis*, *Eatonia peculiaris*, and *Spirifer concinnus*.

As has been noted, the upper part of the Becraft of the Clifton Forge area differs from the lower and middle portions in that as a rule it is quite free from interbedded black chert and is in many places massive and highly crinoidal. It also carries a fauna that differs somewhat from that of the lower portions, notwithstanding the presence of the four species last named. This is due not only to the absence of those New Scotland survivors which, as mentioned above, are restricted in the Becraft to its lower portion, but also to some progressive evolution in *Rhipidomella assimilis* and *Spirifer concinnus*, as well as to the introduction of a number of forms with definite Oriskany affinities.

Thus *Rhipidomella assimilis*, although mentioned above as ranging throughout the formation, is somewhat more abundant in these upper beds and tends to reach a somewhat greater size, with stronger muscle scars, so that whereas the average size of the species is 26 millimeters in length and 28 millimeters in width, several specimens from the upper part of the Becraft at Gala and Back Creek Mountain reach dimensions of 36 and 40 millimeters, respectively; and the ventral muscle scar is as much as 22 millimeters long, as compared with 17 millimeters for the more typical material. These specimens are approaching the *R. musculosa* of the Ridgeley sandstone, which measures 37 millimeters in length and 40 millimeters in width, with a ventral muscle scar as much as 27 millimeters long.

A similar development was noted in *Spirifer concinnus*. Associated with the more typical members of that species there are commonly in these upper Becraft beds specimens which have the same general aspect but differ in the presence of 16 or more plications on the lateral slope, as compared to the typical 12 to 14, and which also reach widths of 40 millimeters, as compared to the average 24 millimeters. This larger, more alate, and more numerously plicated form is here named *Spirifer concinnus* var. *progradius* and is thought to have developed out of earlier members of

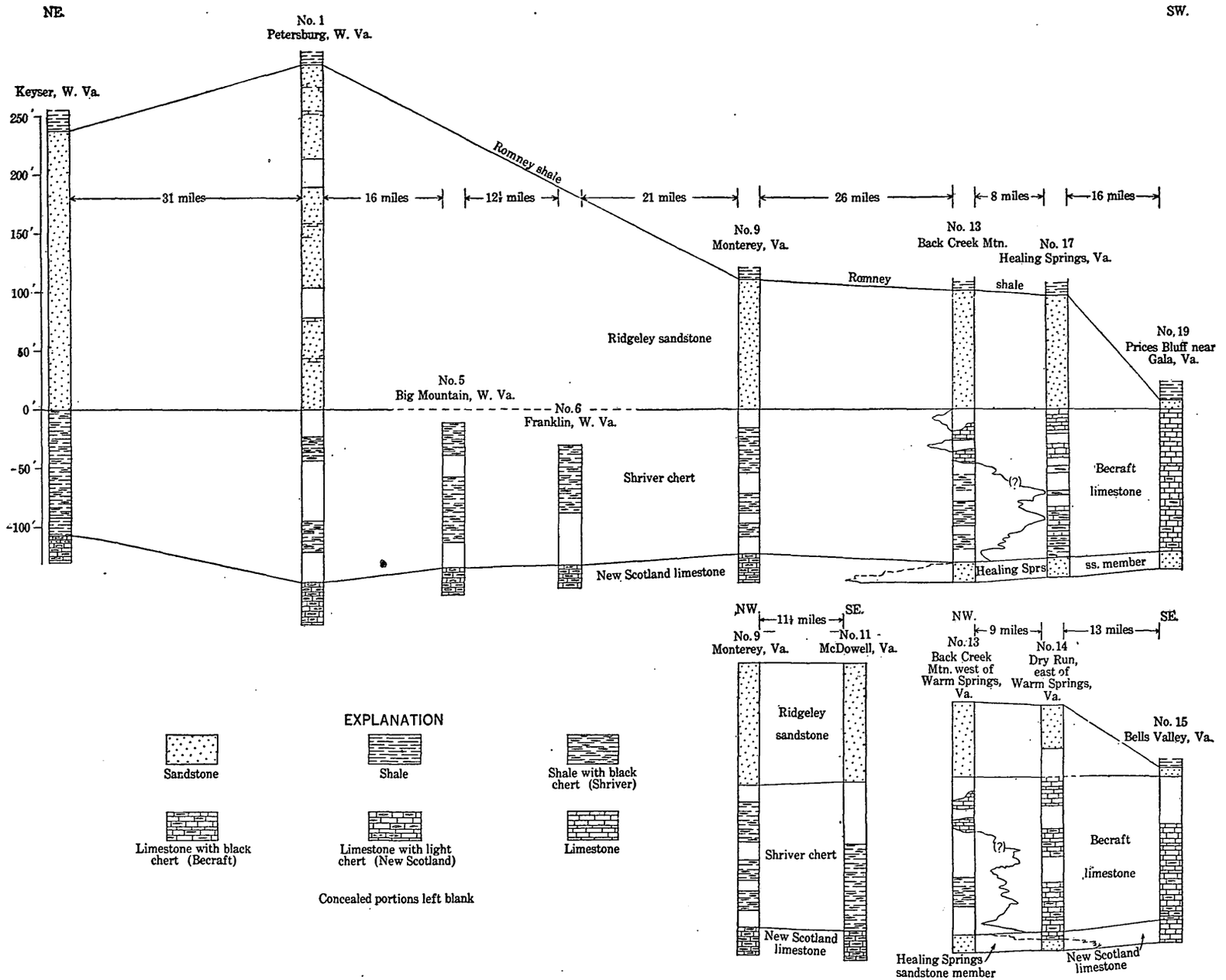

FIGURE 10.—Sections showing stratigraphy of the Shriver chert and Becraft limestone from Keyser, W. Va., to Clifton Forge, Va. See page 63 for correction of Shriver-Ridgeley interval at Monterey, Va.

S. concinnus proper. According to Schuchert,[16] some specimens of *S. concinnus* of the Maryland Becraft also reach widths of 40 millimeters or even more; he does not, however, mention the development of more numerous plications. The Maryland specimens are also more alate than those from New York—a condition that Schuchert ascribes to abrasion of the thin edges of the valves before deposition.

In the ventral valve used as the type for *Spirifer concinnus* var. *progradius* the sinus is broad and rounded; but in several of the associated and otherwise similar specimens the sinus is somewhat angulated and has a very feeble plication on each side toward the front. Similar but stronger plications were noted by Hall in some of the New York specimens which he included in *S. concinnus* but which Schuchert [17] later separated as *S. proavitus*. However, as the Virginian specimens agree more closely on the whole with the variety *progradius*, they are here retained in that form.

The presence at this horizon of a number of species with very definite Oriskany affinities is of particular interest. The most significant of these species are *Rhynchotrema cumberlandicum, Rensselaeria subglobosa, Spirifer angularis, Cyrtina varia, Anoplotheca flabellites*, and *Dalmanites* sp. near *D. dentatus*. The relationships of this portion of the fauna are as follows:

Relationships of Oriskany species in Becraft limestone

[r, closely related species]

	Becraft limestone, Maryland	Lower part of Oriskany, New Jersey	Shriver chert, Maryland	Ridgeley sandstone, Maryland
Rhynchotrema cumberlandicum				×
Rensselaeria subglobosa	×	×		
Spirifer angularis				×
Cyrtina varia		×		
Anoplotheca flabellites	×		×	×
Dalmanites sp		r		r

Of these species, *Rhynchotrema cumberlandicum* is rare. The one specimen from the upper part of the Becraft at Prices Bluff is, however, complete and quite typical. *Rensselaeria subglobosa* is common in the limestones of this horizon at Back Creek Mountain. The material so identified is quite typical in size and in the number and strength of the plications; but, as in that from the Maryland Becraft, the valves are somewhat less convex than in the New Jersey types. *Spirifer angularis* is common in several of the sections and seems to agree rather closely with the material from the Maryland Ridgeley. The presence of *Cyrtina varia* in the upper Becraft of Virginia parallels the occasional occurrence of *C. rostrata* in the Becraft limestone of Maryland. As was noted by Clarke in his original description, *C. varia* is very close to *C. rostrata*, from which it differs in its somewhat smaller size and smaller average number of plications. *Anoplotheca flabellites*, although typically an Oriskany fossil, has been reported from both the Becraft and the New Scotland of Maryland. Finally, the trilobite listed as *Dalmanites* sp. is of interest because the several fragments of pygidia are sufficient to show that the general shape of the pygidium, the width of its axis, the strength, grooving, and probably the number of the ribs, and the general character of the ornamentation are essentially those of *D. dentatus*. The ornamentation differs somewhat in detail from that of *D. dentatus* in that the tubercles lining the summits of the ribs are appreciably more numerous and not quite so prominent—a character which, with the granulation of the surface as a whole, suggests that this form was intermediate between *D. pleuroptyx* of the New Scotland and Becraft and *D. dentatus* of the Oriskany.

The Oriskany elements in this fauna indicate that the upper part of the Becraft limestone of the Clifton Forge area is younger than the top of the Becraft in the type area of southeastern New York. They also suggest that there is no essential time break between the Becraft and the Ridgeley such as there would be if the pre-Ridgeley Shriver chert of the neighboring sections to the north were entirely post-Becraft. This question is considered in further detail in the following discussion of the Shriver chert.

[16] Maryland Geol. Survey, Lower Devonian, p. 418, 1913.

[17] Idem, pp. 418, 419, pl. 71, fig. 17.

TABLE 3.—*Distribution of the fauna of the Coeymans, New Scotland, and Becraft limestones of West Virginia and Virginia.*

Coeymans limestone

[r = very closely related form]

	West Virginia and Virginia				Maryland and Pennsylvania					New Jersey and New York		
	Keyser	Coeymans	New Scotland	Becraft	Keyser	Coeymans	New Scotland	Becraft	Ridgeley	Coeymans	New Scotland	Becraft
BRACHIOPODA												
1. Orthostrophia strophomenoides (Hall)		×			×		×				×	
2. Rhipidomella oblata (Hall)		×				×	×			×	×	×
3. Leptaena rhomboidalis (Wilckens)	×	×	×	×	×	×	×		×	×	×	×
4. Stropheodonta arata (Hall)		×				×	×			×	×	
5. Stropheodonta cf. S. planulata (Hall)	×	×				×	×	×		×		×
6. Strophonella punctulifera (Conrad)		×	×			×	×			×	×	×
7. Schuchertella woolworthana (Hall)		×	×	×		×	×	×			×	×
8. Gypidula coeymanensis Schuchert	r	×			×	×				×	×	
9. Camarotoechia campbellana (Hall)		×		×			×				×	×
10. Uncinulus abruptus (Hall)		×	×	×			×	×			×	
11. Spirifer perlamellosus Hall	r	×	×			?	×				×	
12. Spirifer cyclopterus Hall		×	×	×		×	×	×		×	×	×
13. Nucleospira ventricosa (Hall)	×	×			×	×	×			×	×	
14. Meristella arcuata (Hall)		×	×				×	×			×	
15. Meristella arcuata var. gigas F. M. Swartz, n. var		×										
16. Meristella symmetrica Schuchert		×				×						
MOLLUSCA												
17. Platyceras gibbosum Hall		×									×	
18. Platyceras multiplicatum F. M. Swartz, n. sp		×										
19. Platyceras trilobatum Hall		×					×				×	
TRILOBITA												
20. Dalmanites pleuroptyx (Green)		×					×		×	×	×	

New Scotland limestone

BORIFERA												
1. Hindia sphaeroidalis Duncan			×					×		×	×	
COELENTERATA												
2. Streptelasma strictum Hall			×	×			×			×	×	
BRACHIOPODA												
3. Dalmanella eminens (Hall)			×				×				×	
4. Dalmanella perelegans (Hall)			×			×	×				×	
5. Leptaena rhomboidalis (Wilckens)	×	×	×	×	×	×	×	×	×	×	×	×
6. Strophonella punctulifera (Conrad)		×	×			×	×			×	×	×
7. Strophonella undaplicata C. K. Swartz			×				×					
8. Strophonella leavenworthana (Hall)			×	×		×	×				×	×
9. Schuchertella woolworthana (Hall)		×	×	×		×	×	×		×	×	×
10. Uncinulus abruptus (Hall)		×	×	×			×	×			×	
11. Spirifer perlamellosus Hall	r	×	×			?	×			×	×	
12. Spirifer cyclopterus Hall		×	×	×		×	×	×		×	×	×
13. Spirifer macropleurus (Conrad)			×				×				×	
14. Trematospira equistriata Hall and Clarke			×				×					
15. Meristella arcuata (Hall)		×	×				×	×			×	
16. Meristella lata (Hall)			×	×				×	×			
MOLLUSCA												
17. Platyceras gebhardi Conrad			×	×			×		×		×	×

TABLE 3.—*Distribution of the fauna of the Coeymans, New Scotland, and Becraft limestones of West Virginia and Virginia*—Continued

	West Virginia and Virginia				Maryland and Pennsylvania					New Jersey and New York		
	Keyser	Coeymans	New Scotland	Becraft	Keyser	Coeymans	New Scotland	Becraft	Ridgeley	Coeymans	New Scotland	Becraft
COELENTERATA												
1. Streptelasma strictum Hall			×	×			×			×	×	×
ECHINODERMATA												
2. Edriocrinus pocilliformis Hall				×			×	×			×	×
BRACHIOPODA												
3. Rhipidomella assimilis (Hall)				×				×			×	×
4. Leptaena rhomboidalis (Wilckens)	×	×	×	×	×	×	×	×	×	×	×	×
5. Strophonella leavenworthana (Hall)			×	×		×	×				×	×
6. Schuchertella woolworthana (Hall)		×	×	×		×	×	×		×	×	×
7. Schuchertella becraftensis (Clarke)				×					×			
8. Rhynchotrema cumberlandicum (Rowe)				×					×			
9. Camarotoechia campbellana Hall		×		×			×				×	×
10. Camarotoechia praespeciosa Schuchert				×				×				
11. Uncinulus abruptus (Hall)		×	×	×			×	×			×	
12. Uncinulus pyramidalis (Hall)				×						×	×	
13. Uncinulus vellicatus (Hall)				×			×	×			×	×
14. Eatonia peculiaris (Conrad)				×			×	×	×		×	
15. Rensselaeria cf. R. aequiradiata (Conrad)				×								×
16. Rensselaeria subglobosa (Weller)				×				×				
17. Spirifer concinnus Hall				×				×				×
18. Spirifer concinnus var. progradius F. M. Swartz, n. var				×								
19. Spirifer cyclopterus Hall		×	×	×		×	×	×		×	×	×
20. Spirifer cf. S. angularis Schuchert				×					×			
21. Spirifer sp				×					?			
22. Cyrtina varia Clarke				×				r	r			
23. Anoplotheca flabellites (Conrad)				×			×	×	×			
24. Meristella lata (Hall)			×	×				×	×			
MOLLUSCA												
25. Platyceras gebhardi Conrad			×	×			×		×		×	×
TRILOBITA												
26. Phacops logani Hall				×			×				×	×
27. Dalmanites sp				×					r			

Becraft limestone

SHRIVER CHERT

From Cumberland, Md., to Monterey, Va., the New Scotland is overlain by a siliceous shale with much interbedded black chert, containing few fossils. In the Virginias the shale is generally subordinate to the bedded chert. The shaly chert is in turn overlain by the Ridgeley sandstone, carrying the characteristic *Spirifer arenosus* fauna, and is thus the southward continuation of the Shriver chert, so named from Shriver Ridge,[18] near Cumberland, Md.

The stratigraphic position of the Shriver chert is apparently the same as that occupied in the Clifton Forge area by the Becraft limestone. The conditions are similar in Maryland, where the Becraft lies between the New Scotland limestone and the Ridgeley sandstone in the exposures of the Lower Devonian east of Hancock; whereas at Hancock and westward to Cumberland the Becraft is absent, and the New Scotland-Ridgeley interval is occupied by the Shriver chert. In Virginia, at least, the displacement of the one lithologic unit by the other is relatively abrupt, the Shriver chert and the Becraft limestone appearing in full thickness and more or less typical development in sections less than 20 miles apart.

Although no section containing both formations was known, Schuchert,[19] Stose and Ulrich,[20] and C. K. Swartz [21] considered the Shriver chert to be of lower Oriskany age because the Shriver seems to thin somewhat in the vicinity of Hancock, and, more particularly, because of the following faunal relationships:

Species occurring in the Shriver chert of Maryland	28
Previously described	11
Occurring in the Becraft limestone or older formations of Maryland and New York	6
Occurring in the lower part of the Oriskany sandstone of New York	9
Occurring in the Ridgeley sandstone of Maryland	8
Occurring in the Ridgeley sandstone of Maryland and the Oriskany sandstone of New York	11
Occurring in the last-named sandstones but not in the Becraft or below	5

The outstanding features of the faunal relationships indicated above are the large proportion of species known from only the Shriver chert, the lack of agreement with the fauna of the Becraft, and the apparent affinity to the fauna of the Oriskany sandstone rather than to that of the Helderberg.

A more detailed analysis of the fauna places a somewhat different aspect on the problem from that given by the above figures. Taking the five species cited above as occurring in the Ridgeley and other Oriskany sandstones but not in the Becraft or below, we find that two of these—*Spirifer arenosus* and *Diaphorastoma desmatum*—are represented in the Shriver by but one known specimen each, and that there is some doubt as to the identification, at least of the *Diaphorastoma*. A third form, *Schuchertella becraftensis*, is also very rare; furthermore, one specimen from the Becraft of Virginia seems to be referable to this species. *Meristella lentiformis* is abundant in many places and is more definitely indicative of Oriskany relationships; even so, the Shriver chert material is consistently smaller than that of the Ridgeley sandstone. The citation of *Chonetes hudsonicus* from the New Scotland of New York is questionable; although not included in the above list, this seems to be definitely an Oriskany species and is abundant and typical in the upper part of the Shriver chert. The Shriver species *Beachia suessana* var. *immatura* also suggests the Oriskany. It should furthermore be noted that none of the species common to the Shriver and to the Becraft or lower formations is distinctively Helderbergian. The fauna is then suggestive of the Oriskany, though not distinctively so.

Of greater significance is the fact that the composition of the Shriver chert fauna is not what would be expected in a typical marine deposit of Lower Devonian time. Thus of the 28 described species, 11 are ostracodes, of which 10 are known only from the Shriver, 14 are brachiopods, and 3 are gastropods—including 2 species of *Tentaculites*. The nonostracode fauna is thus small, in number of species as well as in individuals. Furthermore, the corals, Pelmatozoa, Bryozoa, and trilobites are notably absent, and the brachiopod fauna itself is strikingly defective in the absence of the Lower Devonian genera *Dalmanella*, *Rhipidomella*, and *Camarotoechia* and the occurrence of but one rare species of each of the genera *Stropheodonta*, *Eatonia*, and *Beachia*. The impoverishment of this fauna, particularly when compared with the faunas of the Helderberg limestone and the Ridgeley and equivalent Oriskany sandstones, detracts greatly from its significance as a means of correlation.

These facts and the further fact that the Shriver chert and the Becraft limestone occupy analogous stratigraphic positions in near-by sections, without, at least in Virginia, a thinning of either formation toward the general boundary of the areas of development, greatly weaken the argument for the post-Becraft age of the Shriver chert. Indeed, these relationships, together with the fact that the Becraft of Maryland and Virginia contains pronounced Oriskany elements in the fauna of its upper part, suggest the possibility that the Shriver chert is a muddy bottom phase, equivalent in time to the Becraft limestone as developed in Maryland and Virginia, and with a fauna differing from that of the Becraft because of peculiar environmental conditions.

Since this question formulated itself in my mind, I have fortunately been able to revisit several key sections. The sections at Healing Springs and Back Creek Mountain, west of Warm Springs, deserve par-

[18] Swartz, C. K., Maryland Geol. Survey, Lower Devonian, p. 91, 1913.
[19] Schuchert, Charles, U. S. Nat. Mus. Proc., vol. 26, p. 422, 1903.
[20] Ulrich, E. O., in Stose, G. W., U. S. Geol. Survey Geol. Atlas, Pawpaw-Hancock folio (No. 179), p. 9, 1912.
[21] Swartz, C. K., Maryland Geol. Survey, Lower Devonian, pp. 121, 122, 1913.

ticular attention. At Healing Springs the New Scotland to Ridgeley interval is occupied by the Becraft limestone. As usual for the Clifton Forge area, the upper part of the Becraft is composed of very pure, rather massive gray limestone, containing an abundance of *Spirifer concinnus* and also *Spirifer cyclopterus* and *Eatonia peculiaris*. The middle and lower portions are composed of interbedded limestone and black chert, of typical Becraft type, but with the limestone much more subordinate than in the sections at Clifton Forge and Gala. The lower beds also lack the abundance of fossils which characterize them in the Clifton Forge and Gala sections.

At Back Creek Mountain, about 8 miles farther north, the Ridgeley sandstone is underlain by chert-free but not overly pure limestones carrying *Spirifer concinnus*, *S. cyclopterus*, *Eatonia peculiaris*, and *Rhipidomella assimilis*. These beds certainly represent the upper part of the Becraft, as seen at Healing Springs, Clifton Forge, and Gala. They are underlain, however, by bedded impure chert of Shriver rather than Becraft aspect; particularly as it weathers for the most part into soft buff spongy fragments. A minor portion of the chert is purer than is typical of the Shriver, and this weathers into harder whitish fragments. Farther north, at Monterey, the limestone of upper Becraft age is underlain by shaly chert that is even more suggestive of the Shriver.

The evidence offered by the above-mentioned sections favors the view that the Shriver chert and the Becraft limestone of Maryland and the Virginias are at least essentially equivalent in time. As has been shown in the discussion of the Becraft, however, the limestones referred to that formation in Maryland and Virginia seem to range higher than the top of the type Becraft of New York, the upper portion probably being at least as young as the Port Ewen limestone of southeastern New York and New Jersey.

