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Permian Brachiopods from Oman

Juichi YANAGIDA and Alain PILLEVUIT*

Abstract

This paper deals with the examination of fossil brachiopods collected by the junior author (A. PILLEVUIT) during his field investigation for the study of the Oman Exotics in the Arabian Peninsula. Late Early to early Middle Permian brachiopod faunules were discriminated from 4 lacalities in the autochthonous or allochthonous units. As a whole 18 species among 15 genera, including 3 new species, are discriminated. Some fusulines and bryozoans which occasionally accompany brachiopods are also examined for the purpose of comparison of age and paleogeographic implication.

Key words : Permian brachiopods, Oman

Introduction

Permian brachiopod faunules from four localities in the Oman Mountains were introduced by PILLEVUIT (1993) with preliminary identification by YANAGIDA. The brachiopod-bearing formations were geologically examined and discussed by PILLEVUIT. Four localities are distributed as follows from northwest to southeast : Jebel Qamar South (the Permian Asfar Formation in the Ordovician to Permian Ramaq Group, an allochthonous unit), Quryat 1 and 2 (the Permian Saiq Formation, an autochthonous unit), Locality 753 (outcrops characterized by resedimented Permian limestone blocks, Triassic "Batain Melange", allochthonous units). In this paper the brachiopod faunules are examined in detail with the systematic descriptions.

Repository.—All of the registered specimens are kept in the Geological Museum of Lausanne, Switzerland. The registered number of specimens is shown in the descriptive part with abbreviation of MGL.

Acknowledgement.—The authors express their sincere thanks to the Institute of Geology and Paleontology, University of Lausanne, Switzerland, whose collection of the Oman brachiopods we have had an opportunity to study. We also express our cordial thanks to Professor S. SAKAGAMI of Chiba University, Japan, who kindly discriminated the accompanied bryozoans and fusulines from Locality 753 and gave us valuable opinions with their pictures.

Geological setting and brachiopod faunules

Geological outline of the brachiopod-bearing formation of each locality and elements of each faunule are as follows.

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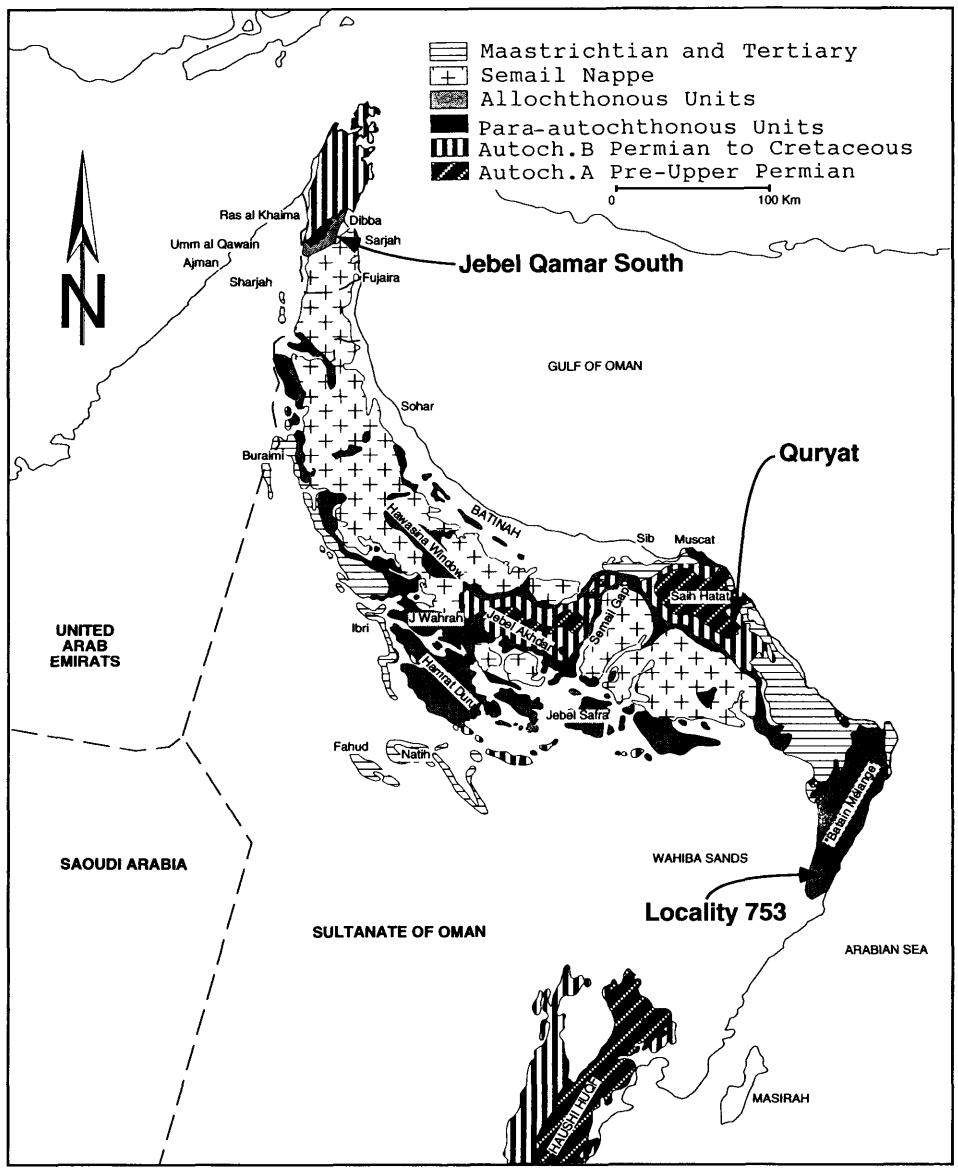


Fig. 1. A brief geologic map of the Oman Mountains region, showing main localities of brachiopod faunules (after PILLEVUIT, 1993).

1. Jebel Qamar South

Brachiopods from Jebel Qamar South, northern part of the United Arab Emirates, belong to the Asfar Formation of the Ramaq Group, a member of allochthonous units called "Oman Exotics" (GLENNIE et al., 1974).

The Ramaq Group has a thickness of about 170m and is divided into the following four formations in ascending order : the Rann Formation, about 80m in thickness with thick quartzite in the main part and green shales of about 10m's

thick at the highest and lowest parts, is middle Ordovician in age; the Ayim Formation, unconformably overlies the Rann Formation, is generally composed of reddish and greenish shales with Orthoceratide cephalopods from the lowest part, about 60m in thickness, and lower Carboniferous in age (NIKO and PILLEVUIT, in prep.); the Asfar Formation, about 40m in thickness and unconformably overlies the Ayim Formation, is mainly composed of black silty limestone with abundant occurrence of Permian brachiopods and locally comprises thin pillow lava at the basal part; in the Qamar Formation, about 20 to 25m in thickness, quartzite predominates in the lower part and grey limestone in the upper, and lower Permian fusulines are discriminated from the upper part.

The brachiopod faunule from the Asfar Formation comprises the following elements: *Marginifera qamarensis*, n. sp., *Waagenoconcha? omanica*, n. sp., *Acosarina* aff. *indica* (WAAGEN), *Perigeyerella* sp., Debyiidae? gen. and sp. indet., *Reticulariina* sp., *Crenispirifer* sp.

2. Quryat 1 and 2

Brachiopods from Quryat 1 and 2 are all from black dolomitised limestones in the basal part of the Permian Saiq Formation distributed in the Saih Hatat area, about few tens kilometers southeast of Muscat. The Permian Saiq Formation belongs to autochthonous units in the Oman province. In the Saih Hatat area the Saiq Formation, variable in thickness from 500m to 1000m, unconformably overlies the Ordovician Amdeh Formation. The Saiq Formation is also variable in lithofacies both longitudinally and laterally. The Permian brachiopod faunule was discriminated from a black dolomitic limestone in the basal part of the Saiq Formation. The upper part of this formation, on the other hand, is partly correlated with the Dzhulfian based on a microfauna (MONTENAT et al., 1976, RABU, 1988).

The brachiopod faunule is composed of the following elements: Quryat 1, *Permophricodothyris*? sp., *Reticulariina* sp., *Elivina* sp., *Neospirifer* sp., *Schuchertella quryatensis*, n. sp., *Stereochia*? sp., *Costiferina* sp.; Quryat 2, *Costiferina* sp.

3. Locality 753

The outcrops of this locality belong to allochthonous units and are called Hawasina Nappe in the "Batain Melange" area (SHACKELTON et al., 1990). Outcrops are characterized by Permian limestone blocks represented by red coral limestone and grey brachiopod, crinoid and fusuline limestones included in the Triassic grey sandy calcarenite.

The brachiopod faunule discriminated from a grey brachiopod limestone block comprises the following elements: *Marginifera* cf. *nesiotes* GRANT, *Bilotina* aff. *acantha* (WATERHOUSE *and* PIYASIN), *Karavankina* sp., *Orbicoelia* aff. *fraterculus* WATERHOUSE and PIYASIN, *Permophricodothyris* sp., *Waagenoconcha? omanica*, n. sp.

These brachiopods are well accompanied by bryozoans and fusulines in limestone. Their paleontological significance is discussed in the chapter of the accompanied faunules.

Systematic descriptions

Superfamily Productacea GRAY, 1840
Family Marginiferidae STEHLI, 1954
Genus *Marginifera* WAAGEN, 1884
Type-species.-Marginifera typica WAAGEN, 1884
Marginifera qamarensis, n. sp.
Pl. 4, Figs. 2-12 ; Pl. 5, Figs. 8 and 9

Material.—Holotype, MGL 63169 (pedicle valve) from Jebel Qamar South ; other 7 pedicle valves, 3 brachial valves and an articulated incomplete specimen available (sample no. 1496).

Description.—Shell small to average for genus ; transversely subquadrate ; pedicle valve moderately geniculate in profile ; median sulcus broad and shallow originating at about a fourth anterior to beak ; widest part at hinge but ears only extended ; umbo slightly incurved over hinge line ; flanks low ; trail short. Pedicle valve ornamented by narrow and weak rugae on visceral disc and flanks ; costellae indistinctly originate at slightly anterior to umbo, rapidly becoming distinct on trail, normally simple and round-topped with rare bifurcation of fine branch ; spines numerous for genus, scattered on costellae often with anteriorly or laterally projected spines ; lateral spines large and discriminated in a row on one side of visceral disc, numbering 5 ; total number of spines on pedicle valve about 50 or slightly more. Pedicle valve interior unknown.

Brachial valve concave with slightly extended flattened ear, suggesting position of marginal ridge. Ornament of brachial valve unknown but suggested to be very weak, no spines.

Interior of brachial valve with sessile, small and ventrally bilobate cardinal process, marginal ridges extending from cardinal process running around inside ears anteriorly with distinct crenulation on sides at auricular chamber for fitting with those of opposite valve ; other internal structures unknown.

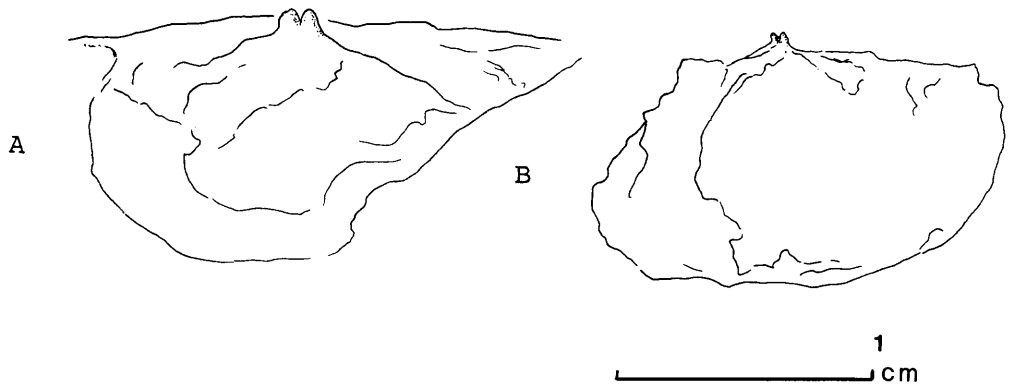


Fig. 2. *Marginifera qamarensis*, n. sp. Incomplete brachial valve interiors, showing small bilobate cardinal processes and poorly preserved lateral ridges. A, MGL 63180 ; B, MGL 63177a.

Measurements (mm) : specimens (MGL nos.)	length	hinge width	midwidth
63166	c.13		c.17
63167	c.16		c.19
63168a	11.5	c.20	16.2
63168b	16.5		19.3
63168c	c.13		c.18
63169 (Holotype)	14.0	c.21	18.0
63172a	c.15	c.21	c.17
63172b	c.14	c.19	c.18
63176	c.18		19.0
63177a	c.18	c.23	c.18
63177b	c.10	c.23	c.17
63181	c.11	22.0	c.17

Remarks.—*Marginifera qamarensis* is characterized by its distinct costellae, with great numbers of spines on them and a row of large lateral spines of about 5. Spines on venter seem to be disposed equidimensionally. The umbonal region of pedicle valve is always characterized by narrowly and tightly arranged rugae and there are no costellae at all.

These characters together with its size and outline of *M.qamarensis* recall to our mind those of *M. typica* WAAGEN, 1884, from the Wargal Formation and *M. echinata* GRANT, 1968, from the Amb Formation of the Permian Zaluch Group in the Salt Range region. The distinguishable character of *M. qamarensis* from *M. typica* is recognizable on its smaller number of the lateral spines. The former has 5 lateral spines, while the latter has 5 to 12. Numbers of spines on the venter also seem to be different with each other. The Oman species has the more numerous spines (about 50 or more) than *M. typica* (about 20-25 in average) has.

Marginifera echinata also has the external similarity to *M. qamarensis* in its mode of disposition of costellae and spines and spine bases on them.

