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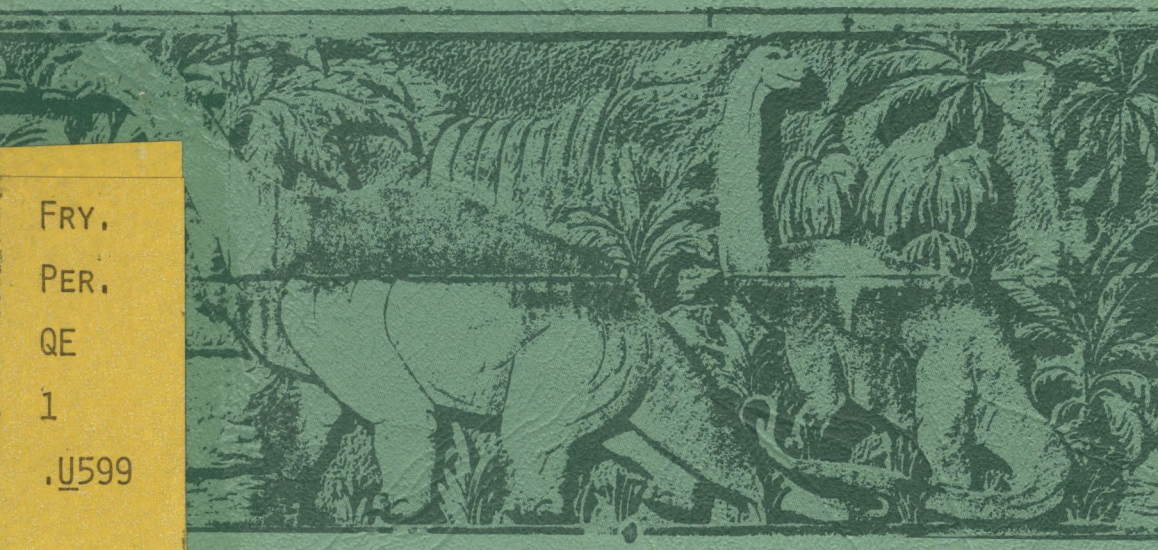

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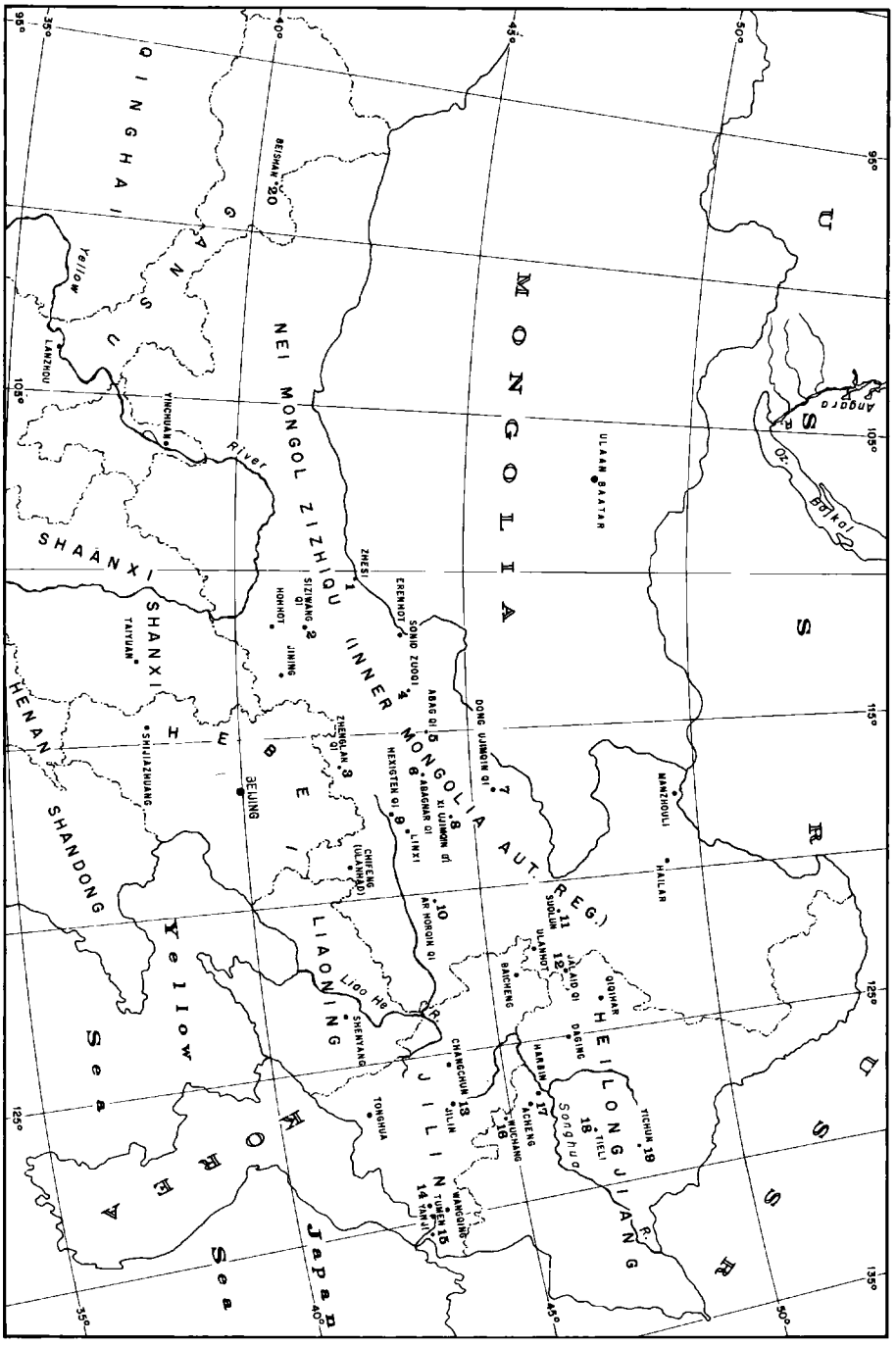
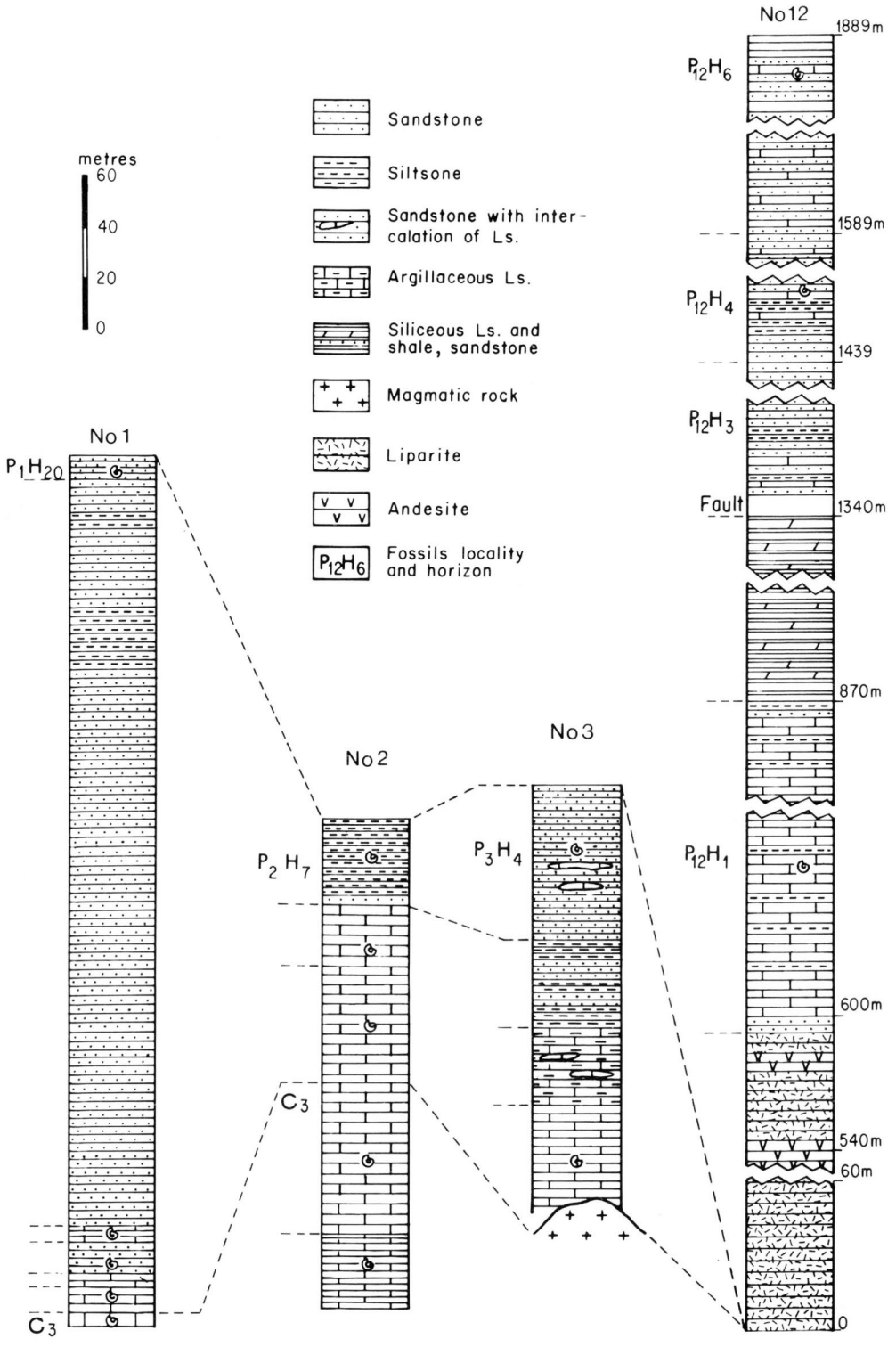
Permian Strata and Brachiopods from Xiujimqinqi Region of Neimongol (Inner Mongolia) Autonomous Region, China

LIU FA and J.B. WATERHOUSE



Text-fig.1. Part of north-east Asia showing geographic distribution, with Xiujimqinqi, Zhesi and Suolon underlined.



Text-fig.2. Stratigraphic columns near Xiujimqinqi. C 3 = Asselian, regarded as Late Carboniferous in China, basal Permian in most other countries.

PERMIAN STRATA AND BRACHIOPODS FROM XIUJIMQINQI REGION OF NEIMONGOL (INNER MONGOLIA) AUTONOMOUS REGION, CHINA

by **Liu Fa & J.B. Waterhouse**

ABSTRACT. Brachiopod species are described from the Zhesi and Houtoumiao Formations of Permian age in the Xiujimqinqi region of Neimongol, including new species *Derbyia dorsosulcata, Dyoros lamellosa, Yakovlevia convexus, Y. borealis, Stenoscisma ovalia, Camerisma rhomboidea, Spiriferella wangi, Elivina sinensis, Neospirifer adpressum, N. sulcoprofundus* and *Kitakamithyris ovata.* Small *Attenuatella* and *Syringothyris* faunules are likely to be of Early Permian age, and do not compare with other faunas so far described from north China, and an overlying assemblage may be of late Early Permian age. Younger brachiopod assemblages compare in a general way with those from nearby sequences at Suolon and Zhesi and may be Middle Permian in age.

