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Title: Taxonomy , Paleoecology, and Paleobiogeography of Wenlockian (Silurian) Brachiopods of the Cape Phillips Formation from Baillie Hamilton Island, Arctic Canada

Abstract approved: A.J. Boucot

Eighty-seven brachiopod species are described and illustrated from a brachiopod fauna of the Cape Phillips Formation of Baillie Hamilton Island, Arctic Canada. Two new families, Wangyuiidae and Rhynchotretidae, are proposed. Six new genera and forty-five new species are recognized. New genera comprise: *Flabellitesia, Wangyuia, Pseudomendacella, Eoplectodonta* (*Paranisopleurella*), *Johnsonatrypa,* and *Dicoelospirifer.* New species include: *Ptychopleurella lenzi, Wangyuia thorsteinssoni, Isorthis* (*Arcualla*) *jini, I.* (*A.*) *walmsleyi, I.*(*A.*) *sulcata boreaina, Dicoelosia bailliehamiltonensis, Epitomyonia amplissima, Parmorthina havliceki, Fascizentina rohri, Pseudomendacella boucoti, Dalejina parahanusi, Salopina gamma, S. carinata, Cliftonia contorta, E.* (*Paranisopleurella*) *cooperi, Chonetoidea? cocksi, Pentlandina harperi, Liljevallia amorpha, Pholidostrophia* (*Mesopholidostrophia*) *lamellosa, P.* (*M.*) *salopiensis granti, Morinorhynchus miniparvicostellus, Vosmiverstum breiveli, Severella arctosulcata, Spondylopyxis potteri, Clorinda geniculata, Amsdenina amsdeni, Caryogyps grayi, C. chattertoni, Rhynchotreta americaniformis, "Ancillotoechia" sheehani, Stegerhynchus estonicus cordillerus, Johnsonatrypa imbricata, Spirigerina copperi, Plectatrypa unicosta, P. rongi, Eospinatrypa bassetti, Eospinatrypa? savagei, Reticulatrypa blodgetti, Gracianella dimorpha, Pseudoprotathyris? modzalevskayae, Dicoelospirifer dicoelospirifer, Cyrtia alatiformis, Plicocyrtia jonesi, Spurispirifer hughesi, Spirinella struszi.*

Graptolites interbedded with the brachiopod fauna indicate a *riccartonensis* Zone (early Wenlock) age.

The fauna is allochthonous and consists of a mixture of both shallow- and deep-water communities. Ten communities are recognized and discussed. The fauna shows a close relationship with the coeval Cordilleran faunas.

Taxonomy, Paleoecology, and Paleobiogeography of Wenlockian (Silurian) Brachiopods of the Cape Phillips Formation from Baillie Hamilton Island, Arctic Canada

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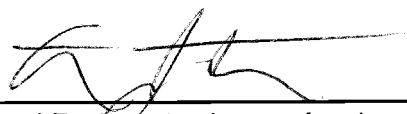

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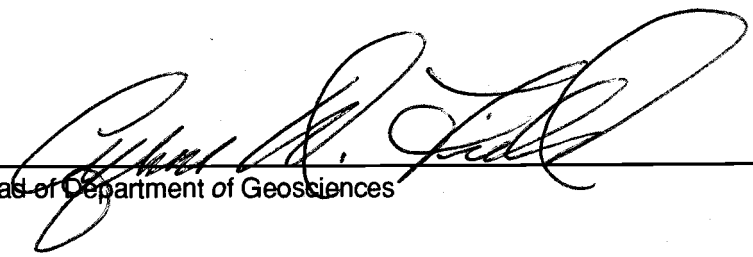

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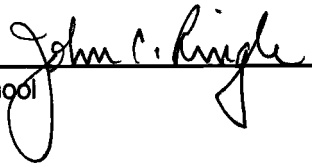

Dean of Graduate School

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TAXONOMY, PALEOECOLOGY, AND PALEOBIOGEOGRAPHY OF WENLOCKIAN (SILURIAN) BRACHIOPODS OF THE CAPE PHILLIPS FORMATION FROM BAILLIE HAMILTON ISLAND, ARCTIC CANADA

INTRODUCTION

In this study, a diverse brachiopod fauna from the Wenlockian part of the Cape Phillips Formation is described. The material was collected by Boucot and Thorsteinsson in 1971 from the south coast of Baillie Hamilton Island (fig. 1), District of Franklin, Arctic Canada. It consists of blocks of limestones containing silicified fossils. The material was etched in hydrochloric acid and it yielded nearly 50,000 silicified brachiopod specimens. In addition, it contains small numbers of trilobites, gastropods, corals, bryozoans, sponges, a few bivalves, and a monoplacophoran. To date, studies of the brachiopods (this study), trilobites (Perry and Chatterton, 1977), gastropods (Rohr, Boucot, and Perry, 1980), and monoplacophoran (Boucot, 1975) have been completed.

Since Boucot and Thorsteinsson's visit, Canadian workers Lenz and Chatterton have made an additional collection from the same locality. Lenz (1987) published a short note on morphological variation in *Dicoelosia* and *Epitomyonia* from the locality. The bulk of their brachiopod fauna has not been studied.

The brachiopod collection from Baillie Hamilton is valuable in several ways. It represents the first Silurian brachiopod collection of any significant size from the Canadian Arctic. It contains an unusually rich fauna. A total of 87 species are identified, including an array of both common and rare species. Many taxa are represented by a large number of specimens. For example, there are 6233 *Dicoelosia* specimens. As a result, morphological variation in many species is fully displayed. The finely preserved specimens reveal structures rarely seen in fossil brachiopods. Study of the interior structure of *Epitomyonia* from the collection has led to better understanding of the evolutionary lineage of the genus (Zhang and Boucot, 1988). The collection consists of a mixture of deep and shallow water communities. On the one hand, this mixed fauna complicates the community study, but on the other hand, a fuller representation of different communities serves as a more reliable basis for biogeographic analysis. Finally, the shallow water elements provide important clues to the platform communities which were largely obliterated by dolomitization.

The collection is referred to as the Baillie Hamilton fauna (B-H fauna for short) in the rest of the paper. The taxonomy, community ecology, and biogeography of the B-H fauna are described and discussed. Specimens illustrated in this study are housed with the Geological Survey of Canada and are given Survey (GSC) numbers. Information regarding the locality and field geology was kindly provided by Thorsteinsson.

LITHOSTRATIGRAPHY

The Cape Phillips Formation consists of shale and thin-bedded, laminated siltstone and limestone. It represents the slope-to-basinal facies equivalent of coeval platform carbonates that occur to the south and east (fig. 1c; see also Thorsteinsson and Uyeno, 1982). The thickness of the Cape Phillips Formation near the zone of facies change is about 3000 m. To the northwest of the zone of facies change the thickness and carbonate fractions of the formation decrease markedly, and on neighboring Bathurst Island the Cape Phillips varies from about 310 to 2700 m and consists mainly of shale (Kerr, 1974).

The brachiopod faunas were obtained from a section of the Cape Phillips Formation on the central south coast of Baillie Hamilton Island (fig. 1c). The section consists of a north-trending, east-dipping sequence. The base of the section has been arbitrarily chosen at the stratigraphically lowest occurrence of a graptolite fauna characterized by the index species *Cyrtograptus sakmaricus*, while the top is marked by a rather thick covered interval in the exposures of the formation as followed eastward along the south coast of the island. The section is broadly divisible into two lithofacies: a lower part about 25 m thick, consists mainly of medium grey, thin-bedded argillaceous limestone that is variably dolomitic and characterized by irregular bedding planes; and an upper part, about 65 m thick, consisting mainly of dark grey, thin-bedded argillaceous limestone that is markedly bituminous and commonly planar laminated. A few discontinuous beds of brown bioclastic limestone that are variably silicified and up to 30 cm thick occur throughout both lithofacies. These beds represent debris flows that were derived from platform carbonates beyond the zone of facies change, which are presumed to have been situated some 10 km to the east (fig. 1b). The brachiopods and conodonts were obtained from the bioclastic beds and are therefore largely allochthonous.

AGE OF THE BRACHIOPOD FAUNA

The brachiopod fauna was collected from five localities; C22184, C22185, and C22187 were from measured section a, C12272 and C12273 were from section b, some 100 m north of section a (fig 2). According to Boucot and Thorsteinsson (personal communication), C12272 correlates somewhere between C22184 and C22185 on section a, while C12273 correlates between C22185 and C22187. The age of the brachiopod-bearing beds can be dated rather accurately on the basis of the graptolites. *Cyrtograptus sakmaricus* occurs abundantly throughout the lower 15.25 m of the section. According to Lenz (1978), the *Cyrtograptus sakmaricus-C. laqueus* Zone marks the top of the Llandoverian in northern and Arctic Canada. *Cyrtograptus* sp. cf. *C. murchisoni* subsp. and *C. insectus* that occur at the 29 m and 31.1 to 32.6 m levels, respectively, are indicative of the *C. murchisoni* Zone, which represents the second oldest Wenlockian zone (Rickards,1976). No diagnostic graptolites were found interbedded with the brachiopod faunas that occur stratigraphically above the occurrence of *C.* cf. *murchisoni*. However, a collection of graptolites (C67168) that includes the index species *C. lundgreni* was collected in beds about 125 m above the highest brachiopod fauna (C22187). *C. lundgreni* marks the third highest graptolite zone of the Wenlockian (Rickards, 1976), and this occurrence indicates that the brachiopod faunas extending from the 50.90 m level (C22184) to 89 m level (C22187) are entirely Wenlockian in age.

The conodonts, which have been identified by Uyeno, offer no greater precision in dating the brachiopod faunas than that already provided by the graptolites. Uyeno reports that the conodonts in C22184 cannot be dated more accurately than middle to late Silurian, but he notes that "if *Kockelella walliseri* is truly present, it would indicate the *ranuliformis* Zone to lower part of *amsdeni* Zone of Barrick and Klapper (1976). This is approximately equivalent to the lower half of the *patula* Zone of Walliser (1964, 1971), i.e. early, but not earliest Wenlockian. According to Larsson (1979), the lower half of the *patula* Zone encompasses parts of the *centrifugus* and *murchisoni* graptolites zones".

PALEOECOLOGY

The Baillie Hamilton fauna was recovered from the distal phase of debris flow deposits. The down slope transportation must have resulted in considerable mixing of communities. It is still possible, however, to reconstruct some of the communities on the basis of careful evaluation of the following criteria:

Morphology: Shell morphology commonly correlates with certain environmental gradients. The study by Faber, Vogel, and Winter (1977) showed that large brachiopods with stronger external ornamentations generally co-occur with coarse grain size, typically shallow water deposits, while small, smooth forms with a high articulation ratio are found in more offshore fine-grained deposits. The B-H fauna contains two groups of brachiopods. The larger group consists of small, thin-shelled brachiopods with a relatively low disarticulation ratio. It typifies an offshore, low energy environment. The other group includes medium size and often thick-shelled forms. They are mostly disarticulated and not noticeably well preserved, indicating a shallow-water environment with relatively high energy.

Taphonomy: Disarticulation and shell fragmentation can be used as a measure of the distance and mode of transportation. The small, thin-shelled brachiopods in the B-H fauna rarely show shell damage and commonly have a relatively high articulation ratio even among forms with the weak deltidiodont type articulating mechanism. The little disturbed nature of these species argues for a nearby source area. They probably colonized slope and basinal environments close to the final burial site. These small shells are likely to be held in suspension in the fluid head portion of a debris flow during down slope transportation; thus they suffer little shell damage. The larger and thick-shelled brachiopods on the other hand are mostly disarticulated and fragmentary. They bear the evident marks of more abrasive shallow-water transportation.

Abundance distribution among samples: Each of the five samples contains fossils brought together by a debris flow on its path to the depositional site. Because of their spatial proximity, it can be assumed that these debris flows had swept through the same ring of communities, which roughly correlate with depth zones. Consequently, the abundance distribution of species may provide clues to their original distribution in communities. Species with an even distribution in five samples are most likely to have come from a closer source or are abundant and widespread. On the other hand, species which show erratic distribution are either from a more distant shallow water community or have fluctuating population densities. Furthermore, species with similar abundance distributions may be assumed to have come from a common source.

Comparison with model communities: Boucot (1975, manuscript) has defined an array of Silurian brachiopod communities. Many of these communities reoccur in places, and thus can serve as models for community study. It is relatively easy to compare low diversity communities with the model. High diversity communities, such as the *Dicoelosia-Skenidioides* Community, often vary in both composition and relative abundance of species from one area to another. One has to make judgment calls in employing a high diversity community model. This study relies primarily on the low diversity community models summarized by Boucot in several of his publications (1975, manuscript, see also Johnson, Boucot, and Murphy 1976; Boucot, Johnson and Zhang 1989).

Used alone, any one of the above criteria may not offer an adequate argument for community assignment, but together they can provide enough clues for the reconstruction of some communities. The notion that communities can be recognized from transported assemblages is based on the principles borrowed here from the botanists of the Braun-Blanquet school, who employ the so-called Braun-Blanquet table to classify plant communities. To paraphrase Gauch (1982): "the Braun-Blanquet approach is founded on three principal ideas. (1) Plant communities are recognizable by their taxic composition apart from environmental information. (2) The stenotopic species of a community are diagnostic or indicator species and are emphasized in Braun-Blanquet analysis. (3) The species associations form building blocks of communities." The first two principals can be readily applied to fossil communities. As to the last principal, fossil data are commonly insufficient for hierarchical community classification.

The foregoing discussion leads to the recognition of the following brachiopod communities in the B-H fauna.

Trimerella Community

Trimerella commonly forms a high dominance community in turbulent waters at a BA 3 position. The genus is represented by 12 fragmentary valves in two samples (C22184, C12272). The occurrence of the genus does not coincide with that of other platform taxa such as pentamerids in the fauna. A typical *Trimerella* Community situated in the platform interior is the most reasonable source for the uncommon *Trimerella* specimens in Baillie Hamilton collection.

Rhipidium-Lissocoelia ? Community

The *Rhipidium* Community has been found in several localities in the North Atlantic Region. Boucot (manuscript) defines the community as a BA 3 rough water community. The nominal genus is present in four samples. It is absent from the medium

sized sample (C12273). *Lissocoelia*? is absent from C12273 and C22184. The shells of both genera are relatively large and thick, are disarticulated and fragmentary, indicating a shallow-water origin. The presence of a platform pentamerid community is further supported by Sodro and Hobson's findings (1979). These Canadian geologists reported pentamerids associated with reef communities in the Wenlockian part of the Allen Bay carbonates on adjacent Cornwallis Island.

Gracianella Community

The *Gracianella* Community has been described by Johnson, Boucot, and Murphy (1976) from the Roberts Mountains Formation of central Nevada. It is a low diversity, high dominance community with abundant articulated *Gracianella*. A BA 2-4 position in a quiet water environment is proposed by Boucot (manuscript) for the community.

In the B-H fauna, *Gracianella* shows a somewhat erratic distribution among the five samples. It is abundant in three samples, but only has four valves in the second largest sample C22184. Nearly one third of the specimens are disarticulated, consisting of almost equal numbers of opposite valves. This suggests that disarticulation occurred shortly before burial. Post-mortem transportation may have caused the high disarticulation ratio of the genus. It is assumed here that a quiet water *Gracianella* Community, probably situated on the upper slope, provided the source for the abundant *Gracianella* in the collection.

Liljevallia-Stromatoporoid Community

This community is described here for the first time. *Liljevallia* is a small cemented brachiopod. *In situ* samples from the Upper Visby Marl of Gotland show that *Liljevalila* attaches to the undersides of stromatoporoids, as well as some coexisting corals. The latter two organisms form both patchy reef and level bottom communities in the Upper Visby. Kershaw (1980) described the environment of the Upper Visby stromatoporoid communities as "a relatively deep and quiet environment subject to periodic turbulence caused by activities such as a storm". In Gotland, only the attached ventral valves of *Liljevallia* are found. The dorsal valves are presumably washed away by scouring currents. Since the cemented brachiopod depended on stromatoporoids as substrate, this special association can be recognized as a fossil community. In Gotland the community can be assigned to BA 3 in a moderately turbulent environment. The community group assignment is uncertain.

In the B-H fauna, *Liljevalila* is mostly disarticulated, dorsal valves are eight times more abundant than ventral valves. This lopsided ratio of opposite valves is consistent in all five samples, which is unique in the collection. It is reasonable to conclude that the Baillie Hamilton *Liljevalila* had a habitat similar to that of the Gotland

species. Because ventral valves are usually cemented firmly to stromatoporoids, only dorsal valves can be readily freed by currents and transported any distance. For a shallow water origin, *Liljevallia* has a rather even distribution in all five samples, suggesting the vast extent of the community. The presence of an extensive stromatoporoid community on the coeval shelf has been substantiated by Sodro and Hobson (1979).

Vosmiverstum-Conchidium Community

Subrianid communities are common in the Uralian-Cordilleran Region. They are commonly characterized by low diversity, high dominance and overcrowding. Boucot (1975, manuscript) suggests a BA 3 moderately turbulent environment for these communities. Five subrianid genera are present in the B-H fauna. The three larger genera, *Vosmiverstum*, *Conchidium*, and *Cymbidium* are present in only two samples (C12273, C12272), while the smaller genera *Severella* and *Spondylopyxis* occur in four and all five samples respectively. For this reason the smaller subrianids are considered to be derived from a community separate from the community with larger subrianids (see below). Many valves of these subrianids show growth deformation induced by overcrowding. The original community is postulated to have been dominated by dense populations of *Vosmiverstum* and *Conchidium* with a subordinate number of *Cymbidium*. Among a total of 1683 specimens, only two are articulate. This correlates well with a BA 3 rough water environment typical for subrianid communities elsewhere.

Severella-Spondylopyxis Community

Boucot (*ibid*) defines the *Severella* Community as a high dominance community and he assigns it to a BA 3 rough water environment based on disarticulated valves of the nominal genus. In the B-H fauna, *Severella* and *Spondylopyxis* are disarticulated. The two genera have a similar distribution. Both are smaller and have thinner shells than the coexisting *Conchidium* or *Vosmiverstum*. They probably lived in an environment deeper than the *Vosmiverstum-Conchidium* Community. A BA 4 or lower BA 3 position on the upper slope is a reasonable assignment for the community. Larger valves of the both species show the kind of deformation which indicates overcrowding.

Janius Community

Boucot (manuscript) has redefined the *Janius* Community based on collections from the Eke Marl on Gotland. It is a high diversity community consisting of abundant orthids, strophomenids, rhynchonellids, atrypids, and spiriferids. Boucot assigned the community to a BA 3 normal current environment.

In the B-H fauna, several species may have been derived from a shallow water *Janius* Community. These are *Janius occidentalis, Amphistrophia* sp., *Pentlandina harperi, Laevicyphomena* ? sp. *Leptaena* sp. Form 1, *Howellella* sp., *Flabellitesia*

kessei, and *Pseudomendacella boucoti*. They are mostly disarticulated, and have larger and thicker valves than most members of the fauna. The larger valves are noticeably fragmented, indicating a shallow water origin. Along with these larger species, a group of small species may also be from the same community because of their similar distribution with *Janius*. The small species include *Ptychopleurella lenzi, Stegerhynchus angaciensis, Plectatrypa unicosta, Fascizentina rohri, Plicoplasia* cf. *acutiplicata*, and *Thebesia* cf. *thebesensis*. The taxic makeup of these two groups of species are compatible with the composition of the *Janius* Community.

The remaining species of the B-H fauna, after subtracting the above described communities, can be separated into three groups based on their distribution. These are (1) species present in one or two samples only, (2) species conspicuously absent in one of the two largest samples or present abundantly in a small sample, and (3) species which do not belong to either (1) or (2).

It is difficult to trace the community origin of those species belonging to the first group. They are thus subtracted from the fauna list to reduce the "noise". These species are:*"Ancilloteochia"* cf. *pentaforma, Antirhynchonella* sp., *Clorinda geniculata, Clorinda* ? sp. *Dicoelospirifer dicoelospirifer, Drabovia* ? sp., *Glassia* ? sp. 2, *Johnsonnatrypa imbricata, Mesopholidostrophia lamellosa, M. salopiensis granti, Opikella* sp., *Parmorthina havliceki, Plectatrypa rongi, Salopina robitaillensis, S. gama, S.*? sp., indet. athyridid sp.

The species of the second group are problematic species. Some of them have wide environmental tolerance and are known from BA 3 to BA 5 communities. They are deducted from the fauna to simplify Baillie Hamilton community reconstruction. These species are: *Barrandina* sp., *Caryogyps chattertoni, Eospinatrypa bassetti, E. sagana, E.*? *savagei, Merista* sp., *Morinorhynchus crispus, Pseudoprotathyris* ? *modzalevskayae, Resserella canalis celtica, Reticulatrypa blodgetti, R. variabilis, Rhynchotreta americaniformis, Spirigerina copperi, Streptis glomerata*.

The third group species mostly have relatively high articulation ratio, even among species with a weak hinge mechanism. These small species are excellently preserved and are evenly distributed among samples. A close, deep water source can be assumed for these species. Furthermore, as a group they fit comfortably into the description of a typical BA 4 high diversity, low dominance *Dicoelosia-Skenidioides* Community. 32 species can be assigned to the community. These species and their distribution are given below (samples are arranged in the order of the increasing size from left to right).

	C-22185	22187	12273	22184	12272
Aegiria grayi	3	0	89	142	384
Amsdenina amsdeni	3	56	68	197	152
"Ancillotoechia" sheehani	1	55	57	10	75
Caryogyps grayi	1	0	3	8	31
Chonetoedea? cocksi	7	98	14	40	215
Cliftonia contorta	1	1	1	5	8
Clorinda sp.	1	1	1	22	4
Cyrtia alatiformis	0	15	32	16	40
Dalejina parahanusi	5	6	13	142	47
Dicoelosia bailliehamiltonensis	77	355	620	3211	1970
Epitomyonia amplissima	10	36	40	86	93
E. clausula	0	113	477	708	1037
Glassia ? sp.1	0	11	17	2	39
Hedeina sp.	0	6	51	25	16
Hirnantia cf. sagittifera	0	5	5	10	23
Isorthis (Arcualla) jini	2	20	102	189	490
I. (A.) walmsleyi	6	28	56	43	233
I. (A.) sulcata boreaina	8	31	68	129	130
Leptaena sp. Form 2	2	6	2	25	30
Lissatrypa cf. atheroidea	26	250	481	484	671
Morinorhynochus miniparvicostellus	0	12	11	45	20
Nucleospira cf. raritas	4	28	121	111	113
Paranisopleurella cooperi	19	78	123	102	477
Plicocyrtia jonesi	0	53	60	44	397
Salopina carinata	0	14	41	25	74
Skenidioides operosa	43	241	528	2249	1777
Spirinella struszi	48	233	374	363	2535
Spurispirifer hughsi	2	8	74	228	430
Stegerhynchus estonicus cordillerus	4	36	25	82	30
Visbyella visbyensis	0	2	20	114	56
Wangyuia thorsteinssoni	5	4	68	139	32
Zygatrypa stenoparva.	0	3	0	11	8

PALEOBIOGEOGRAPHY

Three levels of biogeographic units have been recognized on the basis of their Late Silurian brachiopods (Boucot, 1985, 1990; Wang and others 1984). These are the Malvinokaffric Realm; the North Silurian Realm, Uralian-Cordilleran Region, North Atlantic Region, European Province and American Province. The B-H fauna belongs to the Uralian-Cordilleran Region. A comparative study of the fauna with the coeval faunas of the North Silurian Realm provides a direct test for Boucot's biogeographic scheme based on Silurian brachiopods.

Few brachiopod collections are as accurately dated as the B-H fauna. For practical purposes all faunas of Wenlockian age are treated as coeval. The 13 coeval faunas are compiled from both published and unpublished sources. In areas lacking sufficient age data, the extracted fauna may include upper Llandoverian or Ludlovian genera. The following is a brief description of each selected fauna. Only the main references are given for each fauna:

The British fauna includes all brachiopods from the Wenlockian strata of Great Britain and Ireland (Cocks, 1987; Bassett, 1970, 1972, 1973, 1974).

The Bohemian fauna includes all brachiopods from the Wenlockian strata of Bohemia (Havlicek, 1967, 1977, 1980; Havlicek and Storh, manuscript).

The Baltic fauna includes all brachiopods from the Wenlockian strata of the eastern Baltics of the USSR, Gotland, Norway, and Podolia (Barrli, manuscript; Bassett and Cocks, 1974; Musteikis, manuscript; Gritsenko and others, manuscript).

The Acadian fauna includes all brachiopods from C5 to the Wenlockian strata (possibly including some Ludlovian occurrences) of the coastal area extending from Nova Scotia and New Brunswick to southeastern Maine (Boucot and others, 1966; Harper, 1973).

The North American fauna includes all brachiopods from the Wenlockian strata of the Mid-continent (Amsden, 1968, 1978; Boucot, manuscript; Brett, manuscript; Witzke and Johnson, manuscript).

The Eastern Great Basin fauna includes all brachiopods from the Wenlockian strata of the Eastern Great Basin, southern California and New Mexico (Boucot and others 1989; Sheehan, 1976, 1982, manuscript).

The Uralian fauna includes all brachiopods from the Wenlockian strata of the east-cental Urals (Sapelnikov, 1972; Sapelnikov and others, manuscript).

The Altai fauna includes brachiopods from the Wenlockian strata of the Altai Mountains (Kulkov, 1967).

The Iranian fauna includes brachiopods from the Wenlockian strata of northern Iran (Cocks, 1979).

The Mongolian fauna includes all brachiopods from the Wenlockian strata of Mongolia (Rozman, manuscript; Vladimirskaya, manuscript).

The Chinese fauna includes brachiopods from the upper Llandoverian to Ludlovian strata primarily of South China (Wang and others, 1984).

The Australian fauna includes brachiopods from the Wenlockian strata of Australia (Strusz, 1981, 1985, manuscript).

The Mackenzie fauna includes brachiopods from the Wenlockian strata of the Mackenzie Mountains (Lenz, 1977, manuscript).

The Nevada fauna includes brachiopods from the Wenlockian part of the Roberts Mountains Formation (Johnson and others, 1976).

The generic assignment of some species is updated here in the attempt to obtain a more or less standardized data base. For example, species assigned to *Vagranella* in both the Mackenzie and Nevada faunas are assigned to *Vosmiverstum* because they both have a short medium septum. The type species of *Vagranella* lacks a medium septum. The *Leangella* of those two faunas is assignable to Amsden's subgenus *Opikella* based on its parvicostellate ornament. ?*Fardinia* of the Mackenzie fauna has a well-developed pseudodeltidium and it should be assigned to *Morinorhynchus*. The *Anastrophia* of the Altai is clearly assignable to the subgenus *Grayina*.

The Affinity Index (AI) of Savage and others (1979) is used to measure the taxonomic similarities of the B-H fauna to coeval faunas. The Index is derived from the formula:

$$AI=\{(C-C^{cosm})/(N1-N1^{csom})\}x100$$

where C=number of genera common to the two samples being compared, C^{cosm} is the number of cosmoplolitan genera common to the two samples, N1 is the smaller sample, and $N1^{cosm}$ is the number of cosmopolitan genera in the smaller sample. The comparison results in two sets of AI values given in the table below. AI is based on the data excluding questionably identified genera, and AI', including questionably identified genera.

COEVAL FAUNA	$N\text{-}N^{COSM}$	$C\text{-}C^{COSM}$	AI	AI'
Baillie-Hamilton	35 (40)	/	/	/
Mackenzie	16 (28)	9 (12)	56	43
Nevada	15 (18)	8 (8)	53	44
Iran	6 (7)	2	33	29
Urals	19 (20)	5	26	25

Altai	15 (16)	4	27	25
Mongolia	15 (16)	0	0	0
Australia	13 (14)	3 (4)	23	29
China	50 (54)	6	18	15
Eastern Great Basin	19 (21)	8 (9)	42	43
N. America	44 (47)	4 (6)	12	15
Great Britain	35	3 (4)	9	11
Bohemia	69	5 (6)	15	15
Baltic	39 (45)	3 (4)	9	10
Acadia	21 (22)	1	5	5

As expected, the B-H fauna has its closest relationship with the Mackenzie and Nevada faunas. The three faunas were derived from similar host rocks and are characterized by BA 4-5 communities. Variable amounts of shallow water community elements are present in each fauna as a result of downslope mixing. Each of the faunas actually represents a segment of a continuous faunal belt which rimmed the western margin of the North American continent. The host rock units, i.e. the Cape Phillips in the Arctic, the Whittaker-Road River transition in the Mackenzie Mountain, and the Roberts Mountains, in Nevada, signifies a globally unique environment. It is characterized by a steep slope, indicated by the frequent debris flows, and a vast graptolitic basin. The communities that colonized the steep slopes, however, had few genera endemic to the region. A group of long lobe *Dicoelosia* such as *D. parvifrons* and *bailliehamiltonensis* are distinctive to the region. Study is underway to distinguish this species group from the *D. biloba* group. *Spondylopyxis* is probably endemic to the area too. The biogeographic significance of the new genera *Dicoelospirifer* and *Johnsonatrypa* awaits further study.

The comparison with the Uralian faunas is complicated by environmental factors. BA 4-5 communities are absent from the Urals and China, resulting in depressed AI values. The fact that BA 3 communities are under-represented in the Cordilleran faunas further compounds the problem. Deep water brachiopods are present in the Altai fauna but they are under-represented. Consequently the AI is biased towards a lower value. The Iran fauna, on the other hand, consists of a single BA 5 *Dicoelosia-Skenidioides* Community (from a small sample made at one locality). The incomplete community representation again leads to an unreliable AI value.

The Mongolian fauna has a zero AI value which cannot be entirely attributed to habitat differences. The fauna is characterized by the highly endemic Tuvaella Community. Boucot (1985, 1990) has proposed a subprovince for the fauna.

The Australian fauna includes both shallow and deep water communities. But pentamerids are unusually sparse in the faunal list. Limestones with abundant pentamerids are present in New South Wales, but have not been studied (Boucot, personnel communication). The incompleteness of the fauna probably has a negative effect on the AI value.

Despite the bias caused by comparing different communities, The Uralian faunas in general show higher AI values with the B-H fauna than the N. American and the European faunas do. The free faunal exchange between the Cordilleran and Uralian is illustrated by their abundant subrianids, eospiriferids with a striate cardinal process, as well as such characteristic genera as *Gracianella* and *Epitomyonia*.

The high taxonomic similarity shared by the B-H fauna and the Eastern Great Basin fauna is a result of boundary mixing. The latter is a platform fauna situated on the boundary which divided the North American fauna from the Cordilleran fauna. In this boundary area, brachiopods typical of the North America Region, such as *Apopentamerus, Microcardinalia*, and *Rhipidium*, coexisted with the Uralian Cordilleran genera *Vosmiverstum and Cymbidium* . A mixed boundary fauna is characteristic of a gradational faunal barrier most likely produced by gradual changes in environment such as climatic gradients.

The North American fauna from the Mid-continent has a noticeably low AI value with the B-H fauna. Similarly, the European faunas show distant relationships with the B-H fauna. Both the North American and European faunas are well studied and include a complete spectrum of communities ranging from BA 2 to 5. The low AI values are not affected by environment. It reflects a true biogeographic distinction.

To summarize, the B-H fauna is a part of the Cordilleran megafauna characterized by its deep water, slope-dwelling communities. The faunal exchange between the Cordilleran and the Uralian was not hindered, in spite of largely different habitats of the two regions. Reproductive communication is indicated by both shared brachiopods of the two regions and the lack of endemic genera in the Cordilleran region. The Mongolian fauna was well shielded from the Cordilleran fauna. The zero AI value supports the existence of the Mongolo-Okhotsk Subprovince within the Uralian-Cordilleran Region. Faunal exchange between the Uralian-Cordilleran and the North American or the European faunas was restricted, as indicated by the consistently low AI values. The presence of a mixed boundary fauna in the Eastern Great Basin suggests an environmental gradient, such as a climatic gradient, that may have served as a faunal barrier. The analysis supports Boucot's Silurian biogeographic divisions. Among various models of Silurian terrain reconstruction, the Pangaea proposed by Boucot and Gray

(1979) provides the best fit for the results of this study. In the Pangaea model, faunas of the Uralian-Cordilleran Region are connected by equatorial currents. A faunal barrier associated with climatic gradient is implied, where the North Atlantic Region is sandwiched between the low latitude Uralian-Cordilleran Region and the high latitude Malvinokaffric Realm. Finally, the study by no means proves a Silurian Pangaea; the synthesis is merely more consistent with that model than with others.

SYSTEMATIC PALEONTOLOGY

Phylum Brachiopoda
Class Inarticulata
Order Lingulida
Superfamily Trimerellacea Davidson and King, 1872
Family Trimerellidae Davidson and King, 1872
Genus *Trimerella* Billings, 1862
Type species: *Trimerella grandis* Billings, 1862, p. 166.
Trimerella sp.
Pl. 1, figs. 21-23, 28, 29, 34-37.

Exterior: Valves large, the largest specimen is at least 38 mm wide; biconvex, large dorsal valves may become very deep. Ventral valve elongate triangular with long beak; beak straight or gently incurved; pseudointerarea apsacline to orthocline; homeodeltidium convex, bearing transverse lamellae, laterally continuous with propareas without bounding grooves. Dorsal beak strongly inrolled in large valves; a curved, callous ridge rims inner posterolateral margin of the valve, separated by a groove from the beak; the ridge may develop a posteroventrally projecting tongue which fits into the cardinal socket of ventral valve. Valve surface has widely spaced concentric growth lamellae.

Ventral interior: Muscle platform trapezoidal, medially depressed, supported by a ridge-like median partition; laterally the platform highly elevated, with large platform vaults. Cardinal buttress absent. Muscle scars not impressed.

Dorsal interior: Muscle platform long, highly elevated, medially gently depressed and supported by a high median partition; platform vaults large. Muscle scars not impressed.

Occurrence:	Articulated	Ventral	Dorsal
C22184	0	5	5
C12272	0	0	2

Class Articulata
Order Orthida
Superfamily Orthacea Woodward, 1852
Family Hesperorthidae Schuchert and Cooper, 1931
Subfamily Hesperorthinae Schuchert and Cooper, 1931

Genus *Flabellitesia* n. gen.

Type species: *Hesperorthis kessei* Boucot, Johnson, and Zhang 1988.

Derivation of genus name: After the well known species of the genus, *flabellites* Foerste.

Diagnosis: Unequally biconvex to convexoconcave, costate, interspaces widen anteriorly, with sporadic capillae, concentric lamellae closely spaced, antigydium is present at least in type species, internal crenulations rounded in small valves and rectangular with a medial groove in large valves.

Species assigned:

Hesperorthis kessei Boucot, Johnson, and Zhang. Hidden Valley Dolomite and Cape Phillips Formation.

Orthis flabellites Foerste 1909. Rochester Shale.

Orthis militaris Foerste 1909. Clinton beds.

Orthis juno Barrande 1879. Motol Formation.

Discussion: An antigydium is for first time observed in *F. kessei* from Baillie Hamilton Island. Five out of eighty silicified dorsal valves from the Baillie Hamilton collection possess the delicate antigydium structure. The absence of an antigydium in other species of the genus (including *F. kessei* from the Hidden Valley Dolomite) is probably due to poor preservation, since these species are mostly based on small numbers of poorly preserved specimens. The generic assignment of *F. flabellites* and related species has been a problem. Some placed these species in *Hesperorthis* because of their simple costation, others assigned them to *Dolerorthis* on the basis of its reversed convexity. Sheehan (1982) has suggested the need of a new genus for those species. The Baillie Hamilton material, although not a large sample, possesses a well-developed antigydium, and shows some ontogeny of the species (see pl. 1, figs. 5, 7, 8). *Flabellitesia* differs from *Dolerorthis* in having an antigydium and simple costae and from *Hesperorthis* in developing a reversed convexity in mature shells. *Flabellitesia* also has stronger concentric lamellae and a noticeably lower ventral interarea than most *Hesperorthis* species. On the basis of these differences, a new genus is proposed here for the *flabellites* species group.

Flabellitesia kessei (Boucot, Johnson, and Zhang), 1988

Pl. 1. figs. 1-20, 24-27, 30-33.

1988 *Hesperorthis kessei* Boucot, Johnson, and Zhang, p. 107, pl. 1, figs. 1-16

Exterior: Valves medium size (the largest specimen is 25 mm wide, 19.4 mm long); small valves transversely subquadrate and plano-convex, large valves semi-circular and convexo-concave; hinge line equal to the maximum width in small valves and slightly shorter than the maximum width in large valves. Ventral interarea flat, steeply apsacline; delthyrium narrow, subtriangular; beak erect. Dorsal interarea narrow, anacline; antigydium convex, covers posterior half notothyrium. Dorsal sulcus shallow, poorly defined.

Valves costate, costae vary from 16 in very small valves to 20 in medium to large valves. Costae originate at beak except for ventral median pair and the dorsal median pair in sulcus developed near the beak front. Costae tend to be angular in small valves, become lower and rounded anteriorly in large valves. Interspaces generally U-shaped, widen anteriorly. Capillae uncommon, only one or two in some wider interspaces (pl. 1, fig. 6). Concentric lamellae strong, closely spaced.

Ventral interior: Teeth small, blunt; dental plates receding, laterally define a largely apically restricted, slightly thickened, cone-shaped muscle field. Muscle impressions unclear.

Dorsal interior: Cardinal process blade-like, rests on small notothyrial platform. Brachiophore bases thick, triangular, widely divergent. Sockets small, excavated between interarea and brachiophore bases. Muscle field indiscernible.

Inner surface of both valves variably crenulated; crenulations rounded in small valves, rectangular with medial groove in medium size valves and the medial groove deepens, resulting in the anterior bifurcation of crenulations in large valves.

Occurrence:	Articulated	Ventral	Dorsal
C22184	0	22	49
C22185	0	3	1
C22187	0	3	12
C12273	0	8	10
C12272	0	10	8

Subfamily Glyptorthinae Schuchert and Cooper, 1931

Genus *Ptychopleurella* Schuchert and Cooper, 1931

Type species: *Orthis bouchardi* Davidson 1847, p.64, pl.13, figs. 5-8

Ptychopleurella lenzi n. sp.

Pl. 2, figs. 1-25.

Derivation of species name: In honor of Alfred C. Lenz.

1977 *Ptychopleurella* sp. Lenz, p.1526, pl.1, figs. 1-3

Diagnosis: *Ptychopleurella* with long hinge line and relatively numerous angular costae.

Exterior: Valves intermediate (the largest specimen is 12 mm wide, 8.5 mm long); transversely subquadrate, length:width ratio averages 0.63 (n=30 std=0.08), hinge line equal to the maximum width in small valves and becoming slightly shorter than the maximum width in larger valves; lateral profile ventri-biconvex. Ventral valve subpyramidal; interarea high, flat, and steeply apsacline; beak erect, delthyrium narrow, subtriangular. Dorsal valve gently convex, medially sulcate; interarea low, generally orthocline.

Ornament fascicostate, consisting of strong, angular primary costae and finer costellae, overlapped by closely spaced, strong concentric lamellae. The number of primary costae constant, seven on ventral valve and six on dorsal valve, costellae variable in number, generally increasing with increasing size. The median pair of costellae on either valve originate first, costellae closest to hinge line generally start next, and the rest originate about 2 mm from beak.

Ventral interior: Teeth small, blunt; dental plates receding, laterally bounding elevated muscle field.

Dorsal interior: Cardinal process blade-like in small specimens and its anterior half expands into a ventrally projecting knob in larger specimens. Sockets bounded by curved brachiophore bases. Brachiophores diverge anterolaterally, blade-like in small valves and prism-like in larger ones. Adductor scars, generally preserved in larger and thicker specimens, consist of two or four oval impressions separated by a low, broad, rounded myophragm.

The interior of both valves variably crenulated, valves with fewer costellae have low, broad, subrectangular crenulations, thin valves have angular crenulations commonly in form of bundles corresponding to external fascicostae; thick valves have only peripheral crenulations, subrectangular in cross section.

Comparison: The new species differs from most Silurian Ptychopleurella in having a longer hinge line and finer costae. The immature shells of the species closely resemble Nevada Wenlockian species *P. micula* Johnson, Boucot, and Murphy. The latter is a species of very small size, on the basis of 200 specimens from four localities. It may represent a dwarfed member of the genus.

Occurrence:	Articulated	Ventral	Dorsal
C22184	2	13	14
C22187	0	11	9
C12273	0	14	14
C12272	2	16	8

Family Wangyuiidae n. fam.
Type genus: *Wangyuia* n. gen.

Diagnosis: Ventral valve subpyramidal, dorsal valve flat to gently convex; strongly costellate; ventral muscle field bilobed; dental plates reduced; cardinal process rod-like, may or may not have a bilobed myophore; brachiophores long, plate-like, subparallel to each other; no punctation observed.

Discussion: The new family is monotypic. It resembles the Hesperorthidae in shape, costellation, and ventral interior. It differs from the latter in lacking a notothyrial platform. Instead, it has dalmanellid type cardinalia and muscle field. The family is assigned to the Orthacea on the basis of its ventral valve characters and lack of punctation. Externally, the new family differs from other families of the Orthacea as does the Hesperorthidae.

Genus *Wangyuia* n. gen.
Type species: *Wangyuia thorsteinssoni* n. sp.

Derivation of genus name: In honor of Wang Yu;

Diagnosis: Small, transversely subquadrate; ventral valve subpyramidal; dorsal valve flat to gently convex; costellae strong, overlapped by weak concentric lamellae; cardinal process rod-like, may develop a bilobed myophore; brachiophores long, plate-like, subparallel to each other.

Exterior: Valves small, transversely subquadrate with acute to subangular cardinal extremities: plano-convex to unequally biconvex. Ventral valve subpyramidal with steeply apsacline to procline interarea. Dorsal sulcus shallow, poorly defined.

Ornament angularly costellate. Costellae increase by both insertion and bifurcation. Closely spaced fine concentric lamellae weakly developed to nearly absent.

Interior: Dental plates receding, laterally bounding bilobed muscle field. Cardinal process rod-like, may develop a bilobate myophore; brachiophores long, plate-like, subparallel to each other.

Comparison: The exterior of the new genus somewhat resembles *Ptychopleurella* Schuchert and Cooper and *Glypterina* Boucot, it can be easily distinguished from both of the latter by its dorsal internal structure. The most distinctive features of the genus are (1) a pair of long, plate-like brachiophores which are concave laterally and subparallel to each other, extending anteriorly, (2) a rod-like cardinal process with bilobate myophore; and (3) absence of notothyrial platform.

Wangyuia thorsteinssoni n. sp.
Pl. 2, figs. 26-36, pl. 3, figs. 1-13.

Derivation of species name: In honor of R. Thorsteinsson.

Diagnosis: Same as for the genus because the genus is monotypic.

Exterior: Valves small (the largest specimen is 6.1mm wide, 4.0 mm long); transversely subquadrate, maximum width at hinge line, with acute to subangular cardinal extremities; lateral profile plano-convex to unequally biconvex. Ventral interarea high, flat, steeply apsacline to steeply procline; beak slightly incurved to erect; delthyrium triangular. Dorsal sulcus very shallow, poorly defined by a pair of primary costae.

Costae strong, subangular; 7 to 11 primary costae on ventral valve and 8 to 10 on dorsal valve. Costellae originate by bifurcation and implantation, vary considerably in number, generally from 2 to 7 in mature valves; a pair of costellae frequently developed in sulcus. Primary costae and the associated costellae tend to form bundles of fascicostellae in some valves. Fine concentric lamellae closely spaced, weakly developed or absent.

Ventral interior: Teeth blunt; dental plates extremely short, laterally define the posterior portion of muscle field. Muscle field small, bilobate anteromedially indented.

Dorsal interior: Cardinal process rod-like, with medially indented myophore extending posteroventrally and filling notothyrial cavity. Brachiophores long, plate-like, free-hanging, concave laterally, nearly parallel to each other, extending anteriorly in deep valves, but anteroventrally in flat valves. Sockets defined by brachiophore bases and posterior edge of interarea. Muscle field elongate, faintly impressed, with or without a pair of weak lateral bounding ridges.

Both valves have subangular to rounded radial crenulations; in thick valves crenulations are peripheral and rectangular in cross section.

Remarks: This species shows a relatively high percentage of asymmetrical growth deformation.

Occurrence	Articulated	Ventral	Dorsal
C22184	5(3)	47(14)	87(5)
C22185	2(1)	0	3(1)
C22187	0	3(2)	1
C12273	0	24(7)	44(3)
C12272	0	15(3)	17

* numbers in () are numbers of deformed specimens, in case of C22184, 3 out 5 articulated shells are deformed.

Family Skenidiidae Kozłowski, 1929

Genus *Skenidioides* Schuchert and Cooper, 1931

Type species: *S. billingsi* Schuchert and Cooper, 1931

Skenidioides operosa Johnson, Boucot, and Murphy, 1976

Pl. 3, figs. 14-48.

1976 *Skenidioides operosa* Johnson, Boucot, and Murphy, p. 23, pl. 29, figs. 1-15.

Remarks: *S. operosa* was previously recovered from Nevada Ludlovian strata. The Arctic Wenlockian collection consists of a much larger sample; it includes some larger valves and shows a wider variation of the species, especially in outline and number of costae. The species shows a general trend of decreasing width:length ratio and increasing costellae density with increasing size for the species. However, both the outline and costellae density have too wide a variation range to be reliable taxonomic criteria.

Exterior: Valves small (the largest specimen is 5.4 mm wide, 4.1 mm long); outline varies from transverse with acute cardinal angles to subcircular; strongly ventribiconvex; anterior commissure sulcate. Ventral valve subpyramidal; interarea high, mostly catacline and flat; delthyrium narrow; beak generally erect. Dorsal valve gently convex, occasionally flat; interarea narrow, anacline; dorsal sulcus shallow, deepening and widening anteriorly.

Ribs generally subangular, relatively strong. Each valve commonly with 11 primary costae. Costellae increase in number by bifurcation and implantation. Intercalated costellae appear on the lateral sides of costae on dorsal valve and on the medial sides of costae on ventral valves. Concentric growth lines uncommon.

Ventral interior: Spondylium shallow, about 3/5 of interarea length, varies from free-hanging to supported by a short ridge, no apparent septum present.

Dorsal interior: Cardinal process ridge-like, with or without posterior expansion. Cruralium U-shaped, supported by a high median septum. Brachiophores extend anteroventrally with narrow divergent angle. Fulcral plates absent or very short. A pair of large diamond-shaped adductor impressions preserved in some thickened valves.

Occurrence	Articulated	Ventral	Dorsal
C22184	19	969	1261
C22185	2	21	20
C22187	7	143	91
C12273	13	316	199
C12272	22	1051	704

Suborder Dalmanellidina Johnson and Talent, 1976
Superfamily Dalmanellacea Schuchert, 1913
Family Dalmanellidae Schuchert, 1913
Subfamily Isorthinae Schuchert and Cooper, 1931
Genus *Isorthis* Kozłowski, 1929
Subgenus *Isorthis* (*Arcualla*) Walmsley and Boucot, 1975

Type species: *Orthis* (*Dalmanella*) *arcuaria* Hall and Clarke, 1892

Remarks: Walmsley and Boucot (1975) erected two new subgenera of *Isorthis, I.* (*Ovalella*) and *I.* (*Arcualla*). These two taxa differ from *I.* (*Isorthis*) in being sulcate and having an elongate oval dorsal muscle field. The above authors selected the thickness of the ventral myophragm as the key feature to separate *I.* (*Ovalella*) from *I.* (*Arcualla*). However, this feature appears to be variable in the Baillie Hamilton Island material. It is difficult to assign this material to either subgenus on the nature of myophragm. On the other hand, species of *I.* (*Arcualla*) generally have a narrower, more elongate dorsal muscle field than species of *I.* (*Ovalella*), but this difference is not clear-cut between the two subgenera. Pending further investigation, I assign all three species and subspecies from Baillie Hamilton Island to *I.* (*Arcualla*) on the basis of their narrow, elongate oval muscle field.

The three Wenlockian species and subspecies described below frequently show a well-developed quadripartite dorsal muscle field in contrast with the non-quadripartite muscle field of *I.* (*Arcualla*) occurring in younger strata elsewhere. It is possible that the subgenus was derived from a Llandoverian ancestor with a distinctly quadripartite muscle field and retained this feature until the late Wenlock.

The three species and subspecies of Baillie Hamilton Island fall into two different size ranges: *I.* (*A.*) *sulcata boreaina* is much larger than the other two. The three have very similar length:width and rather variable costellae density. *I.* (*A.*) *walmsleyi* has fewer costellae and lower hinge line:maximum width ratio than *I.* (*A.*) *jini*.

Isorthis (*Arcualla*) *jini* n. sp.
Pl. 3, figs. 49-58.

Derivation of species name: In honor of Jin Yu-gan.

Diagnosis: Small *Isorthis* with fine multicostellae and subangular cardinal extremities; dorsal muscle field commonly quadripartite with the anterior adductor pair much larger than the posterior one.

Exterior: Valves small (the largest specimen is 5.6 mm wide, 4.6 mm long); ventri-biconvex; transversely elliptical; hinge line:width ratio averages 0.80 (n=43, std=0.058), cardinal extremities subangular. Ventral valve length:width ratio averages 0.83 (n=43, std=0.079); interarea moderately high, slightly incurved, apsacline; beak incurved; triangular delthyrium open. Dorsal valve length:width ratio averages 0.74; interarea ribbon-like, anacline to almost orthocline; sulcus shallow and relatively narrow.

Costellae angular to rounded, closely spaced with narrow V-shaped interspaces, increase in number by intercalation and bifurcation. The ventral median costa tends to be more prominent than adjacent ones. Concentric growth lines uncommon.

Ventral interior: Teeth triangular; dental plates short, straight to medially concave. Muscle field bilobed, largely restricted to delthyrial cavity, slightly elevated in most valves, laterally bounded by dental plates and medially divided by a low myophragm of variable thickness. Peripheral crenulations rectangular to subangular, separated by narrow grooves.

Dorsal interior: Cardinal process rod-like with slightly thickened myophore. Brachiophores prism-like; supporting plates narrowly diverge anteriorly and continuous with lateral muscle bounding ridges. Muscle field elongate, about 0.60 as wide as long and extends about 0.74 length of the valve; a pair of transverse ridges developed in some valves; myophragm somewhat carinate. Sockets floored by fulcral plates. Peripheral crenulations similar to those of ventral valves.

Comparison: See comparison under *I.* (*A.*) *walmsleyi* n. sp..

Occurrence	Articulated	Ventral	Dorsal
C22184	7	101	81

C22185	0	1	1
C22187	2	9	9
C12273	1	9	12
C12272	12	306	172

Isorthis (*Arcualla*) *walmsleyi* n. sp.
Pl. 3, figs. 59-67, Pl. 4, figs. 1-19.

Derivation of species name: In honor of V. G. Walmsley;

Diagnosis: Valves small, with relatively coarse costellae, hinge line short, dorsal sulcus poorly defined, dorsal muscle field extends nearly to anterior shell margin.

Exterior: Valves small (the largest specimen is 4.9 mm wide, 4.3 mm long); ventri-biconvex to almost equally biconvex; hinge line:width ratio averages 0.64 (n=21, std=0.071), with rounded cardinal extremities. Ventral valve subcircular, length:width ratio averages 0.84 (n=21, std=0.063); interarea moderately high, flat to gently incurved, generally apsacline, some nearly orthocline; beak small, erect or gently incurved; delthyrium open, relatively large. Dorsal valve transversely elliptical, length:width averages 0.79; interarea ribbon-like, orthocline to anacline, with large, open notothyrium; sulcus shallow and poorly defined, widening anteriorly.

Ornament of fine, rounded multicostellae to coarse, angular semi-fascicostellae. Costellae increase in number by intercalation along sides of costae, less commonly by bifurcation. The density of costellae varies considerably. Concentric growth lines rare.

Ventral interior: Teeth triangular; dental plates moderately short, straight to medially concave, laterally bounding a short, bilobed muscle field. Myophragm low, may be absent in some valves. Peripheral crenulations generally subrectangular with or without medial indentations, separated by narrow grooves.

Dorsal interior: Brachiophores prism-like, laterally joined by fulcral plates; brachiophore supporting plates large, narrowly divergent anteriorly, continuous with lateral muscle bounding ridges. Cardinal process with slightly swollen myophore, resting in notothyrial cavity, continuous anteriorly with long, narrow, carinate median ridge Muscle field elongate, about 0.54 as wide as long and 0.78 as long as the valve length; transverse ridges present in some valves, resulting in a quadripartite muscle field. Muscle bounding ridges may be absent in some valves. Peripheral crenulations similar to those of ventral valves.

Comparison: *I.* (*A.*) *jini, walmsleyi*, and the Nevada species *microscapha* Johnson, Boucot, and Murphy are readily differentiated from other *Isorthis* by their small size and large dorsal muscle field relative to their valve size. Externally, *jini* is characterized by fine costellae and angular cardinal extremities; *walmsleyi* has coarse costellae and rounded cardinal extremities; and *microscapha* is somewhat intermediate between the above two. Internally, the three species differ from each other as follows: *microscapha* has a narrow muscle field bounded by long, subparallel ridges; the anterior adductor pair of *jini* are much larger than its posterior pair; and *walmsleyi* has a large, nearly equally quadripartite muscle field.