Occurrence.—From Jebel Qamar South.

Marginifera cf. *nesiotes* GRANT, 1976

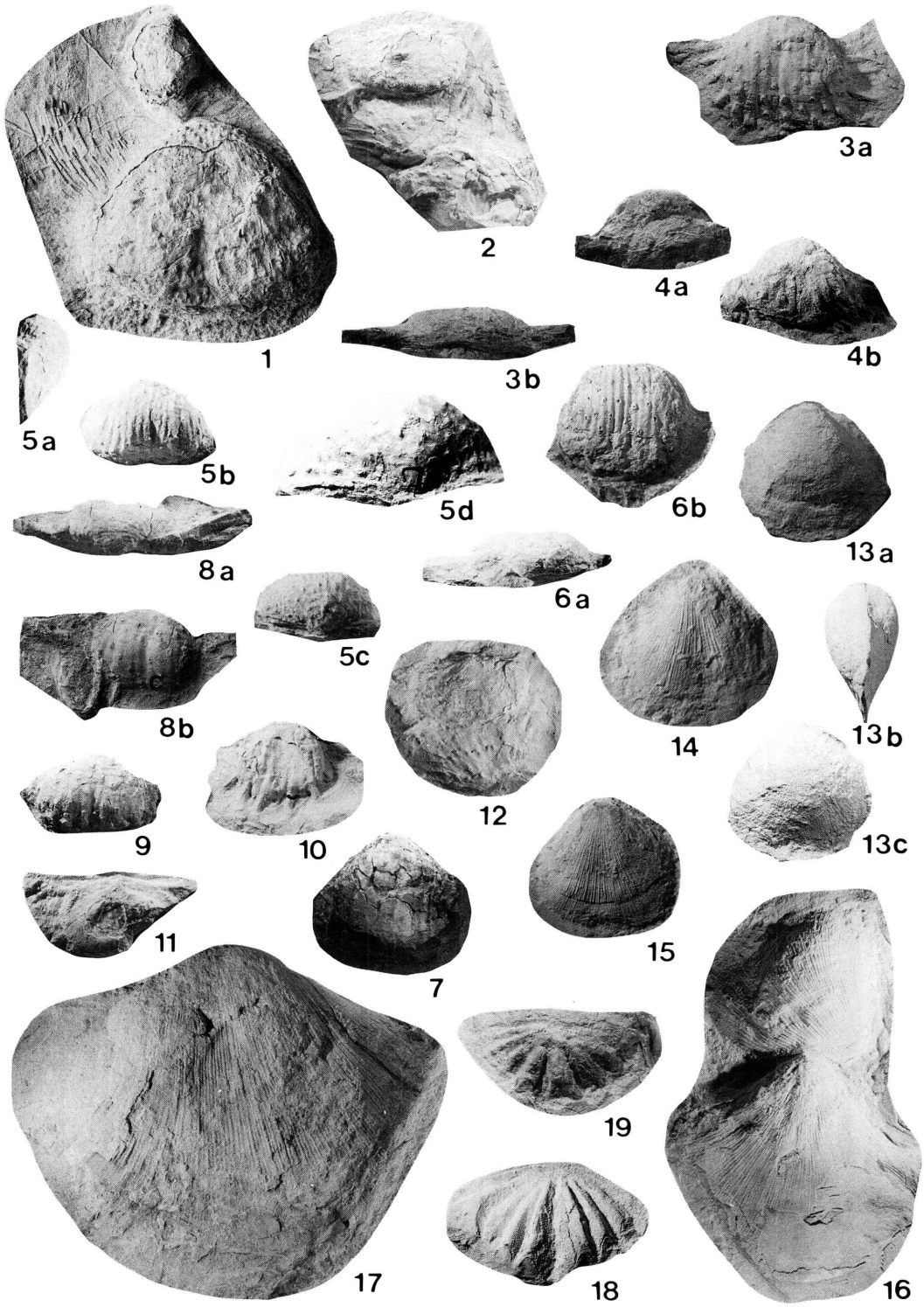
Pl. 5, Figs. 5-7

Compare.

1976. *Marginifera nesiotes* GRANT, Journal of Paleontology, 50 (3), p. 112, pl. 27, figs. 1-34.

Material.—Small numbers of pedicle valves from Locality 753 (sample no. 1602).

Descriptive remarks.—Small for genus ; subrounded to subquadrate in outline with strongly convex profile ; width of hinge probably slightly shorter than largest



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width of valve, beak rather pointed; broad shallow sulcus originates on midvalve; posterior surface nearly smooth with fine, sporadically distributed spine bases; costae broad, low and rounded, normally disposed on anterior half with about 5 small spine bases on them.

Measurements (mm):

specimen (MGL nos.)	length	hinge width	curve length	midwidth
63370	c. 10	—	—	c. 11
63372	7.5	c.7	c.15	10.0

The present species is probably referable to *Marginifera nesiotes* GRANT from middle Permian of Ko Muk, southern Thailand, though the exterior of brachial valve and the internal character are unknown at all.

Occurrence. —Locality 753, "Batain Melange".

Explanation of Plate 4

All from Jebel Qamar South

Fig. 1. *Waagenoconcha ? omanica*, n. sp. ····· page 70
Pedicle valve exterior, ×1, holotype, MGL 63171.

Figs. 2-12. *Marginifera qamarensis*, n. sp. ····· page 64
2. Brachial valve interior, ×1, MGL 63177. 3a-3b. Ventral and posterior views, pedicle valve, ×1, MGL 63176. 4a-4b. Dorsal and ventral views, pedicle valve, ×1, MGL 63172b. 5a-5d. Lateral, ventral, posterior views, ×1, and posterior view (enlarged), ×2, holotype, MGL 63169. 6a-6b. Posterior and ventral views, pedicle valve, ×1, MGL 63167. 7. Pedicle valve exterior, ×1, MGL 63168. 8a-8b. Posterior and ventral views, pedicle valve, ×1, MGL 36166. 9. Pedicle valve exterior, ×1, MGL 63172a. 10. Pedicle valve exterior, ×1, MGL 63171. 11. Brachial valve interior, ×1, MGL 63180. 12. Brachial valve interior, ×1, MGL 63177.

Figs. 13-15. *Acosarina* aff. *indica* (WAAGEN) ····· page 76
13a-13c. Dorsal, lateral and ventral views, articulated shell, ×1, MGL 63173. 14-15. Brachial valve exteriors, ×1, respectively MGL 63170 and 63180.

Fig. 16. *Perigeyerella* sp. ····· page 80
Pedicle valve exterior (lower), ×1, MGL 63178a and brachial valve exterior (upper), ×1, MGL 63178b.

Fig. 17. Derbyiidae ? gen. and sp. indet. ····· page 83
Brachial valve exterior, ×1, MGL 63178c.

Fig. 18. *Crenispirifer* sp. ····· page 86
Pedicle valve exterior, ×1, MGL 63174.

Fig. 19. *Reticulariina* sp. ····· page 84
Brachial valve exterior, ×1, MGL 63166a.

Family Buxtoniidae MUIR-WOOD and COOPER, 1960
Subfamily Juresaniinae MUIR-WOOD and COOPER, 1960
Genus *Bilotina* REED, 1944
Type-species.—Strophalosia (Bilotina) subtecta REED, 1944
Bilotina aff. *acantha* (WATERHOUSE and PIYASIN)
Pl. 5, Figs. 1-4 ; Pl. 6, Fig. 6

Compare.—

1970. *Septasteges acanthus* WATERHOUSE and PIYASIN, Palaeontographica, 135 (A), p. 120, Pl. 19, figs. 13-21.

1976. *Bilotina acantha,* GRANT, Journal of Paleontology, 50 (3), p. 148, pl. 36, figs. 24-36, pl. 37, figs. 1-28.

Material.—Small pedicle and brachial valves from Loc. 753 (sample no. 1602).

Description.—Shell small for genus ; pedicle valve slightly transverse to elongate in outline with slightly convex visceral disc, short trail, and strong geniculation ; ears pointed, nearly equal to largest width ; spines numerous, anteriorly suberect and rarely prostrate ; costellae developed on trail with rounded crests, more or less irregular in their distribution and strength, spine bases closely arranged on costellae, those on visceral disc short, prostrated and radially arranged ; conspicuous to obsolete cicatryx attachment at apex of beak. Pedicle valve interior unknown. Brachial valve with flat visceral disc, very sharp geniculation at right angle and short trail. Brachial valve interior with internally bilobed cardinal process, shaft anteriorly continues as parallel butress plates, continuous to arched lateral septa with thin covering recognized by a transverse section ; breviseptum very low and thin under buttress plates, extending anteriorly ; marginal ridge examined by transverse section of an articulated shell (Fig.4).

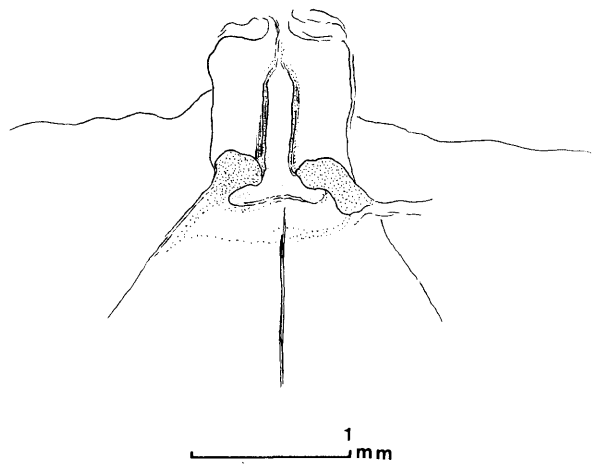


Fig. 3. *Bilotina* aff. *acantha* (WATERHOUSE and PIYASIN). The posterior margin of a brachial valve interior, MGL 63374, showing parallel butress plates. Their anterior continuity to arched lateral septa is broken.

Measurements (mm).

specimen (MGL nos.)	length	curve length	hinge width	midwidth
63369	c.12	c.20	c.7.5	c.11
63372	12.0	c.20	12.5	13.5

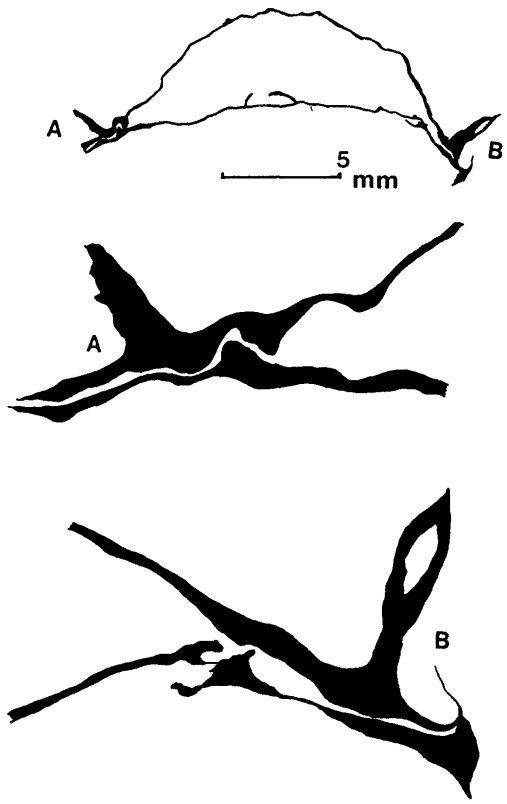


Fig. 4. *Bilotina* aff. *acantha* (WATERHOUSE and PIYASIN). A transverse section, showing arched lateral septa in brachial valve and articulation of marginal ridges near the lateral margin, MGL 63375.

Remarks.—The Oman species is very closely related to *Bilotina acantha* (WATERHOUSE and PIYASIN) from southern Thailand. The former, however, is distinct from the latter by its remarkably small size. Spines are shorter and seem to be smaller in number than in *B. acantha.*

Occurrence. —Locality 753, "Batain Melange".

Family Echinoconchidae STEHLI, 1954
Subfamily Waagenoconchinae MUIR-WOOD and COOPER, 1960
Genus *Waagenoconcha* CHAO, 1927
Type-species.—Productus humboldti D'ORBIGNY, 1842

Remarks.—The present Oman species has a slight doubt in its generic position. The external ornamentation of pedicle valve is composed of spines and very weak rugae. The quincuncially disposed spine ridges are not so closely spaced and the fine concentric rows of spines which are commonly recognizable in the anterior surface of pedicle valve of *Waagenoconcha* are indistinct.

However, densely arranged, long slender and slightly curved spines on ear and basal part of flank strongly suggest those of *Waagenoconcha*. External characters, however, also resemble those of *Taeniothaerus*. Some figured specimens of pedicle valve of *Taeniothaerus*, shown by REED (1944) from the Salt Range and by COLEMAN (1957) from Western Australia, for instance, are externally very similar to the present specimens if the interarea is not well revealed. Present specimens are also externally similar to those of *Juresania*. The latter, however, may be distinguished from the former by its having a very weak sulcus and stronger lateral spines.

Waagenoconcha ? omanica, n. sp.
Pl. 4, Fig. 1

Material.—Holotype, MGL 63171 (pedicle valve) from Jebel Qamar South. Other two incomplete pedicle valves, respectively from Jebel Qamar South and Locality 753 available.

Description.—Pedicle valve of average size for genus ; rounded trapezoidal in outline, moderately convex without geniculation ; hinge line shorter than largest width which locates slightly anterior to midvalve ; umbonal portion rather massive with incurved beak ; sulcus distinct with broad depression, originating at slightly anterior to umbonal portion. Pedicle valve ornament composed of quincuncially arranged spine ridges and hollow spine bases at their anterior margins, numbering about 7 to 8 in distance of 2.5mm in posterior surface with about 1.5mm long of each spine ; on anterior half spine bases poorly preserved, suggesting relatively shorter spine ridges than posterior ones and fine spine bases seem to be added rarely on anterior surface ; on lower part of flank and ear very long, slender spines densely arranged, nearly straight to slightly curving inwardly, and longest spine nearly reaches to length of valve ; anteriorly extended several spines also recognizable along anterior margin of pedicle valve ; five fine growth lines closely disposed on posterior venter and strengthend laterally as rugae on flanks. Pedicle valve interior with large muscle scars with tightly spaced longitudinal striation.