STRATIGRAPHY

Fossils described in this paper were collected by Liu Fa and colleagues Lin Ying-dang and Liu Mao-shu in 1979 from Permian beds in the Xiujimqinqi Region of Neimongol Autonomous Region (117° 30′E; 45° 20′N) – text fig. 1. Here beds are divided into the Zhesi Formation (= Jisu Honguer Formation of Grabau, 1931) characterized by coarse sandstone with limestone lenses, the Houtoumiao Formation, of finer sandstone with limestone beds, and the Amushan Formation, of limestone (text fig. 2). Strata are closely folded and faulted so that no one stratigraphic section has been found to pass from the base to the top of the Lower Permian. Fossils mostly come from section 12, which is folded and faulted. Five brachiopod assemblages are recognised, the first three possibly correlative with Chihsia faunas of south China, and the fourth and fifth assemblages correlative with upper Chihsia and lower Maokou faunas of south China.

Permian sequences of the Xiujimqinqi area are synthesized as follows:

Section no. 12.

Zhesi Formation

9. (top) Chiefly grey brown calcareous sandstone, and siltstone with intercalated limestone lenses. Numerous brachiopod fossils were collected from the limestone ($P_{12}H_6$), including *Kochiproductus* aff. *sinensis* Liu & Waterhouse, *Muirwoodia mammata* (Keyserling), *Stenoscisma* cf. *timorense* (Hayasaka & Gan), *Stenoscisma* sp. A, *Camerisma rhomboidea* sp. nov., *Neospirifer sulcoprofundus* sp. nov., *N. adpressum* sp. nov., *Spiriferella wangi* sp. nov., and *Elivina sinensis* sp. nov.

Pap. Dep. Geol. Univ. Qd., 11*(2)*: 1–44, Pls 1–12, April 1985

8. Grey to grey green medium to coarse sandstone, siltstone and calcareous siltstone intercalated with limestone lenses ($P_{12}H_4$), rich in brachipod fossils *Derbyia dorsosulcata* sp. nov., *Waagenoconcha* sp. B., *Kochiproductus* sp., *Yakovlevia borealis* sp. nov., *Y. convexus* sp. nov., *Stenoscisma* cf. *paucisulcata* Liu & Waterhouse, *S.* cf. *timorense* (Hayasaka & Gan), *Spiriferella wangi* sp. nov., *S.* aff. *antesulcata* Liu & Waterhouse, *Squamularia* sp. 150m

Houtoumiao Formation (=Yanchibeishan and Dalinuoer Formations of Lee, Gu & Li)

7. Grey and brown sandstone and siltstone intercalated with grey black chert bands; limestone lenses ($P_{12}H_3$) contain some brachiopods: *Kochiproductus* sp., *Muirwoodia* cf. *mammata* (Keyserling), *Neospirifer* sp.

6. Grey yellow and grey siliceous fossiliferous limestone and siliceous shale, and sandstone. *Muirwoodia* sp., *Stenoscisma* sp. 470m +

5. Grey bioclastic limestone, thin bedded, intercalated with grey black siltstone and grey yellow siltstone and mudstone, rich in brachiopod fossils ($P_{12}H_1$), including *Dyoros lamellosa* sp. nov., *Waagenoconcha* sp. A, *Magniplicatina* sp., *Muirwoodia* cf. *mammata* (Keyserling), *Stenoscisma ovalia* sp. nov., *Stenoscisma* sp. B, *Spiriferella* sp. and *Kitakamithyris ovata* sp. nov. 270m

4. Yellow brown, grey white liparite (or rhyolite) intercalated with purple andesite with chert at top. 600m

3. Yellow green siltstone, calcareous sandstone with bryozoans, bivalves and brachiopods (P_2H_7, P_3H_4) including chonetid sp., *Syringothyris* sp. A, ?*Pseudosyringothyris* sp., *Neospirifer* sp. 34m

2. Grey, medium to thick bedded limestone with bryozoans and colonial corals: *Polythecalis* cf. *yangtzeensis* Huang, *Wentzellophyllum variabilis* (Gerth), *Yokoyamaella yokoyamai* (Ozawa). 65m

Amushan Formation

1. Grey thick bedded crystalline limestone with fusuline *Pseudoschwagerina sphaerica* Scherbovich) and corals *Amplexocarinia* sp., *Cyathocarinia* sp., and *Lophocariniophyllum* sp. 60m

Section no. 1, 4km north of Houtumiao Commune. (P 8 of Lee, Gu & Li, 1982)

Houtoumiao Formation

7. (top) Dark grey thin to medium bedded poorly sorted sandstone with siltstone containing brachiopods, gastropods and conularids (P_1H_{20}) including *Attenuatella xiujumqinqiensis, Paraconularia* sp. 10m

6. Grey, pale or grey-green poorly sorted sandstone, quartzose sandstone, and siliceous siltstone. 300m

5. Light grey thin bedded crystalline limestone, with crinoids. 6m

4. Yellow green fine grained sandstone, with brachiopods *Neospirifer* sp., *Phricodothyris* sp., spiriferinid.

Amushan Formation

3. Grey thin bedded crystalline limestone, with bryozoans, brachiopods and crinoids. 6m

2. Grey argillaceous limestone, rich in fusuline *Monodiexodina* sp., and small corals *Amplexocarinia heritschi* Schouppe & Stacul, *Calophyllum* sp., *Monophyllum* sp. 11m

1. Grey thick bedded to massive limestone, with fusuline *Pseudoschwagerina* sp. and corals *Amygdalophylloides ivanovi* (Dobrol.), *Calophyllum* sp. 6m

Section no. 2, 500m east of section no. 1.

Houtoumiao Formation

5. (top) Yellow green thin to thick bedded siltstone, rich in fossils (P_2H_7), including brachiopods *Derbyia* sp., *Syringothyris* sp., *Neospirifer* sp., spiriferinid and bivalve *Chaenomya* sp. 35m

Amushan Limestone

4. Grey thick bedded limestone. Corals from upper part include *Wentzellophyllum variabilis* (Gerth), *Polythecalis* sp., *Yokoyamaella yokoyamai* (Ozawa), *Koninckophyllum* sp., *Sinopora dendroides* (Yoh). 27m

3. Light grey medium to thick bedded fine crystalline limestone, with corals *Polythecalis* cf. *yangtzeensis* Huang, *Wentzellophyllum* sp. 48m

2. Greyish thick bedded limestone, rich in fusuline *Pseudoschwagerina sphaerica* (Scherbovich) and corals *Amplexocarinia* sp., *Cyathocarinia* sp., *Lophocarinophyllum* sp. 60m

1. Dark grey thin bedded limestone with *Schwagerina* sp. 30m

Section no. 3 about 500m east of section no. 2.

Houtoumiao Formation

4. (top) Yellow green fine grained sandstone with intercalated limestone lenses, rich in brachiopods (P_3H_4) including chonetid sp., *Syringothyris* spp., ?*Pseudosyringothyris* sp. and *Neospirifer* sp. 61m

3. Dark grey siltsone and fine sandstone, containing brachiopods, bryozoans and crinoids.

2. Grey thin to thick bedded argillaceous limestone and fine sandstone lenses. 29m

Amushan Formation

1. Grey thick bedded bioclastic limestone with coral *Bradyphyllum* sp., bryozoans and crinoids. 59m

Magmatic intrusion

In the Xiujimqinqi Region the terrestrial Linxi Formation of younger Permian age contains bivalves *Palaeodonta* and *Palaeomutela* and floras. In the Suolon region to the east, the Suolon Formation has marine beds with the bivalve *"Aviculopecten"* alternating with non-marine beds containing *Palaeomutela* and *Palaeodonta* and plant fossils *Iniopteris, Comia* and *Supaia.*

FAUNAL ASSEMBLAGES

On the basis of these sections, several brachiopod assemblages or faunules may be recognised:

Houtoumiao Formation

1. *Syringothyris* faunule (P_3H_4, P_2H_7).

Syringothyris with other poorly preserved brachiopods such as *Neospirifer* and a spiriferinid occur in sequences above the *Pseudoschwagerina* fusuline beds of the Amushan Formation and may be correlative, or older or younger than the *Attenuatella* horizon. Speculatively, it may be of early Permian, Sakmarian age, but there is no firm evidence.

2. *Attenuatella xiujumqinqiensis* faunule (P_1H_{20})

This species occurs profusely at Section P_1H_{20} just above beds with *Pseudoschwagerina.* It resembles most closely *Attenuatella australis* Armstrong & Brown from beds of Sakmarian age in Queensland, and its affinities reinforce the stratigraphic position in suggesting a possible Sakmarian age, equivalent to part of the Chihsia Limestone in south China.

3. *Dyoros lamellosa – Muirwoodia – Stenoscisma ovalia* assemblage ($P_{12}H_1$)

In section $P_{12}H_1$, these and other fossils (Table 1) form a distinct association. *Muirwoodia* looks like *M. mammata* (Keyserling) from principally early Middle Permian (Kungurian-Kazanian) faunas, though recorded also from older beds. Present material is too poorly preserved to allow firm specific identification. The species has been reported widely through northern China,

from beds equivalent to the Chihsia and Maokou Formations but reports are seldom fully documented. Nor do accompanying species in this faunule convincingly point to any firm age. *Kitakamithyris ovata* is most like a Sterlitamakian (mid-Sakmarian) shell from Western Australia, but the closest similarities for other species suggest a younger age, with *Dyoros lamellosa* sp. nov. like *D. subliratus* (Girty) and other species from Word-Capitan faunas of Texas, of Kungurian-Punjabian age, and *Stenoscisma ovalia* like *S. maniculum* Cooper & Grant, from Road Canyon (=early Kungurian) faunas of Texas. Stratigraphic position and the presence of *Kitakamithyris* would apparently favour an early Permian age.

Zhesi Formation

4. *Yakovlevia borealis – Stenoscisma* cf. *paucisulcata* assemblage ($P_{12}H_4$).

This assemblage is characterised by numerous large *Derbyia, Yakovlevia, Stenoscisma* and *Spiriferella. Derbyia dorsosulcata* shows some similarities to *D. grandis* Waagen from the Middle Productus Limestone (Wargal Formation) of Kazanian-Punjabian age in the Salt Range, Pakistan. *Yakovlevia borealis* sp. nov. is close to *Y. impressus* (Toula) of early mid-Permian age in Arctic regions, *Y. kaluzinensis* Frederiks of similar or slightly younger age in south Primoyre, and specimens described as *Y. mammatiformis* from Beishan, Gansu Province, considered by Ustritsky (1963) to be Kazanian. *Stenoscisma paucisulcata* is elsewhere found in the Zhesi Formation at Zhesi (Jisu Honguer). This species is allied to *S. gigantea* (Diener) from Punjabian faunas of the Himalayas. In Northeast China *Stenoscisma gigantea* (Diener) was reported from the Fangjiatum Formation of Central Jilin, Miaoling Formation of eastern Jilin, and Tumeling Formation of Heilongjian, correlated in the general way with the lower Maokou Formation of south China. *S. timorense* (Hayasaka & Gan) is mostly of Punjabian age in the Himalayas and Timor. *Spirigerella* is close to *S. proxima* Reed and *S. grandis* Waagen from Wargal and Chhidru beds (Kazanian-Punjabian) of the Salt Range, Pakistan, and perhaps ?*S. timorensis* (Rothpletz) from Basleo beds (Punjabian) of Timor. *Spiriferella wangi* sp. nov. is like the early mid-Permian species *S. loveni* (Diener) and *S. leviplica* Waterhouse & Waddington of especially Kungurian age in the Arctic. *S. antefurcata* Liu & Waterhouse is found also in the Zhesi Formation of Zhesi and is perhaps like *S. qubuensis* Chang from the Selong Group of Tibet.