Occurrence	Articulated	Ventral	Dorsal
C22184	1	20	22
C22185	0	2	4
C22187	2	14	12
C12273	4	20	32
C12272	23	129	81

Isorthis (*Arcualla*) *sulcata* Walmsley and Boucot, 1975
Isorthis (*Arcualla*) *sulcata boreaina* n. subsp.
Pl.4, figs. 20-43.

Derivation of subspecies name: After the Greek boreas, referring to the northern occurrence of the subspecies.

1966 *Isorthis* sp. Boucot, Johnson, Harper, and Walmsley, p. 19, pl. 4, figs. 15, 16; pl. 5, figs. 5, 6 (not 1-4).

Diagnosis: Sulcate *Isorthis* with elongate, quadripartite dorsal muscle field, carinate median ridge, nonlobed cardinal process, and fulcral plates.

Exterior: Valves medium size (the largest specimen is 15.6 mm wide, 12.5 mm long); ventri-biconvex; semi-circular; hinge line:width ratio averages 0.66 (n=38, std=0.063). Ventral valve length:width ratio averages 0.82; interarea moderately low, slightly curved, apsacline; triangular delthyrium open; beak incurved; Dorsal valve length:width ratio averages 0.83; interarea narrow, orthocline to gently anacline; notothyrium open; sulcus widens anteriorly, anterior commissure sulcate.

Ornament multicostellate, costellae subangular to rounded, mainly bifurcating, increase in number with the increasing valve size. Concentric growth lines rare.

Ventral interior: Teeth triangular; dental plates moderately reduced, straight or medially concave, laterally bounding short muscle field. Myophragm variable in size, ends anteriorly in a broad triangular slope in some valves. Peripheral crenulations vary from rectangular with a medial indentation to rounded, separated by rounded grooves.

Dorsal interior: Cardinal process slender, with blade-like shaft and slightly thickened myophore. Sockets deep, supported on fulcral plates. Brachiophores prism-like, diverge anteroventrally, supporting plates high, incline medially and continue anteriorly with lateral muscle bounding ridges. Muscle field elongate suboval, quadripartite; lateral bounding ridges curve towards the end of myophragm; distinct notches in middle of the lateral ridges, defining the boundary between anterior and posterior adductor impressions; transverse ridges variably present; myophragm carinate, continues posteriorly into cardinal process and extends anteriorly about 0.5 to 0.70 valve length. Crenulations similar to those of ventral valves.

Comparison: The new subspecies differs from *I. sulcata sulcata* Walmsley and Boucot, of Oklahoma, in having a longer, distinctively quadripartite dorsal muscle field, non-bilobed cardinal process, and fulcral plates in contrast with socket pads of the latter. The Oklahoma subspecies is of Ludlovian age, it may have been derived from this northern subspecies.

Occurrence	Articulated	Ventral	Dorsal
C22184	2	54	73
C22185	0	3	5
C22187	1	20	10
C12273	1	41	26
C12272	1	62	67

Subfamily Resserellinae Walmsley and Boucot, 1971

Genus *Visbyella* Walmsley, Boucot, Harper, and Savage, 1968

Type species: *Orthis visbyensis* Lindström, 1861

Visbyella visbyensis (Lindström), 1861

Pl. 4, figs. 44-58, Pl. 5, figs. 34-39.

1861 *Orthis visbyensis* Lindström, p. 12, fig. 8.

1932 *Parmorthis visbyensis* -- Schuchert and Cooper, p. 129, pl. 21, figs. 1, 6, 8, 11, 12, 15.

1968 *Visbyella visbyensis* -- Walmsley and others, p. 307, pl. 60, figs. 1-9.

Remarks: The Arctic material closely resembles *V. visbyensis* from Gotland except for being smaller, generally about half the size of the Gotland material. Probably related to its smaller size, the Arctic material lacks a distinct ventral medial depression, its ventral beak does not overhang the dorsal valve, and its dorsal muscle field bounding ridges are absent or weakly developed. The taxonomic significance of the size difference between the Arctic and Gotland specimens is uncertain. A conservative approach is taken here by assigning the Arctic material to *V. visbyensis*.

Exterior: Valves intermediate (the largest valve is 9.5 mm wide, 9.9 mm long); plano-convex to slightly concavo-convex, semi-circular to shield-shaped; hinge line:width ratio averages 0.73 (n=26, std=0.05). Ventral valve deep, length:width ratio increases with increasing size; beak strongly incurved, nearly overhangs dorsal valve in large valves; interarea orthocline in large valves and gently apsacline in small valves; delthyrium triangular. Dorsal valve flat, sulcus shallow, widening markedly anteriorly, flat or slightly raised in the median area; interarea generally catacline.

Ornament of fine multicostellae, rounded to subangular, increase by bifurcation. Ventral median costa tends to split into a pair or more of finer costellae, resulting in a very faint, narrow median depression in some large valves. Dorsal median costa bifurcates asymmetrically. The number of costellae increases with the increasing size, about 40 costellae on either valve and 17 in dorsal sulcus at 5 mm growth stage.

Ventral interior: Teeth large, thick, triangular, bearing laterally inclined accessory sockets; dental plates thick, moderately reduced, divergent anterolaterally, join the side walls of delthyrial cavity at about half their height. Muscle field largely indiscernible, a low median ridge may be present in some valves. Peripheral crenulations rounded to rectangular, separated by narrow interspaces.

Dorsal interior: Cardinal process projects beyond the posterior margin of the valve, bearing a trilobed distal face, laterally continuous with brachiophore bases, forming inverted, V-shaped cardinalia; brachiophores directed ventrally at a small divergent angle; brachiophore bases diverge widely anteriorly, and fuse posterolaterally with thick socket pads. Muscle field cordate, about 0.58 of the valve length, 0.70 as wide as long; lateral bounding ridges weak to absent; median ridge prominent, tends to narrow anteriorly and dies out just anterior of muscle field; transverse ridges faint, present sporadically, divide the larger posterior adductor impressions from the anterior ones. Peripheral crenulations similar to those of ventral valve.

Occurrence	Articulated	Ventral	Dorsal
C22184	21	58	35
C22187	0	1	1

C12273	0	12	8
C12272	0	34	22

Genus *Resserella* Bancroft, 1928
Type species: *Orthis canalis* Sowerby, 1839
Resserella canalis celtica Bassett, 1972
Pl. 5, figs. 1-12, 43, 44.

1971 *Resserella brownsportensis* Walmsley and Boucot, pl. 91, figs. 11, 12; pl. 92, figs. 1-5; not pl. 98, figs. 3-6; not Amsden.
1972 *Resserella canalis celtica* Bassett, p. 49, pl. 10, figs. 9; pl. 11, figs. 1-5.
1976 *Resserella canalis celtica* -- Johnson, Boucot, and Murphy, p. 26, pl. 1, figs. 1-12.

Remarks: The subspecies has been recovered from Wenlockian strata in Wales, Nevada, and the study area. The Nevada material consists of very small valves with a broad central panel developed throughout the length of the valve. The Arctic material is similar to the Welsh material in size and outline. However, the central panel of the former is narrower and only distinct in the anterior half of the valve, somewhat transitional between typical *R. canalis canalis* and *canalis celtica*. The Arctic material is unique in having both implanting and bifurcating costellae in contrast with the basic bifurcation pattern of both Welsh and Nevada specimens.

Exterior: Planoconvex to slightly concavoconvex with semi-circular to transversely elliptical outline; length:width ratio averages 0.85, hinge line:width ratio averages 0.69 (n=28, std=0.07). Ventral valve strongly convex along the midline with relatively steep flanks; interarea steeply apsacline, straight in small valves and moderately incurved in large valves; beak small and pointed, erect in small valves and moderately incurved in large valves, without developing a swollen umbo; triangular delthyrium open. Dorsal valve flat to slightly concave; interarea narrow, anacline; notothyrium filled with cardinal process; sulcus starts in front of beak, initially narrow and deep, widening and flattening markedly anteriorly, becoming flat in anteromedian area of some large valves.

Ornament multicostellate, costellae medium coarse, rounded to subangular, variable in density, increase in number by both insertion and bifurcation. Central triangular panel narrow, smooth or with fine capillae, discernible at anterior half of the valve.

Ventral interior: Teeth triangular, bearing laterally inclined accessory sockets; dental plates receding, diverge widely, joining walls of delthyrial cavity at about half their height; crural fossettes poorly developed to absent. Muscle field bilobed, rarely visible. Peripheral crenulations subrectangular with narrow interspaces.

Dorsal interior: Cardinal process fills the notothyrial cavity, consists of a medially depressed shaft and a medially indented myophore. Brachiophores rod-like, diverge anteroventrally at about 40-60 degrees; Brachiophore bases continuous with socket pads, defining triangular sockets. Muscle field faintly impressed, about 0.7 of valve length, 0.3 of valve width, with weak lateral bounding ridges; the medial part of muscle field slightly raised, resembling a low myophragm. Peripheral crenulations similar to those of ventral valves.

Occurrence	Articulated	Ventral	Dorsal
C22184	0	96	74
C22185	0	4	6
C12273	0	2	4
C12272	0	3	5

Genus *Parmorthina* Havlícek, 1975

Type species: *Parmorthis pragensis* Havlícek, 1956

Parmorthina havliceki n. sp.

Pl. 5, figs. 13-22, 45, 46.

Derivation of species name: In honor of Vladimir Havlícek;

Diagnosis: Valves small for the genus; with coarse, angular fascicostellae; ventral interarea flat, high; ventral axial sulcus lacking.

Exterior: Valves small (the largest specimen is 8 mm wide, 7.4 mm long); plano-convex; subpentagonal to transversely subrectangular; length:width ratio averages 0.76; cardinal extremities subangular. Ventral valve strongly convex along the midline with relatively steep flanks; interarea high, generally flat, steeply apsacline to catacline; beak mostly erect; delthyrium open, narrow, triangular. Dorsal interarea very narrow, anacline; notothyrium open; sulcus starts near beak, initially narrow and deep, widens anteriorly, may result in sulcate anterior commissure.

Ornament semi-fascicostellate, primary costae coarse, about 8 to 9 on each valve, costellae finer, variable in number, produced by splitting from primary costae. Central triangular panel narrow, smooth, distinct at anterior 2/3 of the valves. Concentric growth lines widely spaced, present in less than half of specimens.

Ventral interior: Teeth triangular, small for resserellids; dental plates extremely reduced to absent. Muscle field bilobed, slightly elevated, restricted to the posterior half of the delthyrial cavity. Peripheral crenulations vary from rectangular with narrow interspaces to rounded with variable amplitudes.

Dorsal interior: Brachiophores with pointed tips, diverge anteroventrally at about 80-90 degrees; brachiophore bases thick, triangular, their bottoms curve posterolaterally, defining sockets between hinge line. Cardinal process may have a slightly expanded myophore, its rod-like shaft continuous anteriorly with broad, low myophragm. Muscle field cordate, enclosed by low bounding ridges. Peripheral crenulations similar to those of ventral valves.

Comparison: Havlícek (1975) erected *Parmorthina* to include all the fascicostellate species originally assigned to *Resserella*. He proposed the following criteria for the new genus: (1) angular fascicostellate ornament with "sector M" of fine costellae on either valve, (2) ventral axial sulcus and dorsal axial fold, and (3) without fulcral plates. The new species is angularly fascicostellate, has a smooth central panel, and lacks fulcral plates, but it does not have an axial sulcus and fold. The development of the latter two features may be related to size, because they are generally not well developed in small valves of the type species *P. pragensis* either.

The new species most closely resembles small valves of *P. pragensis*, and both are the most coarsely costellate *Parmorthina*. It differs from the latter in being much smaller, lacking axial sulcus and fold, and having a high, flat ventral interarea. It can be easily distinguished from other species of the genus by its small size and coarse costellae.

Occurrence	Articulated	Ventral	Dorsal
C12272	1	50	52

Genus *Fascizentina* Havlícek, 1975

Type species: *Orthis gervillei konieprusensis* Oehlert, 1886

Fascizentina rohri n. sp.

Pl. 5, figs. 23-33, 40-42.

Derivation of species name: In honor of David M. Rohr;

Diagnosis: Valves small; ventral interarea high, generally flat; fascicostellae poor, underlain by broad, strong plications.

Exterior: Valves small (the largest specimen is 7 mm wide, 6 mm long); plano-convex; hinge line nearly equals the maximum width. Ventral valve strongly convex,

subpentagonal to transversely subrectangular with subangular cardinal extremities; length:width ratio averages 0.76 (n=24, std=0.059); interarea high, steeply apsacline to catacline, flat in small valves and slightly incurved in larger ones; beak erect in small valves and moderately incurved in larger ones; delthyrium triangular, open, some with a minute apical plate. Dorsal valve shield-shaped or semi-circular; length:width ratio averages 0.72 (n=18, std=0.036); interarea narrow, steeply anacline to almost catacline; notothyrium largely filled with the posterior face of cardinal process; sulcus wide, deep in small valves, shallowing anteriorly in larger valves.

Ornament of angular fascicostellae underlain by strong, broad plications. Fascicostellae generally poorly developed, letting the underlying plications stand out, commonly three plications on each flank of either valve. Both ventral and dorsal median plications with smooth, flat top. Concentric growth lines uncommon.

Ventral interior: Teeth triangular, relatively small for the genus; dental plates extremely reduced to absent. Muscle field slightly elevated, apically restricted. Inner surface largely smooth, peripheral crenulations weak, subrectangular to subrounded with narrow interspaces.

Dorsal interior: Cardinal process rod-like, nonlobed, anteriorly continuous with broad, low myophragm. Brachiophores with pointed tips, diverge anteroventrally; brachiophore bases thick, inclined to each other, bound a low notothyrial platform, and merge laterally into socket pads. Muscle field cordate, 0.33 as wide as the valve, extends 0.67 of the valve length in most valves, and bounded by low ridges; bounding ridges posteriorly merge with brachiophore bases and anteriorly curve towards the end of myophragm. Peripheral crenulations similar to those of ventral valves.

Comparison: Havlícek (1975) erected *Fascizentina* and pointed out that *Fascizentina* has a well developed ventral median plication bearing fine costellae of "sector M" whereas *Fascicostella* lacks the median plication. The new species is assigned to *Fascizentina* on the basis of its ventral median plication. The median plication of the new species is smooth; it is possible that costellae were developed on top of the plication, but were not preserved. The new species represents the only Silurian species of the genus. It can be readily distinguished from other species of the genus by its small size, poor fascicostellae, and relatively high, flat ventral interarea.

Occurrence	Articulated	Ventral	Dorsal
C22184	1	29	31
C22187	1	14	8
C12272	0	8	9

Family Dicoelosiidae Cloud, 1948

Genus *Dicoelosia* King, 1850

Type species: *Anomia biloba* Linnaeus, 1758, p. 703.

Dicoelosia baillichamiltonensis n. sp.

Pl. 6, figs 1-42.

1976 *Dicaelosia* sp. Rohr, p. 1175, text-fig. 1.

1986 *Dicaelosia diversifrons* -- Lenz, p. 123, pl. 1, figs. 1-41, pl. 2, figs. 1-3.

Derivation of species name: After Baillie Hamilton Island where the species was recovered.

Diagnosis: A relatively large, long lobed *Dicoelosia*, concavoconvex in profile; secondary costellae fan out from a noticeably stronger crestal costa, ventral sulcus commonly bears a fine median costa.

Exterior: Valves relatively large for the genus (the largest specimen is 5.5 mm wide, 7.8 mm long); concavo-convex; elongate; deeply emarginate; lobes variable in size, from short, broad to long, rod-like; midlength:length ratio range from 0.37 to 0.73, with the majority varying between 0.45 and 0.60 (n=72, std=0.077); divergent angle of the two lobes variable; hinge line straight; cardinal extremities angular in most valves. Ventral interarea high, triangular, steeply apsacline, cleft medially by an open, triangular delthyrium; umbo conspicuous; beak small, erect. Dorsal valves gently concave to nearly flat; interarea linear, anacline.

Ornament of rounded costellae, with a stronger crestal costa on each ventral lobe; crestal costa inconspicuous on dorsal valves; finer secondary costellae fan out from the crestal costa; interspaces about one costella width near the crestal costa, become wider away from the crestal costa. Costellae added primarily by intercalation; the costellae density relatively constant, valves with broader lobes tending to contain more costellae. Ventral sulcus commonly bears a weakly developed median costa; dorsal sulcus may or may not have a median costa.

Ventral interior: Teeth triangular; dental plates short, apically restricted, they descend to the floor and extend anteromedially as low ridges, defining a cordate, occasionally raised, muscle field. Dental plates and muscle bounding ridges are faint to nearly absent in many specimens.

Dorsal interior: Brachiophores large, plate-like, extending anteriorly along the posterolateral inner valve margin. Cardinal process small, knob-like, rests on a small,

thickened notothyrial platform, anteriorly it may be continuous with a short, weak myophragm. Sockets narrow, defined by brachiophore bases and posterolateral valve margin. Muscle field indiscernible. Most valves have porous, secondary shell deposits at the anterior half of each lobe.

Both valves have peripheral subrounded crenulations, separated by slightly narrower grooves.

Comparison: The new species closely resembles *D. alticavata* (Whittard and Barker, 1950) and *D. diversifrons* Johnson, Boucot, and Murphy, 1976. It can be distinguished from *D. alticavata* in being concavoconvex and have only one median costa in the ventral sulcus. It is indistinguishable from *D. diversifrons* on the basis of valve shape, but the latter has more numerous, closely spaced, short costellae on each lobe and generally, lacks costa in sulcus.

Ecological notes: Ten percent of the specimens show deformed features such as an asymmetrical outline, unequal length of two body lobes, and twisted body lobes. The high deformation rate may be caused by (1) overcrowded growth space, (2) diseases, or (3) high variability of the populations.

Occurrence	Articulated	Ventral	Dorsal
C22184	856	1034	1321
C22185	56	7	14
C22187	180	86	89
C12273	304	99	217
C12272	694	501	775

Genus *Epitomyonia* Wright, 1968

Type species: *Epitomoynia glypha* Wright, 1968, p. 128, pl. 1, figs. 1-16.

Epitomyonia amplissima n. sp.

Pl. 7, figs. 24-44.

Derivation of species name: From the Latin *amplissinus* meaning the largest, referring to the largest species of the genus.

Diagnosis: The largest known *Epitomyonia*; concavo-convex; ornament of low, rounded to subangular multicostellae, ventral sulcus narrow, dorsal sulcus broad and shallow; dental plates short to receding; a pair of anteriorly convex, transverse plates developed in front of depressed dorsal muscle field.

Exterior: Valves large (the largest specimen is 12 mm wide, 8.3 mm long); transversely subquadrate, ventral valve length:width ratio averages 0.79, dorsal valve

length:width ratio, 0.67; concavo-convex, with shallow, anterior emargination. Ventral interarea gently curved to straight, apsacline, and cleft by a large delthyrial opening; sulcus narrow and shallow, commonly occupied by a single median costella. Dorsal interarea ribbon-like, anacline; sulcus broad and shallow, widening anteriorly; generally with 6-8 costellae developed in sulcus without distinctive median costella.

Ornament of low multicostellae, rounded to angular, uniform in size, separated by interspaces whose amplitude is similar to that of the costellae; costellae increase in number with size, mainly by intercalation, less commonly by branching; costellae in sulci slightly finer than on flanks in both valves.

Ventral interior: Dental plates short, join the apically restricted, low muscle platform; median ridge strong in the posterior half of the valve and diminishes toward anterior margin; radial crenulation developed near the periphery.

Dorsal interior: Sockets bounded medially by brachiophore bases which support a pair of anteroventrally diverging, oar-like brachiophores; cardinal process bilobate, fused to the rear end of median septum; median septum rises in front of notothyrial cavity to meet the median septum of ventral valve and then descends, following the curve of ventral valve inner arch, anteriorly to floor at the crenulated margin, the high median septum rarely preserved in its complete form; muscle field consists of a pair of oval to subtriangular depressions; a pair of anteriorly convex transverse plates developed at anterior margin of muscle field; muscle field and transverse plates absent in small valves (smaller than 5 mm in width), incipient in medium size valves (6-8 mm in width), and well developed in large valves (larger than 9 mm in width). Peripheral crenulations subrounded, with medial indentations.

Comparison: The new species can be readily distinguished from other *Epitomyonia* by its large size, relatively weak costellae, and anteriorly convex, transverse plates in dorsal valve.

Occurrence	Articulated	Ventral	Dorsal
C22184	16	21	49
C22185	7	1	2
C22187	7	13	16
C12273	5	10	25
C12272	14	27	52

Epitomyonia clausula Johnson, Boucot, and Murphy, 1976

Pl. 7, figs. 1-23.

1972 *Epitomyonia* sp. Johnson, pl. 2, figs. 6-17.
1976 *Epitomyonia clausula* Johnson, Boucot, and Murphy, p. 29, pl. 1, figs. 29-36, pl. 2, figs. 3-12, 15-18, 19?, 20; not pl. 2, figs. 1, 2, 13, 14.
1986 *Epitomyonia sekwiensis* Lenz, p. 127, pl. 2, figs. 4-16, 27, 28; non Lenz, 1977.

Remarks: The Arctic material consists of over two thousand well-preserved specimens which are characterized by having angular, fascicostellate ornament and a pair of pustulose transverse ridges anterior to dorsal muscle field. The dorsal transverse ridges are delicate in young valves and become sturdy and strongly pustulose in mature valves. The Arctic material closely resembles the Nevada species *Epitomyonia clausula* Johnson, Boucot, and Murphy, especially the holotype (Johnson, Boucpt, and Murphy, 1976, pl. 2, figs. 5-9) which has uneven costellae (fascicostellae) and the specimen illustrated in pl. 2, figs. 11, 12 which shows a pair of pustulose dorsal transverse ridges. Johnson, Boucot, and Murphy (1976) described *E. clausula* as having rounded costellae, this could be an artifact of poor preservation of the Nevada specimens. Specimens illustrated in their pl. 2, figs. 1, 2, 13, 14 are larger than typical *E. clausula*, these specimens also have weaker costellae and simple dorsal transverse ridges. They should be assigned to a different species.

Lenz (1986) illustrated some *Epitomyonia* from Baillie Hamilton Island and assigned them to *E. sekwiensis* Lenz 1977, presumably based on their external characters. *E. sekwiensis* is similar to *E. clausula* in size and ornament, but the former's dorsal transverse ridges are weaker, smooth, and situated near the anterior margin. These Baillie Hamilton specimens have the typical transverse ridges characteristic of *E. clausula* and, thus, should be conspecific with the latter. At the same time Lenz assigned some other valves to *E. clausula* (see his pl. 2, figs. 17-22), which closely resemble *E. amplissima*. Since Lenz did not give the magnification, the last comparison can not be confirmed.

Exterior: Valves medium size (the largest specimen is 7.7 mm wide, 6.3 mm long); concavo- to plano-convex; ventral valve transversely subquadrate, length:width ratio averages 0.78, with larger valves being more transverse; dorsal valve length:width ratio, 0.67; anterior emargination shallow. Ventral valve strongly convex, interarea high, generally incurved, apsacline, the inclination of interarea tends to become gentler with increase in shell size; delthyrium large and open; sulcus narrow, distinctive, commonly occupied by a pair of finer median costellae or occasionally by a single median costella. Dorsal interarea narrow, anacline; sulcus moderately broad and

deep, widening anteriorly; generally 4-6 costellae in sulcus, a pair of finer median costellae commonly well developed.

Ornament of fascicostellae; costellae strong, angular, unequal in size; primary costae prominent, costellae finer, increase by branching or insertion along side of costae, variable in number from valve to valve; interspaces narrow, V-shaped. The median pair of costellae generally finer than adjacent ones, resulting in a median notch in either sulcus.

Ventral interior: Dental plates absent in most valves, although a pair of receding dental plates may occasionally be present; muscle platform low, apically restricted; median ridge strong at notothyrial region, diminishes anteriorly and dies out before reaching anterior margin. Radial crenulations developed in area outside apical muscle platform.

Dorsal interior: Sockets bounded medially by brachiophore bases, brachiophores large, oar-like, diverge anteriorly; bilobed cardinal process attached to a median septum which rises steeply right in front of the notothyrial cavity to reach the floor of ventral valve and then following the curve of the ventral valve floor descends anteriorly to floor near the crenulated margin; muscle field short, anteriorly bounded by a pair of pustulose, transverse ridges; the transverse ridges delicate in small valves, become sturdy and strongly pustulose in large valves. Medially grooved crenulations restricted to the periphery.

Occurrence	Articulated	ventral	dorsal
C22184	266	264	278
C22187	30	39	44
C12273	105	156	216
C12272	211	380	446

Family Rhipidomellidae Schuchert, 1913

Subfamily Rhipidomellinae Schuchert, 1913

Genus *Dalejina* Havlícek, 1953

Type species: *Dalejina hanusi* Havlícek, 1953, p. 5, pl. 1, figs. 10, 12-14.

Dalejina parahanusi n. sp.

Pl. 8, figs. 1-26.

Derivation of species name: Refers to its close resemblance to *Dalejina hanusi.*

Diagnosis: Small, hinge line relatively long; angular multicostellae increase in number mainly by intercalation; dorsal sulcus weak; dental plates very short; ventral muscle field small, nonflabellate; cardinal process nonlobate.

Exterior: Valves small (the largest specimen is 7.6 mm wide, 6.0 mm long); subequally biconvex, cardinal extremities rounded. Ventral valve subcircular, hinge line:width ratio averages 0.48, length:width ratio 0.86 (n=41, std=0.058); interarea low, averaging 0.13 of valve length (n=22, std=0.0007), gently curved, apsacline; delthyrium open, triangular, delthyrial angle 60-70 degrees; beak pointed, incurved. Dorsal valve transversely elliptical, hinge line:width ratio 0.50, length:width ratio 0.82; interarea ribbon-like, anacline; notothyrium open, partially filled by cardinal process myophore; beak pointed, erect or incurved, sulcus weak, widening anteriorly.

Ornament of angular to subangular multicostellae. Secondary costellae originate mainly by intercalation within 1-1.5mm distance from umbo, tertiary costellae by both intercalation and bifurcation, largely restricted to the periphery. The density of costellae variable. A dorsal median primary and a pair of ventral median primaries are not very noticeable, but recognizable. Concentric growth lines uncommon.

Ventral interior: Teeth triangular; dental plates very short, diverge anteriorly. Muscle field rarely impressed. One specimen shows a small, oval muscle field consisting of a pair of small, linear adductor scars laterally bounded, but not enclosed, by a pair of larger, lanceolate diductor scars; myophragm ridge-like; muscle bounding ridges weak, continuous posteriorly with dental plates and convergent anteriorly (pl. 8, figs. 23, 24). Peripheral crenulations subrectangular, mostly with medial indentation, separated by narrow grooves.

Dorsal interior: Brachiophores pointed, diverge anteroventrally with thickened bases connected to shell wall by socket pads. Cardinal process ridge-like in small valves, with rod-like shaft and expanded myophore in larger valves. Median ridge low and broad, posteriorly continuous with cardinal process shaft and anteriorly dies out before reaching midlength. Muscle field quadripartite, with anterior pair being larger, commonly weakly impressed or smooth, slightly longer than wide, extends to about midlength. Crenulations similar to those of ventral valves.

Comparison: The new species closely resembles the Bohemian Devonian *Dalejina* species, especially *D. hanusi*, in its small size, nonflabellate ventral muscle field, and short dental plates. It can be distinguished from *D. hanusi* by having a longer hinge line and smaller, nonlobate cardinal process. The new species differs from most other Devonian species in being more transverse, with a longer hinge line, having shorter dental plates, smaller ventral muscle field, and nonlobate cardinal process. From the

Wenlockian Welsh species and Ludlovian Appalachian species it differs by its smaller size, longer hinge line, and its much smaller, nonflabellate ventral muscle field.

Occurrence	Articulated	Ventral	Dorsal
C22184	2	64	76
C22185	1	3	1
C22187	0	3	3
C12273	0	4	9
C12272	0	24	23

Subfamily Proschizophoriinae Boucot, Gauri, and Johnson, 1965

Genus *Pseudomendacella* n. gen.

Type species: *Pseudomendacella boucoti* n. sp.

Derivation of genus name: Refers to its morphological resemblance to genus *Mendacella* Cooper.

Diagnosis: Circular outline; dorsi-biconvex in large valves; large valves develop an anteromedial flattening in ventral valve, a low anteromedian fold in dorsal valve. Ventral muscle field small, elongate, with parallel bounding ridges. Cardinal process small, nonlobate; muscle field short, quadripartite; myophragm low, carinate.

Comparison: Within the subfamily, the new genus resembles *Proschizophoria*. Both have more convex dorsal valves, circular outline, and small, nonlobate cardinal process. It differs from the latter in its smaller size, smaller ventral muscle field with parallel bounding ridges, shorter dorsal muscle field largely lacking bounding ridges, and carinate myophragm. It can be easily distinguished from other genera of the subfamily by its unique cardinalia and muscle field structure. Externally, it differs from most other genera of the subfamily in having a deeper dorsal valve, shorter hinge line, and lower ventral interarea. The new genus also bears some resemblance to *Mendacella* in external and ventral internal features, but the two are different in their dorsal internal structure.

Species assigned:

Pseudomendacella boucoti n. sp. from the Cape Phillips Formation.

indet. proschizophorinid sp. Boucot, Johnson, and Zhang, 1988, from Hidden Valley Dolomite.

Proschizophoria? *favonia* Boucot and Johnson, 1972, from *Antirhynchonella* fauna, Venezuela.

Pseudomendacella boucoti n. sp.

Pl. 8, figs. 27-34.

Derivation of species name: In honor of Arthur J. Boucot.

Diagnosis: Large valves dorsibiconvex; ventral muscle field narrow; dorsal muscle field lacks bounding ridges.

Exterior: The largest specimen is 30 mm wide, 27 mm long; biconvex to dorsibiconvex; nearly circular, length:width ratio about 0.85, hinge line:width ratio 0.40 (n=15, std=0.038). Ventral interarea very low, about 0.1 of shell length, plane, apsacline; delthyrium open, with divergent angle close to 90 degrees; beak small, pointed, slightly incurved; larger valves may develop a median flattening near anterior margin. Dorsal interarea ribbon-like, mostly orthocline; notothyrium partially filled by cardinal process myophore; the largest specimen shows a gentle median fold at the anterior margin.

Ornament of rounded to subangular multicostellae; costellae increase in number with increasing valve size. Secondary costellae originate near beak by intercalation; tertiary costellae by intercalation and bifurcation near anterior margin. Dorsal median primary present. Concentric growth line uncommon, widely spaced.

Ventral interior: Teeth triangular, dental plates short, largely attached to lateral shell wall, continue anteriorly as a pair of low, parallel muscle bounding ridges. Muscle field about 1/3 of valve length, 4/5 as wide as long; myophragm with anteriorly raised end, divides a pair of lanceolate muscle tracks; diductor and adductor scars indistinguishable. Peripheral crenulations subrectangular, separated by narrow grooves, but commonly blurred by secondary shell deposits.

Dorsal interior: Cardinal process small, nonlobate, blade-like in small valves, rod-like with slightly expanded myophore in large valves. Notothyrial platform small, triangular, poorly developed. Brachiophores short, with pointed tips, directed ventrally; brachiophore bases plate-like, diverge anteriorly at 90 degrees and their bottom portion curves toward the posterolateral wall, forming socket pads. Muscle field weak, about 2/5 of valve length or shorter and 4/5 as wide as long, in some valves as slightly raised quadripartite scars, in others as faint, bilobed or quadripartite depressions. Myophragm thin and low, carinate. Muscle bounding ridges absent. Crenulation similar to those of ventral valves.

Comparison: The new species differs from *P. favonia* in having a smaller ventral muscle field, finer dorsal myophragm, and lacking dorsal muscle bounding ridges. From

Californian species it differs in having mainly intercalating costellae and lacking dorsal posterolateral muscle bounding ridges.

Occurrence	Articulated	Ventral	Dorsal
C22184	0	3	7
C22185	0	0	1
C22187	0	12	3
C12273	0	1	0
C12272	0	11	9

Superfamily Enteletacea Waagen, 1884

Family Draboviidae Havlícek, 1951

Genus *Salopina* Boucot, 1960

Type species: *Orthis lunata* J. de C. Sowerby, 1839, p. 611, pl. 5, fig. 15.

Salopina gamma n. sp.

Pl. 9, figs. 38-44.

Derivation of species name: Referring to its presumed ancestral relationship to *Salopina delta* Johnson, Boucot, and Murphy, 1976.

Diagnosis: Small, deeply sulcate, with coarse fascicostellae, brachiophore supporting plates high, triangular, continuous with weak muscle bounding ridges.

Exterior: Valves small (the only complete dorsal valve is 7 mm wide, 4.5 mm long); ventri-biconvex; transversely subquadrate, cardinal extremities obtuse. Ventral interarea high, slightly curved, apsacline. Dorsal interarea narrower, variable in height, anacline; sulcus V-shaped, initiates in front of beak, deepens and widens sharply toward anterior margin.

Ornament coarsely fascicostellate, costellae produced by splitting and implanting along sides of costae; posterior costellae subparallel to hinge line; 34 costellae counted on the only complete dorsal valve.

Ventral interior: Dental plates absent. Other features unknown.

Dorsal interior: Cardinal process slender, rod-like, lies in notothyrial cavity, anteriorly merges with low median ridge which turns into a medially raised area corresponding to the exterior sulcus. Brachiophores pointed, directed ventrally and slightly anteriorly; supporting plates high, triangular, continuous anteriorly with weak muscle bounding ridges. Sockets small, excavated into interarea and brachiophore bases; fulcral plates barely discernible. Muscle field indiscernible. Peripheral crenulations broad, separated by narrow grooves.

Comparison: *Salopina gamma* and *delta* have nearly identical dorsal interior structure, both have a pair of high, triangular brachiophore supporting plates. This indicates that *gamma* may be a direct ancestor of the Ludlovian species delta. *S. gamma* can be distinguished from *delta* by its more transverse outline, stronger fascicostellae, deep sulcus, higher ventral sulcus, and barely discernible fulcral plates. See table 1 for the comparison of the new species with other salopinids.

Occurrence	Articulated	Ventral	Dorsal
C12273	1	0	3

Salopina carinata n. sp.

Pl. 9, figs. 9-24.

Derivation of species name: After the Latin *carinatus*, referring to the carinate ventral valve of the new species.

Diagnosis: Intermediate size for the genus, nearly plano-convex, with coarse semi-fascicostellae, ventral median carina, and nearly V-shaped sulcus.

Exterior: Valves small (the largest specimen is 5.9 mm wide, 4.1 mm long); nearly plano-convex; transversely semi-circular with obtuse cardinal extremities. Ventral valve typically carinate medially with flanks sloping away without curvature; interarea relatively high, steeply apsacline; triangular delthyrium open; beak small, pointed, slightly incurved. Dorsal interarea ribbon-like, gently anacline; triangular notothyrium partially filled with cardinal process myophore; sulcus deep, nearly V-shaped, markedly widens and deepens anteriorly.

Ornament of coarse, angular semi-fascicostellae, increase in number by branching; costellae reach the size of primary costae at marginal area in large valves. Tertiary costellae rare. Ventral median costa stronger than adjacent ones, forms the median carina. Concentric growth lines absent.

Ventral interior: Teeth small, triangular; dental plates receding; muscle field very faintly impressed. Largely confined to the posterior half of delthyrial cavity. Lateral parts of valve floor typically slope down medially, resulting in V-shaped interior view with linear medial depression corresponding to the external carina. Interior surface largely crenulated with broad rounded ridges with or without medial indentations, separated by narrow grooves.

Dorsal interior: Cardinal process small, with knob-like myophore and short shaft. Brachiophores thin, pointed, diverge anteroventrally. Brachiophore supporting plates diverge anteriorly. Sockets excavated into interarea and floored by rudimentary

fulcral plates. Muscle field faintly impressed, generally short, elongate suboval, with weakly developed bounding ridges varying from subparallel to laterally convex. The angular, medial linear elevation corresponds to external V-shaped sulcus. Crenulations similar to those of ventral valve.

Comparison: *Salopina* species can be divided into two groups, one with coarse, fascicostellae or semi-fascicostellae and the other with finer, multicostellae. The new species is coarsely semi- fascicostellate; it is unique in having a distinct ventral carina. Table 1 shows some diagnostic features of different fascicostellate species.

Occurrence	Articulated	Ventral	Dorsal
C22184	1	8	16
C22187	1	12	1
C12273	6	20	15
C12272	4	65	5

Salopina robitaillensis Walmsley, Boucot, and Harper, 1969

Pl. 9, figs. 25-37

1969 *Salopina robitaillensis* Walmsley, Boucot, and Harper, p. 510, pl. 73, figs. 7-12, pl. 74, figs. 1-12, pl. 75, figs. 1-4, pl. 78, figs. 12-16.

Remarks: Walmsley and others described *S. robitaillensis* as non-sulcate. I examined Boucot's *Salopina* collection including some *robitaillensis* specimens figured in the *Salopina* paper by Walmsley and others (1969). *S. robitaillensis* from the type locality is nonsulcate, but specimens from the Sayabec Limestone of Quebec have a shallow dorsal sulcus (see Walmsley and others, 1969, pl. 78, figs. 12-16). The Arctic material is nearly identical with *robitaillensis* from the Sayabec Limestone of Quebec, except that the former is about twice as large as the latter and thus has a better developed sulcus.

Exterior: Ventri-biconvex; transversely elliptical. Ventral interarea low, flat to slightly incurved; delthyrium triangular, open; beak incurved. Dorsal valve gently convex, with ill-defined, shallow sulcus, widening anteriorly; interarea ribbon-like; notothyrium partially filled by cardinal process myophore.

Ornament of multicostellae, rounded to subangular, medium coarse; costellae increase in number by bifurcating and implanting along sides of primary costae; secondary costellae reach the size of the primary ones in a short distance, resulting in even multicostellae. Concentric growth lines rare.

Ventral interior: Teeth relatively small, triangular; dental plates receding, bounding apically restricted muscle field. Peripheral crenulations subrectangular, separated by fine grooves.

Dorsal interior: Brachiophores pointed, directed ventrally and slightly anteriorly; supporting plates high, lateral profile subrectangular, diverge anteriorly at about 65 degrees. Muscle field faintly imprinted, vaguely quadripartite; lateral bounding ridges weak; a low myophragm may or may not be present. Cardinal process with knob-like myophore and short shaft, situated at the posterior tip of notothyrial cavity. Sockets small, excavated between interarea and brachiophore bases; fulcral plates absent. Crenulations similar to those of ventral valves.

Occurrence	Articulated	Ventral	Dorsal
C22184	1	24	14
C12273	0	0	1

Salopina ? sp.

PL. 10, figs. 1-3.

This species is represented by a small dorsal valve only. It is transverse, sulcate, and multicostellate. Costellae subrounded, increase in number mainly by insertion. Internally, the species is characterized by a pair of large sockets supported by fulcral plates; brachiophores consisted of large, thick plates, projecting ventrally; notothyrial cavity narrow; cardinal process small, ridge-like, continuous anteriorly with myophragm; muscle field short, faintly quadripartite, with the anterior pair being larger. Peripheral crenulations subrectangular, separated by narrower grooves.

Occurrence	Articulated	Ventral	Dorsal
C22184	0	0	1

Genus *Hirnantia* Lamont, 1935

Type species: *Orthis sagittifera* M'Coy, p. 398

Hirnantia cf. *sagittifera* (M'Coy, 1851)

Pl. 10, figs. 4-21.

1851 *Orthis sagittifera* M'Coy, p. 398.

See Havlícek 1977 for complete synonymy.

Remarks: The Arctic material closely resembles *H. sagittifera* (especially those specimens illustrated by Temple, 1965), particularly in having fila in interspaces,

inconspicuous ventral carina and dorsal sulcus confined to the umbonal region in large valves. The Arctic material differs from the latter in lacking an expanded cardinal process myophore (at least in valves under 10 mm, the cardinal process of the only large dorsal valve is broken) and having better developed fulcral plates. The Arctic material represents the first Wenlockian occurrence of *Hirnantia*, it differs from the Late Llandovery *H. senecta* in having coarse costellae and more widely divergent brachiophore plates.

Exterior: The largest specimen (a dorsal valve) is 22.3 mm wide, 18 mm long, and 16.8mm deep; ventri-biconvex in valves less than 10mm long and may become dorsi-convex in larger valves; transversely semi-elliptical, length:width ratio averages 0.75; cardinal extremities obtuse, hinge line:width ratio averages 0.73; ventral median sector more convex than flanks, resulting in a low carina; interarea generally plane, steeply apsacline; delthyrium open; apical plate small; beak pointed, incurved. Dorsal median sulcus shallow, restricted to umbonal region in large valves; interarea narrow, plane, gently anacline; notothyrium open.

Ornament of rounded multicostellae, with a single ventral median primary costa and a pair of dorsal median primary costae; costellae increase in number by lateral branching and less commonly by inserting along sides of primary costae. Closely spaced fila developed in interspaces in most valves. Concentric growth lines rare.

Ventral interior: Teeth triangular; dental plates short, slightly convex laterally, bounding short, cone-shaped muscle field. Diductor scars bilobate, separated by a wide, flat adductor track. Inner surface largely smooth, peripheral crenulations rounded to subrectangular, separated by narrow grooves.

Dorsal interior: Brachiophores plate-like, directed anteroventrally; supporting plates high, erect, diverge anteriorly at 90 degrees. Cardinal process blade-like, centered in the broad notothyrial cavity, anteriorly continuous with carinate, low myophragm. Sockets triangular, supported by fulcral plates. Muscle field weakly impressed, faintly quadripartite, with obscure lateral bounding ridges. Peripheral crenulations similar to those of ventral valves.

Occurrence	Articulated	Ventral	Dorsal
C22184	0	2	8
C22187	0	0	5
C12273	0	2	3
C12272	0	6	17

Genus *Drabovia* Havlícek, 1951

Type species: *Orthis redux* Barrande, 1848.

Drabovia? sp.

Pl. 10, figs. 22-32

Remarks: The species is assigned with question to *Drabovia* on the basis of its fascicostellae and its dorsal internal structure. However, it differs from *Drabovia* in having a deep dorsal sulcus, a low ventral fold, and stronger, rounded fascicostellae. It may belong to a new genus, but the four available specimens are inadequate.

Diagnosis: Small, with low ventral fold, deep dorsal sulcus; fascicostellae strong, rounded.

Exterior: Valves small (the largest specimen is 7.2 mm wide, 4.8 mm long); ventri-biconvex; transversely elliptical with obtuse cardinal extremities; anterior commissure sulcate. Ventral valve with a low, median fold, widens anteriorly; interarea plane, steeply apsacline; delthyrium open, triangular, with an apical angle of 40 degrees. Dorsal valve deeply sulcate; interarea narrow, anacline; notothyrium open.

Ornament of rounded, strong fascicostellae, each primary costa and its derivative costellae form a bundle separated from adjacent bundles by deep interspaces. Three bundles of costellae form the ventral fold; two bundles bound the sulcus, but no costellae in the bottom of the deep sulcus. One or two concentric growth lines on ventral valves.

Ventral interior: Teeth small; dental plates very short, laterally bounding apically restricted, cone-shaped muscle field; myophragm variable in size, may end anteriorly with a flat triangular face; anteromedial part of valve depressed, corresponding to the external fold. Lateral valve floors radially corrugated.

Dorsal interior: Cardinal process blade-like, situated in the middle of the broad notothyrial cavity. Brachiophore supporting plates high, triangular, nearly erect, diverge anteriorly at 90 degrees, the very bottom of these plates converge onto median ridge which is a reflection of the external sulcus. Sockets small, triangular, supported by fulcral plates. Muscle field faintly quadripartite, the anterior pair smaller, not enclosed by brachiophore plates; muscle bounding ridges weak, converge anteriorly. Radial corrugations similar to those of ventral valves.

Occurrence	Articulated	Ventral	Dorsal
C12272	0	3	1

Suborder Triplesiidina Moore, 1952

Superfamily Triplesiacea Schuchert, 1913

Family Triplesiidae Schuchert, 1913

Genus *Cliftonia* Foerste, 1909

Type species: *Triplesia* (*Cliftonia*) *striata* Foerste, 1909, p.81, pl.3, figs.42a, b.

Cliftonia contorta n. sp.

Pl. 11, figs. 13-25.

Derivation of species name: After the Latin *contortus*, referring to the strongly contorted shell of the species.

Diagnosis: Transverse, strongly asymmetrical; ventral interarea catacline; pseudodeltidium without median fold; dental plates absent.

Exterior: Valves small for the genus (the largest specimen is 14 mm wide, 10.8 mm long, and 11.6 mm thick); equally biconvex; transversely elliptical; cardinal extremities obstuse; valves strongly asymmetrical, along the median line, one side of valve abruptly elevated more than the other side, resulting in a somewhat S-shaped anterior commissure. Ventral interarea flat, catacline; beak small, truncated by a small, circular foramen, directed posteriorly; in large valves, beak bent over the catacline interarea at a right angle; pseudodeltidium flat, without median fold, but in some valves with a faint median line probably reflecting difference in texture. Dorsal interarea obsolete, umbo swollen. Ornament of coarse, rounded costellae overlapped by closely spaced concentric lamellose frills. Frills develop into short spines in some thick valves. Costellae increase in number by bifurcation and intercalation.

Ventral interior: Teeth triangular; dental plates absent; pedicle tube connected to foramen, variable in length. Muscle scars not impressed.

Dorsal interior: Cardinal process bilobed, projects ventrally with distal faces of the two lobes pointing posteriorly; distal faces bear a blade-like median ridge. Brachiophores short, emerged from base of cardinal process. Adductor scars consist of a pair of subtriangular impressions in front of umbonal cavity.

Comparison: The species is readily differentiated from other *Cliftonia* by its strongly contorted shell, flat, catacline interarea, and lack of a median fold on pseudodeltidium.

Occurrence	Articulated	Ventral	Dorsal
C22184	1	4	0
C22185	0	1	0
C22187	0	0	1

C12273	0	1	0
C12272	1	2	5

Genus *Streptis* Davidson, 1881

Type species: *Terebratula grayii* Davidson, 1848

Streptis glomerata Ulrich and Cooper, 1936

Pl. 11, figs. 1-12.

1928 *Streptis grayii*--Thomas, p. 138, pl. 36, fig. 12.

1936 *Streptis glomerata* Ulrich and Cooper, p. 345, pl. 50, figs. 4, 5, 9, 31.

1968 *Streptis glomerata*--Amsden, p. 39, pl. 12, figs. 4a-4o.

Exterior: Valves small (the largest specimen is 6.1 mm wide, 5 mm long); transverse; subequally biconvex; bisulcate. Sulcus narrow, divides each valve into two unequal lobes. Ventral interarea gently curved, apsacline; pseudodeltidium with a distinct medial fold; beak suberect.

Ornament of concentric lamellose frills. Fila and weak, sparse costellae superimposed on frills. Costellae variable, generally developed in anterior portion of the longer lobe.

Ventral interior: Teeth thick, triangular; dental plates very short. Muscle scars not impressed.

Dorsal interior: Cardinal process consists of two nearly discrete lobes, projecting ventrally. Brachiophores short, plate-like, laterally bounding triangular sockets. Muscle scars not impressed.

Occurrence	Articulated	Ventral	Dorsal
C22185	0	1	0
C22187	0	2	2
C12272	0	3	5

Order Strophomenida

Suborder Strophomenidina Öpik, 1934

Superfamily Plectambonitacea Jones, 1928

Family Leptellinidae Ulrich and Cooper, 1936

Genus *Leangella* Öpik, 1933

Subgenus *Leangella* (*Opikella*) Amsden, 1968

Type species: *L.* (*Opikella*) *dissiticostella* Amsden, 1968, p. 48, pl. 5, figs. 1a-1q; pl. 16, figs. 1a-1e; pl. 19, figs. 2a, 2b; text-figs. 33, 34; table 11

Leangella (*Opikella*) sp.
Pl. 11, figs. 26-30.

Exterior: Valves small, 6mm wide, 2.8mm long; gently concavo-convex; transverse, hinge line equal to maximum width. Ventral interarea narrow, catacline; delthyrium covered by small, arched deltidium. Dorsal interarea about same size as ventral one, catacline; notothyrium small, covered.

Ornament of unequal parvicostellae, with 5 rounded primary costae and fine capillae between them. Concentric growth lines vaguely present on dorsal valves.

Ventral interior: Unknown.

Dorsal interior: Cardinal process incompletely preserved. socket plates subparallel with hinge line, define small sockets. Platform elevated, with lateral radial striae; platform rim high, W-shaped; anteromedial portion of platform arched, resembling a short median ridge. Papillae present outside platform.

Comparison: The Arctic material can be distinguished from *L.* (*O.*) *dissiticostella* by having catacline interareas in both valves and very fine capillae between costae.

Occurrence	Articulated	Ventral	Dorsal
C12272	2	0	2

Family Sowerbyellidae Öpik, 1930
Subfamily Sowerbyellinae Öpik, 1930
Genus *Eoplectodonta* Kozlowski, 1929
Subgenus *Eoplectodonta* (*Paranisopleurella*) n. subgen.

Type species: *E.* (*Paranisopleurella*) *cooperi* n. sp.

Derivation of subgenus name: Referring to its exterior resemblance to *Anisopleurella* Cooper.

Diagnosis: An eoplectodontid with unequal parvicostellae consisting of two to five strong primary costae and numerous fine costellae between them; rudimentary dental plates present, teeth absent, denticles variably developed; dorsal internal structure same as that of *Eoplectodonta* s.s..

Comparison: Externally, the new subgenus resembles *Anisopleurella* in having two to five strong costae and very fine costellae developed between them. It differs from the latter in being larger and having a different dorsal interior structure. The new subgenus is nearly identical with Wenlockian species of *E.* (*Eoplectodonta*) in size and

dorsal internal characters. It can be distinguished from the latter by its external ornament and less well developed denticles on hinge line. Phyletically, it is apparently related to *Eoplectodonta* despite its repetition of the external character of the Ordovician genus *Anisopleurella*.

Species assigned: *E.* (*Paranisopleurella*) *cooperi* n. sp. From Wenlockian part of the Cape Phillips Formation of Arctic Canada."*Eoplectodonta*" sp. Boucot, Johnson, and Zhang. From the Hidden Valley Dolomite of California.

Eoplectodonta (*Paranisopleurella*) *cooperi* n. sp.
Pl. 12, figs. 30-44, pl. 13, figs. 1-3, 6-8, 11, 12, 15, 16.

Derivation of species name: After G. A. Cooper.

Diagnosis: Same as for the subgenus.

Exterior: The largest valve in the collection is 18mm wide, 10.5mm long; valves concavoconvex; semi-circular with alate cardinal extremities, length:width ratio averages 0.64 (n=57, std=0.056). Ventral umbo commonly incurved; interarea narrow, generally orthocline, but enrolled in strongly incurved, larger valves; small delthyrium open. Dorsal valve interarea ribbon-like, hypercline; notothyrium with a pair of small, discrete chilidial plates.

Ornament of unequal parvicostellae, consisting of two to five strong primary costae and very fine costellae between them. Ventral median costa varies from prominent to absent. Rarely, additional strong costellae may arise from fine costellae. Some large ventral valves have a faint median depression. About one third of the valves in the collection bear 4 to 8 rows of concentric frills; frills regularly spaced, interrupted by costae, and leave no marks on valve surface after being eroded.

Ventral interior: Hinge line mostly smooth, but a few larger valves have weak denticles on medial portion of their hinge lines (counted 16 denticles on each side in one specimen, see pl. 12, fig. 44). Teeth absent; vestigial dental plates present in some valves. A very short myophragm and a pair of faintly depressed suboval muscle scars restricted to incurved delthyrial cavity. Inner surface largely covered with fine pustules.

Dorsal interior: Cardinal process plate-like, with trifid posterior face, projects posteroventrally and continues anterolaterally with widely divergent socket plates. A pit separates cardinalia from septa. Median septum noticeably weaker and shorter than side septa; inner side septa prominent, diverge anteriorly at about 25 degrees, extends to about 0.64 of valve length; outer side septa lower and shorter, parallel to the inner side

septa. Bema only faintly developed in some larger valves. Muscle scars largely indiscernible. Pustules coarse, distributed in crude concentric rows.

Discussion: It is difficult to determine the relationship between frilly and nonfrilly valves. Concentric frills can be easily abraded without leaving any trace, partially abraded to severely abraded frilly valves form a series of intermediates between fully frilly and nonfrilly valves in the collection. On the other hand, if nonfrilly valves are a result of abrasion, one would expect that concave dorsal valves would have a better chance to preserve frills than convex ventral valves. The data do not show a significantly higher ratio of frilly vs. nonfrilly dorsal valves than that of ventral valves. The two forms are treated as belonging to the same species on the assumption that frills are a variable character not developed in all valves.

Occurrence	Frilly Valves			Nonfrilly Valves		
	Articulated	Ventral	Dorsal	Articulated	Ventral	Dorsal
C22184	7	19	22	14	22	18
C22185	1	3	1	0	13	1
C22187	0	5	3	12	32	26
C12273	3	7	3	23	59	28
C12272	23	165	115	4	107	63

Subfamily Aegiromeninae Havlícek, 1967

Genus *Chonetoidea* Jones, 1928

Type species: *Plectambonites papillosa* Reed, 1905, p. 451, pl. 23, figs. 13-15.

Chonetoidea? cocksi n. sp.

Pl. 12, figs. 13-29.

Derivation of species name: After L. R. M. Cocks.