Measurements : Holotype (MGL 63171) ; thickness, 15.0 mm, length, 29.5 mm, width, 39.0 mm, length along longitudinal curveture, 40.0 mm, number of spine ridges in 25 mm^2 on posterior and anterior venter, respectively 16.

Remarks.—*Waagenoconcha ? omanica*, n. sp. resembles *Waagenoconcha abichi* (WAAGEN) from the Middle and Upper Productus Limestones of the Salt Range in the outline and arrangement of spine ridges on the posterior half of the pedicle valve. Both species have larage spine ridges for the genus. The latter species has also the trapezoidal outline and both species are nearly same in the size. The distinctive character of both species is recognizable in spines on anterior half of the pedicle valve. *W. abichi* suddenly decreases the strength of spine ridges or spines on the anterior fourth along the longitudinal curveture. The present species,

however, does not show an apparent change on the size of spines and mode of their growth. However, long slender bush of spines near the cardinal margin as well as anteriorly elongated several spines along the anterior margin recall to our minds the spinose character of *W.abichi* (WAAGEN) shown by GRANT (1966) from the top of the Middle Productus Limestone, khisor Range, Pakistan.

Occurrence.—From Jebel Qamar South and Locality 753, "Batain Melange".

Subfamily Echinoconchinae STEHLI, 1954
Genus *Karavankina* RAMOVS, 1966
Type-species.—*Karavankina typica* RAMOVS, 1966
Karavankina sp.
Pl. 5, Fig. 10

Material.—An well preserved pedicle valve from Locality 753 available, sample no. 1602.

Descriptive remarks.—Pedicle valve average for genus, transversely subcircular in outline with small ears ; posteriorly more convex than anterior half with small beak slightly incurved over hinge, anterior profile uniformly arched ; hinge much shorter than largest width ; surface of valve ornamented by uniformly arranged concentric bands, each band slightly raised with shallow grooves between adjoining ones, about 20 bands observable and they gradually increase in width anteriorly, about 1 to 1.5 mm wide on median anterior half ; very fine spines densely arranged on each band, about 2 or 3 spine rows disposed on each band on posterior surface and 3 or 4 rows visible on median to anterior surfaces, normally most posterior row characterized by slightly larger spines and sometimes prostrated anteriorly, comparing with other spines on same band.

Measurements (mm) : Pedile valve, MGL 63366 ; length, 14.5 ; midwidth, 15.0 ; hinge width, c.12 ; thickness, c.6.

The present species is externally well preserved but the brachial valve exterior and internal characters of both valves are unknown at all. Externally it is very similar to *Karavankina schellwieni* from middle Permian of Trogkofel Limestone, Karavanke by RAMOVS (1966). The latter, however, is distingushable from the present species by its different mode of ornamentation. The Oman species has large numbers of concentric bands, and fine spines are densely crowded but the posterior larger spines are not so conspicuous. WATERHOUSE (1981) described *Karavankina typica* RAMOVS from middle Permian of southern Thailand. It is different from the present species by its much larger size and having relatively larger ears than the latter.

Occurrence.—Locality 753, "Batain Melange".

Family Dictyoclostidae STEHLI, 1954
Subfamily Dictyoclostinae STEHLI, 1954
Genus *Costiferina* MUIR-WOOD and COOPER, 1960
Type-species.—*Productus indicus* WAAGEN, 1884

Remarks.—Based on following characters, such as the large and strongly convex pedicle valve, elongately quadrate outline with conspicuous ears, broadly shallow sulcus, and broad costae, the present species is referable to *Costiferina*, though materials are pronouncedly deformed. It is distinct from species of

Stereochia by having a less extensive reticulated zone and the broader costae on the anterior part of trail than those of the latter.

Costiferina sp.
Pl. 8, Figs. 1, 2.

Material.—Incomplete pedicle valves, MGL 63388 and 63586, respectively from Quryat 1 and Quryat 2 available.

Descriptive remarks.—Shell large for genus, elongately subquadrate to quadrate in outline, profile strongly curved without geniculation ; flanks rather steep ; ears large and inflated ; beak slightly incurved ; shallow sulcus broadly marked on venter and trail ; rugae numerous on visceral disc, making reticulated structure between rounded costae, reticulated zone occupies about two fifths length along longitudinal curveture of pedicle valve from beak ; costae numerous with rounded crests, about 4 in distance of 5mm on midvalve and about 3 near anterior margin, large costae sometimes appear anteriorly, showing tendency to converge in sulcus. Spine bases rarely observable near anterior margin of trail and on posterior flanks. Pedicle valve interior with longitudinally striated diducter muscle scars.

Measurements (mm) : Two pedicle valves from Quryat 1 and 2.

Specimen (MGL nos.)	length	curve length	hinge width	midwidth
63586	c.54	c.95	—	c.56
63388	c.70	c.100	c.74	c.68

Explanation of Plate 5

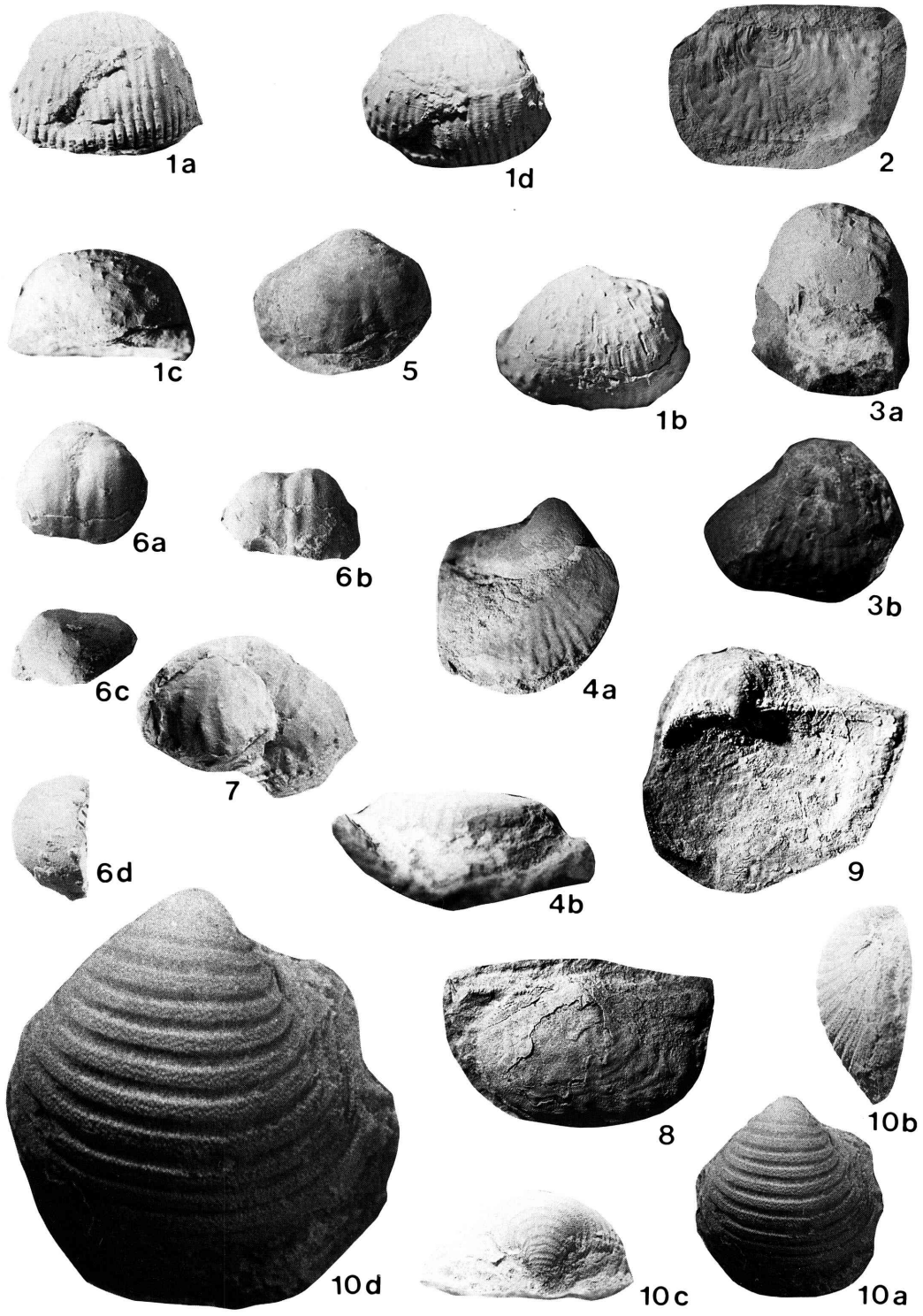
Figs. 1-7, 10 from Locality 753
Figs. 8, 9 from Jebel Qamar South

Figs. 1-4. *Bilotina* aff. *acantha* (WATERHOUSE and PIYASIN) ..... page 68
1a-1d. Anterior, ventral, posterior and antero-ventral views, pedicle valve, ×2, MGL 63372a. 2. External mould, brachial valve, × 1, MGL 63377. 3a-3b. Posterior and ventral views, × 2, MGL 63369. 4a-4b. External mould, incomplete brachial valve, ×2, MGL 63368.

Figs. 5-7. *Marginifera* cf. *nesiotes* GRANT ..... page 65
5. Pedicle valve exterior, ×2, MGL 63375. 6a-6d. Ventral, anterior, posterior and lateral views, pedicle valve, ×2, MGL 63372b. 7. Pedicle valve exterior, × 2, MGL 63370.

Figs. 8-9. *Marginifera qamarensis*, n. sp. ..... page 64
8. Incomplete brachial valve interior, × 2, MGL 63167. 9. Pedicle valve exterior, dorsal view, ×2, MGL 63117a.

Fig. 10. *Karavankina* sp. ..... page 71
10a-10d. Ventral, lateral, posterior views, pedicle valve, × 1, and an enlarged ventral view, ×2, MGL 63366.



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The present species is characterized by its large size and strong convexity, broad sulcus and costae near the anterior margin.

Among the known species of *Costiferina* in the Tethys region, *Costiferina spiralis* (WAAGEN) from the Lower Productus Limestone of the Salt Range, Pakistan resembles the present species in external characters. The latter, however, has the narrower and weaker costae than those in the former.

TSCHERNYSCHEW (1902) described a large species under the name of *Productus uralicus* from the *Schwagerina* Horizon of the Urals. This species seems to be very close to the present one in external characters.

Occurrence.—From Quryat 1 and 2.

Genus *Stereochia* GRANT, 1976

Type-species.—*Stereochia litostyla* GRANT, 1976

Stereochia? sp.

Pl. 7, Figs. 9, 10

Material.—Two pedicle valves, deformed one, MGL 63336, and fragmentary external mould, MGL 63346, both from Quryat 1, available.

Descriptive remarks.—Large for genus, outline may be slightly transverse with widest part at hinge; detail of convexity unknown but broad shallow sulcus distinct, originating at about 1cm anterior to beak; ears slightly convex with bluntly quadrate cardinal extremities; trail not long; rugae numerous on posterior half of pedicle valve, remarkable reticulation consequently visible on same area

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Explanation of Plate 6

Figs. 1, 2 and 5 from Quryat 1
Figs. 3, 4 and 6 from Locality 753

Fig. 1. *Neospirifer* sp. ····· page 91
1a-1c. Lateral, posterior and ventral views, pedicle valve, ×1, MGL 63338.

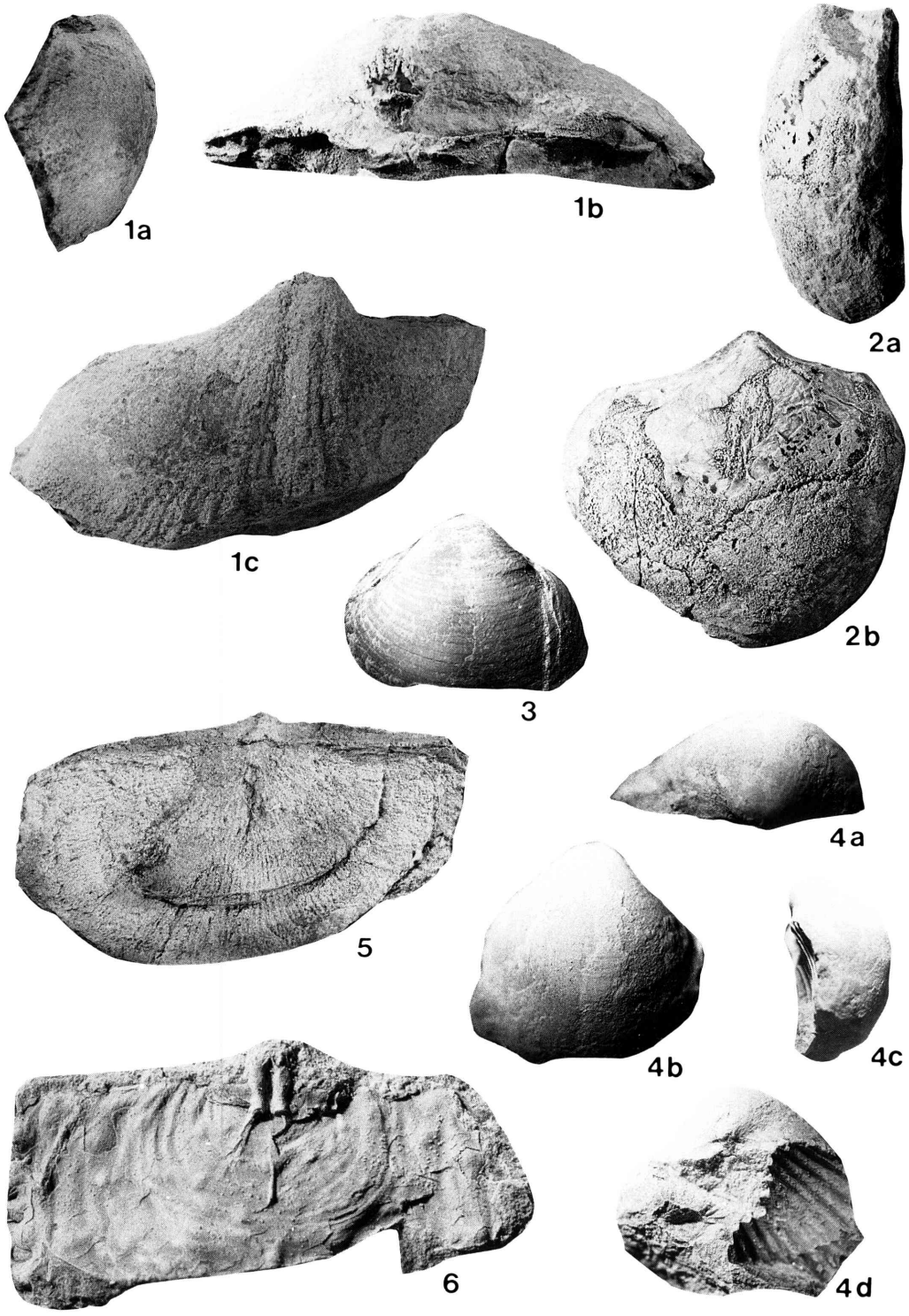
Fig. 2. *Permophricodothyris*? sp. ····· page 87
2a-2b, Lateral and ventral views, pedicle valve, ×1, MGL 63334.