Acceptance of the conclusions suggested above would still leave some questions as to terminology. If Helderberg group is used primarily with a time significance, I think that the Shriver would necessarily be included in it, although admitting that the Shriver and the Becraft of the Virginia-Maryland area range above the top of the Becraft, and thus above the Helderberg of the type area of New York. On the other hand, if the term is accepted as having a lithologic and faunal rather than a purely time significance, then the Shriver would be placed in the Oriskany group, being more closely related in those aspects to the lower Oriskany of southeastern New York than to the members of the type Helderberg. This usage seems somewhat the more acceptable and has been followed here.

POSITION AND NATURE OF THE SILURIAN-DEVONIAN BOUNDARY IN THE APPALACHIAN BASIN

One of the most unsettled questions of Paleozoic stratigraphy, both in Europe and in North America, has been that concerning the position in our sections of the Silurian-Devonian boundary. This doubt has resulted largely because the type Silurian gives way above to brackish and fresh water and not marine deposits, because the base of the Devonian is scarcely defined in Devonshire, and because the relationships of the Lower Devonian in Shropshire, Devonshire, the Rhine Valley, the Harz Mountains, and the Bohemian basins are obscured by the development of facies in the faunas. The controversies over the possible upper Silurian or Lower Devonian age of the Hercynian shales of the Harz Mountains,[22] the Koniepruss (F_2) limestone of Bohemia,[22] the Helderberg of New York,[23] and the Downtonian of Shropshire [24] have been concerned with the various local aspects of the same general problem.

Limiting ourselves to the Appalachian area and considering only the later phases of the problem even as it concerns that province, we may note that it was not until the end of the nineteenth century that the efforts of Clarke and Schuchert led the majority of American stratigraphers to concur in placing the Helderberg group (in which Clarke and Schuchert [25] in 1899 included the Coeymans, New Scotland, and Becraft limestones) at the base of the Devonian. The assignment was made because of what Clarke and Schuchert considered the definite Devonian affinities of the fauna as a whole, as well as because of its apparent equivalency to that of the Koniepruss (F_2) limestone of Bohemia, generally accepted as basal Devonian by European geologists, following Kayser and Frech.

Somewhat more recently it has been suggested, first by Ulrich [26] and then in further detail by C. K. Swartz [27] and Reeside,[28] that the Keyser limestone, so named from its exposure at Keyser, W. Va., should be considered the lowest division of the Helderberg and as such placed at the base of the Devonian of the Appalachian province.

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[22] For review and bibliography see Clarke, J. M., The Hercynian question: New York State Mus. Forty-second Ann. Rept., pp. 408–437, 1889.

[23] Schuchert, Charles, Lower Devonic aspect of the lower Helderberg and Oriskany formations: Geol. Soc. America Bull., vol. 11, pp. 241–332, 1900.

[24] Stamp, L. D., The base of the Devonian: Geol. Mag., vol. 60, pp. 276–281, 331–336, 367–372, 385–410, London, 1923. Robertson, T., The Siluro-Devonian junction in England: Idem, vol. 65, pp. 385–400, 1928.

[25] Clarke, J. M., and Schuchert, Charles, The nomenclature of the New York series of geological formations: Science, new ser., vol. 10, pp. 874–878, 1899.

[26] Ulrich, E. O., Revision of the Paleozoic systems: Geol. Soc. America Bull., vol. 22, p. 590, pl. 28, 1911.

[27] Swartz, C. K., Maryland Geol. Survey, Lower Devonian, pp. 105–117, 1913.

[28] Reeside, J. B., jr., The Helderberg limestone of central Pennsylvania: U. S. Geol. Survey Prof. Paper 108, pp. 193–199, 1917.

Several aspects of the present investigation are of interest in this connection. In the Virginias, as in Maryland and Pennsylvania, a considerable percentage of the Keyser fauna continues into the higher Helderberg, there being 17 Keyser species that are identical with or at least very closely allied to forms occurring in the Coeymans, New Scotland, and Becraft limestones. This is a somewhat smaller number than the 35 Coeymans or younger species reported from the Keyser of Maryland and Pennsylvania but is of interest in that several of the strictly Helderberg species that occur in the Keyser of the Virginias have not been reported from the Keyser of Maryland and Pennsylvania.

Among the Helderberg species occurring in the Keyser limestone of the Virginias, but not known from that formation farther north, the specimens placed in *Striatopora bella* and *Cyrtina dalmani* may be considered strictly identical with the Coeymans and New Scotland material. *Striatopora bella* is locally common in the upper part of the Keyser at Little Mountain, Va.; *Cyrtina dalmani* is comparatively rare but is known from several localities. Mention might also be made here of the abundance of typical *Nucleospira ventricosa* in the upper part of the Keyser at Big Mountain, Monterey, and several other localities, as there is possibly some uncertainty about previous citations of this species from the lower part of the Keyser farther north.

The upper Keyser Camarotoechias referred in this report to *C. altiplicata* are somewhat smaller than the New Scotland material but seem to be similar in other respects. They should perhaps be separated under a varietal name. The new *Spirifer perlamellosus* var. *praenuntius* is somewhat more definitely removed from the type material of the New Scotland, having fewer plications as well as being smaller; nevertheless, its similarity in aspect shows it to be closely related to the species to which it is introductive. The new *Gypidula coeymanensis* var. *similis* is also very suggestive of the younger material of the Coeymans limestone—more so than the variety *prognosticus* of the Keyser of Maryland and Pennsylvania.

The two middle Keyser Stropheodontas cited as *Stropheodonta* cf. *S. planulata* are more questionable and less significant. The one *Meristella* which I am using as the type of *M. nasutaformis*, although suggestive of the younger Meristellas in its relatively large size, does not seem to be closely akin to any of the later forms described; it is of importance, however, as another Keyser representative of this Devonian genus.

The presence of these additional Helderberg elements in the Keyser fauna gives some added weight to the opinion that the Keyser limestone should be considered a part of the Helderberg group. It must nevertheless be admitted that the number of well-determined species continuing from the Keyser into the younger beds is not exceptionally great. Thus out of the total known Keyser fauna of about 180 species, 38 are known from the Coeymans and younger formations, 9 are derived from the Tonoloway limestone, and an additional 11 come from other pre-Keyser formations. The Helderberg aspect of the Keyser fauna gains somewhat by comparison if the species of little stratigraphic value are eliminated. Thus among the 20 Keyser species derived from the known older faunas, *Halysites catenularia*, *Stromatopora constellata*, *Leptaena rhomboidalis*, and *Atrypa reticularis* are devoid of any exact stratigraphic significance, while two other species are also long ranging forms, as they continue into the New Scotland. Of the remainder, two are Bryozoa and four are ostracodes and are species whose stratigraphic value is somewhat uncertain. On the other hand, a similar removal of the stratigraphically worthless or obscure species from the Helderberg element of the Keyser fauna results in the loss of a smaller number.

Too much weight should not be placed upon such statistics as those above given without some examination of the faunas with which comparison is being made. A study of the faunas of the Coeymans, New Scotland, and Becraft limestones shows them to consist of many and varied species and leads to the conclusion that these faunas are finely representative of the marine life of their day. This is not true of the faunas of the Cayugan deposits, including the Tonoloway limestone. Thus in New York the impoverishment of the Cayugan faunas has long been recognized and was suggested by Schuchert [29] to be an important factor contributing to the notable break in that State between the faunas of the Helderberg group and those of the subjacent Silurian deposits.

The case is similar in Maryland, where the Tonoloway limestone and the Wills Creek shale are comparatively unfossiliferous, except at a few horizons. Although twice as thick as the overlying Keyser, the Tonoloway contains less than half as many species. Furthermore, about 40 per cent of the known species are ostracodes, almost all new; the nonostracode fauna is composed of but 46 species, including 21 brachiopods, 6 Bryozoa, 5 gastropods, 4 pelecypods, 4 cephalopods, 2 corals, 1 stromatoporoid, 1 trilobite, 1 eurypterid, and 1 fish. Of these, the corals, Bryozoa, cephalopods, eurypterid, and fish are extremely rare, and only a few of the ostracodes, brachiopods, and gastropods are really abundant. The fauna of the underlying Wills Creek shale is still smaller in number of species and individuals.

The comparative impoverishment of the Cayugan faunas detracts somewhat from the force of the plea that the Keyser should be placed in the Helderberg group and thus at the base of the Devonian because of the greater specific agreement of its fauna with those

[29] Schuchert, Charles, Geol. Soc. America Bull., vol. 11, p. 275 and footnote, 1900

of the overlying than with those of the underlying deposits. If it were merely a question whether the Keyser should or should not be placed in the Helderberg group the apparent faunal relationships would be of greater significance. The injection of the question whether the Keyser should be considered Devonian or Silurian places greater emphasis upon the problem of age relationships, and the impoverished character of the Cayugan faunas leaves us with the doubt as to whether there might not be greater specific agreement between the fauna of the Keyser and those of the older deposits if only the older deposits carried more representative marine faunas.

The question, then, is not so much whether the Keyser should be placed in the Devonian because it belongs in the Helderberg group, as whether the Keyser should be placed in the Helderberg group because it is Devonian. We are thus not primarily concerned to know whether the fauna of the Keyser limestone contains a considerable number of Helderberg species; the question is, Does the Keyser fauna contain a marked number of those elements which have led stratigraphers to place the Helderberg of Clarke and Schuchert's definition in the Devonian? Great weight must therefore be accorded to the fact that members of the distinctive Devonian genera *Chonostrophia, Rensselaeria, Beachia, Meristella, Merista, Actinopteria,* and *Aviculopecten* make their first known appearance in the Keyser limestone, at least so far as the Appalachian province is concerned. The several species of *Uncinulus* of the type of *U. nucleolatus* probably also deserve a place in this category. The presence of these forms outweighs the evidence of the Silurian stragglers, of which *Calymene camerata* and *Whitfieldella prosseri* are the most abundant, and their testimony is upheld by the disappearance of the upper Silurian genera *Hindella* (*Greenfieldia*) and *Hormatoma,* both of which are well represented in the underlying Tonoloway limestone. I would thus concur in placing the Keyser limestone at the base of the Devonian and in including it in the Helderberg group, primarily because of the Devonian affinities of the Keyser fauna.

If the Keyser limestone is to be considered Devonian, as suggested, and the Silurian-Devonian boundary accordingly placed at the Keyser-Tonoloway contact, the nature of that contact becomes a matter of greater interest, particularly with respect to its time significance. So far as the physical aspect of the contact is concerned, the passage from the older formation into the younger seems to be transitional rather than abrupt, except south of Bolar, Va., where both the Tonoloway and the Keyser become much thinner. However, such evidence as is thus afforded is rather negative; and on the basis of the statement that the Keyser contains a large and varied fauna, of which only a comparatively few are derived from the Tonoloway or other known pre-Keyser faunas, it might be supposed that the Keyser is separated from the underlying Tonoloway by a hiatus of some magnitude.

We have already seen that the faunas of the Cayugan deposits of the Appalachian province seem to be considerably impoverished, and it has been suggested that the absence from the Cayugan deposits of a fauna with more direct affinities to that of the Keyser may be due more to the exclusion of such a fauna from the Appalachian Basin than to its actual nonexistence. It remains to be shown, of course, that such was the case.

A zone of fossils discovered in the middle of the Tonoloway at Monterey, McDowell, Fulks Run, and Bells Valley is of some interest in this connection. The most abundant species are *Atrypa reticularis,* which, although it has no precise bearing on the relationships of the fauna, does indicate marine connections; and an *Uncinulus,* which differs from the *U. convexorus* characteristic of the lower part of the Keyser only in its somewhat finer ribbing. One small specimen of *Stenochisma deckerensis* was found at the exposure of the zone at Monterey; although this specimen was loose, the supposition that it could have survived a trip down the hillside from the exposure of the lower Keyser *S. deckerensis* zone, some 250 feet higher up the slope, seemed very improbable. Another species occurring in this zone is a fairly large lamellose *Spirifer,* whose description will be reserved for another paper.

The above-described occurrence represents a short and restricted invasion of the area by a fauna with at least some definite affinities to that of the Keyser. It seems possible that, if the opportunities for invasion had been of longer duration and more widespread, the fauna might have been larger, and the affinities to the younger fauna more pronounced. There is thus no definite evidence of a marked time break between the Tonoloway and the Keyser limestones.

An aspect of the views above set forth that merits further comment is the diastrophic control of the apparent paleontologic relations of these formations in the sense that geographic and environmental conditions are ultimately controlled by diastrophic processes. Thus the Keyser of Maryland and the Virginias contains a large fauna, with a considerable number of species that continue into the overlying Coeymans, New Scotland, and Becraft limestones, and a lesser number derived from older deposits. The pronounced faunal change is found at the Tonoloway-Keyser contact in this area. As the Keyser is traced northward through central Pennsylvania the number of distinctly Helderberg species is diminished, and in the apparently equivalent Decker, Rondout, and so-called Manlius limestones of New Jersey and Cobleskill, Rondout, and so-called Manlius limestones of southeastern New York the fauna is much smaller, the species that continue into the overlying formations are only 6 in number,

and the proportion of species derived from the underlying formations is greater in comparison to the total number of species in the fauna. Furthermore, the change in the fauna eliminates the members of the genera upon whose presence is here based the assignment of the Keyser to the Devonian. In the New Jersey and southeastern New York area the pronounced faunal change occurs at the base of the Coeymans limestone. The facts are, then, that a large and varied fauna, with a considerable number of Helderberg and Devonian species, was present in the Virginian and Maryland seas during Keyser time; the fauna present in the New Jersey and southeastern New York seas was smaller and practically devoid of Helderberg or Devonian species, although the seas of the two areas appear to have been connected, as shown by the fact that the Keyser sediments are continuous across Pennsylvania, with a more or less progressive change in lithology and fauna from the Maryland to the New Jersey development. The differences in fauna must then be accounted for by a lateral change in environmental conditions in a continuous sea, rather than by a barrier of some type, separating two seas. In other words, the oceanic connections of the Keyser sea must have been such that the marine fauna was able to penetrate in considerable numbers to Virginia and Maryland, while adverse environmental conditions, such as a change to more brackish water, excluded much of the fauna, and particularly its Devonian elements, from the New Jersey-New York area during this time; and it was not until Coeymans time that the progressive change in geographic relations permitted a representative marine fauna to invade the New York as well as the Maryland area. It is this difference in local development that has caused the difference in conclusions arrived at by the New York and New Jersey workers, on the one hand, and by those of Maryland and the adjoining States, on the other.

SUMMARY

In brief, then, as the Helderberg group is traced southward from Maryland, the formations recognized in that State are found to persist for a considerable distance with little change in thicknesses or faunas. Throughout the area covered by this study the Helderberg deposits are underlain by the Tonoloway limestone or limestones of Tonoloway lithology and fauna, while the younger Ridgeley sandstone persists as far south as Clifton Forge.

The most notable changes are as follows: In the Keyser limestone a shale unit, here named the Big Mountain shale member, is developed, separating the lower limestone member from the upper limestone member. The lower limestone member preserves, as far south as Clifton Forge, Va., the fauna and the essentially nodular character which are features of the lower part of the Keyser of Maryland. At Clifton Forge, however, this member has thinned considerably, its upper beds being replaced by sandstone, beginning in the sections west of Warm Springs and Hot Springs, Va. The Big Mountain shale member is maintained as far south as Bolar, Va., and then tongues out, giving place to sandstone. South of Petersburg, W. Va., the upper limestone member of the Keyser becomes purer and simulates the Coeymans limestone in lithology, and with this change in composition appear a number of forms that are not known beneath the Coeymans farther north. At Warm Springs a tongue of shaly sandstone appears near the base of the upper limestone member of the Keyser; as it is followed to Clifton Forge, this tongue of sandstone thickens, becomes more massive, and, with the sandstone beds replacing the Big Mountain shale and the upper part of the lower limestone members, forms what is here named the Clifton Forge sandstone member of the Keyser. This member is 66 feet thick at Clifton Forge, where the lower and upper limestone members of the Keyser are only 15 and 33 feet thick, respectively. The Keyser was not seen south of Clifton Forge. It is absent in the sections seen near Saltville and Big Stone Gap, in southwestern Virginia, and is probably missing in the intervening sections at Hollybrook and Rocky Gap.

The Coeymans remains a massive, highly crinoidal limestone, at least as far south as Clifton Forge. The "guide fossil" *Gypidula coeymanensis*, so abundant farther north, is very rare in the Clifton Forge area; one characteristic specimen was, however, seen in the Coeymans limestone at Hot Springs. Still farther south, at Rocky Gap and Hollybrook, the Coeymans may possibly be represented by a part of the sandstones that form the middle portion of the Giles formation of M. R. Campbell and lie between platy limestone of Tonoloway age and bedded chert of probable Oriskany age.

The New Scotland is a massive limestone with much interbedded white chert as far south as Monterey, Va. At Bolar, however, the cherty limestone is much thinner, and the lower part is replaced by a calcareous sandstone (in part an arenaceous limestone), here named the Healing Springs sandstone member, from the section west of Healing Springs, where the cherty limestone has disappeared. Part of the sandstone forming the middle of the Giles formation at Rocky Gap may be of New Scotland age. The New Scotland has been reported to occur as an arenaceous limestone in Wise County, supposedly with characteristic fossils. The exact relations of this supposed New Scotland are, however, debatable; its correlation presents a special problem.

The Shriver chert overlies the New Scotland in most of the sections studied but is replaced in the more easterly sections by the Becraft limestone with its

characteristic fossils. The suggestion also arises that the Shriver chert is a muddy phase of the Becraft, as that formation is developed in Maryland and the Virginias.

The bedded chert forming the upper part of the Giles formation in the vicinity of Saltville, Va., simulates the Shriver chert in character and occupies an analogous stratigraphic position. Its post-Shriver age is shown by the presence in it of *Diaphorastoma ventricosum* and a variety of *Spirifer arenosus*. The similar bedded chert of the upper part of the Giles at Rocky Gap and Hollybrook is here correlated with that at Saltville, in spite of the absence of the fossils seen at the latter locality. This chert is possibly equivalent to the Harriman chert of western Tennessee.

The Silurian-Devonian boundary is placed at the base of the Keyser limestone chiefly because of the presence in the Keyser of members of important Devonian genera. That the species common to the faunas of the Keyser and the younger rocks are greater in number than those common to the faunas of the Keyser and the older rocks is thought to be due to the fact that the known upper Silurian deposits of the Appalachian area do not contain an entirely representative marine fauna, rather than to any considerable time break between the Tonoloway and the Keyser.

NOTES ON THE LOCAL FAUNAS OF THE HELDERBERG GROUP, WITH DESCRIPTIONS OF NEW FORMS

PORIFERA

Hindia sphaeroidalis Duncan.—Spherical; about 25 millimeters in diameter; skeleton of minute spicules uniting to form delicate radiating canals. Common in the New Scotland limestone.

ANTHOZOA

Streptelasma strictum Hall (pl. 8, figs. 13, 14).—Simple, regularly expanding, nearly straight, conical corallum; length 25 millimeters; diameter of calyx 16 millimeters; septa about 50; alternate septa short, frequently coalescing with the primary septa a short distance from the walls; some of the primary septa unite at the center to form a pseudocolumella; surface strongly ribbed. Abundant in the New Scotland limestone and basal part of the Becraft limestone.

Cyathophyllum radiculum Rominger.—Simple, conical, slightly curved corallite; length 14 millimeters; diameter of calyx as much as 8 millimeters; calyx fairly deep; septa low, denticulate, about 40. Common in the upper part of the Keyser limestone, Little Mountain, Va.

Favosites cf. *F. helderbergiae* Hall.—Corallum large, more or less hemispherical; base with wrinkled epitheca; corallites prismatic, intimately united, about 1.5 millimeters in diameter; 10 to 15 tabulae in space of 10 millimeters; mural pores in one or two ranges. The *Favosites* from the Coeymans and New Scotland limestones were generally referred to this species, but without critical study; those from the upper part of the Keyser limestone were mostly placed with the variety *praecedens* Schuchert.

Striatopora bella C. K. Swartz.—Corallum dendroid; stems 5 to 10 millimeters in diameter, consisting of closely united prismatic corallites, terminating obliquely at the surface, unequal in size and irregular in cross section; calyces funnel-shaped, as much as 2.5 millimeters in diameter; sides striated by 12 low ridges. Common in the upper part of the Keyser limestone, coral zone, Little Mountain, Va.

Cladopora rectilineata Simpson (pl. 7, figs. 9–11).—Corallum ramose, branching dichotomously; stems circular, about 2 millimeters in diameter; consisting of intimately united corallites, which ascend parallel to the axis and then turn outward and terminate obliquely at the surface; orifices small, arranged in 8 to 10 vertical rows, which are separated by low ridges. Abundant in the upper part of the Keyser limestone at many localities; rare in the lower part of the Keyser.

Aulopora schohariae Hall.—Corallum incrusting, composed of a loose network of elongate, thick-walled, nearly tubular corallites, which increase by basal or double laterobasal gemmation; corallites 5 to 7 millimeters in length; greatest diameter 1.5 millimeters. Abundant in upper part of Keyser limestone, coral zone, Little Mountain, Va.

Aulopora schucherti C. K. Swartz.—Corallum consisting of an intricately branched network of small nearly tubular corallites, irregularly fused so as to form a more compact corallum than in *A. schucherti*. Rare at the middle of the Keyser limestone.

ECHINODERMATA

Jaekelocystis hartleyi Schuchert.—Theca small, more or less pyriform; ambulacra narrow, prominent, extending nearly to the column; about eight folds in each pectinirhomb. Rare, lower part of Keyser limestone, Clifton Forge, Va.

Mariacrinus sp. (pl. 7, fig. 8).—Dorsal cup of medium size, subglobose; plates depressed convex, unornamented; basals unknown; radials rather large, hexagonal; primibrachs 2×5, the lower hexagonal, smaller than the radials; the upper pentagonal and axillary; secundibrachs 2×10, the upper axillary and bearing two tertibrachs each; tertibrachs 2×20, more or less pentagonal, each bearing an arm on the upper truncated edge; intersecundibrach one, heptagonal; interradials numerous, arranged in three irregular rows, with about four plates to the row above the level of the second primibrach; tegmen, stem, and arms unknown. Height of dorsal cup 26 millimeters; lateral diameter 23 millimeters. This description applies to one specimen from the upper part of the Keyser limestone at Petersburg, W. Va., which might well be considered a new species.