Remarks: The generic assignment of this species is a problem. Its external ornamentation resembles *Aegiria,* it further resembles *A. grayi* (Davidson) in lacking a definable bema and having concentrically ordered pustules in the dorsal valve. However, it has side septa in the dorsal valve, which is characteristic of the Ordovician genus *Chonetoidea*, although the latter generally has more than one pair of side septa and an elevated bema. The Arctic material may represent a new genus, but pending a better understanding about Silurian species of the Aegiromeninae the new species is assigned with question to *Chonetoidea.*

Diagnosis: Unequally parvicostellate; dorsal median septum short, with one pair of slightly longer side septa; lacking definable bema; dorsal pustules arranged in crude concentric rows.

Exterior: Valves small (the largest specimen is 9.6 mm wide, 5 mm long but most specimens are less than 6 mm wide); concavoconvex; transversely subfusiform. Ventral valve median sector slightly depressed near anterior margin in some large valves; length:width ratio 0.52 (n=48, std=0.032); interarea narrow, apsacline; delthyrium triangular with divergent angle varying from 100 to 160 degrees; small, arched deltidium rarely preserved; beak small. Dorsal valve concavity greatest anterior to the protegular node; interarea narrow, catacline.

Ornament of angular, unequal parvicostellae, with 7 to 10 primary costae and fine costellae between them. Spacing between costae regular, larger costellae may arise near margin by intercalation. Concentric growth lines only present near anterior margin of protegular node in some valves.

Ventral interior: Hinge line denticles absent; teeth triangular, plate-like; dental lamellae absent. A short myophragm restricted to notothyrial cavity. Muscle field indiscernible. Pustules poorly developed. Internal striae and radial undulations reflect external costation.

Dorsal interior: Cardinal process simple, projects ventrally, laterally continuous with widely divergent socket plates; cardinal pit deep. Muscle field largely smooth, rarely discernible, with medial depression separating a pair of subtriangular muscle scars. Three short septa developed in anterior part of muscle field; side septa subparallel to and slightly longer than median septum. Coarse pustules developed in two to three crude concentric rows. Radial striae correspond to exterior costation.

Occurrence	Articulated	Ventral	Dorsal
C22184	25	15	0
C22185	2	4	1
C22187	49	34	15
C12273	0	14	0
C12272	108	79	28

Genus *Aegiria* Öpik, 1933

Type species: *Aegiria norvegica* Öpik 1933, p. 55, pl. 10, figs 1-5, pl. 11, figs. 3-5.

Aegiria grayi (Davidson), 1849

Pl. 12, figs. 1-12.

1849 *Leptaena grayi* Davidson, p. 271, figs. 1, 1a.
See Cocks (1970) for a complete synonymy.

Remarks: *Aegiria* contains two groups of species, the Early-earlier Late Llandovery (pre-C3) species group is characterized by an elevated bema and poorly ordered pustules in the dorsal valve, while post-C3 to Ludlovian species lack a definable bema and have well ordered pustules in the dorsal valve. *Aegiria grayi* from Wenlockian and Ludlovian strata is a typical representative of the second group, but *A. grayi* from Upper Llandovery strata has randomly arranged pustules that are somewhat transitional between the two groups. The Arctic material resembles Wenlockian to Ludlovian *A. grayi*.

Exterior: Valves small (the largest specimen is 6.5 mm wide, 3.8 mm long); concavo-convex; transversely rectangular with hinge line equal to maximum width. Ventral valve medially carinate; length:width ratio averages 0.65 (n=48, std=0.037); interarea narrow, steeply apsacline, with arched deltidium; beak small. Dorsal valve length:width ratio averages 0.57; interarea obsolete; concavity greatest just anterior to the protegular node.

Valves ornamented with 10 to 20 larger, angular costae and costellae; generally with a median primary and two pairs of lateral primaries on ventral valves, one median pair and two lateral primaries on dorsal valve. Secondary larger costellae arise by intercalation alongside costae; fine costellae developed between costae, resulting in bundled parvicostellae. Costae of medial area are strongest with V-sped interspaces, costation amplitude decreases towards cardinal extremities. Concentric growth lines absent.

Ventral interior: Hinge line denticles absent; teeth triangular, plate-like; dental lamellae absent. Muscle field smooth without discernible muscle scar impressions. A short myophragm restricted to apical chamber. Pustules smaller than those of dorsal valve. Radial striae correspond to strong external costation.

Dorsal interior: Cardinal process simple, projects ventrally, laterally continuous with widely divergent socket plates. Cardinal pit deep. Median septum high, extends to about 0.65 of valve length. No trace of lateral septa. Muscle field largely smooth, indiscernible. Pustules coarse, arranged in two to three crude concentric rows. Radial striae correspond to external costation.

Occurrence	Articulated	Ventral	Dorsal
C22184	108	22	12
C22185	3	0	0
C12273	36	35	18
C12272	98	205	81

Superfamily Strophomenacea King, 1846

Family Strophomenidae King, 1846

Genus *Pentlandina* Bancroft, 1949

Type species: *Strophomena* (*Pentlandina*) *tartana* Bancroft, 1949, p. 13, pl. 1, figs. 10.

Pentlandina harperi n. sp.

Pl. 13, figs. 19, 20, 22-30, pl. 14, figs. 1-7.

Derivation of species name: After Charles W. Harper, Jr.

Diagnosis: Small, commonly asymmetrical; fold and sulcus weak to absent; pseudodeltidium large; rugae strong.

Exterior: Valves small for the genus (the largest specimen is 19 mm wide, 11 mm long); asymmetrical; generally biconvex to slightly resupinate; transversely semi-circular; hinge line about equal to maximum width; length:width ratio averages 0.70 (n=45, std=0.072). Ventral valves vary from resupinate to geniculate, some with marginal frills; sulcus weak, restricted to anterior half of the valves, not developed in all valves; interarea high (interarea height:valve length ratio 0.31, n=21, std=0.06), catacline to apsacline; pseudodeltidium convex, almost covers entire delthyrium; foramen small, truncates erect beak. Dorsal valve flat to gently convex, slightly geniculate dorsally; fold uncommon, restricted to anterior half of the valve; interarea narrow, catacline; chilidium convex, small, rarely preserved.

Ornament of three types: (1) most commonly parvicostellate with interrupted, wave-like rugae, (2) less commonly parvicostellate with strong, uninterrupted rugae, and (3) rarely, costellate with either interrupted or uninterrupted rugae.

Ventral interior: Teeth thick; dental plates strong, convex laterally, and join together forming a short conical muscle chamber; muscle chamber mostly attached to valve floor. Myophragm low and small, divides muscle chamber. Muscle scars indiscernible.

Dorsal interior: Cardinal process bilobed, projects posteroventrally, the posterior face of each lobe with a median furrow; cardinal process sessile or with very short shaft, united with widely divergent socket plates. Notothyrial platform medially cleft, supported by two pairs of lateral septa. The posterior lateral septa short, laterally welded to the posterior extensions of prominent, anterior lateral septa. A pair of rod-like structures developed between socket plates and lateral septa. The posterior adductor pair bilobed, suboval, situated on the platform; the anterior pair situated on floor bounded by anterior lateral septa and divided by a weak myophragm.

Comparison: The new species differs from most *Pentlandina* in its asymmetry and irregularity in shape and ornamentation, large pseudodeltidium, and irregular fold and sulcus. The new species most closely resembles *P. loveni* (de Verneuil, 1848; see Bassett and Cocks, 1974) which is asymmetrical and has a relatively weak fold and sulcus. But the latter has much stronger radial ornament than the new species.

Occurrence	Articulated	Ventral	Dorsal
C12272	0	19	66
C12273	0	0	2
C22184	1	11	11
C22187	0	16	17

Genus *Laevicyphomena* Cocks, 1968

Type species: *Cyphomena* (*Laevicyphomena*) *feliciter* Cocks, 1968, p. 317, pl. 12, figs. 13, 14; pl. 13, figs. 1-9.

Laevicyphomena? sp.

Pl. 13, figs. 4, 5, 9, 10, 13, 14, 17, 18, 21.

Exterior: The largest specimen is 16 mm wide, 10 mm long. Valves somewhat asymmetrical; ventri-biconvex, both valves gently geniculate toward each other. Ventral valve convexity greatest in umbonal region; interarea high, apsacline; delthyrium covered by large, convex pseudodeltium. Dorsal valve initially flat to gently convex, anterior portion geniculate ventrally; interarea narrow, catacline; chilidium small, arched.

Valve surface bumpy, costellae superimposed on highly irregular concentric rugae.

Ventral interior: Teeth prism-like; dental plates convex laterally, unite medially above floor, forming an elevated muscle field divided by a low myophragm. Muscle scars indiscernible.

Dorsal interior: Cardinal process consists of two disjunct lobes, each with a grooved face directed posteriorly. Short socket ridges diverge widely. A pair of parallel lateral septa extend anteriorly about 1/3 of valve length, posteriorly thicken and form a pair of disjunct, elevated pads, presumably for muscle attachment; myophragm thread-like. Muscle scars indiscernible.

Comparison: This species differs from other *Laevicyphomena* because of its highly irregular concentric wrinkles overlapped by costellae.

Occurrence	Articulated	Ventral	Dorsal
C12272	0	0	4

C22184	1	3	2
C22187	0	0	1

Family Leptaenidae Hall and Clarke, 1894

Genus *Leptaena* Dalman, 1828

Type species: *Leptaena rugosa* Dalman, 1828, p. 106, pl. 1, fig.1.

Leptaena sp.

Form 1

Pl. 14, figs. 8-10, 13, 17, 18, 21, 22, 25, 26, 29-34.

Exterior: Generally small for the genus; transversely rectangular, somewhat alate; plano-convex; disc subrectangular, with length:width ratio averaging 0.64; both valves geniculate dorsally at right angles, forming a distinct tail commonly bearing a shallow sulcus. Ventral interarea narrow, apsacline; pseudodeltidium convex, variable in size; foramen truncates beak. Dorsal interarea ribbon-like, anacline; chilidium present.

Ornament of rugae overlapped by multicostellae. Rugae vary in amplitude and regularity, generally 6 to 8 on disc, weak to absent on the umbo and absent from the tail. Costellae low, rounded, increase mainly by bifurcation.

Ventral interior: Teeth commonly strong, triangular. Dental plates strong but short, fused at bases with muscle bounding ridges. Muscle field with inverted cordate outline, well defined by high lateral bounding ridges; adductor scars elongately lanceolate, laterally bounded by a pair of larger, oval-shaped diductor scars. Myophragm low, bisects muscle scars. Disc area commonly with tubercles and the reflection of external ornament.

Dorsal interior: Cardinal process bilobate, projects ventri-posteriorly, with a deep median groove separating the two lobes. Anterolaterally, the two lobes fused at their bases with socket ridges, the latter diverge anteriorly at a 90 to 100 degrees angle. A rounded pit separates cardinal process from muscle field. Muscle field elongate oval to cordate, with lateral bounding ridges which may or may not meet anteromedially. The posterior pair of muscle scars generally slightly raised and the anterior pair depressed. A low, slender myophragm bisects muscle scars. Disc defined by high peripheral ridge, generally with tubercles and various degrees of reflection of external ornament.

Form 2

Pl. 4, figs. 11, 12, 14-16, 19, 20, 23, 24, 27, 28.

Discussion: Typical Form 2 is different enough from Form 1 to be a separate species, but there are some specimens in the collection that appear to be intermediate between the two forms. Thus, they are treated as variants of a single species here. The following description is brief, and only emphasizes the unique characteristics of the form.

Exterior: Rugae weak; tail generally lacks sulcus.

Ventral interior: Teeth triangular, plate-like; dental plates obsolete or very short. Muscle scars weakly impressed, with very low bounding ridge.

Dorsal interior: Cardinalia slender. Muscle field largely smooth, without discernible scars; bounding ridges faint or absent. Disc peripheral bounding ridge very low or absent.

Discussion: According to Cocks (1968), British Llandovery *Leptaena* species can be divided into three groups: large with oval ventral muscle field; large with parallel-sided ventral muscle scars; and small, loosely knit group. The Baillie Hamilton species belongs to the small-species group.

Occurrence	Form 1			Form 2		
	Articulated	Ventral	Dorsal	Articulated	Ventral	Dorsal
C22184	2	14	16	0	5	20
C22185	0	0	0	0	0	2
C22187	0	2	1	0	0	6
C12273	0	0	2	0	0	2
C12272	0	0	0	0	8	22

Genus *Liljevallia* Hedstrom, 1917

Type species: *Liljevallia gotlandica* Hedstrom, 1917, p. 9, pl. 2, figs. 1-4, pl. 3, figs. 1-5.

Liljevallia amorpha n. sp.

Pl. 15, figs. 1-20.

Derivation of species name: From the Greek *amorphos*, meaning misshapen, referring to the irregular shape of the new species.

Diagnosis: Small, irregular valves; surface irregular and bumpy, with concentric wrinkles and variable radial ornament.

Exterior: Shells irregular, mirroring in variable degrees the irregular shaped objects to which these shells attached. Shells generally concavo-convex with dorsal

geniculation; transversely subquadrate to semi-circular, with hinge line about equal to maximum width. Ventral interior about 1/5 shell length, apsacline; pseudodeltidium convex, completely covers delthyrium. Dorsal disc flat or gently convex; interarea hypercline to anacline, ribbon-like to obsolete; chilidium small.

Surface irregular and bumpy, with concentric wrinkles overlapped or interrupted by widely spaced parvicostellae in some shells and by closely spaced fine costellae in others. A few shells lack radial ornament.

Ventral interior: Teeth plate-like, denticulate, generally with 5-7 denticles on each tooth plate (pl. 5, fig. 17). Dental plates absent. Muscle field variable, a pair of elevated linear adductors bounded laterally by a pair of depressed, much larger, lanceolate diductors; less commonly, the entire muscle field is elevated.

Dorsal interior: Socket plates denticulate, recurved laterally toward smooth hinge line, medially continuous with cardinal process. Cardinal process consists of a pair of disjunct, plate-like lobes protruding ventrally, each lobe with medially grooved posterior face. Muscle field variable, commonly elevated, with cordate outline divided by a median trough; the posterior adductor pair large, lanceolate, elevated, posterolaterally bounding smaller anterior adductors. Myophragm low, may or may not be present, consists of two parts in some shells, the posterior part broad, continuous with cardinalia, anteriorly may be cleft by the incipient anterior adductors, the anterior part slender, divides anterior adductors. Marginal ridge variably developed.

Comparison: Available specimens of *L. gotlandica* are preserved as ventral valves attached to reefal fragments (Edward, 1986), their external ornamentation and dorsal valves are unknown. It is thus only possible to compare the new species with *L. gotlandica* in size and ventral internal structures. The new species is only about half the size of the type species, *L. gotlandica*. The ventral muscle field of the new species is variable, from depressed to elevated, infrequently defined by raised lateral ridges; while *L. gotlandica* invariably has raised lateral ridges defining the muscle field which is divided by a slender median ridge.

Occurrence	Articulated	Ventral	Dorsal
C22184	1	43	197
C22185	0	0	1
C22187	2	4	55
C12273	1	7	60
C12272	1	6	104

Superfamily Stropheodontacea Caster, 1939

Family Amphistrophiidae Harper and Boucot, 1978

Genus *Amphistrophia* Hall and Clarke, 1892

Subgenus *Amphistrophia* (*Amphistrophia*) Hall and Clarke, 1892

Type species: *Strophomena striata* Hall, 1843, p. 104, fig. 3.

Amphistrophia (*Amphistrophia*) sp.

Pl. 16, figs. 14-23, 37, 38.

Exterior: Valves small for the genus (the largest specimen is 34 mm wide, 21 mm long); alate, small valves transversely semi-circular, large ones less transverse; small valves gently concavo-convex, large ones resupinate anteriorly. Ventral interarea narrow, steeply apsacline. Dorsal interarea narrower, anacline. Valves unequally parvicostellate.

Ventral interior: Denticular plates triangular, about 1/3 of hinge line length. Muscle field cordate, posterolaterally bounded by curved ridges and medially divided by a low, narrow myophragm; adductor scars small, lanceolate, enclosed by large diductor scars.

Dorsal interior: Cardinal process bilobate; each lobe with posteriorly directed face; two lobes disjunct, basally join socket ridges. Other features are not preserved in fragmented specimens.

Occurrence	Articulated	Ventral	Dorsal
C22184	2	9	4
C22185	1	1	1
C22187	0	10	1
C12273	0	0	0
C12272	2	41	6

Family Pholidostrophiidae Stainbrook, 1943

Subfamily Pholidostrophiinae Stainbrook, 1943

Genus *Pholidostrophia* Hall and Clarke, 1892

Subgenus *Pholidostrophia* (*Mesopholidostrophia*) Williams, 1950

Type species: *Pholidostrophia* (*Mesopholidostrophia*) *nitens* Williams, 1950, p. 280, figs. 7-10.

Pholidostrophia (*Mesopholidostrophia*) *lamellosa* n. sp.

Pl. 15, figs. 21-34.

Derivation of species name: Refers to the thick, concentric lamellae of the species.

Diagnosis: Valves relatively large for the genus, with thick, irregular concentric lamellae.

Exterior: Valves relatively large (the largest specimen is 22 mm wide, 9 mm long); concavo-convex with narrow body cavity, some larger valves slightly geniculate; transversely subrectangular, alate; length:width ratio averages 0.51 (n=20, std=0.077). Ventral interarea narrow, apsacline to almost orthocline; pseudodeltidium convex; umbo low; beak incurved; apical pedicle opening small, commonly abraded into a longitudinal slot on the umbo; some small valves have a pedicle sheath protruding posteroventrally. Dorsal interarea anacline, very narrow, about 1/3 width of ventral interarea; chilidium present; protegulum small, cigar-like.

Valves smooth or weakly costellate to parvicostellate, superposed by thick, irregular lamellae. Lamellae strongly developed on ventral valves, but variable on dorsal valves, about 1/3 of dorsal valves in the collection without lamellae. Lamellae generally do not interrupt radial ornament, but may leave faint rugae on valve surface after being abraded.

Ventral interior: Hinge denticulate for 1/3 of its length, with 12 to 20 denticles on each of the two well developed denticular plates. Pedicle tube about 0.4 mm in diameter and 1/5 of valve length, developed on the floor of the delthyrial cavity. Muscle field indiscernible.

Dorsal interior: Cardinal process bilobed, protrudes ventrally, the two lobes nearly disjunct and each lobe with a medially grooved posterior face. Cardinal process base either anteriorly pitted or slightly raised. lateral muscle bounding ridges low, divergent, generally consist of coarse pustules, developed only in some valves. Median ridge weak, present in some valves. Muscle field indiscernible. Interior of both valves finely pustulose.

Comparison: The new species is distinguished from other *Pholidostrophia* in having thick, irregular concentric lamellae. It appears to have similar length:width ratio as *P. (M.) salopinensis granti* n. subsp. This is because the latter has long alae, apart from alae, *P. (M.) lamellosa* is noticeably more transverse than *P. (M.) salopinensis granti.*

Discussion: *Pholidostrophia* has been regarded as characterized by the loss of a functional pedicle during adult life (Hurst, 1974). Consequently it is assumed that adult pholidostrophiids lay unattached on their ventral valves on the sea floor. The presence of a pedicle tube and pedicle opening in mature pholidostrophiids of Baillie Hamilton Island

indicates that some pholidostrophiids, if not all, had functional pedicles throughout life, thus they may have lived in a vertical position. Three specimens in the collection provide additional evidence for a vertical life position of pholidostrophiids. These specimens have epizonal corals on their ventral valves. The corallum is attached to the shell surface below lamellae and interrupts the growth pattern of lamellae (pl. 15, fig. 25). This proves that these corals were growing on living shells. The corallum reaches at least 1.5 mm height. Therefore, these shells are likely to have been in a vertical living position, because otherwise further coral growth would have been impossible.

The pedicle tube is present in the two new species and subspecies. It is probably also present in the type species because Hurst (1974) described an atrophied supra-apical opening and pedicle sheath on the pedicle protegular node of the type species from the Mulde Marl of Gotland. The pedicle tube is such a delicate structure that it is difficult to preserve in its original form. The ventral process described by some authors in internal molds of some pholidostrophiids probably represents the pedicle tube.

Occurrence	Articulated	Ventral	Dorsal
C22184	145	214	66

Pholidostrophia (*Mesopholidostrophia*) *salopiensis* Cocks, 1967
Pholidostrophia (*Mesopholidostrophia*) *salopiensis granti* n. subsp.
Pl. 16, figs. 1-13.

Derivation of subspecies name: After Richard Grant.

Diagnosis: Valves small, hemispherical; weakly parvicostellate; ventral muscle bounding ridges absent.

Exterior: Valves small (the largest specimen is 14 mm wide, 5.7 mm long); concavo-convex; hemi-spherical apart from ears. Pedicle opening present as small circle or longitudinal slot on ventral umbo. Ventral valve weakly parvicostellate; dorsal valve weakly costellate or smooth. Faint growth lines or rugae may be present.

Ventral interior: Denticles for about 1/3 of hinge line. Pedicle tube well developed, bisects faintly impressed, bilobed muscle field. Muscle bounding ridges absent.

Dorsal interior: Cardinal process disjunct. Socket ridges slender. Lateral muscle bounding ridges low, consist of coarse pustules. Muscle scars indiscernible. Interior of both valves finely pustulose.

Comparison: Externally, the new subspecies closely resembles *P.* (*M.*) *salopiensis salopiensis* except in being less convex. Internally, it differs from

salopiensis salopiensis and *salopiensis johnsoni* Hurst in lacking ventral muscle bounding ridges. It differs further from *salopiensis johnsoni* in having better developed radial ornament.

Occurrence	Articulated	Ventral	Dorsal
C22184	9	61	13
C12272	4	13	5

Superfamily Fardeniacea Williams, 1965

Family Fardeniidae Williams, 1965

Genus *Morinorhynchus* Havlícek, 1965

Type species: *Morinorhynchus dalmanelliformis* Havlícek 1965, p. 292, pl. 1, figs. 1-3.

Morinorhynchus crispus (Lindström, 1861)

Pl. 16, figs. 24-36, pl. 17, figs. 28, 33, 38, 39.

1861 *Strophomena crispa* Lindström, p. 373, pl. 13, fig. 17.

1861 *Strophomena serrulata* Lindström, p. 373, pl. 13, fig. 18.

1974 *Morinorhynchus crispus*--Bassett and Cocks:20, pl. 4, figs. 1-8.

Remarks: The Arctic material includes variants closely resembling both *M. crispus* and *M. adnatus* (Hedstrom) from Gotland, thus is supportive of the suggestion that *M. adnatus* may be a junior synonym of *M. crispus* (Bassett and Cocks, 1974; Bassett, 1974). The Arctic material shows wide variation in the size and density of costellae. Variants with fine, dense costellae resemble *M. attenuatus* (Amsden, 1951). It is possible that the Oklahoma species can be synonymized with the Gotland species *M. crispus*. The alternative possibility is that the Arctic material represents the earliest occurrence of the genus and encompasses a wide range of variants which later evolved into separate species in the Ludlovian.

Exterior: Valves relatively large (the largest specimen is 24 mm wide, 15 mm long); biconvex, the convexity of both valves variable; outline transversely subrectangular, cardinal extremities alate to subangular. Ventral valve length:width ratio averages 0.67 (n=30, std=0.11); interarea varies from catacline to almost orthocline, but generally steeply apsacline; pseudodeltidium large, convex; beak erect, truncated by foramen; ventral carina uncommon. Dorsal valve length:width ratio averages 0.61 (n=27, std=0.05); interarea narrow; small chilidial plates poorly preserved; commonly, less convex valves have catacline interarea and shallow sulcus while more convex valves have anacline interarea and no sulcus.

Ornament of rounded to angular multicostellae, costellae increase by intercalation only. The density and size of costellae variable. Concentric growth lines variable, strong in some larger valves but weak to absent in most valves.

Ventral interior: Teeth supported by short dental plates. Muscle field not impressed.

Dorsal interior: Cardinalia raised above valve floor, consists of bilobate cardinal process and socket plates; both lobes of cardinal process medially grooved, directed posteriorly; socket plates anterolaterally divergent, in convex valves socket plates curve toward hinge line, forming elevated sockets, in less convex valves socket plates descend to valve floor, defining sessile sockets. Muscle field preserved as a pair of shallow suboval depressions bisected posteriorly by a low myophragm, muscle field and myophragm rarely present in more convex valves.

Radial crenulations of variable size developed in both valves.

Occurrence	Articulated	Ventral	Dorsal
C22184	2	90	139
C22185	0	1	2
C22187	1	170	198
C12273	0	27	36
C12272	1	251	341

Morinorhynchus miniparvicostellus n. sp.

Pl. 17, figs. 18-27, 29-32, 34-37.

Derivation of species name: Referring to the small size and parvicostellae of the new species.

Diagnosis: Valve small; plano-convex; parvicostellate with closely spaced concentric lamellae.

Exterior: Valves small (the largest specimen is 13 mm wide, 6 mm long); ventral valve convex, dorsal valve flat to slightly convex; outline semi-circular to transversely rectangular, length:width ratio averages 0.53 (n=28, std=0.064); cardinal extremities angular to alate. Ventral interarea generally catacline; pseudodeltidium large, convex; beak erect, truncated by foramen. Dorsal interarea catacline, ribbon-like or obsolete; shallow sulcus developed in some slightly convex valves.

Ornament of parvicostellae overlapped by closely spaced concentric lamellae. Costellae rounded, increase in number by intercalation, separated by wider interspaces.

Ventral interior: Dental plates very short. Muscle field not impressed.

Dorsal interior: Cardinalia slender, with two variants. One, resembling *Fardenia*, consists of two minute disjunct cardinal process lobes and anterolaterally extended socket plates or brachiophores (pl. 17, figs. 25, 37); the other is a more typical *Morinorhynchus* type, consisting of socket plates subparallel to hinge line and larger, bilobate cardinal process. Muscle field not impressed. Interior of both valves largely crenulated.

Comparison: The new species can be readily distinguished from other *Morinorhynchus* by its small size and parvicostellate ornament.

Occurrence	Articulated	Ventral	Dorsal
C22184	0	12	33
C22187	0	5	7
C12273	0	5	6
C12272	0	8	12

Order Pentamerida

Suborder Syntophiidina

Superfamily Porambonitacea Davidson, 1853

Family Parastrophinidae Ulrich and Cooper, 1938

Subgenus *Anastrophia* (*Grayina*) Boucot, 1975

Type species: *Anastrophia magnifica* Kozłowski, 1929, p. 140, pl. 6, figs. 14-16, text-fig. 42.

Anastrophia (*Grayina*) cf. *magnifica* Kozłowski, 1929

Pl. 17, figs. 1-17.

1929 *Anastrophia magnifica* Kozłowski, p. 140, pl. 6, figs. 14-16; text-fig. 42.

1954 *Anastrophia magnifica*--Nikiforova, p. 65, pl. 4, fig. 1.

1968 *Anastrophia magnifica*--Modzalevskaya, pl. 30, figs. 5-8.

1975 *Grayina magnifica*--Boucot, p. 354.

1985 *Anastrophia* (*Grayina*) *magnifica*--Nikiforova, Modzalevskaya, and Bassett, p. 32, pl. 8, figs. 10-12.

Remarks: The Arctic material has a rather variable outline and costellae density. It is less transverse and has a shorter hinge line than most *A.* (*Grayina*) species. It most closely resembles small valves of *A.* (*G.*) *magnifica* (see Nikiforova and others, 1985, pl. 8, figs. 11a, 11b).

Exterior: Valves small (the largest specimen is 12.9 mm wide, 8.3 mm long); biconvex, transversely elliptical, with rounded cardinal extremities, length:width ratio averages 0.68 (n=18, std=0.054); ventral sulcus and dorsal fold asymmetrical in some valves. Ventral interarea low, apsacline; delthyrium open.

Ornament of angular costellae, separated by V-shaped interspaces; costellae increase by bifurcation, variable in number. Concentric growth lamellae variably developed.

Ventral interior: Spondylium V-shaped, supported by a short median septum. Teeth small.

Dorsal interior: Sockets small, defined by socket plates and socket ridges. Crural plates high, subparallel, continuous with socket ridges. A pair of flange-like plates projecting laterally from crural plates just below socket ridges.

Inner surfaces of both valves are radially crenulated, reflecting the external costation.

Occurrence	Articulated	Ventral	Dorsal
C22184	0	14	8
C12273	0	10	0
C12272	0	17	4

Suborder Pentameridina

Superfamily Pentameracea M'Coy, 1844

Family Pentameridae M'Coy, 1844

Subfamily Pentamerinae M'Coy, 1844

Genus *Harpidium* Kirk, 1925

Subgenus *Harpidium* (*Lissocoelina*) Schuchert and Cooper, 1931

Type species: *Pentamerus pergibbosus* Hall and Whitfield, 1875, p. 139, pl. 7, figs. 10, 11.

Harpidium (*Lissocoelina*)? sp.

Pl. 18, figs. 7-15.

This species is represented by fragmented material. These shell fragments have a smooth surface, without sulcus or fold. Internally, ventral valves have a narrow spondylium with keyhole-like cross- section, supported by a high septum; dorsal valves have broad, triangular inner plates, long, subparallel outer plates, fine myophragm, and a small cardinal process consisting of a pair of conjunct, triangular plates.

Occurrence Articulated Ventral Dorsal

C22185	0	1	0
C22187	0	3	6
C12272	0	0	34

Genus *Rhipidium* Schuchert and Cooper, 1931

Type species: *Pentamerus knappi* Hall and Whitfield, 1872, p. 184, pl. 10, figs. 10-12.

Rhipidium? sp.

Pl. 18, figs. 1-6.

This material is assigned to *Rhipidium* on the basis of its rounded costellae and long, subparallel outer plates. Ventral valves unknown.

Occurrence	Articulated	Ventral	Dorsal
C22184	0	0	2
C22185	0	0	2
C22187	0	0	2
C12272	0	0	4

Subfamily Subrianinae Sapelnikov, 1961

Genus *Vosmiverstum* Breivel and Breivel, 1970

Type species: *Conchidium triquetrum* Sapelnikov, 1961, p. 47, pl. 4, figs. 9, 10; text-fig. 6.

Remarks: J. and M. Breivel erected the genus *Vosmiverstum* to include two Wenlockian species from the eastern slope of the Ural Mountains. They differentiated *Vosmiverstum* from *Conchidium* in that the former has poorly developed medial flanges on its brachial plates. Sapelnikov (1985) classified *Vosmiverstum* as a subgenus of *Conchidium* and he defined *Vosmiverstum* as being smaller, having an asymmetrical outline, and lacking medial flanges. However, I find it difficult to distinguish *Vosmiverstum* from *Conchidium* on the basis of the characters mentioned by the Russian authors for the following reasons: (1) serial sections of *V. triquetrum* Sapelnikov and *V. elkinensis* Breivel and Breivel show that these species have essentially *Conchidium* type medial flanges developed in the anterior portion of their brachial plates (Breivel and Brievel, 1970, pl. 10:1-8, 9-13; Sapelnikov, 1972, p. 94, text-fig. 30); (2) probably due to secondary shell material buildup, medial flanges are not evident in the posterior portion of the brachial plates in some *Conchidium* species (see pl. 8, fig. 18);

(3) asymmetrical valves are common in Pentameridae; and (4) several small Conchidium species have been described from the Roberts Mountains Formation from Nevada. Instead of dorsal internal characters, I rely mainly on the relative length of the median septum to spondylium, and spondylium to valve length to distinguish *Vosmiverstum* from *Conchidium*. *Vosmiverstum* generally has a short spondylium rarely extending more than 2/3 of valve length, supported by a median septum of less than 2/3 of the spondylium length. Whereas, *Conchidium* has a longer spondylium ranging from 2/3 of valve length to valve length, its median septum is generally about the same length or longer than the spondylium.

Vosmiverstum breiveli n. sp.
Pl. 19, figs. 14-37.

Derivation of species name: After J. and M. Breivel.

Diagnosis: Valves small for the genus; umbonal area generally smooth; numerous costellae; concentric lamellae closely spaced; median septum short.

Exterior: Valves small (the largest specimen is 23 mm wide, 25 mm long; but most specimens are less than 20 mm wide); variable in shape and degree of convexity. Ventral valves length:width ratio averages 1.01 (n=30, std=0.13); palintrope height:valve length ratio, 0.40 (n=30, std=0.12), larger valves tend to have higher palintropes, resulting in large, conical variants; beak pointed, gently incurved, commonly twisted. Dorsal valves gently convex, length:width ratio 0.92 (n=30, std=0.11,); sulcus and fold absent.

Ornament of angular to subrounded costellae, overlapped by closely spaced, fine concentric growth lines. Umbonal area of both valves generally smooth or with growth lines only. Costellae increase by bifurcation variable in number from valve to valve.

Ventral interior: Spondylium averages 0.53 valve length (n=30, std=0.12), a few larger valves have much longer spondylia. Median septum short, mostly apically restricted.

Dorsal interior: Cardinal process small, consists of crenulated callous under the beak. Brachial plates average 0.33 valves length (n=30, std=0.06). Outer plates and inner plates about the same length; outer plates low, medially inclined and narrowly divergent; inner plates wide, triangular, meet outer plates almost at a right angle. Medial flanges prominent at anterior portion of brachial plates. Myophragm thread-like, nearly reaches midlength. Adductor scars commonly absent, but a few valves have a pair of faint, oval impressions anterior to outer plates.

Interior of both valves largely corrugated, reflecting external ornament.

Comparison: The new species is about 2/3 the size of Uralian *V. triquetrum* and *V. elkinensis* Breivel and Breivel, 1970. It can be distinguished from the type species *V. triquetrum* by its more numerous, finer costellae, smooth umbo, and commonly incurved ventral beak; from *elkinensis* by its much coarser costellae. The new species closely resembles California species *V. wenlockum* Boucot, Johnson, and Zhang (1988), but it differs from the latter in having numerous concentric lamellae, generally smooth umbo, commonly twisted ventral beak, and shorter ventral median septum.

Occurrence	Articulated	Ventral	Dorsal
C12273	0	57	29
C12272	0	405	672

Genus *Conchidium* Oehlert, 1877

Type species: *Anomia bilocularis* Hisinger, 1799, p. 285.

Conchidium cf. *microlocularis* Johnson, Boucot, and Murphy, 1976

Pl. 18, figs. 16-35.

1976 *Conchidium microlocularis* Johnson, Boucot, and Murphy, p. 37, pl. 35, figs. 1-26, pl. 36, figs. 1-3.

Remarks: The Arctic material closely resembles the Nevada Ludlovian species *C. microlocularis* except for being larger and lacking the finer median costa.

Exterior: Valves small for the genus, the largest specimen is 19 mm wide, 21 mm long (estimated); ventri-biconvex; weak ventral sulcus and dorsal fold present in some valves. Ventral palintrope gently curved, medially cleft by a triangular delthyrium; beak incurved. Larger dorsal valves have strongly incurved beaks.

Ornament of rounded costellae; increasing in number by bifurcation. Concentric lamellae fine, variably developed.

Ventral interior: Spondylium V-shaped, about 2/3 to 4/5 of shell length; median septum about same length as spondylium.

Dorsal interior: Cardinal process consists of a pair of thickened callous pads under the beak. Outer plates and inner plates about the same length; outer plates variable in height, nearly erect to dorsally divergent; inner plates triangular. Medial flanges evident in anterior portion of brachial plates. Brachial process spiky. Myophragm thread-like. Muscle field indiscernible.

Interior of both valves corrugated, reflecting the external ornament.

Occurrence	Articulated	Ventral	Dorsal

C12273	0	18	24
C12272	2	231	82

Genus *Cymbidium* Kirk, 1926

Type species: *Cymbidium actum* Kirk, 1926, p. 2.

Cymbidium sp.

Pl. 9, figs. 1-13.

Exterior: The largest specimen is 15 mm wide, 14.3 mm long; ventri-biconvex. Ventral palintrope high in large valves, apsacline; delthyrium triangular, large, without evident deltidial plates; beak slightly incurved. Dorsal valves gently convex. Fold and sulcus absent.

Ornament of rounded costellae, increasing in number by bifurcation and intercalation. The umbonal region of both valves smooth. Concentric lamellae generally developed near anterior margin.

Ventral interior: Spondylium V-shaped, slightly longer than palintrope, without supporting plates.

Dorsal interior: Inner plates and outer plates about the same length. Outer plates narrow, divergent dorsally, subparallel to each other; inner plates wider, meet outer plates at an acute angle. Medial flanges not evident. Myophragm blade-like, extends to near midlength. Adductor scars preserved as a pair of oval depressions in front of the bases of outer plates.

Comparison: *Cymbidium* sp. resembles *C. imitor* Johnson, Boucot, and Murphy in having smooth umbo, but differs from the latter in being larger, and having more abundant costellae. It differs from *C. actum* Kirk in being smaller, having finer costellae, and smooth umbo.

Occurrence	Articulated	Ventral	Dorsal
C12273	0	1	7
C12272	0	38	17

Genus *Severella* Sapelnikov, 1963

Type species: *Brooksina* (*Severella*) *magnificaformis* Sapelnikov, 1963, p. 15.

Severella arctosulcata n. sp.

Pl. 20, figs. 24-46.

Derivation of species name: From the Latin *arcto* meaning compressed, referring to the narrow sulcus of the species.

Diagnosis: Transversely elliptical, with weak, narrow ventral sulcus and dorsal fold; costellae fine, numerous.

Exterior: Valves generally small (the largest specimen is 19.5 mm wide, 12.5 mm long, but valves generally under 11 mm width); subequally biconvex, transversely elliptical to rhomboidal, larger valves tend to be less transverse. Ventral valve length:width ratio averages 0.59 (n=25, std=o.180); beak slightly incurved; palintrope low; delthyrium triangular, open; sulcus narrow, shallow, poorly defined. Dorsal valve length:width ratio average 0.64 (n=25, std=0.106); median fold low, semi-carinate, weakening anteriorly.

Ornament of numerous angular to rounded costellae, generally not more than three costellae in either sulcus or on fold. Costellae increase by branching, less commonly by intercalation, variable in density. Concentric growth lines weak, present in anterior portion of larger valves.

Ventral interior: Spondylium short, averages 0.43 of valve length (n=25, std=0.132); median septum about same length as spondylium.

Dorsal interior: Brachial plates short, average 0.33 of valve length (n=25, std=0.047); outer plates low, diverging moderately, generally shorter than inner plates. Site of diductor attachment consists of a pair of conjunct, triangular plates under the beak; adductor scars not impressed.

Interior of both valves largely corrugated longitudinally, reflecting external ornament.

Comparison: The new species resembles *S. magnificaformis* Sapelnikov and *S. lichensis* Khodalevich, 1939 in having numerous costellae, but can be distinguished from the latter two by its smaller size, narrower sulcus, and semi-carinate fold. It differs from other *Severella* species in having more abundant costellae, weaker concentric lamellae, narrower sulcus, and semi-carinate fold.

Occurrence	Articulated	Ventral	Dorsal
C22184	0	45	0
C22187	1	112	24
C12273	4	226	213
C12272	12	934	879

Genus *Spondylopyxis* Johnson, Boucot, and Murphy, 1976

Type species: *Spondylopyxis ignotus* Johnson, Boucot, and Murphy, p. 48, pl. 37, figs. 12-24.

Spondylopyxis potteri n. sp.

Pl. 20, figs. 1-23.

Derivation of species name: After Alfred Potter.

Diagnosis: Small, lenticular; smooth shells with fine concentric growth lines; spondylium and median septum short.

Exterior: Valves small (the largest specimen is 6.7 mm wide, 6.8 mm long); ventri-biconvex, lenticular outline. Ventral valve length:width averages 1.03 (n=25, std=0.09); palintrope low, apsacline, slightly curved; beak slightly incurved. Dorsal valve length:width ratio averages 1.01 (n=24, std=0.09); beak small, straight.

Shells smooth, with weak, fine concentric growth lines of variable density.

Ventral interior: V-shaped spondylium extends slightly beyond hinge line, spondylium:shell length ratio averages 0.36 (n=25, std=0.05); median septum generally shorter than the spondylium.

Dorsal interior: Brachial plates length:shell length ratio averages 0.31 (n=24, std=0.14); outer and inner plates about the same length; outer plates low, diverge anteriorly at a small angle; inner plates wide, lie at a sharp angle to outer plates. The site of diductor attachment consists of a poorly preserved, horizontal, plate-like callous under the beak; adductor scars not impressed; myophragm thread-like, generally present.

Comparison: The new species differs from the type species *S. ignotus*, the only other species of the genus, in being smaller, lacking irregular undulations on shell surface, and having shorter spondylium and median septum.

Occurrence	Articulated	Ventral	Dorsal
C22184	0	28	3
C22185	0	4	1
C22187	0	12	5
C12273	0	45	18
C12272	6	853	679

Family Clorindidae Rzhonsnitskaya, 1956

Genus *Clorinda* Barrande, 1879

Type species: *Clorinda armata* Barrande, 1879, p. 109.

Remarks: The type species of the genus and other Devonian species have short but high outer plates (see Drot, 1969; Johnson and Ludvigsen, 1972). In contrast, the two species described below have exceedingly low outer plates. They are tentatively assigned to Clorinda because of our poor knowledge about the internal structure of Silurian *Clorinda* species (Sapelnikov in his 1985 paper listed 22 Silurian *Clorinda* species, the internal structures of most of these species are unknown). Further investigation may result in making a new genus for those species with obsolete outer plates.

Clorinda geniculata n. sp.

Pl. 21, figs. 1-15.

Derivation of species name: Refers to the geniculate ventral valve of the species.

Diagnosis: Small, thin valve; ventral valve with a prominent, geniculate tongue; sulcus and fold angular; spondylium small, apically restricted; incipient outer plates nearly invisible.

Exterior: Valves small (the largest dorsal valve is 5.3 mm wide, 3.3 mm long); ventri-biconvex at umbonal region, becomes concavo-convex anteriorly. Ventral sulcus with angular bottom, begins at umbo, widens rapidly and geniculate dorsally, producing a prominent tongue. Dorsal fold peak-like, enlarges markedly anteriorly to accommodate the tongue. Shell smooth, without plications or grooves, some valves may have faint concentric growth lines near anterior margin.

Ventral interior: Spondylium minute, apically restricted, supported by a large median septum extending 1/2 of shell length.

Dorsal interior: Brachial plates minute; inner plates indistinguishable from plate-like brachial process; outer plates incipient, nearly invisible. An anchor-like mark in one valve (pl. 21, figs. 15) may represent adductor scars.

Comparison: The new species can be readily distinguished from other *Clorinda* species by its small size and geniculation. It resembles *C. substantiva* Kulkov, 1967 in some degree, both having angular sulcus and fold. But the new species has a much stronger fold and ventral tongue. Further comparison of the two species is hindered by the lack of information on dorsal internal structure of the Altai species.

Occurrence	Articulated	Ventral	Dorsal
C22187	2	0	0
C12272	1	26	11

Clorinda sp.

Pl. 21, figs. 16-28.

Exterior: Valves small (the largest specimen is 6.7 mm wide, 5.1 mm long); transversely elliptical; ventral valve deep, with incurved umbo; sulcus begins at umbo as a furrow, and widens anteriorly; palintrope low, curved; triangular delthyrium open. Dorsal valve nearly flat except for the narrow, rounded median fold. Valves lack ornament except for faint concentric growth lines in some valves.

Ventral interior: Teeth minute; V-shaped spondylium extends anteriorly slightly beyond hinge line, supported by a high median septum of variable length; in general, septum shorter than spondylium in larger valves and longer than the latter in small ones.

Dorsal interior: Inner plates short, triangular; brachial processes plate-like, diverge anteriorly; outer plates not exposed.

Remarks: This species is about the same size as *C. geniculata*, but it has thicker valves, suggesting that the two species may have adapted to different environments.

Occurrence	Articulated	Ventral	Dorsal
C22184	2	11	9
C22185	0	1	0
C22187	1	0	0
C12273	0	1	0
C12272	4	0	0

Clorinda? sp.

Pl. 21, figs. 29-34.

This species is represented by 6 ventral valves and the largest valve is 6.7 mm wide, 5.9 mm long. Valves gently convex; subtriangular, with the maximum width near anterior margin; beak small, erect; anterior margin bears a weak, sometimes asymmetric, median sulcus. Valve surface smooth, two valves have variably developed concentric lamellae. Spondylium short, keyhole-like in cross-section, supported by a median septum of the same length.

Occurrence	Articulated	Ventral	Dorsal
C22184	0	6	0

Genus *Antirhynchonella* Oehlert, 1887

Type species: *Atrypa linguifera* Sowerby in Murchison, 1839, p. 629

Antirhynchonella sp.

Pl. 22, figs. 1, 7, 15, 19, 22, 25.

Exterior: The largest valve (dorsal) is 22 mm wide, 16.5 mm long; ventri-biconvex; transversely elliptical, with relatively long and straight hinge line. Ventral umbo tumid; beak small, incurved; palintrope low, curved, gently apsacline; triangular delthyrium open. Dorsal fold narrow, flat-topped, widens anteriorly. The only ventral valve in the collection is broken at the anterior margin, but it appears to show a shallow anterior sulcus. Fine concentric growth line and lamellae present in some valves.

Ventral interior: Spondylium small, with rounded bottom, posteriorly supported by a short median septum. Mantle canal pinnate, with nearly parallel vascular media.

Dorsal interior: Sockets defined by small socket plates and rod-like socket ridges; inner plates nearly erect; outer plates converge to form a V-shaped cruralium supported by a low septum. Brachial processes plate-like, embedded between inner and outer plates, only distinguishable from the latter two by their short anterior extensions beyond cruralium.

Occurrence	Articulated	Ventral	Dorsal
C22184	0	1	3
C12273	0	0	1

Genus *Barrandina* Booker, 1926

Type species: *Pentamerus linguifer* var. *wilkinsoni* Etheridge, 1832.

Barrandina sp.

Pl. 22, figs. 2, 8, 16, 20, 23, 24, 26, 27.

Exterior: The largest specimen is 30 mm wide, 25 mm long (estimate based on an incomplete ventral valve); ventri-biconvex; transversely suboval, with short, curved hinge line. Ventral sulcus and dorsal fold begin near midlength; sulcus shallow, produces a short tongue extending dorsally; fold flat-topped. Ventral palintrope gently curved, apsacline; triangular delthyrium open. Surface smooth.

Ventral interior: Spondylium small, V-shaped, posteriorly supported by a short median septum.

Dorsal interior: A pair of medial flanges divide inner plates from outer plates; inner plates triangular, inclined ventrimedially; outer plates straight, slightly divergent anteriorly.

Occurrence	Articulated	Ventral	Dorsal
C22184	0	5	6
C22187	0	8	13
C12273	0	1	3

Family Gypidulidae Schuchert and Le Vene, 1929

Genus *Amsdenina* Boucot, 1975

Type species: *Sieberella roemeri* Hall and Clarke, 1892, p. 247, pl. 2, fig. 6.

Remarks: According to Amsden (1949, 1951), the type species *A. roemeri* has a dorsal median septum supporting the cruralium. But in a later study, Gauri and Boucot (1968) illustrated the noticeable difference between *Sieberella sieberi* (Oehlert) and *A. roemeri* in dorsal internal structure. The former has a well-developed median septum which forms a continuum with the shell floor, whereas the latter has convergent outer plates which form a cruralium with its bottom submerged by secondary deposit accumulated on the shell floor. I have examined *A. roemeri* in the U.S. National Museum collection and noticed the following variations: the cruralium is better developed and may be lifted above the floor by a median septum in early growth stages because some specimens show a short apical median septum. The cruralium widens and wedges deeper into the floor during growth, so that outer plates in mature valves appear to be discrete. This makes it difficult to recognize the cruralium without serial sections. With silicified material, if there is a large sample, the ontogeny of the cruralium can be easily observed.

Amsdenina amsdeni n. sp.

Pl. 22, fig. 3-6, 9-14, 17, 18, 21, 28-31, pl. 23, figs. 1-11.

Derivation of species name: After Thomas W. Amsden.

Diagnosis: A small *Amsdenina* with few low, anterior plications and short ventral median septum.

Exterior: Valves medium size (the largest specimen is 15.9 mm wide, 12.7 mm long). Ventral valve deep, transversely rhomboidal; palintrope gently curved, triangular delthyrium open; fold variable, generally with two rounded plications. Dorsal

valve gently convex, transversely elliptical; sulcus weak, may produce a short, ventrally projecting tongue, generally with one median plication. Lateral plications weaker, generally confined to near anterior margin, vary from none to two on each flank of either valve. Closely spaced concentric growth lines developed near anterior margin in some valves.

Ventral interior: Teeth minute. Spondylium V-shaped, supported by a short apical septum.

Dorsal interior: Inner plates triangular, dorsally convergent; brachial process thin, plate-like, subparallel; outer plates low; in small valves, outer plates converge to form a sessile cruralium; in large valves the cruralium may be supported by a short septum at apical region, the cruralium descends anteriorly and is submerged by secondary deposits accumulated on floor so that outer plates appear to be discrete anteriorly. In some valves, inner plates bear a pair of minute callous plates, the probable the sites of diductors attachment (pl. 23, fig. 6).

Comparison: The new species can be readily distinguished from the type species, *A. roemeri*, in being smaller, having fewer plications, and much shorter ventral median septum. The Nevada Ludlovian species *Gypidula* cf. *orbitatus* (Barrande) Johnson, Boucot, and Murphy, and California Wenlockian species *G.* cf. *biloba* Boucot, Johnson, and Zhang may belong to *Amsdenina*. Both these species are small and without plications.

Occurrence	Articulated	Ventral	Dorsal
C22184	0	84	113
C22185	1	1	1
C22187	0	32	24
C12273	0	18	50
C12272	0	39	113

Genus *Caryogyps* Johnson, Boucot, and Murphy, 1976

Type species: *Caryogyps plicata* Johnson, Boucot, and Murphy, 1976, p. 54, pl. 42, figs. 3-15, pl. 43, figs. 1-11.

Caryogyps grayi n. sp.

Pl. 23, figs. 23-34.

Derivation of species name: After Jane Gray.

Diagnosis: Small *Caryogyps* with strong, subangular plications, numbering two on fold and one in sulcus.

Exterior: Valves small (the largest specimen is 8.5 mm wide, 6 mm long); ventri-biconvex; transverse with short, curved hinge line; ventral fold flat-topped, shortened to receive dorsal sulcus tongue. Ventral palintrope low, slightly curved; triangular delthyrium open.

Plications strong, subangular, begin near midlength. Two plications on fold, one in sulcus, two on each flank of either valve. Concentric growth line weak, closely spaced, near anterior margin.

Ventral interior: Spondylium V-shaped, short, about 1/4 of valve length, posteriorly supported by a median septum 1/2 of its length.

Dorsal interior: Inner plates large, triangular; outer plates narrower, strongly diverge laterally, extend anteriorly the same length as inner plates; brachial process strong, plate-like, diverge anteriorly. Muscle field indiscernible.

Comparison: The new species closely resembles the type species *C. plicata* in size and shape, but can be distinguished from the latter by its fewer plications on fold and sulcus, a better developed ventral median septum, and the fact that its inner plates and outer plates are of equal length.

Occurrence	Articulated	Ventral	Dorsal
C22184	0	2	6
C22185	0	0	1
C22187	0	0	0
C12273	0	0	3
C12272	0	21	10

Caryogyps chattertoni n. sp.

Pl. 23, figs. 12-22.

Derivation of species name: After Brian Chatterton.

Diagnosis: Large *Caryogyps* with numerous, low plications and very low outer plates.

Exterior: Valves large for the genus (the largest specimen is 16.5 mm wide, 12.5 mm long); ventri-biconvex; transverse, with short, curved hinge line; ventral fold and dorsal sulcus wide, fold low and flat-topped, sulcus shallow, with a short ventral projecting tongue. Ventral beak incurved; palintrope low, curved; triangular delthyrium open.

Plications low, subangular, begin near midlength. Interspace angular, narrower than plications. Generally 5 plications on fold, 4 to 3 in sulcus, 4 to 6 on each flank of either valve. Concentric growth lines may be present near anterior margin.

Ventral interior: Teeth minute; spondylium V-shaped, short, posteriorly supported by a apical median septum.

Dorsal interior: Inner plates large, triangular; outer plates very low, slightly longer than inner plates; brachial process thick, plate-like, narrowly divergent anteriorly. Muscle field not impressed.

Comparison: The new species differs from *C. grayi* and *C. plicata* in being larger, having more plications, and very low outer plates.

Occurrence	Articulated	Ventral	Dorsal
C22184	0	0	12
C22185	0	0	2
C22187	0	16	9
C12273	0	1	7
C12272	0	0	2

Order Rhynchonellida

Superfamily Rhynchonellacea Gray, 1848

Family Rhynchotretidae n. fam.

Type genus: *Rhychotreta* Hall, 1879.

Diagnosis: Triangular shells with small ß angle, shell flares laterally beyond midlength; uniplicate, ventral sulcus and dorsal fold commonly developed; costae strong, simple; dental plates present; short, low median ridge supporting open septalium; cardinal process absent.

Discussion: Schmidt (in Schmidt and McLearen, 1965) assigned *Rhynchotreta* to the Oligorhynchiidae with a question mark. Other members of the family consist of a small group of Middle Ordovician genera, all of which are noticeably different from *Rhynchotreta*. They are very small, generally about 1/3 the size of *Rhynchotreta*, longer than wide, without lateral flaring, and lack a dorsal median ridge supporting the septalium. Only immature *Rhynchotreta* resemble these genera in their elongate triangular outline. The difference between the mature shells of the two is striking. Therefore, a new family, Rhynchotretidae is proposed here for *Rhynchotreta*.