Fig. 3. *Permophricodothyris* sp. ····· page 89
Pedicle valve exterior, ×2, MGL 63375.

Fig. 4. *Orbicoelia* aff. *fraterculus* WATERHOUSE and PIYASIN ····· page 92
4a-4d. Posterior, ventral, lateral and dorsal views, pedicle valve, ×2.5, MGL 63376.

Fig. 5. *Schuchertella quryatensis*, n. sp. ····· page 82
Brachial valve exterior and posterior part of pedicle valve, ×1, holotype, MGL 63333.

Fig. 6. *Bilotina* aff. *acantha* (WATERHOUSE and PIYASIN) ····· page 68
Brachial valve interior, showing incomplete bilobed cardinal process and broken buttress plates, ×5, MGL 63374.



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formed at intersections of rugae and costae ; costae slightly increase in width anteriorly, numbering about four to five in distance of 5 mm at midvalve and at anterior margin, those in sulcus show tendency to converge anteriorly ; small spines occasionally preserved on ears. Pedicle valve interior with longitudinally striated diductor muscle scar, partly preserved on exfoliated surface.

Measurements (mm) : (pedicle valves)

specimen (MGL nos.)	length	curve length	hinge width	midwidth
63336	c.50	c.90	—	c.60
63346	c.35	—	c.50	—

The present species is characterized by having the slightly transverse outline, though it is deformed, an widely reticulated zone for the whole valve surface, and distinct costae on the whole surface with nearly same width. *Stereochia litostyla*, the type-species, from southern Thailand is smaller than the present species. Of the figured specimens of *Productus semireticulatus* by BROILI (1916) from lower Permian of Timor, figs. 15 and 16 were referred to *Stereochia* by GRANT (1976). They resemble the present specimens, especially in having the wide reticulated zone, strong costae, and the large size.

Occurrence.—From Quryat 1.

Superfamily Enteletacea WAAGEN, 1884
Family Schizophoriidae SCHUCHERT and LE VENE, 1969
Genus *Acosarina* COOPER and GRANT, 1969
Type-species.—*Acosarina dorsisulcata* COOPER and GRANT, 1969

Acosarina aff. *indica* (WAAGEN)
Pl. 4, Figs. 13-15.

Compare.—
1884. *Orthis indica* WAAGEN, Palaeont. Indica, ser. 13, vol. 1, part 4, p. 568, pl. 56, figs. 7,8, 14-16.
1962. *Orthotichia indica*, CHAN and LI , Acta Palaeont. Sinica, vol. 10, p. 473, pl. 1, figs. 1, 2.
1965. *Orthotichia indica*, SESTINI, Riv. Ital. Pleont., vol. 71, no. 1, p. 31, pl. 3, figs. 1, 2.

Material.—One incomplete shell (MGL 63173) and two incomplete brachial valves (MGL 63170 and 63180) available. Internal structures examined and shown by serial sections of articulated specimen (MGL 63173).

Description.—Shell large for genus ; subrounded with widest part at midlength of shell ; hinge line much shorter than largest width. Pedicle valve slightly convex with posterior half much more convex than anterior one where surface very weakly convex or becoming flat near anterior margin. Brachial valve more convex than opposite valve ; mode of convexity same with that of pedicle valve ; very shallow depression or sulcus visible on anterior two thirds of valve length with slightly sulcate anterior commissure. Beak regions of both valves very poorly

preserved. However, external configuratin and serial sections strongly suggest existence of small interareas on both valves and open delthyrium in pedicle valve. Both valves ornamented by multicostellae, about 4 fine costellae arranged in distance of 1mm, and normally larger one appears in every 2 or 3 finer costellae.

Pedicle valve interior with strong teeth and short dental plates ; median septum low but distinct, extending more than a third length of pedicle valve. Brachial valve interior with small cardinal process ; deep sockets accompanied by developed fulcral plates ; brachiophore supporting plates well developed.

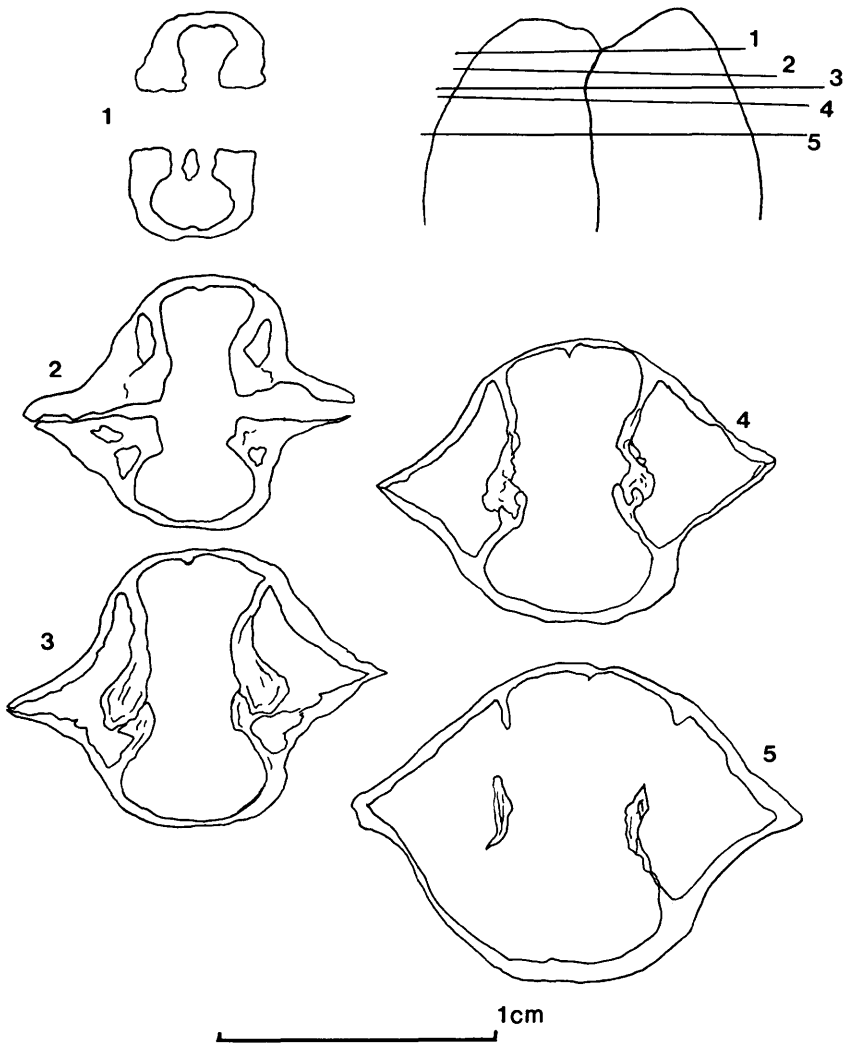


Fig. 5. *Acosarina* aff. *indica* (WAAGEN). Transverse serial sections of an articulated shell, showing internal structures, MGL 63173.

Measurements (mm):

Specimen (MGL nos.)	length	width	thickness
63170 (brachial valve)	c.21	c.20	c.2
63173 (articulated valves)	18.5	21.0	11.2
63180 (brachial valve)	21.0	21.0	c.3

Remarks.—This species is characterized by its large size for genus, nearly equidimensional subrounded outline, and shallow broad depression on the anterior surface of brachial valve. In these points the present species seems to be closely related to *Acosarina indica* (WAAGEN, 1884) from the Lower Procuctus Limestone of Amb, the Salt Range. Main differences between the two species can be recognizable in size, the mode of convexity, and fine ornament of both valves. SESTINI (1965) described *Orthotichia indica* from the lower part of the Permian Ruteh Formation in North Iran. It resembles the present species, although the latter has the less convex and slightly larger valves than the former.

SESTINI (1965) referred the age of the Ruteh Formation to the Middle Permian Murgabian.

Occurrence.—From Jebel Qamar South.

Explanation of Plate 7

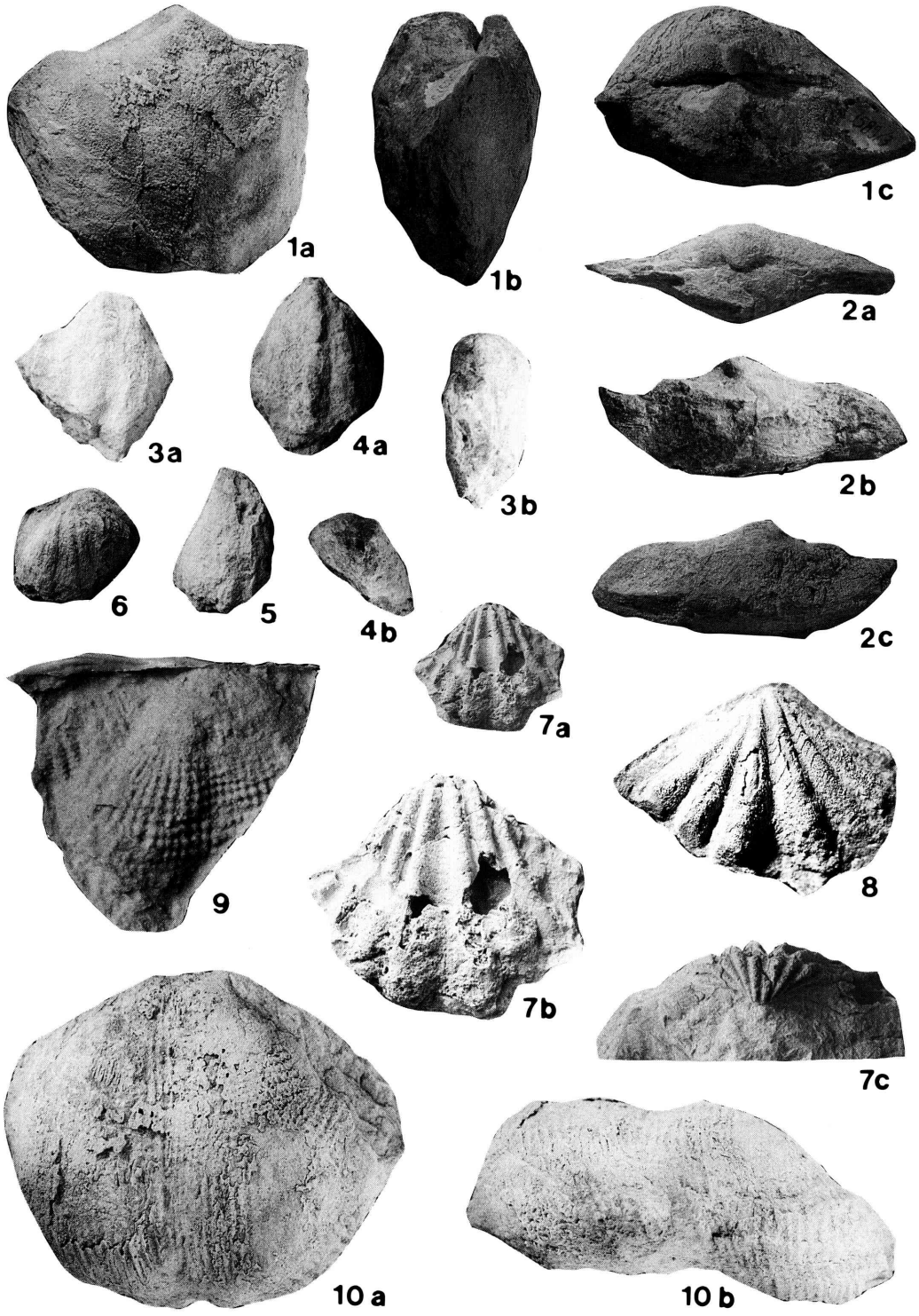
Figs. 1-7, 9, 10 from Quryat 1
Fig. 8 from Jebel Qamar South

Figs. 1-2. *Permophricodothyris*? sp. ····· page 87
1a-1c. Ventral, lateral and posterior views, incomplete shell, ×1, MGL 63335. 2a-2c. Posterior, dorsal and ventral views, incomplete shell, ×1, MGL 63341.