Edriocrinus pocilliformis Hall (pl. 8, fig. 15).—Cup very small, hemispheric or subturbinate, always detached; interior more or less deeply concave; when well preserved, the upper margin is scalloped with five large and one smaller depression; plates obscure; sutures generally obliterated. Very abundant at the base of the Becraft limestone, Clifton Forge area, Virginia.

Aspidocrinus caroli F. M. Swartz, n. sp. (pl. 9, figs. 10–12).—Body cup-shaped, fairly large, depressed subhemispherical, the thin edge flaring outward; interior broadly concave, with a sharper conical depression at the center; the apex of this depression reaching nearly to the attachment scar, which is about 6 millimeters in diameter and set in a depressed area; known only from the empty molds, which show no trace of plates and no points of attachment for arms. Like the other species referred to this genus, *A. caroli* probably represents the basal expansions of crinoid columns. Greatest diameter 38 millimeters; height 10 millimeters. The empty molds of *A. caroli* are very abundant in the upper portion of the sandstone forming the middle part of the Giles formation at Hollybrook and Rocky Gap, Va. Mr. Charles Butts, of the United States Geological Survey, who was so kind as to examine a specimen, identified it as an *Aspidocrinus* and suggested comparison with *A. scutelliformis* of the Becraft limestone of New York. Mr. Edwin Kirk agreed with the generic determination but did not believe it to be the species mentioned. As compared with *A. scutelliformis*, the Virginian material is distinguished by the

shorter radius of curvature of the body, by the sharp conical depression at the center of the interior, and particularly by the peculiar outward flare of the margin. Also, the attachment scar is larger. *A. caroli* is named in honor of Dr. Charles K. Swartz, with whom I visited the sections at Hollybrook and to the south in connection with a study of the underlying Silurian.

BRYOZOA

Although Bryozoa are rather abundant at various horizons in the Helderberg group, particularly in the Keyser limestone, only the more obvious species have been identified.

Orthopora rhombifera (Hall).—Zoarium ramose; branches slender, elongate, 1 millimeter or less in diameter; zoecial apertures oval, set into rhomboidal or hexagonal, inward-sloping vestibular areas and arranged in diagonal intersecting lines. Abundant in Big Mountain shale member, 94 feet above base of Keyser limestone, Little Mountain, Va.

Cyphotrypa corrugata (Weller) (pl. 6, fig. 6).—Zoarium petasiform or hemispherical, as much as 50 millimeters in diameter; maculæ not elevated, consisting of large zoecia; zoecia tubular, thin-walled, polygonal; mesopores apparently wanting; acanthopores frequently developed at the angle of junction; diaphragms distant one or two times the diameter of the tubes. Although the lower Keyser material placed in this species has not been studied in thin section, the identification seems unquestionable. Common in the lower part of the Keyser limestone.

BRACHIOPODA

Orthostrophia strophomenoides (Hall).—Shell transverse, semioval; ventral valve with narrow mesial elevation from beak to front; corresponding narrow sinus confined to anterior half of dorsal valve; surface marked by coarse radiating striae, with concentric striae visible in depressions between the radiating striae. One specimen from the Coeymans limestone.

Dalmanella concinna (Hall).—Shell subcircular to longitudinally oval; hinge line straight; ventral valve the more convex and almost subcarinate, with rather prominent beak; surface with fine, even radiating striae. Length and width of Virginian material about 13 millimeters. Abundant at a few places in either the upper or the lower part of the Keyser limestone.

Dalmanella planiconvexa (Hall).—Shell of medium size, about 17 millimeters in length and 19 millimeters in width; transversely suboval; the dorsal valve almost flat, the ventral convex. Occurs sparingly in the New Scotland limestone.

Dalmanella perelegans (Hall) (pl. 8, figs. 10, 11).—Shell large, about 27 millimeters in length and 30 millimeters in width; transversely suboval; hinge line half the width of the shell or a little less; valves about equally convex; the dorsal valve with a shallow mesial sinus extending from the beak to the front margin; the ventral valve elevated along the middle, beak small, pointed and incurved. Surface with fine fasciculate radial striae. This species is a conspicuous element of the New Scotland fauna, to which it seems to be confined in the Virginias.

Dalmanella eminens (Hall).—Similar to *D. perelegans*, from which it differs in its somewhat more subquadrate outline and particularly in the much wider hinge line, which is about three-quarters as long as the width of the shell, and the greater height of the ventral area. Occurs sparingly in the New Scotland limestone.

Rhipidomella emarginata (Hall).—Shell small, subtrigonal; dorsal valve the more convex; the broad ventral sinus producing a marked emargination of the anterior margin. Length 15 millimeters; width 18 millimeters. Common in the lowest part of the Keyser limestone, to which it seems to be restricted.

Rhipidomella oblata (Hall).—Shell of medium size, transversely suboval to nearly circular; ventral valve depressed convex toward the beak, flattened to concave anteriorly, with a broad, shallow sinus; ventral beak extending only a little beyond the opposite; area very small; surface finely striated; ventral vascular impressions large and foliate. Length 20 millimeters; width 25 millimeters. This species is particularly characteristic of the top of the Coeymans limestone, where it is abundant at many places in the Monterey-Clifton Forge area.

Rhipidomella assimilis (Hall) (pl. 8, fig. 22).—Shell suborbicular, suggestive of *R. oblata* but differing in its larger size and relatively larger area and ventral beak. Length 27 millimeters; width 30 millimeters. Characteristic of the Becraft limestone, where it occurs more commonly in the upper portion. A few of the specimens from the upper part of the Becraft are larger, reaching 36 millimeters in length and 40 millimeters in width.

Leptaena rhomboidalis (Wilckens).—Shell semicircular, the hinge line slightly extended as a rule; dorsal valve nearly flat toward the umbo and sharply deflected near the margin; the flattened portion with strong concentric undulations; ventral valve deeply concave; radiating striae prominent. Common in all divisions of the Helderberg group.

Stropheodonta bipartita (Hall) (pl. 6, fig. 7).—Shell subsemielliptical; the hinge line produced into small mucronate extensions; dorsal valve nearly flat; ventral valve only slightly convex; surface with fine, angular striae, which are irregularly alternating in size, are not continuous to the beak, and curve outward on the sides of the shell in passing to the lateral margins. Length 28 millimeters; width 30 millimeters. This is a characteristic element in the fauna of the lower part of the Keyser limestone.

Stropheodonta cf. *S. planulata* (Hall).—Shell semielliptical; hinge line slightly extended; dorsal valve flat; ventral valve depressed convex; surface with extremely fine, rounded radiating striae, which are crossed by much finer, closely arranged concentric striae. Length 30 millimeters; width 40 millimeters. Several fragmental specimens from the middle part of the Keyser limestone seem to be most closely allied to this species. Also rare in the Coeymans limestone.

Stropheodonta arata (Hall).—Shell relatively small, semielliptical; dorsal valve more or less concave; ventral valve convex to gibbous. Surface marked by sharp angular plications and intermediate fine undulating striae. Length 15 millimeters; width 24 millimeters; five to six plications in 5 millimeters along anterior margin in the Virginian material. Rare in the Coeymans limestone.

Strophonella keyserensis C. K. Swartz.—Shell subsemicircular in outline; dorsal valve concave toward the umbo, convex toward the margins; ventral valve convex in the umbo, concave toward the margins; surface with numerous fine striae, about eight in 5 millimeters along the anterior margin; interior of valves pustulose. Length as much as 30 millimeters; width 37 millimeters. This forerunner of *S. punctulifera* is rare in the middle and upper parts of the Keyser limestone.

Strophonella punctulifera (Conrad).—Shell subsemicircular, somewhat contracted below the extremities of the hinge; ventral valve concave; dorsal valve concave near the umbo, very convex near the middle; hinge line straight; area narrow, linear; surface with strong sharp radiating striae, which are distinctly punctate on well-preserved shells. Length 35 millimeters; with 45 millimeters; about six plications in 5 millimeters. Occurs sparingly in the Coeymans limestone.

Strophonella leavenworthana (Hall).—Shell large, subsemicircular; both valves flattened except toward the margins, where the ventral valve is concave and the dorsal highly convex; surface with fine, obscure radiating striae, which are crossed on the flattened portions of the valve by small regular concentric wrinkles. Length 35 millimeters; width 45 millimeters. New Scotland and Becraft limestones.

Strophonella undaplicata C. K. Swartz.—Shell very large, subsemicircular, with the hinge line slightly extended; ventral valve convex anteriorly, umbo concave, and paralleled by dorsal valve; surface with coarse, peculiarly sinuous plications, which may unite, forming elliptical depressions between them. Length as much as 45 millimeters; width 52 millimeters. About four plications in 5 millimeters near anterior margin. Occurs sparingly in the New Scotland limestone.

Schuchertella deckerensis (Weller).—Shell transversely subelliptical; pedicle valve depressed, wrinkled and distorted by attachment in the umbonal region; brachial valve regularly convex; surface with rounded radiating striae, of which about 15 occupy 5 millimeters along the anterior margin. Length 20 millimeters; width 28 millimeters. Occurs sparingly in the lower part of the Keyser limestone, to which it is restricted.

Schuchertella sinuata (Hall and Clarke).—Shell transversely subelliptical; dorsal valve very convex, with a well-defined sinus extending from the strongly incurved beak to the anterior margin; surface with fine rounded radiating ribs, of which 10 occupy a space of 5 millimeters along the anterior margin. Length 27 millimeters; width 35 millimeters; these are the measurements of the Virginian specimens, which are larger than those from Maryland. Rare in the lower part of the Keyser limestone, to which it is restricted.

Schuchertella prolifica Schuchert.—Shell of medium size, semielliptical, flattened; hinge line straight; cardinal area narrow, linear; surface with low, rounded, fine radiating striae, of which there are 13 to 20 in 5 millimeters. Length 26 millimeters; width 35 millimeters. This species is closely allied to *S. woolworthana*, of the Coeymans limestone, to which it is introductory. It is common in the upper part of the Keyser limestone, and in the section at Petersburg, W. Va., it occurs very profusely in a zone just below the *Tentaculites* zone.

Schuchertella woolworthana (Hall).—Similar to *S. prolifica* but larger, slightly more convex, and with 7 to 12 radiating striae in 5 millimeters, instead of 13 to 20, as in that species. Length 35 millimeters; width 45 millimeters. This is an abundant element of the Coeymans, New Scotland, and Becraft faunas.

Schuchertella becraftensis (Clarke).—Shell small, suborbicular; pedicle valve erect at the beak; with triangular, broad, fairly high cardinal area; brachial valve depressed at the beak, becoming more convex toward the middle; surface with strong rounded radiating striae, increasing by implantation; also with exceedingly fine concentric striae. Length 13 millimeters; width 17 millimeters. One specimen from the Becraft limestone seems to belong to this species, which has been reported only from the Shriver chert and Ridgeley sandstone in Maryland.

Chonetes jerseyensis Weller (pl. 6, figs. 1, 2).—Shell subquadrate; brachial valve flat or slightly concave; pedicle valve depressed convex, beak small; cardinal area low, with about seven oblique marginal spines; surface with rather coarse radiating ribs; the lateral ribs commonly have a peculiar and characteristic anterior curvature. Length 14 millimeters; width 22 millimeters; about 8 to 10 ribs in 5 millimeters along anterior margin. Typical specimens of this species are common to abundant in the lower part of the Keyser limestone, to which they are restricted.

Gypidula coeymanensis Schuchert (pl. 6, figs. 25, 26; pl. 7, figs. 29, 30).—Shell ovoid to subglobose; ventral valve gibbous, becoming in old shells very ventricose about the umbonal region, beak swollen, arched, incurved; ventral valve convex, nearly circular. Surface generally with 15 to 20 well-developed plications, of which about five are raised on the anterior half of the ventral valve to form a distinct mesial elevation; the medial plications on both valves reach the beaks. Internally the ventral valve has a long spondylium and strong median septum, which stand out on weathered specimens. Length, 30 millimeters; width, 26 millimeters. This fossil is generally abundant in the Coeymans limestone, although it disappears from that formation in the Clifton Forge area. The Virginian material is considerably smaller than the dimensions given above and, as in the northern specimens, shows great variations in the plications and other features.

Gypidula coeymanensis var. *prognostica* Maynard (pl. 6, fig. 24).—Differing from *G. coeymanensis* proper in its smaller size, less inflated ventral beak, lack of distinct fold or sinus, and less distinct plications, which do not reach the beaks. Usual dimensions, length, 18 millimeters; width, 17 millimeters. Abundant in the middle of the Keyser limestone at Petersburg and Big Mountain, W. Va., also in Maryland and Pennsylvania.

Gypidula coeymanensis var. *similis* F. M. Swartz, n. var. (pl. 6, figs. 20–23).—I am proposing this name for the Gypidulas occurring in the middle of the Keyser limestone in the vicinity of Monterey and Warm Springs, Va. These specimens are comparable to the largest Coeymans material in size, some individuals measuring as much as 45 millimeters in length and 33 millimeters in width. The chief differences lie in the slightly less swollen ventral beak and the somewhat broader, less elevated plications, of which there are only about 12. However, about four of the medial plications of the ventral valve are raised into a low though fairly distinct elevation toward the front of the valve, and these plications reach the beak, as in *G. coeymanensis* proper. Internally, the ventral spondylium and median septum are quite comparable to those of the typical material in size and strength. As has been noted, the Coeymans material is itself rather variable, and the middle Keyser Gypidulas here noted are almost identical with the pauciplicate specimens found in that formation. The material placed in the variety *similis* should, however, be considered most closely akin to that included in the variety *prognostica* in the more northerly sections, which evidently occurs at exactly the same horizon, as is shown by the position of the overlying *Camarotoechia gigantea* and *Merista typa* zones.

Rhynchotrema cumberlandicum Rowe (pl. 8, figs. 23–25).—Shell trigonal to subpentagonal; somewhat wider than long; ventral valve depressed convex, beak nearly erect, rather prominent; sinus shallow, with three plications; dorsal valve moderately convex, with four plications on the depressed fold; surface with four or five sharply elevated, angulated plications on each side of the fold and sinus. Length, 18 millimeters; width, 19 millimeters. Rare at top of Becraft limestone, Gala, Va.

Stenochisma deckerensis (Weller) (pl. 6, figs. 10–12).—Shell transversely subovate; ventral valve less convex than the dorsal, its beak prominent, arched but not strongly incurved; sinus and elevation abrupt near the front and reaching the beaks; surface of each valve with 20 to 24 simple angular plications, of which three rather coarser than the rest lie in the ventral sinus and four on the dorsal fold. Length, 15 millimeters; width, 19 millimeters; thickness, 10 millimeters. Abundant in the lower part of the Keyser limestone, of which this species is diagnostic.

Camarotoechia litchfieldensis (Schuchert) (pl. 6, figs. 3–5).—Shell subtrigonal, very small; ventral sinus shallow; dorsal fold low; surface with 16 to 22 simple angulated plications, of which three occupy the sinus and four the fold. Length 9 millimeters; width 9.5 millimeters; thickness 5 millimeters. Common in the basal Keyser *Whitfieldella minuta* subzone; locally abundant at higher horizons of the Keyser.

Camarotoechia gigantea Maynard (pl. 6, figs. 27, 28).—Shell subtrigonal, rather large; ventral beak closely incurved over that of the dorsal valve; ventral sinus broad in front, not reaching the beak; dorsal valve much the more convex; surface with 18 to 20 simple, prominent rounded plications on each valve, with five or six in the ventral sinus and a corresponding number on the low dorsal fold. Length 25 millimeters; width 30 millimeters. Profuse at the middle of the Keyser limestone, just above the *Gypidula* zone.

Camarotoechia gigantea var. *gigas* F. M. Swartz, n. var. (pl. 6, figs. 29–31).—Similar in general character and proportions to *C. gigantea* proper but nearly twice as large and with 26 instead of 20 plications to the valve; seven of the plications, instead of five, are depressed toward the anterior margin of the ventral valve to form a broad sinus, which is rather sharply deflected. Length 40 millimeters; width 45 millimeters. Occurs in the *C. gigantea* zone, Monterey, Va.

Camarotoechia cf. *C. altiplicata* (Hall) (pl. 7, figs. 26–28).—Shell subtrigonal, rather small; ventral valve depressed convex, beak pointed, somewhat arched; dorsal valve the more convex, surface with 10 to 19, usually 14 simple angular plications, with three or less depressed on the middle of the ventral valve into a distinct sinus, with four or less on the dorsal elevation. Length 12 millimeters; width 14 millimeters. The material here referred to *C. altiplicata* is common in the upper part of the Keyser limestone south of Big Mountain, W. Va. It is somewhat smaller than the typical New Scotland material but otherwise similar.

Camarotoechia praespeciosa Schuchert.—Shell longitudinally ovoid, vertically flattened on the sides; ventral valve much the less convex; beak incurved; sinus shallow, broad, undefined; surface with 32 to 36 strongly elevated, subangular plications on each valve. Length 30 millimeters; width 26 millimeters. This species is introductory to *C. speciosa* of the Oriskany group. Occurs sparingly in the upper part of the Becraft limestone at Clifton Forge, Va.

Camarotoechia campbellana (Hall).—Shell longitudinally ovate; ventral valve depressed convex, beak small, incurved, sharply deflected at the lateral margins, depressed into a broad rounded sinus, which curves upward toward the other valve, forming a linguiform extension; dorsal valve much more convex, elevated into a broad fold near the front margin; surface with 22 to 24 plications to each valve, with about five or six on the sinus and fold. Length 25 millimeters; width 23 millimeters. Occurs sparingly at the top of the Coeymans limestone in the Clifton Forge area, Virginia.

Uncinulus convexorus Maynard (pl. 6, figs. 8, 9).—Shell trigonal to subpentagonal; ventral beak prominent, pointed, somewhat incurved; dorsal valve the more convex; no distinct fold or sinus; surface of each valve with 30 or more low simple rounded plications. Length 18 millimeters; width 16 millimeters. Abundant in the lower part of the Keyser limestone, of which it is characteristic.

Uncinulus gordoni Maynard.—Shell subpentagonal, small; ventral beak fairly prominent; dorsal valve much the more convex; surface of each valve with 19 to 26 subangular plications, three of which are depressed in the shallow ventral sinus and four are raised anteriorly to form a low dorsal prominence. Length 10 millimeters; width 9 millimeters. Several specimens were found in the upper part of the Keyser limestone.

Uncinulus nucleolatus (Hall).—Shell subpentagonal; ventral valve depressed convex; beak small, closely incurved; dorsal valve often gibbous. Surface with 15 to 20, usually 18 simple rounded plications; three to five depressed at the front of the ventral valve into a shallow sinus, which is continued into a short linguiform extension; a corresponding prominence on the dorsal valve. Length 14 millimeters; width 13 millimeters. Small specimens of this New Scotland form occur sparingly in the upper part of the Keyser limestone.

Uncinulus angulatus Maynard.—Shell subpentagonal; both valves depressed convex; surface with strong angular plications, of which there are said to be 23 in Maynard's description, although not more than 14 are indicated on the figured specimens; three plications depressed toward the front in a shallow ventral depression; a corresponding number on the dorsal prominence. Length 12 millimeters; width 9 millimeters. Several specimens in the upper part of the Keyser limestone, with 14 plications to the valve. Does not seem closely allied to *U. nucleolatus*, although it was originally described as a variety of that form.

Uncinulus abruptus (Hall).—Shell transversely oval to subpentagonal; ventral beak small, closely incurved; dorsal valve much the more convex. Surface with 25 to 33 simple subangular plications on each valve; six to eight depressed into a broad undefined sinus, and seven or eight elevated into a rather distinct dorsal prominence. Length 20 millimeters; width 24 millimeters. Common at the top of the Coeymans limestone and the base of the Becraft limestone in the Clifton Forge area, Virginia; also in New Scotland limestone.

Uncinulus pyramidatus (Hall).—Shell pyramidal, dorsal valve very gibbous, highest toward the front and declining toward the beak; cardinal slopes abruptly vertical, with a distinctly impressed suboval space beneath the beaks; surface with 13 to 22 simple strong subangular plications, four to six of which are somewhat elevated toward the front of the dorsal valve, forming a mesial prominence. Length 24 millimeters; width 23 millimeters; gibbosity of dorsal valve as much as 17 millimeters. One dorsal valve from the upper Becraft of Back Creek Mountain, Va., although suggestive in many ways of the *U. ventricosa* of the New York Becraft, agrees with *U. pyramidatus* in the presence of six plications on the mesial prominence and in that it is highest toward the front and flattened at the middle, rather than being nearly circular in vertical section.

Uncinulus vellicatus (Hall).—Shell subtrigonal to subovate; dorsal valve the more convex, gibbous; surface with 24 to 36 (usually 30) simple rounded plications, of which five to seven are depressed into a shallow indistinct sinus toward the front of the ventral valve and prolonged into an upward inflected lingual extension, while six to eight are slightly elevated at the front of the dorsal valve. Length 20 millimeters; width 22 millimeters. Occurs sparingly in the upper part of the Becraft limestone at Gala, Clifton Forge, and Healing Springs, Va. The specimens here included in *U. vellicatus* are somewhat narrower than is typical.

Eatonia medialis (Vanuxem) (pl. 8, fig. 12).—Shell transversely subquadrate, fairly large; hinge line very obtuse; ventral beak small, closely incurved; dorsal valve much the more convex; surface of each valve with 12 to 16 broad rounded plications, three of which are depressed to form the broad ventral sinus, with four on the mesial fold of the dorsal valve. Length 25 millimeters; width 28 millimeters. Abundant in the New Scotland limestone.