Genus *Rhynchotreta* Hall, 1879

Type species: *Terebratula cuneata* Dalman, 1828, p. 141, pl. 6, figs. 3a-c.

Rhynchotreta americaniformis n. sp.

Pl. 24, figs. 1-25, 36, 37, 43.

Derivation of species name: Refers to its resemblance to *Rhynchotreta americana* (Hall).

Diagnosis: Small *Rhynchotreta* with ß angle varying from 80-90 degrees; costae subangular, varying from 9 to 11, with 3 in sulcus and 4 on fold; septalium sessile, myophragm low.

Exterior: Valves small (the largest specimen is 12 mm wide, 8.7 mm long, 7.3 mm thick); trapezoid to triangular, with length:width ratio averaging 0.86 (n=26, std=0.088); biconvex or dorsi-biconvex in large shells, with thickness:width averaging 0.53 (std=0.137); shell flares laterally beyond midlength, ß angle varies from 70 to 105 degrees, with 80-90 degrees being the most common. Ventral beak straight; rudimentary palintrope catacline; delthyrium triangular, hypothrid; deltidial plates not observed. Sulcus begins anterior to midlength, deepening and widening anteriorly to produce a prominent tongue in large shell. Dorsal valve bears a faint medial depression in umbonal area; fold distinctive, developed in anterior half of the valve.

Costae low, subangular, tend to have wider, rounded interspaces, vary from 3 to 4 on each flank of either valves, 3 in sulcus, and 4 on fold with the medial pair much stronger than the rest. Concentric growth lines weak, absent in some valves.

Ventral interior: Teeth plate-like, parallel to posterolateral wall; dental plates thin, very close to posterolateral wall. A pair of elongate oval muscle depressions rarely preserved.

Dorsal interior: Septalium short, largely sessile, continuous with a low myophragm anteriorly; hinge plates triangular with concave upper surfaces; cardinal process absent. Muscle field indiscernible.

Comparison: The new species closely resembles *R. americana* (Hall) in general. It differs from the latter in having a smaller ß angle. *R. americana* has medially tilted hinge plates supported by a relatively high median ridge, but in the new species the septalium is largely sessile and myophragm is low. In addition, the new species is smaller, has slightly finer costae, and lacks conjunct deltidial plates in contrast to *R. americana*. It differs from other *Rhynchotreta* as *R. americana* does.

Occurrence	Articulated	Ventral	Dorsal
C22184	1	2	0
C22185	11	5	0

C22187	11	2	1
C12273	13	23	15
C12272	40	39	54

Family Trigonirhynchiidae Schmidt, 1965

Subfamily Trigonirhynchiinae Schmidt, 1965

Genus *Ancillotoechia* Havlícek, 1959

Type species: *Rhynchonella ancillans* Barrande, 1879, pl. 36, figs. 1, 2, 4, 5.

"*Ancillotoechia*" *sheehani* n. sp.

Pl. 24, figs. 26-35, 38-42, 44-62.

Derivation of species name: After Peter M. Sheehan.

Remarks: *Ancilloteochia* typically has a completely covered septalium, but the new species and several other North American species have only partially covered septalia (Sheehan, 1982). They appear to resemble the Upper Devonian genus *Ptychomalotoechia* Sartenaer more closely. The generic assignment of these species clearly needs further study.

Diagnosis: Small "*Ancillotoechia*" with 4 to 7 angular costae on each flank, 3 in sulcus, and 4 on fold.

Exterior: Small (the largest specimen is 7.0 mm wide, 5.1 mm long, and 5.1 mm thick); equal biconvex to slightly dorsi-biconvex, with thickness:width ratio averaging 0.53 (n=35, std=0.082); ventral view transersely pentagonal and dorsal view transversely elliptical, with length:width ratio averaging 0.80 (n=35, std=0.063); ß angle varies from 80 to 130 degrees. Ventral beak small, gently incurved, palintrope catacline to steeply apsacline; delthyrium triangular, hypothyrid; deltidial plates not observed. Sulcus starts near the midlength, deepening and widening anteriorly. The complementary dorsal fold low, flat-topped. Median groove distinct at posterior half of the dorsal valve.

Costae angular, with V-shaped interspaces, rarely branching or inserting, commonly 3 in sulcus, 4 on fold, and 4-7 on each flank. Concentric growth lines absent.

Ventral interior: Teeth plate-like, erect and subparallel to hinge line; dental plates short, very close to posterolateral wall. Muscle field small, elongate, may be slightly raised anteriorly.

Dorsal interior: Triangular hinge plates flat, separated by triangular notothyrial cavity; a rounded low myophragm may or may not unite with hinge plates to form a small septalium.

Comparison: This species differs from the ventri-biconvex *Ancillotoechia perryi* Sheehan, 1982 in its equal biconvex to slightly dorsi-biconvex profile, finer costae, 3 costae in sulcus and 4 on fold in contrast to 2 in sulcus and 3 on fold of the latter species, and lack of concentric growth lines. From *Ancillotoechia? pahranagatensis* (Waite) of Sheehan 1982, it is smaller, has coarser and fewer costae in sulcus and fold, and has a lower dorsal myophragm.

Occurrence	Articulated	Ventral	Dorsal
C22184	7	1	2
C22185	0	0	1
C22187	54	1	0
C12273	25	13	19
C12272	31	11	33

"*Ancillotoechia*" cf. *pentaforma* Lenz, 1977

Pl. 26, figs. 52, 53.

1977 *Ancillotoechia pentaforma* Lenz, p. 1544, pl. 9, figs. 1-16.

This species is represented by a single dorsal valve in the collection from locality C12273. It has dorsal internal structure and external costation similar to "*A.*" *pentaforma* Lenz except that its fold extends farther away beyond the anterior margin.

Subfamily Virginiatiinae Amsden, 1974

Genus *Thebesia* Amsden, 1974

Type species: *Rhynchotreta thebesensis* Foerste, 1909, p. 94, pl. 6, figs. 6a-c.

Thebesia cf. *thebesensis* (Foerste, 1909)

Pl. 25, figs. 1-17

1909 *Rhynchotreta thebesensis* Foesrte, p. 94, pl. 6, figs. 6a-c.

1913 *Rhynchotreta thebesensis*--Savage, p. 126, pl. 6, figs. 19, 20.

1913 *Rhynchotreta thebesensis multistriata* Savage, p. 127, pl. 6, figs. 21, 22.

1913 *Rhynchotreta parva* Savage, p. 125, pl. 7, figs. 9, 10.

1974 *Thebesia thebesensis*--Amsden, p. 69, pl. 13, figs. 5, 6; pl. 14, figs. 1, 2; Text-fig. 43; table 10.

Remarks: The Arctic material is essentially the same as the Early Llandoverian species *T. thebesensis* except for being smaller, with nearly equal length:width ratio instead of elongate outline, and having better developed concentric growth lines.

Exterior: Valves relatively small (the largest specimen is 10.8 mm wide, 10.5 mm long, and 6.5 mm thick); subequally biconvex; sides of either valves bent at right angles toward each other, forming truncated, or even concave sides. ß angle varies from 65 to 95 degrees, with 70-80 degrees being the most common. Maximum width near anterior margin, length:width ratio remains about one throughout growth, thickness:length ratio changes from 0.4-0.5 in small valves to 0.5-0.7 in larger ones. Ventral valve convexity greatest at umbol; beak slightly bent; a faint sulcus may develop at anterior margin, resulting in slightly curved commissure; rudimentary palintrope procline to catacline; triangular delthyrium large and open. Dorsal valve has a faint medial depression at umbo; fold not developed.

Costae strong, angular, with V-shaped interspace, vary from 8 to 15 with 9 to 11 being the most common on either valve. Concentric growth lines absent or developed near anterior margin on some valves.

Ventral interior: Teeth plate-like, parallel to posterolateral wall; dental plates thin, close to posterolateral wall. Delthyrial cavity maybe slightly thickened by a thin layer of secondary material which is continuous with bases of dental plates. Muscle impression not observed.

Dorsal interior: Triangular hinge plates with concave surface, nearly horizontal, medially cleft by a triangular cavity; cardinal process absent; sockets defined by lateral shell wall and socket ridges; short septalium supported by a median septum which dies out before reaching midlength.

Occurrence	Articulated	Ventral	Dorsal
C22184	216	105	101
C22187	1	0	0
C12273	7	3	1
C12272	13	6	4

Family Rhynchotrematidae Schuchert, 1913

Subfamily Rhynchotrematinae Schuchert, 1913

Genus *Stegerhynchus* Foerste, 1909

Type species: *Rhynchonella* (*Stegerhynchus*) *whitiipraecursor* Foerste 1909, p. 96, pl. 3, figs. 47 a, b, c.

Stegerhynchus estonicus Rubel, 1977

Stegerhynchus estonicus cordillerus n. subsp.

Pl. 26, figs. 19-51.

1976 *Rhynchotrema* sp. Johnson, Boucot and Murphy, p. 63, pl. 5, figs. 7-13.

1988 *Stegerhynchus estonicus* --Boucot, Johnson and Zhang, pl. 6, figs. 9-33.

Derivation of subspecies name: Refers to its occurrence in the Cordilleran region.

Diagnosis: Valves with strong angular costae crossed by regularly spaced strong concentric lamellae.

Exterior: Valves medium size (the largest specimen is 13.7 mm wide, 11.8 mm long, and 6.8 mm thick); small valves about equi-dimensional, become wider than long in larger valves with variable thickness; small shells subequally biconvex with elongate, triangular ventral view, larger ones dorsi-biconvex with transverse pentagonal ventral view; ß angle increases with size. Ventral palintrope catacline to procline; deltidial plates small, triangular, developed at the base of the triangular delthyrium, resulting in a key-hole like foramen; beak straight. Sulcus well defined, with flat-bottom, begins at umbo; fold wide and low, indistinct in smaller valves.

Costae strong, angular, with V-shaped interspace; commonly 3 to 4 on each flank, 3 finer ones in sulcus, and 4 on fold with the median pair being noticeably finer. Concentric lamellae strong, regularly spaced.

Ventral interior: Teeth sturdy, resemble two thick square pads, attached to posterolateral walls, and supported by short dental plates partially attached to posterolateral walls. In mature valves, diductor scars elongate, cordate, slightly depressed, may or may not be divided by a short myophragm anteriorly; posteriorly the muscle field indistriguishable from a tunnel-like pedicle passage depression.

Dorsal interior: Septalium sessile to partially suspended; hinge plates thick, with concave surfaces, tilted ventromedially, strongly elevated; large sockets excavated into posterolateral wall; cardinal process ridge-like, may or may not be present; crural plates slender; median septum high, shorter than midlength. Muscle field indiscernible.

Comparison: *S. estonicus cordillerus* is distinguished from Ludlovian *S. estonicus estonicus* Rubel in having much stronger concentric growth lamellae.

Remarks: 3% of specimens show a different number of costae in sulcus; among them three have 2 costae in sulcus 3 on fold; one has 4 in sulcus 5 on fold; and one has 2 additional costae implanted on the flank.

Occurrence	Articulated	Ventral	Dorsal
C22184	64	9	9
C22185	3	1	0
C22187	34	2	0
C12273	13	9	3

C12272 20 4 6

Stegerhynchus angaciensis Chernyshev, 1937
Pl. 25, figs. 18-30, 33-36, 39-43, 46, 47; Pl. 26, figs. 1-18.

1937 *Stegerhynchus decemplicatus angaciensis* Chernyshev, p. 71, pl. 1, figs. 15-18; text-figs. 1, 2.
See Jones (1981) for a complete synonymy.

Remarks: The Baillie Hamilton Island species is similar to the species from Prongs Creek described by Lenz (1970). Both are small and have 4-5 costae on each flank. According to Chernyshev (1937), *S. angaciensis* is characterized by 7-8 costae on each flank, but in his plate (pl. 26, fig.15), one specimen shows only 4 or 5 costae. In North America, large *S. angaciensis* with 7-8 costae are reported from Member C of the Read Bay Formation, a platform carbonate unit (Jones, 1981); Small ones with 4-5 costae are restricted to deeper water limestone beds inerbedded with graptolitic shales. A reassessment of Tuva material is needed to determine whether the two forms of *S. angaciensis* represent different species or ecological variants.

Exterior: Valves small (the largest specimen is 12.1 mm wide, 9.3 mm long, and 5.5 mm thick); transverse, length:width ratio averages 0.81 (n=58, std=0.092); dorsibiconvex; sulcus and fold commonly start at midlength, sulcus deepens anteriorly, producing a dorsally projecting tongue (not extending beyond anterior margin); thickness:width ratio averages 0.51 (n=58, std=0.097); ß angle variable, specimens from locality C22184 generally has smaller ß angle than those from C12272. Ventral beak pointed, straight to slightly incurved; delthyrium triangular, hypothyrid; deltidial plates narrow, minute.

Costae strong, angular, 3-4 on each flank, 1 in sulcus, and 2 (stronger than those on flanks) on fold. Concentric growth lamellae uncommon, widely spaced, present mainly in anterior half of the valve.

Ventral interior: Teeth thick, plate-like, subparallel to posterolateral margin, supported by thick dental plates close to posterolateral wall; myophragm rarely present; muscle field indiscernible.

Dorsal interior: Sockets partially excavated into shell walls; hinge plates thick, with concave, triangular upper surfaces lying nearly horizontal; flattened crural processes extend from inner edges of hinge plates; cardinal process blade-like; septalium sessile; low median ridge absent or shorter than midlength. Muscle field indiscernible.

Discussion: Specimens less than 6 mm in length from C22184 tend to have nearly equal width:length ratio, weakly convex profile, a ß angle less than 90 degrees, and incipient sulcus and fold. Specimens from other beds are generally less than 6 mm in length, but they have features of larger specimens from C22184 i.e. highly transverse, with a larger ß angle, fairly strongly biconvex with well-developed sulcus and fold. C22184 is the lowest horizon of the collection, it appears that *S. angaciensis* becomes dwarfed from lower to higher horizons. It is unclear whether this change is related to evolutionary processes or local environmental factors.

Occurrence	Articulated	Ventral	Dorsal
C22184	215	48	54
C22185	19	0	5
C22187	0	0	0
C12273	25	26	29
C12272	79	45	54

Order Spiriferida
Suborder Atrypidina
Superfamily Atrypacea Gill, 1871
Family Zygospiridae Waagen, 1883
Subfamily Zygospirinae Waagen, 1883
Genus *Zygatrypa* Copper, 1977

Type species: *Zygospira paupera* Billings, 1866, p. 46.
Zygatrypa stenoparva Johnson, Boucot, and Zhang, (1988)
Pl. 27, figs. 1-12.

Exterior: Valves small (the largest specimen is 4.0 mm wide, 4.6 mm long, 2.7 mm thick); ventri-biconvex; elongately pentagonal. Ventral valve carinate, a pair of median costae prominent, lateral costae finer, variable in number. Dorsal valve sulcate, with a strong median costa.

Interior: Teeth plate-like, lie in the plane of commissure; dental plates absent. Muscle field not impressed. Dorsal interior not exposed.

Occurrence	Articulated	Ventral	Dorsal
C22184	10	1	0
C22187	3	0	0
C12272	3	5	0

Family Lissatrypidae Twenhofel, 1914

Genus *Lissatrypa* Twenhofel, 1914

Type species: *Lissatrypa atheroidea* Twenhofel, 1914, p. 31.

Lissatrypa cf. *L. atheroidea* Twenhofel

Pl. 27, figs. 13-37, 40, 41, 46, 47.

1914 *Lissatrypa atheroidea* Twenhofel, p. 33, pl. 1, figs. 11-15.

1928 *Lissatrypa atheroidea* Twenhofel, p. 218.

1973 *Lissatrypa atheroidea*--Copper, p. 73-75, pl. 1, figs. 1-5, pl.2, figs. 1-17, text-figs. 1-4.

Exterior: Generally small (the single largest specimen is 9.2 mm wide, ?10 mm long, and 5.0 mm thick); circular to subpentagonal, with a few variants being elongate, length:width ratio averages 1.01 (n=31, std=0.073); ventri-biconvex to equally biconvex, thickness:width ratio 0.53 (n=31, std=0.073); anterior commissure rectimarginate to slightly uniplicate. Ventral beak suberect to incurved; conjunct deltidial plates close the delthyrium anterior to a mesothyrid foramen. Shell surface finely spinose; concentric growth lines widely spaced or absent.

Ventral interior: Dental plates absent, but a few variants with shell thickening or rudimentary dental plates supporting the teeth. Muscle field elongate, rarely preserved, divided or bounded anteriorly by a variably developed median platform (pl. 27, figs. 31, 32, 37, 47).

Dorsal interior: Hinge pads variable (pl. 27, figs. 40, 41, 46), generally with flat upper surfaces and divided by a narrow slit; cardinal process absent; myophragm low, about 1/3 of shell length, nearly absent in some valves; muscle field circular; sockets excavated into thickened shell wall. Spiralia point dorsimedially.

Occurrence	Articulated	Ventral	Dorsal
C22184	333	79	72
C22185	23	1	2
C22187	250	0	0
C12273	421	24	36
C12272	498	57	116

Genus *Glassia* Davidson, 1881

Type species: *Atrypa obovata* Sowerby, in Murchison, 1839, p. 618.

Glassia? sp. 1

Pl. 27, figs. 38, 39, 42-45, 48-51.

Remarks: The two species described below consist of a small number of poorly preserved valves. Their elongate outline and the ventral anterior tongue-like extension recall *Atrypoidea* or *Dubaria*. However, one specimen of sp. 2 has partially preserved spiralia which appear to be medially directed. If the species has truly medially directed spiralia, it would be closely related to *Glassia* rather than *Atrypoidea*. The overall resemblance between sp. 1 and sp. 2 favors a congeneric assignment of the two species, thus both species are assigned to *Glassia* with question.

Exterior: Valves elongate oval, dorsibiconvex; ventral valve has a tongue-like extension corresponding to the low dorsal fold. Ventral beak gently incurved; delthyrium open. Shell surface smooth.

Ventral interior: Teeth plate-like, dental plates absent. One ventral valve shows a partially preserved muscle field laterally bounded by a pair of linear depressions probably representing impressions of vascula media (pl. 27, fig. 43).

Dorsal interior: Hinge plates small, triangular, discrete, attached to curved socket plates; thicker valves show a pair of small adductor scars divided by a low myophragm.

Occurrence	Articulated	Ventral	Dorsal
C22184	2	0	0
C22187	11	0	0
C12273	15	2	0
C12272	15	12	12

Glassia? sp. 2

Pl. 27, figs. 52-55.

This species is characterized by elongate subfusiform outline. It has a short, anterior ventral sulcus and a corresponding low dorsal fold, ventral beak small, gently incurved. Surface is smooth.

Occurrence	Articulated	Ventral	Dorsal
C12272	2	0	0

Genus *Johnsoniatrypa* n. gen.

Type species: *Johnsoniatrypa imbricata* n. sp.

Derivation of genus name: After J. G. Johnson.

Diagnosis: Small, hinge line long, straight; ventral plane areas catacline; concentric growth lamellae imbricate, superimposed by radial capillae; dental plates absent; socket ridges widely divergent.

Comparison: The ornament of the new genus is unique among atrypoids. It resembles *Davidsoniatrypa* in outline and ventral plane areas, its cardinalia resemble some members of the Atrypidae. Its affinity is a problem. It is provisionally assigned to the Lissatrypidae on the basis of lacking ribbing.

Johnsoniatrypa imbricata n. sp.

Pl. 28, figs. 1-9.

Derivation of species name: From the Latin, *imbricatus*, referring to its overlapping concentric growth lamellae.

Diagnosis: Same as for the genus.

Exterior: Valve small (the largest specimen is 5 mm wide, 3.6 mm long); ventri-biconvex; transversely semicircular; hinge line long and straight, nearly equal to maximum width; cardinal extremities subrounded. Ventral plane areas catacline; delthyrium open; the absence of delthyrial plates could be due to poor preservation. Dorsal valve shallowly sulcate, sulcus widens anteriorly.

Ornament of imbricate concentric lamellae. Fine capillae developed on lamellae and may extend beyond the edges of lamellae as short, hair-like spines.

Ventral interior: Teeth plate-like, lie in plane of plane areas, parallel with hinge line; dental plates absent. Muscle field not impressed.

Dorsal interior: Sockets widely divergent, defined by curved socket plates and thick socket ridges. Cardinal process absent; muscle field not impressed.

Occurrence	Articulated	Ventral	Dorsal
C22185	1	6	4

Family Atrypidae Gill, 1871

Subfamily Spirigerininae Copper, 1982

Genus *Spirigerina* d'Orbigny 1849

Type species: *Terebratula marginalis* Dalman, 1828, p. 143, pl. 6, fig. 6.

Spirigerina copperi n. sp.

Pl. 28, fig. 12, pl. 29, figs. 1-20, 22-25.

Derivation of species name: After Paul Copper.

Diagnosis: Coarsely costate *Spirigerina* with a pair of pronounced ventral median costae; dental plates reduced.

Exterior: Valves relatively small (the largest specimen is 14 mm wide, 12 mm long); nearly equi-dimensional, length:width ratio 0.95 (n=23, std=0.062); small shells ventri-biconvex, larger ones tend to be dorsi-biconvex. Ventral plane areas apsacline; beak straight or slightly incurved, delthyrium triangular, partially closed by small deltidial plates anterior to a subhypothyrid foramen. Ventral valve subcarinate at posterior part and becomes sulcate anteriorly. Dorsal valve bears the corresponding shallow posterior depression and anterior fold.

Ornament of narrow, rounded costellae, bifurcating, or less commonly, intercalating anteriorly. A pair of ventral medial costae prominent, posteriorly form the carina and anteriorly define the sulcus. Concentric growth lines variably developed.

Ventral interior: Teeth triangular, pointing medially; dental plates reduced.

Dorsal interior: Sockets defined laterally by socket plates and partially covered by slightly concave hinge plates.

Muscle field of both valves are indiscernible. Shells slightly thickened by secondary deposits. Radial corrugation corresponds to exterior costation.

Comparison: The new species is coarsely costellate. It can be distinguished from *S. marginalis* by its smaller size, coarser and fewer costellae, and the presence of dental plates. It differs from the coarsely costellate Russian species *S. duoia* Menakova 1964 in being larger and having more costellae. *S.* cf. *S. marginalis* and *S.* sp. D (Johnson, Boucot, and Murphy, 1976) from Ludlovian part of the Roberts Mountains Formation, central Nevada may belong to this species.

Occurrence	Articulated	Ventral	Dorsal
C22184	2	0	0
C22185	1	2	1
C22187	18	1	1
C12273	25	27	24
C12272	16	11	9

Subfamily Atrypinae Gill, 1871

Genus *Plectatrypa* Schuchert and Cooper, 1930

Type species: *Terebratula imbricata* Sowerby, 1839, p. 624, pl.12, fig. 12.

Remarks: This species is assigned to *Plectatrypa* on the basis of its frills. It lacks the track-like ventral diductor scars characteristic of the genus, probably due to its

small size and thin shell. Diductor scars are only rarely preserved in the co-occurring small species *P. rongi* n. sp. (pl. 28, fig. 36).

Plectatrypa unicosta n. sp.
Pl. 28, figs. 10, 11, 13-29.

1976 *Plectatrypa* cf. *P. rugosa* (Hall); Johnson, Boucot, and Murphy, p. 68, pl. 6, figs. 20-27.

Derivation of species name: Refers to the single costa in ventral sulcus of the species.

Diagnosis: Small, with coarse costae which rarely increase in number, a finer costa commonly developed in ventral sulcus.

Exterior: Small (the largest specimen is 9.4 mm wide, 8.7 mm long, 3.5 mm thick); transverse, length:width ratio averages 0.85 (n=15, std=0.063); nearly equibiconvex, thickness:width ratio 0.44 (std=0.037). Ventral beak straight, plane areas rudimentary, gently apsacline; a pair of minute, conjunct deltidial plates partially close the small delthyrium anterior to the submesothyrid foramen. Ventral valve subcarinate posteriorly and becomes sulcate anteriorly. Dorsal valve bears a corresponding posterior shallow depression and a low anterior fold.

Costae strong, rounded, with wide interspaces. The ventral median pair, more prominent than others, posteriorly form the carina and anteriorly define the sulcus. The dorsal median costa commonly splits into two near anterior margin. Lateral costae rarely split. Most valves have three primary costae on each flank and an implanted finer costa in ventral sulcus. Concentric lamellae imbricate, closely spaced.

Ventral interior: Teeth plate-like, parallel to hinge line; dental plates absent. Muscle field indiscernible.

Dorsal interior: Sockets widely diverge, defined by curved socket plates and socket ridges. Hinge plates small. Cardinal process absent. Spiralia directed dorsomedially. Muscle field indiscernible. Valves slightly thickened. Pronounced radial corrugations correspond to external costae.

Comparison: The new species can be easily distinguished from other *Plectatrypa* by its coarse, simple costae. It resembles *P. rugosa* (Hall) in small size and having a single costa in sulcus, but differs from the latter in having longer hinge line, wider sulcus, and fewer lateral costellae.

Occurrence	Articulated	ventral	dorsal
C22187	9	0	0

C12273	16	28	20
C12272	12	8	8

Plectatrypa rongi

Pl. 28, figs. 30-44.

Derivation of species name: After Rong Jiayu.

Diagnosis: Small, with gently incurved beak and conjunct deltidial plates.

Exterior: Valve small (the largest specimen is 11.8 mm wide, 8.5 mm long, 5.4 mm thick); equi-biconvex, thickness:width ratio averages 0.46 (n=18, std=0.037); ventral view transversely subpentagonal, dorsal view transversely elliptical, length:width ratio 0.87 (n=18, std=0.079). Ventral beak gently incurved, does not overhang plane areas; plane areas rudimentary, orthocline, nearly absent in larger valves; conjunct deltidial plates close delthyrium anterior to submesothyrid foramen. Ventral valve carinate posteriorly and sulcate anteriorly, dorsal valve with a low median fold at anterior margin.

Ornament of rounded, coarse costellae; commonly 3 pairs of lateral primary costae on each valve, 3 costellae in ventral sulcus, and 4 on fold. Ventral median pair stronger than others, commonly bifurcate before reach midlength, ventral lateral costellae increase by insertion and may or may not reach the size of primary costae; dorsal costellae increase by bifurcation. Concentric lamellae strong, with short frills, and closely spaced.

Ventral interior: Teeth plate-like, parallel to hinge line; dental plates absent. Diductor scars prominent, track-like, anterior to delthyrial cavity; adductor scars small, enclosed by diductor scars.

Dorsal interior: Sockets defined by curved socket plates; minute hinge plates developed on medial sides of socket ridges and taper into ventrolaterally directed crural process. Cardinal process and muscle field absent.

Comparison: The new species closely resembles the type species *P. imbricata* (Sowerby) in shape and costation, but can be distinguished from the latter in being smaller, having an orthocline plane areas and deltidial plates. Small valves of the latter generally have only one pair of costellae on the fold in contrast with two pairs in similar size, or smaller, valves of the former. The new species differs from *P. unicosta* in having numerous costellae.

Occurrence	Articulated	Ventral	Dorsal
C22184	28	27	18

C22185 1 0 0

Genus *Eospinatrypa* Copper, 1973

Type species: *Atrypa nodostriata* Hall, 1852, p. 272, pl. 56, figs. 2d, 2e.

Eospinatrypa bassetti n. sp.

Pl. 29, figs. 21, 26-56.

Derivation of species name: After Michael G. Bassett.

Diagnosis: A relatively large, finely costellate *Eospinatrypa*, biconvex to slightly dorsi-biconvex; concentric growth lamellae widely spaced, some valves with long spines.

Exterior: Large specimens about 20-18 mm in width; semi-circular to circular, length:width ratio averages 0.99 (n=55, std=0.063); moderately globose, biconvex to slightly dorsi-biconvex, thickness:width ratio 0.46 (n=47, std=0.10); anterior commissure broadly uniplicate. Small valves tend to be pentagonal with gently convex dorsal valve, anterior commissure sulcate. Ventral valve medially carinate in umbonal area, the carina consists of one or two accentuated median costae which bifurcate and subside anteriorly; the anterior commissure of larger valves becomes dorsally deflected. Ventral beak straight, may become incurved only in very large valves; plane areas small, apsacline, reduced in larger valves; deltidial plates small, discrete, rarely preserved; foramen submesothyrid. Dorsal sulcus shallow, confined to umbonal area in larger valves.

Costellae fine, rounded, undulose, crossed or interrupted by concentric lamellae; costellae increase by bifurcation or less commonly by insertion; little change in size and density of costellae over valve. Long, hollow spines preserved on some valves.

Ventral interior: Teeth plate-like, directed dorsomedially. Dental plates short. Muscle field indiscernible.

Dorsal interior: Sockets crenulated, widely divergent; socket plates simple, disjunct; socket ridges well developed. Cardinal process absent. Brachiophores not preserved. Myophragm short, variably developed, divides a pair of oval-shaped adductors.

Comparison: The new species differs from the type species, *E. nodostriata* and most other *Eospinatrypa* species in having numerous, finer costellae. Some variants of the species closely resemble *Eospinatrypa actustriata* (Foerste, 1909). But the new species is larger than the latter, has better developed plane areas in medium size valves which are equal to the large valves of the latter species. Small valves of the new species

are difficult to distinguish from some Silurian *Reticulatrypa* species. In general, *Reticulatrypa* has finer costellae and better developed plane areas.

Discussion: The new species and *E. actustriata* have characteristics of both *Eospinatrypa* and *Reticulatrypa*. The *Eospinatrypa* assignment of these species is based on their relatively large size and loss of plane areas in larger valves, which agrees with the evolutionary trend of later spinatrypids rather than that of the Devonian *Reticulatrypa*. *Eospinatrypa bassetti* and *E. actustriata* represent a finely costellate *Eospinatrypa* species group whose young closely resembles some Silurian *Reticulatrypa* species.

Occurrence	Articulated	Ventral	Dorsal
C22184	142	97	126
C22185	16	34	17
C22187	842	140	151
C12273	145	239	249
C12272	59	62	62

Eospinatrypa sagana Boucot, Johnson, and Zhang, (1988)
Pl. 30, figs. 1-24.

1988 *Eospinatrypa sagana* Boucot, Johnson, and Zhang, pl.7, figs. 31-37.

Exterior: Small (the largest specimen is 7.0 mm wide, 6.4 mm long), semi-circular, equi-dimensional to slightly transverse, length:width ratio averages 0.92 (n=40, std=0.05); hinge line relatively long; larger valves ventri-biconvex, smaller ones plano-convex. Ventral beak small, slightly curved; delthyrium partially closed by minute deltidial plates anterior to mesothyrid foramen.

Costae rounded, coarse, bifurcate infrequently, crossed by strong, widely spaced concentric growth lamellae; short spines and frills developed on some valves. Ventral median pair strong, form carina; in large valves the carina tends to reverse and bend dorsally at the anterior margin. The shallow dorsal sulcus generally has a single costa.

Ventral interior: Teeth small, plate-like, parallel to hinge line; dental plates not evident.

Dorsal interior: Socket plates simple, disjunct. Notothyrial area slightly elevated. Muscle field not impressed.

Remarks: The Arctic material differs from the California specimens in having a longer, less curved hinge line and being more spinose.

Occurrence	Articulated	Ventral	Dorsal

C22184	0	0	0
C22185	0	4	0
C22187	85	10	11
C12273	72	30	0
C12272	27	57	40

Eospinatrypa? savagei n. sp.
Pl. 30, figs. 25-49.10.

Derivation of species name: After Norman M. Savage.

Diagnosis: Small, with coarse costellae separated by wider interspace and superimposed by strong, closely spaced concentric lamellae.

Exterior: Valves small (the largest ventral valve is 8.2 mm wide, 6.2 mm long; rest of valves are under 6 mm.); nearly equi-biconvex; subcircular, slightly transverse, with length:width ratio averaging 0.90 (n=42, std=0.05); ventral valve subcarinate, dorsal valve shallowly sulcate. Ventral beak straight; plane areas narrow, apsacline; a pair of minute deltidial plates close delthyrium anterior to subhypothyrid foramen.

Ornament of coarse, rounded costellae separated by wider interspaces; six primary costae on ventral valve and seven on dorsal valve. A pair of prominent ventral median costae form the carina; one costa in sulcus. Costellae increase mainly by bifurcation. Costellae of mature valves vary from 8 to 12. Concentric growth lamellae strong, closely spaced.

Ventral interior: Teeth plate-like, subparallel to hinge line. Dental plates low and short. Muscle field not preserved.

Dorsal interior: Sockets defined by sharply curved socket plates. Crura spiky, rarely preserved. A small notothyrial platform and very short myophragm may or may not be present. muscle field not preserved.

Comparison: *E.? savagei* differs from most *Eospinatrypa* by its small size and coarse costellae separated by wider interspace. It most closely resembles *E. sagana*, but can be distinguished from the latter by its better developed plane areas, deltidial plates, and especially, the closely spaced, strong concentric growth lamellae.

Occurrence	Articulated	Ventral	Dorsal
C22184	0	0	0
C22185	0	0	0
C22187	29	1	1

C12273	142	78	101
C12272	81	48	49

Genus *Reticulatrypa* Savage 1970

Type species: *Reticulatrypa fairhillensis* Savage, 1970, p. 663, pl. 102, figs. 1-31.

Reticulatrypa blodgetti n. sp.

Pl. 31, figs. 1-31.

Derivation of species name: After Robert B. Blodgett.

Diagnosis: Small, finely costellate *Reticulatrypa*, with transversely elliptical outline, long hinge line, and lacking ventral carina.

Exterior: Small (the largest specimen is 10.6 mm wide, 8.4 mm long, and 4.4 mm thick.); transversely elliptical with long hinge line, length:width ratio averages 0.81 (n=38, std=0.065); equi-biconvex to ventri-biconvex, thickness:width ratio 0.39 (n=38, std=0.038). Posteriorly, ventral valve has flanks sloping off without much curvature from the umbo, but anteriorly the valve becomes evenly convex; dorsal valve evenly convex with a weak posterior medial depression. Ventral beak straight; a pair of triangular deltidial plates closes the delthyrium anterior to the large, submesothyrid foramen.

Costellae fine, relatively constant in size from posterior to anterior, four to five costellae in one millimeter near anterior margin. Costellae increase by bifurcation and implantation. Concentric growth lamellae variably developed.

Ventral interior: Teeth plate-like, subparallel to hinge line; dental plates short. Muscle field indiscernible.

Dorsal interior: Curved socket plates define widely divergent, narrow sockets; socket ridges expand laterally, partially covering sockets. Crura not preserved. Low myophragm divides a pair of oval-shaped muscle scars.

Comparison: The most distinctive features of the new species are its non-carinate ventral valve, long hinge line, and uniform costellae size. Most *Reticulatrypa* species have either a carinate ventral valve or anteriorly narrowing costellae, and thus are readily separated from the new species. The new species co-occurs with *R. variabilis* Johnson and others on Baillie Hamilton Island. The latter has a distinct carina generally consisting of a pair of coarse median costae. The new species also is noticeably more transverse, except that a few variants tend to have long ventral beaks, which results in a increased length:width ratio. The Hidden Valley species *R. ryanensis* Boucot, Johnson,

and Zhang has uniform size costellae, but it is less transverse and tends to have a much stronger carina and dorsal median furrow.

Occurrence	Articulated	Ventral	Dorsal
C22184	19	8	8
C22185	3	1	0
C22187	20	1	3
C12273	41	43	50
C12272	50	65	106

Reticulatrypa variabilis Johnson, Boucot, and Murphy, 1976
Pl. 31, figs. 32-66.

1976 *Reticulatrypa variabilis* Johnson, Boucot, and Murphy, p. 73, pl. 47, figs. 13-26.

1984 *Reticulatrypa variabilis*--Perry, p. 87, pl. 30, figs. 39-59.

Exterior: Small (the largest specimen is 9.8 mm wide, 8.2 mm long, and 4.0 mm thick); transversely semi-circular to equi-dimensional, with relatively long hinge line, length:width ratio averages 0.89 (n=39, std=0.069); ventri-biconvex to nearly equi-biconvex, thickness:width ratio 0.45 (n=39, std=0.048). Ventral valve posteriorly subcarinate; plane areas very low or absent; deltidial plates close the delthyrium anterior to foramen; beak generally erect. Dorsal valve evenly convex, sulcus narrow, well defined in posterior half of the valve.

Ornament of rounded costellae, variable in size from valve to valve, relatively coarse for the genus. Costellae increase mainly by bifurcation. Imbricate concentric growth lamellae either widely spaced or tend to be crowded near anterior margin.

Ventral interior: Teeth small, supported by short dental plates. Muscle field not preserved.

Dorsal interior: Sockets crenulated, defined by curved socket plates. A small notothyrial platform may or may not be present. Myophragm short, may split anteriorly. Muscle field circular.

Discussion: *R. variabilis* has been reported from strata of Ludlovian age in central Nevada and the District of Mackenzie. The Baillie Hamilton *R. variabilis* represents an earlier occurrence. It has a less well developed ventral plane areas than the Ludlovian *R. variabilis*. It closely resembles the Nevada *R. variabilis* in having a long, straight hinge line. The Mackenzie species is more rounded, with a curved hinge line.

Occurrence	Articulated	Ventral	Dorsal
C22184	0	0	0
C22185	2	1	0
C22187	36	1	3
C12273	49	37	56
C12272	114	133	147

Family Carinatinidae Rzhonsnitskaya, 1960

Subfamily Gracianellinae Johnson, 1973

Genus *Gracianella* Johnson and Boucot, 1967

Type species: *G. lissumbra* Johnson and Boucot, 1967, p.871, pl. 109, figs. 21-40.

Gracianella dimorpha n. sp.

Pl. 32, figs. 1-37.

Derivation of species name: Refers to the two forms of the species.

Diagnosis: The species consists of two forms. Form 1 is a large *Gracianella* with transversely subelliptical outline and lenticular lateral profile. Form 2 is smaller and characterized by a flat dorsal valve, relatively long and straight hinge line, and strong, angular, bifurcating costellae.

Form 1

Pl. 32, figs. 9-37.

Exterior: Large for the genus (the largest specimen is 7.3 mm wide, 6.3 mm long); gently ventri-biconvex with lenticular lateral profile; outline varies from transversely subelliptical to, less commonly, elongately suboval; larger valves tend to be more transverse; hinge line short and curved. Ventral beak straight, plane areas varies from apsacline in small valves to orthocline in larger ones; delthyrium completely closed by a flat deltidium; apical foramen small; median carination prominent, consists of the median costa which rarely splits anteriorly. A narrow, shallow sulcus correspondingly developed on dorsal valve; dorsal sulcus commonly bears a weak median costa. Lateral costation varies considerably, from nearly smooth or weakly costate to angularly costellate with strong, bifurcating costellae. Concentric ornament commonly present, consisting of closely spaced, fine growth lines. Dorsal sulcus shallow. Concentric growth lines variably developed.

Ventral interior: Teeth plate-like, subparallel to inner posterolateral margin of the valve; dental plates absent; muscle platform elevated, cella deep.

Dorsal interior: Socket ridges disjunct, diverge anteriorly, define sockets between them and the posterior valve margin. Notothyrial platform small, may continue anteriorly with a very short myophragm. Muscle field indiscernible.

Inner surfaces of both valves commonly corrugated radially.

Form 2

Pl. 32, figs. 1-8.

Exterior: Medium size (the largest specimen is 5.6 mm wide, 5.0 mm long); plano-convex; slightly transverse, subpentagonal. Hinge line relatively long and straight. Ventral valve strongly carinate, the median costa tends to split into two anteriorly. Lateral costellae strong, angular, commonly bifurcating. Dorsal sulcus deep and wide, gives dorsal valve an almost concave appearance. Concentric growth lines rare.

Interior: Same as Form 1 except that its ventral valve medial depression is deeper corresponding to the strong carination.

Comparison: The new species is unique in consisting of two distinctive forms. Form 1 resembles *G. umbra* (Barrande) in general, but it can be distinguished from the latter in being less transverse, commonly having stronger, angular costellae. Form 1 also resembles *G. plicumbra* Johnson and Boucot and *G. cryptumbra* Johnson, Boucot, and Murphy to a lesser degree. It is larger than the latter twospecies. In addition, it differs from *G. plicumbra* in being transverse and from *G. cryptumbra* in being biconvex and having stronger costellae. Form 2 is unique and can be easily distinguished from other species by its subpentagonal outline, long and straight hinge line, strong, angular costellae, and flat dorsal valve.

Remarks: *Gracianella dimorpha* occurs abundantly in three localities. Form 1 is more abundant than Form 2 in all localities. Intergradational forms between Form 1 and 2 are present in all three localities. The ratio of the two forms does not show significant change from locality to locality. In C22187 and C12272, Form 1 mostly consists of varieties having less transverse valves with strong, bifurcating, angular costellae, while in C12273 there are more transverse valves with low, rounded costae. Form 2 does not show parallel variation from locality to locality.

Occurrence	Form 1			Form 2		
	articulated	ventral	dorsal	articulated	ventral	dorsal
C22184	4	0	0	0	0	0
C22185	11	2	4	0	0	0
C22187	500	39	45	88	5	4

C12273	448	276	238	387	42	38
C12272	1013	595	599	103	9	22

Suborder Athyrididina

Superfamily Athyridacea M'Coy, 1844

Family Meristellidae Waagen, 1883

Subfamily Meristellinae Waagen, 1883

Genus *Merista* Suess, 1851

Type species: *Terebratula herculea* Barrande, 1847.

Merista sp.

Pl. 33, figs. 1-13.

Exterior: Valves small; elongate suboval; biconvex; both valves have anteromedial flattening, resulting in a slightly indented anterior margin. Ventral beak small, nearly straight; delthyrium open. Shell surface smooth except for faint concentric growth lines near anterior margin.

Ventral interior: Teeth plate-like, relatively thin, supported by thin, high dental plates, medially convex; shoe-lifter structure with subangular top. Mystrochial plates present (see Amsden, 1968).

Dorsal interior: Median septum high, about 2/5 of the valve length; hinge plates relatively large, discrete. Muscle field indiscernible.

Comparison: This species is represented by poorly preserved material, but it differs from known species of the genus by its anteromedial flattening on both valves.

Occurrence	Articulated	Ventral	Dorsal
C22184	0	1	0
C22185	1	0	0
C22187	0	4	1
C12273	2	21	8
C12272	0	9	10

Family Athyrididae M'Coy, 1844

Subfamily Didymothyridinae Modzalevskaya, 1979

Genus *Pseudoprotathyris* Modzalevskaya, 1979

Type species: *Protathyris infantile* Kozlowski, 1929, p. 230, pl. 11, fig. 47.

Pseudoprotathyris? modzalevskayae n. sp.

Pl. 33, figs. 14-31.

Derivation of species name: After T. L. Modzalevskaya.

Discussion: This species resembles *Glassina dissecta* Modzalevskaya in general except for lacking posteriorly pierced cardinal plates. It is assigned to *Pseudoprotathyris* on the basis of its variably conjunct hinge plates which would resemble a curved cardinal plate in serial sections, a characteristic feature of *Pseudoprotathyis* (see Nikiforova and others, 1985).

Exterior: Valves small (the largest specimen is 6.9 mm wide, 6.9 mm long, 4.2 mm thick); equi-dimensional to slightly elongate; equi-biconvex; bisulcate anteriorly with shallowly emarginate anterior commissure; ventral sulcus stronger than dorsal sulcus, some valves lack sulci. Ventral beak gently incurved, interarea rudimentary, orthocline; delthyrium triangular, open. Dorsal umbo conspicuous. Shell surface smooth except for a few concentric growth lines at anterior margin in some valves.

Ventral interior: Teeth strong, triangular, supported by high, parallel dental plates. Muscle field indiscernible.

Dorsal interior: Hinge plates thick, ventromedially tilted, conjunct in various degrees, without supporting plates. Muscle field faintly impressed in a few valves.

Comparison: The new species differs from *Pseudoprotathyris infantilis* in having a shallowly emarginate anterior commissure and longer dental plates.

Occurrence	Articulated	Ventral	Dorsal
C22184	4	0	1
C22187	41	0	0
C12272	356	260	312

indet. athyridid sp.

Pl. 32, figs. 51-54, 58, 59.

This species is represented by only two articulated specimens. It is gently biconvex, with short hinge line, without interarea; its ventral sulcus is shallow, broad, defined by a pair of plications, and the corresponding dorsal fold is bounded by a pair of troughs. Shell surface is smooth. Its general outline resembles the Devonian *Anathyris* von Peetz, but without internal structure its generic assigment is uncertain.

Occurrence	Articulated	Ventral	Dorsal
C12272	2	0	0

Family Nucleospiridae Davidson, 1881

Genus *Nucleospira* Hall, 1859

Type species: *Spirifer ventricosta* Hall, 1857, p. 57.

Nucleospira cf. *N. raritas* Amsden, 1958

Pl. 32, figs. 38-50, 55-57.

1951 *Nucleospira concentrica* Amsden, p. 89, pl. 19, figs. 17-24; non Hall, 1859.

1958 *Nucleospira raritas* Amsden; Boucot and Amsden, p. 160.

1968 *Nucleospira raritas*? Amsden, p. 89, pl. 8, figs. 8a-h.

Remarks: The Arctic material is larger than *N. raritas* from Oklahoma and its ventral beak does not hook over dorsal valve.

Exterior: Small (the largest specimen is 9.7 mm wide, 10.5 mm long, estimated 6.5 mm thick); equi-biconvex; subcircular, equi-dimensional to slightly transverse; bisulcate, sulci narrow, furrow-like, extend from umbo, produce a slightly emarginate anterior margin. Ventral beak higher than dorsal beak, incurved, but not hooked over dorsal beak; interarea largely formed by a wide, triangular pseudodeltidium. Shell surface smooth, except for faint concentric growth lines and dense spines.

Internal structures of the species are typical of the genus. One valve shows laterally directed spiral with 4-5 whorls and a V-shaped jugum; one ventral valve shows faintly impressed, elongate cordate muscle field, divided by median ridge (pl. 32 fig. 46).

Occurrence	Articulated	Ventral	Dorsal
C22184	30	42	39
C22185	1	1	2
C22187	13	7	8
C12273	37	40	44
C12272	41	42	30

Suborder Spiriferidina

Superfamily Cyrtiacea Frederiks, 1924

Family Ambocoeliidae George, 1931

Subfamily Ambocoeliinae George, 1931

Remarks: The Ambocoeliinae proliferated in the Devonian. Their occurrences in the Silurian are sparse. *Dicoelospirifer* and *Plicoplasia* of Baillie Hamilton represent the earliest known ambocoeliinids. It shows that from the very beginning the Ambocoeliinae were divided into non-plicate and plicate forms. It is possible that

Dicoelospirifer is ancestral to other non-plicate ambocoeliinids while *Plicoplasia* is ancestral to plicate ones. Other Silurian occurrences of the subfamily include *Plicoplasia* from the Ludlovian part of the Roberts Mountains Formation of central Nevada, from late Wenlockian age beds on Cornwallis Island in Arctic Canada, and from the Ludlovian age Black Bog Beds of New South Wales, Australia (Johnson, Boucot, and Murphy, 1976); *Metaplasia* from the Ludlovian-Pridolian age Prongs Creek Formation of northern Yukon (Lenz, 1970), and from the Ludlovian part of the Delorme Formation, District of Mackenzie (Perry, 1984).

Genus *Dicoelospirifer* n. gen.

Type species: *Dicoelospirifer dicoelospirifer* n. sp.

Derivation of genus name: Refers to the bilobate shape of the genus.

Diagnosis: Small, thin shelled, bisulcate, with anterior emargination. Valve surface smooth except for having very fine concentric growth lines invisible to the naked eye. Dental plates absent; cardinal process striate.

Comparison: The new genus lacks a pair of basally convergent crural plates, therefore, it belongs to the subfamily Ambocoeliinae. It is unique in the subfamily because of its bilobed outline and small size. *Crurithyris* George and *Bisinocoelia* Havlícek are bisulcate, but the new genus is much more strongly bisulcate with deeper anterior emargination.

Species assigned:

Dicoelospirifer dicoelospirifer n. sp.

Dicoelospirifer dicoelospirifer n. sp.

Pl. 33, figs. 32-43.

Diagnosis: Same as for the genus.

Exterior: Valves small, thin shelled; gently ventri-biconvex; equi-dimensional to transverse, with rounded cardinal extremities; bisulcate, sulcus initiated near beak, deepens and widens anteriorly resulting in anterior emargination. Ventral interarea poorly developed, consisting of a pair of small, triangular flat areas, nearly orthocline; triangular delthyrium open. Dorsal interarea linear, nearly indiscernible. Surface smooth, except for very fine concentric growth lines invisible to naked eye.

Measurements of figured specimens:

WIDTH	LENGTH	MIDLENGTH	L/W	ML/L

Ventral					
GSC 88485	3.0	3.0	2.3	1.0	0.77
GSC 88486	3.3	2.9	2.4	0.88	0.83
Dorsal					
GSC 88488	3.4	2.5	2.3	0.74	0.92 holotype
GSC 88484	3.0	2.3	1.9	0.77	0.83
GSC 88487	2.8	2.3	1.7	0.82	0.74

Ventral interior: Teeth triangular, dental plates absent. Muscle field indiscernible.

Dorsal interior: Sockets triangular, supported by horizontal socket plates and bounded by inner socket ridges. Hinge plates triangular, erect; crural bases resemble the medial flanges of subrianids; crural plates short, only attach to shell floor at apex. Cardinal process striate. Muscle field indiscernible.

Occurrence	Articulated	Ventral	Dorsal
C22187	0	7	3

Genus *Plicoplasia* Boucot, 1959

Type species: *Plicoplasia cooperi* Boucot, 1959:20, pl.1, figs. 13, 14, pl. 2, figs. 1-5.

Plicoplasia cf. *P. acutiplicata* Lenz, 1972

Pl. 34, figs. 1-22.

1972 *Plicoplasia acutiplicata* Lenz, p. 102, pl. 2, figs. 1-22.

1977 *Plicoplasia acutiplicata* Lenz, p. 127, pl. 31, figs. 1-17.

1978 *Plicoplasia acutiplicata*--Jackson, Lenz, and Pedder, pl.10, figs. 24-34.

1984 *Plicoplasia acutiplicata*--Perry, p. 125, pl. 44, figs. 35-46.

Exterior: Valves small (the largest dorsal valve is 9 mm wide, 4.2 mm long), commonly mucronate, ventri-biconvex. Ventral interarea flat to weakly concave, catacline to apsacline; beak incurved; traces of deltidial plates preserved as ridges on both sides of the triangular delthyrium. Ventral sulcus deep, generally V-shaped; dorsal fold low, commonly flat-topped. Plications subangular, generally 2 to 3 on each flank. Radial micrornament not observed. Closely spaced, fine concentric growth lines visible on the anterior of some valves.

Ventral interior: Dental plates short, confined to apical region, sulcus-bounding. Myophragm absent. Muscle field indiscernible.

Dorsal interior: Hinge plates triangular, ventromedially tilted, crural bases rod-like, free-hanging along most of their length; short crural plates may be present at

the apex of the valve; crural processes subparallel, ribbon-like. Cardinal process preserved as small callus at apex. Muscle field indiscernible.

Occurrence	Articulated	Ventral	Dorsal
C22184	4	36	87
C22185	0	0	0
C22187	6	4	7
C12273	0	2	6
C12272	3	5	23

Family Cyrtiidae Frederiks, 1924

Subfamily Cyrtiinae Frederiks, 1924

Genus *Cyrtia* Dalman, 1828

Type species: *Anomites exporrectus* Wahlenberg, 1821, p. 64.

Cyrtia alatiformis n. sp.

Pl. 34, figs. 43-57, pl. 35, figs. 1-7.

Derivation of species name: Refers to its strongly alate form.

Diagnosis: Relatively small, strongly transverse and alate; sulcus V-shaped, boundaries between sulcus and lateral flanks sharp and angular, fold bounded by furrows; a thread-like myophragm present in dorsal valve.

Exterior: Valves relatively small for the genus (the largest specimen is 18 mm wide, 6.7 mm long, and 8.1 mm thick with a 6.6 mm high ventral interarea); pyramidal to hemi-pyramidal, with ventral interarea height:width ratio averaging 0.39; strongly transverse and alate, with length:width ratio averaging 0.47 (n=20, std=0.062), thickness:width ratio 0.52. Ventral interarea catacline to steeply procline, generally flat; delthyrium narrow, covered by convex deltidium with a pedicle tube developed at its lower portion; sulcus V-shaped, the boundaries between sulcus and lateral flanks are sharp and angular. Dorsal interarea narrow, orthocline; fold low, rounded, separated from the flanks by a pair of deep grooves. Capillae finer than interspaces, increase by implantation, less commonly by bifurcation. Very fine concentric growth lines developed on top of capillae.

Ventral interior: Dental plates convex medially, intrasinal (Havlícek's terminology, 1980, p. 9), about 1/3 of shell length. Muscle field indiscernible.

Dorsal interior: A small notothyrial platform, absent in some valves, supports socket plates and posterior portion of crural bases, crural bases unsupported

anteriorly; hinge plates narrow, triangular; myophragm thread-like. Cardinal process absent. Muscle field indiscernible.

Comparison: The new species can be distinguished from the type species *C. exporrecta* and most other species by its much greater width than length and alate outline. *C. extensa* Bolton 1957 closely resembles the new species; it is transverse and alate, but its illustration is inadequate for detailed comparison.