5. *Elivina sinensis – Neospirifer adpressum* assemblage ($P_{12}H_6$).

Spiriferaceans are predominant in this assemblage, especially *Spiriferella, Elivina* and *Neospirifer. Muirwoodia, Stenoscisma timorensis* and *Spiriferella wangi* persist from older faunas. *Kochiproductus* is allied to *Kochiproductus sinensis* Liu & Waterhouse, a species characteristic of the upper Zhesi section at Zhesi. Other species of *Stenoscisma* look like *Stenoscisma humbletonensis* (Howse) from early mid-Permian beds of north Europe, and like *S. multicostum* Stehli from Wolfcampian (=Hess) beds of Sierra Diablo (Stehli, 1954, p. 339) and Hess Formation of Glass Mountains, of Sakmarian age. *Camerisma*

rhomboidea sp. nov. is a distinct species with no specific alliance. *Elivina sinensis* is a very distinctive species showing some approach to the Kungurian Arctic species *E. cordiformis* Waterhouse & Waddington and also to the Asian species *E. tibetana* (Diener) from Kazanian and Punjabian faunas in Tibet, Timor and Cambodia. *Neospirifer sulcoprofundus* approaches *N. striato-paradoxus* (Toula) from Kungurian faunas in the Arctic. In northeast China this species was reported from the Yuchuan Limestone of Heilongjiang Province, which is equivalent to the upper Chihsia Formation and Tumenling Formation (lower Maokou) (Lee & Gu in Lee *et al.* 1980, pl. 177, fig. 3, 6, 9). *Neospirifer adpressum* is like *N. marcoui* (Waagen) from the Amb Formation of the Salt Range, principally of Baigendzinian age, and is also found in beds of comparable age in Western Australia. *N. adpressum* appears to be a member of a lineage of *Neospirifer* with large innermost plication on the ventral valve, and seems to lie between *N. marcoui* (Baigendzinian) and *N. ravana* (Punjabian) in development.

Overall, species range in their affinities from Sakmarian to Punjabian in age, but most point to a Kazanian or Punjabian age, and the assemblage may be correlative with the upper Zhesi fauna of Zhesi.

CORRELATION

Comparison with Suolon Region

The faunas from the Xiujimqinqi Region are not exactly like those of the Suolon Region (formerly called western Jilin Province) in eastern Neimongol, where Zhan & Lee (1977) listed four brachiopod assemblages. The oldest Suolon assemblage included *Anidanthus aagardi* (Toula), *Muirwoodia mammata* (Keyserling), *Stenoscisma purdoni* (Davidson), and *Paeckelmanella expansa* (Chernyshev) associated with the ammonoid *Popanoceras* sp. which is common in the Chihsia Formation. The second assemblage was characterized by *Muirwoodia mammata* (Keyserling), *Yakovlevia mammatiformis* (Frederiks), *Cancrinella koninckiana* (Keyserling), *C. cancriniformis* (Chernyshev), *Waagenochoncha humboldti* (d'Orbigny), and *Spiriferella persaranae* Grabau etc. The third assemblage contained *Waagenites deplanata* (Waagen), *Yakovlevia mammatiformis* (Frederiks), *Waagenoconcha irginae* (Stuckenberg), *Liosotella spitzbergiana* (Toula), and *Spiriferella keilhaviiformis* Frederiks. The fourth assemblage was characterized by numerous *Licharewia,* including *Licharewia grewingki* (Nechaev), *L. keyserlingi* (Nechaev), *L. tsaregradskyi* Zavodowsky, *L. micluchomaclayi* Zavodowsky, *Spiriferella keilhaviiformis* Frederiks, *Yakovlevia mammatiformis* Frederiks, *Neospirifer moosakhailensis* (Davidson), *Horridonia timanica* (Stuckenberg) (=*Sowerbina*) and *Rhynchopora* sp. Zhan & Lee (1977) correlated the first and second assemblages with the Chihsia Formation of south China, equivalent to Sakmarian. The third and the fourth assemblages were correlated with the Maokou Formation of south China.

Younger faunal assemblages in the Xiujimqinqi region are close to those of the Suolon area at a generic level, but there is scarcely any degree of satisfactory correlation, and it is clear that much needs to be done on these faunas and

sequences from northern China. The older faunules from Xiujimqinqi with *Attenuatella* and *Syringothyris* are not recognisable within the four Suolon assemblages, the closest resemblance being offered by the report of an ambocoelid in the oldest Suolon assemblage, a report not elaborated by Lee & Gu (1976) or Lee *et al* (1980). We may speculate that the *Attenuatella* and *Syringothyris* faunules are of the same age as the first Suolon assemblage on the basis of stratigraphic position, but this is a dubious procedure, and they could be older. The third Xiujimqinqi brachiopod assemblage with *Dyoros lamellosa* shares with Suolon assemblages genera such as *Muirwoodia, Waagenoconcha, Stenoscisma,* and simply plicate *Spiriferella,* but it is objectively difficult to decide which Suolon assemblage is correlative – as the lower three all look somewhat similar. Probably either the first or second Suolon assemblage is close in age, to judge from stratigraphic and sequential evidence. The fourth Xiujimqinqi *Yakovlevia* assemblage with large *Yakovlevia* and simply plicate *Spiriferella* is also generally like the first three Suolon assemblages, and, from sequential considerations insofar as it overlies at least one similar but older assemblage, might match Suolon assemblage 2 or 3, rather than 1. The fifth, *Elvina* assemblage of Xiujimqinqi, dominated by spiriferids, also finds no obviously restricted match in the Suolon sequence. The fourth Suolon faunule is dominated by *Licharewia* species, which we did not find at Xiujimqinqi, either because of facies differences, or perhaps because the fourth Suolon fauna is slightly younger.

Thus, overall, similarities between the two regions are at a general level only, and tightly controlled correlations are not yet possible. Unfortunately the studies by Lee & Gu (1976) and Lee *et al.* (1980) which elaborate species descriptions from Suolon are too cryptic to enable a closer correlation, for they distinguished only two stratigraphic levels, and provided brief reports on species.

Brachiopod faunules from Xiujimqinqi have also been assessed by Lee, Gu & Li (1982) and matched with the brachiopod assemblages of Lee & Zhan (1977). The basal 'M' assemblage resembled that of *Muirwoodia mammatus-Anidanthus* of Lee & Zhan (1977) of Early Permian age, followed by a *Spiriferella – Yakovlevia mammatiformis* 'S' assemblage of late Early Permian age, including *Paeckelmanella* and *Spiriferella* compared with faunas of the lower Zhesi (i.e. upper Zhesi in our interpretation) Formation of Jisu Honguer. Above came a 'W' assemblage with *Waagenoconcha, Liosotella, Kochiproductus, Attenuatella xiujumqinqiensis* and other forms, thought to be Kungurian in age, and said to match the upper part of the Zhesi Formation of Jisu Honguer. We did not find other brachiopods with our *Attenuatella.* The 'W' assemblage was reported as occuring in bioclastic limestone and was only tentatively regarded as younger than the 'S' assemblage. In our section P 12, bands 3, 4 and 6 equal 'W' and 'S' assemblages, and P 12 H 1 equals the 'M' assemblage. The *Licharewia* ('L') assemblage is dominated by spiriferids such as *Licharewia, Pseudosyrinx, Neospirifer* and *Spiriferella* with a *"Chonetes"* sandstone, and assigned to a Kazanian age. We found *Syringothyris,* rather than *Pseudosyrinx,* apparently low in the sequence, and with no shells that could be definitely identified as *Licharewia.* An 'F' assemblage characterised by a

Compressoproductus-like form called *Fallaxoproductus* was not found by Lee, Gu and Li (1982) in sequence, and was regarded as being of uncertain, but possibly Early Permian age.

Comparison with Zhesi Formation of Damao County, Neimongol

Liu & Waterhouse (in press) recognised several faunal assemblages in the Zhesi Formation at Zhesi (Jisu Honguer) in Damao County, in the sequences also studied by Grabau (1931). Early Zhesi faunules have many palaeotropical genera, such as *Enteletes, Edriosteges, Spinomarginifera, Leptodus, Notothyris,* together with Arctic genera *Yakovlevia* and *Muirwoodia*, and some *Stenoscisma* and *Spiriferella*; a middle assemblage lacks *Muirwoodia* and *Yakovlevia,* and has many palaeotropical genera, and a topmost assemblage has many Arctic genera, such as *Magniplicatina, Kochiproductus, Yakovlevia,* and *Spiriferella,* without the palaeotropical forms. To some extent, the topmost Zhesi fauna looks like the uppermost assemblage from Xiujimqinqi, and shares *Kochiproductus* and large *Yakovlevia,* and perhaps *Spiriferella antesulcata. Stenoscisma* cf. *paucisulcata* from a slightly older Xiujimqinqi fauna is found in the uppermost Zhesi fauna in Damao County. The upper faunules of these two areas also look to be close to faunas described by Ustritsky (1963) from Beishan, Gansu Province. The Xiujimqinqi faunas lack the palaeotropical genera of the Jisu Honguer beds, either because they are of different age, or of different facies, or have not been so fully collected.

Implications and cautions in assessment of Permian faunas from north China

Studies on the brachiopods from the Zhesi district, Damao County, and Xiujimqinqi, and Suolon, to mention the fullest sequences, have not yet revealed a clearly developed succession of well defined brachiopod zones like those generally found in Permian sequences elsewhere, and moreover, show substantial differences between faunal sequences of each region. To some extent, these correlation difficulties might be due to the involvement of faunas from different faunal realms – notably the very diverse fauna of the lower Zhesi district, and incomplete collecting might also have played a role. But we must also allow for the possibility that the various faunal assemblages and faunules represent slightly different time intervals. It would be a gross error to expect these northerly faunas to fall in a two-fold subdivision equivalent roughly to Chihsia and Maokou of south China. Zhan & Lee (1977) have avoided this error by recognising four faunal assemblages at Suolon. Equally, we cannot expect to find that all the assemblages from northern China will fit into these four Suolon assemblages. Indeed, several of the Xiujimqinqi assemblages clearly do not fit. World faunas correlative with the Chihsia and Maokou beds and faunas of south China fall into some eleven zones – fusuline and brachiopod – not into just four. It is thus clear from the scattering of faunal assemblages now recognised in north China that much needs to be done before we can attain a standard of correlation comparable to that found widely through, for example, south China, Texas, Arctic Canada, east and west Australia, Himalayas-Iran-Armenia, and other regions.