Eatonia peculiaris (Conrad) (pl. 8, figs. 16–18).—Shell longitudinally ovate, cardinal margins sloping rather abruptly from the beaks; ventral valve flattened, abruptly inflected along the cardinal slopes; toward the front, depressed into a broad rounded sinus, continued into a deflected linguiform extension; dorsal valve depressed convex toward the beak, rising into a high rounded mesial prominence toward the front; surface marked by fine radiating striae, with a stronger elevated one along the center of the mesial sinus. Length 20 millimeters; width 18 millimeters. Occurring throughout the Becraft limestone, but more abundant in the lower portion.

Rensselaeria mutabilis (Hall) (pl. 7, figs. 21–25).—Shell longitudinally subpentagonal, with a peculiar and characteristic outline; valves depressed convex, generally compressed toward the front border; ventral beak arched, pointed; surface with as many as 28 obscure radiating striae, which are usually obsolete in the upper part of the shell. Length 10 millimeters; width 9 millimeters. Locally abundant in the upper part of the Keyser limestone.

Rensselaeria cf. *R. aequiradiata* (Conrad) (pl. 8, figs. 19–21).—Shell subglobular, of medium size; dorsal valve somewhat the more convex; surface with 50 to 60 simple rounded fine plications, which become obsolete before reaching the beak. Length 18 millimeters; width 16 millimeters; thickness 12 millimeters. An abundance of fragmentary material, chiefly weathered pos-

terior halves of brachial valves, found at the base of the Becraft limestone in the Clifton Forge area, Virginia, agrees with this New York species in size and shape. The lateral and anterior margins were not seen, so the number and strength of the plications are unknown, and the determination is uncertain. Not *R. subglobosa*.

Rensselaeria subglobosa (Weller).—Shell subglobular, length a little greater than the breadth; pedicle valve a little the more convex; beak small, closely incurved; surface marked by 50 to 60 simple rounded plications, becoming obsolete toward the beak. Length 18 millimeters; width 16 millimeters; thickness 11 millimeters. Occurs sparingly in beds representing the upper part of the Becraft limestone on Back Creek Mountain, west of Warm Springs, Va.

Atrypa reticularis (Linné).—Shell subrotund; dorsal valve much the more convex, gibbous; surface with fine dichotomous rounded radiating striae, of which the Helderberg material carries about six in 5 millimeters along the anterior border. Length 26 millimeters; width 24 millimeters; thickness of adult 20 millimeters. Abundant in the lower and middle parts of the Keyser limestone; otherwise rare in the Helderberg group.

Spirifer modestus Hall (pl. 6, figs. 16, 17).—Shell small, transversely subellipsoidal; extremities rounded; ventral beak prominent, acutely pointed, incurved; sinus and elevation faint, undefined; distinct plications absent on the lateral slopes; surface with very faint concentric striae. Length 10 millimeters; width 12 millimeters; thickness 8 millimeters. Very abundant in the lower part of the Keyser limestone in many of the sections.

Spirifer modestus var. *plicatus* Maynard (pl. 6, figs. 18, 19).—Very similar to *S. modestus* proper but differing in its slightly larger size and in the presence of three or four indistinct plications on the lateral slope. Length 15 millimeters; width 19 millimeters. As this form is strictly identical in stratigraphic and geographic range with *S. modestus* proper, it should be considered consanguineous with that form.

Spirifer octocostatus Hall.—Shell transversely suboval; central beak moderately elevated, incurved; sinus subangular; surface with four or five rounded plications to the lateral slope; these are crossed by very fine, closely arranged, sublamellose striae. Length 20 millimeters; width 25 millimeters; thickness 13 millimeters. Occurs sparingly in the lower part of the Keyser limestone.

Spirifer vanuxemi var. *prognosticus* Schuchert.—Shell small; subsemicircular; moderately gibbous; extremities rounded; surface with five or six plications on the lateral slope, instead of only three or four, as in *S. vanuxemi* proper. Length 8 millimeters; width 10 millimeters. Profuse at the top of the Keyser limestone at Franklin, W. Va.

Spirifer perlamellosus Hall. —Shell of medium size, more or less extended on the hinge line; ventral beak prominent, incurved at apex; sinus and fold strongly developed; surface with three to six elevated plications on each lateral slope; the plications are crossed by strong imbricating lamellae, which are abruptly arched in passing over the plications. Length 17 millimeters; width 30 millimeters. Common in the New Scotland limestone; rare in the Coeymans limestone.

Spirifer perlamellosus var. *praenuntius* F. M. Swartz, n. var. (pl. 7, figs. 18–20).—Seven specimens found in the upper part of the Keyser limestone agree very closely with *S. perlamellosus*, except in their somewhat smaller size. There are generally three or four plications on the lateral slope. Although the plications are not less numerous than in some of the New Scotland material, and although there is close agreement in the strength of the plications and of the imbricating lamellae, it seems better to separate these earlier and somewhat smaller forms as a distinct variety. Length 12 millimeters; width 16 millimeters. Occurs sparingly in the upper part of the Keyser, from Big Mountain, W. Va., to Monterey, Va.

Spirifer cyclopterus Hall.—Shell semicircular, extremities rounded; ventral valve the more convex, often gibbous; ventral beak moderately elevated, incurved; sinus of medium depth, flat-bottomed; dorsal fold strongly elevated; surface with five to seven strong rounded plications on each lateral slope, and with fine, close concentric striae. Length 17 millimeters; width 26 millimeters. Common in the Coeymans, New Scotland, and Becraft limestones.

Spirifer macropleurus (Conrad) (pl. 8, fig. 9).—Shell very large, transversely semielliptical; valves almost equally convex; extremities blunt; generally with four broad rounded plication on each side of the strong rounded sinus and elevation; entire surface with distinct closely arranged radiating striae. Length 40 millimeters; width 65 millimeters. Profuse in the New Scotland limestone as far south as Warm Springs, Va.

Spirifer concinnus Hall (pl. 9, fig. 1).—Shell semicircular, of medium size; extremities rounded; ventral beak somewhat elevated, abruptly incurved at apex; sinus wide, subangular; dorsal fold obtusely angular; surface with 12 to 14 rounded simple plications on each lateral slope; best specimens show radial lines of minute interrupted granules. Length 21 millimeters; width 24 millimeters. Common throughout the Becraft limestone in the Clifton Forge area, Virginia.

Spirifer concinnus var. *progradius* F. M. Swartz, n. var. (pl. 9, figs. 2–5).—Shell transversely subsemielliptical, cardinal angles more or less rounded; ventral valve most convex toward the beak; beak somewhat elevated, apex incurved; cardinal area of medium size, extending to the extremities of the hinge line; mesial sinus fairly broad, rounded, of moderate depth; surface with about 16 simple, rounded, little elevated plications on each lateral slope; the plications become obsolete in the region of the cardinal extremities, no trace of any plications being seen on these areas in the specimens at hand; dorsal valve not observed. Length 23 millimeters; width 40 millimeters. The general aspect of this species is that of *S. concinnus*, of which it is evidently a derivative. It differs from that form in its larger size and more transverse outline and particularly in its somewhat more numerous, relatively narrower plications. The finer surface detail is not preserved on the specimens seen, but is most likely that of *S. concinnus*. Occurs sparingly at the top of the Becraft limestone in the Clifton Forge area, Virginia.

A number of specimens occurring with the type material of *S. concinnus* var. *progradius* at the top of the Becraft limestone present the same expression but differ in the subangulation of the ventral mesial sinus, and also in the development of a faintly suggested plication on each side of the sinus, in the anterior half of the valve. The latter feature is seen in some of the Spirifers of the New York Becraft, which Hall included in *S. concinnus* but which Schuchert has separated as *S. proavitus*. However, as the Virginian specimens agree with *S. concinnus* var. *progradius* rather than with *S. proavitus* in size, in the width of the plications, and in the obsolescence of the plications toward the cardinal extremities, they are retained with the former species.

Spirifer angularis Schuchert (pl. 9, fig. 6.)—Shell transversely semielliptical; ventral beak moderately elevated, somewhat incurved; area of medium height; mesial sinus deep, angular; dorsal fold sharply elevated, angular. Surface with seven to nine elevated subangular plications to the lateral slope. Length 20 millimeters; width 35 millimeters. One specimen from the top of the Becraft limestone at Gala, Va., agrees closely with Schuchert's description of the type material from the Ridgeley sandstone of Maryland.

Spirifer arenosus var. *planicostatus* F. M. Swartz, n. var. (pl. 9, figs. 13–15).—Shell very large, semielliptical to subquadrate, extremities rounded; valves almost equally convex; ventral beak moderately elevated, incurved at the apex; area

fairly high, extending to the extremities of the hinge line; mesial sinus of ventral valve gradually expanding, fairly wide, rather shallow, rounded; mesial elevation of the dorsal valve pronounced, broad, rounded, not sharply defined; surface with about 15 broad, low, very flat plications to the lateral slope; the intervening sulci are very narrow, angular, and of but little depth; the mesial fold and sinus are also plicate, carrying five or six plications similar to those of the lateral slopes; the plications are less numerous in the posterior portions of the fold and sinus, addition resulting from dichotomous division, as in *S. arenosus* proper. Maximum length 54 millimeters; maximum width 80 millimeters. This form differs from the *S. arenosus* of the Ridgeley sandstone farther north chiefly in the very flat plications; the plications of *S. arenosus* are rounded or even subangular. The cardinal angles also seem to be somewhat more definitely rounded and somewhat flatter. Abundant in the dark cherts and interbedded sandstones in the upper part of the Giles formation on Tumbling Creek, near Saltville, Va.

Cyrtina dalmani (Hall) (pl. 7, figs. 4–7).—Shell small, transverse; ventral valve pyramidal; beak simple, angular, not incurved; area high, flat or nearly so; foramen narrow. Dorsal valve depressed convex, beak scarcely elevated. Surface with five to seven plications to the lateral slope, crossed by strong imbricating concentric lamellae. Length 10 millimeters; width 14 millimeters; ventral area 5 to 7 millimeters in height. Rare in the middle of the Keyser limestone at Big Mountain, W. Va., and Monterey, Va.

Cyrtina varia Clarke.—Shell of moderate size; ventral valve pyramidal; beak angular, not incurved; area high, nearly flat; foramen narrow; dorsal valve depressed convex, beak scarcely elevated; surface with 7 to 10 plications on the lateral slope, crossed by concentric striae, which are not prominent on the specimens seen. Length 9 to 15 millimeters; width 18 to 23 millimeters; area 8 to 12 millimeters in height, forming an angle of 80° to 85° to the plane between the two valves. Occurs sparingly in beds representing the upper part of the Becraft on Back Creek Mountain, west of Warm Springs, Va.

Rhynchospira globosa (Hall).—Shell small, globose; ventral valve more convex than the dorsal; beak prominent, arched, perforated at the extremity by a round aperture; surface of each valve with 12 to 16 somewhat angular plications, of which two or three are slightly depressed along the middle of each valve. Length 11 millimeters; width 11 millimeters. Occurs sparingly in the lower part of the Keyser limestone.

Rhynchospira formosa (Hall).—Longitudinally subovate; ventral beak arched, tapering; dorsal valve the more gibbous; surface of each valve with 18 to 22 simple rounded plications, of which two or three are smaller and are slightly depressed along the median line of each valve. Rare in the lower part of the Keyser limestone.

Trematospira equistriata Hall and Clarke.—Shell transversely oval, of medium size; valves about equally convex; ventral beak only slightly extended beyond the dorsal valve, incurved; ventral sinus small; dorsal fold obsolete; surface with fine, simple radial plications, of which there are six plications on the sinus and 23 on each side. Occurs sparingly in the New Scotland limestone, to which it is restricted.

Nucleospira swartzi Maynard (pl. 6, figs. 13–15).—Shell subcircular, slightly transverse, hinge line shorter than greatest width of the shell; ventral valve somewhat the more convex, beak somewhat elevated, strongly incurved over that of the dorsal valve; valves without distinct mesial depressions, although these may be very faintly developed in some specimens; surface with very faint concentric growth lines and some stronger growth varices. Length 15 millimeters; width 16 millimeters. Abundant in the lower part of the Keyser limestone, *Stenochisma deckerensis* subzone.

Nucleospira ventricosa (Hall).—Shell globose, valves almost equally convex, very small; ventral valve with a narrow sinus from beak to front along medial line, while the median depressed line of the dorsal valve is nearly obsolete; ventral beak the more prominent, pointed, strongly incurved. Surface with some concentric growth lines. Length 8 millimeters; width 9 millimeters. Occurs in the Coeymans limestone and is abundant at the top of the Keyser limestone at Monterey and McDowell, Va.

Whitfieldella minuta Maynard (pl. 6, figs. 3, 4).—Shell minute, longitudinally subovate; both valves strongly convex; ventral beak prominent, pointed, incurved; no fold or sinus on either valve; surface smooth or marked by obscure concentric growth lines. Length 3 millimeters; width 2 millimeters. Abundant at the base of the Keyser limestone, to which it is restricted.

Whitfieldella? prosseri Grabau.—Shell elongate, oval to subpentagonal; ventral valve somewhat the more convex, gibbous; beak prominent, strongly incurved, with a faint longitudinal depression, enlarging somewhat toward the front and truncating the anterior margin; surface smooth except for some faint concentric striae and a few stronger growth lamellae, developed near the front. Length 20 millimeters; width 15 millimeters. Abundant at the top of the Keyser limestone at Franklin, Va.; rarer at the same horizon at McDowell, Va.

Meristella praenuntia Schuchert (pl. 7, figs. 12–15).—Shell ovoid, variable as to relative length and width; ventral valve much the more convex, gibbous in the unbonal region; beak strongly incurved, a mesial sinus more or less developed in the anterior part of the valve; dorsal valve often with a linear median depression toward the front; surface smooth. Length 19 millimeters; width 18 millimeters. Common to abundant in the upper part of the Keyser limestone. A forerunner of *M. arcuata* of the Coeymans and New Scotland limestones.

Meristella nasutaformis F. M. Swartz, n. sp. (pl. 7, figs. 16, 17).—Shell longitudinally ovoid; fairly large; greatest width a little front of the middle. Ventral valve convex to gibbous, arched toward the beak, which is closely incurved over that of the opposite valve; the anterior margin prolonged into a gently raised, very broad nasute extension, marked centrally by a narrow linear depression; this raised portion is continued to the middle of the valve, where it merges into the general convexity of the valve. The brachial valve in this specimen is crushed and broken, but the small incurved beak, fitting closely beneath the ventral beak, and interior median septum of the posterior half are shown. Surface with obscure lines of growth. Length 28 millimeters; width 25 millimeters. The one specimen came from about the middle of the Keyser limestone at Big Mountain, W. Va. It is sharply differentiated from the other Meristellas of the Keyser by its large size and from those of the Helderberg group in general by the nasute extension. *M. nasuta*, of the Schoharie grit of New York, also possesses a ventral nasute extension, but it is narrower and lacks the median depression seen on the Keyser specimen. *M. nasutaformis* should be regarded as a development from those members of *M. praenuntia* whose ventral valves have fairly strong plications on each side of a narrow median depression, such as is suggested by the larger of the two specimens figured in this report. It does not seem to have been ancestral to any of the later Meristellas described from the Appalachian areas.

Meristella arcuata (Hall) (pl. 8, figs. 1–4).—Shell large, broadly ovate; ventral valve gibbous in the central and umbonal regions; beak incurved, fairly prominent; a shallow rounded depression at the front of this valve; dorsal valve often abruptly elevated along the middle and sloping laterally but without a distinct fold; surface smooth. Length 20 millimeters; width 29 millimeters. Common to abundant in the Coeymans and New Scotland limestones; very abundant at the top of the Coeymans limestone in the Monterey and Clifton Forge area, Virginia; also seen just beneath the sandstones of the middle of the Giles formation at Rocky Gap, Va.

Meristella arcuata var. *gigas* F. M. Swartz, n. var. (pl. 8, figs. 5–7).—Associated with the normal *M. arcuata* of the top of the Coeymans limestone at Monterey and Bolar, Va., are some individuals reaching in maturity 40 millimeters in length. These are longitudinally oval, with the greatest width just in front of the middle. The ventral valve is highly convex and arcuate in the umbonal region, the beak is rather prominent and incurved, and there is a rather narrow, shallow sinus extending from the anterior border about halfway to the beak. The growth lines show that in the more youthful stages this form exhibited all the features of the typical *M. arcuata*, with the breadth about equal to the width. Surface with a few distinct growth lines. The interior features are those of *M. arcuata*. Length 40 millimeters; greatest width 35 millimeters.

Meristella cf. *M. symmetrica* Schuchert (pl. 8, fig. 8).—Shell almost circular; valves regularly and almost equally convex; no fold or sinus on either valve; surface with some concentric growth lines. Length 50 millimeters; width 50 millimeters. One specimen, with the dimensions stated, agrees with Schuchert's description of this Oriskany species. At the top of the Coeymans limestone at Monterey, Va.

Meristella lata (Hall) (pl. 9, figs. 8, 9).—Shell subquadrate to longitudinally ovate; ventral valve gibbous in the middle, with a shallow depression in front; beak elevated and closely incurved over the opposite; dorsal valve abruptly elevated in the middle, forming a rather prominent dorsal ridge. Length 30 millimeters; width 28 millimeters. Occurs sparingly in the Becraft limestone.

Merista typa (Hall) (pl. 7, figs. 1–3).—Shell longitudinally subovate; subglobose; ventral valve much the larger. The interior of the ventral valve has a more or less highly arched transverse septum, which, rising from beneath the rostral cavity, extends forward nearly to the middle of the valve. This "shoe-lifter process" is commonly seen on the weathered interiors and is very distinctive. Length 25 millimeters; width 21 millimeters. Profuse at about the middle of the Keyser limestone, just above the *Gypidula* zone, forming a distinct subzone, to which it is restricted.

PELECYPODA

Actinopteria cf. *A. reticulata* Weller.—Left valve large, subrhomboidal; body subovate, with an obliquity of 27° between the hinge line and the umbonal region; surface with conspicuous concentric lines of growth, and more or less dicontinuous radiating costae, giving the upper portion of the shell, where the lines are strongest, a nodose appearance. Height 35 millimeters; length of hinge line 29 millimeters; oblique diameter from beak to posterolateral extremity 48 millimeters. One fragmental specimen, found in the upper part of the Keyser limestone at Little Mountain, Va.

Cypricardinia cf. *C. lamellosa* Hall.—Shell subovoid; gibbous; umbones slightly elevated; posterior slope prominent, with a scarcely defined ridge; surface with strong elevated distant lamellae. Length 12 millimeters; height 8 millimeters. One specimen from the middle of the Keyser limestone at Monterey, Va.

GASTROPODA

Straparollus welleri F. M. Swartz, n. name (cf. *Straparollus* sp. Weller, Paleontology of New Jersey, vol. 3, p. 246, pl. 22, fig. 14, 1903).—Shell consisting of four or five volutions, very gradually expanding; shell plane above, with a broad umbilicus below, in which all the volutions are visible; surface features uncertain, although the shell seems to have been essentially smooth. Diameter of shell 25 millimeters; of body whorl 5 millimeters. One incomplete specimen from the lower part of the Keyser limestone on Big Mountain, W. Va.

Platyceras gibbosum Hall.—Spire small, of one or two closely coiled volutions; body volution very rapidly expanding, highly ventricose below, free; surface marked by fine, undulating, transverse striae. Diameter of shell 35 millimeters; of aperture 28 millimeters. One specimen from the Coeymans limestone at Monterey, Va.

Platyceras multiplicatum F. M. Swartz, n. sp. (pl. 7, figs. 31, 32).—Shell large, obliquely subovate, composed of three or four volutions, somewhat gradually expanding, with the last volution free near the aperture; flattened on the upper side, somewhat ventricose below; spire closely coiled, rising slightly above the plane of the body whorl; aperture unknown; surface with eight or more strong longitudinal plications, which are crossed by fine, obscure, closely arranged transverse striae. Diameter of shell 60 millimeters; of whorl near aperture 35 to 40 millimeters. This species is somewhat similar to *P. multisinuatum*, of the New Scotland limestone of Maryland and New York, but differs from that species in its larger size and in the more numerous longitudinal plications, which are continued farther toward the apex and occur on the lower as well as the upper and outer sides of the whorls. Common in the Coeymans limestone at Bells Valley and McDowell, Va. One fragment from the sandstones of the middle part of the Giles formation at Hollybrook, Va., is referred with some doubt to this species.

Platyceras gebhardi Conrad.—Shell of four gradually expanding volutions, which are contiguous, except the last one near the aperture; apex in the plane of the outer whorl; body whorl becoming ventricose; aperture expanded; surface with fine transverse undulating striae; shell occasionally carinate along the dorsolateral curvature. Diameter 40 millimeters. Common in the New Scotland limestone; rare in the Becraft limestone.

Tentaculites gyracanthus (Eaton).—Shell elongate conical, gradually tapering to the apex; surface with smooth rounded annulations, at irregular intervals, with about three in 1 millimeter; interspaces between annulations with fine annual striae. Length 5.5 millimeters; diameter 0.7 millimeter. Profuse near the top of the Keyser limestone at Petersburg, W. Va.; this subzone, which is prominent in Maryland and Pennsylvania, disappears south of Petersburg.

CEPHALOPODA

Orthoceras cf. *O. rigidum* Hall.—Shell of medium size, elongate, gradually tapering; cross section circular; siphuncle central; septa closely spaced, moderately convex, about six in a space equal to the diameter of the tube; surface with fine transverse striae; apical angle 10°. The specimens found are small, with diameter toward the aperture as great as 20 millimeters. Occurs sparingly near the base of the Keyser limestone.

TRILOBITA

Proetus protuberans Hall.—Pygidium semicircular; axis very prominent, nearly one-third the width of the pygidium, with eight annulations; lateral lobes with four or five segments, which are grooved and do not reach the margin, leaving a fairly broad border. Length 10 millimeters; width 18 millimeters. Several pygidia from the lower part of the Keyser limestone agree with Hall's description of this New Scotland trilobite. Reeside has also described *P. protuberans* from the lower Keyser in Pennsylvania.