Occurrence	Articulated	Ventral	Dorsal
C22184	5	5	6
C22187	6	4	5
C12273	1	11	20
C12272	3	18	19

Genus *Plicocyrtia* Boucot, 1963

Type species: *Cyrtia petasus* Barrande, 1848, p. 184, pl. 17, fig. 1.

Plicocyrtia jonesi n. sp.

Pl. 34, figs. 23-42.

Derivation of species name: After Brian Jones.

Diagnosis: Small, hemipyramidal *Plicocyrtia*, with short dental plates, lacks crural plates.

Exterior: Small (the largest specimen is 13.6 mm wide, 6 mm long, and 5.4 mm thick); transverse with angular to subangular cardinal extremities, length:width ratio (measured on dorsal valves) averages 0.51 (n=47, std=0.068); hemi-pyramidal, thickness:width ratio 0.52. Ventral interarea height:width ratio averages 0.31; flat to gently curved, steeply apsacline to procline; delthyrium narrow, elongate, covered by convex deltidium except for the anterior pedicle opening; beak small, straight or incurved. Sulcus varies from angular to rounded; fold low, rounded; the maximum width of sulcus and fold (measured at anterior margin) about 1/3 of shell maximum width (measured at hinge line). Two pairs of rounded lateral plications on each valve. The pair defining sulcus or adjacent to fold are stronger, extend to anterior margin; the outer pair weak to obscure, do not extend to anterior margin. Capillae separated by interspaces of similar width, although the density of capillae shows some variation from valve to valve. Capillae increase mainly by implantation. Concentric growth lines very fine, developed on top of capillae.

Ventral interior: Dental plates about 1/3 of valve length, diverging toward floor, sulcus-bounding to nearly extrasinal (Havlícek's usage, 1980, p. 9). Myophragm absent or thread-like.

Dorsal interior: Hinge plates narrowly divergent anteriorly (about 35 degrees), erect or decline medially; crural bases ribbon-like, unsupported anteriorly; Cardinal process absent. Muscle field indiscernible. Myophragm faint, uncommon.

Remarks: Many valves have twisted beaks as shown in pl. 34, figs. 27, 40.

Comparison: The new species is unique in lacking crural plates. In addition, it differs from the type species *P. petasus* in being smaller, having denser capillae, shorter dental plates, and lacking a well developed myophragm.

Occurrence	Articulated	Ventral	Dorsal
C22184	2	20	22
C22185	0	0	0
C22187	15	15	23
C12273	3	29	28
C12272	20	152	225

Subfamily Eospiriferinae Schuchert and Le Vene, 1929

Genus *Hedeina* Boucot, 1957

Type species: *Anomia crispa* Linnaeus, 1758, p. 702.

Hedeina sp.

Pl. 35, figs. 8-21.

Exterior: Valves relatively large (the largest specimen is about 25 mm wide, 17.8 mm long), transverse, strongly ventri-biconvex. Ventral beak pointed, overhang a gently curved, catacline to steeply apsacline interarea; delthyrium narrow, with an apical angle of 35 to 40 degrees; deltidial plates poorly preserved. Ventral sulcus shallow, dorsal fold tends to be flat-topped. Plications low, rounded, 1 or 2 on each flank. Capillae rounded to subangular, increase by insertion, separated by wide interspaces. Concentric growth lines rare.

Ventral interior: Dental plates high, extrasinal (Havlícek's usage, 1980), gently inclined to each other, diverge anteriorly in accordance with delthyrial angle, extend to about 1/3 of valve length. Muscle field indiscernible.

Dorsal interior: Sockets defined by horizontal socket plates and inner socket ridges. Hinge plates triangular, relatively large, nearly erect to medially inclined.

Crural plates shorter than hinge plates, variably present. Cardinal process and muscle field not observed.

Occurrence	Articulated	Ventral	Dorsal
C22184	0	1	24
C22185	0	0	0
C22187	0	1	5
C12273	0	1	50
C12272	0	9	7

Genus *Janius* Havlícek, 1957

Type species: *Spirifer nobilis* Barrande, 1948, p. 184, pl. 18, fig. 2.

Janius occidentalis Boucot, Johnson, and Zhang, 1988

Pl. 35, figs. 22-33, pl. 36, figs. 1-10.

1988 Janius occidentalis Boucot, Johnson, and Zhang.

Exterior: Transverse, ventri-biconvex, the largest specimen is about 40 mm wide and 26 mm long. Ventral beak incurved, interarea flat to gently curved, catacline, delthyrium triangular with its apical angle varying from 45 to 55 degrees. Ventral sulcus shallow, flat bottomed in larger valves. Dorsal fold flat-topped, may or may not be medially depressed. Plications rounded, high and narrow, become broader and lower anteriorly. Plications vary in number, generally 2-3 pairs of primary plications on each valve, with frequent branching and insertion in valves larger than 15mm. Capillae rounded to angular, separated by wider interspace. Concentric growth lines finer than capillae.

Ventral interior: Dental plates short, reach the midlength of delthyrial cavity, extra-basinal.

Dorsal interior: Hinge plates large, triangular, supported by short crural plates at apex. Cardinal process and muscle field not preserved.

Occurrence	Articulated	Ventral	Dorsal
C22184	6	35	79
C22185	0	0	0
C22187	6	10	3
C12273	0	30	21
C12272	1	41	54

Subfamily Pinguispiriferinae Havlícek 1970

Genus *Spurispirifer* Havlícek, 1970

Type species: *Spirifer spurius* Barrande, 1848, p. 174, pl. 18, fig. 17.

Spurispirifer hughesi n. sp.

Pl. 36, figs. 11-36.

Derivation of species name: After Scott S. Hughes.

Diagnosis: Relatively small; sulcus and fold weak; with 2 to 4 pairs of rounded plications on either valve; dental plates short.

Exterior: Valves small (the largest specimen is 11.0 mm wide, 7.0 mm long); ventri-biconvex; generally transverse with rounded to subangular cardinal extremities; ventral valve length:width ratio averages 0.72 (n=30, std=0.106), thickness:width 0.39 (std=0.059); dorsal valve length:width, 0.66 (std=0.065), thickness:width 0.23 (std=0.030). Ventral interarea apsacline, moderately recurved; beak incurved; delthyrium triangular, deltidial plates not observed (probably due to the poor preservation). Sulcus shallow, bounded by a pair of rounded costae. Dorsal fold rounded and low.

Macrornament consists of 1 to 4 pairs of rounded plications on either valves. Plications, except for the medial pair, become weak or obscure toward posterior margin. Concentric growth lamellae widely spaced, only present in some valves, may or may not interrupt dense capillae; closely spaced, fine concentric fila may developed on top of capillae.

Ventral interior: Dental plates short, about 1/4 of the valve length or shorter, extrasinal to sulcus-bounding. Muscle field indiscernible.

Dorsal interior: Hinge plates triangular, slightly concave, ventrally tilted, vary from subparallel to anteriorly divergent at up to a 55 degrees angle. Crural bases spiky, free along most of their length, and attach to the base of the valve only at the apex. Cardinal process poorly preserved, appears to consist of two tiny pads at apex. Muscle field indiscernible.

Comparison: The new species differs from the type species *S. spurius* in being smaller, with stronger plications, and having weaker and narrower sulcus and fold. The two Devonian species, *S. derelictus* (Barrande) and *S. fuscus* Havlícek, are about the same size as the new species, but they both have only one pair of weak plications. In addition, *S. fuscus* can be distinguished from the new species by its prominent fold, sulcus, and long dental plates.

Occurrence	Articulated	Ventral	Dorsal
C22184	3	81	144

C22185	2	0	0
C22187	1	5	2
C12273	1	23	50
C12272	14	173	243

Superfamily Spiriferacea King, 1846
Family Delthyrididae Phillips, 1841
Subfamily Delthyridinae Phillips, 1841
Genus *Howellella* Kozlowski, 1946

Type species: *Delthyris elegans* Muir-Wood, 1925 (=*Terebratula crispa* Hisinger, 1826, pl. 7, fig. 4); not Linne, 1758.

Howellella sp.
Pl. 37, figs. 21, 23-25, 27-29, 31-33.

Exterior: Valves small, transverse with rounded cardinal extremities; ventribiconvex. Ventral interarea apsacline, moderately recurved to flat; beak incurved; triangular delthyrium open. Sulcus and fold low. Generally two to three rounded plications on each flank (one large valve has 6 plications); micrornament poorly preserved, consists of concentric lamellae overlapped by discontinuous fine capillae.

Ventral interior: Dental plates short, extrasinal to sulcus-bounding. Muscle field indiscernible.

Dorsal interior: Sockets large, triangular; hinge plates narrow; crural bases free-hanging, crural plates incepient. Cardinal process striate. Muscle field indiscernible.

Occurrence	Articulated	Ventral	Dorsal
C22184	0	2	4
C22187	0	1	2
C12273	0	4	5
C12272	0	17	14

Superfamily Reticulariacea Waagen, 1883

Family Reticulariidae Waagen, 1883

Genus *Spirinella* Johnston, 1941

Type species: *Spirinella caecistriata* Johnston, 1941, p. 161, pl. 7, figs. 1-11, text-fig. 2.

Spirinella struszi n. sp.

Pl. 37, figs. 1-20, 22, 26, 30.

Derivation of species name: After Desmond L. Strusz.

Diagnosis: Small; ventral valve high, with high, catacline interarea; ventral median groove and dorsal fold weak; dental plates reduced; crural plates narrowly divergent.

Exterior: Small (generally less than 10 mm in width except for one specimen that is 14.9 mm wide, 8.0 mm long), transversely elliptical, with length:width ratio averaging 0.67 (n=36, std=0.107); strongly ventri-biconvex. Ventral interarea high, catacline, delthyrium triangular, closed by a convex deltidium at its apex; beak tumid, strongly incurved. Ventral valve with a faint median groove; dorsal fold low, only distinctive in larger valves.

Ornament of closely spaced concentric growth lines interrupts finer, dense capillae. A few valves developed a pair of weak lateral costae.

Ventral interior: Dental plates short or nearly absent. Myophragm low, narrow. Muscle field elongate, without clear outline.

Dorsal interior: Sockets defined by horizontal socket plates and widely divergent socket ridges. Hinge plates triangular, ventromedially tilted; crural bases free-hanging anteriorly, short crural plates restricted to the apex of the valve. Cardinal process and hinge plates variably developed. Myophragm absent. Muscle field indiscernible.

Comparison: There are six non-costate *Spirinella* species including the new species. Among them, *S. striatissima* (Holtedahl) of Kul'kov (1967) is nearly equibiconvex; *S. biplicata* (Chu) and *S. sparasa* Rong and Yang, 1980 have well-developed sulcus and fold, which produce a dorsally protruding tongue. The new species closely resembles *S. caecistriata* Johnston, 1941 and *S. rootensis* Perry, 1984 in general outline. It can be distinguished from *S. caecistriata* in having a higher, less curved ventral interarea and shorter dental plates. From *S. rootensis* it differs in having a less pointed ventral beak, lacking a medially grooved myophragm, and having narrowly divergent crural bases.

Occurrence	Articulated	Ventral	Dorsal
C22184	14	184	165
C22185	9	24	15
C22187	25	117	91
C12273	13	151	210
C12272	41	1114	1380

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APPENDIX

EXPLANATION OF PLATES

Plate 1

Figs. 1-20, 24-27, 30-33. *Flabellitesia kessei* (Boucot, Johnson, and Zhang).

1, 10. C22184; dorsal exterior, interior, X2, GSC87818.

2-5. C12272; ventral exterior, interior, anterior, X2, lateral view, X1, GSC 87822.

6, 31, 33. C22184; dorsal exterior, antigydium, X6, interior, X2, GSC87819.

7, 24, 25, 30. C12272; ventral valve lateral view, X1, posterior, interior, exterior, X2, GSC87823.

8, 15, 19, 20. C12273; ventral lateral view, posterior, exterior, interior, X1, GSC87824.

9, 16, 17, 26, 27. C22187; antigydium viewed from ventriposterior, from posterior X4, dorsal posterior, interior, exterior, X2, GSC87826.

11, 12, 18. C12273; ventral interior, exterior, lateral view, X4, GSC86825.

13, 14. C22184; dorsal exterior, X4, interior, X2, GSC87820.

32. C22184; dorsal interior, X2, GSC87821.

Figs. 21-23, 28, 29, 34-37. *Trimerella* sp.

21, 22. C22184; ventral exterior, interior, X2, GSC87812.

23. C12272; dorsal interior, X4, GSC87813.

28, 29. C22184; dorsal interior, oblique view, X1.5, GSC87814.

34, 35. C22184; ventral interior, exterior, X2, GSC87815.

36. C22184; dorsal interior, X1.5, GSC87816.

37. C22184; dorsal interior, X1, GSC87817.

Plate 2.

Figs. 1-25. *Ptychopleurella lenzi* n. sp..

1, 2. C12273; ventral exterior, interior, X2, GSC87827.

3, 4. C12273; ventral exterior, interior, X3, GSC87828.

5, 6. C12273; dorsal interior, exterior, X3, GSC87829.

7, 8. C12273; ventral exterior, interior, X3, GSC87830.

9, 10. C12273; dorsal exterior, interior, X2, GSC87831, holotype.

11, 12. C22184; dorsal interior, exterior, X3, GSC87832.

13-17. C22184; ventral, dorsal, posterior, anterior, lateral views, X3, GSC87833.

18, 19. C22184; dorsal interior, exterior, X2, GSC87834.

20, 21. C22184; dorsal exterior, interior, X3, GSC87835.

22, 23. C22184; dorsal exterior, interior, X3, GSC87836.

24, 25. C22184; ventral interior, exterior, X2, GSC87837.

Figs. 26-36. *Wangyuia thorsteinssoni* n. sp..

26, 27. C22184; dorsal interior, X8, exterior, X4, GSC87838.

28, 29. C22184; dorsal exterior, X4, interior, X8, GSC87839.

30, 31. C22184; dorsal exterior, X4, interior, X8, GSC87840.

32, 33, 34. C22184; ventral exterior, X2, X8, interior, X8, GSC87841.

35, 36. C22184; dorsal exterior and interior, X8, GSC87842, holotype.

Plate 3.

Figs. 1-13. *Wangyuia thorsteinssoni* n. sp..

1, 2. C22184; ventral exterior, interior, X4, GSC87843.

3-5. C12273; ventral, lateral, dorsal views, X4, GSC87846a.

6, 7. C12273; ventral exterior, interior, X4, 878466b.

8-11. C22184; ventral, dorsal, lateral, posterior views, X4, GSC87844.

12, 13. C22184; ventral exterior, interior, X4, GSC87845.

Figs. 14-48. *Skenidioides operosa* Johnson, Boucot, and Murphy.

14, 15. C22184, ventral, dorsal views, X4, GSC87847a. 16-19. C22184, dorsal, ventral, anterior, posterior views, X4, GSC87847b.

20-24. C22184, ventral, dorsal, anterior, lateral, posterior views, X4, GSC87848.

25, 26. C22184, ventral exterior, interior, X4, GSC87849.

27-29. C22184; dorsal exterior, interior, oblique view, X4, GSC87850.

30, 31. C12273; dorsal exterior, interior, X4, GSC87851.

32-34. C12273; posterior, dorsal, ventral views, X4, GSC87852.

35, 36. C12272; ventral exterior, interior (note the short spondylium without supporting septum), X4, GSC87855.

37-40. C12273; ventral, dorsal, posterior, anterior views, X4, GSC87853.

41, 42. C12272; dorsal exterior, interior, X4, GSC87856.

43, 44. C12272; ventral exterior, interior, X4, GSC87857.

45-47. C12272; dorsal exterior, interior, oblique view, X4, GSC87858.

48. C12273; dorsal exterior. X4, GSC87854.

Figs. 49-58. *Isorthis* (*Arcualla*) *jini* n. sp..

49, 50. C22184; dorsal exterior, interior, X4, GSC87859, holotype.

51-53. C22184; ventral, dorsal, lateral views, X4, GSC87860.

54, 55. C22184; ventral exterior, interior, X4, GSC87861.

56-58. C22184; dorsal interior, X8, exterior, X8, X2, GSC87862.

Figs. 59-67. *Isorthis* (*Arcualla*) *walmsleyi* n. sp..

59. C22184; ventral exterior, X2, GSC87863.

60, 61. C22184; dorsal, ventral views, X4, GSC87864.

62, 63. C22184; dorsal exterior, interior, X4, GSC87865.

64, 65. C12273; dorsal exterior, interior, X8, GSC87866, holotype.

66, 67. C12272; dorsal exterior, interior, X8, GSC87867.

Plate 4.

Figs. 1-19. *Isorthis* (*Arcualla*) *walmsleyi* n. sp..

1, 2. C12272; ventral exterior, interior, X4, GSC87868.

3, 4. C12272; dorsal exterior, interior, X4, GSC87869.

5-7. C12272; ventral, dorsal, lateral views, X4, GSC87870.

8, 9. C12272; dorsal exterior, interior, X4, GSC87871.

10, 11. C12272; ventral exterior, interior, X4, GSC87872.

12, 13. C22184; dorsal exterior, interior, X4, GSC87873.

14, 15. C22184; dorsal exterior, interior, X4, GSC87874.

16, 17. C22184; dorsal exterior, interior, X4, GSC87875.

18, 19. C22184; ventral exterior, interior, X4, GSC87863.

Figs. 20-43. *Isorthis* (*Arcualla*) *sulcata boreaina* n. subsp..

20, 21. C22184; dorsal interior, exterior, X3, GSC87876.

22-25. C22184; ventral, dorsal, lateral, posterior views, X2, GSC87877.

26, 27. C22184; dorsal exterior, interior, X2, GSC87878.

28, 29. C22184; ventral interior, exterior, X2, GSC87879.

30, 31. C12272; dorsal exterior, interior, X3, GSC87880.

32, 33. C12272; dorsal exterior, interior, X3, GSC87881.

34, 35. C12272; dorsal exterior, interior, X3, GSC87882, holotype.

36, 37. C12272; ventral exterior, interior, X3, GSC87883.

38, 39. C12272; ventral exterior, interior, X3, GSC87884.

40. C12272; ventral interior, X3, GSC87885.

41. C12272; dorsal interior, X3, GSC87886.

42, 43. C12272; dorsal exterior, interior, X2, GSC87887.

Figs. 44-58. *Visbyella visbyensis* (Lindström).

44-46. C22184; ventral, lateral, dorsal views, X2, GSC87888.

47-49. C22184; ventral exterior, interior, anterior, X3, GSC87889.

50-52. C22184; ventral, lateral, dorsal views, X3, GSC87890.

53, 54. C12272; ventral exterior, interior, X2, GSC87893.

55, 56. C22184; ventral exterior, interior, X3, GSC87891.

57, 58. C22184; dorsal exterior, interior, X3, GSC87892.

Plate 5.

Figs. 1-12, 43, 44. *Resserella canalis celtica* Bassett.

1, 2. C22184; ventral exterior, interior, X3, GSC87897.

3, 4. C22184; ventral exterior, interior, X3, GSC87898.

5, 6. C12273; ventral interior, exterior, X3, GSC87901.

7, 8. C22184; dorsal interior, exterior, X3, GSC87899.

9, 10. C12272; ventral exterior, interior, X3, GSC87902.

11, 12. C12272; dorsal exterior, interior, X3, GSC87903.

43, 44. C22184; dorsal exterior, interior, X6, GSC87900.

Figs. 13-22, 45, 46. *Parmorthina havliceki*, n. sp..

13, 14. C12272; dorsal exterior, interior, X3, GSC87904.

15, 16. C12272; ventral exterior, interior, X3, GSC87905.

17, 18. C12272; ventral exterior, interior, X3, GSC87906.

19. C12272; dorsal interior, X3, GSC87907.

20. C12272; dorsal exterior, X3, 87908.

21, 22. C12272; ventral exterior, interior, X3, GSC87909, holotype.

45, 46. C12272; dorsal interior, exterior, X6, GSC87910.

Figs. 23-33, 40-42. *Fascizentina rohri* n. sp..

23-25. C22187; ventral, lateral, dorsal views, X4, GSC87911.

26, 27. C22184; ventral exterior, interior, X3, GSC87913.

28, 29. C22184; dorsal interior, exterior, X3, GSC87914, holotype.

30, 31. C22184; ventral exterior, X3, interior, X4, GSC87915.

32, 33. C22187; ventral interior, exterior, X4, GSC87911.

40, 41. C22184; dorsal exterior, interior, X6, GSC87916.

42. C22184; dorsal interior, X4, GSC87917.

Figs. 34-39. *Visbyella visbyensis* (Lindström).

34, 35. C12272; dorsal interior, exterior, X4, GSC87894.

36, 37. C12272; dorsal exterior, interior, X3, GSC87895.

38, 39. C12272; dorsal exterior, interior, X3, GSC87896.

Plate 6.

Figs. 1-42. *Dicoelosia bailliehamiltonensis* n. sp..

1. C22184; ventral exterior, X6, GSC87918.
2, 3. C22184; dorsal exterior, interior, X6, GSC87919.
4, 5. C22184; ventral, dorsal views, X5, GSC87920.
6, 7. C22184; ventral, dorsal views, X5, GSC87921.
8. C22184; ventral exterior, X5, GSC87922.
9. C22184; ventral view, X5, GSC87923.
10, 11. C12272; dorsal exterior, interior, X5, GSC87933.
12. C12272; dorsal interior, X5, GSC87934.
13, 14. C12272; dorsal, ventral views, X5, GSC87935.
15-17. C22184; ventral, lateral, dorsal views, X5, GSC87924, holotype.
18, 19. C12272; ventral, dorsal views, X5, GSC87936.
20. C12272; ventral interior, X5, GSC87937.
21. C22184; dorsal interior, X5, GSC89925.
22-24. C12272; ventral, dorsal, lateral views, X5, GSC87938.
25, 26. C12272; lateral oblique view, posterior, X5, GSC87939.
27, 28. C22184; ventral, dorsal views, X7, GSC87926.
29-31. C22184; ventral, dorsal, lateral views, X6, GSC87927.
32. C12273; dorsal interior, X5, GSC87940.
33, 34. C22184; ventral, dorsal views, X5, GSC87928.
35. C22184; dorsal interior, X5, GSC87929.
36, 37. C22184; dorsal interior, exterior, X5, GSC87930.
38, 39. C22184; ventral exterior, interior, X5, GSC87931.
40-42. C22184; ventral, lateral, dorsal views, X5, GSC87932.

Plate 7.

Figs. 1-23. *Epitomyonia clausula* Johnson, Boucot, and Murphy.

1, 2. C22184; dorsal exterior, interior, X4, GSC87941.
3, 4. C22184; ventral exterior, interior, X4, GSC87942.
5, 6. C22184; ventral, dorsal views, X4, GSC87943.
7, 8. C12273; dorsal exterior, interior, X4, GSC87949.

9, 10. C22184; dorsal exterior, interior, X4, GSC87944.

11, 12. C12272; ventral, dorsal views, X4, GSC87950.

13, 14. C22184; ventral, dorsal views, X4, GSC87945.

15, 16. C22184; ventral exterior, interior, X4, GSC87946.

17-20. C22184; ventral, dorsal, lateral, anterior views, X4, GSC87947.

21-23. dorsal exterior, interior, oblique view, X4, GSC87948.

Figs. 24-44. *Epitomyonia amplissima* n. sp..

24. C22187; ventral interior, X4, GSC87951.

25. C22184; ventral interior, X4 GSC87953.

26, 27. C12272; ventral, dorsal views, X3, GSC87961.

28. C22184; dorsal interior, X4, GSC87954.

29. C22187; dorsal interior, X4, GSC87952.

30. C12273; dorsal interior, X3, GSC87962.

31-33. C22184; ventral, dorsal, lateral views, X3, GSC87955.

34-36. C22184; ventral, dorsal, lateral views, X3, GSC87956.

37-39. C22184; dorsal exterior, interior, oblique view, X3, GSC87960, holotype.

40, 41. C22184; dorsal exterior, interior, X4, GSC87957.

42. C22184; ventral interior, X4, GSC87958.

43, 44. C22184; dorsal exterior, interior, X3, GSC87959.

Plate 8.

Figs. 1-26. *Dalejina parahanusi* n. sp..

1, 2. C12272; dorsal exterior, interior, X4, GSC87963.

3, 4. C22184; dorsal exterior, interior, X4, GSC87969.

5-7. C22184; dorsal exterior, interior, oblique view, X4, GSC87968, holotype.

8-10. C12272, dorsal exterior, anterior, interior, X4, GSC87964.

11, 12. C12272; dorsal exterior, interior, X4, GSC87965.

13-15. C22184; ventral muscle field, X9, interior, exterior, X4, GSC87970.

16, 17. C12272; ventral exterior, interior, X4, GSC87966.

18-21. C22184; ventral, dorsal, posterior, anterior views, X4, GSC87971.

22-24. C12272; ventral exterior, interior, X4, muscle field, X9, GSC87967.

25, 26. C22184; dorsal exterior, interior oblique view, X4, GSC87972.

Figs. 27-34. *Pseudomendacella boucoti* n. sp..

27, 28. C12272; dorsal exterior, interior, X2, GSC87974.

29. 30. C22187; ventral exterior, interior, X2, GSC87976.

31-34. C12272; dorsal exterior, interior, posterior, X1, cardinalia and muscle field, X5, GSC87973.

Plate 9.

Figs, 1-8. *Pseudomendacella boucoti* n. sp..

1, 2. C12272; dorsal exterior, interior, X2, GSC87975.

3, 4. C22187; dorsal exterior, interior, X2, GSC87977.

5, 6. C22187; ventral exterior, interior, X2, GSC89978.

7, 8. C22184; ventral muscle field, X3, interior, X1, GSC87979.

Figs. 9-24. *Salopina carinata* n. sp..

9, 10. C12272; dorsal exterior, interior, X3, GSC87980a.

11-14. C12272; ventral, dorsal, anterior, lateral views, X4, GSC87980b.

15, 16. C12272; dorsal exterior, interior, X4, GSC87981.

17, 18. C12272; ventral exterior, interior, X4, GSC87982.

19, 20. C12273; dorsal exterior, interior, X6, GSC87985.

21, 22. C12272; dorsal exterior, interior, X4, GSC87983.

23, 24. C12272; ventral exterior, interior, X4, GSC87984, holotype.

Figs. 25-37. *Salopina robitaillensis* Walmsley, Boucot, & Harper.

25, 26. C22184; dorsal exterior, interior, X3, GSC87986.

27, 28. C22184; ventral exterior, interior, X3, GSC87987.

29, 30. C22184; ventral exterior, interior, X3, GSC87988.

31-33. C22184; ventral, dorsal, lateral views, X3, GSC87989.

34, 35. C22184; dorsal exterior, interior, X3, GSC87990.

36, 37. C22184; dorsal exterior, interior, X6, GSC87991.

Figs. 38-44. *Salopina gamma* n. sp..

38-40. C12273; ventral, dorsal, lateral views, X6, GSC87992.

41-44. C12273; dorsal valve anterior view, interior, X6, exterior, X1.2, X6. GSC87993, holotype.

45. C12273; dorsal interior, X6, 87994.

Plate 10.

Figs. 1-3. *Salopina*? sp..

1-3. C22184; dorsal exterior, interior, oblique view, X6, GSC87995.

Figs. 4-21. *Hirnantia cf. sagittifera* (M'C0y).

4, 5. C22187; dorsal exterior, interior, X3, GSC87996.

6, 7. C12273; ventral exterior, interior, X3, GSC87998.

8-11. C12272; ventral exterior, interior, lateral view, X3, enlarged ornament showing fila, X6, GSC88000.

12, 13. C12273; dorsal exterior, interior, X3, GSC87999.

14-17. C22187; dorsal exterior, interior, lateral view, X1, cardinalia, X4, GSC87997.

18, 19. C12272; dorsal exterior, interior, X3, GSC88001.

20, 21. C12272; ventral exterior, X6, interior, X3, GSC88002.

Figs, 22-32. *Drabovia*? sp..

22-24. C12272; ventral exterior, interior, anterior, X6, GSC88003.

25-28. C12272; ventral exterior, X6, X1.2, interior, posterior, X6, GSC88004.

29-32. C12272; dorsal exterior, X1.2, exterior, interior, oblique view, X6, GSC88005.

Plate 11.

Figs. 1-12. *Streptis glomerata* Ulrich and Cooper.

1-3. C12272; ventral exterior, interior, X4.5, interarea, X10, GSC88006.

4, 5. C12272; dorsal exterior, interior, X4.5, GSC88007.

6, 9, 10. C12272; ventral valve anterior view, X9, interior, 6, exterior, X4.5, GSC88008.

7, 8. C22187; dorsal exterior, interior, X7, GSC88009.

11, 12. C22187; Ventral exterior, interior, X4.5, GSC88010.

Figs. 13-25. Cliftonia contorta n. sp..

13, 14. C22184; ventral posterior, interior, X3, GSC88011.

15, 20. C22184; ventral exterior, X4, interior, X3, GSC88012.

16-19. C22184; ventral, dorsal, anterior, posterior views, X2, GSC88013, holotype.

21, 22. C12272; dorsal exterior, X3, interior, X2.5, GSC88014.

23-25. C12272; dorsal exterior, X3, cardinal process, X5, interior, X5, GSC88015.

Figs. 26-30. *Leangella* (*Opikella*) sp..

26-28. C12272; ventral, dorsal, posterior views, X8, GSC88016.

29-30. C12272; dorsal interior, exterior, X8, GSC88017.

Plate 12

Figs. 1-12. *Aegiria grayi* (Davidson).

1, 2. C12272; dorsal exterior, interior, X4, GSC88018.

3-5. C12272; ventral, dorsal, lateral views, X4, GSC88019.

6, 7. C12272; dorsal exterior, interior, X4, GSC88020.

8-10. C12272; ventral exterior, anterior view, interior, X4, GSC88021.

11, 12. C12272; ventral exterior, interior, X4, 88022.

Figs. 13-29. *Chonetoidea? cocksi* n. sp..

13. C12272; dorsal interior, X4, GSC88023.

14, 15. C22187; ventral, dorsal views, X4, GSC88027.

16, 17. C22187; ventral, dorsal views, X4, GSC88028.

18, 29. C22187; ventral interior, X4, X8, GSC88029.

19, 25. C22187; dorsal exterior, X4, interior, X8, GSC88031, holotype.

20. C22187; ventral view, X4, GSC88030.

21-23. C12272; dorsal interior, exterior, X4, posterior, X8, GSC88024.

24, 28. C12272; ventral exterior, interior, X4, GSC88025.

26, 27. C12272; dorsal exterior, interior, X7, GSC88026.

Figs. 30-44. *Eoplectodonta* (*Paranisopleurella*) *cooperi* n. sp..

30, 31. C12272; ventral exterior, interior, X3, GSC88033.

32, 35. C12272; ventral, dorsal views, X3, GSC88034.

33, 34. C12272; ventral exterior, interior, X2, GSC88035.

36, 37. C22185; ventral, dorsal views, X2, GSC88032.

38, 39. C12272; dorsal exterior, interior, X3, GSC88036.

40, 41. C12272; ventral exterior, interior, X3, GSC88037.

42-44. C12272; ventral exterior, interior, X2, denticles, X6, GSC88038.

Plate 13

Figs. 1-3, 6-8, 11, 12, 15, 16. *E.* (*Paranisopleurella*) *cooperi* n. sp.

1, 6. C12273; ventral exterior, interior, X2, GSC88039.

2, 7. C12273; ventral exterior, interior, X2, GSC88040.

3, 8. C12273; ventral exterior, interior, X3, GSC88041.

11, 12. C12273; dorsal exterior, interior, X3, GSC88042.

15, 16. C12273; dorsal exterior, interior, X3, GSC88043, holotype.

Figs. 4, 5, 9, 10, 13, 14, 17, 18, 21. *Laevicyphomena*? sp..

4, 5. C22184; ventral exterior, interior, X2, GSC88044.

9, 10. C22184; dorsal exterior, interior, X2 GSC88045.

13, 14. C22184; dorsal exterior, interior, X3, GSC88046.

17, 18. C22184; dorsal, ventral views, X3, GSC88047.

21. C12272; dorsal interior, X4, GSC88048.

Figs. 19, 20, 22-30. *Pentlandina harperi* n. sp..

19, 20. C22184; dorsal exterior, interior, X4, GSC88049.

22, 26. C12272; dorsal exterior, interior, X8, GSC88053.

23, 24. C22184; ventral exterior, interior, X4, GSC88050.

25. C12272; dorsal interior, X2, GSC88054.

27, 28. C22184; dorsal exterior, interior, X4, GSC88051.

29, 30. C22184; ventral exterior, interior, X4, GSC88052.

Plate 14

Figs. 1-7. *Pentlandina harperi* n. sp..

1, 2. C12272; dorsal exterior, interior, X4, GSC88055.

3, 4. C12272; ventral interior, exterior, X8, GSC88056.

5. C12272; cardinalia and septa, X8, GSC88057.

6, 7. C12273; dorsal exterior, interior, X1, GSC88058, holotype.

Figs. 8-34. *Leptaena* sp..

8-10, 13, 17, 18, 21, 22, 25, 26, 29-34. Form 1.

8-10. C22184; ventral, dorsal, lateral views, X2, GSC88059.

13, 18. C22184; ventral exterior, interior, X2, GSC88060.

17, 21. C12272; ventral exterior, interior, X2, GSC88065.

22. C22184; Dorsal interior, X2, GSC88061.

25, 26. C12272; dorsal exterior, interior, X3, GSC88066.

29, 30, 34. C22184; ventral, dorsal, posterior views, X2, GSC88062.

31. C12272; dorsal interior, X2, GSC88067.

32, 33. C22184; dorsal exterior, interior, X3, GSC88063, type specimen.

11, 12, 14-16, 19, 20, 23, 24, 27, 28. Form 2.

11, 12. C12272; ventral exterior, interior, X2, GSC88064.

14, 15. C22184; ventral exterior, interior, X2, GSC88068.

16. C22184; dorsal interior, X3, GSC88069.

19, 20. C12272; ventral exterior, interior, X2, GSC88072.

23. C22184; dorsal interior, X2, GSC88070.

24. C12272; dorsal interior, X3, GSC88073.

27, 28. C22184; dorsal exterior, interior, X2, GSC88071, type specimen.

Plate 15

Figs. 1-20. *Liljevallia amorpha* n. sp.

1, 2. C22184; dorsal exterior, interior, X3, GSC88074.

3, 4. C12272; dorsal exterior, interior, X2, GSC88080.

5, 6. C12272; ventral interior, exterior, X2, GSC88081.

7. C22184; dorsal exterior, X2, GSC88075.

8, 9. C22184; dorsal exterior, interior, X4, GSC88076.

10, 11. C12272; ventral interior, exterior, X4, GSC88082.

12. C22184; dorsal interior, X4, GSC88077.

13. C22184; ventral interior, X2, GSC88078.

14-17. C22184; ventral exterior, interior, anterior, X2, denticle plates, X8, GSC88079, holotype.

18-20. C22187; dorsal interior, X4, cardinal process posterior view, X8, GSC88083.

Figs. 21-34. *Pholidostropia* (*Mesopholidostrophia*) *lamellosa* n. sp.

21. C22184; dorsal interior, X2, GSC88084.

22, 23. C22184; ventral, dorsal views, X2, GSC88085.

24. C22184; ventral view, X3, GSC88086.

25. C22184; Dorsal exterior, X2, GSC88087.

26, 27. C22184; ventral exterior, interior, X2, GSC88092, holotype.

28, 29. C22184; ventral, dorsal views, X2, GSC88088.

30, 34. C22184; ventral interior, X2, pedicle tube, X8, GSC88089.

31, 33. C22184; ventral view, X8, dorsal view, X3, GSC88090.

32. C22184; cardinalia, X2, GSC88091.

Plate 16

Figs. 1-13. *P.* (*Mesopholidostrophia*) *salopiensis granti* n. subsp.

1, 2. C22184; ventral exterior, interior, X2, GSC88093.

3. C22184; ventral exterior, X3, GSC88094.

4, 5. C22184; ventral, dorsal views, X3, GSC88098, holotype.

6, 7, 12, C22184; ventral extior, interior, X3, pedicle tube, X8, GSC88095.

8, 11. C22184; dorsal interior, X3, X8, GSC88096.

9, 10, 13. C22184; ventral exterior, interior, X3, beak, X8, GSC88097.

Figs. 14-23, 37, 38. *Amphistrophia* sp..

14, 15. C12272; ventral exterior, interior, X1, GSC88099.

16, 17. C12272; ventral exterior, interior, X2, GSC88100.

18. C12272; cardinalia, X2, GSC88101.

19, 20. C12272; ventral exterior, interior, X1, GSC88102.

21, 22. C12272; ventral exterior, interior, X2, GSC88103.

23. C12272; cardinalia and denticulate hinge line, X3, GSC88104.

37, 38. C22184; ventral, dorsal views, X2, GSC88105.

Figs. 24-36. *Morinorhynchus crispus* (Lindström).

24, 25. C12272; ventral exterior, interior, X2, GSC88106.

26-28. C22184; posterior view, X4, ventral, dorsal views, X2, GSC88108.

29, 30. C12272; ventral exterior, interior, X2, GSC88107.

31, 32. C22187; ventral exterior, interior, X2, GSC88111.

33, 34. C22184; ventral exterior, interior, X2, GSC88109.

35, 36. C22184; ventral exterior, interior, X2, GSC88110.

Plate 17

Figs. 1-17. *Anastrophia* (*Grayina*) cf. *magnifica* Kozlowski.

1-3. C22184; ventral exterior, interior, anterior view, X2, GSC88124.

4. C22184; spondylium and brachial plates viewed from anterior, X4, GSC88125.

5, 6. C22184; ventral exterior, interior, X2, GSC88126.

7. 8. C22184; dorsal exterior, interior, X2, GSC88127.

9, 10. C12272; ventral exterior, interior, X2, GSC88130.

11, 12. C12272; ventral exterior, interior, X2, GSC88131.

13, 14. C22184; ventral exterior, interior, X4, GSC88128.

15, 16. C12272; dorsal exterior, interior, X4, GSC88132.

17. C22184; dorsal interior, X4, GSC88129.

Figs. 18-27, 29-32, 34-37. *Morinorhynchus miniparvicostellus* n. sp.

18, 19. C12273; ventral exterior, interior, X3, GSC88114.

20, 21. C12272; dorsal interior, exterior, X3, GSC88118.

22. C12273; ventral interior, X3, GSC88115.

23, 24. C12272; ventral exterior, interior, X3, GSC88119.

25. C22184; cardinal process, X8, GSC88121.

26, 27. C12273; dorsal exterior, interior, X3, GSC88116.

29, 30. C12272; ventral exterior, interior, X3, GSC88120.

31, 32. C12273; dorsal exterior, interior, X3, GSC88117.

34, 35. C22184; dorsal exterior, interior, X6, GSC88122.

36, 37. C22184; dorsal exterior, interior, X6, GSC88123. holotype.

Figs. 28, 33, 38, 39. *Morinorhynchus crispus* (Lindström).

28, 33. C22187; ventral exterior, interior, X2. GSC88112.

38, 39. C12273; dorsal interior, exterior, X2, GSC88113.

Plate 18

Figs. 1-6. *Rhipidium* sp..

1, 2. C12272; dorsal interior, exterior, X2, GSC88133.

3, 4. C12272; dorsal exterior, interior, X2, GSC88134.

5, 6. C12272; dorsal exterior, interior, X2, GSC88135.

Figs. 7-15. *Harpidium* (*Lissocoelia*)? sp..

7, 8. C12272; dorsal exterior, interior, X3; GSC88136.

9, 11. C12272; dorsal exterior, interior, X2, GSC88137.

10. C22187; ventral interior, X1, GSC88140.

12. C12272; dorsal interior, X2, GSC88138.

13, 14. C12272; dorsal exterior, interior, X2, GSC88139.

15. C22187; spondylium and medium septum X2, GSC88141.

Figs. 16-35. *Conchidium* cf. *microlocularis* Johnson, Boucot, & Murphy.

16-18. C12272; dorsal exterior, interior, X1, cardinalia, X4.5, GSC88143.

19, 20. C12272; ventral exterior, interior, X2, GSC88144.

21, 22. C12272; ventral exterior, interior, X1, GSC88145.

23-25. C12272; ventral, dorsal, lateral views, X2, GSC88146.

26, 27. C12273; dorsal exterior, interior, X2, GSC88142.

28, 29. C12272; dorsal exterior, interior, X2, GSC88147.

30, 31. C12272; ventral exterior, interior, X2, GSC88148.

32, 33. C12272; ventral, dorsal views, X2, GSC88149.

34, 35. C12272; dorsal exterior, interior, X3.3, GSC88150.

Plate 19

Figs. 1-13. *Cymbidium* sp..

1, 2. C12272; ventral exterior, interior, X2, GSC88151.

3, 4. C12272; ventral exterior, interior, X1.5, GSC88152.

5-7. C12272; ventral exterior, interior, anterior view, X2, GSC88153.

8-10. C12272; ventral valve anterior view, X1.5, exterior, X2, interior, X1.5, GSC88154.

11. C12272; dorsal interior oblique view, X3.3, GSC88155.

12, 13. C12272; dorsal exterior, interior, X3.3, GSC88156.

Figs. 14-37. *Vosmiverstum breiveli* n. sp..

14, 15. C12272; dorsal exterior, interior, X2, GSC88158.

16, 17. C12272; ventral exterior, interior, X1, GSC88159.

18-20; C12272; ventral exterior, interior, anterior view, X1, GSC88157, holotype.

21-23. C12272; ventral exterior, anterior view, interior, X2, GSC88160.

24, 25. C12273; dorsal exterior, interior, X1, GSC88167.

26, 29. C12272; ventral exterior, interior, X2, GSC88161.

27, 28. C12272; dorsal exterior, interior, X1.5, GSC88162.

30-32. C12272; ventral interior, exterior, anterior view, X1, GSC88163.

33, 34. C12272; ventral exterior, interior, X2, GSC88164.

35. C12272; cardinalia, X3, GSC88165.

36, 37. C12272; dorsal exterior, interior, X3, GSC88166.

Plate 20

Figs. 1-23. *Spondylopyxis potteri* n. sp..

1, 10, 18. C12272; dorsal exterior, interior, X3, cardinalia, X7, GSC88169.

2-4. C12272; ventral, dorsal, lateral views, X3, GSC88170.

5-7. C12272; ventral, dorsal, lateral views, X3, GSC88171.

8, 9. C12272; ventral exterior, interior, X3, GSC88172.

11, 12. C12272; ventral exterior, interior, X3, GSC88173.

13, 14. C12272; ventral exterior, interior, X3, GSC88174.

15-17. C22187; ventral exterior, interior, anterior view, X2, GSC88168, holotype.

19, 20. C12272; dorsal exterior, interior, X3, GSC88175.

21. C12272; ventral interior, X3, GSC88176.

22, 23. C12272; dorsal exterior, X3, interior oblique view, X7, GSC88177.

Figs. 24-46. *Severella arctosulcata* n. sp..

24, 25. C12272; dorsal exterior, interior, X2, GSC88179.

26, 27. C12272; ventral, dorsal views, X2, GSC88180.

28, 29. C12272; ventral exterior, interior, X2, GSC88181.

30-34. C12272; ventral, dorsal, anterior, posterior, lateral views, X2, GSC88178, holotype.

35, 40. C12272; ventral exterior, interior, X1.5, GSC88182.

36, 37. C12272; ventral exterior, interior, X2, GSC88183.

38, 39, 46. C12272; dorsal exterior, interior, X1.5, cardinalia, X4, GSC88184.

41, 42. C12272; dorsal exterior, interior, X2, GSC88185.

43-45. C12272; dorsal exterior, X2, anterior view of interior, cardinalia, X5, GSC88186.

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Figs. 1-15. *Clorinda geniculata* n. sp..

1, 2. C12272; ventral exterior, interior, X4.5, GSC88187.

3, 6. C12272; dorsal exterior, interior, X4.5, GSC88188.

4, 5. C12272; dorsal exterior, interior, X4.5, GSC88189.

7, 9, 11. C12272; ventral exterior, oblique view, interior, X6, GSC88190.

8, 10, 12, 14. C12272; ventral, dorsal views, X6, posterior, lateral views, X7, GSC88192, holotype.

13, 15. C12272; dorsal exterior, X6, interior, X10, GSC88191.

Figs. 16-28. *Clorinda* sp..

16, 17. C22184; ventral exterior, interior, X6, GSC88193.

18. C22184; dorsal interior, X6, GSC88194.

19-21. C12272; ventral, dorsal, lateral views, X4.5, GSC88198.

22. C22184; dorsal view, X6, GSC88195.

23, 24. C22185; ventral interior, exterior, X4.5, GSC88199.

25, 26. C22184; ventral interior, exterior, X4.5, GSC88196.

27, 28. C22184; dorsal exterior, interior, X6, GSC88197.

Figs. 29-34. *Clorinda*? sp..

29, 30. C22184; ventral exterior, interior, X5, GSC88200.

31, 34. C22184; ventral exterior, interior, X5, GSC88201.

32, 33. C22184; ventral exterior, interior, X5, GSC88202.

Plate 22

Figs. 1, 7, 15, 19, 22, 25. *Antirhynchonella* sp..

1. C12273; dorsal interior, X2, GSC88203.

7, 15, 19. C22184; ventral exterior, interior, anterior view, X2, GSC88204.

22, 25. C22184; dorsal exterior, interior, X2, GSC88205.

Figs. 2, 8, 16, 20, 23, 24, 26, 27. *Barrandina* sp..

2, 8. C22184; ventral exterior, interior, X2, GSC88206.

16, 20, 23. C12273; ventral exterior, interior, oblique view, X2, GSC88207.

24, 26, 27. C12273; brachial plates, X4, dorsal exterior, interior, X2, GSC88208.

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3, 4. C22184; dorsal exterior, interior, X2, GSC88209.

5, 6. C22187; ventral exterior, interior, X3, GSC88215.

9, 10. C22184, dorsal exterior, interior, X2, GSC88210.

11, 14. C22184; ventral exterior, interior, X2, GSC88211.

12, 13. C22184; ventral exterior, interior, X2, GSC88212.

17, 18. C22187; dorsal exterior, interior, X2, GSC88214, holotype.

21. C22184; ventral exterior, X2, GSC88213.

28, 29. C22185; dorsal exterior, interior, X2, GSC88216.

30, 31. C22185; ventral exterior, interior, X2, GSC88217.

Plate 23

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1, 2. C12272; dorsal exterior, interior, X3, GSC88218.

3, 4. C12272; dorsal exterior, interior, X2, GSC88219.

5, 6. C12272; dorsal exterior, interior, X2, GSC88220.

7, 8. C12272; ventral exterior, interior, X2, GSC88221.

9. C12273; dorsally convergent outer plates, X3, GSC88223.

10, 11. C12272; dorsal exterior, interior, X2, GSC88222.

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12, 13. C12273; dorsal exterior, interior, X2, GSC88224.

14, 15. C12273; dorsal exterior, interior, X2, GSC88225.

16, 17. C12272; dorsal exterior, interior, X2, GSC88226.

18, 19. C22187; dorsal exterior, interior, X2, GSC88227, holotype.

20, 21. C22187; ventral exterior, interior, X2, GSC88228.

22. C22184; ventral interior, X2, GSC88229.

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23, 24. C12272; ventral exterior, interior, X4, GSC88230.

25, 26. C12273; dorsal exterior, interior, X4, GSC88235.

27, 28. C12273; dorsal exterior, interior, X4, GSC88236.

29. C12272; ventral exterior, X4, GSC88231.

30. C12272; dorsal interior, X4, GSC88232.

31, 32. C12272; dorsal interior, X8, exterior, X2, GSC88234, holotype.

33, 34. C12272; ventral exterior, interior, X4, GSC88233.

Plate 24

Figs. 1-25, 36, 37, 43. *Rhynchotreta americaniformis* n. sp.

1, 2. C12273; dorsal exterior, interior, X2, GSC88237.

3, 4. C12273; dorsal exterior, interior, X2, GSC88238.

5, 6. C12272; dorsal exterior, interior, X2, GSC88239.

7, 8. C12272; ventral exterior, interior, X2, GSC88240.

9, 10. C12272; ventral, dorsal views, X2 GSC88241.

11, 12. C12272; dorsal exterior, interior, X2 GSC88242.

13, 14. C12272; ventral, dorsal views, X2, GSC88243.

15, 16. C12272; ventral exterior, interior, X2, GSC88244.

17-19. C22185; ventral, dorsal, lateral views, X2, GSC88249, holotype.

20, 21. C22187; ventral, dorsal views, X2, GSC88250.

22, 23. C12272; ventral, dorsal views, X2, GSC88245.

24. C12272; ventral interior, X2, GSC88246.

25, 37. C12272; posterior, anterior views, X2, GSC88247.

36, 43. C12272; dorsal exterior, X2, interior, X4, GSC88248.

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26, 27. C12273; dorsal interior, exterior, X3, GSC88251.

28-30. C22187; ventral, dorsal, anterior views, X3, GSC88257.

31, 32. C12273; ventral, dorsal views, X3, GSC88252.

33-35. C12273; ventral, anterior, dorsal views, X3, GSC88253.

38, 39. C12272; ventral, dorsal views, X3, GSC88295.

40-42. C12272; ventral, dorsal, anterior views, X3, GSC88260.

44-46. C12272; ventral, dorsal, anterior views, X3, GSC88261.

47, 48. C12272; anterior, ventral views, X3, GSC88262.

49, 50. C12272; ventral exterior, interior, X3, GSC88263.

51-53. C22187; posterior, dorsal, anterior views, X3, GSC88258, holotype.

54, 55. C12273; dorsal exterior, interior, X3, GSC88254.

56. C12273; dorsal interior, X3, GSC88255.

57. C22184; dorsal interior, X3, GSC88266.

58, 59. C12273; ventral exterior, interior, X3, GSC88256.

60. C12272; dorsal interior, X5, GSC88264.

61, 62. C12272; dorsal exterior, X3, interior, X5, GSC88265.

Plate 25

Figs. 1-17, 31, 32, 37, 38, 44, 45. *Thebesia* cf. *thebesensis* Amsden.

1-5. C22184; ventral exterior, interior, dorsal exterior, interior, lateral view, X2, GSC88267.

6, 7. C22184; dorsal exterior, interior, X2, GSC88268.

8-11. C22184; ventral, dorsal, posterior, lateral views, X2, GSC88269.

12, 13. C22184; ventral exterior, interior, X2, GSC88270.

14-17. C22184; lateral, ventral, anterior, dorsal views, X2, GSC88271.

31, 32. C22184; ventral, dorsal views, X4, GSC88272.

37, 38. C22184; ventral interior, exterior, X4, GSC88273.

44, 45. C22184; dorsal exterior, interior, X4, GSC88274.

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18. C22184; dorsal interior, X2, GSC88275.

19-21. C22184; ventral, dorsal, lateral views, X2, GSC88276.

22-26. C12272; ventral, anterior, dorsal, posterior, lateral views, X2, GSC88282.

27-29. C12272; ventral, dorsal, anterior views, X2, GSC88283.

30, 36, 41. C22184; ventral, dorsal, lateral views, X2, GSC88277.

33-35. C22184; ventral, dorsal, lateral views, X2, GSC88278.

39. C12272; dorsal interior, X4, GSC88284.

40, 43. C12272; ventral exterior, X2, interior, x5, GSC88285.

42, 46. C12272; ventral interior, exterior, X4, GSC88286.

47. C12272; dorsal interior, X5, GSC88287.

Plate 26

Figs. 1-18. *Stegerhynchus angaciensis* Chernyshev.

1-5. C12272; ventral, dorsal, anterior, lateral, posterior views, X2, GSC88288.

6-8. C12272; ventral, anterior, dorsal views, X2, GSC88289.

9-11. C22184; ventral, dorsal, lateral views, X2, GSC88279.

12-14. C22184; ventral, dorsal, lateral views, X2, GSC88280.

15, 16. C12272; ventral, dorsal views, X2, GSC88290.

17, 18. C22184; ventral, dorsal views, X2, GSC88281.

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19-21. C22184; ventral, dorsal, lateral views, X2, GSC88292.

22, 28. C22185; ventral exterior, interior, X2, GSC88291.

23, 29, 36, 42, 48. C12272; ventral, dorsal, lateral, anterior, posterior views, X2, GSC88298, holotype.

24, 30, 37, 43, 49. C12272; ventral, dorsal, lateral, anterior, posterior views, X2, GSC88299.

25, 31, 38, 44, 50. C22184; ventral, dorsal, lateral, anterior, posterior views, X2, GSC88293.

26. C22184; ventral interior, X2, GSC88294.

27. C22184; dorsal interior, X2, GSC88295.

32, 33. C12272; ventral, dorsal views, X2, GSC88300.

34, 35. C22184; dorsal exterior, interior, X4, GSC88396.

39, 45, 51. C22184; ventral, dorsal, lateral views, X2, GSC88297.

40, 46. C22187; ventral, dorsal views, X2, GSC88301.

41, 47. C22187; ventral, dorsal views, X2, GSC88302.

Figs. 52, 53. "Ancillotoechia" cf. pentaforma Lenz.

52, 53. C12273; dorsal exterior, interior, X2, GSC88303.

Plate 27

Figs. 1-12. *Zygatrypa stenoparva* Johnson, Boucot, and Zhang.

1, 2. C12272; ventral, dorsal views, X3, GSC88304.