The analyses in the preceeding text, and in Lui & Waterhouse (in press) on the Zhesi faunas indicate age from the preponderance (however slight) of affinities, with some input from stratigraphic succession. They indicate that faunas from Suolon, Zhesi and Xiujimqinqi may be correlative, but differ substantially from each other. The *Licharewia* fauna of Suolon is not found elsewhere, nor is the Zhesi middle assemblage, rich in palaeotropical genera and species. What if most faunas so far recorded from north China were of slightly different ages as set out in one option on Table 1? That would be permitted by our present knowledge of the stratigraphy. In this alternative model, the *Licharewia* faunal assemblage from Suolon 4 is regarded as early Kazanian, and the older Suolon 1-3 assemblages are treated as tentatively early Middle Permian, all close in age, reflecting the high number of shared species and genera. Even the basal Suolon fauna appears to be rich in early mid-Permian species, such as *Waagenites deplanata, Liosotella spitzbergiana,* and *Muirwoodia mammata* etc. It also contains the ammonoid *Popanoceras,* which according to Zhan & Lee (1977), demanded an Early Permian age. But although *Popanoceras* is well represented in Artinksian and Darvasian faunas, and in the Chihsia fauna of south China, it is also widely reported from Kungurian, Kazanian and Punjabian faunas of Asia (Waterhouse, 1976, p. 228) and so provides little age constraint, pending close specific study. We still do not know the answer. Firm age determination for the Suolon faunas requires more published information on stratigraphic sequence and amplification of the preliminary studies by Lee & Gu (1976) and Lee *et al* (1980).

Faunas from the Zhesi Formation at Zhesi, as described by Grabau (1931) and Liu & Waterhouse (in press) mostly differ from the Suolon assemblages in that the two lower faunal assemblages are much richer in palaeotropical genera and species. If they are of different age, they could be younger than the *Licharewia* assemblage of Suolon 4, and so approximately late Kazanian and Punjabian in age. These ages would fit with the sequences and faunas of south Primorye, summarized by Likharev & Kotlyar (1978), with the lowest Zhesi fauna like the *Parafusulina stricta* fauna (Golubin Complex) and the middle Zhesi fauna like the *Metadoliolina lepida* fauna (Chandalaz Suite). Certainly the assemblages are similar at a generic level, and a number of species are shared. The presence of the fusuline *Lepidolina* and ammonoid *Timorites* in the Chandalaz beds ensures a Punjabian – probably Kalabaghian age for at least part of the suite.

A Punjabian age for younger Zhesi faunas would explain the presence of a number of Neimongol species that resembled species from the Punjabian faunas of the Salt Range, Pakistan and the Himalayas. The uppermost Zhesi fauna is presumably of late Punjabian age, for it lacks any Djulfian links. The uppermost Zhesi cold-water assemblage, would under this model appear not to be represented in south Primorye. However, younger faunas include Araxoceratidae in the Ludyargin Horizon of south Primorye, of Djulfian age.

The older Xiujimqinqi faunules have little in common with Suolon faunas, and so are tentatively considered to be different, and older, though they are too small to be significant, or datable with any accuracy. The younger Xiujimqinqi faunas are also hard to date because they are also very

World Standard		North China			E. USSR
Stage	Substages	Zhesi and Suolon faunas		Xiujimqinqi faunules	South Primorye zone (horizon)
		(1)	(2)		
Dorashamian (-Changxingian)	Ogbinian Vedian				
Djulfian =(Longtanian)	Baisalian Abadehian-Urushtenian				(Ludyarzin) *Colaniella parva*
Punjabian	Chhidruan (=Kufrian)	Zhesi 3			
	Kalabaghian	Zhesi 2			*Metadoliolina lepida*
Kazanian	Sosnovian	Zhesi 1			*Parafusulina stricta*
	Kalinovian	Suolon 4	Suolon 4		*Monodiexodina sutschanica*
Kungurian	Ufimian	Suolon 3	Zhesi 3	?*Elivina*	Vladivostok
	Irenian	Suolon 2	Zhesi 2	?*Yakovlevia*	
	Filippovian	Suolon 1	Zhesi 1		
Baigendzinian	Krasnoufimian Sarginian			*Dyoros*	
Sakmarian	Aktastinian				
	Sterlitamakian			*Attenuatella*	
	Tastubian			*Syringothyris*	?Pospelov
Asselian					

Table 1. Tentative correlations from some Permian faunas from north China, with world standard as in Waterhouse (1976) and Waterhouse & Gupta (1983). For the Zhesi and Suolon faunas, 1 offers possible ages based on apparent correlations, and 2 shows the arrangement more favoured in China, in which Suolon 4 is regarded as younger than other faunas.

incompletely represented in our collections. The species from section 12, H_1, H_3 might be Sakmarian-Baigendzinian, because *Kitakamithyris* of H_1 is usually no younger than Early Permian. $P_{12}H_3$ shares *Stenoscisma ovalia* with $P_{12}H_1$. *Yakovlevia* in P_{12}, H_4 and other forms would allow correlation with the earlier Suolon faunas (1–3), and it is difficult to decide .f the upper Xiujimqinqi fauna is of the same age, or only slightly younger, as the two share *Stenoscisma* cf. *timorensis, Camerisma rhomboidea,* and *Spiriferella wangi.*

Summary. Pending discovery of one complete faunal sequence in north China, it will be necessary to assemble slowly and to integrate faunal studies through a great deal of field work and systematic study, to which we hope that this paper contributes. Much more work needs to be done before we can achieve a refined level of correlation consistent with that now attained elsewhere.

SYSTEMATIC DESCRIPTIONS

The material is housed at the Changchun College of Geology, Jilin. Details of distribution and individual numbers will be provided in a further separate study by Liu Fa.

Order Strophomenida Öpik, 1934
Family Derbyiidae Stehli, 1954
Genus *Derbyia* Waagen, 1884
Derbyia dorsosulcata sp. nov.
Pl. 1, fig. 1, 7, 8, 10

Locality. $P_{12}H_4$.

Diagnosis. Shell moderately large, subrectangular in shape, dorsal valve convex, with deep dorsal sulcus, ventral valve subplanar, visceral cavity thin; hinge at greatest width of shell; interarea low, triangular; costellae of uniform size.

Holotype. CCGBH55, pl. 1, fig. 1, 7, 10.

Description. Ventral valve subplanar originally, holotype now crushed to be concave but convex at postero-lateral sides; interarea low, transverse, with few strong horizontal growth ridges, pseudodeltidium broad, convex, hinge at maximum shell width. Umbonal angle 160°, beak pointed. Costellae sub-uniform in size, increase by intercalation, secondaries as strong as primaries within 7-10mm; 9 costellae in 5mm at cardinal extremities and 10 in 5mm over central shell 25mm from beak; crests low, sharp or round, interspaces wide; a few concentric wrinkles developed, 2-3 growth increments per mm, 'pseudo-punctae' crowded and dense.

Dorsal valve strongly convex, interarea linear, lateral flanks thin, deep median sulcus, costellae subequal in strength, increase from midvalve by intercalation; 5-6 concentric wrinkles anteriorly. Dense ?pseudopunctae irregularly spread along interspaces and crests of costellae.

Ventral median septum high, extends to midlength; muscle scars large, cordate, with fine longitudinal striae. Dorsal interior with bilobed cardinal process; muscle scars large, oval, with crenulate surface; median septum thick, begins in front of cardinal process, extending in front of scars.

Measurements in mm

No.	Width	Length	Height	Interarea height
CCGBH55	94	55	11.5	10.5
CCGBH56	80	60	–	–

Comparison. This new species is characterized by its plano-convex lateral profile, very thin visceral cavity, low transverse triangular interareas, and deep dorsal sulcus. It resembles *Derbyia grandis* Waagen (1884) from the Middle Productus Limestone (Wargal Formation) of the Salt Range, Pakistan, in its large shell and outline, but has a different profile and narrow interarea. *Derbyia hemisphaerica* Waagen, 1884 from the Upper Productus Limestone (= Chhidru Formation s.l.) of the Salt Range is similar to this species in its flat to slight convex ventral valve and large size, but has a high ventral interarea and the fine costellae tend to form radial plicae. *Derbyia plattsmouthensis* Dunbar & Condra (1932, pl. 11, fig. 1-4) from the Plattsmouth Limestone, Home Creek Limestone of Missouri, Kansas, is a large shell, with gently convex ventral valve and moderately convex dorsal valve and rather low interarea. It differs from the new species in its narrower hinge and less concave ventral valve and ornament of coarse and fine ribs.

Order Productida Sarytcheva & Sokolskaya, 1959
Family Rugosochonetinae Muir-Wood, 1962
Genus *Dyoros* Stehli, 1954
Dyoros lamellosa sp. nov.
Pl. 1, fig. 2-6, 9

Locality. $P_{12}H_1$.

Diagnosis. Shell small, subrectangular in outline; maximum width at hinge-line; cardinal extremities obtuse; ventral sulcus shallow and broad, dorsal fold inconspicuous, surface smooth; concentric bands developed.

Holotype. CCGBH57, pl. 1, fig. 4, 5, 6.

Description. Ventral valve moderately convex, umbonal slopes low, moderately steep, diverge at 100-110°. Ears large, prominent, not very distinctly marked off from the visceral disc, cardinal extremities obtuse with angle of 80-100°. Hinge line at greatest width of shell, interarea with narrow delthyrium covered by convex pseudodeltidium. Sulcus shallow and faint posteriorly, sulcal angle of 18°, bordered by broad flanks. Shell surface smooth; concentric growth lines well developed, 5-7 concentric bands on ventral valve at nearly

equal intervals; a row of oblique cardinal spines located along posterior margin. Body spines conspicuous, 1.5-2mm apart along concentric rows; radial striae number 4-5 per mm on weathered shell.

Dorsal valve moderately concave, interarea low, ears large, almost flat. Surface marked by conspicuous concentric laminae, and worn to show capillae, with conspicuous pustules, possibly representing spine bases but not certain, dense, like internal pustules.

Ventral interior has median septum and strong capillae over lateral floor of valve, with large pustules, 2-3 per mm, more numerous than spines. Dorsal interior with low median septum, further detail obscure.

Measurements in mm

No.	Width	Length	Height
CCCGBH57	15	9.5	1.5
CCCGBH58	17	10.5	
CCCGBH59	16	10	
CCCGBH60	16.5	10	
CCCGBH61	19	12.5	
CCCGBH62	20	13.5	

Comparison. This species is characterized by its subrectangular outline, obtuse cardinal extremities, and broad and shallow sulcus. It resembles *Dyoros subliratus* (Girty) from the Word Formation, basal Capitan Formation, and Bell Canyon Formation (Pinery Member) in Texas (Muir-Wood, 1962, pl. 11, fig. 1-4, 6, 9-12; Cooper & Grant, 1976, pl. 484, fig. 33-37, pl. 485, fig. 35-37) in general outline and its shallow sulcus. It differs from *subliratus* in its subrectangular outline with obtuse cardinal extremities whereas the latter has alate cardinal extremities and a larger shell. *Dyoros convexus* Cooper & Grant (1976, pl. 482, fig. 6-32; pl. 501, fig. 32-61) from the Cherry Canyon and Word Formations of west Texas resembles the new species in its shallow sulcus, but differs in its acute cardinal extremities. *Dyoros planiextensus* Cooper & Grant (1976, pl. 484, fig. 38-62; pl. 485, fig. 38-51) from the Word Formation between the Willis Ranch and Appel Ranch Members is similar to the new species in general outline and broad shallow sulcus, but differs from the present species in its acute cardinal extremities and large ears as well as flatly concave dorsal valve.