Calymene camerata Conrad.—Pygidium with prominent axis, which is about one-fifth the width of the pygidium and carries eight annulations; the axis tapers gradually to the obtusely rounded extremity lying well within the posterior margin; lateral lobes with six broad ribs, which are strongly bent downward and are bifurcated toward the margins by deep longitudinal grooves. Length 14 millimeters; width 20 milli-

meters. One pygidium found in the basal part of the Keyser limestone at Clifton Forge, Va.

Phacops logani Hall.—Cephalon semicircular; genal angles obtuse; glabella subpentagonal, very prominent in front, projecting somewhat beyond the frontal limb; upper surface convex to gibbous, highly pustulose; lateral furrows undefined; occipital furrow strong; eyes fairly large. Occurs sparingly at the base of the Becraft limestone at Gala and Bells Valley, Va.

Dalmanites pleuroptyx (Green).—Pygidium triangular, convex, posterior extremity extended in a caudal spine; axis prominent, well defined, one-fifth the width of the pygidium in front, gradually tapering to the rounded extremity; annulations 17; lateral lobes with 11 to 13 ribs, which are bent backward. Length 45 millimeters; width 60 millimeters. One specimen from the Coeymans limestone at Petersburg, W. Va.; a second from the middle of the Becraft limestone at Dry Run, Va. Two specimens obtained above the middle of the Shriver (?) chert at Back Creek Mountain, Va., seem to belong to this species.

Dalmanites sp.—Fragments of several pygidia in beds representing the upper part of the Becraft limestone on Back Creek Mountain, west of Warm Springs, Va., show agreement with the pygidia of *Dalmanites dentatus* Barrett in the general shape of the shield, in the strong grooving of the pleurae, in the lack of a conspicuous marginal border, apparently in the width of the axis, and in the presence of a row of pronounced tubercles on either side of the groove of the pleurae. These tubercles are, however, smaller and more numerous, there being as many as 10 in a row, rather than 5, the average number seen on specimens of *D. dentatus* from the lower part of the Oriskany sandstone at Nearpass, N. J. The surface is granulose near the margins. This species should probably[6] be considered intermediate and transitional between *D. pleuroptyx* and *D. dentatus*.

OSTRACODA

Kloedenia smocki (Weller).—Shell subelliptical; hinge line straight, with a narrow margin set off by a narrow furrow; valves divided into three lobes each; two vertical furrows bending toward each other at their lower extremities; posterior furrow somewhat the longer, reaching slightly below the middle of the valve; subcentral in position; surface smooth. Common near the top of the Keyser limestone at Big Mountain, W. Va.

LOCAL SECTIONS OF THE HELDERBERG GROUP

[The numbers of the following sections correspond to those showing locations on Figure 6. In the lists of fossils striking profusion or great rarity is indicated by the symbol "aa" or "r," respectively, after the name of the fossil concerned; otherwise the species will be found readily enough, at least after some search. A number after the name of a fossil indicates feet above the base of the unit and means that within the unit the species is very profuse at or is restricted to that horizon]

1. *Section near Petersburg, W. Va.*

[This section is to be seen about 2½ miles east of Petersburg, W. Va., along the road to Moorefield, in the east end of the gap of the South Branch of the Potomac, where the Helderberg beds are brought up in the eastern limb of a low anticline. The base of the exposure is about 105 feet west of the Hardy-Grant County boundary marker; the New Scotland is exposed along the road 800 feet east of the county line and 280 feet west of the bridge by which the highway crosses the South Branch; and the Shriver-Ridgeley contact is about opposite the bridge. The measurements of the Ridgeley and Shriver are only approximate]

	Feet
Oriskany group:	
Ridgeley sandstone:	
Medium to thick bedded hard gray sandstone	50
Concealed along road; some sandstone on hill	70
Thick-bedded to massive calcareous gray sandstone	60
Concealed	25
Thin to medium bedded calcareous gray sandstone; middle part concealed	60
Oriskany group—Continued.	
Shriver chert:	
Concealed	10
Hard black chert, bedded, and some interbedded sandstone; *Anoplotheca flabellites, Spirifer* sp.	50
Mostly concealed; some bedded black chert 80 and 110 feet above base	125
Helderberg group:	
New Scotland limestone:	
Thin-bedded shaly limestone. *Spirifer macropleurus, S. cyclopterus*	3
Medium to thick bedded hard blue limestone, with much interbedded white chert. *Streptelasma strictum, Dalmanella perelegans, Leptaena rhomboidalis, Strophonella undaplicata, Schuchertella woolworthana, Spirifer macropleurus, S. perlamellosus* (r)	30
Coeymans limestone: Thick-bedded to massive hard crystalline crinoidal gray limestone, grading into the overlying cherty limestone of the New Scotland but separated more abruptly from the underlying Keyser. *Leptaena rhomboidalis, Schuchertella woolworthana,* and *Meristella arcuata* (aa), all in upper 3 feet; *Gypidula coeymanensis* (aa), 9; *Dalmanites pleuroptyx* (r)	19
Keyser limestone:	
Upper limestone member:	
Hard dark-blue thick-bedded, somewhat nodular limestone. Chaetetoid Bryozoa (aa), 16; *Tentaculites gyracanthus* (aa), 12–14; *Schuchertella prolifica* (aa), 3	26½
Medium-bedded hard blue limestone	8½
Thick-bedded hard blue, partly crystalline limestone; weathered surfaces rutted. *Strophonella keyserensis* (r)	16½
Nodular impure limestone, partly concealed. *Mariacrinus* sp. (r), Bryozoa, *Schuchertella prolifica*	6½
Concealed	4
Band of hard gray limestone	½
Nodular impure shaly limestone. *Meristella praenuntia,* 5	6½
Band of hard gray crystalline limestone	½
Nodular impure limestone, partly concealed. *Camarotoechia* cf. *C. altiplicata,* Bryozoa	11
Heavy-bedded hard nodular blue limestone	6½
Concealed	9
Thick-bedded hard grayish, somewhat crystalline limestone; a few chert nodules toward center. *Stromatopora* reef near center	14
Nodular impure limestone. *Dalmanella concinna* (aa)	3½
Massive gray, somewhat crystalline limestone, weathering yellow. *Atrypa reticularis* (aa)	5
Thick-bedded hard dark-blue limestone. Chaetetoid Bryozoa, 2	9½
Nodular impure limestone	6
Hard blue limestone	2
Concealed	3
Hard blue fossiliferous limestone. *Merista typa* (aa), *Strophonella keyserensis* (r), *Leptaena rhomboidalis*	2
Somewhat nodular blue limestone; this unit is largely concealed along the roadside but may be seen on the slope above. *Gypidula coeymanensis* var. *prognostica* and *Camarotoechia gigantea* in lower 2 feet	9

Helderberg group—Continued.

	Feet
Keyser limestone—Continued.	
Big Mountain shale member: Concealed; some shale fragments seen in upper part	28
Lower limestone member:	
Hard nodular fine-grained limestone. Unfossiliferous	10
Concealed; probably shale	13
Thick-bedded pearly-gray crystalline crinoidal limestone	15½
Blue, somewhat crinoidal limestone	3⅗
Massive impure, very nodular limestone, weathering into grayish lumpy masses, with a somewhat cross-bedded appearance. *Chonetes jerseyensis, Atrypa reticularis, Stenochisma deckerensis,* and *Uncinulus convexorus* are more or less abundant throughout	15
Massive nodular hard fine-grained blue limestone. *Stenochisma deckerensis, Spirifer octocostatus* (r)	23
Thin-bedded blue, somewhat crystalline limestone, with gray calcareous shale at top and bottom. *Favosites* sp., *Cyphotrypa corrugata, Rhipidomella emarginata, Camarotoechia litchfieldensis* (aa), *Whitfieldella minuta* (aa), *Rhynchospira globosa*(?)	11
Hard blue fine-grained limestone	2
Tonoloway limestone:	
Thin-bedded gray calcareous shale	7
Laminated blue limestone, weathering into plates	2
Thin-bedded soft calcareous shale	5
Concealed to western limb of anticline.	

2. *Section in field just north of road to Moorefield, about 4 miles west of Wardensville, W. Va.*

[The section can be located by the prominent exposure of the Ridgeley sandstone, which dips steeply to the west and then is followed, in succession, by the Helderberg, Tonoloway, and Wills Creek, the lower half of the Tonoloway and the entire Wills Creek are well exposed along the roadside]

	Feet
Oriskany group: Ridgeley sandstone: Massive calcareous sandstone, weathering yellowish	275±
Helderberg group:	
Concealed. Some white chert fragments found at the middle of this interval apparently represent the New Scotland, as they contain large strophonellids and a fragmental *Spirifer* which is perhaps *S. macropleurus.* Whether the New Scotland is overlain in this section by the Becraft or the Shriver chert (Oriskany) is uncertain	95
Keyser limestone (probably should include basal portion of overlying interval).	
Upper limestone member:	
Dark-gray fine-grained limestone	5
Nodular shaly limestone, with some interbedded shale. *Merista typa, Atrypa reticularis*	19
Dark-blue limestone, with a chaetetoid Bryozoa zone. *Merista typa?*	4
Big Mountain shale member:	
Calcareous greenish shale and some impure interbedded limestone	8
Shaly limestone. *Spirifer modestus*	4
Calcareous greenish shale	33
Lower limestone member:	
Massive dark-blue limestone	17
Shaly nodular limestone and some calcareous shale	14
Tonoloway limestone, excellently exposed in the field and along the highway.	

3. *Section in gap of Trout Run about 3 miles south of Wardensville, W. Va.*

[The Ridgeley sandstone is exposed at the west end of the gap, the beds dipping to the west. The Helderberg is exposed along the banks of the creek]

	Feet
Oriskany group: Ridgeley sandstone: Massive gray quartzitic sandstone; lower beds softer	275
Helderberg group:	
Upper part of Helderberg (Becraft, New Scotland, Coeymans):	
Massive dense, somewhat impure limestone, containing interbedded black chert. Probably Becraft	7½
Concealed	24
Massive dark, somewhat crinoidal limestone, containing fragmental fossils, possibly *Gypidula.* Coeymans?	1½
Concealed	28
Very massive dark-blue limestone	3
Massive gray, highly crinoidal crystalline limestone. All or part of this unit may belong in the Keyser	15
Keyser limestone (top doubtful):	
Upper limestone member:	
Lumpy drab-gray limestone	9
Concealed	8
Lumpy dark-blue limestone	8
Concealed	10
Massive gray crinoidal limestone	3
Concealed	9
Massive gray crinoidal limestone	2½
Impure lumpy limestone	9
Big Mountain shale member: Shaly limestone to calcareous shale	38
Lower limestone member:	
Massive gray crinoidal limestone	23
Lumpy impure grayish limestone. *Uncinulus convexorus* (aa) throughout, *Spirifer modestus*	16
Tonoloway limestone: Thin-bedded platy limestone.	

4. *Section at Fawcetts Gap, Little North Mountain, near Marlboro, Va.*

[The section is exposed at west end of gap, on slope above the county road running north from the road from Marlboro to Star Tannery]

	Feet
Romney shale: Somewhat fissile brownish shale.	
Concealed (Romney shale?)	30
Helderberg group:	
Becraft limestone:	
Massive arenaceous gray limestone with much interbedded black chert. Probably Becraft	9
Concealed	14½
Gray limestone, some chert	3½
New Scotland limestone: Massive gray crystalline limestone, with a few lenses of chert. *Dalmanella perelegans, Spirifer macropleurus, Meristella arcuata* (aa)	10
Keyser limestone (the upper crystalline beds may belong to the Coeymans limestone; division of the Keyser into the members recognized elsewhere is not feasible):	
Gray crystalline limestone, weathering thin-bedded. Possibly Coeymans rather than upper Keyser	14
Massive gray crinoidal limestone	8

Helderberg group—Continued.
Keyser limestone—Continued.

	Feet
Thick-bedded dark-blue limestone, weathering somewhat nodular	25
Medium-bedded gray crinoidal limestone; coral zone at top. *Stenochisma deckerensis*	5

Tonoloway limestone: Platy limestone, shaly above.

5. *Section on Big Mountain, W. Va.*

[The Helderberg group is well exposed on Big Mountain along the county road running through the gap of the South Fork of the Potomac. The section is in the eastern limb of the Big Mountain anticline and is about 1½ miles west of Upper Tract, a small settlement on the highway to Franklin, about 17 miles south of Petersburg, W. Va.]

	Feet
Oriskany group:	
Shriver chert:	
Concealed. The measurement to the first exposures of the Ridgeley sandstone is unsatisfactory but could be obtained in the western limb of the anticline.	
Bedded black chert, weathering buff; layers 4 to 6 inches thick	45
Concealed	6
Bedded black chert, weathering buff; the lower half is largely concealed	70
Helderberg group:	
New Scotland limestone:	
Thin-bedded, somewhat shaly limestone, with some interbedded white chert. *Spirifer macropleurus*	16½
Thick-bedded limestone with much interbedded white chert. *Hindia sphaeroidalis, Streptelasma strictum* (aa), and *Spirifer macropleurus* (aa) in all but the lower 2 feet or so. *Dalmanella perelegans, Leptaena rhomboidalis, Schuchertella woolworthana,* and *Meristella arcuata* (aa), throughout	20½
Coeymans limestone: Thick-bedded to massive hard somewhat crystalline gray crinoidal limestone. *Orthostrophia strophomenoides* (r), *Rhipidomella oblata, Schuchertella woolworthana,* and *Uncinulus abruptus* (r) near top; *Spirifer cyclopterus* and *Meristella arcuata* (aa) throughout; *Gypidula coeymanensis* (r) near middle	24
Keyser limestone:	
Upper limestone member:	
Thin to medium bedded hard bluish-gray, somewhat crinoidal limestone. *Camarotoechia* cf. *C. altiplicata; Kloedinia smocki,* 13	44½
Thick-bedded hard blue crinoidal limestone. *Camarotoechia* cf. *C. altiplicata, Schuchertella prolifica, Rensselaeria mutabilis* (r), 4	13½
Shaly impure limestone, partly concealed. *Schuchertella prolifica*	10
Thick-bedded hard bluish-gray, somewhat crinoidal limestone. *Meristella praenuntia* (aa), 14; *Stromatopora,* 10; chaetetoid Bryozoa	19
Thin-bedded shaly limestone, with several beds of gray crinoidal limestone. Many Bryozoa near top	21

Helderberg group—Continued.
Keyser limestone—Continued.
Upper limestone member—Continued.

	Feet
Thin to medium-bedded gray, somewhat crinoidal limestone; the weathered surfaces have a peculiar rutted appearance. *Cyrtina dalmani* (r), 20; *Stromatopora* (aa), 18; Bryozoa; *Merista typa* (aa), 4–6; *Gypidula coeymanensis,* 4; *Meristella nasutaformis* (r), 1	21
Big Mountain shale member:	
Thin-bedded greenish shale, with some beds of very impure lumpy limestone. *Dalmanella concinna, Leptaena rhomboidalis* (r), *Chonetes jerseyensis, Atrypa reticularis, Orthoceras rigidum* (r)	25
Impure lumpy limestone	7
Thin-bedded greenish shales	9
Lower limestone member:	
Gray, somewhat crystalline limestone. *Chonetes jerseyensis, Schuchertella deckerensis, Uncinulus convexorus*	14
Blue, very nodular limestone. *Cyphotrypa corrugata, Dalmanella concinnus, Stropheodonta bipartita, Chonetes jerseyensis, Stenochisma deckerensis, Uncinulus convexorus, Atrypa reticularis, Spirifer modestus, S. modestus* var. *plicatus, Nucleospira swartzi, Straparollus welleri* (r), *Orthoceras rigidum* (?) (r), *Proetus protuberans*	15
Hard blue nodular limestone, partly concealed. *Rhipidomella emarginata, Chonetes jerseyensis, Stenochisma deckerensis,* and *Uncinulus convexorus,* all in the upper half of the unit. *Camarotoechia litchfieldensis* and *Whitfieldella minuta* in lower 5 feet	29
Thin-bedded blue limestone, weathering yellow	7½
Hard blue somewhat crinoidal limestone. *Cyphotrypa corrugata*	4½
Hard blue fine-grained somewhat nodular limestone	3
Tonoloway limestone:	
Thin-bedded laminated blue limestone	1½
Concealed. The Tonoloway is well exposed in the western limb of the anticline, where it can be seen along the roadside.	

6. *Section near Franklin, W. Va.*

[This section is exposed on the south end of the Pond Range, along the State highway to Circleville, W. Va., about 4 miles west of Franklin. It is in the eastern limb of a large anticline that brings up the Tuscarora sandstone farther west. The Helderberg group is for the most part concealed along the immediate roadside but is almost continuously exposed on the slope above the road]

	Feet
Oriskany group:	
Ridgeley sandstone: Thick-bedded gray sandstone.	
Shriver chert:	
Bedded black chert, partly concealed	105
Concealed	45

Helderberg group:	Feet
New Scotland limestone: Thick-bedded to massive limestone, with much interbedded white chert. *Hindia sphaeroidalis, Streptelasma strictum* (aa), *Dalmanella perelegans, D. eminens* (r), *Leptaena rhomboidalis, Schuchertella woolworthana, Eatonia medialis, Spirifer perlamellosus* (r), *S. cyclopterus, S. macropleurus* (aa), *Trematospira equistriata, Meristella arcuata*	22
Coeymans limestone: Massive gray crystalline crinoidal limestone, more or less transitional with the overlying New Scotland. *Meristella arcuata* (aa), near top; *Schuchertella woolworthana; Gypidula coeymanensis* at middle	20
Keyser limestone:	
Upper limestone member:	
Very arenaceous limestone, weathering thin-bedded. This bed might be placed at the base of the overlying Coeymans. *Spirifer vanuxemi* var. *prognosticus* (aa) and *Whitfieldella prosseri* (aa), 7	10
Thin-bedded argillaceous limestone, somewhat concretionary. *Schuchertella prolifica, Spirifer vanuxemi* var. *prognosticus; Whitfieldella? prosseri*	4
Thick-bedded to massive gray, coarsely crystalline crinoidal limestone. *Cladopora rectilineata,* 45 to 50; *Mariacrinus?* sp. (aa), 50; *Camarotoechia* cf. *C. altiplicata,* 16 and above; *Rensselaeria mutabilis* (aa), 16; *Uncinulus keyserensis* (r); *Uncinulus nucleolatus* (r)	70
Thick-bedded gray crystalline limestone, forming a series of small cliffs on the hillside. *Stromatopora*—coral reef near top; *Cladopora rectilineata,* 2 and 32; *Camarotoechia* cf. *C. altiplicata,* 22; *Uncinulus nucleolatus* (r), 22; *Rensselaeria mutabilis,* 22	36
Medium-bedded gray, somewhat crystalline limestone, mostly concealed	18
Massive pearly-gray crystalline limestone, forming a series of small cliffs. *Stromatopora* bed, 28	32
Medium to thick-bedded, somewhat crystalline gray limestone, weathering more readily than the overlying beds. *Gypidula coeymanensis* var. *prognosticus* (aa), *Camarotoechia gigantea* (aa), *Atrypa reticularis* (aa), and *Merista typa* (aa), all in the lower 6 feet. *Merista typa,* however, ranges a little higher than the three other species, and the Gypidulas are practically confined to the basal foot or so	12
Big Mountain shale member: Soft yellowish shale, concealed for the most part	45
Lower limestone member:	
Crystalline crinoidal limestone, weathering thin-bedded	6
Massive dark-blue, very nodular limestone. *Cyphotrypa corrugata, Dalmanella concinna* (r), *Stropheodonta bipartita, Chonetes jerseyensis, Stenochisma deckerensis, Uncinulus convexorus, Spirifer modestus, S. modestus* var. *plicatus, S. octocostatus.* The above fossils are not as abundant here as they are in the equivalent beds in most of the other sections	28

Helderberg group—Continued.	
Keyser limestone—Continued.	
Lower limestone member—Continued.	Feet
Thick-bedded blue limestone. This bed should probably be considered the base of the Keyser, although it was not seen in contact with the underlying Tonoloway	6

7. *Section near Fulks Run, Va.*

[A fine exposure of the Lower Devonian can be seen along the highway from Broadway, Va., about half a mile west of the Fulks Run store and post office]

	Feet
Oriskany group: Ridgeley sandstone: Massive calcareous sandstone	100+
Shriver chert:	
Bedded black chert, matrix sandy	7
Bedded black chert, largely concealed	43
Sandy, impure limestone, with some black chert. The character of this unit suggests that it should be considered transitional with the Becraft limestone	6
Helderberg group:	
New Scotland limestone:	
Drab shale, partly concealed	3½
Limestone with some interbedded dark-colored chert. *Spirifer macropleurus, Meristella arcuata*	13½
Keyser limestone (including beds of age of the Coeymans limestone?):	
Upper limestone member:	
Concealed. Any beds of Coeymans age would lie in the upper part of this interval	85
Impure, somewhat nodular limestone	4
Concealed	8
Calcareous sandstone, weathered buff	1
Impure shaly limestone above to calcareous shale below	14
Massive crinoidal limestone. *Merista typa*	3
Big Mountain shale member:	
Concealed; probably shale	21
Nodular blue limestone	1½
Greenish shaly limestone and calcareous shale	16½
Lower limestone member:	
Massive crinoidal limestone	3
Greenish shaly limestone. *Chonetes jerseyensis*	15
Massive crinoidal limestone	17
Tonoloway limestone: Blue platy limestone.	