3, 4. C12272; ventral, dorsal views, X5, GSC88305.

5-7. C12272; ventral exterior, anterior view, interior, X5, GSC88306.

8, 9. C22184; ventral, dorsal views, X6, GSC88309.

10. C12272; ventral exterior, X6, GSC88307.

11, 12. C12272; ventral, dorsal views, X6, GSC88308.

Figs. 13-37, 40, 41, 46, 47. *Lissatrypa* cf. *atheroidea* Twenhofel.

13-15. C12272; ventral, dorsal, lateral views, X3, GSC88310.

16, 24. C12273; ventral, dorsal views, X3, GSC88319.

17, 18. C12272; ventral exterior, interior, X3, GSC88311.

19, 20. C22184; ventral, dorsal views, X3, GSC88323.

21-23. C22184; ventral, dorsal, lateral views, X3, GSC88324.

25-27. C12273; ventral, dorsal, anterior views, X3, GSC88320.

28-30. C12272; anterior, ventral, dorsal views, X3, GSC88312.

31, 32. C12273; ventral interior, anterior view, X3, GSC88321.

33. C12272; dorsal interior, X7, GSC88313.

34-36. C12272; ventral, dorsal, lateral views, X3, GSC88314.

37. C12272; ventral interior, X7, GSC88315.

40. C12272; dorsal interior, X7, GSC88316.

41. C12273; dorsal interior, X7, GSC88322.

46. C12272; dorsal interior, X7, GSC88317.

47. C12272; ventral interior, X7, GSC88318.

figs. 38, 39, 42-45, 48-51. *Glassia*? sp. 1.

38, 39. C12272; ventral, dorsal views, X1.5, GSC88325.

42, 43. C12272; ventral exterior, interior, X1.5, GSC88326.

44, 45. C12272; dorsal exterior, interior, X1.5, GSC88327.

48. C12272; cardinalia, X1.5, GSC88328.

49-51. C12272; lateral, ventral, dorsal views, X1.5, GSC88329.

Figs. 52-55. Glassia? sp. 2.

52-55. C12272; ventral anterior, dorsal, lateral views, X2, GSC88330.

Plate 28

Figs. 1-9. *Johnsonatrypa imbricata* n. sp..

1, 2. C22185; ventral exterior, interior, X7, GSC88332.

3, 4. C22185; dorsal exterior, interior, X7, GSC88333.

5-7. C22185; ventral interior, exterior, anterior view, X7, GSC88334.

8, 9. C22185; dorsal exterior, interior, X7, GSC88331.

Figs. 10, 11, 13-29. *Plectatrypa unicosta* n. sp..

10, 11. C12273; ventral, dorsal views, X3, GSC88335.

13. C12273; dorsal interior, X3, GSC88336.

14, 15. C12272; ventral, dorsal views, X3, GSC88340.

16. C12272; dorsal view, X3, GSC88341.

17, 18. C12272; ventral, dorsal views, X3, GSC88342.

19, 20, 26, 27. C12273; ventral, dorsal, anterior, posterior views, X3, GSC88337.

21-23, 28, 29. C12273; ventral dorsal, lateral, posterior, anterior views, X3, GSC88339, holotype.

24, 25. C12273; ventral exterior, interior, X3, GSC88338.

Fig. 12. *Spirigerina copperi* n. sp..

12. C12272; dorsal interior, X3, GSC88350.

Figs. 30-44. *Plectatrypa rongi* n. sp..

30-32. C22185; posterior, ventral, dorsal views, X3, GSC88343, holotype.

33-35. C22184; ventral, dorsal, anterior views, X3, GSC88344.

36, 41. C22184; ventral interior, exterior, X4, GSC88345.

37, 42. C22184; dorsal exterior, interior, X4, GSC88346.

38, 39. C22184; ventral, dorsal views, X3, GSC88347.

40, 44. C22184; ventral exterior, X3, interior, X5, GSC88348.

43. C22184; dorsal view, X3, GSC88349.

Plate 29

Figs. 1-20, 22-25. *Spirigerina copperi* n. sp..

1, 2. C12272; dorsal exterior, interior, X2, GSC88351.

3, 4. C12272; ventral, dorsal views, X2, GSC88352.

5, 6. C12273; ventral, dorsal views, X3, GSC88356.

7. C12273; dorsal interior, X3, GSC88357.

8-10, 16, 17. C12272; ventral, dorsal, lateral, anterior, posterior views, X2, GSC88355, holotype.

11-13, 19, 20. C12272; ventral dorsal, lateral, posterior, anterior views, X2, GSC88353.

14, 15. C12272; ventral, dorsal views, X2, GSC88354.

18. C12273; dorsal interior, X3, GSC88361.

22, 23. C22187; ventral, dorsal views, X3, GSC88359.

24. C12273; ventral interior, X3, GSC88359.

25. C12273; ventral interior, X3, GSC88360.

Figs. 21, 26-56. *Eospinatrypa bassetti* n. sp..

21. C22187; ventral view, X3, GSC88363.

26. C22187; ventral view, X3, GSC88364.

27. C22187; ventral view, X3, GSC88365.

28-30. C22187; ventral, dorsal, lateral views, X1, GSC88362, holotype.

31, 32. C22184; ventral, dorsal views, X1, GSC88372.

33-35. C22184; ventral, dorsal, lateral views, X1.5, GSC88373.

36-38. C22187; ventral dorsal, lateral views, X2, GSC88366.

39. C22184; dorsal view, X3, GSC88374.

40-43; C22187; ventral lateral, dorsal, posterii views, X2, GSC88367.

44. C22187; ventral view, X3, GSC88368.

46-47. C22184; ventral, dorsal, lateral views, X1.5, GSC88375.

48-51. C22187; ventral, lateral, dorsal, posterior views, X2, GSC88369.

52. C12273; ventral interior, X3, GSC88376.

53. C22187; dorsal interior, X3, GSC88370.

54. C12273; cardinalia and muscle field, X3, GSC88377.

55. C12273; dorsal interior, X3, GSC88378.

56. C22187; ventral view, X3, GSC88371.

Plate 30

Figs. 1-24. *Eospinatrypa sagana* Boucot, Johnson, and Zhang.

1, 2. C12273; ventral, dorsal views, X4, GSC88379.

3-5. C12273; ventral, dorsal, lateral views, X4, GSC88380.

6. C12273; ventral interior, X4, GSC88381.

7. C22187; ventral view, X4, GSC88383.

8. C22187; ventral view, X4, GSC88384.

9, 10. C22187; dorsal exterior, interior, X4, GSC88385.

11, 12. C12273; ventral exterior, interior, X4, GSC88382.

13, 14. C12272; dorsal exterior, interior, X4, GSC88389.

15-17. C22187; ventral, dorsal, lateral views, X4, GSC88386.

18, 19. C12272; ventral exterior, interior, X4, GSC88390.

20. C22187; ventral view, X4, GSC88387.

21. C22187; ventral view, X4, GSC88388.

22, 23. C12272; ventral, dorsal views, X4, GSC88391.

24. C12272; dorsal interior, X4, GSC88392.

Figs. 25-49. *Eospinatrypa? savagei* n. sp..

25, 26. C12273; ventral exterior, interior, X4, GSC88394.

27-29. C22187; ventral, dorsal, lateral views, X4, GSC88393.

30-32. C12273; ventral, dorsal, lateral views, X4, GSC88395.

33, 37, 47. C12273; ventral exterior, interior, anterior oblique view, X4, GSC88396.

34-36. C12273; ventral, dorsal, lateral views, X4, GSC88397.

38-40. C12272; ventral dorsal, lateral views, X4, GSC88400, holotype.

41. C12273; ventral view, X4, GSC88398.

42-44. C12273; dorsal exterior, interior, anterior view, X4, GSC88399.

45, 46. C12272; ventral exterior, interior, X4, GSC88401.

48, 49. C12272; dorsal exterior, interior, X4, GSC88402.

Plate 31

Figs. 1-31. *Reticulatrypa blodgetti* n. sp..

1-3. C22814; ventral, dorsal, posterior views, X2, GSC88403.

4, 5. C12273; dorsal exterior, interior, X2, GSC88405.

6. C12272; ventral interior, X2, GSC88408.

7-9. C22187; ventral, dorsal, posterior views, X3, GSC88415.

10-12. C12272; ventral, dorsal, posterior views, X2, GSC88409.

13, 23. C12272; ventral exterior, interior, X2, GSC88410.

14-16. C22187; ventral, dorsal, posterior views, X2, GSC88416.

17-20. C12272; ventral, dorsal, lateral, posterior views, X2, GSC88411.

21. C22184; dorsal interior, X3, GSC88404.

22. C12272; ventral view, X3, GSC88412.

24, 25. C12273; ventral, dorsal views, X2, GSC88406.

26, 27. C12273; ventral exterior, interior, X2, GSC88407.

28-30. C12272; ventral, dorsal, posterior views, X2, GSC88414, holotype.

31. C12272; ventral view, X3, GSC88413.

Figs. 32-66. *Reticulatrypa variabilis* Johnson, Boucot, & Murphy.

32. C12272; ventral view, X3, GSC88417.

33. C12273; ventral view, X3, GSC88421.

34-36. C12273; ventra, dorsal, posterior views, X2, GSC88422.

37-40. C22187; ventral, dorsal, posterior, lateral views, X2, GSC88430.

41-43. C12272; ventral, dorsal, posterior views, X2, GSC88418.

44-46. C22187; ventral, dorsal, anterior views, X2, GSC88431.

47. C12272; ventral view, X3, GSC88419.

48, 49. C12272; dorsal exterior, interior, X2, GSC88420.

50. C12273; ventral exterior, X3, GSC88423.

51-54. C12273; ventral, dorsal, posterior, anterior views, X2, GSC88424.

55-57. C22187; ventral dorsal, posterior views, X3, GSC88432.

58, 59. C12273; ventral exterior, interior, X3, GSC88425.

60, 61. C12273; dorsal exterior, interior, X3, GSC88426.

62, 63. C12273; dorsal exterior, interior, X3, GSC88427.

64. C12273; ventral interior, X3, GSC88428.

65, 66. C12273; dorsal exterior, interior, X3, GSC88249.

Plate 32

Figs. 1-37. *Gracianella dimorpha* n. sp..

1-8. Form 2.

1, 2. C22187; ventral, dorsal views, X3, GSC88433.

3, 4. C22187; ventral, dorsal views, X3, GSC88434.

5, 6. C12272; ventral, dorsal views, X3, GSC88447, type specimen.

7. C12273; ventral view, X3, GSC88439.

8. C12272. dorsal interior, X3, GSC88448.

9-37. Form 1.

9, 10. C22187; ventral, dorsal views, X3, GSC88435.

11, 12. C22187; ventral, dorsal views, X3, GSC88436.

13, 14. C12273; ventral, dorsal views, X3, GSC88440.

15. C12273; ventral view, X3, GSC88441.

16. C12272; dorsal interior, X3, GSC88449.

17, 18. C12272; ventral, dorsal views, X3, GSC88453, holotype.

19, 20. C12272; dorsal exterior, interior, X3, GSC88450.

21. C12273; ventral interior, X3, GSC88442.

22, 23. C12273; anterior view of dorsal interior, dorsal interior, X3, GSC88443.

24, 25. C12273; ventral, dorsal views, X3, GSC88444.

26, 27. C12273; ventral, dorsal views, X3, GSC88445.

28, 29. C12273; ventral exterior, interior, X3, GSC88446.

30, 37. C22187; ventral, dorsal views, X3, GSC88437.

31, 32. C12272; ventral exterior, interior, X3, GSC88451.

33, 34. C12272; ventral, dorsal views, X3, GSC88452.

35, 36. C22187; ventral, dorsal views, X3, GSC88438.

Figs. 38-50, 55-57. *Nucleospira* cf. *raritas* Amsden.

38. C22184; ventral view, X3, GSC88454.

39-42. C12272; ventral, dorsal, anterior, posterior views, X3, GSC88456.

43, 44. C12273; dorsal exterior, interior, X3, GSC88458.

45, 46. C12273; ventral exterior, interior, X3, GSC88459.

47. C12273; dorsal view, X2, GSC88460.

48. C12272; ventral view, X3, GSC88457.

49, 50. C22187; ventral exterior, interior, X2, GSC88461.

55-57. C22184; dorsal exterior, interior oblique view, posterior oblique view, X4, GSC88455.

Figs. 51-54, 58, 59. indet. athyridid sp..

51-53, 58. C12272; anterior, posterior, ventral, dorsal views, X3, GSC88462.

54, 59. C12272; ventral, dorsal views, X3, GSC88463.

Plate 33

Figs. 1-13. *Merista* sp..

1-3. C12273; ventral, dorsal, lateral views, X3, GSC88464.

4-6. C12272; dorsal exterior, interior, interior oblique view, X3, GSC88466.

7, 8. C12272; dorsal exterior, interior, X3, GSC88467.

9. C12273; ventral view, X3, GSC88465.

10, 11. C12272; ventral exterior, intrerior, X3, GSC88468.

12, 13. C12272; oblique view of ventral interior, X4, interior, X3, GSC88469.

Figs. 14-31. *Pseudoprotathyris*? *modzalevskaya*e n. sp..

14. C22187; ventral view, X3, GSC88470.

15. C22187; ventral view, X3, GSC88471.

16. C22187; ventral view, X3, GSC88472.

17. C12272; dorsal interior, X3, GSC88473.

18. C12272; dorsal interior, X3, GSC88474.

19. C12272; dorsal interior, X3, GSC88475.

20. C12272; dorsal interior, X3, GSC88476.

21-23. C12272; posterior, X3, ventral, dorsal views, X4, GSC88477.

24. C12272; dorsal interior, X4, GSC88478.

25. C22184; dorsal interior, X4, GSC88483.

26. C12272; ventral interior, X4, GSC88479.

27. C12272; dental plates and cardinalia, X4, GSC88480.

28. C12272; ventral interior, X4, GSC88481.

29-31. C12272; ventral, dorsal, lateral views, X4, GSC88482, holotype.

Figs. 32-43. *Dicoelospirifer dicoelospirifer* n. sp..

32, 38. C22187; dorsal exterior, X6, interior, X8, GSC88484.

33, 39. C22187; ventral interior, X8, exterior, X6, GSC88485.

34, 40. C22187; ventral exterior, interior, X6, GSC88486.

35, 41. C22187; dorsal exterior, interior, X8, GSC88487.

36-43. C22187; dorsal exterior, interior, anterior view, lateral oblique view, X8, GSC88488, holotype.

Plate 34

Figs. 1-22. *Plicoplasia* cf. *acutiplicata* Lenz.

1. C12272; anterior view of a broken shell, X3, GSC88489.

2, 3. C12272; ventral exterior, interior, X3, GSC88490.

4, 5. C22184; dorsal exterior, interior, X3, GSC88492.

6. C22184; dorsal interior, X3, GSC88493.

7, 8. C12272; dorsal exterior, interior, X3, GSC88491.

9, 10. C22184; dorsal exterior, interior, X3, GSC88494.

11, 12. C22184; dorsal exterior, interior, X3, GSC88495.

13. C22184; ventral interior, X3, GSC88496.

14. C22184; ventral interior, X3, GSC88497.

15-18. C22184; ventral, dorsal, posterior, anterior views, X3, GSC88498.

19-22. C22184; ventral, dorsal, posterior, anterior view, X5, GSC88499.

Figs. 23-42. *Plicocyrtia jonesi* n. sp..

23, 24. C22187; dorsal exterior, interior, X2, GSC88500.

25, 26. C12272; dorsal exterior, interior, X2, GSC88504.

27-30. C22187; ventral, dorsal, anterior, posterior views, X2, GSC88501, holotype.

31. C22184; ventral interior, X2, GSC88508.

32-34. C22187; ventral, dorsal, posterior views, X2, GSC88502.

35, 36. C12272; ventral exterior, interior, X2, GSC88505.

37, 38. C12272; dorsal exterior, interior, X2, GSC88506.

39, 40. C22187; interarea, ventral exterior, X3, GSC88503.

41, 42. C12272; ventral exterior, interior, X2, GSC88507.

Figs. 43-57. *Cyrtia alatiformis* n. sp..

43, 52. C12272; anterior, posterior, X3, GSC88509.

44-47. C22184; posterior, dorsal, anterior, lateral views, X2, GSC88512.

48-51. C22184; posterior, dorsal, anterior, lateral views, X2, GSC88513.

53-56. C22184; posterior, anterior, dorsal, lateral views, X2, GSC88514, holotype.

57. C12272; ventral interior, X2, GSC88510.

Plate 35

Figs. 1-7. *Cyrtia alatiformis* n. sp..

1, 2. C12273; ventral exterior, interior, X3, GSC88515.

3, 4. C12273; dorsal exterior, interior, X3, GSC88516.

5. C12272; interarea, X2, GSC88510.

6, 7. C12272; dorsal exterior, interior, X3, GSC88511.

Figs. 8-21. *Hedeina* sp..

8, 9. Cd12272; ventral exterior, interior, X3, GSC88517.

10. C22184; dorsal exterior, X1.5, GSC88520.

11, 12. C12273; dorsal exteior, interior, X2, GSC88522.

13, 14. C12272; ventral exterior, interior, X1.5, GSC88518.

15, 16. C12273; dorsal exterior, interior, X3, GSC88523.

17, 21. C12272; dorsal exterior, interior, X1.5, GSC88519.

18, 19. C22184; ventral exterior, interior, X1.5; GSC88521.

20. C22187; dorsal exterior, X1.5, GSC88524.

Figs. 22-33. *Janius occidentalis* Boucot, Johnson, and Zhang.

22, 23. C12273; dorsal exterior, interior, X1.5, GSC88529.

24, 25, 29, 30. C22184; ventral, dorsal, anterior, posterior views, X1.5, GSC88525.

26, 31. C22187; ventral exterior, dorsal interior, X1.5, GSC88527.

27, 28. C22184; dorsal exterior, interior, X1.5, GSC88526.

32, 33. C22187; ventral exterior, interior, X1, GSC88528.

Plate 36

Figs. 1-10. *Janius occidentalis*.

1. C12273; dorsal exterior, X1.5, GSC88530.

2. C12273; ventral exterior, X1.5, GSC88531.

3, 4. C12273; dorsal exterior, interior, X1.5, GSC88532.

5-7. C12272; ventral exterior, anterior, view, interior, X1.5, GSC88533.

8, 9. C12272; ventral exterior, interior, X1, GSC88534.

10. C12272; dorsal exterior, X1, GSC88535.

Figs. 11-36. *Spurispirifer hughesi* n. sp..

11. C12272; dorsal exterior, X6, GSC88538.

12, 13. C12273; dorsal exterior, interior, X3, GSC88536.

14, 15. C12273; ventral exterior, interior, X3, GSC88537.

16, 17. C12272; ventral exterior, interior, X3, GSC88539.

18-21. C12272; anterior, posterior, dorsal, ventral views, X3, GSC88540.

22, 23. C12272; ventral exterior, interior, X3, GSC88541.

24, 25. C12272; ventral exterior, interior, X3, GSC88542.

26, 27, 36. C12272; dorsal interior, oblique view, X3, exterior, X5, GSC88543.

28, 33. C12272; ventral exterior, interior, X3, GSC88544.

29, 30. C12272; dorsal exterior, interior, X3, GSC88545.

31, 32. C12272; dorsal exterior, interior, X3, GSC88546.

34, 35. C12272; ventral exterior, interior, X3, GSC88547, holotype.

Plate 37

Figs. 1-20, 22, 26, 30. *Spirinella struszi* n. sp..

1-4. C22187; ventral, dorsal, anterior, lateral views, X4, GSC88549.

5, 6. C12272; ventral, dorsal views, X4, GSC88552.

7, 8. C12272; dorsal exterior, interior, X4, GSC88553.

9, 10. C12272; ventral exterior, interior, X4, GSC88554.

11, 12. C12272; ventral exterior, interior, X4, GSC88555.

13, 14. C22184; dorsal exterior, interior, X2, GSC88548.

15. C12272; dorsal interior, X6, GSC88556.

16. C12272; dorsal interior, X6, GSC88557.

17. C12272; dorsal interior, X6, GSC88558.

18. C22187; posterior view, X5, GSC88550.

19, 20. C12272; ventral exterior, interior, X2, GSC88559.

22, 26, 30. C22187; posterior, ventral, dorsal views, X5, GSC88551, holotype.

Figs. 21, 23-25, 27-29, 31-33. *Howellella* sp..

21, 25. C12273; dorsal exterior, interior, X5, GSC88560.

23, 24. C22187; dorsal exterior, interior, X5, GSC88562.

27, 28. C12273; ventral exterior, interior, X5, GSC88561.

29, 30. C22187; ventral exterior, interior, X3, GSC88563.

31, 32. C12272; ventral exterior, interior, X3, GSC88564.

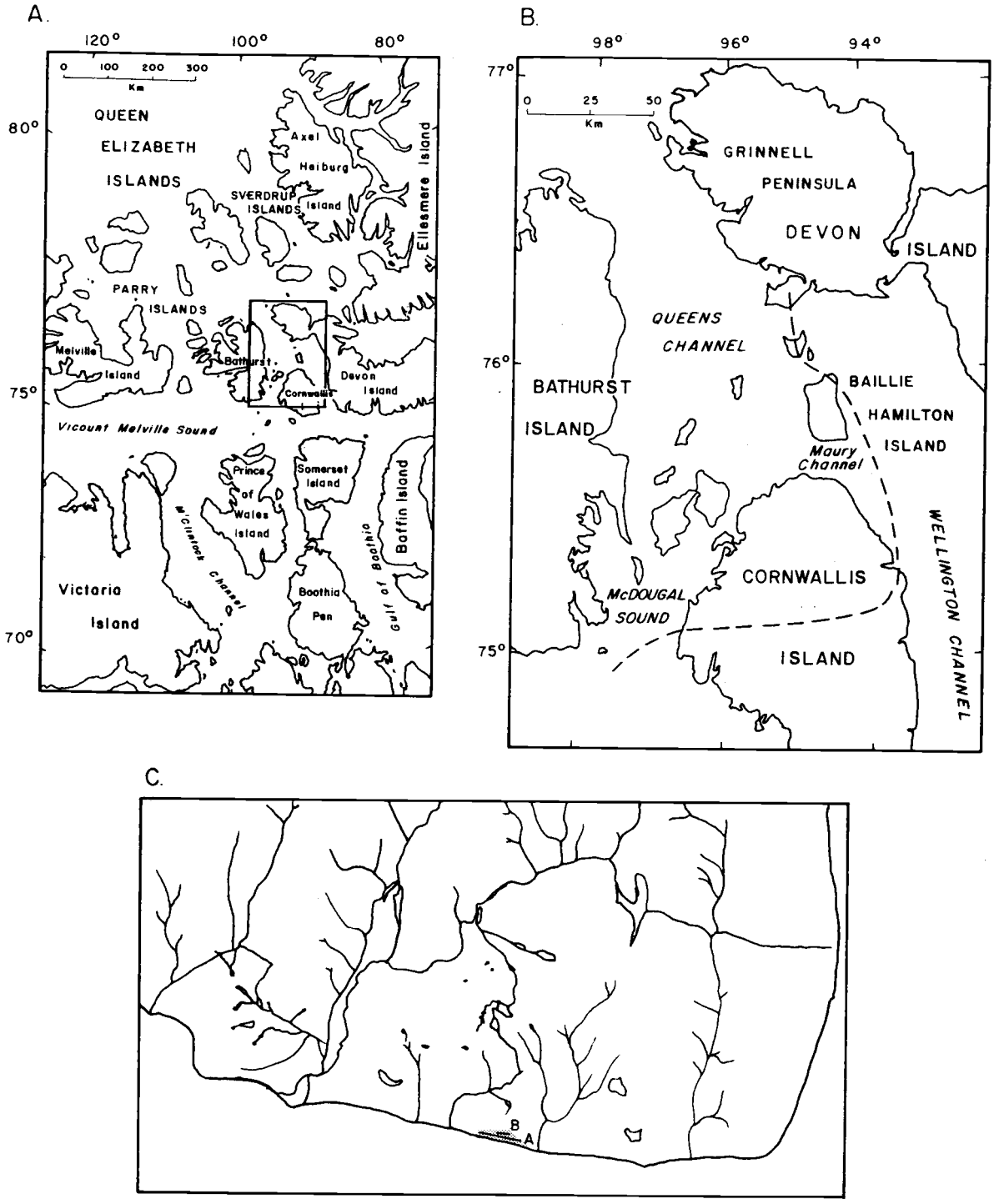

Figure 1. Locality map. A--index map, B--map showing the facies boundary separating graptolitic rocks of the Cape Phillips Formation in the northwest from platform carbonate rocks in the southeast (this figure was kindly provided by Thorsteinsson), C--map showing the location of sections a and b on the south coast of Baillie Hamilton Island.

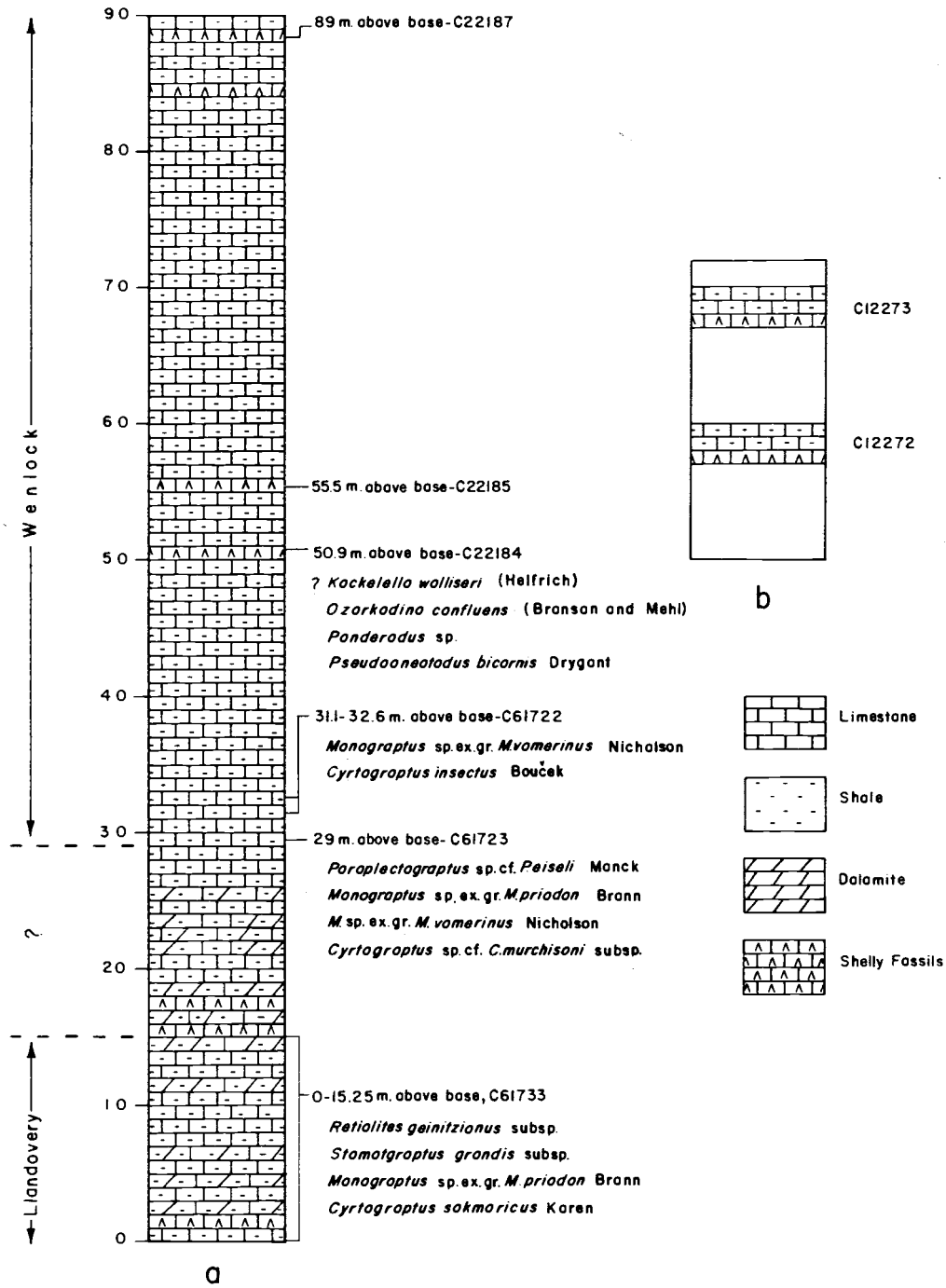

Figure 2. Lithostratigraphic section. Sections a and b showing general lithology and stratigraphic positions of fossil collections (this figure was kindly provided by Thorsteinsson).

Species Name	Size	Outline	Ventral Carina	Dorsal Sulcus	Costellae	Dorsal Interior	Age
carinata n. sp.	medium	transversely semicircular	present	deep	coarse, angular semifascicostellae	no median ridge	Early Wenlockian
gamma n. sp.	medium	transversely subquadrate	no	deep	coarse fascicostellae	brachiophore plates high	Early Wenlockian
delta JOHNSON et al. 1976	medium	transversely suboval	no	shallow	medium coarse semifascicostellae	brachiophore plates high	Ludlovian
tubulata (LINDSTRÖM) 1861	large	transversely subelliptical	no	medium	subround semifascicostellae	no median ridge	Ludlovian
kosovensis HAVLÍČEK 1977	large	transversely subquadrate	no	shallow	coarse, angular semifascicostellae	?	Late Ludlovian
submurifer JOHNSON et al. 1973	small	transversely subquadrate	weak	deep	subangular semifascicostellae	median ridge long	Lochkovian
hitchcocki WALMSLEY et al. 1969	medium	subcircular	no	weak	medium coarse semifascicostellae	median ridge short	Pragian
hazardensis WALMSLEY et al.	small	transversely elliptical	no	non	medium coarse semifascicostellae	no median ridge	Eifelian

Table 1. Diagnostic characters of fascicostellate species of *Salopina*.

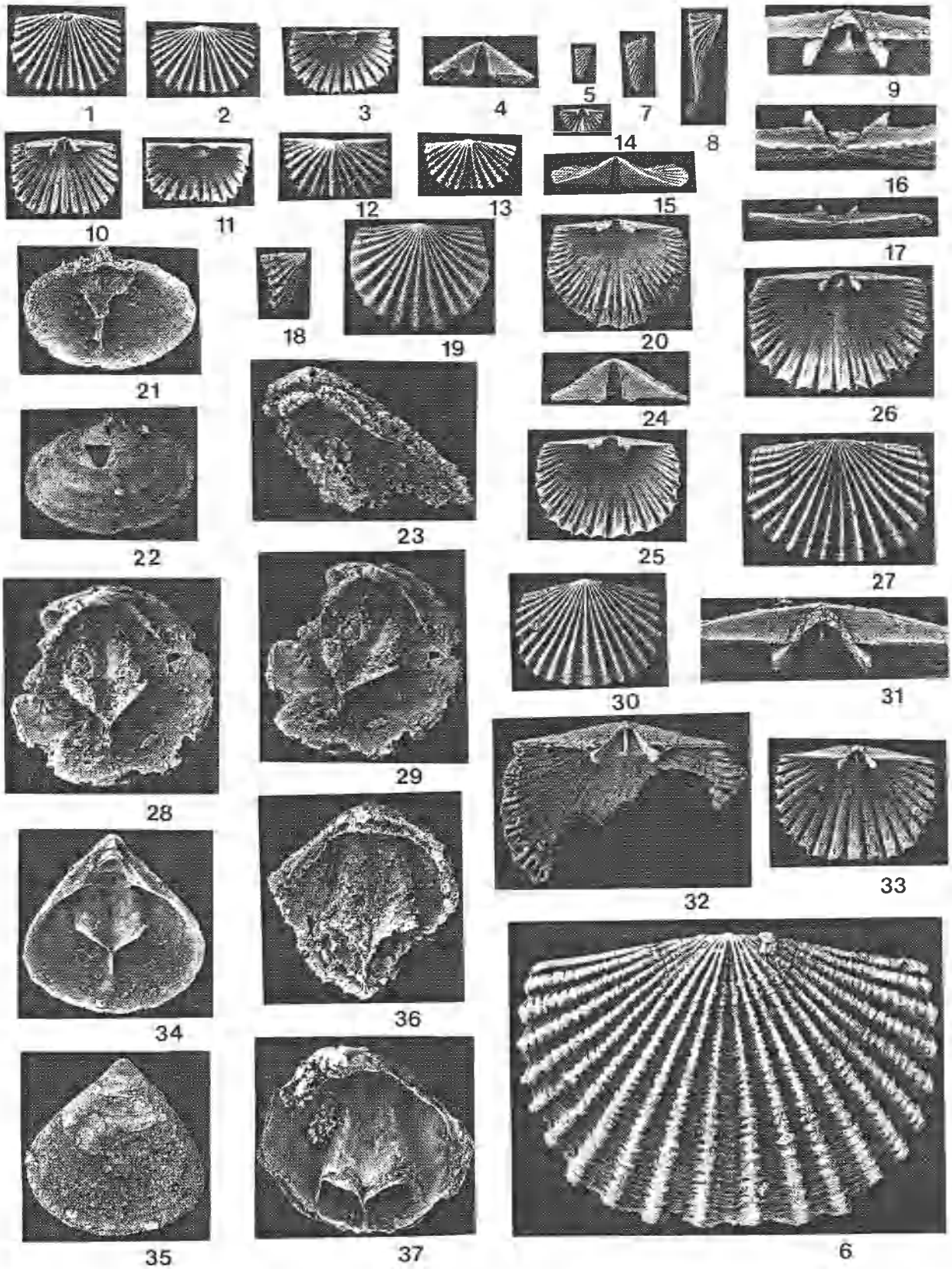
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PLATE 2


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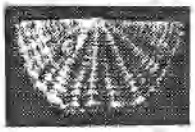
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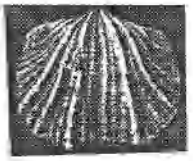
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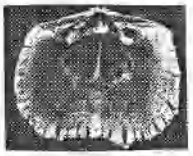
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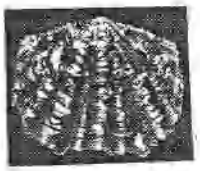
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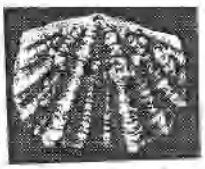
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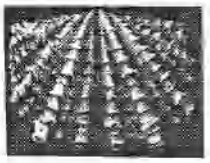
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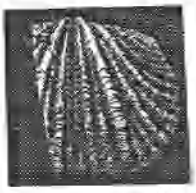
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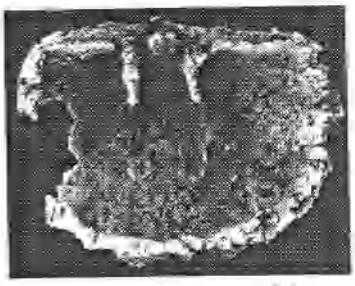
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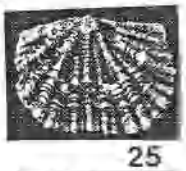
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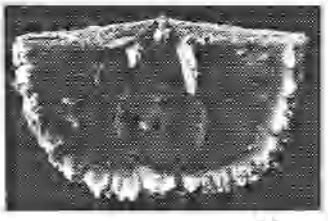
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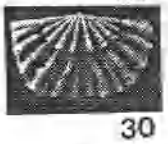
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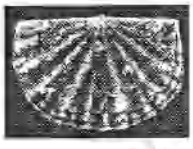
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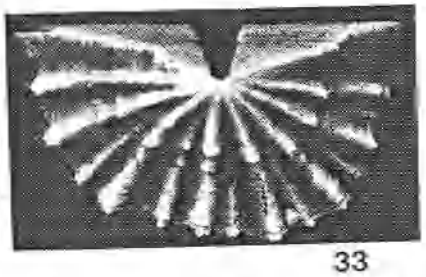
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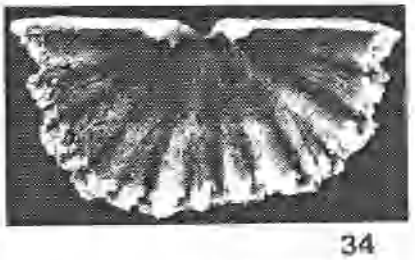
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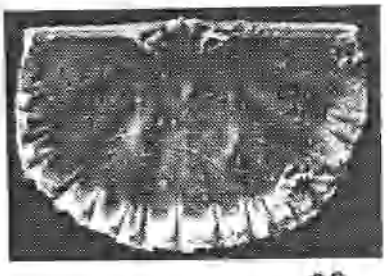
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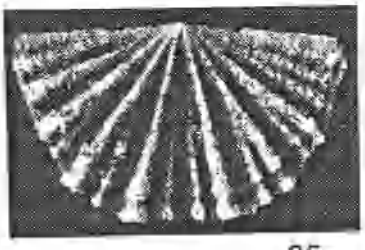
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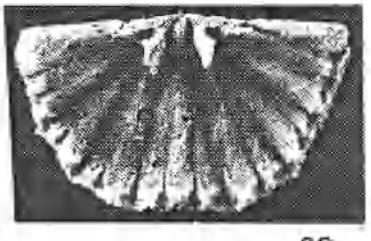
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PLATE 3