Subfamily indet.
Chonetid gen. & sp. indet.
Pl. 2, fig. 1

Locality. P_3H_4.

Description. Shell small, semicircular in outline, ventral valve gently convex with greatest width at hinge line. Row of hinge spines; cardinal extremities obtuse with angle about 80°. Sulcus shallow over anterior half. Worn surface covered by capillae.

Ventral interior with short septum and two ridges diverging from hinge. Dorsal valve almost flat, cardinal process bilobate, sockets deep with strong short ridges not recurved; median septum long, lateral septa short, inner surface covered with capillae and numerous pits.

Specimen CCGBH63, 14mm wide, 8mm long, cardinal angle 80°.

This genus cannot be identified in the absence of exteriors, although shape and flat dorsal interior suggest a possible approach to *Svalbardia* Barkhatova, 1970.

Family Waagenoconchidae Muir-Wood & Cooper, 1960
Genus *Waagenoconcha* Chao, 1927
Waagenoconcha sp. A
Pl. 1, fig. 12, 13; pl. 2, fig. 2, 9

Locality. $P_{12}H_1$.

Diagnosis. Shell of medium size, plano-convex; subcircircular to subquadrate in outline, sulcus prominent. Ears small, cardinal extremities rounded; greatest width at midvalve. Spine bases arranged in quincunx, elongate on posterior part, shorter anteriorly.

Description. Ventral valve moderately convex, beak small, incurved, umbonal slopes steep, ears small, well defined, cardinal extremities rounded, maximum width at midvalve. Sulcus starts about 5mm from beak, widens at angle of 27°, floor concave. Spine bases 1.8mm long, 5 in 1mm on posterior shell, compared with spine bases 1mm long, 4-5 in 1mm, anteriorly and laterally. Concentric rugae well shown on ears, faint centrally, concentric bands well developed over anterior shell.

Dorsal valve flat over visceral disc, subgeniculate short trail, low fold begins posteriorly. Spine bases small, about 5 in 1mm regularly arranged in quincunx.

Measurements in mm

No.	Width	Length	Height	Length of hinge
CCGBH64	32.5	31.5	12	22
CCGBH65	39	33	15	28

Comparison. This species is moderately close to *Waagenoconcha humboldti* (d'Orbigny) as revised by Kozlowski, 1914; Muir-Wood & Cooper, 1960; Newell *et al.*, 1953; and Samtleben, 1973; from the Copacabana Group of Bolivia, of Asselian-Sakmarian age, but the present specimens have coarser ventral spines, longer and better spaced.

Waagenoconcha parvispinosa Cooper (1957, pl. 4, fig. 8-12) from Oregon, of Asselian-Sakmarian age (Bamber & Waterhouse, 1971, p. 153), is close in general outline and sculpture, but is smaller with shallower broader sulcus and much finer spines.

Waagenoconcha sp. B
Pl. 2, fig. 3, 4

Locality. $P_{12}H_4$.

Diagnosis. Shell large, subcircular to subquadrate outline, maximum width between midvalve and anterior third. Sulcus prominent, fold very low. Large spine bases posteriorly, smaller spine bases in concentric pattern anteriorly.

Description. Ventral valve of medium size, umbo narrow, projecting beyond hinge. Umbonal slopes steep, ears small, cardinal extremities rounded, maximum width situated near midlength. Sulcus starts at beak, deep and broad, with sinal angle of 35°. Posterior spine bases number 5-6 in 5mm, up to 3mm long posteriorly, 10-12 in 5mm and erect, 0.3mm wide anteriorly, arranged in concentric pattern. Concentric wrinkles well developed over middle and anterior shell.

Dorsal valve slightly concave to flat, sharply geniculate, fold very low.

Ventral adductors long, with longitudinal striae; diductors large, faintly impressed. Dorsal median septum extends from base of bilobate cardinal process for half length of valve; hinge ridges short and high, adductor scars suboval, slightly raised, scored by pustules as over rest of shell. Brachial ridges not clearly shown.

Measurements in mm

No.	Width	Length	Height	Length of hinge
CCGBH67	55	52	21.5	42
CCGBH68	48.5	52.5		43
CCGBH66	41	37	15	36

Comparison. *Waagenoconcha permocarbonica* Ustritsky, 1963 from the Turuzov Horizon of Upper Carboniferous to Asselian age from Taimyr Peninsula, Siberia, is similar in outline, but has a higher dorsal fold and smaller posterior and coarser anterior spines. This species was reported by Lee & Gu in Lee *et al.* (1980, p. 364) from the Wujiatun Formation of eastern Inner Mongolia. The present shells resemble *Waagenoconcha irginae* (Stuckenberg, 1898) in general outline, but are larger with narrow higher umbo, more prominent sulcus, smaller ears, and different outline. *W. xiujumqinqiensis* Lee, Gu & Li, 1982 from the W fauna of Xiujimqinqi has a deeper sulcus and longer outline.

Waagenoconcha sp. C
Pl. 2, fig. 5

Locality. $P_{12}H_6$.

Description. Shell large, subrectangular in outline. Ventral valve moderately convex, umbonal area inflated, lateral slopes steep. Sulcus arises well in front of umbo, broad and shallow. Valve covered by spine bases which are large and

elongate on posterior part and become smaller and crowded anteriorly, arranged in concentric pattern. Diductor scars visible through decorticated shell.

Measurements in mm

No.	Width	Length
CCGBH69	49	55

Comparison. This specimen is similar to *Waagenoconcha irginaeformis* Stepanov, 1937 from Kungurian Spiriferkalk of Spitsbergen in its elongate subrectangular outline, broad sulcus, and the size of the shell.

Family Buxtoniidae Muir-Wood & Cooper, 1960
Genus *Kochiproductus* Dunbar, 1955
Kochiproductus aff. *sinensis* Liu & Waterhouse
Pl. 2, fig. 6-8; pl. 3, fig. 1-2

Localities. $P_{12}H_3$, $P_{12}H_4$, $P_{12}H_6$.

Diagnosis. Shell large, elongate, rectangular in outline, umbonal region swollen, sulcus broad and shallow; trail narrow and long, lateral slopes steep posteriorly. Surface marked by elongate spine bases.

Description. Ventral valve strongly inflated posteriorly, beak strongly incurved, angle close to 80°, projecting beyond hinge. Umbonal slopes steep and high, maximum width anteriorly placed. Ears apparently small, but broken. Geniculation at 24mm from beak, forming long trail. Sulcus starts 12mm from beak, widens at 15°, deeper in shell from $P_{12}H_4$. Ornament of elongate spine bases on posterior shell, spines possibly arise from interrupted costae anteriorly, but ornament poorly preserved. Small spine bases clustered on flanks near ears. Dorsal valve from $P_{12}H_6$ has fold.

Ventral interior with elongate dendritic adductors separated by a low septum. Dorsal septum extends to midlength, adductors dendritic, otherwise dorsal interior poorly preserved.

Measurements in mm

No.	Width	Length	Width of Hinge
CCGBH70	60	80	> 40
CCGBH71	56	82	> 42

Comparison. These specimens are characterized by elongate shape, steep posterior walls and incurved ventral umbo. *Kochiproductus elongatus* Cooper & Grant (1975, p. 1049, pl. 358, fig. 4-6; pl. 360, fig. 3; pl. 361, fig. 9-11) from the Skinner Ranch and Bone Spring Formations of Texas, of Sakmarian age, resembles this species in its elongate outline, but has a different sulcus and more

arched shell. The specimen described by Lee & Gu (1976, p. 253, pl. 168, fig. 2) as *Kochiproductus porrectus* (Kutorga) from the Zhesi Formation of Inner Mongolia has an elongate outline, and narrow and deep sulcus, different from *K. porrectus* (Kutorga) but approaching present specimens. Our specimens are poorly preserved and even the generic assignment must be tentative. In size and shape they compare with large individuals of the somewhat variable species *Kochiproductus sinensis* Liu & Waterhouse from the upper Zhesi section of Neimongol. Each of the present specimens show perceptible differences from the others, but allowing for the paucity of material and indifferent preservation, all may be tentatively compared to the Zhesi species. The material from $P_{12}H_4$ with the deep sulcus is especially close.

Family Linoproductidae Stehli, 1954
Genus *Magniplicatina* Waterhouse, 1983
Magniplicatina sp.
Pl. 1, fig. 11

Locality. $P_{12}H_1$.

Diagnosis. Shell small, oval in outline, maximum width at midvalve, no sulcus. Surface marked by costellae and undulations, faint posteriorly and strong anteriorly, moderately large spine bases over ventral valve.

Description. Ventral valve convex, beak slightly incurved, umbonal angle close to 110°. Umbonal and lateral slopes rather steep, hinge short, ears small, distinct, no sulcus, maximum width at midlength. Shell ornamented by costellae, 14 in 5mm at midvalve, concentric wrinkles well developed, stronger over anterior shell, totalling 19-20, fine, 3 in 5mm posteriorly. Usually 2-3 costellae unite to form a spine base 4mm long, 1mm wide, and 3-4 costellae extend in front of each spine base. Ear and hinge spines obscure.

Specimen CCGBH73, 26.5mm long and 27.5mm wide, hinge 18mm wide.

Comparison. In outline and sculpture this specimen resembles *Cancrinella expansa* Cooper & Grant (1975) from the Word Formation of Kazanian age between the Willis Ranch and Appel Ranch Members, but the species from Texas has weaker growth rugae anteriorly, larger spine bases and many ear spines, features not determinable in our specimen. It is similar to *Magniplicatina circularis* Liu & Waterhouse from the Zhesi Formation of Inner Mongolia in general outline and strong undulations, but differs in its less developed posterior growth rugae and its oval outline.

Family Yakovleviidae Waterhouse, 1975
Genus *Muirwoodia* Likharev, 1947
Muirwoodia mammata (Keyserling, 1846)
Pl. 4, fig. 4-6
1846 *Productus mammatus* Keyserling, p. 206, pl. 4, fig. 5.

Localities. $P_{12}H_1$, $P_{12}H_3$, $P_{12}H_6$.

Diagnosis. Shells of medium size, transversely rectangular in outline, flanks converging anteriorly, shell strongly geniculated anteriorly. Sulcus shallow and broad.

Description. Ventral valve moderately convex; umbonal region and visceral disc almost flat, beak slightly incurved, projecting beyond wide hinge with low interarea. Ears prominent, flat, marked off from visceral disc by shallow re-entrants. Cardinal extremities may be acute with angle about 65°–70°, or nearly obtuse; lateral margins of shell subparallel. Sulcul originates near umbo, inconspicuous over visceral disc, abruptly develops into a broad, shallow sulcus at trail 14.5mm – 22mm from beak. Shell ornamented by costellae, 15 in 5mm on visceral disc near beak, costellae coarser anteriorly, increase by bifurcation and intercalation, 8-10 costellae in 5mm at anterior geniculation; concentric wrinkles absent, growth lines faint. Spine bases scattered on ventral valve, row of oblique spines located along posterior margin near hinge, projecting obliquely outward; traces of perhaps 6 large spine bases apparently arranged symmetrically on ventral valve; one on each ear, one on each side of sulcus near front, one on each flank anterior to geniculation, but pattern obscure.