8. *Section at Strait Creek, Va.*

[The lower part of the Keyser is exposed along the road from Franklin, W. Va., to Monterey, Va., about ½ mile east of the store at Strait Creek, Va., in the eastern limb of the anticline through which the road runs at this place. The higher part of the Helderberg is concealed, although some New Scotland float was seen]

Helderberg group:	
Keyser limestone:	
Big Mountain shale member:	
Concealed.	Feet
Fissile olive-green shale	10
Lower limestone member:	
Thick-bedded hard gray, somewhat crystalline limestone	11

Helderberg group—Continued.
Keyser limestone—Continued.
Lower limestone member—Continued. Feet
Shaly, very lumpy limestone, weathering yellowish. *Dalmanella concinna* (aa), *Stropheodonta bipartita, Chonetes jerseyensis* (aa), *Atrypa reticularis, Spirifer modestus* (aa), *S. modestus* var. *plicatus, Nucleospira swartzi* (aa), *Orthoceras* cf. *O. clavatum* (r) 35
Medium-bedded dark gray limestone. *Chonetes jerseyensis* (r) 3
Tonoloway limestone: Laminated blue limestone, upper part concealed.

9. *Section near Monterey, Va.*

[The Helderberg group is well exposed half a mile east of Monterey, Va., just north of the State highway to Staunton, on the first foothill of Jacks Mountain. The Becraft limestone and the cherty New Scotland limestone are conspicuous on the hillside]

Oriskany group: Feet
Ridgeley sandstone: Mostly concealed, with boulders of friable sandstone, weathered whitish on the surface but iron stained within 50±
Concealed, with a few exposures of very fine grained calcareous sandstone. *Anoplotheca flabellites* 50±
Helderberg group:
Becraft limestone:
Heavy-bedded white calcareous sandstone 10
Massive grayish sandy limestone. *Rensselaeria subglobosa, Spirifer cyclopterus* 4
Massive gray sandy limestone to limy sandstone 5
Hard massive bluish-gray limestone, very fossiliferous; a few lenses of dark chert in lower part. *Eatonia medialis, E. peculiaris, Spirifer cyclopterus, S. concinnus,* etc 71
Partly concealed; some beds of limestone with much interbedded black chert 20
Shriver (?) chert:
Mostly concealed, with much impure dark bedded chert of Shriver type on the surface 85
New Scotland limestone: Fine-grained limestone with much interbedded white chert, conspicuous on the hillside. The upper 6 feet is less resistant than the remainder. *Hindia sphaeroidalis, Streptelasma strictum* (aa), *Favosites helderbergiae?, Dalmanella perelegans* (aa), *Leptaena rhomboidalis, Strophonella undaplicata, S. leavenworthana, Schuchertella woolworthana, S. punctulifera, Eatonia medialis, Spirifer cyclopterus, S. macropleurus* (aa), *Trematospira equistriata, Meristella arcuata* 25
Coeymans limestone:
Massive hard gray crystalline crinoidal limestone. *Rhipidomella oblata, Leptaena rhomboidalis, Stropheodonta arata* (r), *Schuchertella woolworthana, Uncinulus abruptus, Meristella arcuata,* and *M. arcuata* var. *gigas,* all in the upper 5 feet. *Schuchertella woolworthana, Gypidula coeymanensis* (r), and *Meristella arcuata* near middle and about 10 feet above base. *Nucleospira ventricosa* (aa) near base 44
Thin-bedded, somewhat arenaceous limestone 6
Keyser limestone:
Upper limestone member:
Thick-bedded blue limestone, with narrow brown sandy lines on the weathered surface 13

Helderberg group—Continued.
Keyser limestone—Continued.
Upper limestone member—Continued. Feet
Medium-bedded blue limestone, with a few lenses of light-colored chert 4
Concealed 81
Thick-bedded gray, somewhat crinoidal limestone. *Aulopora schucherti,* 2; *Strophonella keyserensis* (r); *Stropheodonta* cf. *S. planulata,* 4; *Schuchertella prolifica; Gypidula coeymanensis* var. *similis,* 5; *Camarotoechia gigantea* and *C. gigantea* var. *gigas,* 2; *Cyrtina dalmani* (r), 19; *Nucleospira ventricosa* (aa), 19; *Merista typa* (aa), 4 to top 20
Gray, somewhat crinoidal crystalline limestone; upper part concealed. *Striatopora bella, Leptaena rhomboidalis, Chonetes jerseyensis, Atrypa reticularis* 7
Big Mountain shale member: Yellowish shale, with some thin arenaceous shale layers; largely concealed 28
Lower limestone member:
Thick-bedded gray, somewhat crinoidal limestone 7
Shaly, much weathered nodular limestone 21
Massive, very nodular blue limestone. *Favosites* sp. (r), *Stropheodonta bipartita, Chonetes jerseyensis, Uncinulus convexorus, Stenochisma deckerensis, Atrypa reticularis* (aa) 39
Thin-bedded grayish limestone. *Cyphotrypa corrugata, Rhipidomella emarginata, Strophonella keyserensis* (r), *Stropheodonta bipartita, Chonetes jerseyensis, Stenochisma deckerensis* (r), *Camarotoechia litchfieldensis, Reticularia* cf. *R. bicostata* (r), *Whitfieldella minuta* 8
Tonoloway limestone:
Laminated blue limestone, largely concealed 219
Thick-bedded nodular blue limestone. *Atrypa reticularis* (aa), *Stenochisma deckerensis* (one specimen, loose) 75
Laminated blue limestone, largely concealed 262

10. *Section on Little Mountain, Va.*

[All but the topmost part of the Keyser is exposed on the western slope of Little Mountain, along the State highway to Bartow, W. Va., about 5 miles west of Monterey, Va. The section is in the western limb of the anticline that centers in Crabbottom Valley, east of Little Mountain; but as the beds are overturned, they dip to the east. The Coeymans, New Scotland, Shriver, and Ridgeley are not exposed here and have possibly been cut out by faulting. The section here given is a composite of two exposures along the roadside. In going down the road from the mountain top, the Tonoloway is the first limestone seen. It crops out for some distance, as the road makes only a small angle with the strike; the road then turns sharply to the left and cuts through the upper Tonoloway and through the lower Keyser to a level about 15 feet above the *Gypidula* zone. The road then cuts back into the underlying shale member, until it bears to the left again and cuts through the upper part of the Keyser about 500 feet farther on. The two exposures may be matched by means of the *Gypidula* zone, seen on the bank above the second exposure]

Helderberg group:
Keyser limestone:
Upper limestone member: Feet
Concealed. (Compare with the Monterey section.)
Thin to medium-bedded drab-gray limestone, with a few minor lenses of white chert. *Stromatopora,* 13; *Camarotoechia* cf. *C. altiplicata, Nucleospira ventricosa* 16

Helderberg group—Continued.
Keyser limestone—Continued.

	Feet
Upper limestone member—Continued.	
Thin-bedded, somewhat argillaceous limestone. Many Bryozoa throughout. *Camarotoechia* cf. *C. altiplicata*, *Uncinulus gordoni* (r), *Rensselaeria mutabilis*, 27; *Spirifer perlamellosus* var. *praenuntia*, *Actinopteria* cf. *A. reticulata* (r)	28
Massive gray crystalline limestone. *Stromatopora*, 26; *Cladopora rectilineata* (aa), *Striatopora bella*, 16–28; *Ceratopora marylandica*, 16–28; *Aulopora schohariae*, 16–28; *Cyathophyllum radiculum*, 16–28; *Schuchertella prolifica*, *Spirifer perlamellosus* var. *praenuntia*, *Nucleospira ventricosa*	28
Massive, somewhat crystalline crinoidal limestone, with a fine-grained greenish matrix	6
Thick-bedded gray crinoidal limestone. Chaetetoid Bryozoa, 15. The following fauna occurs in the lower 8 feet: *Leptaena rhomboidalis*, *Strophonella keyserensis*, *Schuchertella prolifica*, *Chonetes jerseyensis*, *Gypidula coeymanensis* var. *similis* (aa), 5; *Camarotoechia gigantea*, 5–7; *Atrypa reticularis* (aa), 7; *Merista typa*, 7	27
Big Mountain shale member: Soft olive-green shale, with a 1-foot bed of shaly sandstone 5 feet above base. *Orthopora rhombifera* (aa), 12; *Strophonella keyserensis*, *Schuchertella sinuata*, *Chonetes jerseyensis* (r)	28
Lower limestone member:	
Massive hard gray crystalline crinoidal limestone	4½
Thin-bedded shaly nodular limestone. *Dalmanella concinna*, *Chonetes jerseyensis*, *Stenochisma deckerensis* (aa), *Uncinulus convexorus* (aa), *Atrypa reticularis*, *Spirifer modestus*, *Camarotoechia litchfieldensis*, 15	18
Thick-bedded nodular blue limestone. *Chonetes jerseyensis*, *Atrypa reticularis* (aa)	29½
Thin-bedded, somewhat nodular grayish limestone. *Atrypa reticularis*, *Spirifer octocostatus* (r)	3
Hard, somewhat crystalline limestone. *Atrypa reticularis*	3
Thin-bedded grayish, somewhat crinoidal limestone. *Cyphotrypa corrugata*, *Dalmanella concinna*, *Rhipidomella emarginata*, *Stropheodonta bipartita*, *Chonetes jerseyensis*	7½
Hard grayish limestone	4
Thin-bedded grayish shaly limestone. *Camarotoechia litchfieldensis*	12½
Tonoloway limestone:	
Concealed	49
Laminated blue limestone	28
Concealed.	

11. *Section near McDowell, Va.*

[The Helderberg group is finely exposed on the eastern slope of Bullpasture Mountain, about 4 miles east of McDowell, Va., on the highway to Staunton]

	Feet
Oriskany group:	
Ridgeley sandstone: Thick-bedded gray sandstone, weathered buff	115
Shriver chert:	
Concealed. Comparison with the section on Black Creek Mountain, west of Warm Springs, suggests that this interval may contain tongues of the upper part of the Becraft. So far as seen, the soil does not indicate chert of the Shriver type	75
Bedded black chert, unfossiliferous	57
Helderberg group:	
New Scotland limestone: Massive gray limestone, with much interbedded white chert. The chert is not, however, as predominant here as at Monterey and farther north. *Hindia sphaeroidalis*, *Streptelasma strictum*, *Dalmanella perelegans*, *Schuchertella woolworthana*, *Uncinulus abruptus* (r), *Spirifer perlamellosus* (r), *S. cyclopterus*, *S. macropleurus* (aa), *Meristella arcuata* (aa)	23
Coeymans limestone:	
Massive gray crystalline limestone. *Rhipidomella oblata*, *Schuchertella woolworthana*, and *Meristella arcuata* (aa) in upper 2 feet. *Spirifer cyclopterus* (aa), 20–45; *Whitfieldella prosseri*, 8; *Platyceras multiplicatus* (r)	53
Arenaceous gray limestone	4
Keyser limestone:	
Upper limestone member:	
Medium-bedded gray, somewhat crystalline crinoidal limestone. *Nucleospira ventricosa* (aa)	11
Medium-bedded, somewhat nodular blue limestone. *Nucleospira ventricosa* and *Meristella praenuntia*, 16–20	28
Thick-bedded arenaceous blue limestone	8
Medium-bedded gray crystalline limestone	5
Blue, somewhat nodular limestone	4
Thick-bedded to massive gray crystalline crinoidal limestone. *Gypidula coeymanensis* var. *similis* (aa), *Camarotoechia gigantea*, and *Atrypa reticularis* (aa), 0–5; *Merista typa* (aa), 5	42
Big Mountain shale member: Soft fissile yellowish shale	15
Lower limestone member: Massive gray crystalline crinoidal limestone; the nodular character that is generally so conspicuous is lacking here. *Cladopora rectilineata* (r), 40; *Chonetes jerseyensis*, *Stenochisma deckerensis*, *Uncinulus convexorus*, *Spirifer modestus*, *S. modestus* var. *plicatus*, *Whitfieldella minuta* (r), 3. These fossils are by no means so abundant here as they are in the equivalent beds at Monterey and farther north	42
Tonoloway limestone:	
Laminated blue limestone; upper 30 feet shaly	185
Lumpy shaly blue limestone. *Atrypa reticularis*, *Uncinulus convexorus* var	16
Laminated blue limestone	

12. *Section south of Bolar, Va.*

[The Helderberg group is exposed about 3½ miles south of Bolar, Va., on the southern slope of a foothill west of Jacks Mountain, just east of the bridge over which the road from Monterey to Warm Springs crosses the Jackson River. A large eastern loop of the river cuts into the north side of this hill, and the Helderberg is exposed there also. The formations above the New Scotland are concealed]

	Feet
Helderberg group:	
New Scotland limestone:	
Hard gray arenaceous limestone with some interbedded white chert. This member forms the southward-thinning tongue of the cherty limestone phase of the New Scotland. *Streptelasma strictum* (aa), *Dalmanella perelegans, Leptaena rhomboidalis, Schuchertella woolworthana, Spirifer cyclopterus, S. macropleurus*	6
Medium to thick-bedded gray arenaceous limestone to calcareous sandstone. This member (here named the Healing Springs sandstone member) forms the entire New Scotland farther south	13
Coeymans limestone: Massive gray crystalline, somewhat crinoidal limestone. *Rhipidomella oblata, Schuchertella woolworthana, Meristella arcuata* (aa), and *M. arcuata* var. *gigas* in upper 5 feet; *Stropheodonta arata* (r), *Schuchertella woolworthana, Gypidula coeymanensis* (r), and *Meristella arcuata* (aa) at about middle	53
Keyser limestone:	
Upper limestone member:	
Medium to thick-bedded crystalline limestone, largely concealed	29
Massive grayish, somewhat nodular limestone. *Stromatopora*	9
Concealed	30
Massive limestone, abounding in reef corals and Bryozoa embedded in a greenish limestone matrix	15
Thick-bedded gray, rather coarsely crystalline limestone. *Stromatopora* and corals at top; *Cladopora rectilineata* (r), *Aulopora schucherti*, and *Merista typa*, 25	38
Concealed	6
Gray arenaceous limestone, weathering buff and porous. This is a northern tongue of the Clifton Forge sandstone member of the Keyser	3
Concealed. It is possible that part of this interval belongs with the Big Mountain shale member	22
Big Mountain shale member: Thin-bedded greenish, somewhat arenaceous shale	18
Lower limestone member:	
Hard gray crystalline, somewhat arenaceous limestone	2
Massive bluish-gray nodular limestone	6
Medium-bedded hard gray, somewhat crystalline limestone	25
Medium to thick bedded hard gray arenaceous limestone	8
Tonoloway limestone:	
Concealed	180
Thick-bedded blue limestone, partly concealed	170
Concealed.	

13. *Section on Back Creek Mountain, west of Warm Springs, Va.*

[The Helderberg group is exposed on the eastern slope of Back Creek Mountain about 4 miles west of Warm Springs along the road to Frost, W. Va. The road ascends for a considerable distance along the slope of the Oriskany sandstone and then, turning sharply to the left, cuts through the Helderberg, Tonoloway, and Wills Creek formations, finally exposing the Bloomsburg sandstone member of the Wills Creek shale near the summit of the mountain. The Helderberg group is mostly concealed above the *Gypidula* zone of the Keyser; consequently the thicknesses given for that part of the section are only approximate]

	Feet
Oriskany group: Ridgeley sandstone: Massive sandstone, weathering buff. Upper contact not seen	100
Helderberg group:	
Becraft limestone:	
Concealed	30
Dark-gray, somewhat crystalline limestone. *Schuchertella woolworthana, Rhipidomella assimilis, Eatonia peculiaris, Rensselaeria subglobosa, Spirifer cyclopterus, S. concinnus, Cyrtina varia, Dalmanites* sp. (suggests *D. dentatus*)	4
Concealed	12
Hard gray, somewhat crystalline limestone. *Rhipidomella assimilis, Schuchertella woolworthana, Eatonia peculiaris, Uncinulus pyramidalis, Rensselaeria subglobosa, Spirifer cyclopterus, S.* cf. *S. angularis, S. concinnus, Anoplotheca flabellites* (r), *Meristella lata* (r), *Dalmanites* sp. (suggests *D. dentatus*). This and the higher bed of limestone represent part of the upper beds of limestone assigned to the Becraft in the Bells Valley and Clifton Forge sections	3
Concealed	20
Shriver? chert: Impure bedded dark chert, weathering buff, partly concealed. Some of the chert is purer than is typical of the Shriver and weathers whiter. In my opinion, this chert is more or less transitional between what I regard as the equivalent lower part of the cherty Becraft limestone of the Healing Springs section and the lower part of the more typical Shriver chert of Monterey and farther north. Affinity to the Becraft is shown by the occurrence of *Eatonia medialis* and *Dalmanites pleuroptyx?* 70 feet above the base	100
New Scotland limestone (Healing Springs sandstone member): Calcareous sandstone, weathered buff and porous	10
Coeymans limestone: Concealed. The thickness given is taken from the Dry Run section	34±
Keyser limestone:	
Upper limestone member:	
Concealed	60
Calcareous sandstone, weathered buff. This, with the underlying unit, forms a tongue of the Clifton Forge sandstone member	12
Thin-bedded, somewhat concretionary shaly sandstone. *Atrypa reticularis* and *Camarotoechia gigantea* abundant in the lower 5 feet	11
Gray crystalline limestone	2
Blue fine-grained limestone, abounding in *Gypidula coeymanensis* var. *similis*	2
Soft, weathered arenaceous limestone. This may be considered another tongue of the Clifton Forge sandstone member	3

Helderberg group—Continued.
Keyser limestone—Continued.
Upper limestone member—Continued. Feet
Hard blue arenaceous limestone, with a somewhat lumpy appearance 5
Big Mountain shale member:
Yellowish fissile shale, partly concealed 7
Hard blue arenaceous limestone, weathering buff and sandy; another tongue of the Clifton Forge sandstone 18
Olive-green shale, with thin sandy layers 11
Lower limestone member:
Massive, somewhat lumpy blue limestone, very arenaceous in the upper half. *Cyphotrypa corrugata*, abundant in the lower half; *Stenochisma deckerensis, Stropheodonta bipartita, Chonetes jerseyensis, Uncinulus convexorus* 46
Concealed 4
Sandy limestone 6
Tonoloway limestone:
Laminated blue limestone 21
Blue limestone and some calcareous shale 160
Thin-bedded calcareous sandstone 60
Dark-blue limestone.

14. *Section along Dry Run east of Warm Springs, Va.*

[An instructive section of the Helderberg group can be seen on the north bank of Dry Run, just west of the point where it cuts across the road to Williamsville, about 2¾ miles northeast of the Alleghendoah Club (shown as Bath Alum on the United States Geological Survey's topographic map of the Monterey quadrangle). The section is in the western limb of the Tower Hill syncline. The Ridgeley sandstone crops out immediately west of the Williamsville road, and the underlying rocks are exposed more or less continuously to the base of the sandstone overlying the *Gypidula* zone of the Keyser. The beds from the sandstone of lower New Scotland age (Healing Springs sandstone member) to a horizon 30 feet below the *Gypidula* zone are much better exposed about 200 feet farther west along the bank of the run, where they are repeated, probably by faulting. The two sections are here combined. Neither section reaches to the base of the Keyser]

Romney shale: Black shale seen along run. Feet
Oriskany group: Ridgeley sandstone: Massive gray sandstone, weathering buff. At the time of my visit the contact with the Romney could be seen along the creek 32
Helderberg group:
Becraft limestone:
Concealed; probably Becraft 23
Medium to thick bedded limestone, with minor lenses of black chert. *Leptaena rhomboidalis, Spirifer cyclopterus, S. concinnus, Meristella lata, Dalmanites pleuroptyx* 57
Blue limestone, with much interbedded black chert; largely concealed 98
New Scotland limestone:
Massive gray limestone, with a few lenses of white chert. *Streptelasma strictum, Dalmanella perelegans, Leptaena rhomboidalis, Schuchertella woolworthana, Eatonia medialis, Spirifer cyclopterus, S. macropleurus* 6
Hard gray arenaceous limestone to calcareous sandstone (Healing Springs sandstone member) 10
Coeymans limestone: Massive crystalline, somewhat crinoidal gray limestone. *Leptaena rhomboidalis, Schuchertella woolworthana, Rhipidomella oblata*, and *Meristella arcuata* (aa) at top 34
Keyser limestone:
Nodular blue limestone 5
Thick-bedded gray, somewhat crystalline limestone 10
Helderberg group—Continued.
Keyser limestone—Continued. Feet
Concealed 12
Thick-bedded gray, somewhat crinoidal limestone. *Cladopora rectilineata* 13
Thin-bedded calcareous sandstone, with pronounced cross-bedding. This and the underlying sandstone form a small cliff at both exposures. These sandstones, like the corresponding ones in the section west of Warm Springs, form a northward tongue of the Clifton Forge sandstone member 20
Sandy shale to shaly sandstone, somewhat concretionary 14
Thick-bedded gray limestone, abounding in *Gypidula coeymanensis* var. *similis* 7
Thick-bedded gray crystalline limestone 12
Arenaceous limestone, showing some cross-bedding on weathered surfaces; the lower half is colored red by hematite. *Camarotoechia litchfieldensis* (aa) 15
Concealed. (See Back Creek Mountain section.)

15. *Section at Bells Valley, Va.*

[The section as given is a composite of the exposures along the county road leading southeast from Bells Valley, and of those on the southern side of the hollow, in and near the old quarry in the New Scotland-Coeymans limestone. The sections were matched chiefly by means of the 4-foot bed of hard sandstone which forms the backbone of the knolls both north and south of the hollow]

Feet
Oriskany group: Ridgeley sandstone: Hard gray sandstone, weathered buff 5
Helderberg group:
Becraft limestone:
Concealed, most probably Becraft 40
Thick-bedded dark-blue limestone, with minor layers of black chert. *Spirifer concinnus* (r) 84
Medium-bedded limestone, with much interbedded black chert. *Edriocrinus pocilliformis, Schuchertella woolworthana, S. becraftensis?* (r), *Phacops logani* 8
New Scotland and Coeymans limestones: Massive gray crystalline, highly crinoidal limestone, forming the quarry bed of the area. The presence of *Spirifer macropleurus* and other characteristic New Scotland forms in the upper 20 feet shows that that part is of New Scotland age. That the lower 55 feet should be assigned to the Coeymans is indicated by the absence of the New Scotland fossils and by the presence, about 55 feet above the base, of the *Meristella arcuata* zone which is so prominent at the top of the Coeymans at Monterey, Bolar, and Dry Run. *Leptaena rhomboidalis, Schuchertella woolworthana, Uncinulus abruptus, Eatonia medialis*, and *Spirifer macropleurus* (aa) in the upper 20 feet; *Favosites helderbergiae* and *Meristella arcuata* (aa) 52 to 56 feet above base; *Platyceras multiplicatum* in lower half 78
Keyser limestone:
Thin-bedded shale and limestone; the upper surface is extensively ripple marked 6
Thick-bedded crystalline limestone 7
Thin-bedded shaly limestone. *Dalmanella concinna, Schuchertella prolifica* (r) 3
Massive fine-grained limestone, weathering greenish; many Bryozoa and *Stromatopora* 10 feet beneath top 42

Helderberg group—Continued.