Figs. 3-6. *Elivina* sp. ····· page 89
3a-3b. Ventral and lateral views, pedicle valve, × 1, MGL 63347a. 4a-4b. Ventral and posterior views, pedicle valve, × 1, MGL 63347b. 5-6. Ventral views, pedicle valves, ×1, respectively MGL 63347c and MGL 63347d.

Figs. 7-8. *Reticulariina* sp. ····· page 84
7a-7b. Ventral views of a pedicle valve, 7a, × 1, 7b, × 2. 7c, postero-dorsal view of the same specimen, × 2, MGL 63393. 8. Pedicle valve exterior, × 2, MGL 63166b.

Figs. 9-10. *Stereochia*? sp ····· page 74
9. A rubber replica of an external mould of pedicle valve, ×1, MGL 63346. 10a-10b. Ventral and anterior views of a pedicle valve, ×1, MGL 63336.



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Superfamily Derbyiacea STEHLI, 1954
Family Meekellidae STEHLI, 1954
Genus *Perigeyerella* WANG, 1955
Type-species.—*Perigeyerella costellata* WANG, 1955
Perigeyerella sp.
Pl. 4, Fig. 16.

Material.—Incomplete pedicle valve (MGL 63178a) and brachial valve (MGL 63178 b) available. Internal characters of both valves examined and shown by serial transverse sections of short length of their beak regions.

Description.—Shell average for genus ; both valves slightly deformed. Pedicle valve with posteriorly protruded beak, suggesting slightly conical profile ; interarea low and narrow with convex pseudodeltidium, hinge line much shorter than largest width which locates at about midlength of valve ; brachial valve strongly convex with largest convexity at midlength ; both valves ornamented by costellae, about 3 to 4 costellae in distance of 1mm at midvalve, with slightly stronger ones at distances ; irregular rugae recognizable on both valves.

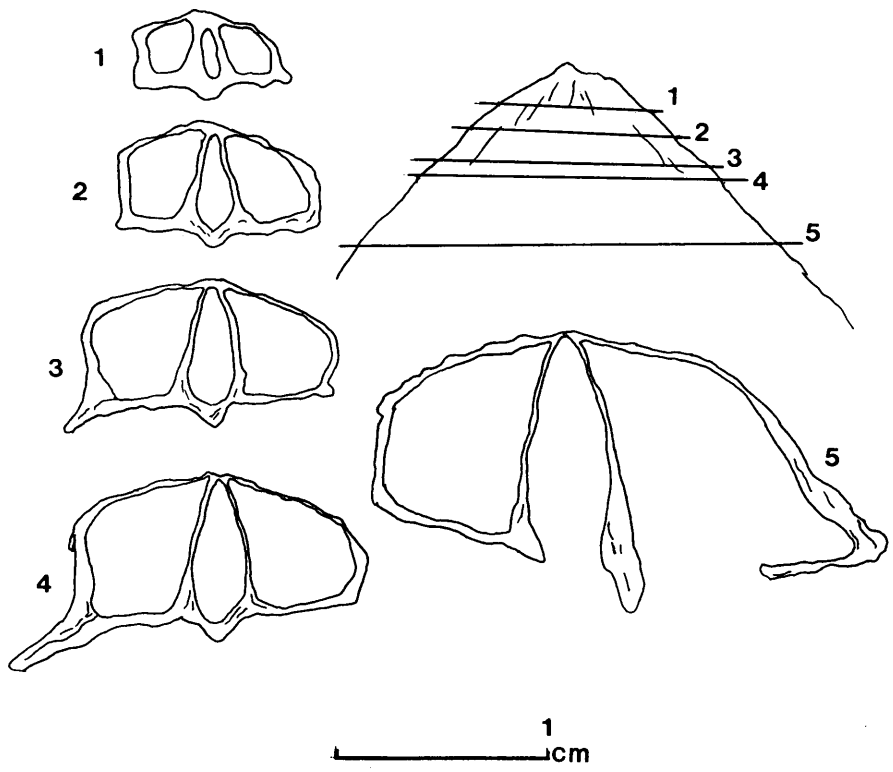


Fig. 6. *Perigeyerella* sp. Transverse serial sections of a pedicle valve, MGL 63178a, showing a sessile spondylium of dental plates.

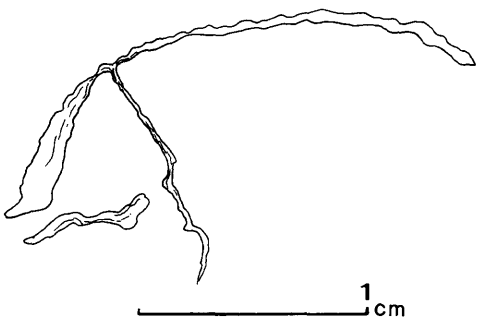


Fig. 7. *Perigeyerella* sp. A transverse section of a brachial valve, incompletely showing a part of adminicula, MGL 63178b.

Pedicle valve interior with small teeth supported by slender dental plates, posteriorly continuous to dental ridges, forming sessile spondylium, and extending anteriorly with form of sessile spondylium for about a sixth length of pedicle valve and after that they seperate with each other, forming narrowly subparallel plates ; brachial valve interior only a part of adminicula observable.

Measurements (mm) :

specimen (MGL nos.)	length	width	thickness	hinge width	height of interarea	length of dental plate
63178 a (pedicle valve)	c.37	c.39	c.8	c.24	c.7	c.12
63178 b (brachial valve)	c.25	c.27	c.8	—	—	—

Remarks.—The present species is more or less deformed and then the original conical form is not apparently examined. The pedicle valve, however, well reveals the conical character by its posteriorly protruded beak. Characters of interarea, pseudodeltidium and hinge are well understood through the serial sections. The type species, *Perigeyerella costellata* WANG, from upper Permian of South China has a spondylium supported on a very low septum at the extreme part of beak. *P. tricosa* GRANT, 1976, from lower Permian of Southern Thailand, also has the elevated spondylium at the extreme apex of the pedicle valve. We could not observe the same character in the apex region of pedicle valve of the Oman specimen. However, we recognized a sessile spondylium started in the extreme apex region for a short distance. Then the dental plates anterriorly extend separately in narrowly parallel way for a short distance. These characters are basically in harmony with those observable in *P. costellata* and *P. tricosa*. As far as the characters of spondylium are concerned, the Oman species seems to be the most undeveloped among the three species.

Occurrence.—From Jebel Qamar South.

Superfamily Orthotetacea WAAGEN, 1884

Family Schuchertellidae WILLIAMS, 1953
Subfamily Schuchertellinae WILLIAMS, 1953
Genus *Schuchertella* GIRTY, 1904
Type-species.—Streptorhynchus lens WHITE, 1862
Schuchertella quryatensis, n. sp.
Pl. 6, Fig. 5

Material.—Holotype, MGL 63333, from Quryat 1, slightly deformed but well preserved and distinctive from known species. Pedicle valve posteriorly slightly sectioned to examine internal structures.

Description.—Large size for genus, transversely subquadrate with widest part at slightly anterior to hinge and bluntly angular cardinal extremities. Pedicle valve only posteriorly preserved, showing low conical form with rather pointed beak, probably flat or slightly concave in complete profile ; interarea low, flat and apsacline at about 45° to commissural plane ; pseudodeltidium slightly convex and narrow, about 7mm in width along hinge ; interior of pedicle valve characterized by very short low and sporadic median ridge ; hinge teeth pointed and supported by strong but short teeth ridges.

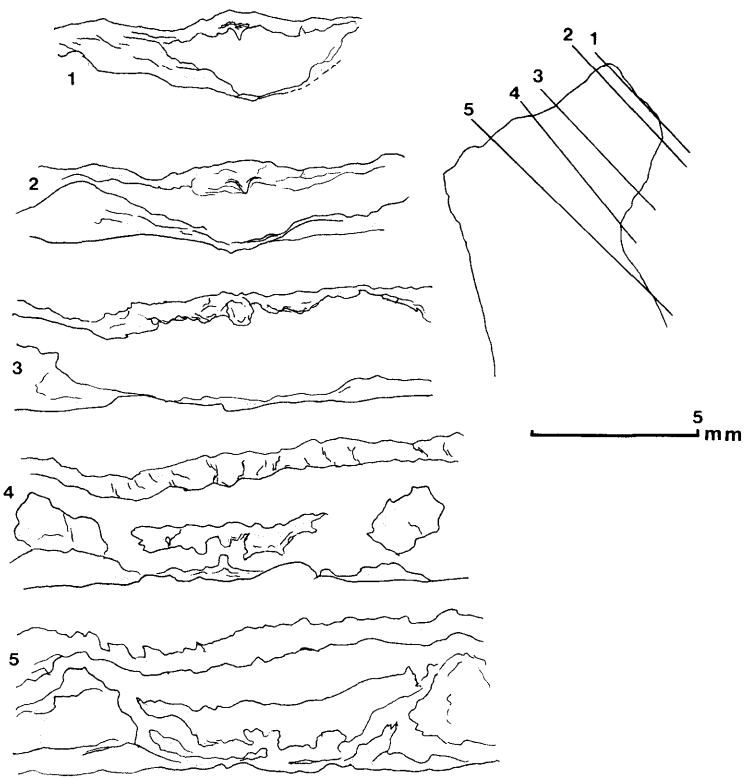


Fig. 8. *Schuchertella quryatensis*, n. sp. Serial transverse sections of a part of posterior region of the holotype, MGL 63333, showing character of the cardinal process.

Brachial valve very slightly convex with two pronounced concentric wrinkles of growth at broad distance ; surface covered by costellae, rather fine and uniform in strength, about 10 costellae in distance of 5mm at about a third length of valve from anterior margin, and increase in number by intercalation. Brachial valve interior with trilobed, low cardinal process with two broad myophores, separated by a narrow and low median ridge, each myophore posteriorly with shallow slit for diductor muscle ; crural plates stout but short. Other posterior structures unknown.

Measurements of holotype as follows : maximum width, 70.0mm ; length of hinge line, 62.0mm ; thickness of brachial valve, 11.5mm ; width of pseudodeltidium along hinge line, 7.0mm ; height of interarea, 6.5mm.

Remarks.—*Schuchertella quryatensis*, n. sp., is characterized by its transversely subrectangular outline, flatly convex brachial valve, very low conical form of the pedicle valve, sporadic concentric wrinkles and rather fine costellae with posteriorly discernible intercalation. Among the Tethyan species of this genus no apparent species is comparable with the present species. However, *Schuchertella cooperi* GRANT (1976) from the Ko Muk island along the western coast of southern Thailand is very closely related to the present species. The latter is, however, distinguished from the former by its much larger size. *Schuchertella frechi* HUANG from Kweichou in association with *Oldhamina* is much smaller and the cardinal extremities are more rounded than the present species.

Occurrence.—From Quryat 1.

Derbyiidae ? gen. and sp. indet.
Pl. 4, Fig. 17

Material.—Large deformed brachial valve (MGL 63178c) from Jebel Qamar South available. Internal characters of the posterior region examined by a transverse section.

Descriptive remarks.—Brachial valve large with widest part probabaly at midlength, moderately pressed ventrally but still remains strongly convex and short hinged character of original form. Surface ornamented by fine costellae, increasing in number by intercalation anteriorly, normally stronger costellae appear at distance of 2mm on anterior half, and in interval between larger costellae, 2 or 3 very fine ones disposed in average.

Brachial valve interior with small cardinal process and long slender erismata.

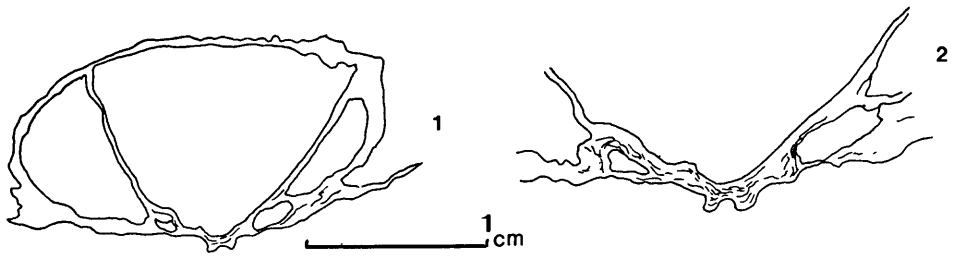


Fig. 9. Derbyiidae ? gen. and sp. indet. A transverse section near the posterior margin of a brachial valve, MGL 63178, 1, and a partly enlarged figure of the cardinal process, 2. Scale bar is for fig. 1.

Brief measurements as follows ; width, c. 57mm ; length, c. 51mm.

The present specimen is represented by the following characters ; large size, rather short hinge width, posteriorly moderately convex valve and internally small cardinal process with long erismata. These characters recall some species of *Derbyia* with moderately convex brachial valve.

Occurrence.—From Jebel Qamar South.

Superfamily Spiriferinacea DAVIDSON, 1884
Family Paraspiriferinidae COOPER and GRANT, 1976
Genus *Reticulariina* FREDERIKS, 1916
Type-species.—*Spirifer spinosus* NORWOOD and PRATTEN, 1855
Reticulariina sp.
Pl. 4, Fig. 19 ; Pl. 7, Figs. 7-8

Material.—Two fragmentary pedicle valves and a brachial valve available from Jebel Qamar South and Quryat 1.