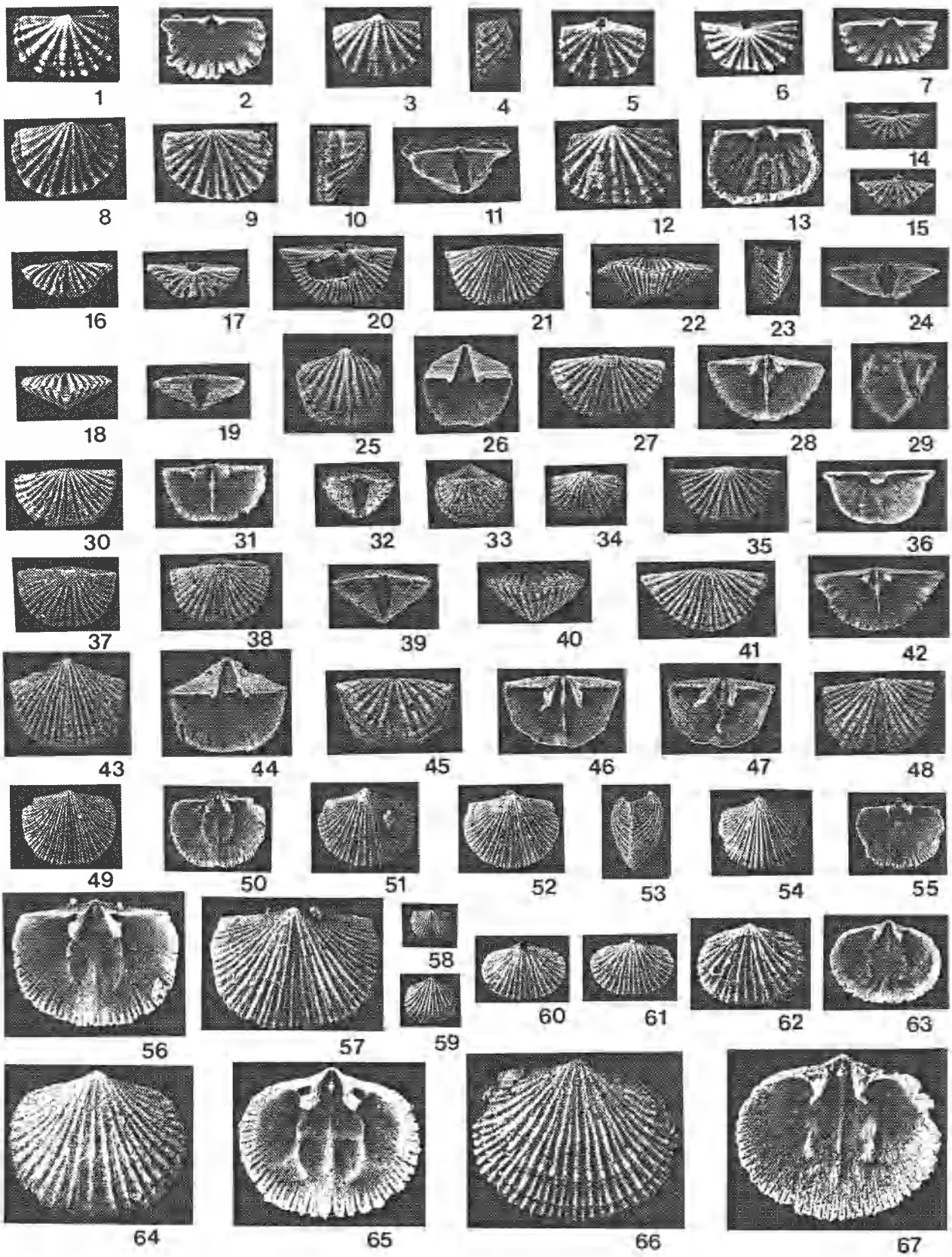
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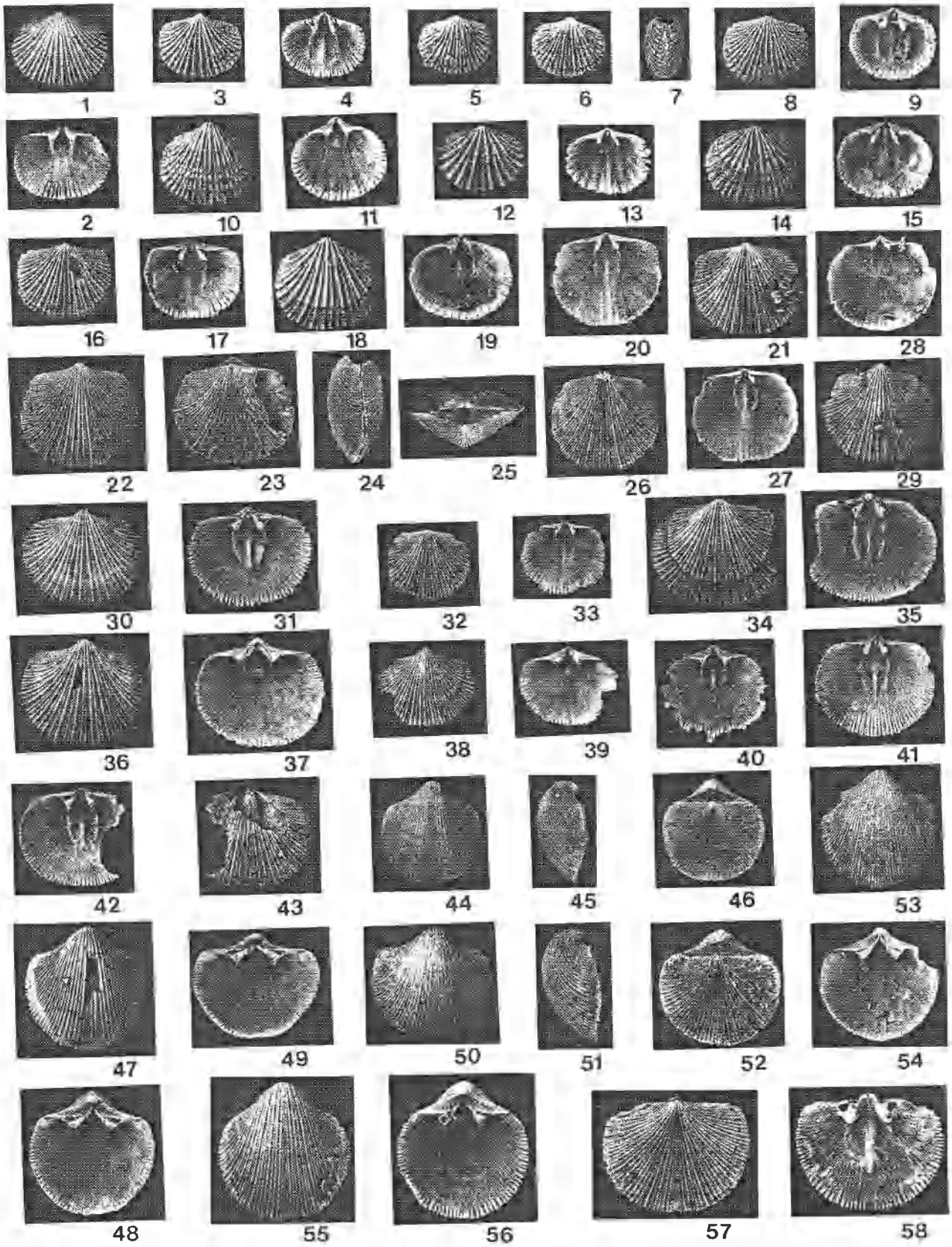
PLATE 4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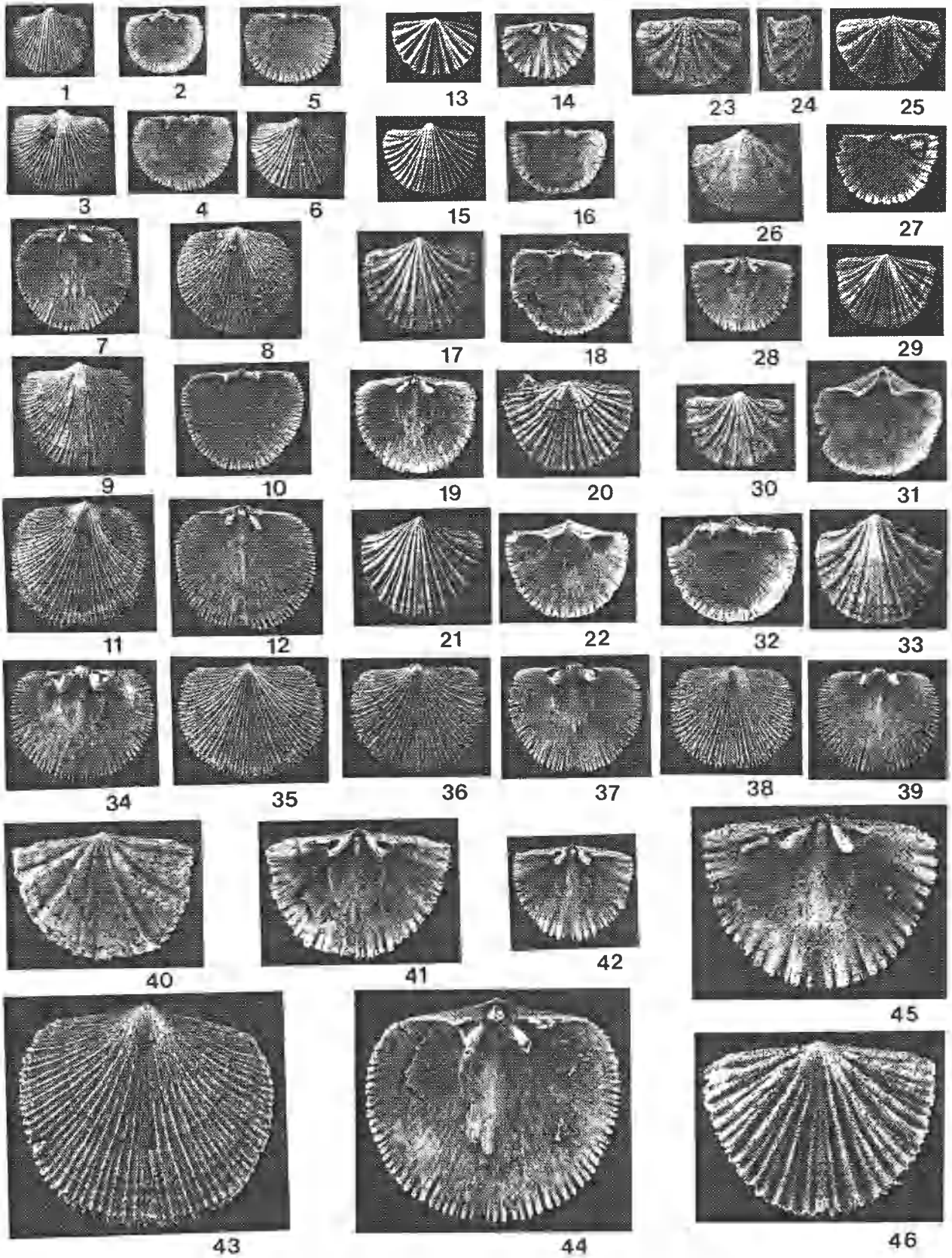
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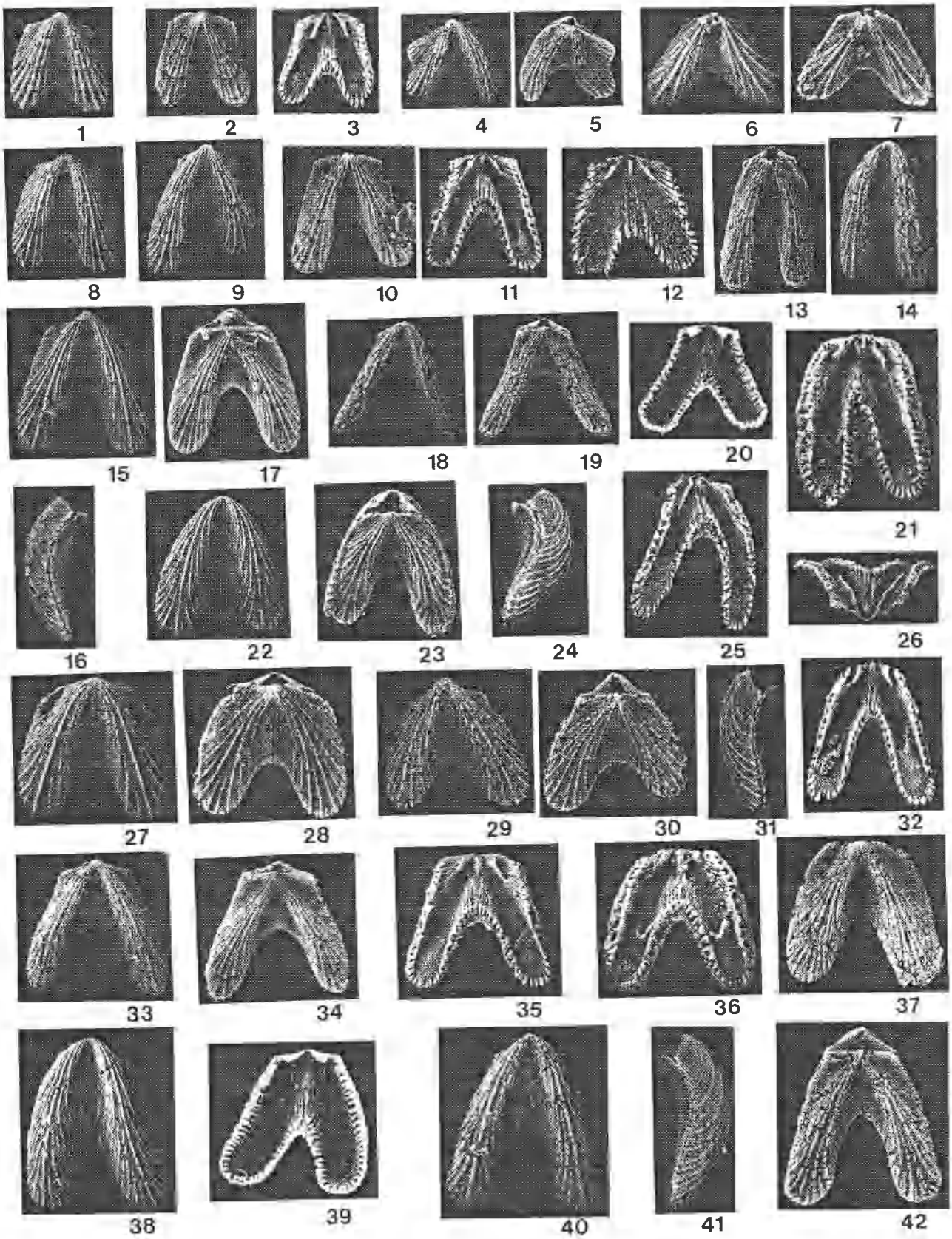
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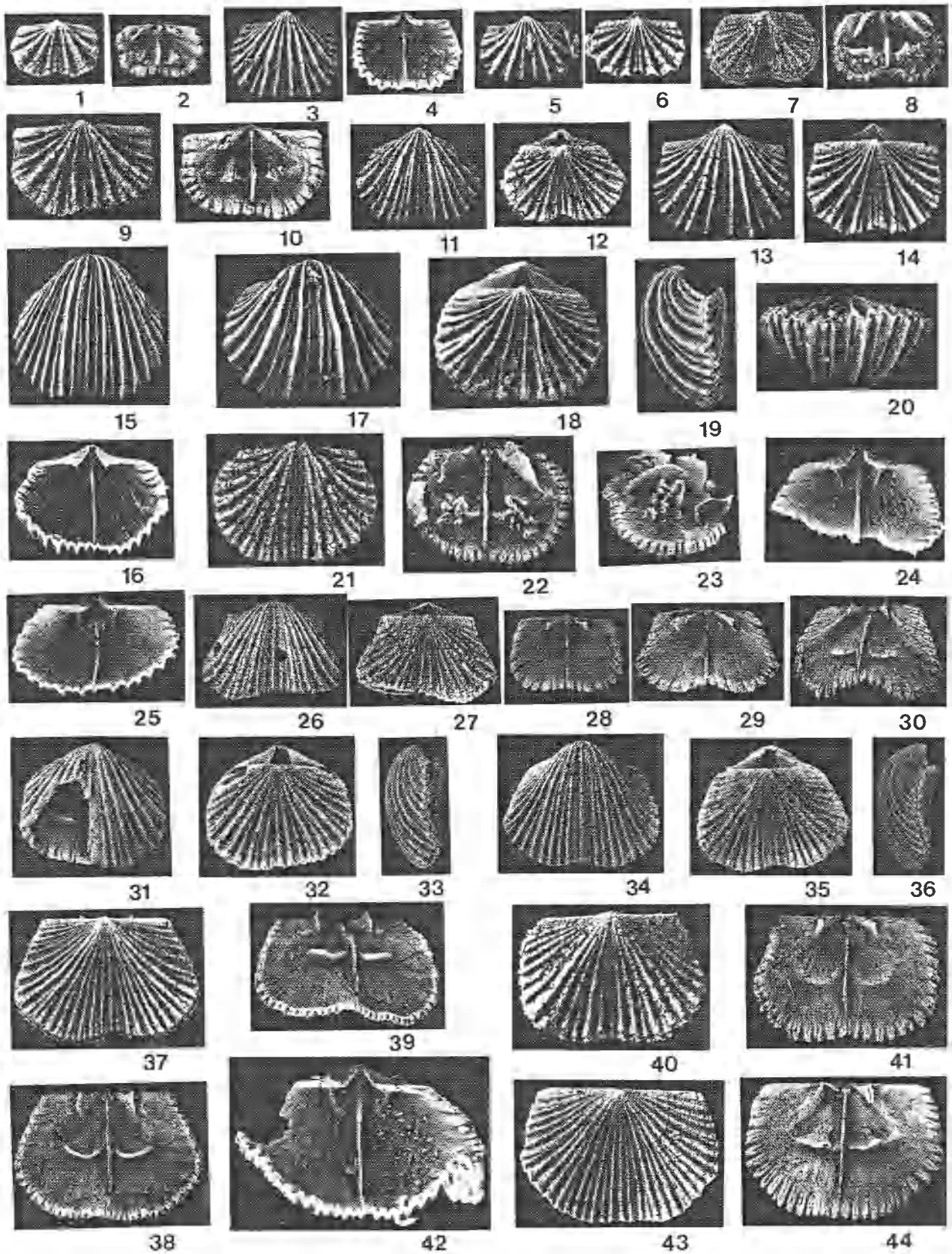
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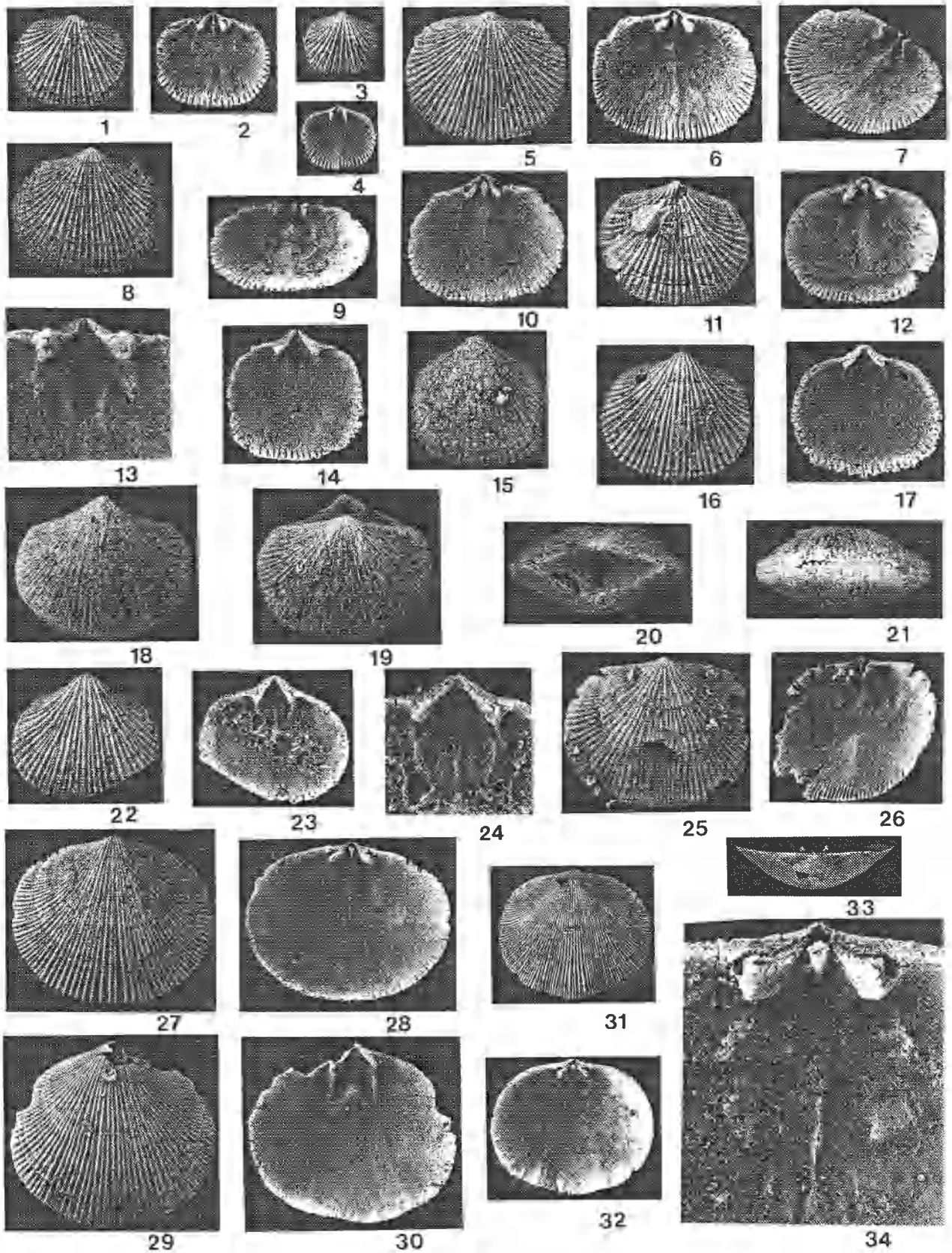
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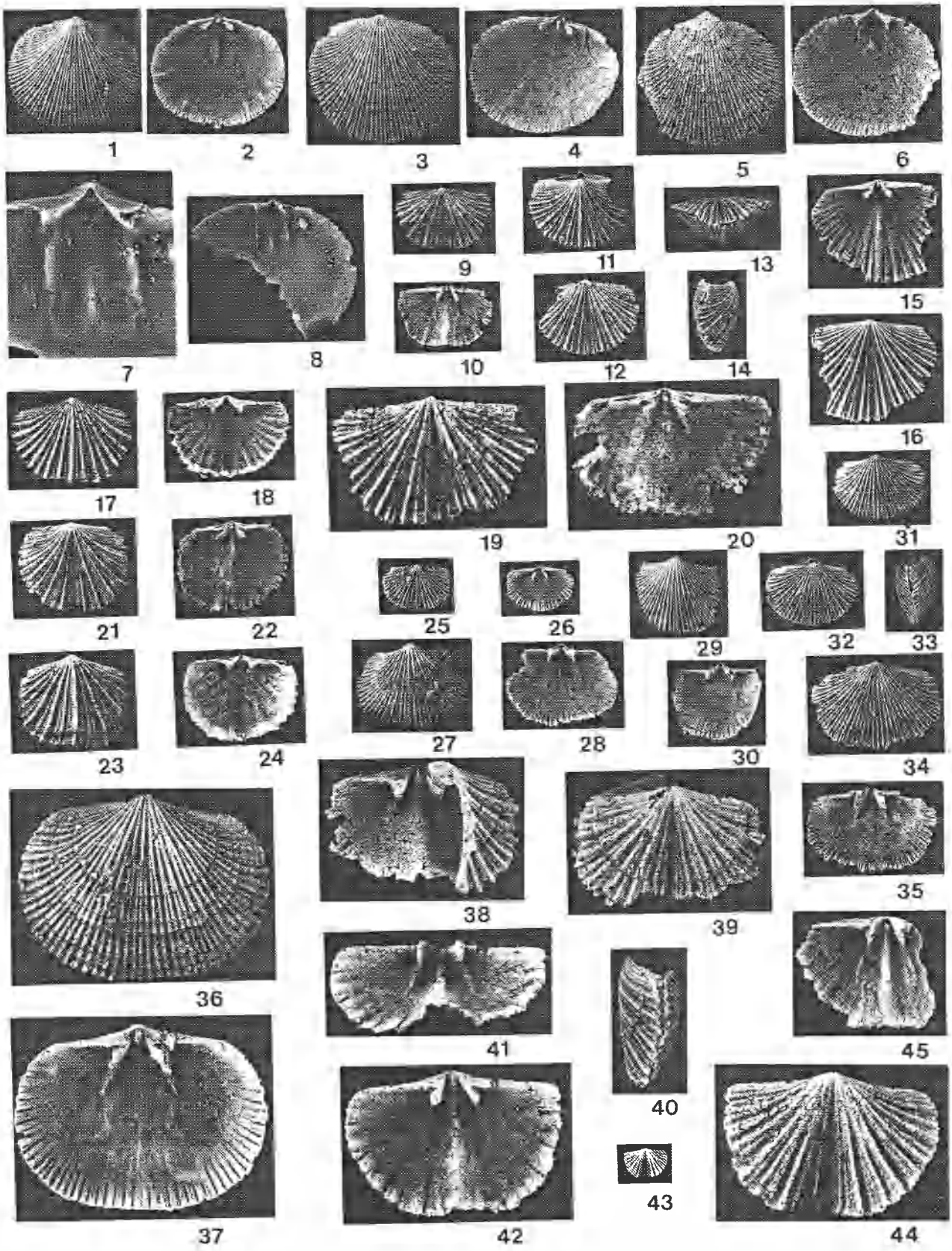
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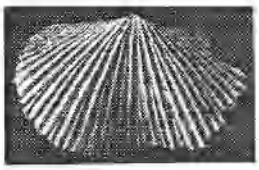
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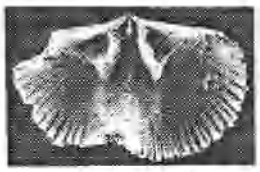
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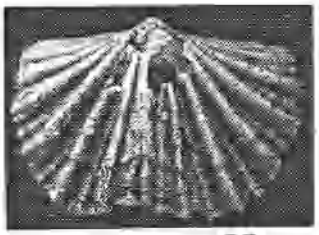
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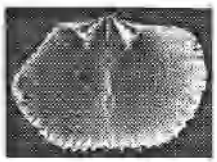
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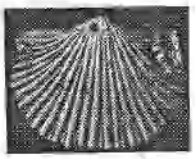
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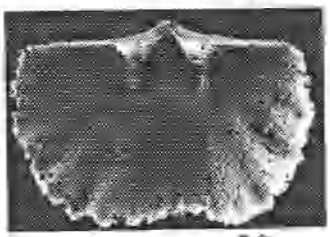
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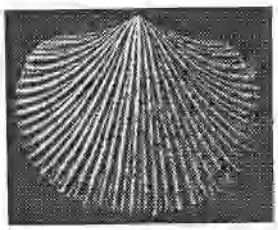
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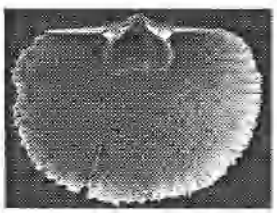
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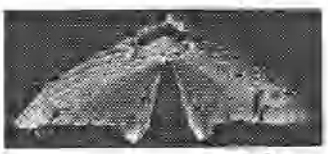
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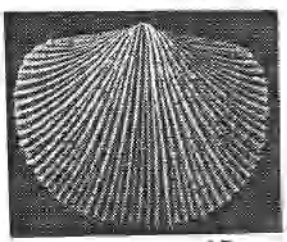
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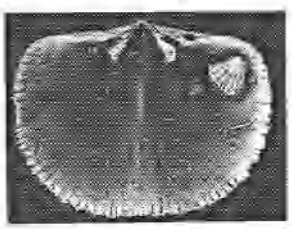
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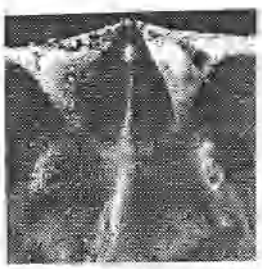
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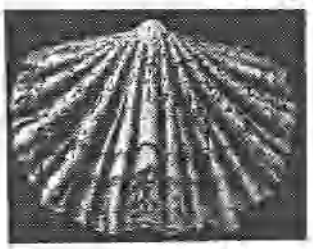
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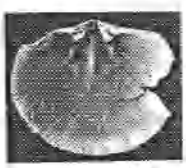
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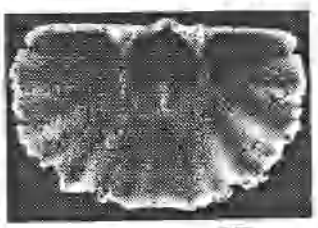
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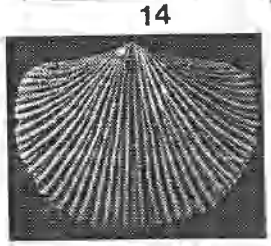
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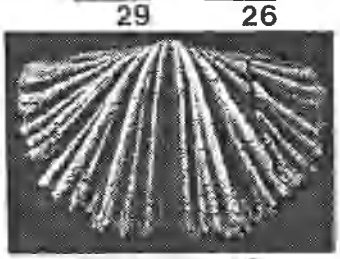
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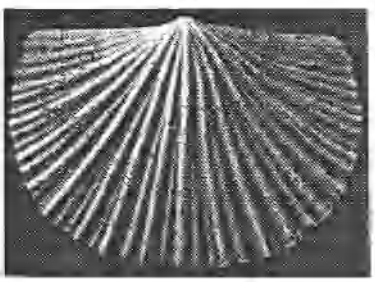
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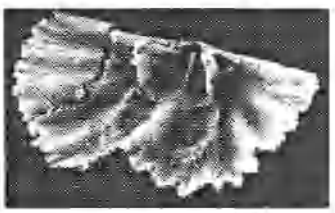
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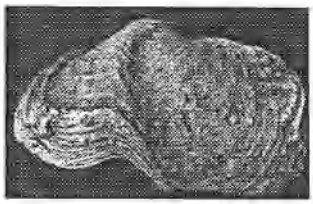
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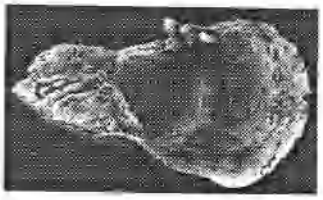
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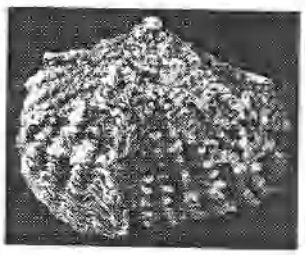
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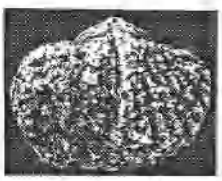
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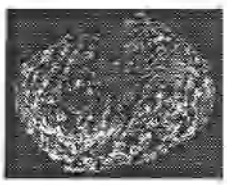
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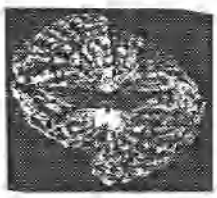
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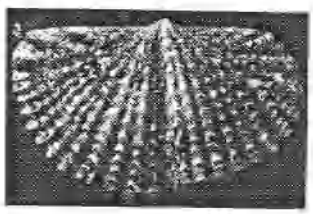
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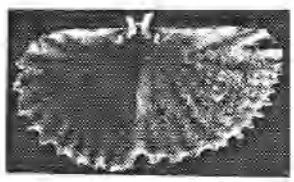
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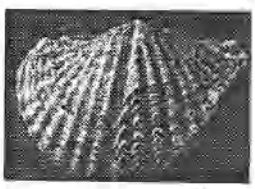
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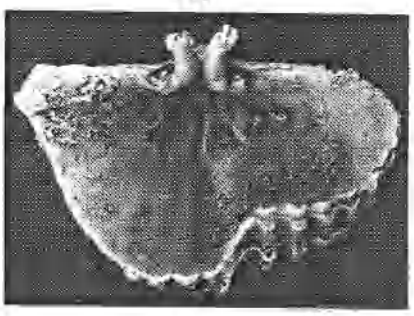
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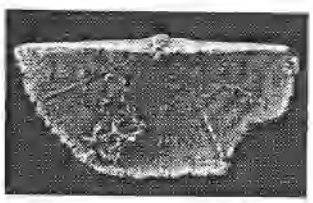
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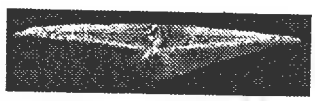
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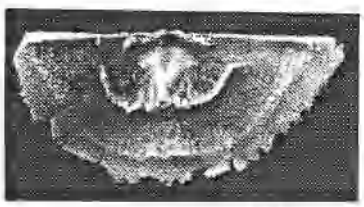
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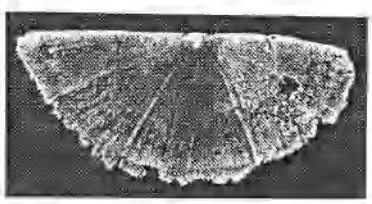
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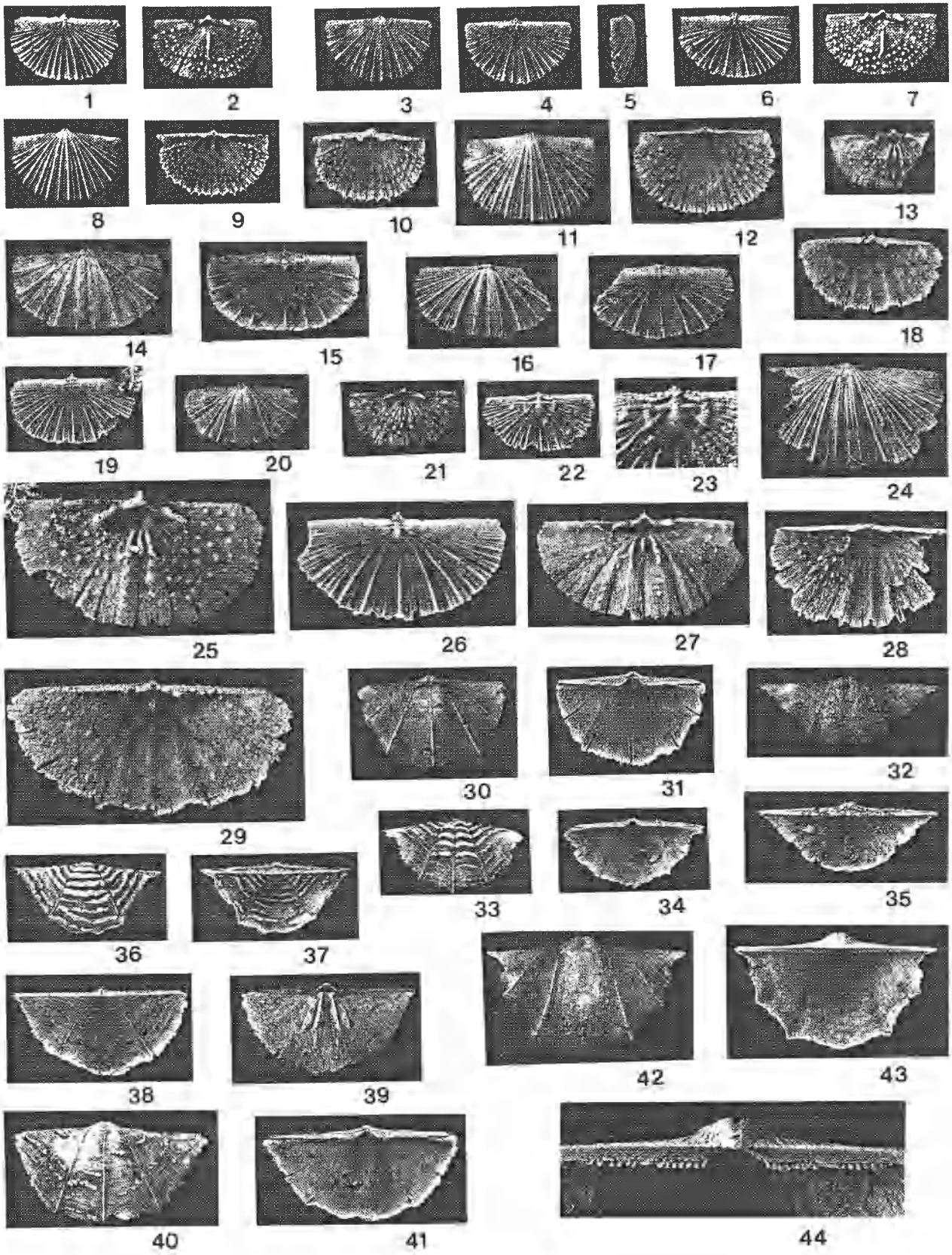
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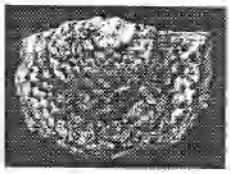
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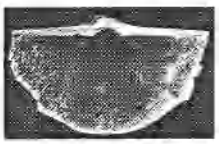
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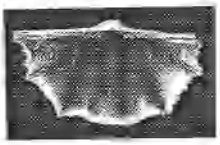
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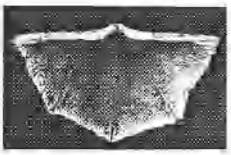
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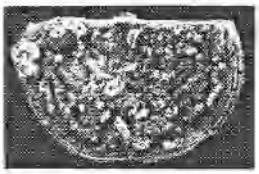
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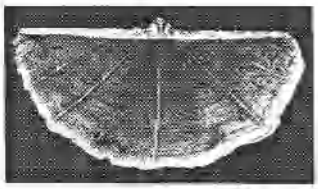
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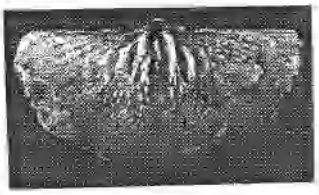
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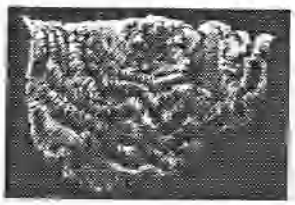
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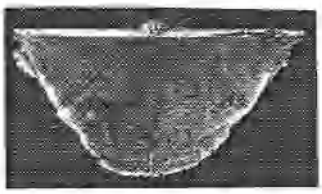
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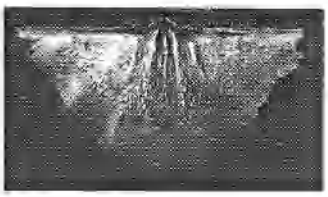
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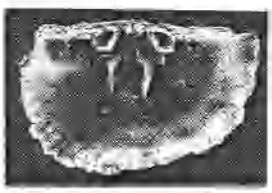
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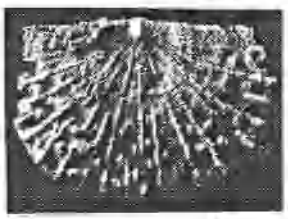
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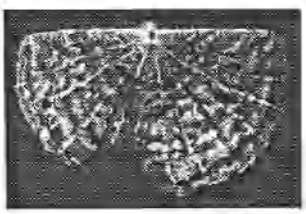
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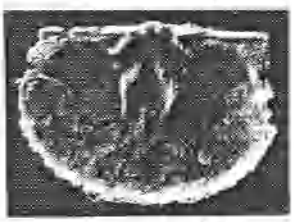
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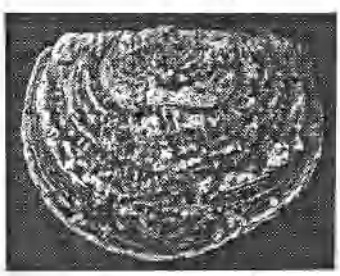
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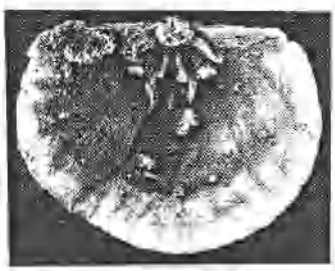
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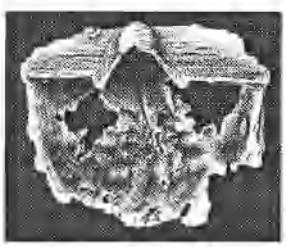
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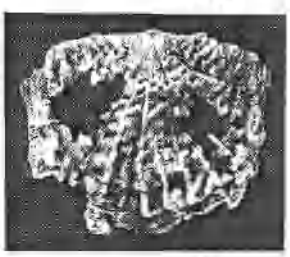
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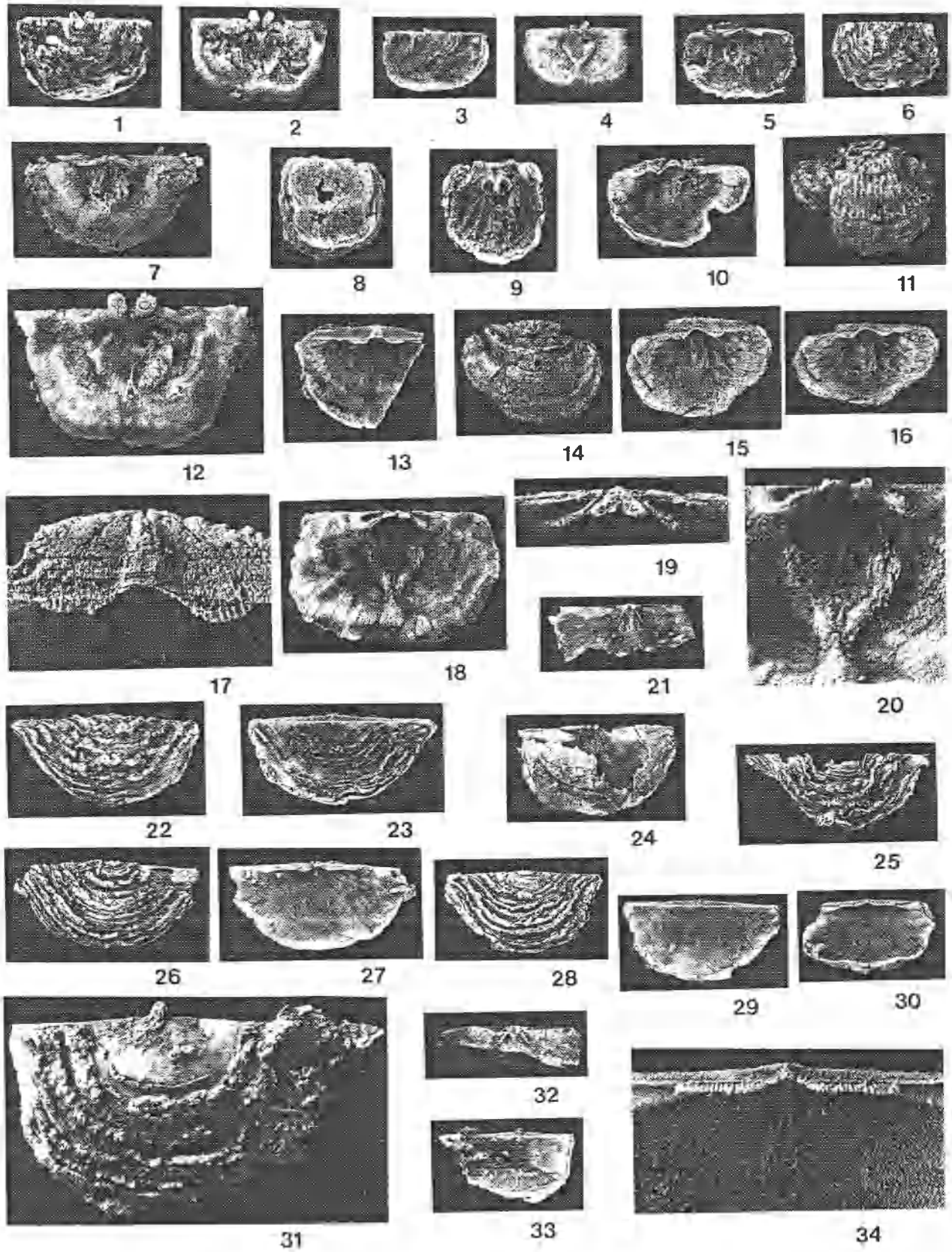
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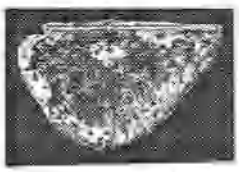
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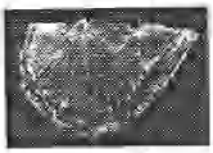
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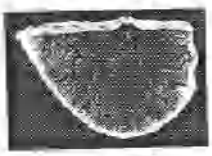
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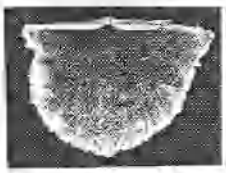
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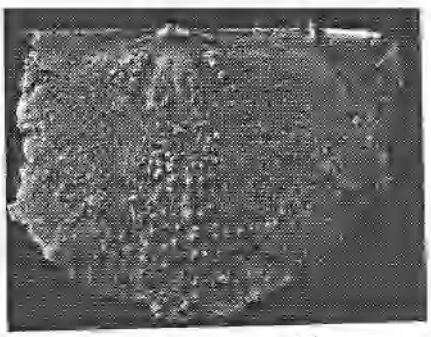
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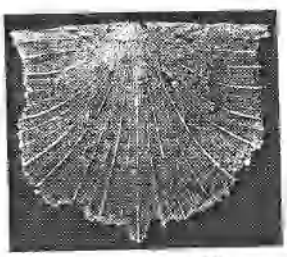
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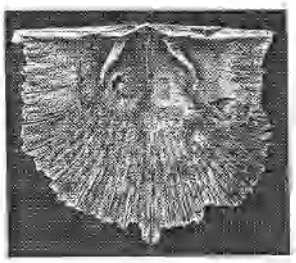
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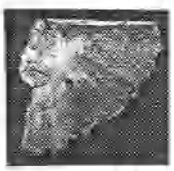
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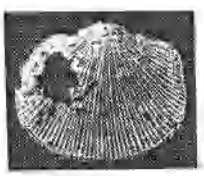
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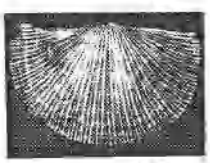
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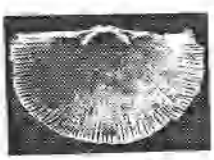
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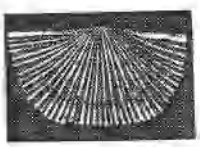
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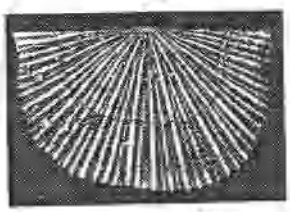
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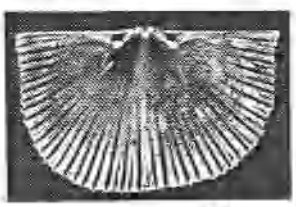
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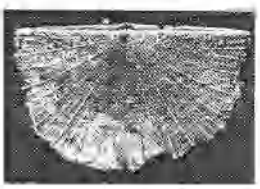
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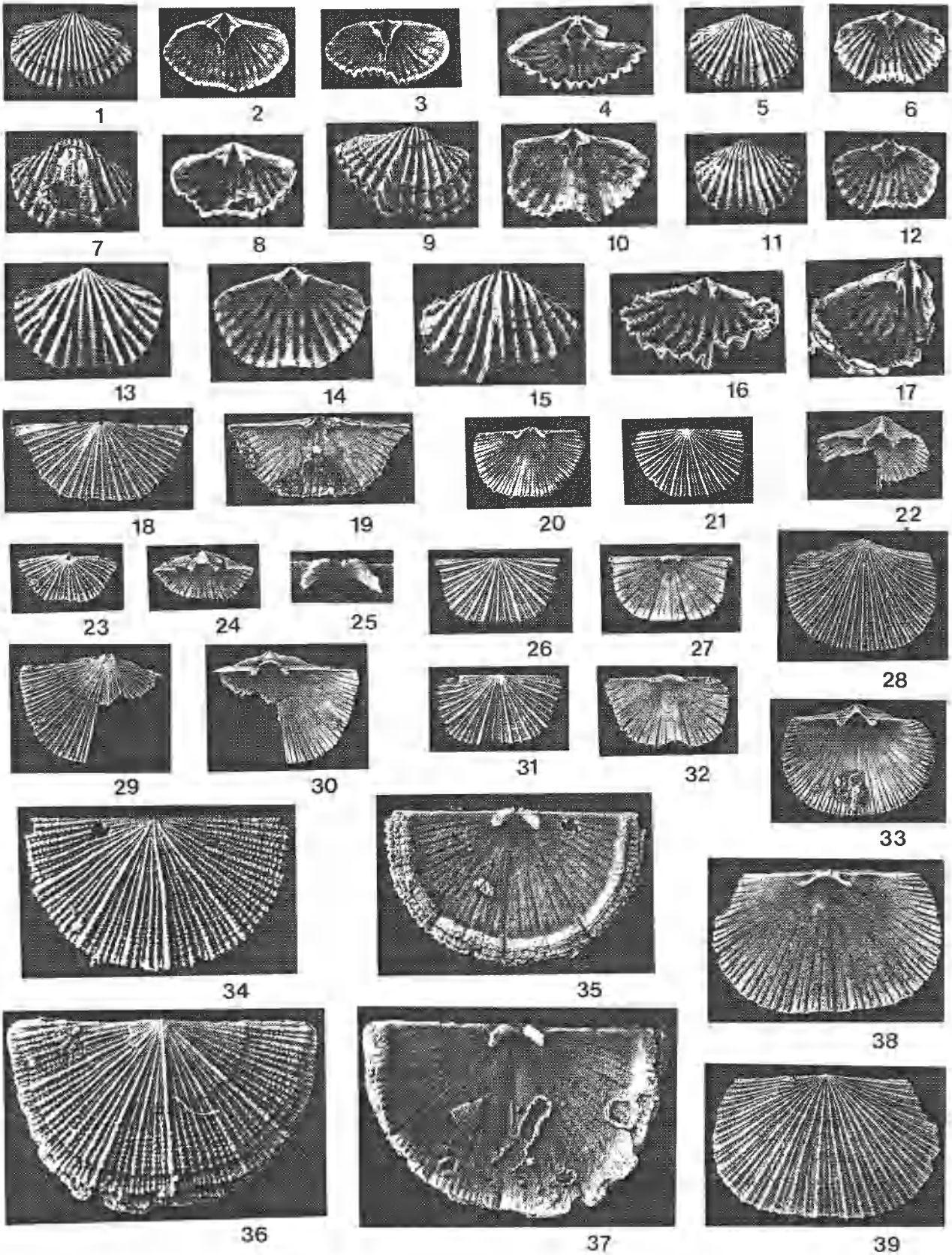
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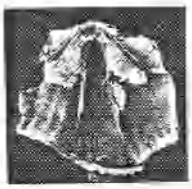
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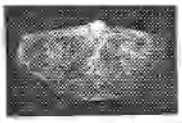
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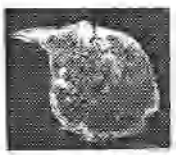
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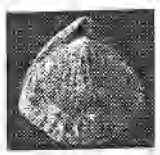
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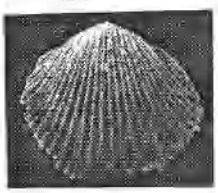
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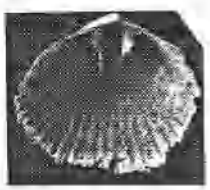
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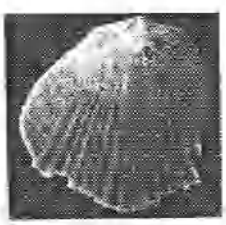
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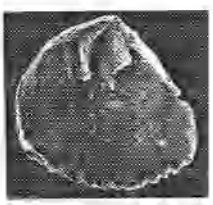
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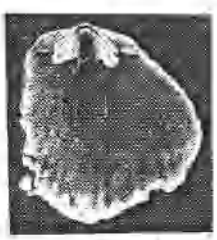
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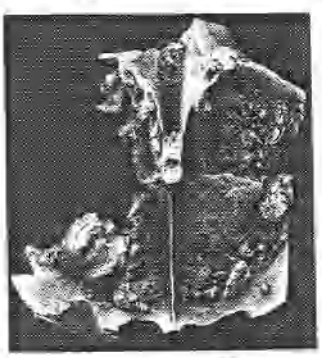
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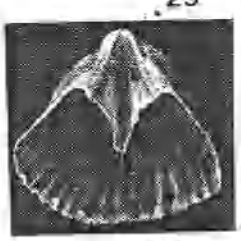
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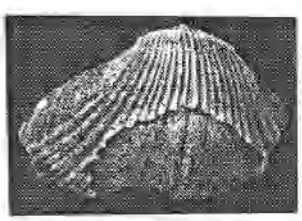