	Feet
Keyser limestone—Continued.	
Thick-bedded hard gray sandstone, weathered buff to white, forming the backbone of the knoll. Like the underlying sandstones, this is a tongue of the Clifton Forge sandstone member of the Keyser	4
Thin-bedded yellowish-green, somewhat arenaceous shale (tongue of the Big Mountain (?) shale member)	9½
Medium-bedded gray sandstone (tongue of the Clifton Forge sandstone member)	4½
Dark-grayish soft shale, mostly concealed	8
Calcareous sandstone, weathered buff (tongue of the Clifton Forge sandstone member)	6
Thick-bedded gray, somewhat crystalline limestone	10
Concealed. Some arenaceous shale toward top. Keyser (?)	34
Tonoloway limestone:	
Laminated blue limestone, concealed in part	135
Nodular blue limestone, much weathered. *Uncinulus convexorus* var., *Atrypa reticularis*	10

16. *Section in gap just west of Hot Springs, Va.*

[Section along railroad at west end of gap]

	Feet
Romney shale: Brownish shale exposed along railroad cut.	
Oriskany group: Ridgeley sandstone: Massive buff, iron-stained sandstone, forming a prominent ledge on each side of the railroad	80
Helderberg group:	
Concealed. Includes Becraft limestone (possibly with some beds of Shriver chert facies) and New Scotland limestone	200
Coeymans limestone: Highly crinoidal crystalline, limestone. *Gypidula coeymanensis* (r), *Platyceras trilobatum*	23
Keyser limestone:	
Upper limestone member:	
Concealed	2
Arenaceous limestone	3
Concealed	20
Clifton Forge sandstone member:	
Calcareous sandstone, weathered buff	12
Arenaceous shale to shaly sandstone, somewhat concretionary. This unit is probably equivalent to the concretionary shaly sandstone above the *Gypidula* zone in the sections east and west of Warm Springs	20
Thick-bedded hard calcareous sandstone, weathered buff, making prominent ledges along the railroad, except the upper 7 feet, which is more weathered	70
Lower limestone member: Blue to gray limestone, somewhat nodular above; crinoidal and somewhat crystalline below	25

17. *Section in gap west of Healing Springs, Va.*

[Seen along road and creek near west end of gap about 3 miles south of section 16. This locality is of interest because it affords a fine exposure of the sandstone phase of the New Scotland (the Healing Springs sandstone member), and because the Becraft limestone presents characters that are more or less intermediate between those of the Becraft of Clifton Forge and those of the Becraft and Shriver (?) chert as seen on Back Creek Mountain, west of Warm Springs]

	Feet
Oriskany group: Ridgeley sandstone: Massive gray sandstone. A bridge crosses the stream at the basal contact	101
Helderberg group:	
Becraft limestone:	
Massive gray crystalline, somewhat crinoidal limestone, lower part more or less concealed. *Eatonia peculiaris*, *Uncinulus vellicatus*, *Spirifer concinnus* (aa), *S. cyclopterus*	35
Limestone, with much interbedded black chert; the lower part in particular is almost solid chert; the upper part is somewhat concealed. Unfossiliferous	70
New Scotland limestone (Healing Springs sandstone member): Massive calcareous sandstone to arenaceous limestone. *Leptaena rhomboidalis*, *Schuchertella woolworthana*, and *Spirifer macropleurus* (r) were found in the exposure north of the creek. South of the creek, above the road, the sandstone makes a prominent ledge on the hillside	20
Coeymans limestone and upper limestone member of Keyser limestone: Massive limestone, largely concealed	105
Clifton Forge sandstone member of Keyser limestone: Massive calcareous sandstone	92
Lower limestone member of Keyser limestone.	
Lumpy blue limestone	14
Somewhat crinoidal arenaceous limestone	19
Tonoloway limestone: Laminated blue limestone.	

18. *Section near Clifton Forge, Va.*

[The most complete exposure of the Helderberg group in the immediate vicinity of Clifton Forge is that at the east end of the gap of the James River, along the road to Iron Gate. Other partial sections can be seen along the railroad just north of Clifton Forge and at Island Ford Bridge, about 8 miles south of Clifton Forge on the road to Covington. The Becraft can also be seen in quarries in the vicinity of Low Moor, 3 or 4 miles south of Clifton Forge. The exposure along the railroad north of Clifton Forge of the sandstone overlying the Becraft limestone is of particular interest in that the sandstone there carries *Spirifer arenosus*, *S. murchisonia*, and other fossils that permit definite correlation with the Ridgeley sandstone (of Oriskany group) of Maryland. The section given below is the one first mentioned]

	Feet
Helderberg group:	
Becraft limestone:	
Concealed. The upper part of the Becraft as seen north of Clifton Forge along the railroad is gray, crinoidal, and massive and contains *Uncinulus vellicatus*, *Eatonia peculiaris*, *Spirifer concinnus*, and other fossils.	
Thick-bedded to massive gray limestone, with some interbedded black chert	43
Massive gray, somewhat nodular limestone, with a little interbedded black chert. *Streptelasma strictum*, *Edriocrinus pocilliformis* (aa), *Uncinulus abruptus*, *Eatonia peculiaris*, *Rensselaeria* cf. *R. aequiradiata*, *Spirifer concinnus* (r)	8
New Scotland formation (Healing Springs sandstone member): Thick-bedded gray calcareous sandstone to arenaceous limestone	16
Coeymans limestone: Massive gray crystalline crinoidal limestone, arenaceous at base. *Rhipidomella oblata* (aa), *Stropheodonta arata* (r), *Schuchertella woolworthana*, *Camarotoechia campbellana*, *Uncinulus abruptus* (r), and *Meristella arcuata* (aa), all in upper 5 feet	18
Keyser limestone:	
Upper limestone member:	
Massive gray limestone, abounding in reef corals and *Stromatopora* best seen below road, along railroad	15

Helderberg group—Continued.
Keyser limestone—Continued.
Upper limestone member—Continued. Feet
Massive hard gray, somewhat crystalline limestone, seen along railroad. *Cladopora rectilineata* is very abundant at this horizon along the railroad north of Clifton Forge and at Island Ford Bridge 19
Cilfton Forge sandstone member:
Thin to medium-bedded shaly sandstone 12
Massive hard white sandstone 8½
Thin-bedded arenaceous shale 2½
Massive hard white to buff calcareous sandstone 25
Thin-bedded shaly sandstone, thicker bedded toward the middle 18
Lower limestone member: Somewhat lumpy arenaceous limestone. *Dalmanella concinna, Stropheodonta bipartita, Stenochisma deckerensis, Uncinulus convexorus, Nucleospira swartzi.* The following additional fossils were found at this horizon in exposures along the railroad north of Clifton Forge: *Atrypa reticularis, Calymene camerata* (r), *Jaekelocystites hartleyi* (r) 15

19. *Section at Prices Bluff, near Gala, Va.*

[An excellent section of the Helderberg group can be seen at Prices Bluff, along the Norfolk branch of the Chesapeake & Ohio Railway, 1 mile north of Gala, Va. R. J. Holden, of the Virginia Polytechnic Institute, at Blacksburg, Va., kindly told me of this exposure]

Feet
Romney shale: Brown shale with some interbedded limestone; of Onondaga age (?).
Oriskany group: Ridgeley sandstone: Gray quartz sandstone, weathering brown; exposed at southeast end of bluff 1½
Helderberg group:
Becraft limestone:
Massive gray crystalline, highly crinoidal limestone, with some brown sandstone lines on weathered surfaces. *Rhipidomella assimilis, Leptaena rhomboidalis, Schuchertella woolworthana, Spirifer concinnus, S. concinnus* var. *progradius,* and *S.* cf. *S. angularis* in upper part 59
Massive gray crystalline limestone, with some lenses of black chert 18
Massive, very arenaceous limestone 11
Very massive gray limestone, somewhat nodular toward the base. *Streptelasma strictum, Edriocrinus pocilliformis, Rhipidomella assimilis*(r), *Rensselaeria* cf. *R. aequiradiata, Eatonia peculiaris, Platyceras* cf. *P. gebhardi,* and *Phacops logani* in the lower 15 feet 31
New Scotland formation (Healing Springs sandstone member): Massive gray arenaceous limestone to calcareous sandstone 15½
Coeymans limestone:
Very massive crinoidal limestone, abounding in large crinoid rings. *Meristella arcuata* (aa) at top 19½
Massive gray arenaceous limestone 5½
Keyser limestone:
Upper limestone member:
Massive limestone, with many *Stromatopora* and *Favosites* 15
Medium-bedded, somewhat nodular limestone, with some interbedded chert 10

Helderberg group—Continued.
Keyser limestone—Continued.
Upper limestone member—Continued. Feet
Arenaceous limestone. *Cladopora rectilineata* (aa) 3
Massive dark-blue limestone, with a few chert lenses 4½
Clifton Forge sandstone member:
Massive calcareous sandstone. Some interbedded arenaceous shale in lower 14 feet 37
Sandy limestone, with chaetetoid bryozoan zone at middle 1
Very massive blue limestone, weathering gray. This and the underlying unit might be placed in the lower limestone member of the Keyser 10
Massive calcareous sandstone to arenaceous limestone 21
Tonoloway limestone: Laminated blue limestone.

20. *Section at Hollybrook, Va.*

[This section is fairly well exposed in a washway on the hillside north of the road along No Business Creek, about 720 feet northeast of the intersection with the Kimberling road, at Hollybrook, Va. The exposures around Hollybrook were cited by M. R. Campbell in his description of the Giles formation, in the Pocahontas folio. The sandstone at the top of the Giles is not seen in this particular section, as it has been eroded from the hilltop. An exposure showing this sandstone, practically in contact with the overlying Genesee shale, can be seen along the road to Bland about a quarter of a mile east of the crossroads. The sandstone is greenish, carries a post-Oriskany (apparently Onondaga) fauna, and is evidently equivalent to the greenish sandstone at the top of the Giles at Rocky Gap, Cove Mountain, and Tumbling Creek, near Saltville. The Hollybrook, Rocky Gap, Cove Mountain, and Tumbling Creek section were measured by C. K. and F. M. Swartz in 1927, in connection with a study of the underlying Silurian.]

Giles formation: Feet
Mostly concealed at top of hill; fragments of sandy chert and some weathered sandstone strew the surface. (See Rocky Gap section.)
Thick-bedded to massive quartz sandstone conglomerate, forming a prominent ledge about 35 feet below top of hill. The many cavities formed by the weathering out of bulbs of *Aspidocrinus caroli* are a very striking feature. There are also poor molds of a *Spirifer* that suggests *S. cyclopterus* of the Helderberg group. The stratigraphic evidence afforded by this section and those at Rocky Gap and near Saltville suggests that this conglomeratic sandstone is of New Scotland or Becraft age 22
Concealed. Probably calcareous sandstone for the most part. If any portion of the Keyser limestone is present here it would lie in the lower part of this interval 86
Laminated blue limestone (Tonoloway lithology and fauna). This limestone was included in the Giles formation by Campbell. In exposures on Ding Run, in and near Burton's quarry, about 3 miles northeast of Hollybrook, this limestone carries *Leperditia* sp. (probably *L. alta*) and *Hindella congregata* 68

21. *Section at Rocky Gap, Va.*

[Section at east end of gap 2 miles east of Rocky Gap, about 15 miles south of Narrows, Va.]

Feet
Genesee shale: Black shale seen along road to Bland.
Giles formation:
Greenish sandstone, same as the sandstone at top of the Giles at Hollybrook and Cove Mountain 5+

Giles formation—Continued. Feet

Bedded black chert, forming riffles in the creek. The contact with the overlying sandstone was not seen, but the sandstone was projected along the strike from the road to the creek for a rather unsatisfactory measurement of the interval. This black chert, although somewhat suggestive of the Shriver chert of the sections farther north, is most likely equivalent to the chert that carries *Spirifer arenosus* var. *planicostatus* in the Saltville region. Upper part concealed ---------- 65+

Calcareous sandstone, exposed in part in bed of creek and seen also along the State road to Bland. *Aspidocrinus caroli* (aa) in upper 20 feet; *Spirifer cyclopterus?* at about middle; a large *Schuchertella* near base ---------- 62

Concealed. A few weathered chert masses were seen at the top of this interval, along the road to Bland; these contained an abundance of casts of a *Meristella* which is apparently *M. arcuata*. The zone is suggestive of that at the top of the Coeymans limestone in the Clifton Forge area, although correlation with that zone is not assured. It seems probable that much of this concealed interval is occupied by the Tonoloway limestone. 40

Blue limestone (Tonoloway lithology and fauna) mostly concealed; the most definite exposures were seen in diggings for the abutments of the highway bridge.

22. *Section at Cove Mountain, near Wytheville, Va.*

[The top of the Giles formation is exposed along the old road from Wytheville to Bland at the gap through Cove Mountain, about 4 miles northwest of Wytheville. The mountain is made by the Clinch sandstone, which dips to the east and is overlain by the black chert and the upper greenish sandstone of the Giles formation. The intervening beds are absent, probably owing to faulting rather than to an unconformity. The best exposures are on the hillside south of the creek, just opposite an old mill]

Feet

Genesee shale: Black shale, seen along creek bank.

Giles formation:

Greenish, very fossiliferous sandstone. *Amphigenia?* sp., *Athyris spiriferoides*, *Spirifer* cf. *S. manni*, *Reticularia fimbriata*, etc. Probably Onondaga ---------- 10±

Giles formation—Continued. Feet

Black bedded chert; a little interbedded shale. No fossils seen. Probably equivalent to the chert of the Saltville section ---------- 25

Fault (?). Lower part of Giles (Tonoloway, etc.), and Clinton absent.

Clinch sandstone: Massive white to gray sandstone.

23. *Section along Tumbling Creek, near Saltville, Va.*

[The strata above and below the Silurian-Devonian boundary are exposed along Tumbling Creek, about 6 miles southwest of Saltville, Va. (The United States Geological Survey map shows a second Tumbling Creek north of Saltville.) The fossils collected from this section have not yet been thoroughly studied]

Feet

Genesee shale: Black shale exposed east of abandoned mill.

Giles formation:

Weathered sandstone, largely concealed ---------- 14

Greenish calcareous sandstone, with a few lenses of chert. *Chonetes coronatus?*, *Spirifer* cf. *S. manni*, *Anoplotheca acutiplicata*, etc. Probably of Onondaga age ---------- 22

Red sandstone with some limonite mottling ---------- 2

Bedded black chert. Some calcareous matrix? *Spirifer arenosus* var. *planicostatus* and *Diaphorastoma ventricosum* at middle; *Ambocoelia umbonata* a few feet lower. Of late Oriskany age ---------- 21

Sandstone, with red staining at top ---------- 9

Massive blue limestone ---------- 4

Greenish calcareous sandstone ---------- 12

Red sandstone with limonite mottling ---------- 2½

Greenish-brown sandstone, with some chert ---------- 21

Blue limestone; a few minor chert lenses. *Meristella* sp.; corals ---------- 4

Greenish-brown sandstone, with some lenses of black chert; upper 8 inches red, with some mottling. *Spirifer arenosus*, rather abundant at top. Of Oriskany age ---------- 4½

Thin-bedded yellowish-brown sandstone ---------- 3

Greenish-brown sandstone, with 3 inches of cherty limestone, in somewhat irregular lenses, at base. *Rhipidomella* cf. *R. oblata*, *Dalmanella perelegans?*, etc. This and the overlying unit appear to be of New Scotland or Becraft age ---------- 4½

Hard blue limestone (Tonoloway lithology and fauna) weathering platy in part.

PLATES 6–9

PLATE 6

KEYSER FAUNA

CHONETES JERSEYENSIS ZONE

1, 2. *Chonetes jerseyensis* Weller (p. 54).

1. Nearly complete ventral valve, showing spines of cardinal margin. A very characteristic specimen. Petersburg, W. Va., about 50 feet above base of Keyser limestone.
2. Incomplete ventral valve, showing somewhat stouter ribs. Little Mountain section, west of Monterey, Va., *Gypidula* subzone, 113 feet above base of Keyser limestone.

3–5. *Camarotoechia litchfieldensis* (Schuchert) (p. 54) and *Whitfieldella minuta* Maynard (p. 57).

3. Slab showing ventral valves of these two associated species. Petersburg, W. Va., *Whitfieldella minuta* subzone, base of Keyser limestone.
4. Ventral valve of *Whitfieldella minuta*.
5. Ventral valve of *Camarotoechia litchfieldensis*.

6. *Cyphotrypa corrugata* (Weller) (p. 53). Vertical section of a large zoarium. West of Warm Springs, Va., *Cyphotrypa corrugata* subzone, 20 feet above base of Keyser limestone.

7. *Stropheodonta bipartita* (Hall) (p. 53). Exterior of ventral valve. Warm Springs, Va., *Cyphotrypa corrugata* subzone, 20 feet above base of Keyser limestone. Specimen partly exfoliated.

8, 9. *Uncinulus convexorus* Maynard (p. 55).

8. Dorsal view. Franklin, W. Va., *Stenochisma deckerensis*, etc., subzone, 20 feet above base of Keyser limestone.
9. Side view of somewhat imperfect specimen, showing detail of interlocking of serrated margins of the two valves. Near Warm Springs, Va., *Stenochisma deckerensis*, etc., subzone, 30 feet above base of Keyser limestone.

10–12. *Stenochisma deckerensis* (Weller) (p. 54).

10. Dorsal view showing the relatively great width of this species. Petersburg, W. Va., *Stenochisma deckerensis*, etc., subzone, about 45 feet above base of Keyser limestone.
11. Side view of same specimen showing the high dorsal elevation.
12. Dorsal view of somewhat smaller specimen. Clifton Forge, Va., *Stenochisma deckerensis*, etc., subzone, 10 feet above base of Keyser limestone.

13–15. *Nucleospira swartzi* Maynard (p. 57).

13. Ventral view. Big Mountain section, south of Petersburg, W. Va., *Stenochisma deckerensis*, etc., subzone, 40 feet above base of Keyser limestone.
14. Side view of same specimen.
15. Dorsal view. Clifton Forge, Va., *Stenochisma deckerensis*, etc., subzone, 10 feet above base of Keyser limestone.

16, 17. *Spirifer modestus* Hall (p. 56).

16. Ventral view. Strait Creek, north of Monterey, Va., *Stenochisma deckerensis*, etc., subzone, 30 feet above base of Keyser limestone.
17. Dorsal view of same specimen.

18, 19. *Spirifer modestus* var. *plicatus* Maynard (p. 56).

18. Dorsal view, showing the low plications from which this variety derives its name. Strait Creek north of Monterey, Va., *Stenochisma deckerensis*, etc., subzone, 15 feet above base of Keyser limestone.
19. Side view of same specimen.

20–23. *Gypidula coeymanensis* var. *similis* F. M. Swartz, n. var. (p. 54).

20, 21. Exterior and side views of type specimen of ventral valve, showing large size, somewhat inflated beak, and broad, rather indistinct plications. Little Mountain, near Monterey, Va., *Gypidula* subzone, 113 feet above base of Keyser limestone.
22, 23. Weathered interiors of ventral valves; same place and horizon.

24. *Gypidula coeymanensis* var. *prognostica* Maynard (p. 54). Ventral valve. Petersburg, W. Va., *Gypidula* subzone, 122 feet above base of Keyser limestone. The material which I am including under the variety *similis* is undoubtedly consanguineous with the variety *prognostica* of the more northern sections.