Dorsal valve slightly concave or flat, strongly geniculated in front of visceral disc, with faint fold on trail; costellate as in ventral valve, no spines.

Ventral adductor scars narrowly elongate, set on a short median ridge enclosed by large, flabellate diductor scars.

Measurements in mm

No.	Width	Length	Height	Length of visceral disc	Length of trail
CCGBH74	31	24	10	14.5	25
CCGBH75	35	23		15.5	22.5
CCGBH76	33.5	22		18	18
CCGBH78	32	19.5		18	17.5

Comparison. These shells have the compact shape and general appearance of *Muirwoodia* Likharev, which has in recent years been synonymised with *Yakovlevia*. The two genera are certainly very close to each other and as noted by Cooper & Grant (1975), Kotlyar (1961) could find no significant difference between the types. However Likharev & Kotlyar (1978) used the genus *Muirwoodia*, and although no explanation was offered, the two names do distinguish shells of different appearance, size and geniculation. We therefore provisionally retain the name *Muirwoodia*, as do Abramov & Grigorieva (1983).

Zhan & Lee (1977) indicated that *Muirwoodia* (as *Yakovlevia*) *mammata* ranged throughout much of the Permian in northern China, and present specimens from various faunal levels do approach each other, and look moderately like *Muirwoodia mammata*. But our material is poorly preserved, with ornament worn, spines lost, interior not revealed and dorsal valve seldom preserved, so that we cannot yet substantiate the suggestion that this species *mammata* ranged for a long time interval, unlike many other productidid species. Abramov & Grigorieva (1983) considered that the species ranged down to the Middle Carboniferous in Verchoyan.

?*M. mammatiformis* Frederiks of Asselian – Kungurian age in Russia (see Ifanova, 1972) is moderately close but the type is a more transverse shell, approaching *M. artiensis* (Chernyshev, 1889 – see Ifanova, 1972). Specimens figured by Ifanova (1972) from the Petchora Basin are closer to our specimens in shape, especially Asselian-Sakmarian shells of the Yunyargin Series (Ifanova, 1972, pl. 7, fig. 1). Irbichan (Early Permian) shells from Kolyma figured by Zavodowsky (1970, pl. 35, fig. 8-10) as *Y. mammatiformis* are also close.

Yakovlevia paragreenlandica Lee & Gu in Lee *et al.*(1980, p. 171, fig. 5-7) is similar to the present form, but has a deeper sulcus. It comes from the Dashizhai Formation of Early Permian age in eastern Neimongol. *Muirwoodia transversa* Cooper (1957) from basal Permian beds in Oregon is close in size and outline to some of the older shells (e.g. $P_{12}H_1$) with lateral walls converging anteriorly and slightly deeper sulcus.

Muirwoodia greenlandica Dunbar (1955, pl. 16, fig. 1-18) of Kungurian age in east Greenland is similar to present specimens in size and outline. *Yakovlevia sulcata* Cooper & Grant (1975, pl. 472, fig. 1-39) from the Road Canyon and Ross Mine Formations of Kungurian age in Texas resembles this species in size and outline, but has more prominent sulcus and more acute cardinal extremities, and the same is true of some other Word species from Texas, described as *Yakovlevia intermedia* Cooper & Grant (1975) and *Y. indentata* Cooper & Grant (1975).

Genus *Yakovlevia* Frederiks, 1925
Yakovlevia borealis sp. nov.
Pl. 3, fig. 4-6

Locality. $P_{12}H_4$.

Diagnosis. Shell large, transversely rectangular in outline, posterior disc gently convex, lateral margins converge anteriorly, sulcus starts at posterior third of shell, moderately deep.

Holotype. CCGBH81, pl. 3, fig. 4-5.

Description. Ventral valve gently convex posteriorly, with conspicuous geniculated trail. Beak small, slightly projecting beyond hinge, over low ginglymus. Umbonal slopes gently depressed; ears large, flat and prominent. Subrounded geniculation appears about 25-26mm from break. Shell bends abruptly at margins. Sulcus prominent, deep and wide anteriorly, originating near beak at posterior third, pronounced on disc, broad, deep on trail, sinal angle of 25-30°. Costellae begin on umbo, 7 in 5mm anteriorly near sulcus and 12 in 5mm posteriorly near beak, increase by intercalation and bifurcation. A row of oblique spines lies along hinge, pointing laterally. Large strut spine bases, apparently 6 in number, symmetrically placed on ventral valve: one on each cardinal extremity, one on frontal flank of sulcus and one each side of sulcus at midvalve.

Dorsal disc concave with low fold, valve strongly geniculated anteriorly, fold low over trail. Ears flat, prominent, separated from visceral disc. Ornament of costellae; no spines.

Interior not observed.

Measurements in mm

No.	Width	Length	Height
CCGBH80	62	44	15
CCGBH81	61	40	6

Comparison. These shells are close to *Yakovlevia impressus* Toula (1875) from the Spirifer Limestone (Kungurian) of Spitsbergen, a species that has been extensively reviewed by Ifanova (1972). Although our specimens are of similar size and general appearance, the sulcus is somewhat broader and a little deeper anteriorly than in Spitsbergen shells, and the ventral umbonal region less swollen and curved. *Y. kaluzinensis* Frederiks, 1925 – see Likharev & Kotlyar, 1978 – from mid-Permian beds of the Chandalaz Suite, south Primorye, is very close with flatter ventral posterior and almost comparable ventral sulcus. *Yakovlevia baeyinensis* Lee & Gu (1976, pl. 163, fig. 3) from Lower Permian beds in the eastern part of Inner Mongolia has a similar outline and prominent sulcus, but has a larger shell, transverse outline and obtuse cardinal extremities. *Y. hessorum* Cooper & Grant (1975) from the Word Formation (China Tank and Willis Ranch Members) of Texas resembles this species in prominent sulcus on visceral disc and trail. It differs in its alate cardinal extremities and large ears. The present shells in some respects look like those reported as *Y. mammatiformis* (Frederiks) by Ustritsky (1963) from Beishan of Gansu Province; and reported by Zhan & Lee (1977) from the Wujiatun Formation of eastern Inner Mongolia but these have a flat disc and more abrupt geniculation. Typical *mammatiformis* appears to be a somewhat smaller species with more transverse outline and long ventral sulcus and abrupt geniculation. *Y. baiyinensis sinuata* Lee & Gu in Lee *et al.* (1980, pl. 172, fig. 1, 2) from Permian beds of unspecified age in Neimongol is close in size but has a shallower sulcus and shorter trail.

Yakovlevia convexus sp. nov.
Pl. 3, fig. 7; pl. 4, fig. 1-3

Locality. $P_{12}H_4$.

Diagnosis. Shell large, elongate rectangular in outline with subparallel lateral margins, maximum width at hinge line. Visceral disc highly convex, ears small, sulcus broad and shallow.

Holotype. CCGBH87, pl. 4, fig. 1-3.

Description. Ventral valve strongly convex with moderately arched visceral disc. Beak small, projecting a little beyond hinge, ears small, flat, poorly defined. Cardinal extremities obtuse with angle close to 90°. Geniculation prominent; trail long with steep lateral slopes. Sulcus originating from middle of disc, prominent over anterior half of disc and beginning of trail, wide and shallow on trail. Shell marked by costellae, 10 in 5mm at 20mm from beak, increase by intercalation and bifurcation, large spine bases scattered on ventral valve.

Interior of ventral valve with small elongate elevated diductor scars, adductor scars depressed, bordered by large lateral ridges extending from margin of delthyrium.

Measurements in mm

No.	Width	Length	Length of disc	Length of trail
CCGBH87	56	55	35	49.5
CCGBH88	52	>45	34	>45

Comparison. This species is similar to *Yakovlevia elongata* Liu & Waterhouse from the Zhesi District, Damao County, in its broad flat umbonal area and rather steep subparallel lateral margins, but is larger with slightly elevated umbonal area and disc and long trail. The sulcus in the other species is well developed on the trail. *Muirwoodia greenlandica* Dunbar of Lee & Gu (1976, p. 263, pl. 163, fig. 1a-c) from Lower Permian faunas of Neimongol is close in shape, but is smaller with larger ears and less convex visceral disc, with other differences.

Order Rhynchonellida Kuhn, 1949
Family Stenoscismatidae Oehlert, 1887
Genus *Stenoscisma* Conrad, 1839
Stenoscisma cf. *paucisulcata* Liu & Waterhouse
Pl. 4, fig. 8-12

Locality. $P_{12}H_4$.

Diagnosis. Shell large, pentagonal in outline, biconvex, dorsal valve more inflated than ventral valve, 7-9 ribs in sulcus and 6-8 ribs on each flank, sulcus shallow, fold low.

Description. Ventral valve gently convex, umbo small, angle 80-85°. Sulcus begins posteriorly, broad and shallow anteriorly, with very low, steep non-costate flanks. Ornament of numerous ribs commencing near umbonal tip, 7-9 ribs in sulcus and 6-8 non-branching ribs on each flank; increase by bifurcation and intercalation.

Dorsal valve more convex than ventral valve, most inflated at midvalve; umbonal region slightly curved. Fold pronounced at anterior half of shell, bears 8-10 ribs and 8-10 ribs each side.

Ventral interior with teeth, and spondylium supported by median septum. Dorsal interior with undivided hinge plate, camarophorium and median septum.

Measurements in mm

No.	Width	Length	Height	Width of sulcus	Sinal ribs	Lateral ribs
CCGBH84	44	35	18	20	8	7
CCGBH85	41.5	?	23	22	9	10

Comparison. Poor preservation prevents complete analysis of these specimens but they appear to be very close to *Stenoscisma paucisulcata* Liu & Waterhouse (in press) from the Zhesi Formation at Zhesi, Damao County, Neimongol, also recorded as *S. gigantea* from that formation by Lee & Gu (1976). The sulcus and fold seems to be slightly more emphasized in present specimens.

These specimens resemble *Stenoscisma gigantea* (Diener) from Chitichun no. 1, south Tibet, in general outline, and number of ribs, but present specimens are smaller than those described by Diener, and have a shallower sulcus and non-branching lateral ribs. Chang & Ching (1976) reported *S. gigantea* from the Selong Group of Tibet, and it was recorded from the Miaoling Formation of eastern Jilin Province and Tumenling Formation of Heilongjian Province of northeast China by Lee & Gu in Lee *et al.*(1980, p. 395). This species differs from *S. timorensis* (Hayasaka & Gan) in its more numerous ribs in the sulcus and on the flanks.

S. purdoni (Davidson, 1862) from the Salt Range, Pakistan, is smaller with bifurcated ribs and fewer ribs in the sulcus and on the flanks. *S. trabeatum* Cooper & Grant (1976, p. 576, fig. 1-31; pl. 577, fig. 9-24) from the Bell Canyon and Capitan Formations of Texas resembles this species in size and bifurcated ribs, but has a more prominent sulcus and fold and strong costae with sharp crests.