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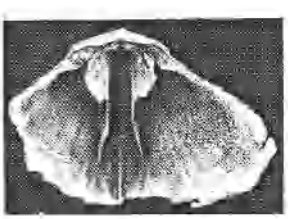
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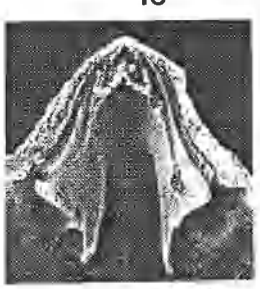
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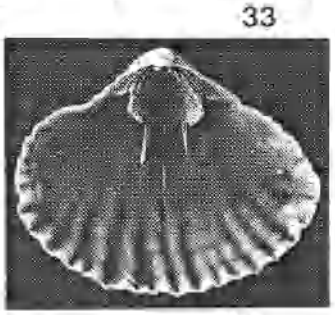
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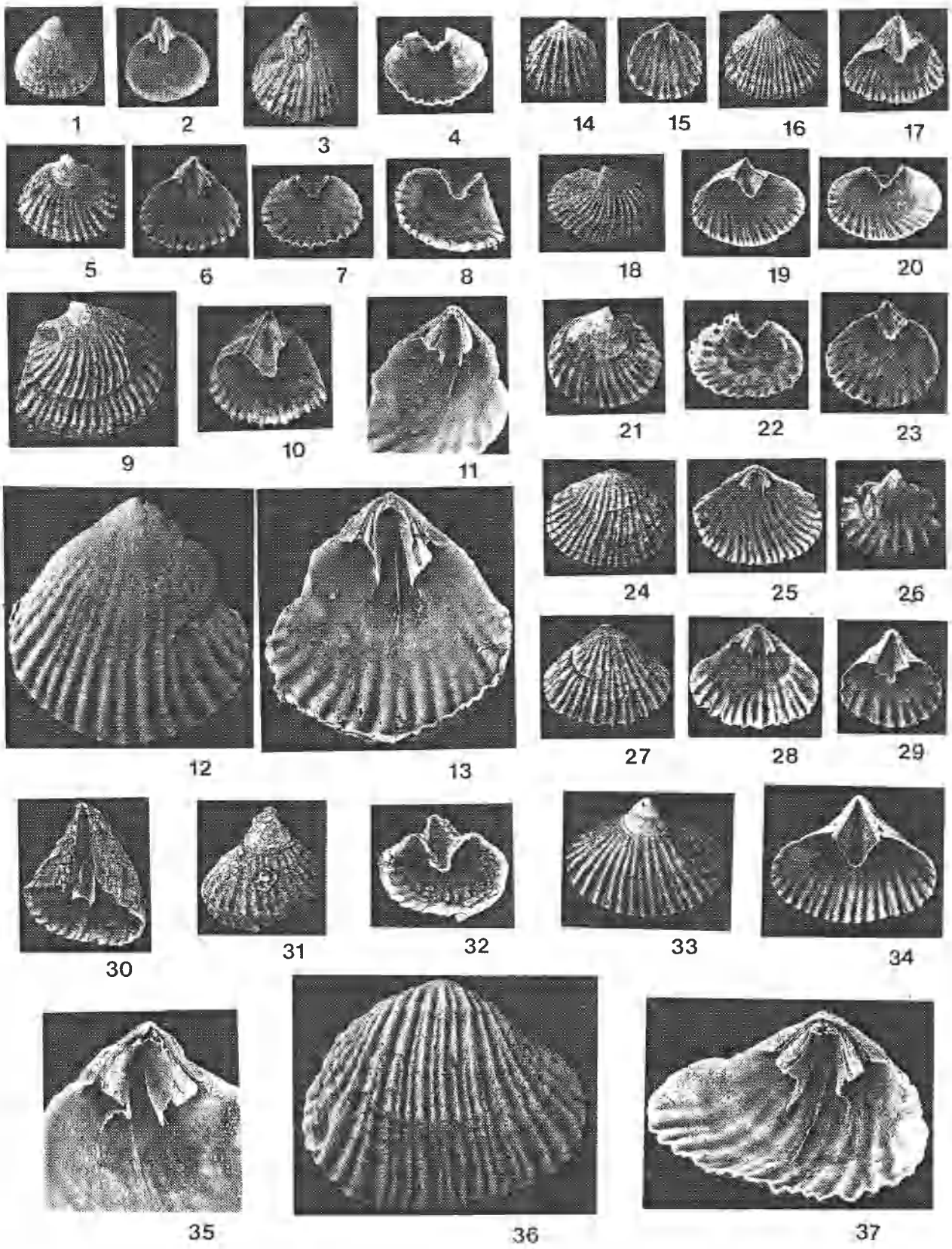
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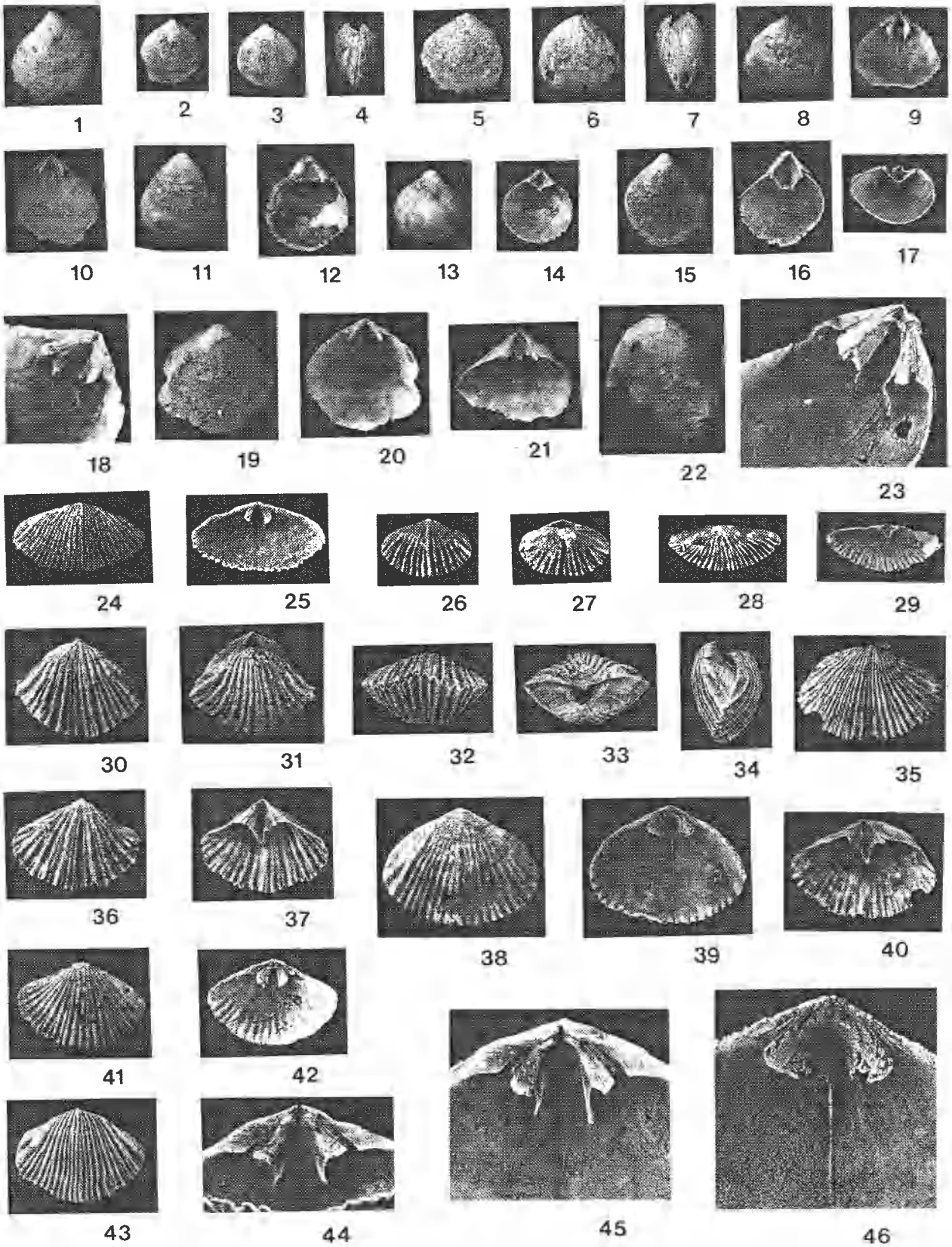
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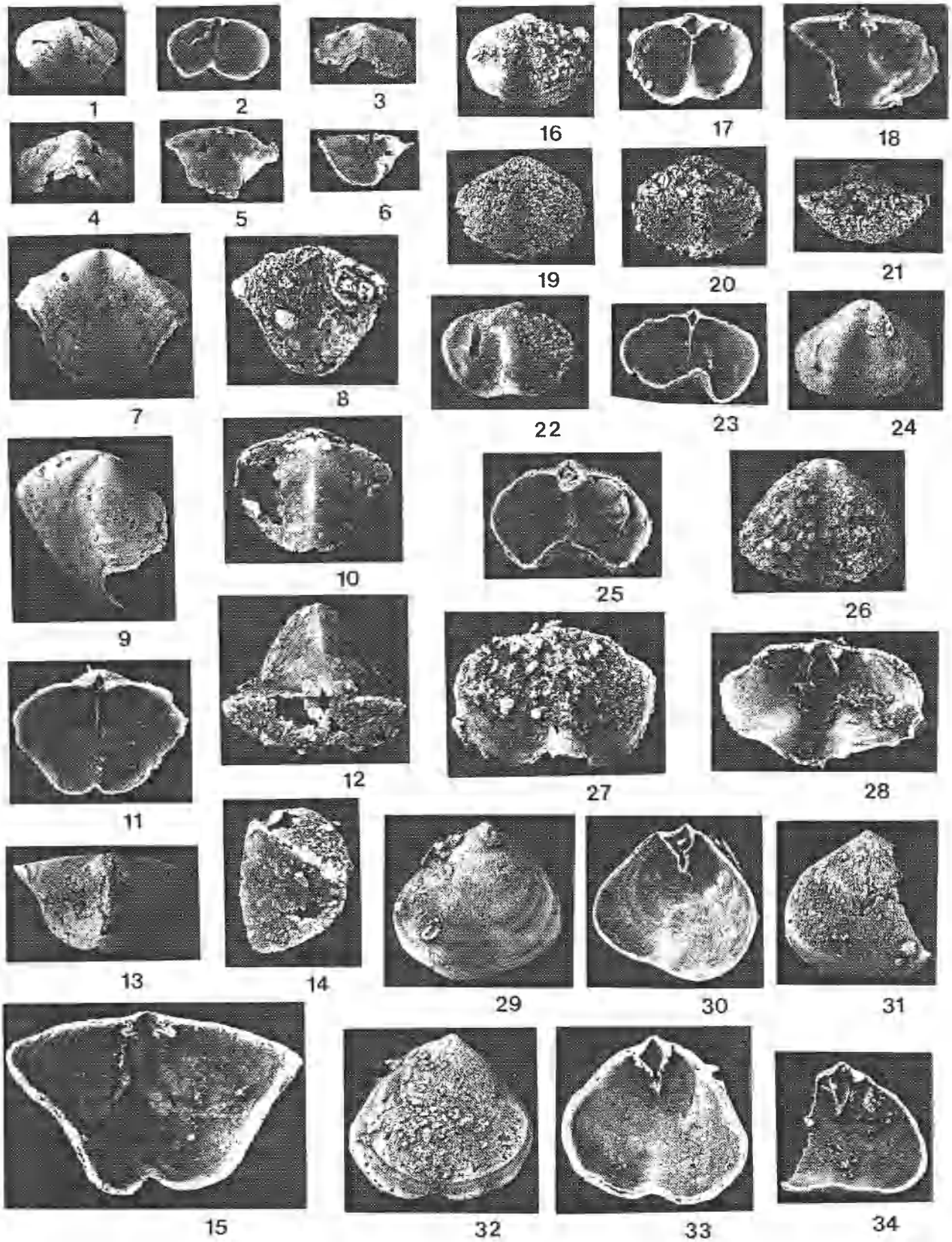
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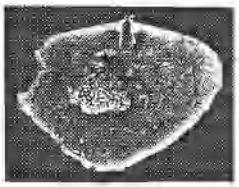
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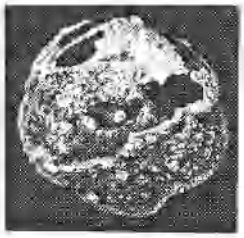
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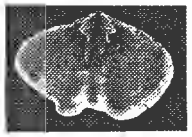
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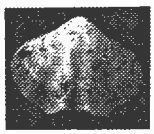
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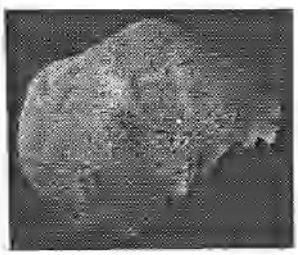
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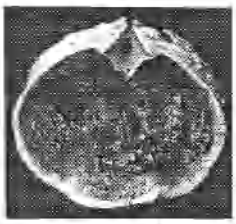
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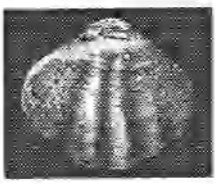
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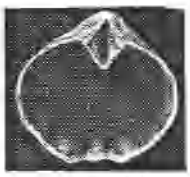
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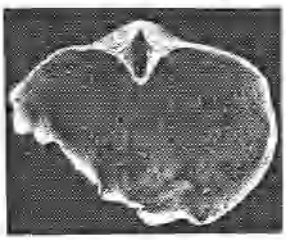
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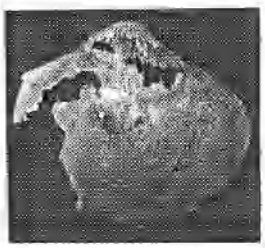
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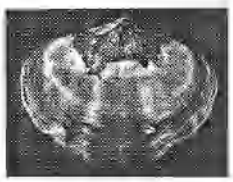
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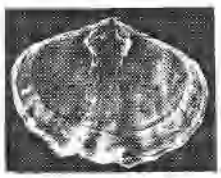
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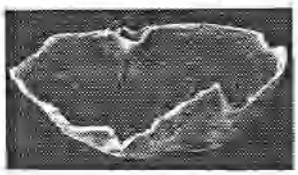
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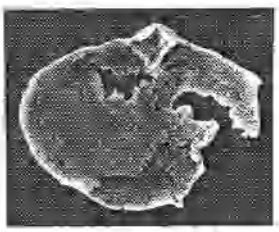
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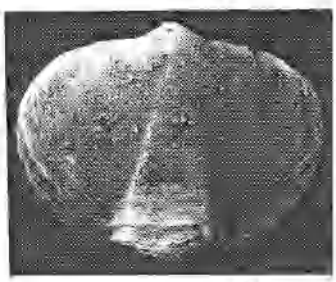
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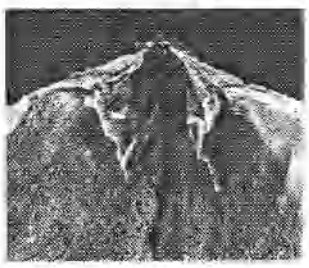
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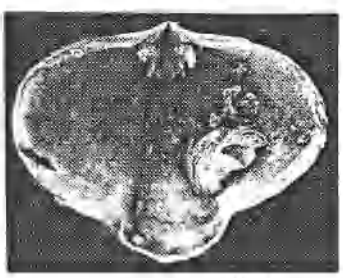
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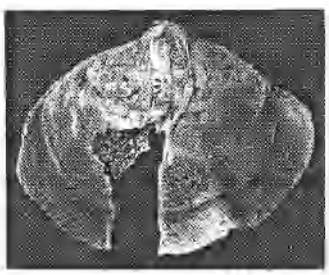
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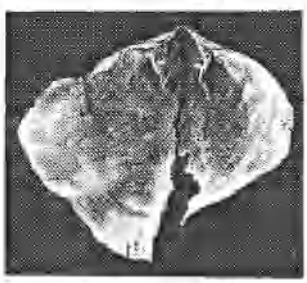
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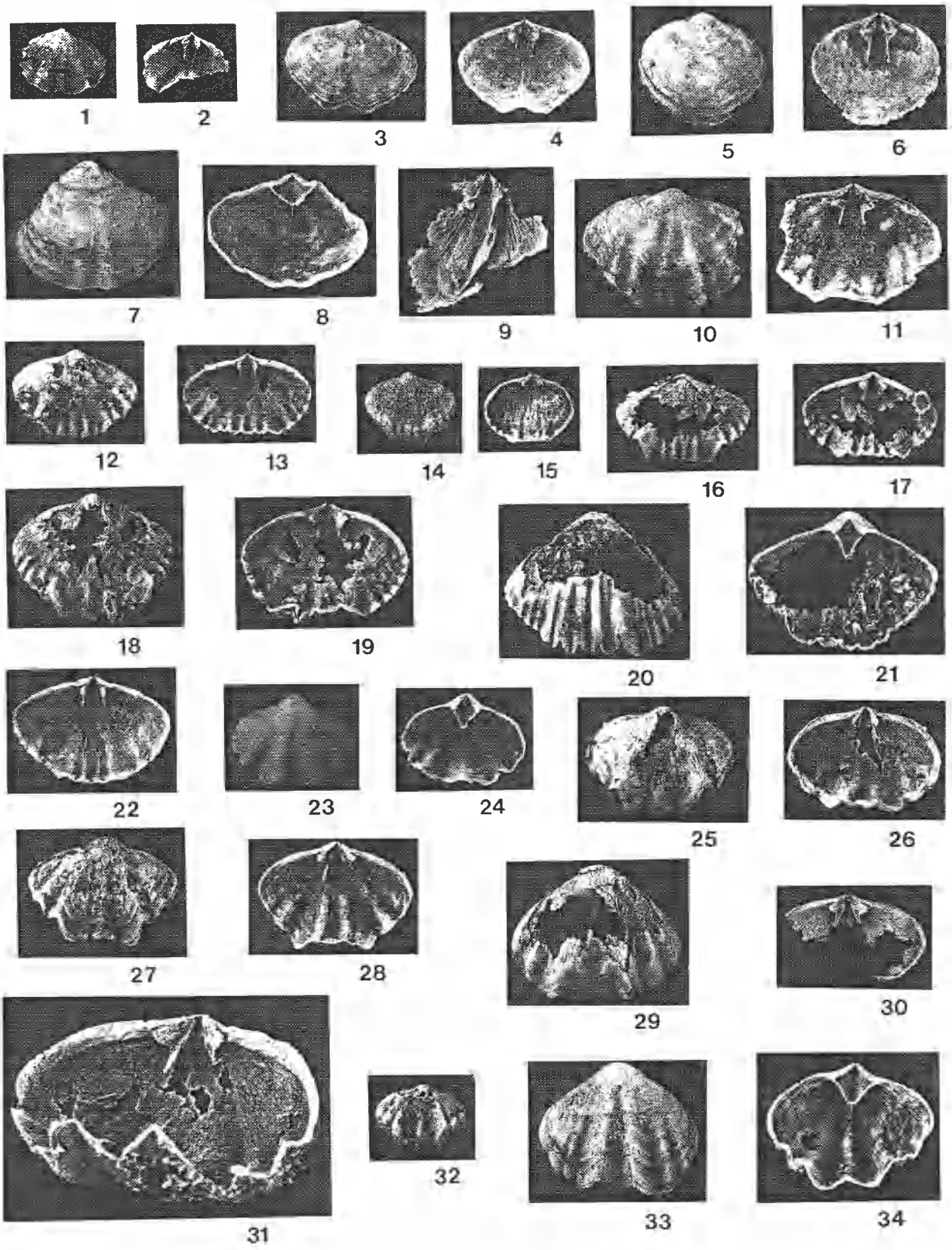
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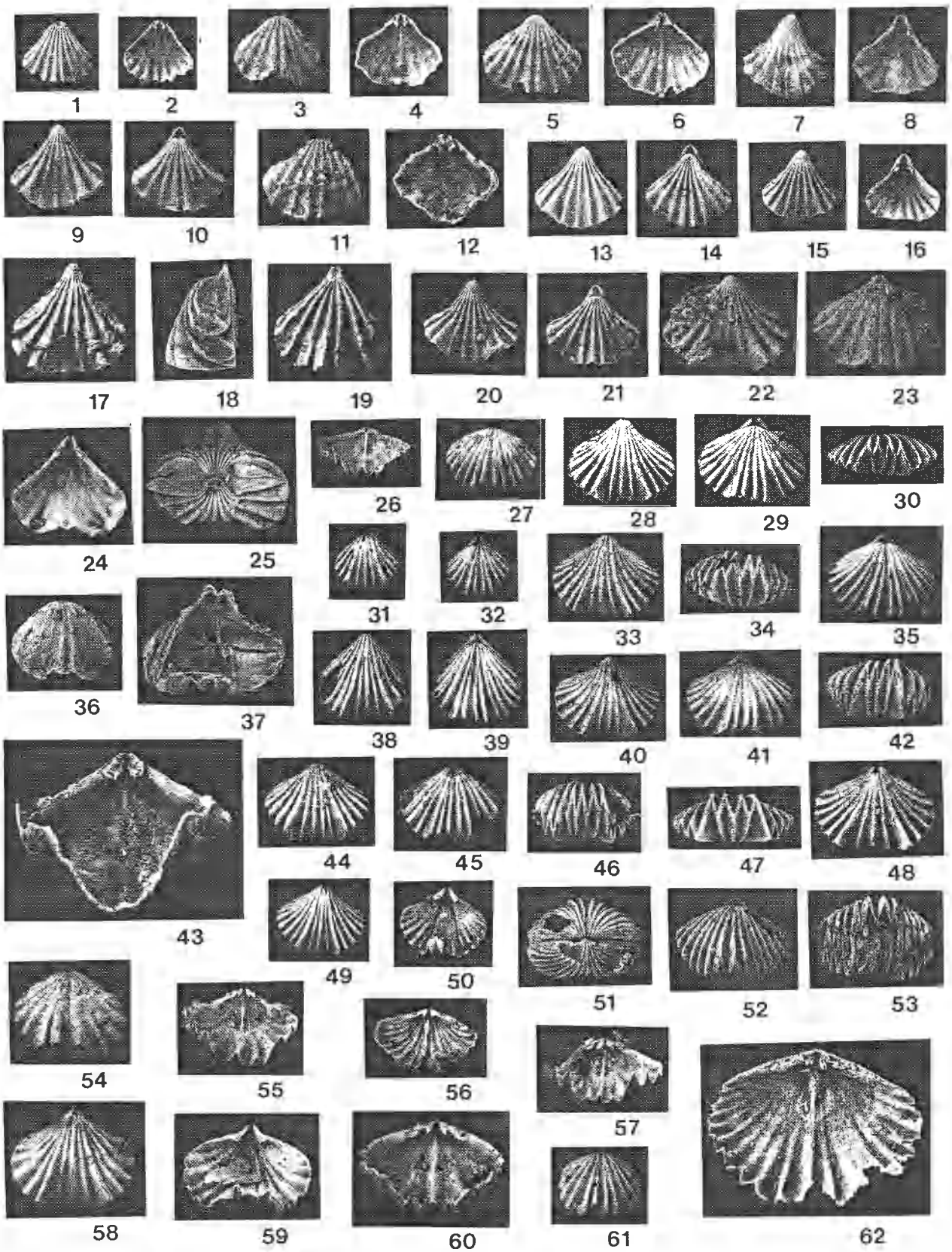
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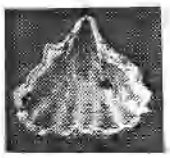
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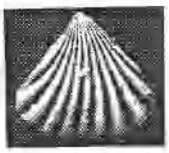
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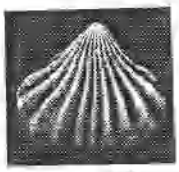
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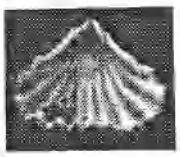
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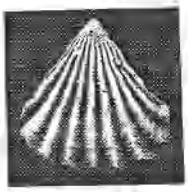
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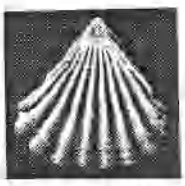
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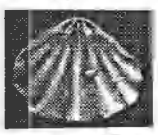
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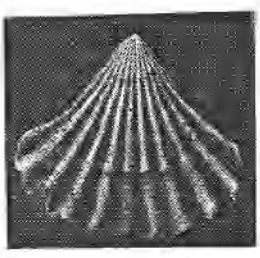
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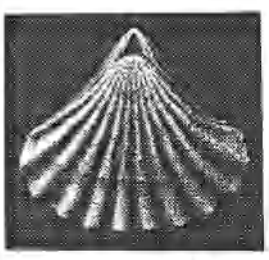
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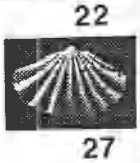
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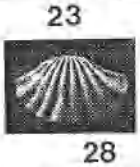
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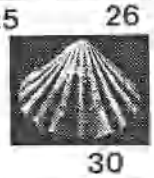
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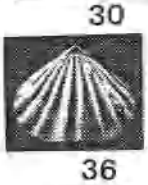
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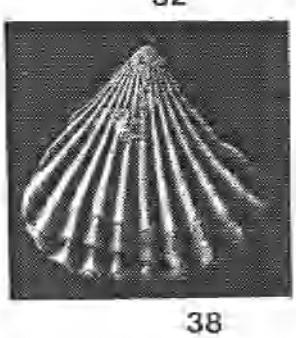
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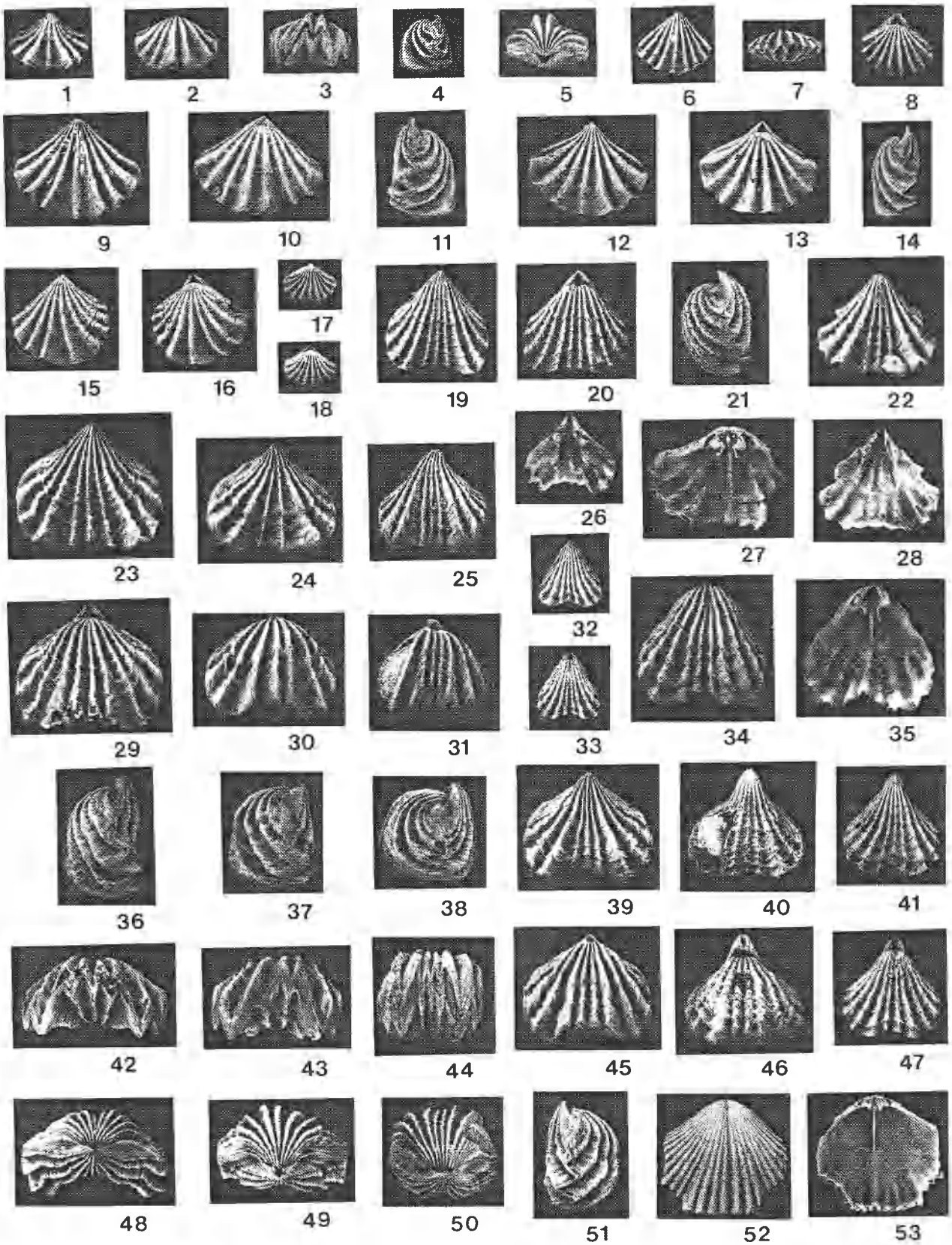
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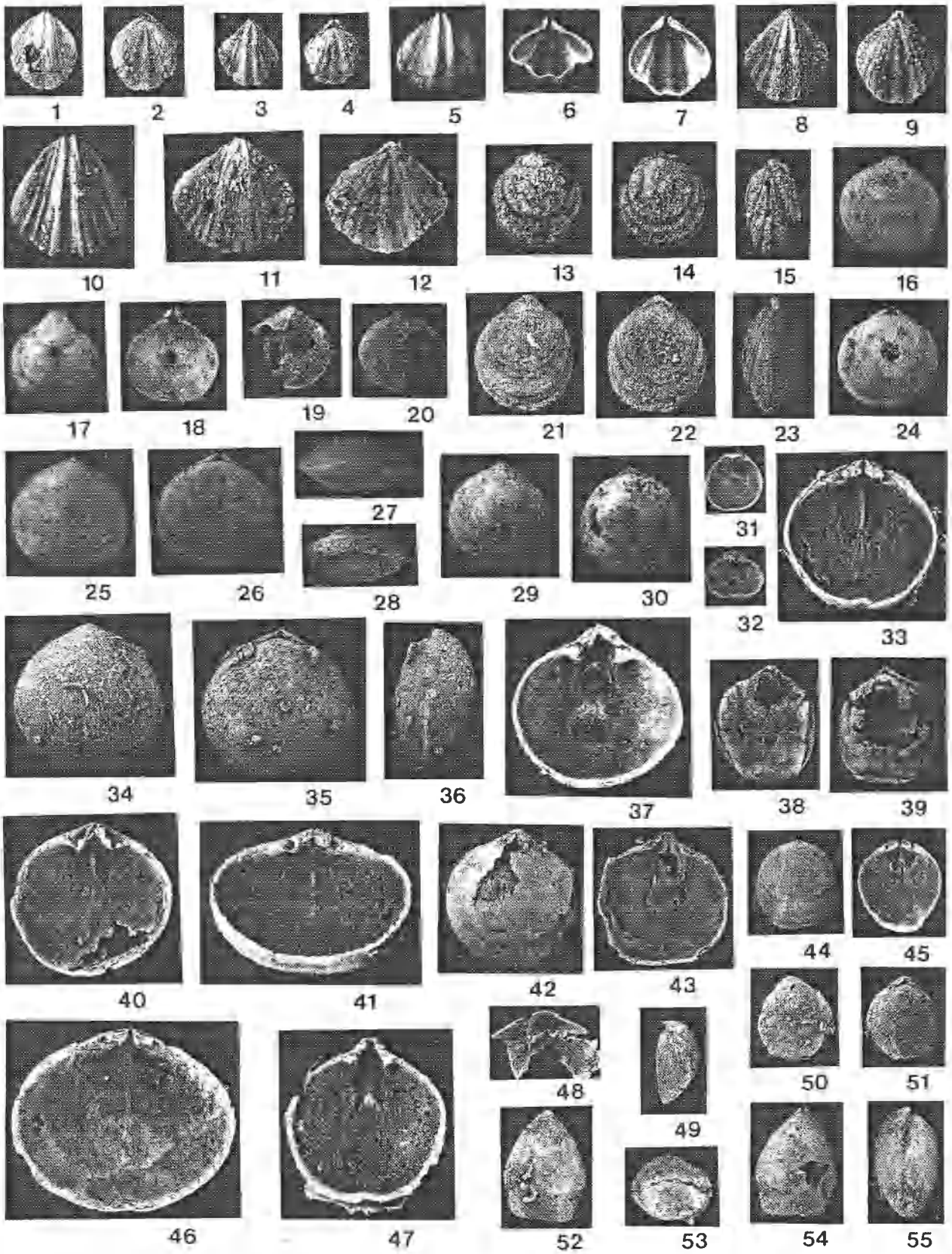
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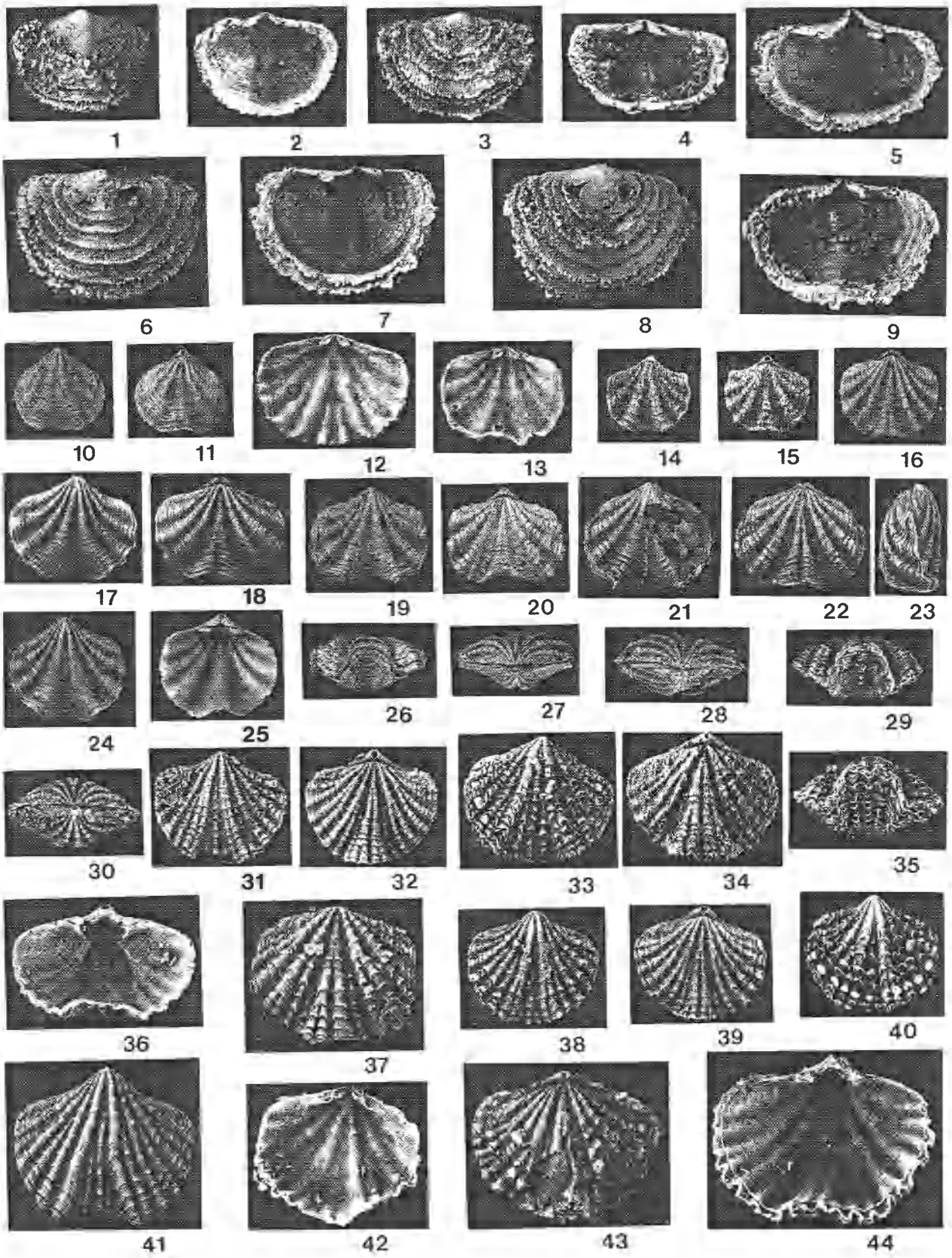
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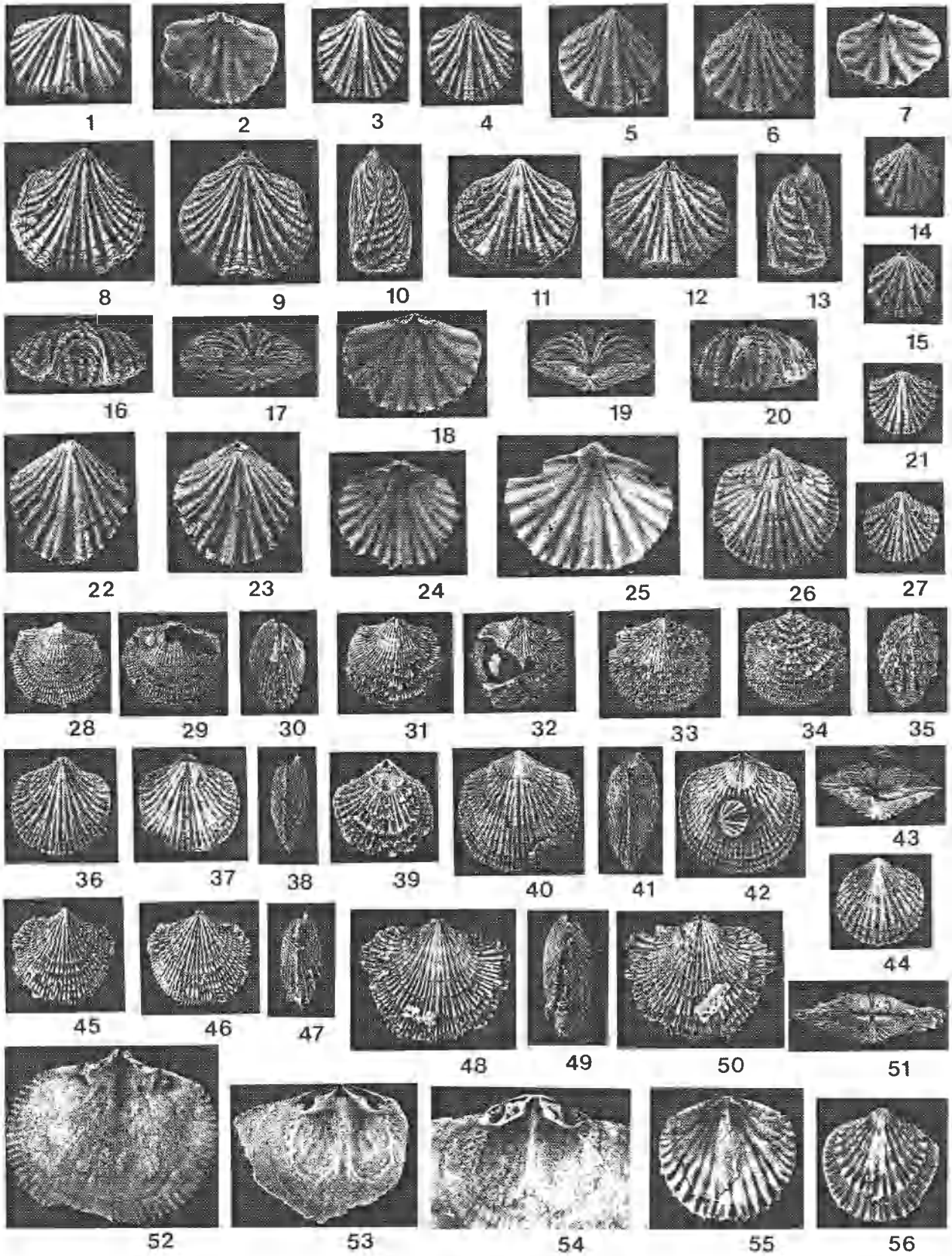
PLATE 29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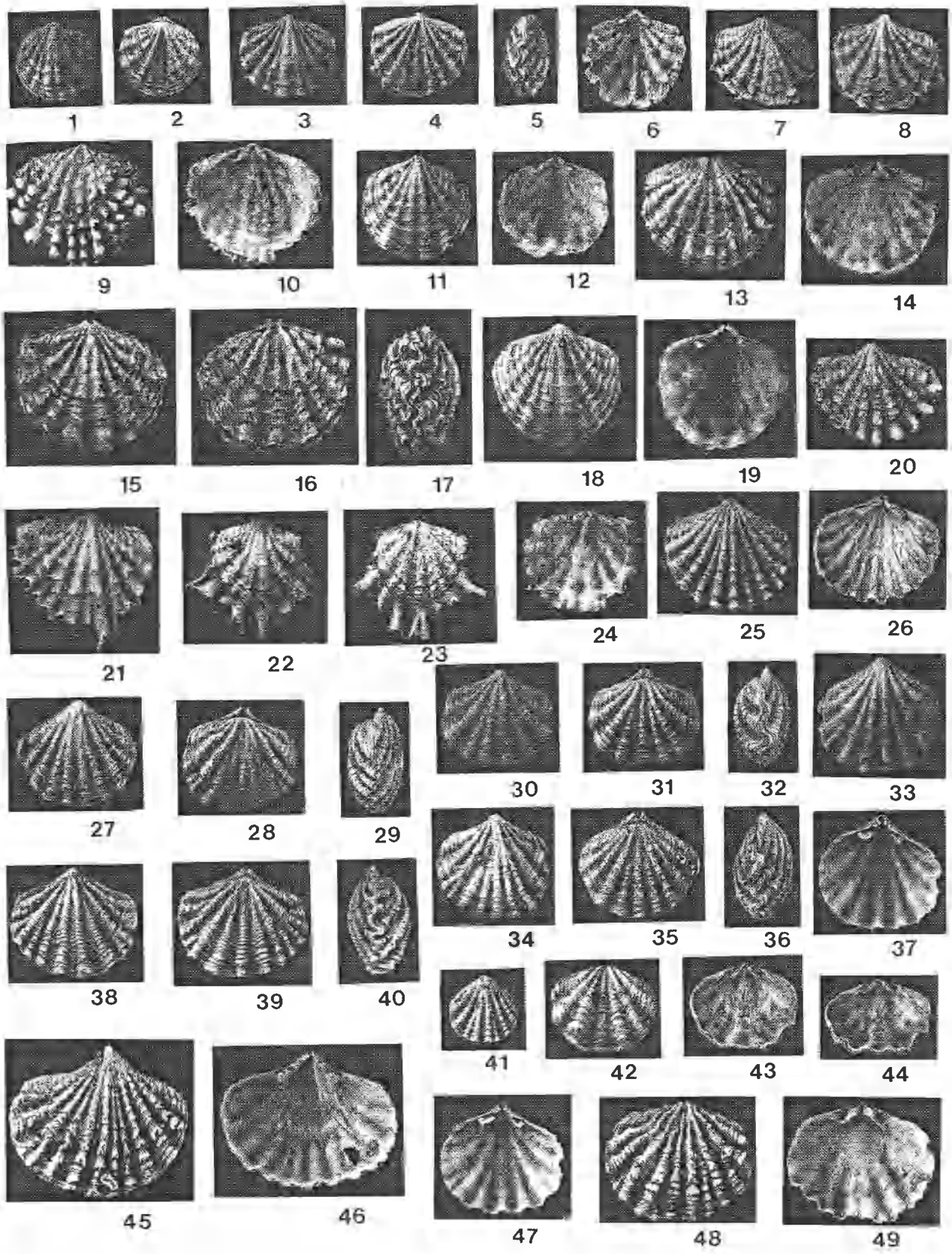
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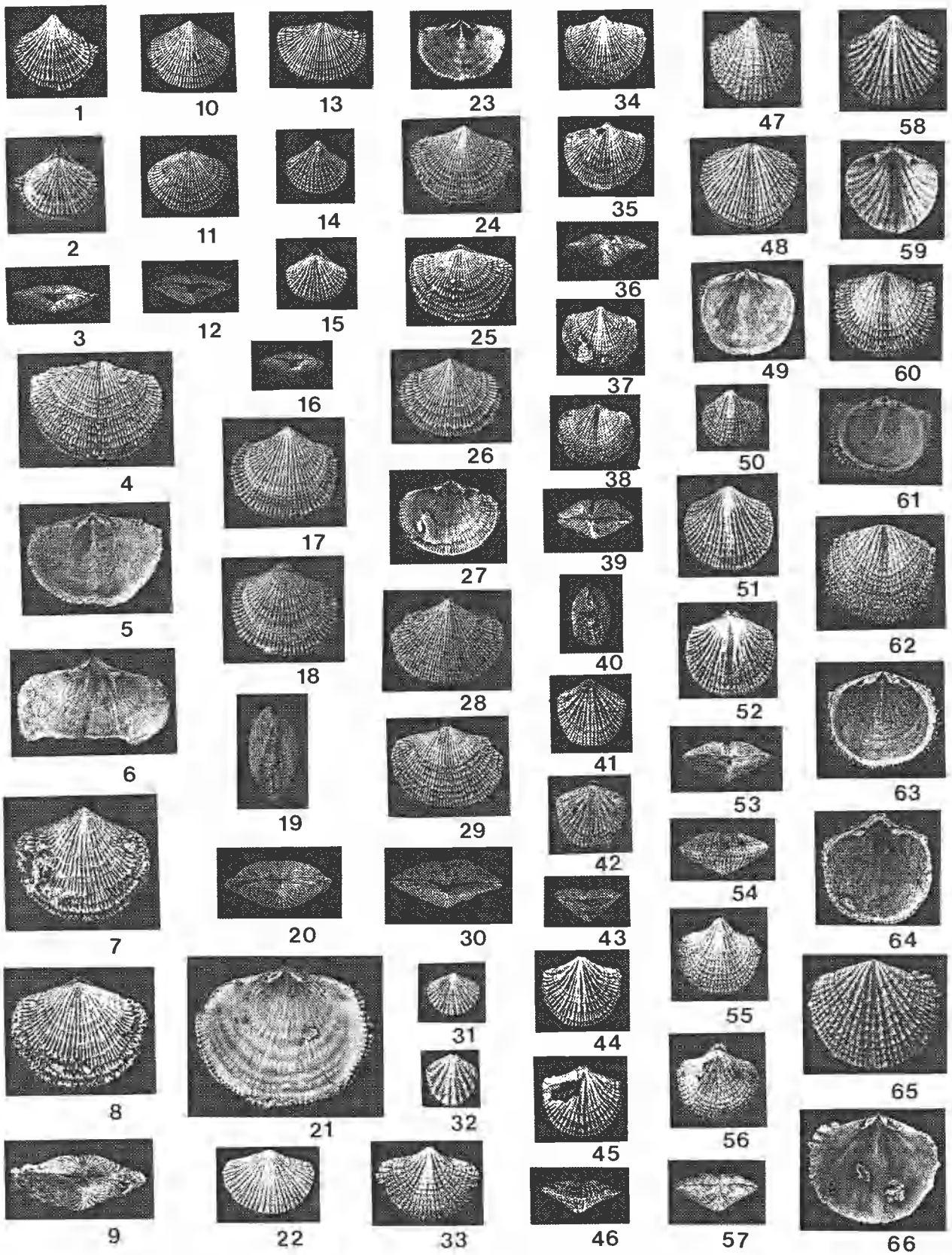
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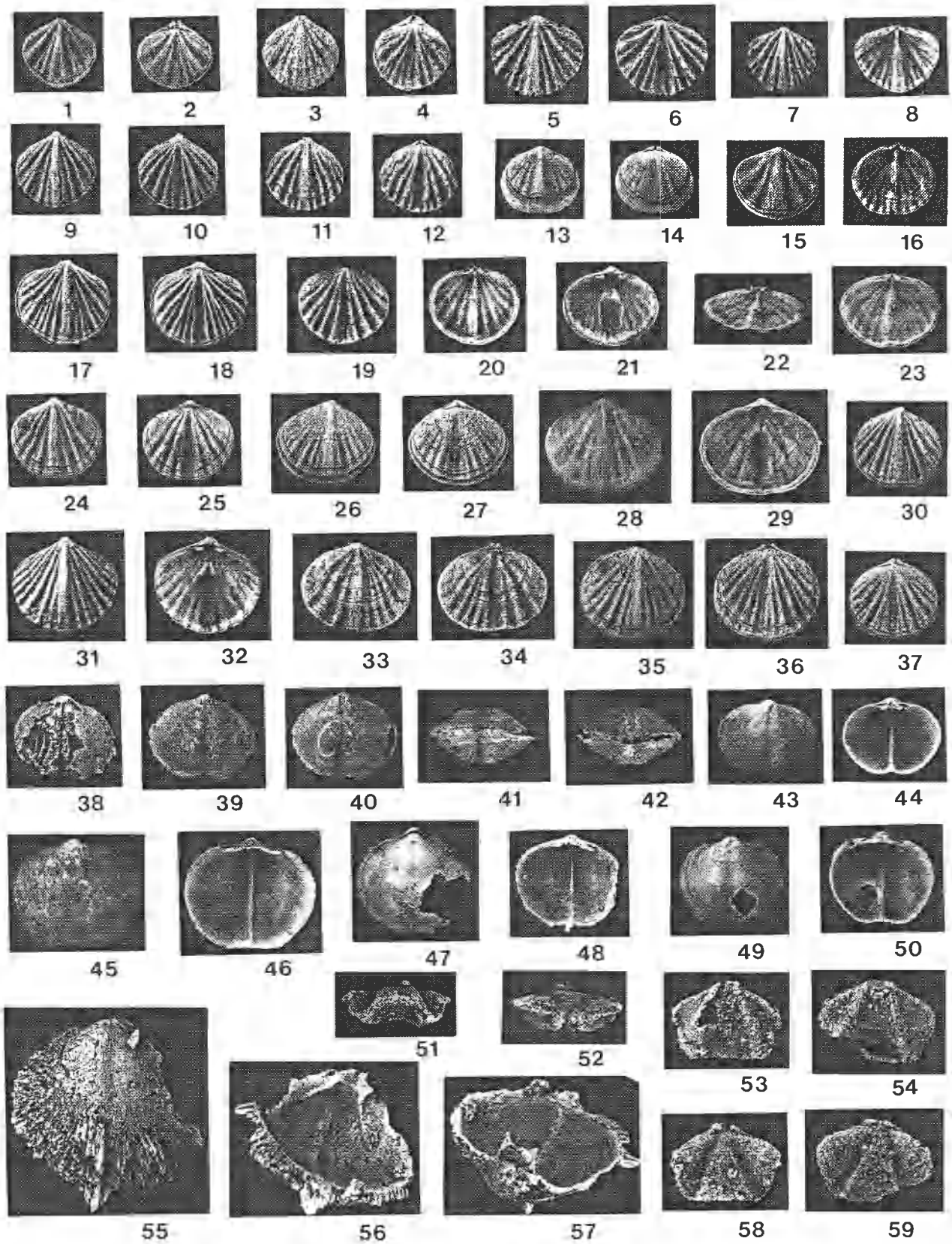
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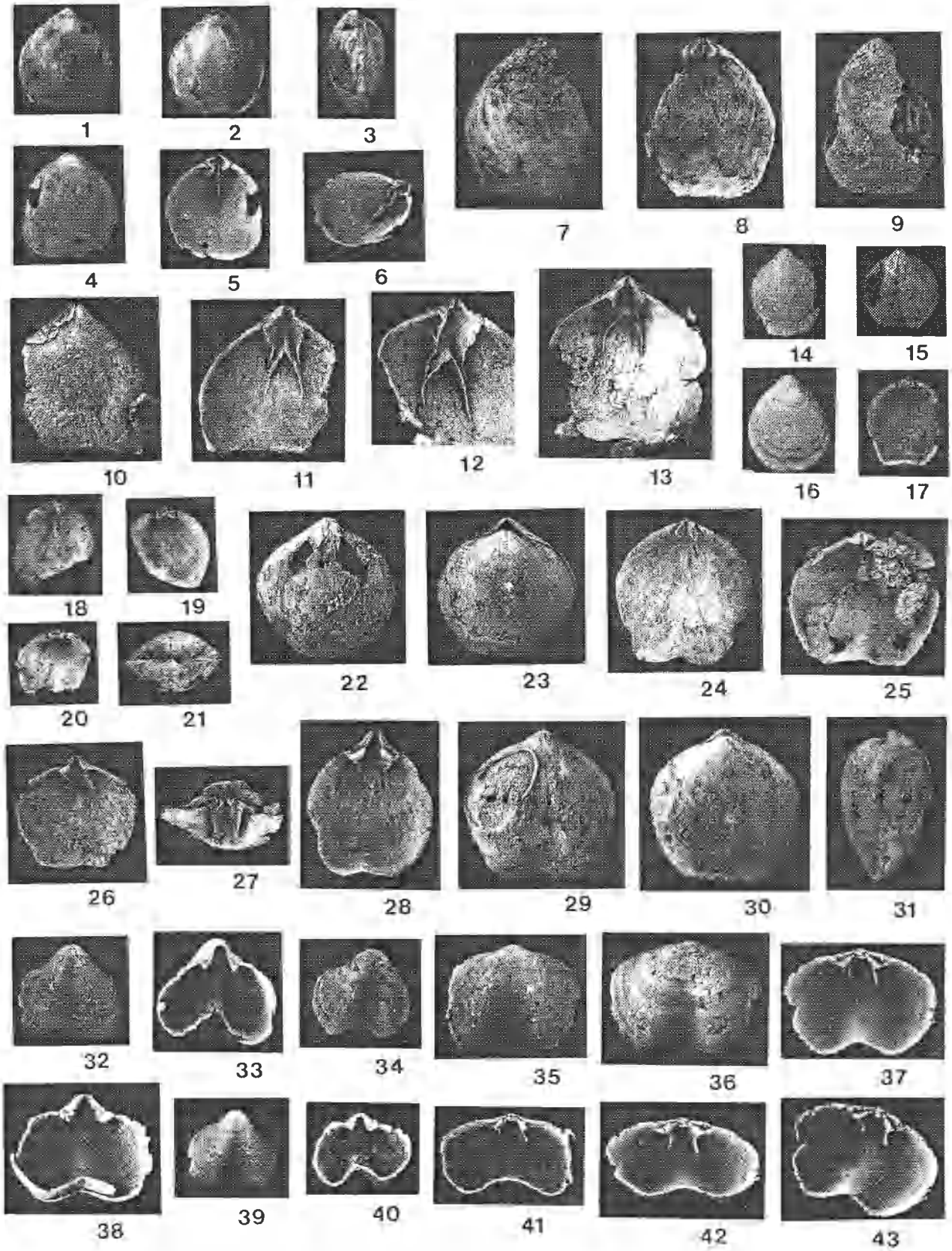
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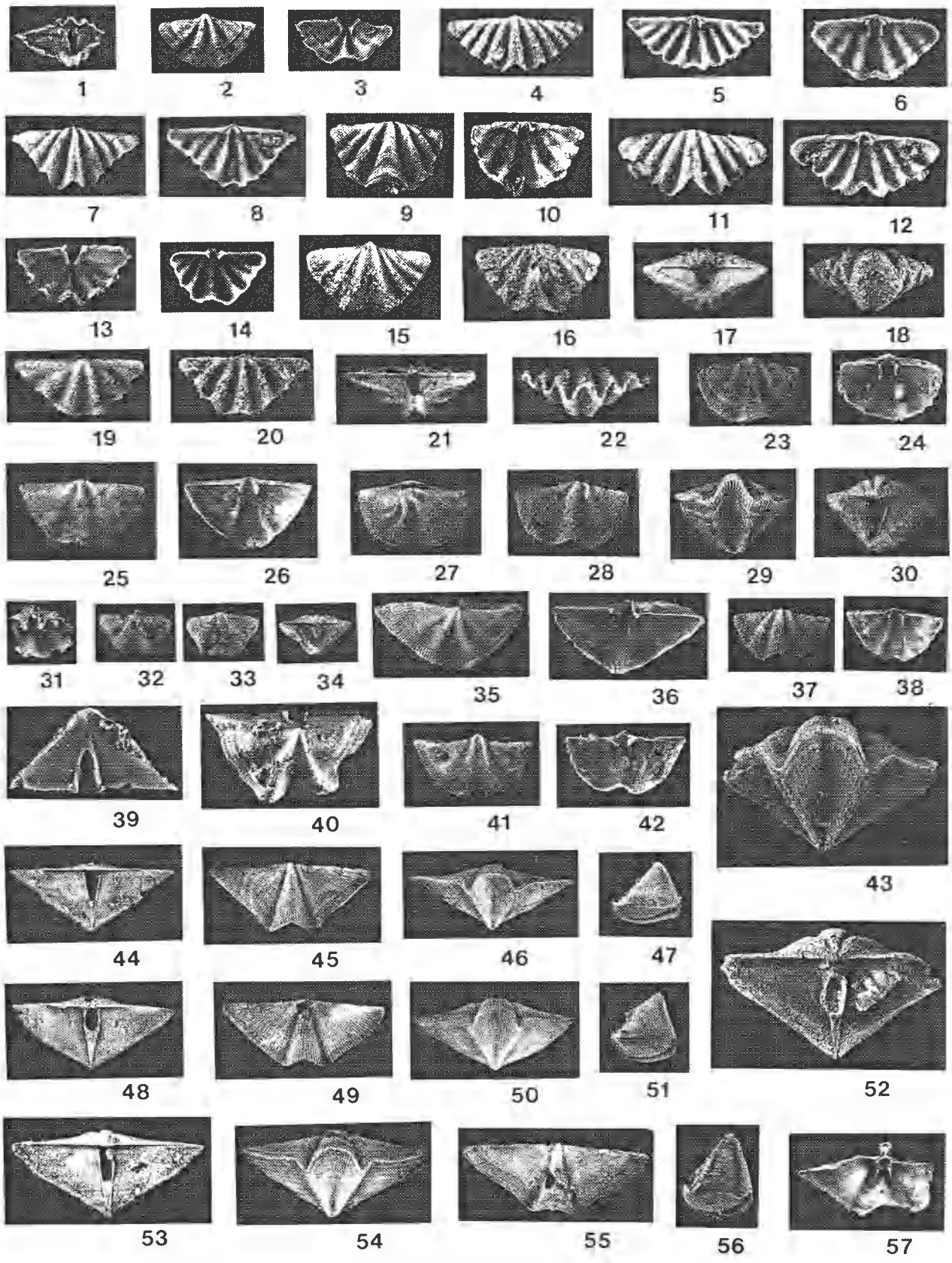
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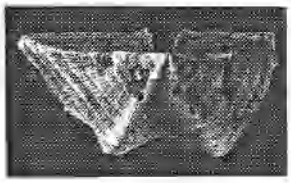
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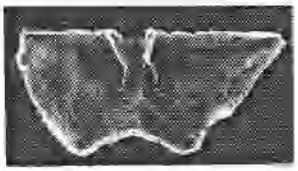
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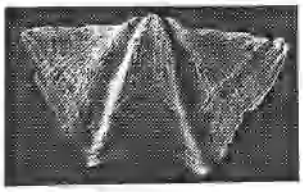
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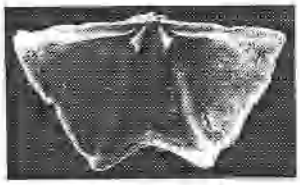
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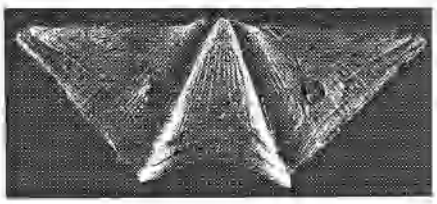
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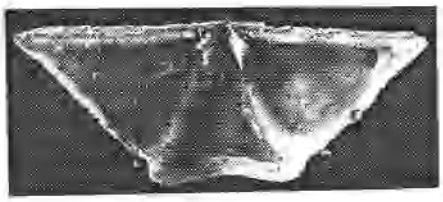
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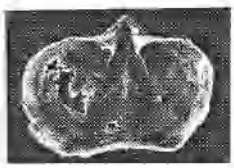
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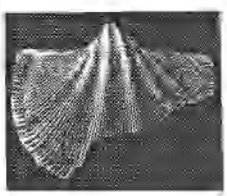
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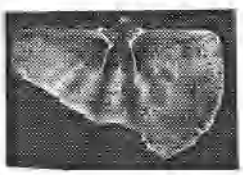
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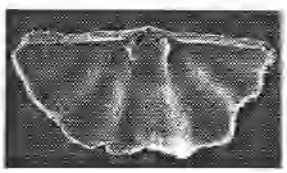
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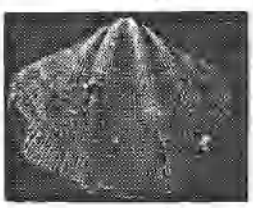
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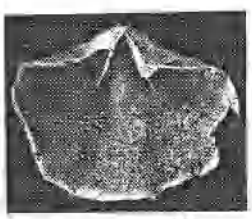
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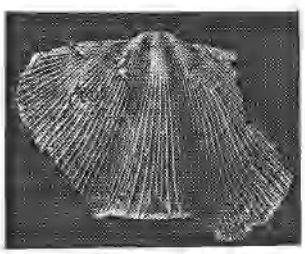
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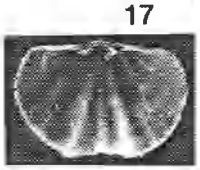
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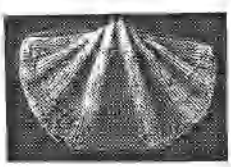
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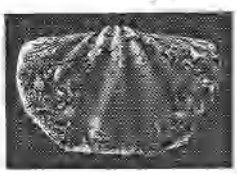
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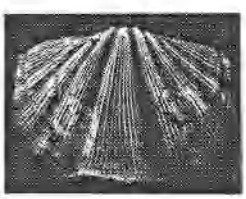
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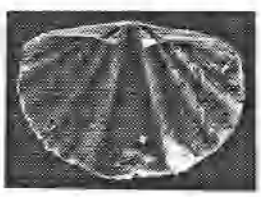
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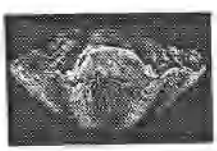
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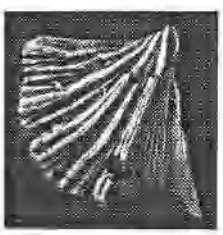
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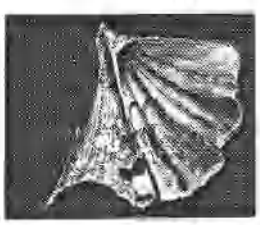
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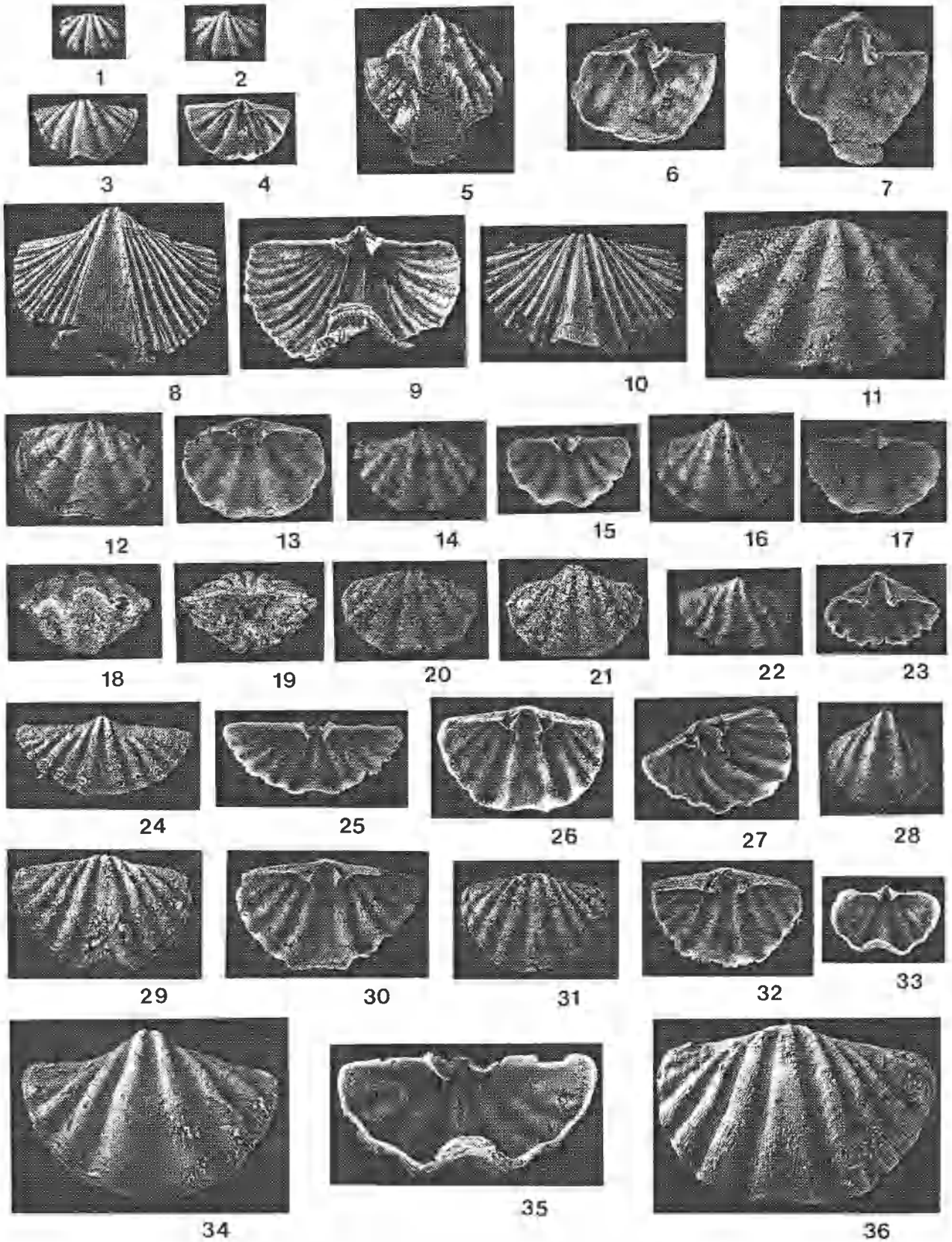
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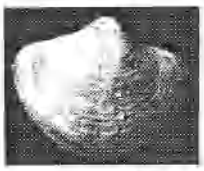
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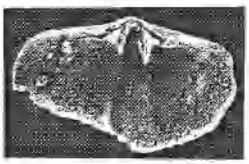
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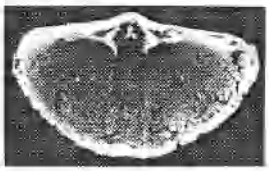
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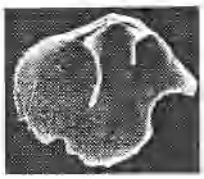
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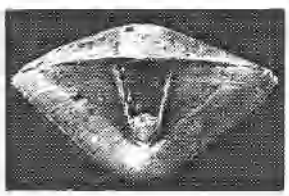
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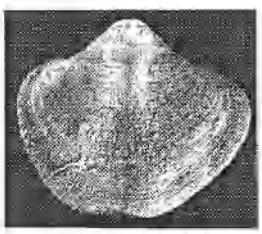
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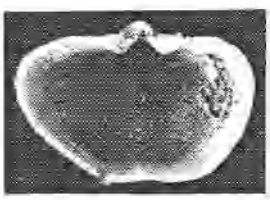
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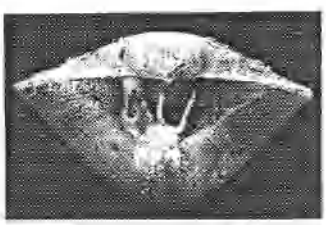
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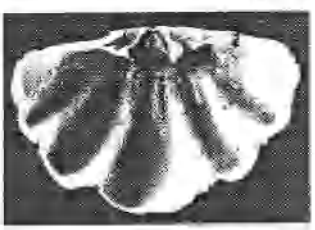
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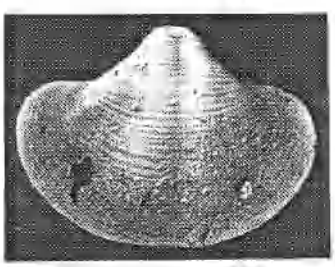
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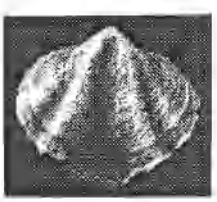
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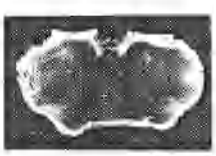
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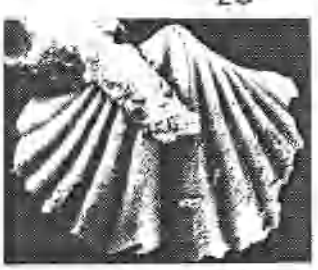
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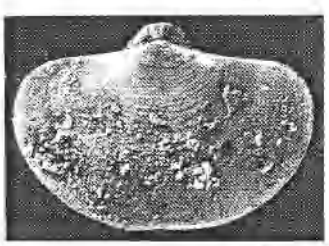
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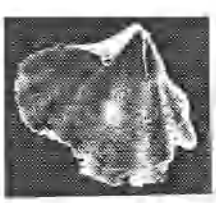
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