Descriptive remarks.—Average to large for genus ; outline not completely preserved in pedicle valve but incomplete brachial valve strongly suggests transverse outline ; both valves moderately convex. Sulcus of pedicle valve rapidly increases width and depth anteriorly with narrow concave bottom and rather steep lateral slopes. Costae simple with narrow rounded crests and rather deep, narrow and round-bottomed, intercostal furrows, numbering 3 to 4 on each lateral slope. Both valves finely ornamented by punctae, about 50 to 60 in area of $1mm^2$ near anterior margin ; very fine pustules rarely preserved along or near growth lines in tight arrangement ; growth lines rather irregular but tightly arranged.

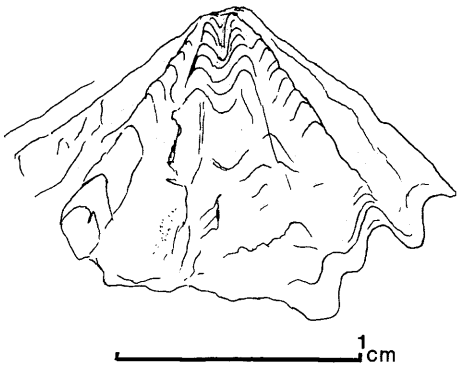
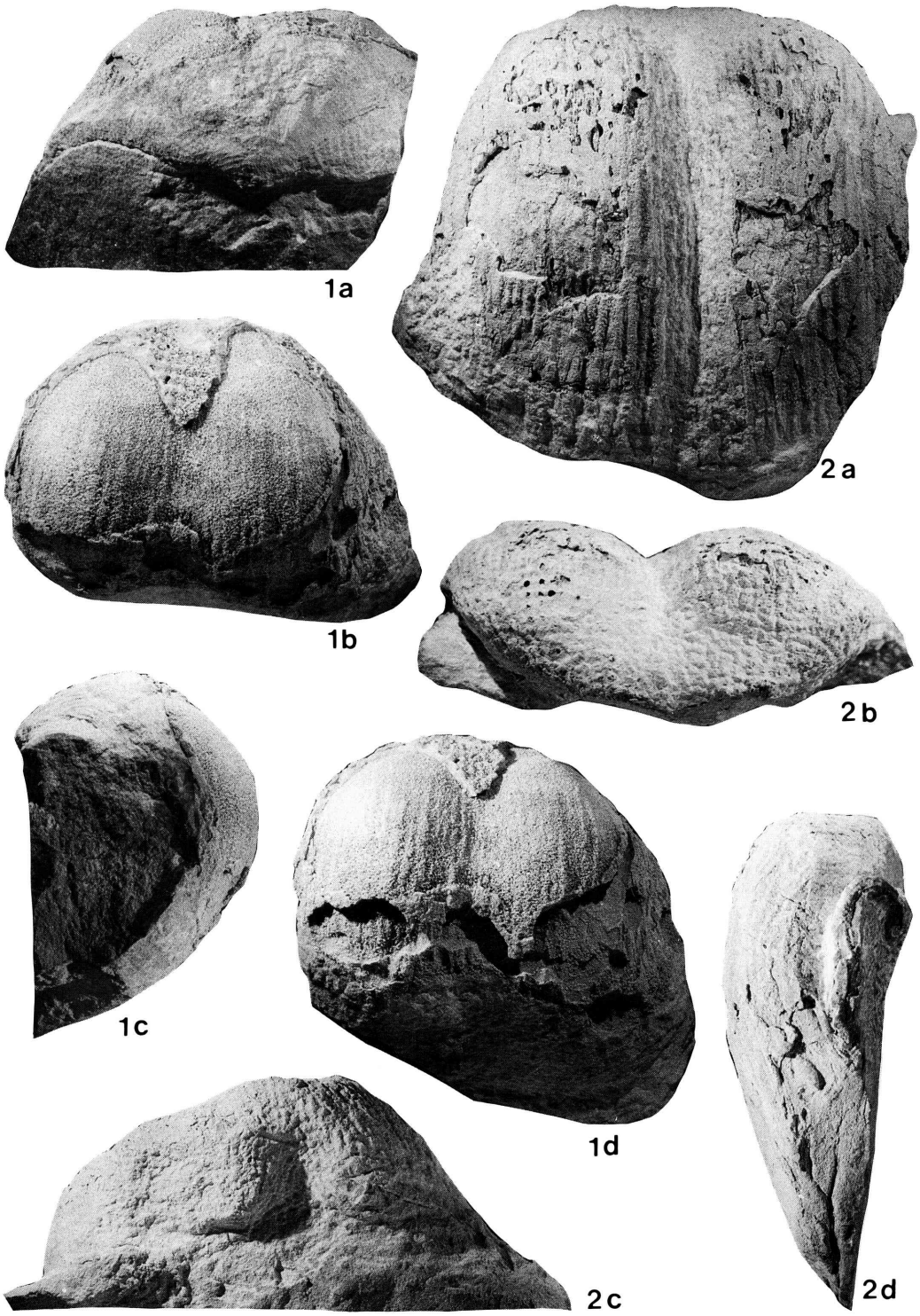


Fig. 10. *Reticulariina* sp. A pedicle valve showing tightly arranged growth lines and partly preserved fine pustules, MGL 63166b.

Explanation of Plate 8

Fig. 1 from Quryat 2
Fig. 2 from Quryat 1

Figs. 1-2. *Costiferina* sp. ..... page 72
1a-1d. Posterior, ventral, lateral and antero-ventral views of a pedicle valve, × 1, MGL 63586. 2a-2d. Ventral, posterior, dorsal and lateral views of a pedicle valve, ×1, MGL 63388.



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Measurements as follows: MGL 63166 b (pedicle valve), length, c.15mm, width, c. 20mm, number of costae, 6 or more; MGL 63166 a (brachial valve), length, c.11mm, width, c.20mm, number of costae, 6 or more.

The present species is characterized by its average to rather large size for *Reticulariina*, rather small number of costae, irregularly arranged growth lines, punctae and fine pustules occasionally observable along growth lines, and broad sulcus with narrow bottom. Its outline may be slightly transverse.

Among the known species of *Reticulariina*, *R. transindica* REED (1944) from the uppermost part of the Middle Productus Limestone, Trans-Indus province, the Salt Range, resembles the present species. The former differs from the latter by its larger numbers of costae and by having the more rounded crests of costae and bottom of sulcus.

Occurrence.—From Jebel Qamar South and Quryat 1.

Family Crenispiriferidae COOPER and GRANT, 1976

Genus *Crenispirifer* STEHLI, 1954

Type-species.—*Spiriferina angulata* R.E. KING, 1931

Crenispirifer sp.

Pl. 4, Fig. 18

Material.—Incomplete pedicle valve, MGL 63174, from Jebel Qamar South, available with following measurements: width, c. 25mm; length, c. 15mm; number of costae, 6 or more.

Descriptive remarks.—Shell average for genus, slightly convex and transverse in outline. Pedicle valve with broad sulcus and simple costae; sulcus rapidly increases in width and depth anteriorly with very narrow bottom and steep lateral slopes; costae with sharp crests, deep intercostal furrows and narrow bottom, numbering 3 on each slope but shell outline suggests existence of one more costae on each lateral margin; surface of costae and sulcus covered by micro-ornamentation of two kinds, fine punctae densely scattered with average number of 40 to 50 in $1mm^2$, and fine pustules with density of 9 to 16 in $1mm^2$ near midlength; growth lines not confirmed.

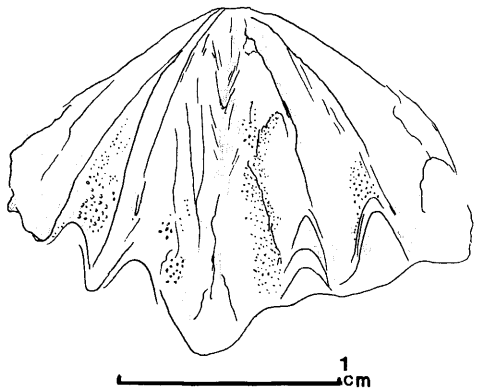

Fig. 11. *Crenispirifer* sp. A pedicle valve showing costae with sharp crests and deep intercostal furrows, and fine pustules, MGL 63174.

An incomplete and large pedicle valve reveals the present species. It is characterized by the large size, v-shape sulcus and simple costae with sharp crests, and fine pustules on sulcus and costae. Among the known species of *Crenispirifer, C. angulatus* (R. E. KING) from the Lower (?) Permian Bone Spring Formation, Skinner Ranch Formation, and Gibolo Formation, West Texas (KING, 1931 ; STEHLI, 1954 ; COOPER and GRANT, 1976) resembles the present species in size and other characters on costae, sulcus and micro-ornamentation.

Occurrence.—From Jebel Qamar South.

Superfamily Reticulariacea WAAGEN, 1883
Family Elythidae FREDERIKS, 1924
Genus *Permophricodothyris* PAVLOVA, 1965
Type-species.—Permophricodothyris ovata PAVLOVA, 1965
Permophricodothyris? sp.
Pl. 6, Fig. 2 ; Pl. 7, Figs. 1–2

Material.—Available specimens slightly deformed and external micro-ornaments completely disappeared by recrystalization. Internal structures examined by the serial transverse sections of an articulated shell (MGL 63335).

Descriptive remarks.—Shell large for genus ; outline subrounded, nearly equidimensional with largest width at midlength ; biconvex with brachial valve more inflated than pedicle valve; beak of brachial valve strongly incurved over hinge ; pedicle valve moderately convex with suberect beak and low, and small narrow interarea under beak.

Pedicle valve interior with small blunt teeth. Brachial valve interior with small cardinal process, finely striated in transverse section ; sockets deep with inner and outer socket plates.

Measurements (mm) :

Specimen (MGL nos.)	length	width	length of hinge line	thickness
63334 (ped. valve)	c.48	c.50	c.36	c.20
63335	c.41	c.46	33.0	c.23

We have some doubts about the generic identification of the present species to *Permophricodothyris* because of the complete loss of the micro-ornamentation of the shell surface by the secondary recrystalization, and the more or less deformed outline. Nevertheless the equidimensional or slightly transverse, rounded outline with rectimarginate anterior commissure, and internally the absence of dental plates and median septum strongly suggest characters of *Permophricodothyris.*

Of the figured specimens of *P. notialasiatica* GRANT (1976) from lower Permian in Phanganga, southern Thailand, the holotype specimen (pl. 61, figs. 1–5) much resembles the present specimens in external characters. The latter, however, is slightly larger and less convex in the pedicle valve than the former.

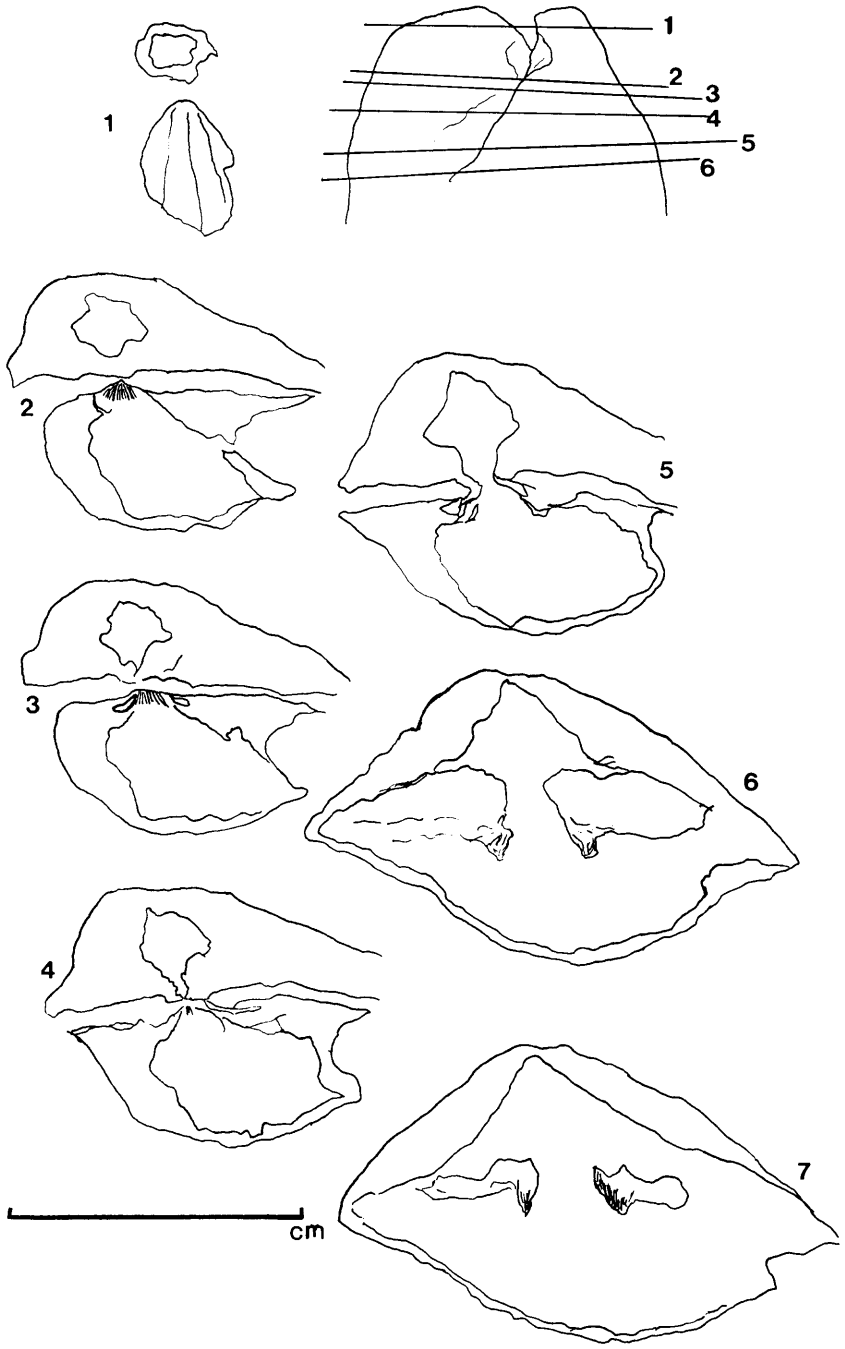

Fig. 12. *Permophricodothyris*? sp. Serial transverse sections of a deformed shell, MGL 63335, showing strong teeth and conspicuously striated cardinal process.