Stenoscisma cf. *timorense* (Hayasaka & Gan)
Pl. 4, fig. 13, 14; pl. 5, fig. 1-4

cf. 1899 *Camarophoria* cf. *purdoni* Diener, p. 79, pl. 7, fig. 4

cf. 1916 *Camarophoria purdoni* Broili, p. 55, pl. 11, fig. 7-17.

cf. 1940 *Camarophoria timorense* Hayasaka & Gan, p. 129, pl. 8, fig. 1-7.

cf. 1965 *Stenoscisma purdoni* Grant, pl. 20, fig. 1-4.

cf. 1976 *Stenoscisma timorense* Chang & Ching, p. 193, pl. 11, fig. 20-27.

cf. 1978 *Stenoscisma timorense* Likharev & Kotlyar, pl. 17, fig. 8.

Localities. $P_{12}H_4$, $P_{12}H_6$.

Diagnosis. Shell large, pentagonal in outline, dorsal valve more inflated than ventral valve, ventral sulcus broad and shallow with 6-7 ribs, and 6 faint ribs on each flank, all originating posteriorly in front of umbones.

Description. Ventral valve convex posteriorly, apical angle about 110-115°. Sulcus originates 10mm from beak, widens and deepens anteriorly, exceeding half width of shell, bearing 5-7 ribs which commence just behind midlength. Lateral ribs faint, simple and rounded, seldom bifurcated, about 6 in number, starting close to anterior margin.

Dorsal valve moderately convex, most inflated at midvalve. Fold faint posteriorly but prominent over anterior half, bearing 5-6 ribs, 6-7 on each flank over anterior third to half of shell.

Ventral interior with spondylium supported by high, short median septum. Dorsal interior with camarophorium and high median septum, but hinge plate and intercamarophorial plate obscure. Cardinal process not exposed.

Measurements in mm

No.	Width	Length	Height	Width of sulcus	Sinal ribs	Lateral ribs
CCGBH89	43	37	20	21	5	
CCGBH90	42	35	18	21	5	6
CCGBH91	44	37	22	23	4	7

Comparison. These shells appear to be very close to *Stenoscisma timorense* (Hayasaka & Gan) from faunas of Punjabian (=upper Maokou) age in Timor and the Himalayas, but the ventral umbo is less incurved and the fold less sharply raised, with flanks less steep. They differ from *S. purdoni* in the larger size, and smooth posterior shell and have fewer costae on the flanks. *S. gigantea* (Diener) is similar in outline and ornament, but Diener's species has more costae over the sulcus and the flanks and is larger.

Stenoscisma sp. A

Locality. $P_{12}H_6$.

Diagnosis. Large multicostate shell, widely trigonal in outline, with deep wide anterior ventral sulcus.

Description. Ventral valve triangular in outline, large, beak small, apical angle 87°, incurved; delthyrium and deltidial plates not observed. Sulcus originates from apex of shell, widens at 110°, and deepens anteriorly to be very pronounced. Some 5 narrow rounded costae lie on each flank, 5 or more costae lie in sulcus.

Dorsal valve much more convex than ventral valve, most inflated posteriorly. Fold low, not well marked off from lateral shell. Costae mostly destroyed by decortication except antero-laterally, possibly arising further forward than in ventral valve.

Ventral interior with spondylium, supported by low septum. Dorsal interior with camarophorium, intercamarophorial plate and high septum extending over posterior third of shell length, cardinal process not shown.

Specimen 37mm wide, 29 mm long, and 15.5 mm high.

Comparison. This specimen is similar to *Stenoscisma multicostum* Stehli, 1954 in outline and costation. The species has been described by Stehli (1954), Grant (1965) and Cooper & Grant (1975) from the Hess, Cibolo and Bone Spring Formations of Sakmarian-Artinskian age in Texas. The characteristics of the species are large size with numerous costae that are narrow, rounded, and bifurcated anteriorly. Our species, poorly preserved, appears to have slightly coarser lateral ribs and a less well defined fold.

Stenoscisma sp. B
Pl. 5, fig. 17-20

Locality. $P_{12}H_1$.

Diagnosis. Shell of medium size, transversely oval in outline and inflated with wide deep sulcus. Costae confined to anterior margin in ventral sulcus and fold, faint on flanks.

Description. Ventral valve gently arched toward lateral margins, most convex at midvalve. Beak small and pointed with apical angle of 85°. Sulcus broad, deep over anterior half, with 6 costae apparently confined to anterior. Flanks each with 2 faint anterior costae.

Dorsal valve more convex than ventral valve, beak small, incurved, fold poorly developed, bearing 5 costae which begin in front of posterior third of shell length. Four faint costae lie on outer shell. Concentric laminae well developed over lateral and posterior shell.

Ventral interior with dental plates, spondylium and septum. Dorsal valve interior with camarophorium and high median septum.

Measurements in mm

No.	Width	Length	Height	Width of sulcus	Sinal costae	Lateral costae
CCGBH93	23.5	16.5	14.5	14	6	4
CCGBH94	22.5	17	13.4	14	4	–

Comparison. These specimens resemble *Stenoscisma ovalia* sp. nov. in having faint anterior costae and oval outline. They differ in their transversely oval outline, and the way in which the sulcal tongue projects well into the dorsal fold.

Stenoscisma ovalia sp. nov.
Pl. 5, fig. 5-16

Localities. $P_{12}H_1$, $P_{12}H_3$.

Diagnosis. Transversely oval shells of medium size with maximum width at midvalve. Sulcus broad, shallow, starting at midlength, with 4-5 costae, fold broad, rounded, moderately elevated, with 5-6 costae; flanks with 3-4 faint costae.

Holotype. CCGBH95, $P_{12}H_1$, pl. 5, fig. 5-7.

Description. Ventral valve gently inflated. Beak strongly incurved, with small elongate foramen. Shallow broad sulcus begins from midvalve, prominent anteriorly, bearing 4-5 costae, 3-4 costae on each flank. Costae start 4-12mm from beak, and fine poteriorly, coarse in front.

Dorsal valve moderately convex, umbo concealed under ventral umbo. Broad rounded fold begins near beak and highly elevated, bearing 5-6 costae; 3 costae on each flank, costae starting just in front of beak, fine and faint posteriorly.

Ventral interior with large spondylium and strong low median septum 6-10mm long, extending almost to midlength. Dorsal valve with united hinge plate, small camarophorium, large cardinal process and thin intercamarophorial plate, median septum high, 6mm long in larger specimens.

Measurements in mm

No.	Width	Length	Height	Sinal costae
CCGBH95	28	22	15	5
CCGBH96	28	24.5	15.5	5
CCGBH97	28	24	17.5	4
CCGBH98	20	18	13	4
CCGBH99	26	21	10	4

Comparison. In outline and ornament the new species resembles *Stenoscisma maniculum* Cooper & Grant (1976, pl. 565, fig. 16-23) from the Road Canyon Formation, of Kungurian age in Texas, but differs in its larger size and faint costae. It resembles *S. hueconianum* (Girty) from the Leonardian beds of Hueco Mountains (Cooper & Grant, 1976, pl. 563, fig. 1-54) in general outline, broad shallow sulcus and ornament, but is more transverse and has fainter costae.

Stenoscisma sp. C
Pl. 5, fig. 21, 22

Locality. $P_{12}H_6$.

Description. Shell of medium size, subtriangular in outline, crushed laterally. Ventral valve gently convex, sulcus begins at midvalve, broad and deep over anterior half, bearing 5 costae, originating at apex. Lateral shell with simple costae, 5-6 over each flank, beginning over umbo. Dorsal valve moderately convex, with prominent fold bearing 8-9 costae anteriorly. Lateral shell steep, bearing 6 simple costae beginning at umbo.

Dorsal camarophorium and median septum, ventral interior not known. Specimen CCGBH97 27 mm wide and 33mm long.

Comparison. This specimen resembles shells ascribed to *Stenoscisma humbletonensis* (Howse) by Waagen (1884, p. 44, pl. 32, fig. 8) from Virgal

beds (Middle Productus Limestone, =Wargal Formation) of the Salt Range, Pakistan. It differs having fewer costae in the sulcus and over the flanks. *Stenoscisma* sp. of Cooper (1953, p. 55, pl. 14A, fig. 1-5) from the *Leiorhynchoidea-Cancrinella* and *Dictyoclostus* zones in the Monos Formation (Kungurian) of El Antimonio, western Sonora, Mexico, is somewhat similar to the present material.

Camerisma Grant, 1965

Discussion. *Camerisma* is characterized by its smooth or nearly smooth shell, high vaulted fold and broad shallow sulcus sometimes bearing a narrow trough along its medial line. The ventral interior has a spondylium and median septum duplex, and the dorsal interior has a camarophorium, undivided hinge plate, well developed cardinal process, thick intercamarophorial plate and medium septum duplex. The present species is shaped like *Camerisma* but has more costae than usual.

Camerisma rhomboidea sp. nov.
Pl. 5, fig. 23, 24; pl. 6, fig. 1-4

Localities. $P_{12}H_4$, $P_{12}H_6$.

Diagnosis. Shell of medium size, rhomboidal in outline, sharp, high dorsal fold and deep costate ventral sulcus, flank smooth.

Holotype. CCGBH97, P_{12}, H_6, pl. 5, fig. 23, 24; pl. 6, fig. 1, 2.

Description. Ventral valve gently convex posteriorly, maximum width at midlength. Sulcus broad and deep, originating from umbo, with some 6 costae over anterior half, lateral slopes steep, bearing short anterior costae.

Dorsal valve strongly convex with high, sharp fold, starting at umbo, bearing 3 costae on crest from midlength, and possibly 5-6 anterior costae over flanks of fold and steeply inclined outer shell.

Ventral spondylium and septum duplex in ventral valve. Dorsal interior with camarophorium and septum duplex; intercamarophorial plate and hinge plates not observed.

Measurements in mm

No.	Width	Length	Height
CCGBH95	26	28	20.5
CCGBH96	30	31	23

Comparison. These specimens are swollen shells like species of *Psilocamara* and *Camerisma*, and closely similar to *Camerisma sella* (Kutorga, 1842) in general outline, broad and deep sulcus and high fold (Chernyshev, 1902, pl. 23, fig. 4) from the Schwagerina beds of the Urals. They differ in their larger size,

rhomboidal outline and costate sulcus and fold. *Camerisma girtyi* Grant (1965, pl. 8, fig. 3-3a) from unnamed Upper Mississippian limestone of Condon, Craig Quadrangle, southeastern Alaska, resembles our specimens in costate fold and broad sulcus. It differs from present specimens in its subtrigonal to subelliptical outline, shallow sulcus and moderately high fold.

Camerisma rasililaterensis Solomina, 1978 (see also Abramov & Grigorieva, 1983) from the mid-Carboniferous Syorgan Suite of Verchoyan, Siberia, is closely but more finely costate anteriorly, and is a broader shell. *Camerisma* sp. of Abramov & Grigorieva (1983, pl. 14, fig. 7-8; fig. 29-31) from the mid-Carboniferous Mishkin Suite, and Davnin and Abagin horizons is close in overall appearance with anterior coarse ribs, but less well defined sulcus and fold.