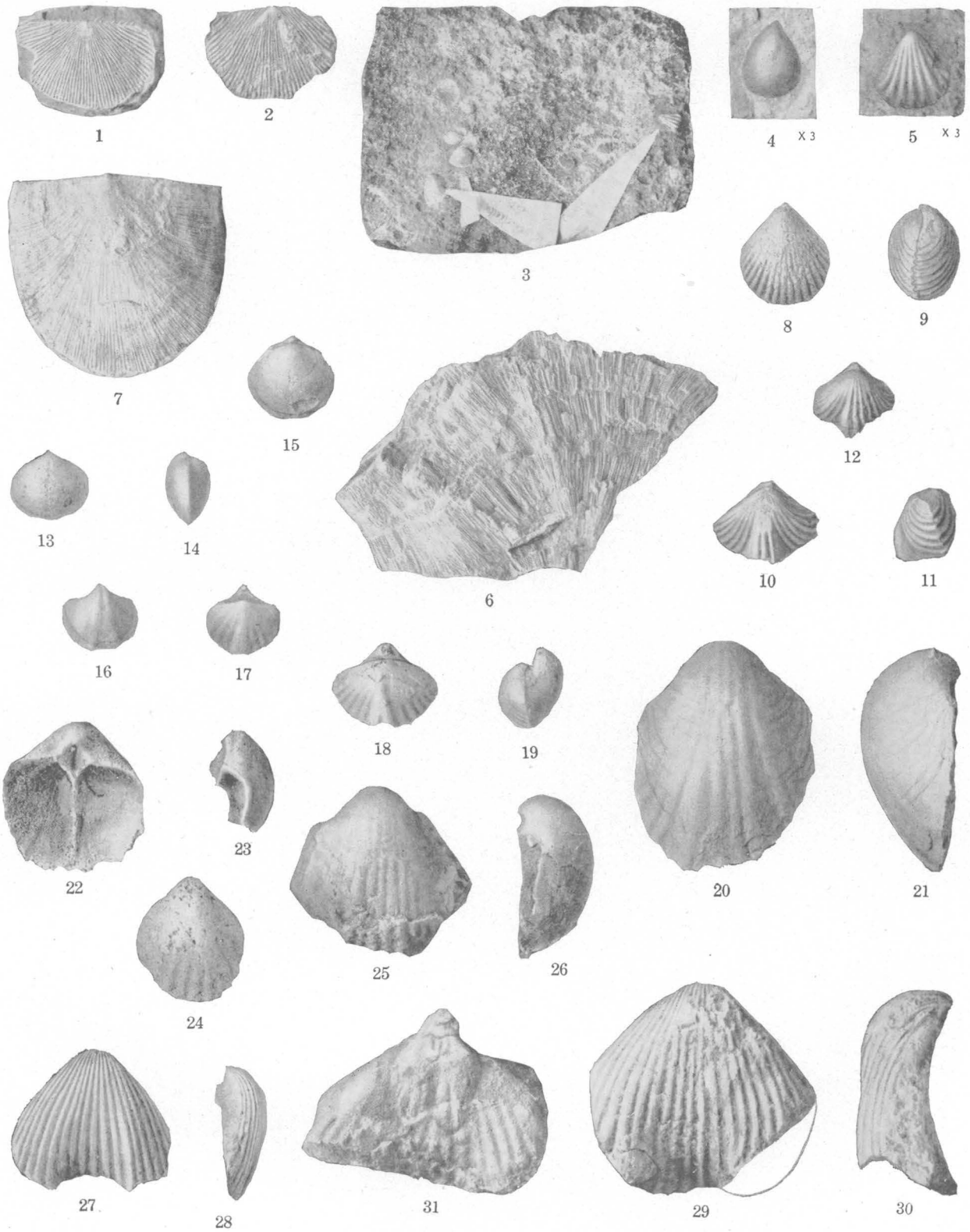
25, 26. *Gypidula coeymanensis* Schuchert (p. 54). Exterior and ventral views. Coeymans limestone, Nearpass, N. J. Show the close similarity of the Little Mountain middle Keyser material to typical specimens of the species.

27, 28. *Camarotoechia gigantea* Maynard (p. 54).

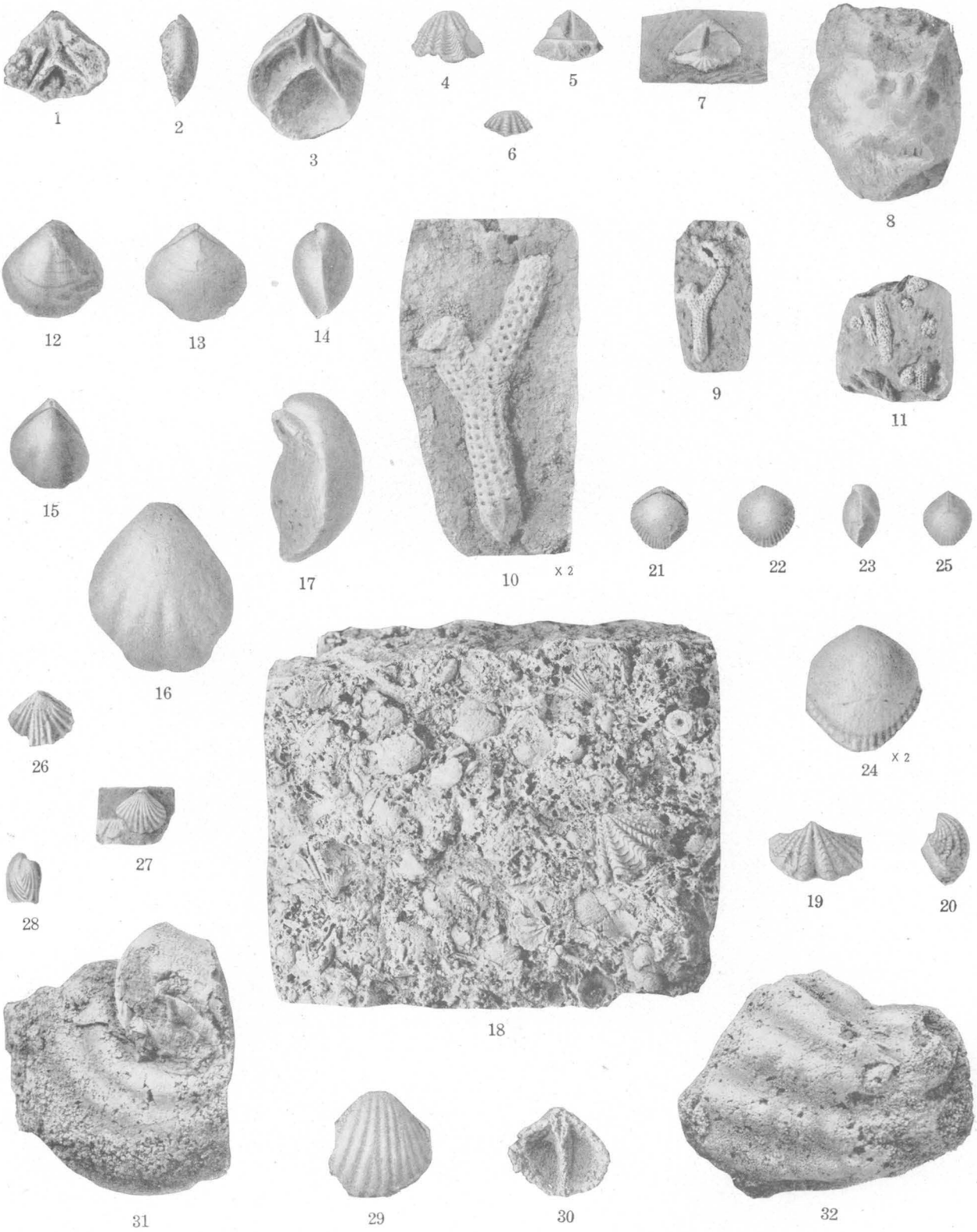
27. Characteristic ventral valve of this abundant species. Warm Springs, Va., *Camarotoechia gigantea* subzone, 105 feet above base of Keyser limestone.
28. Side view of same specimen.

29–31. *Camarotoechia gigantea* var. *gigas* F. M. Swartz, n. var. (p. 55).

29. Ventral valve, showing large size and broad, deep sinus. Monterey, Va., *Camarotoechia gigantea* subzone, 112 feet above base of Keyser limestone.
30. Side view of same specimen, showing closely incurved beak.
31. Internal cast of ventral valve showing casts of muscle scars. Same locality and horizon.



CHARACTERISTIC FOSSILS OF THE HELDERBERG GROUP OF VIRGINIA AND WEST VIRGINIA



CHARACTERISTIC FOSSILS OF THE HELDERBERG GROUP OF VIRGINIA AND WEST VIRGINIA

PLATE 7

KEYSER FAUNA

CHONETES JERSEYENSIS ZONE

1–3. *Merista typa* (Hall) (p. 58).

1. Interior of ventral valve, showing characteristic "shoe lifter" arched plate. East of McDowell, Va., *Merista typa* subzone, 64 feet above base of Keyser limestone.
2. Side view of same specimen.
3. Weathered interior of ventral valve. West of Wardensville, W. Va., *Merista typa* subzone, 95 feet above base of Keyser limestone.

FAVOSITES HELDERBERGIAE VAR. PRAECEDENS ZONE

4–7. *Cyrtina dalmani* (Hall) (p. 57).

4. Imperfect ventral valve, showing elevated plications and strong lamellae. Monterey, Va., 130 feet above base of Keyser limestone.
5. Cardinal view of same specimen.

6, 7. Dorsal and cardinal views. Big Mountain, W. Va., 139 feet above base of Keyser limestone.

8. *Mariacrinus* sp. (p. 52). Side view of imperfect calyx. Petersburg, W. Va., 218 feet above base of Keyser limestone.

9–11. *Cladopora rectilineata* Simpson (p. 52).

9. A typical corallum. Bolar, south of Monterey, Va., 114 feet above base of Keyser limestone.
10. The same specimen enlarged.
11. Several specimens from upper part of Keyser limestone, Island Ford Bridge, south of Clifton Forge, Va.

12–15. *Meristella praenuntia* Schuchert (p. 57).

12–14. Ventral, dorsal, and side views of a transverse specimen. McDowell, W. Va., *Meristella praenuntia* subzone, 136 feet above base of Keyser limestone.

15. Dorsal view of a more elongate specimen. Same locality and horizon.

16, 17. *Meristella nasutaformis* F. M. Swartz, n. sp. (p. 57). Ventral and side views of ventral valve. Big Mountain, W. Va., 113 feet above base of Keyser limestone.

18–20. *Spirifer perlamellosus* var. *praenuntius* F. M. Swartz, n. var. (p. 56).

18. Slab showing ventral valve and small portion of dorsal valve, associated with *Dalmanella concinna* and *Camarotoechia altiplicata*. Little Mountain, west of Monterey, Va., upper part of Keyser limestone.

19, 20. Ventral and side views. Big Mountain, W. Va., 181 feet above base of Keyser limestone.

21–25. *Rensselaeria mutabilis* (Hall) (p. 55).

21–23. Dorsal, ventral, and side views of a large specimen. Little Mountain, west of Monterey, Va., *Rensselaeria mutabilis* subzone, 195 feet above base of Keyser limestone.

24. Enlarged ventral view of same specimen, showing ornamentation.

25. Ventral view of a smaller specimen. Franklin, W. Va., *Rensselaeria mutabilis* subzone, 200 feet above base of Keyser limestone.

26–28. *Camarotoechia* cf. *C. altiplicata* (Hall) (p. 55).

26. Dorsal view. Little Mountain, west of Monterey, Va., *Camarotoechia* cf. *C. altiplicata* subzone, 195 feet above base of Keyser limestone. The Keyser material here referred to *C. altiplicata* is smaller and somewhat less gibbous than the New York types, but more similar to the specimens from the Maryland New Scotland.

27. Dorsal view, showing ventral beak. Franklin, W. Va., *Camarotoechia* cf. *C. altiplicata* subzone, 200 feet above base of Keyser limestone.

28. Side view of imperfect specimen, Franklin, W. Va., *Camarotoechia* cf. *C. altiplicata* subzone, 195 feet above base of Keyser limestone.

COEYMANS FAUNA

29, 30. *Gypidula coeymanensis* Schuchert (p. 54).

29. Exterior of ventral valve. Monterey, Va., Coeymans limestone.
30. Weathered interior ventral valve. Petersburg, W. Va., Coeymans limestone. Note small size and stronger plications of the Coeymans material as compared to the Gypidulas from the Keyser limestone.

31, 32. *Platyceras multiplicatum* F. M. Swartz, n. sp. (p. 58).

31. Top view of imperfect specimen, showing general character of the shell, McDowell, W. Va., Coeymans limestone.
32. Fragment of outer whorl. Hollybrook, Va., conglomeratic sandstone of Giles formation.

PLATE 8

COEYMANS FAUNA

1–4. *Meristella arcuata* (Hall) (p. 57).
1, 2. Ventral and side views of a gibbous specimen. Monterey, Va., New Scotland limestone.
3. Ventral view. Near Clifton Forge, Va., *Meristella arcuata* zone, top of Coeymans limestone.
4. Interior of ventral valve, showing characteristic muscle scars. Bells Valley, Va., *Meristella arcuata* zone, top of Coeymans limestone.

5–7. *Meristella arcuata* var. *gigas* F. M. Swartz, n. var. (p. 58).
5, 6. Ventral and side view of ventral valve. Monterey, Va., *Meristella arcuata* zone, top of Coeymans limestone.
7. Ventral valve, Bolar, Va., *Meristella arcuata* zone, top of Coeymans limestone.

8. *Meristella* cf. *M. symmetrica* Schuchert (p. 58). Ventral valve, Monterey, Va., *Meristella arcuata* zone, top of Coeymans limestone.

NEW SCOTLAND FAUNA

9. *Spirifer macropleurus* (Conrad) (p. 56). Dorsal view of weathered specimen. Monterey, Va., New Scotland limestone.

10, 11. *Dalmanella perelegans* (Hall) (p. 53). Ventral and side views of a specimen whose dorsal sinus is that of *D. perelegans*, but whose ventral cardinal area approaches that of *D. eminens* in height. Monterey, Va., New Scotland limestone.

12. *Eatonia medialis* (Vanuxem) (p. 55). Dorsal view of characteristic specimen. Monterey, Va., New Scotland limestone.

13, 14. *Streptelasma strictum* Hall (p. 52).
13. Side view of specimen showing the strong exterior septal ridges and the growth constrictions. The apex has been lost. Monterey, Va., New Scotland limestone.
14. Weathered transverse section, showing the septa. Same locality and horizon.

BECRAFT FAUNA

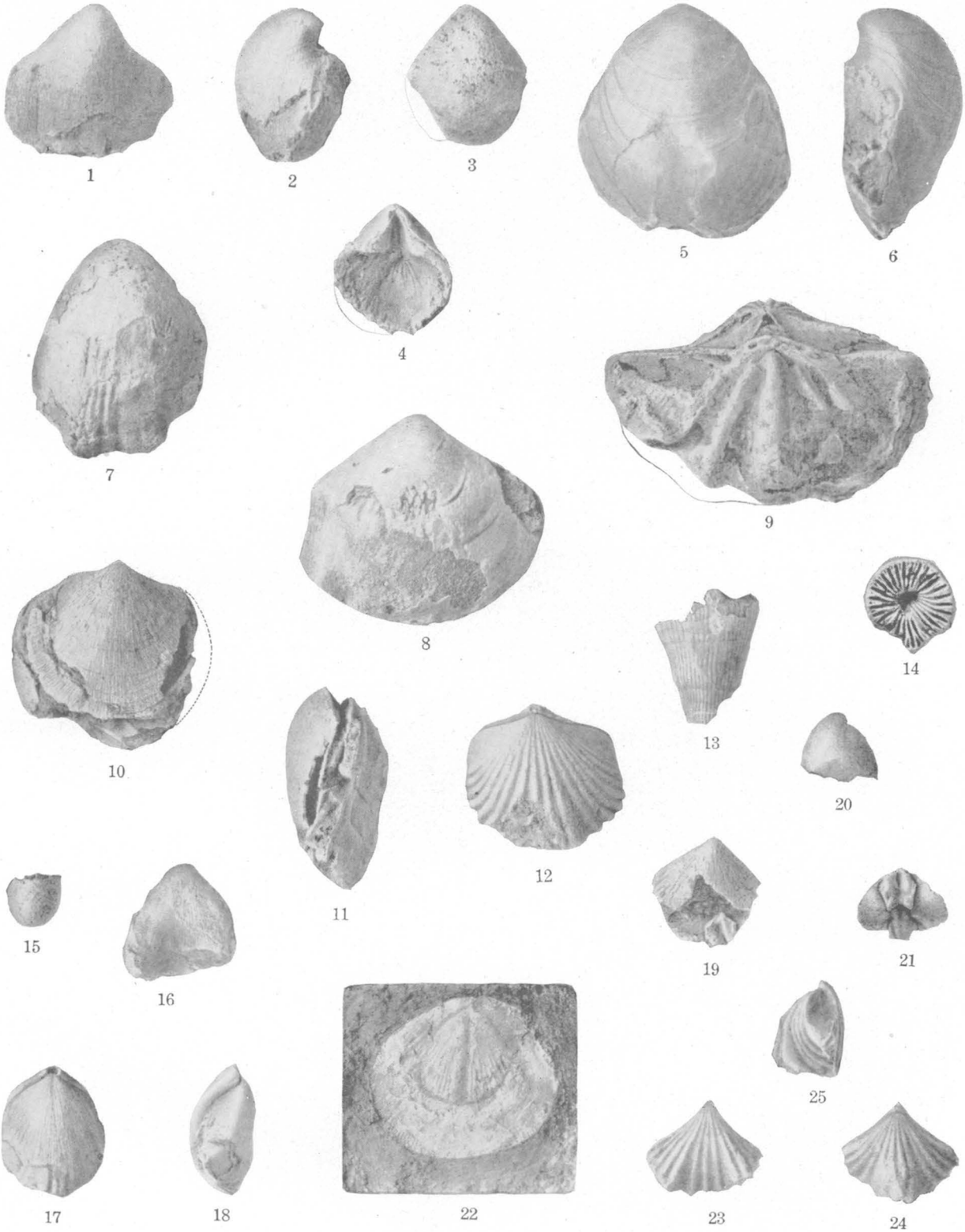
15. *Edriocrinus pocilliformis* Hall (p. 52). Side view of weathered calyx. Gala, Va., base of Becraft limestone.

16–18. *Eatonia peculiaris* (Conrad) (p. 55).
16. Ventral view. Gala, Va., 10 feet below top of Becraft limestone.
17, 18. Dorsal and side views. Gala, Va., lower part of Becraft limestone.

19–21. *Rensselaeria* cf. *R. aequiradiata* (Conrad) (p. 55).
19. Posterior portion of ventral valve. Gala, Va., basal part of Becraft limestone.
20. Side view of posterior part of shell; ventral beak somewhat imperfect. Bells Valley, Va., base of Becraft limestone.
21. Weathered interior of posterior part of brachial valve, showing crural plates. Gala, Va., basal part of Becraft limestone.

22. *Rhipidomella assimilis* (Hall) (p. 53). Exfoliated ventral valve, showing casts of muscle scars. Gala, Va., upper part of Becraft limestone.

23–25. *Rhynchotrema cumberlandicum* Rowe (p. 54). Ventral, dorsal, and side views. Gala, Va., upper part of Becraft limestone.



CHARACTERISTIC FOSSILS OF THE HELDERBERG GROUP OF VIRGINIA AND WEST VIRGINIA

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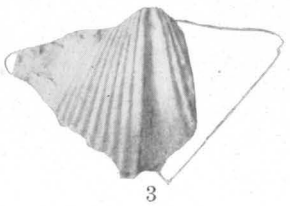

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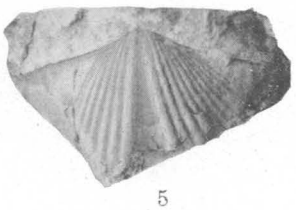

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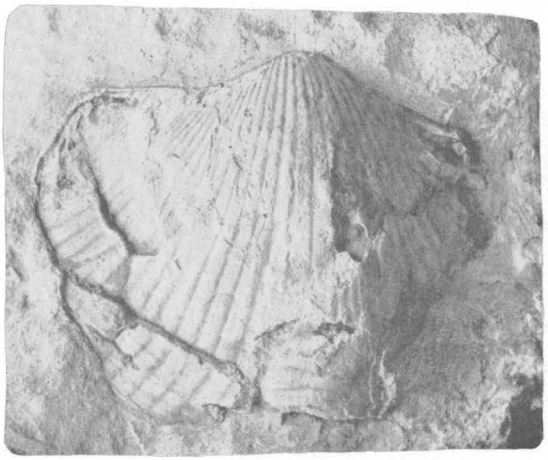

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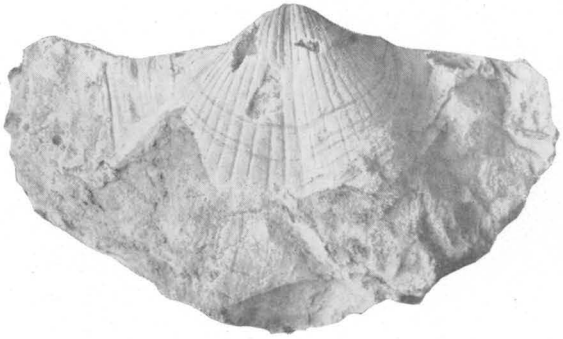

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CHARACTERISTIC FOSSILS OF THE HELDERBERG GROUP OF VIRGINIA AND WEST VIRGINIA

PLATE 9

BECRAFT FAUNA

1. *Spirifer concinnus* Hall (p. 56). Ventral valve. Gala, Va., upper part of Becraft limestone.

2–5. *Spirifer concinnus* var. *progradius* F. M. Swartz, n. var. (p. 56).

2. Ventral valve, showing large size, rather narrow ribs, and apparent alation of this progressive variety. Gala, Va., 10 feet below top of Becraft limestone.

3. Exterior of fragmentary ventral valve. Same locality and horizon.

4. Longitudinal section of specimen shown in Figure 3, showing the rather strong dental plate and indicating the moderately high cardinal area.

5. Smaller specimen with a feeble plication on each side of the ventral sinus, near the front margin. This feature, which is also found in the specimen illustrated in Figures 3 and 4, suggests *Spirifer proavitus* Schuchert.

6. *Spirifer angularis* Schuchert (p. 56). Ventral valve, Gala, Va., 6 feet below top of Becraft limestone.

7. *Spirifer* sp. Fragmental ventral valve. Clifton Forge, Va., upper part of Becraft limestone. The narrow sinus and the fairly prominent but narrow plications suggest *S. cumberlandiae* Hall, of the Oriskany group.

8, 9. *Meristella lata* (Hall) (p. 58). Dorsal and side views of dorsal valve. Dry Run, east of Warm Springs, Va., middle part of Becraft limestone.

GILES FAUNA

[See text for relations of Giles formation to Helderberg group]

10–12. *Aspidocrinus caroli* F. M. Swartz, n. sp. (p. 52). (Named for Dr. Charles K. Swartz, with whom the sections in southwestern Virginia were visited in connection with work on the Silurian.)

10. Vertical section of mold of the cup, as ordinarily seen in the rock. Hollybrook, Va., at top of sandstones of middle part of Giles formation.

11, 12. Side and top views of wax casting from same specimen.

13–15. *Spirifer arenosus* var. *planicostatus* F. M. Swartz, n. var. (p. 56).

13. Dorsal view of large specimen. Tumbling Creek, near Saltville, Va., dark chert beds of upper part of Giles formation.

14, 15. Exterior and cardinal views of a smaller ventral valve; margins imperfect. Same locality and horizon.