The present specimens are especially characterized by having the small and slightly incurved ventral beak. In this point of character together with the small convexity, a large specimen of pedicle valve, MGL 63334 (pl. 6, Fig. 2), is very similar to the specimen figured by WAAGEN (1883) under the name of *Reticularia elegantula* from the Middle Productus Limestone of Morah, the Salt Range.

Occurrence.—From Quryat 1.

Permophricodothyris sp.
Pl. 6, Fig. 3.

Material.—Single incomplete pedicle valve, MGL 63375, from Locality 753, "Batain Melange", available with following measurements ; length, 15 mm or more, width, 20 mm, apical angle, c. 75°.

Descriptive remarks.—Shell small for genus ; elongately oval in outline with faint and narrow longitudinal depression on pedicle valve ; widest part probably at midvalve with short hinge, about two thirds maximum width, and rounded cardinal extremities ; surface covered by very fine, regularly arranged growth laminae partly with obsolete micro-sculpture of double barreled spines. The present species is normally included in the guoup of *Neophricodothyris asiatica* (CHAO), well known in lower Permian of South China.

Occurrence.—From Locality 753, "Batain Melange".

Superfamily Spiriferacea KING, 1846
Family Brachythyrididae FREDERIKS, 1924
Genus *Elivina* FREDERIKS, 1924
Type-species.—Spirifer tibetanus DIENER, 1897
Elivina sp.
Pl. 7, Figs. 3-6

Material.—More than 10 disarticulated valves densely scattered in hand rock specimen, sample no. 1589-15. Only pedicle valves discriminated. Most of them more or less deformed and under bad state of preservation.

Descriptive remarks.—Shell medium for genus, elongately subovate and strongly convex with largest convexity at umbo ; hinge narrow with widest part of valve possibly at anterior to midlength ; beak of pedicle valve strongly incurved ; sulcus originates near beak, developing anteriorly with wide depression ; sulcus bounding plications seem to be broad and strong, lateral plications not clearly traceable by exfoliation, about 4 or 5 round-topped, weak plications only recognizable on each lateral slope, on sulcus very weak plications partly observable ; delthyrium rather wide comparing with interarea.

Pedicle valve interior with moderately large hinge teeth supported by short dental ridges, converging toward midline, and anteriorly extending about a fourth length of valve ; pedicle valve posteriorly thickened.

Measurements (mm) : (pedicle valves from sample no. 1589-15).

Specimen (MGL nos.)	length	width	thickness	length of hinge line
63347 a	23.1	c.16	c.9	c.10
63347 b	22.8	19.8	c.12	c.13

Because of an unfortunate state of preservation of the external characters, the mode of costation is very difficult to recognize. Nevertheless other characters, such as about 4 or 5 rounded costae on each lateral surface, broad shallow sulcus, and elongate form with the widest part at anterior to midvalve, suggest that the better preserved specimen (Pl. 7, Fig. 4) is well in harmony with a figured specimen of *Spirifer tibetanus*, the type-species of *Elivina*, by DIENER (1897. pl. 6, fig. 5). Other figured specimens of *S. tibetanus* by DIENER from lower Permian of Chitichun Himalaya are much larger than the present specimens.

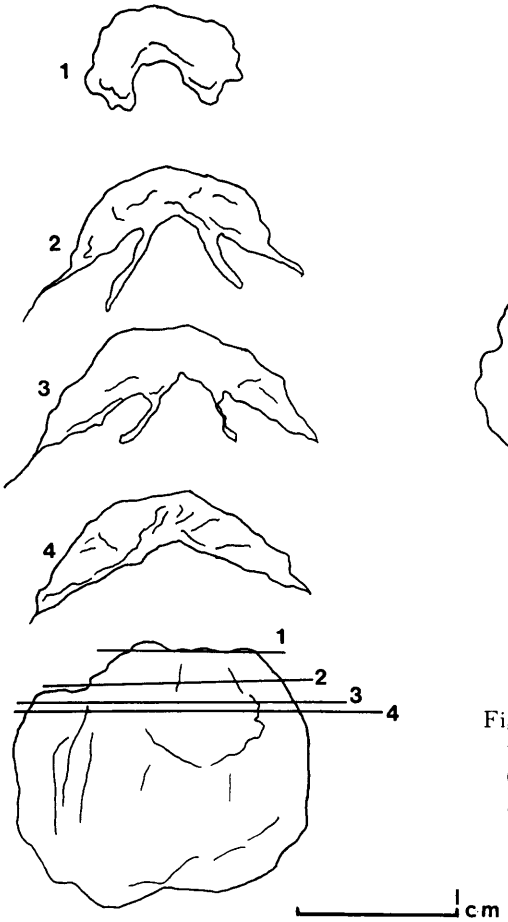

Fig. 13. *Elivina* sp. Transverse serial sections of an incomplete pedicle valve, MGL 63347a, showing thick valve and short dental ridges.

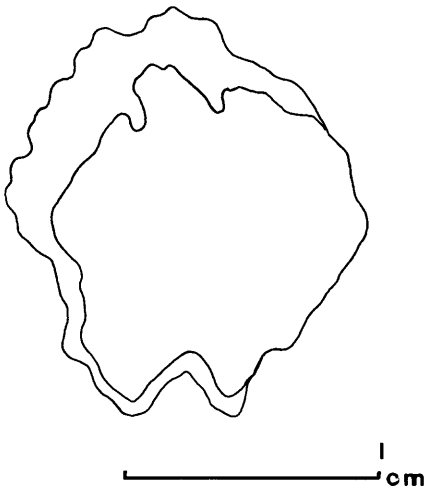

Fig. 14. *Elivina* sp. A section of an incomplete pedicle valve, MGL 63347b, showing teeth, broad sulcus and rounded costae.

Elivina compacta (GIRTY) described by COOPER and GRANT (1976) from the Lower Permian Bell Canyon and Capitan Formations, Texas, externally resembles the present species although the former seems to be slightly more convex than the latter.

Occurrence.—From Quryat 1.

Family Spiriferidae KING, 1846
Subfamily Neospiriferinae WATERHOUSE, 1968
Genus *Neospirifer* FREDERIKS, 1924
Type-species.—*Spirifer fasciger* KEYSERLING, 1846

Remarks.—Generic identification of the present specimen encountered difficulty because of the serious exfoliation of the external ornaments and moderate deformation. Based on the posteriorly partly preserved, slight fasciculation and the internal characters examined by serial transverse sections, the present species is referred to *Neospirifer*.

Neospirifer sp.
Pl. 6, Fig. 1

Material.—Deformed pedicle valve (MGL 63338) available.

Description.—Large for genus and transversely subrectangular in outline; hinge line presumably represents widest part; pedicle valve normally gently convex both longitudinally and transversely, excepting for strongly convex umbonal region; interarea low and wide; beak incurved but slightly emphasized by deformation; sulcus originates near beak, extending anteriorly with broad, shallow and rounded depression with suggestion of decreasing depth toward anterior margin; cardinal extremities seem to be obtusely angular; surface covered by numerous, low rounded costae, mode of costation not clearly examined, median posterior surface barely shows fasciculated appearance and dichotomous structure sometimes also recognizable in younger stage of growth; sulcus bounding costae not strong, about 4 or 5 costae anteriorly disposed on each slope of sulcus.

Pedicle valve interior with hinge teeth, supported by thick dental ridges, separately disposed in apex region; teeth ridges anteriorly continuous to long inwardly convex dental plates; delthyrium apically closed by pseudodeltidium and opens anteriorly; apical callosity not strong; short median ridge buried in callosity recognized in transverse sections.

Measurements (mm): length, c. 35; width, c. 60; length of hinge line, c. 60; thickness, c. 23.

Remarks.—The present species is characterized by its posteriorly very weakly fasciculated costae which do not form plications, and shallow sulcus that decreases depth anteriorly.

Among spiriferaceans these species described by REED (1944) as *Choristites* cf. *gortani* (HERITSCH) (pl. 27, fig. 13) and *Choristitella internatus* REED (pl. 28, figs. 1, 2), respectively from the Lower Productus Limestone, Amb, and the Middle Productus Limestone, the Salt Range, are externally similar to the present

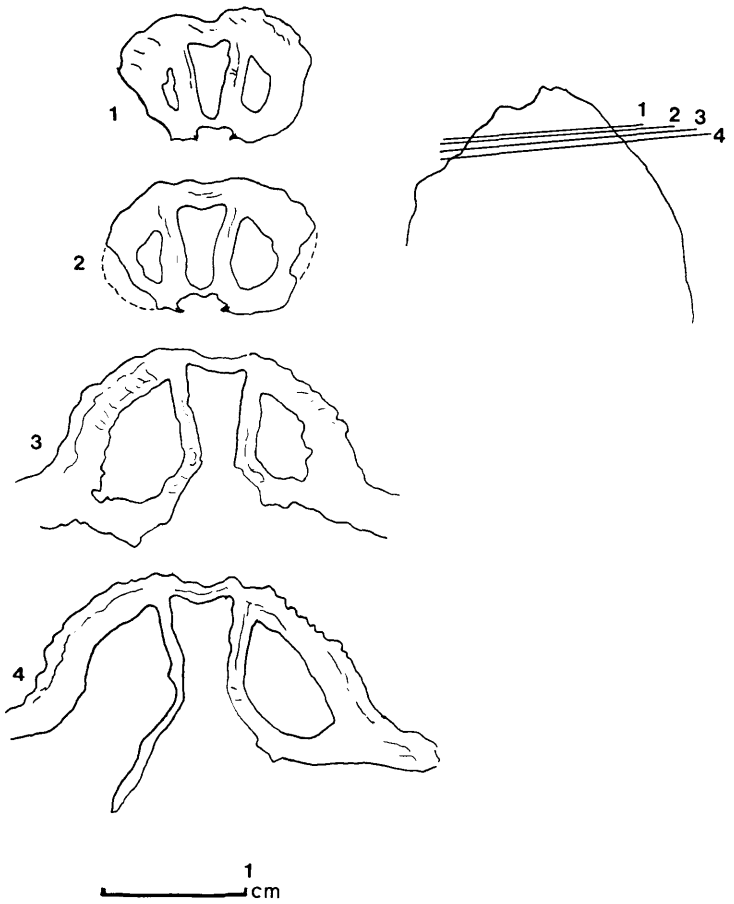

Fig. 15. *Neospirifer* sp. Serial transverse sections of an incomplete pedicle valve, MGL 63338, showing strong teeth ridges and dental plates.

species. REED (1944) discussed nothing about the internal structures of them and the figures shown by Reed reveal costae that are not flat-crested. Flat-crested costae are commonly observable in *Choristites* and *Choristitella*. The Salt Range specimens, however, have no trace of fasciculation on the surface.

Occurrence.—From Quryat 1.

Superfamily Cyrtiacea Frederiks, 1924
Family Ambocoellidae GEORGE, 1931
Genus *Orbicoelia* WATERHOUSE and PIYASIN, 1970
Type-species.—*Orbicoelia fraterculus* WATERHOUSE and PIYASIN, 1970
Orbicoelia aff. *fraterculus* WATERHOUSE and PIYASIN
Pl. 6, Fig. 4

Compare.–

1970. *Orbicoelia fraterculus* WATERHOUSE and PIYASIN, Palaeontographica, Band 135, Abt. A, p. 145, pl. 26, figs. 1-4.

1976. *Orbicoelia fraterculus*, GRANT, Journal of Paleontology, vol. 50, no. 3, p. 193, pl. 52, figs. 1-24.

Material.–Small pedicle valves in good state of preservation in brachiopod limestone, from Locality 753 (sample nos. 1602-3, 9, 11).

Descriptive remarks.–Shell small for genus; outline slightly elongate to transverse, normally nearly equidimensional; pedicle valve moderately convex with largest convexity at umbonal region ; beak relatively narrow and slightly incurved over delthyrium; interarea low and narrow but open delthyrium not confirmed; hinge line much shorter than maximum width of valve, about a third maximum width with rounded cardinal extremities; pedicle valve without sulcus and surface rarely with faint growth lines anteriorly, other micro-ornaments not preserved at all.

Measurements (mm) : (pedicle valves)

Specimen (MGL nos.)	length	width	hinge width	thickness
63376 a	13.0	12.0	c. 5	c. 6
63376 b	c. 9	c. 8	c. 4	c. 4

The present species is characterized by its smooth surface without sulcus, very narrow interarea and hinge. It is slightly different from *O. fraterculus* by WATERHOUSE and PIYASIN from middle Permian of Khao Phrik, southern Thailand in its less transverse outline than the latter.

Occurrence.–From Locality 753, "Batain Melange".

Ages and affinities of the brachiopod faunules

The geology of the Oman Mountains region is strongly complicated and the autochthonous and allochthonous units are distributed in distances very close to each other. Among the four brchiopod localities Quryat 1 and 2 are represented by the autochthonous units. Other two localities, Jebel Qamar South and Locality 753 in "Batain Melange" belong to the allochthonous units.

In general the Oman Mountains region is included in the Gondowana Tethyan (Perigondowana land) province in early Permian time (NAKAMURA, SHIMIZU and LIAO, 1985) and as the brachiopod provinciality became much more differentiated in middle Permian time, this region was recognized as a part of the West Tethyan subprovince (NAKAMURA, SHIMIZU and LIAO, 1985).

Through comparison with known faunas in other areas, early to middle Permian age is suggested for the brachiopod faunules of the Oman Mountains region as follows.

1. The Jebel Qamar South faunule (from Allochthonous units)

Specific elements of this faunule have the following affinities. *Marginifera qamarensis*, n. sp., is closely related to *M. typica* WAAGEN from the Wargal Formation, the Salt Range, Pakistan. *M. qamarensis*, however, is smaller in size and in number of spines of a row on flank than *M. typica*. *Waagenoconcha? omanica*, n. sp., is closely related to *W. abichi* (WAAGEN) from the Middle to Upper Productus Limestones of the Salt Range and Khisor Range. *Waagenoconcha? omanica* externally much resembles species of *Taeniothaerus* from the Lower Permian of Western Australia and also from the Lower Productus Limestone (the Amb Formation) of the Salt Range. *Acosarina* aff. *indica* (WAAGEN) is very close to *A. indica* (WAAGEN) from Amb, Pakistan. *Perigeyerella* sp. seems to be related to P. *tricosa* GRANT from the upper Lower Permian of southern Thailand. *Perigeyerella* sp. seems to be the most primitive comparing with *P. tricosa* and *P. costelata* WANG, the type species of this genus, from upper Permian of south China in development of spondylium. Derbyiidae gen. and sp. indet. seems to have characters of *Derbyia* but it is much larger than the representative form of *Derbyia*. The large size of the present specimen recalls to our minds those of *Derbyia* in the Wargal Formation, the Salt Range, Pakistan. *Reticulariina* sp. much resembles R. *transindica* REED from the top of the Middle Productus Limestone. *Crenispirifer* sp. is similar to the Lower Permian *C. angulatus* (R. E. KING) from West Texas. The brachiopod faunule from Jebel Qamar South is composed of specific elements which are very closely related to those of the Lower to Middle Permian faunas of the Gondowana Tethyan and Cathaisia Tethyan provinces.

It is highly probable that the age of the faunule is the late Early Permian mainly based on the comparison of the most abundant and well preserved specimens of *Marginifera qamarensis*, n. sp., and other accompanied brachiopods.

2. The Quryat faunule (from Quryat 1 and 2, Autochthonous units)

The Quryat faunule comprises moderately deformed seven genera and species. However, of the discriminated elements *Costiferina* sp. and *Stereochia?* sp. are large in size and they work well for considering the geologic age and for examining paleobiogeography. Both *Costiferina* and *Stereochia* range from the Lower Permian to the Upper Permian, but most abundant in occurrence in the Lower Permian. *Costiferina* sp. resembles *C. spiralis* (WAAGEN) from the Lower Productus Limestone, the Salt Range and *Productus uralicus* TSCHERNYSCHEW from lower Permian of the Urals. *Stereochia?* sp. is large for the genus, having a remakably reticulated zone. *Reticulariina* sp. also resembles *R. transindica* REED.

3. The Locality 753 faunule (from Allochthonous units)

This Permian brachiopod faunule came from limestone blocks included in the Triassic calcareous sediments. It is noteworthy that the specific elements are strongly related to those of early Permian fauna from southern Thailand and those of the Lower and Middle Productus Limestones, the Salt Range. They are

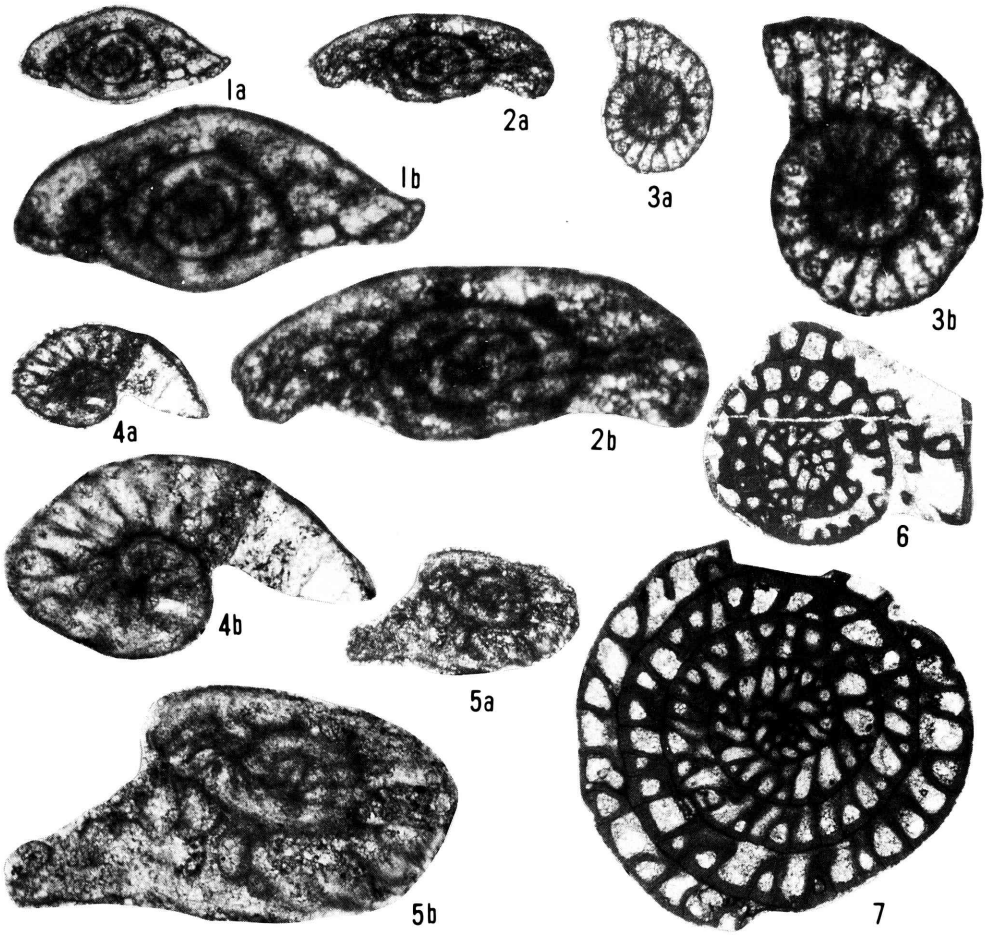

Fig. 16. Fusulines
1-3. *Boultonia* sp. indet. 1a. 2a. 3a, ×50 ; 1b, 2b, 3b, ×100. Slide nos. 1602/1-3, 1602/1-3 and 1602/1-4, respectively.
4, 5. *Codonofusiella* sp. indet. 4a, 5a, ×50 ; 4b, 5b, ×100. Slide nos. both 1602/2-2.
6, 7. Schwagerinid, gen. et sp. indet, ×20. Slide nos. 1602-1/2 and 1602/2-6, respectively.

the following species : *Marginifera* cf. *nesiotes* GRANT, *Bilotina* aff *acantha* (WATERHOUSE and PIYASIN), *Orbicoelia* aff. *fraterculus* WATERHOUSE and PIYASIN. *Waagenoconcha*? *omanica*, n. sp.,

The brachiopod faunule from Loc. 753 is closely accompanied by foraminifers and bryozoans. Of them fusulines and bryozoans were examined by SAKAGAMI and the faunules were introduced in the following chapter.

Accompanied faunules (by Sumio SAKAGAMI)

In thin sections (Slide nos. 1602/1-1, 7), smaller foraminifers, fusulines and

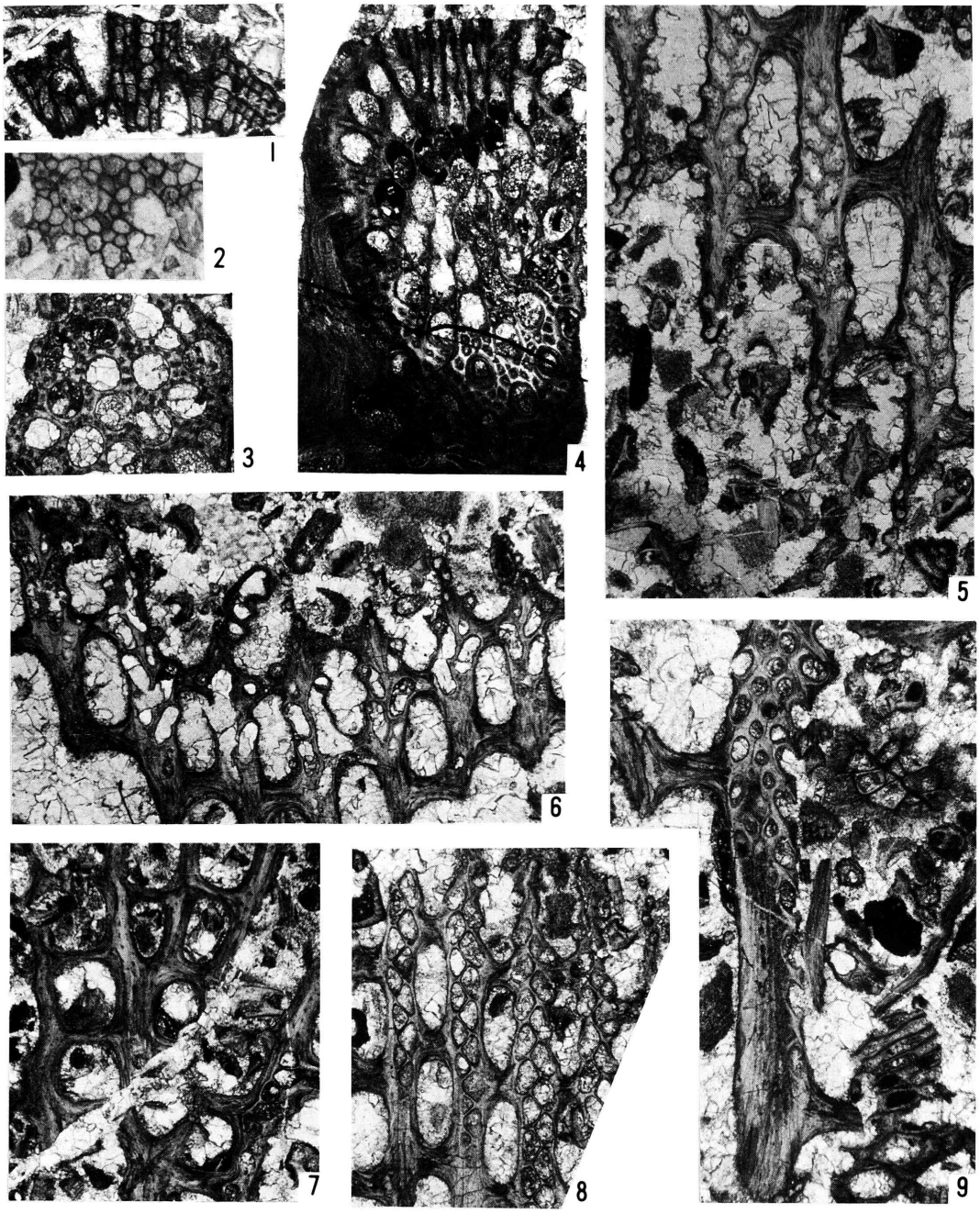

Fig. 17. Bryozoans, all figures are in ×20.
1, 2. *Fistulipora* sp. indet. Slide nos. 1602/1-1 and 1602/1-2.
3. Trepostomata, gen. et sp. indet. Slide no. 1602/1-2.
4. *Streblascopora* aff. *diaphragma* SAKAGAMI. Slide no. 1602/1-1.
5-8. *Fenestella* spp. indet. Slide nos. 5, 1602/1-3 ; 6-8, 1602/1-1.
9a, b. *Polypora* sp. indet. and *Sulcoretepora* sp. indet., respectively. Slide nos. both 1602/1-1.

bryozoans were observed. Fusulines are discriminated 3 indeterminable species in 3 genera as follows. *Boultonia* sp. indet., *Codonofusiella ?* sp. indet., Schwagerinidae, gen. and sp. indet.

According to TORIYAMA (1970), the genus *Boultonia* covers the upper part of the *Pseudoschwagerina* to the upper part of Yabeina zones. On the other hand, the genus *Codonofusiella* ranges from the *Neoschwagerina* zone to the *Palaeofusulina-Codonofusiella* zones. The specimens of *Codonofusiella* sp. indet. at hand are questionably referred to the primitive type of the genus.

Bryozoans, although only fragmentary remains, are discriminated at least the following forms in 6 genera. *Fistulipora* sp. indet., *Sulcoretepora*? sp. indet., *Trepostomata*, gen. and sp. indet., *Streblascopora* aff. *diaphragma* SAKAGAMI, *Fenestella* spp. indet., *Polypora* sp. indet.

In the bryozoans, *Fistulipora*, *Fenestella* and *Polypora* are world wide and very popular genera especially in the Carboniferous and Permian, but they cannot be made easily their specific identifications because of the fragments and/or poor preservation. The species of *Streblascopora* may be identical to *S. diaphragma* which was described from the *Parafusulina* zone of the Akiyoshi Limestone, Southwest Japan by SAKAGAMI (1964).

As concluded comment from the present fusuline and bryozoan faunules, the estimated geologic age may be Middle Permian and most probably the upper Artinskian or lower Guadalupian.

Concluding Remarks

Permian brachiopod faunules found from three major localities in the Oman Mountains region are composed of elements which are common or closely related to those of the Lower Permian and/or Middel Permian faunas in the Gondowana Tethyan (Perigondowana land) province and/or West Tethyan subprovince.

The Jebel Qamar South and Quryat faunules are composed of elements which are highly referable to the Artinskian in age. The faunule from limestone blocks of "Batain Melange" (Loc. 753) is highly comparable with the Lower Permian fauna of southern Thailand and the Lower and Middle Productus Limestones fauna of the Salt Range, Pakistan. Taking accompanied fusulines and bryozoans into consideration, the age of the Locality 753 faunule is referable to the upper Artinskian to lower Guadalupian.

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