Order Athyridida Dagys, 1984
Family Athyrididae M'Coy, 1844
Genus *Spirigerella* Waagen, 1883
Spirigerella sp.
Pl. 6, fig. 5, 7

Locality. $P_{12}H_4$.

Diagnosis. Shell large, suboval, strongly biconvex with more convex dorsal valve. Faint ventral sulcus anteriorly, low dorsal fold, concentric laminae strong anteriorly, fine posteriorly.

Description. Ventral valve elliptical in outline, moderately convex. Umbo incurved, area flattened, small, well defined. Sulcus absent posteriorly, faint anteriorly. Concentric lines of growth very strong and regular anteriorly.

Dorsal valve strongly inflated, subcircular in outline, low fold at anterior margin, concentric laminae strong and regular anterolaterally.

Ventral interior with large muscle field; dorsal interior with compact adductors and anterior radial pallial grovves, no medium septum, further detail not shown.

Specimen CCGBH98, 38mm wide, 43.5mm long, 38mm high.

Comparison. This specimen is strongly biconvex with very strongly inflated dorsal valve, weakly developed sulcus and fold. It resembles *S. grandis* (Davidson, 1862; Waagen, 1882) from the Wargal Formation of the Salt Range, Pakistan, in outline and convexity as well as its prominent concentric bands at the anterior margin. But its ill-developed sulcus and fold, more convex dorsal valve and globular appearance are different.

S. proxima Reed, 1944 from the upper Wargal Formation is close in outline but is less globular and has posterior walls more concave in outline. In absence of the anterior sulcal projection, the present specimen comes close to *Spirigerella* specimens described by Reed (1944) from the Wargal and Chhidru beds of the Salt Range, allowing for some variation such as those shown in the suite that he figured, the present shell having slightly more massive posterior walls, but otherwise close and displaying a similar well defined short differ-

entiated palintrope. Reed (1944) identified his specimens with Timor shells described as *Composita timorensis* by Rothpletz (1892) and Broili (1916). The Timor shells come from Basleo and Amarassi beds equivalent to Kalabagh and early Chhidru beds of the Salt Range.

Order Spiriferida Waagen, 1883
Family Ambocoeliidae George, 1931
Genus *Attenuatella* Stehli, 1954
Attenuatella xiujumqinqiensis Lee, Gu & Li, 1982
1982 *Attenuatella xiujumqinqiensis* Lee, Gu & Li, p. 118, pl. 2, fig. 3-5
Pl. 6, fig. 6, 8, 9, 12, 15, 16

Locality. P_1H_{20}.

Diagnosis. Shell small, elongately oval in outline, plano-convex in profile, dorsal valve gently convex posteriorly, maximum width at midvalve. Ornament of pustules, no costae.

Lectotype. Specimen figured by Lee, Gu & Li (1982, pl. 2, fig. 3) UBr 770459, here designated.

Description. Ventral valve strongly convex, umbonal angle 40°, umbo narrow incurved over hinge. Interarea high, moderately curved; delthyrium triangular with an angle of about 23°, closed by plates (or plate). Maximum width situated at midvalve, sulcus shallow. Shell smooth with dense pustules in concentric rows, 9-10 in 1mm.

Dorsal valve subquadrate in outline, gently convex posteriorly, flat to slightly concave in front. Lateral and anterior margins rounded; pustular ornament, no costae. Beak and interarea not visible.

Interior of ventral valve with broad muscle ridges scored by irregular fine longitudinal markings, fusing anteriorly into medium ridge that narrows in front, failing to reach anterior margin, bordered and subdivided by slender low ridges in some shells. Dorsal interior with stout crura, three low broad septa. Muscle scars large, suboval in outline, bearing low ridges with depressions.

Measurements in mm

No.	Width	Length	Dorsal width	Height	Hinge width
CCGBH99	7	9.5	7	5	5
CCGBH100	7	8.5	6.5	5	5.5
CCGBH101	8.5	10			
CCGBH102	9.5	11			
CCGBH103	9.5	10			
CCGBH104	6.5	9			

Comparison. This species is characterized by its small size, elongately oval outline, moderately curved ventral interarea with overhanging beak and almost plano-convex lateral profile. This species resembles *A. incurvata* Waterhouse

(1964) from New Zealand in the Arthurton and Kuriwao Groups of Chhidruan and Urushtenian age in general outline and plano-convex profile. The new species differs from *A. incurvata* in its smaller size, fewer pustules, less curved interarea and less enrolled beak above the hinge. *Attenuatella attenuata* (Cloud, 1944) of the "*Waagenoceras* zone" (sensu lato) in Mexico resembles the new species in outline and a posteriorly convex anteriorly planar dorsal valve, but is smaller and lacks dorsal septa. *A. paraincurvata* Lee & Gu (1980, pl. 176, fig. 17, 20-22) from the Wujiatun Formation of eastern Inner Mongolia is similar to the new species in small size and to some extent its plano-convex profile, but has a more elongate triangular outline with the greatest width anteriorly placed.

Attenuatella dorogoyi Zavodowsky (1970) from the Asselian Paren beds of Kolyma might be allied because the ventral exterior is of comparable outline, but Zavodowsky's species is poorly preserved, and many details not available. *A. texana* Stehli (1954) from the Bone Spring Formation of west Texas (Sterlitamakian) is somewhat similar in shape but has a more distinct sulcus and smaller size.

Attenuatella altilis Waterhouse, 1968 from the upper Takitumu Group of New Zealand, of Baigendzinian age, is close in many respects, including the profile of the dorsal valve, and spines are of similar, or slightly greater density. The dorsal valve usually has low costae, unlike the Chinese material. *A. australis* Armstrong & Brown, 1968, from the ?Sakmarian Gigoomgan Limestone of Queensland is very close in spinosity and dorsal valve, which lacks ribs. The ventral valve has much the same shape, but appears to be slightly more incurved, though not as much as in *A. incurvata* Waterhouse. The dorsal interior seems to have only two low lateral ridges, without the median septum.

Family Syringothyrididae Frederiks, 1926
Genus *Syringothyris* Winchell, 1863
Syringothyris sp. A
Pl. 6, fig. 10, 11, 13, 14; pl. 7, fig. 3

1982 *Pseudosyrinx* sp. Lee, Gu & Li, p. 120.

Localities. P_2H_7, P_3H_4.

Description. Ventral valve strongly convex, transversely rhomboidal in outline, lateral profile pyramidal, umbonal angle 112-130°. Hinge at greatest width of shell, interarea transversely triangular in form, with horizontal growth lines laterally, ratios of height to width of interareas vary from 1:2.5-3.4; mostly 1:3-3.4, delthyrium broad, triangular, obscure, apparently covered by depressed delthyrial plate. Cardinal extremities with acute angle of 35°. Sulcus originates over umbo, sulcal angle varies from 30-50°, cross section V-shaped, without plica or costae, bounding plications strong, angular, lateral plicae simple, 8-12 on each flank, diminishing laterally in strength.

Shell finely punctate, micro-ornament not preserved. Dorsal valve less convex than ventral valve; poorly known, external and internal structures scarcely preserved.

Internally dental plates diverge at angle of 60° then converge to adminicula, thickened by secondary shelly deposits, forming subcircular delthyrial cavity; syrinx under delthyrial plate.

Measurements in mm

No.	Width	Length	Height of interarea	Width of interarea	Umbonal angle
CCGBH105	83	38	26	83	118°
CCGBH106	90	43	27	90	127°
CCGBH107	81	37.5	32	81	112°
CCGBH108	66	32.5	22	66	124°
CCGBH109	60	26	22	60	124°
CCGBH110	52	24	15	52	130°
CCGBH111	50	21.5	16.5	50	130°
CCGBH112	40	18	13	40	124°

Syringothyris sp. B
Pl. 7, fig. 1, 2, 4, 5, 7

Locality. P_3H_4.

Description. Ventral valve moderately convex, pyramidal in lateral view, interarea high, flat, erect, bisected by elongate triangular delthyrium with angle of 35-40°, closed by delthyrial plate. Proportion of height to width of interarea varies from 1:2-2.6, most 1:2-2.2; shoulders of interarea angular or rounded, lateral end of interarea rectangular. Sulcus well developed, begins at umbo, deep and angular, non-costate, well defined by angular bounding plications. Lateral plicae simple, more than 10-12 on each flank. Shell finely punctate; micro-ornament and dorsal valve not preserved; ventral interior not exposed.

Measurements in mm

No.	Width	Length	Height of interarea	Width of interarea	Umbonal angle
CCGBH113	48	25	20	48	105°
CCGBH114	39	17	15	39	115°
CCGBH115	52	32.5	24	52	100°
CCGBH116	48	28.5	18	48	115°
CCGBH117	44	30?	21	44	107°
CCGBH118	22.5	19.5	11	22.5	105°
CCGBH119	50	21	21	50	107°
CCGBH120	96	40	36.5	96	120°
CCGBH121	52	35.5	33.5	52	107°
CCGBH122	35.5	22	20	35.5	110°

Comparison. In outline and interarea these specimens resemble *Syringothyris bushbergensis* Weller (1914, p. 391, pl. 73, fig. 8-10) from the Bushberg Sandstone, Missouri, of Mississipian age, but differ in their much wider triangular interarea and broad delthyrium as well as larger shell. The present specimens resemble *Syringothyris* sp. A. in general outline and ornament, but the ratio of height to width for the interarea is smaller.

Genus *Pseudosyringothyris* Frederiks, 1916
?*Pseudosyringothyris* sp.
Pl. 7, fig. 6, 8

Locality. P_3H_4.

Description. Shell large, subconical in lateral profile, umbo broad with angle of 130°. Interarea large, high and mostly flat but inner triangular segment slopes dorsally to high narrow delthyrium with angle of about 30°. Sulcus begins from beak, with angle of 50°, possibly smooth, some 12 pairs of lateral plicae. Other detail not preserved, or not exposed.

Specimen CCGBH123, 104mm wide, about 60mm long, interarea 53mm high.

Comparison. This specimen resembles *Pseudosyringothyris dickinsi* Thomas (1971) from the Callytharra Formation, Carnarvon Basin, of Western Australia (of Sterlitamakian age – Waterhouse, 1976). But our specimen has fewer plicae than *P. dickinsi* and is too poorly preserved to be identified at even generic level with any confidence.

Family Spiriferellidae Waterhouse, 1968
Genus *Spiriferella* Chernyshev, 1902
Spiriferella wangi sp. nov.
Pl. 7, fig. 9; pl. 8, fig. 1-5, 7, 8

Localities. $P_{12}H_4$, $P_{12}H_6$.

Diagnosis. Shell of average size, elongately oval in outline, hinge shorter than greatest width of shell, ornament of 5-7 pairs of simple plicae. Fold low, rounded, divided by broad median groove.

Holotype. CCGBH135, $P_{12}H_4$, pl. 8, fig. 1-3.

Description. Ventral valve moderately convex, elongately oval in outline, umbo incurved, narrow umbonal angle at 70°. Interarea high, slightly concave, divided by narrow delthyrium with angle of 35°, bordered by dental ridges, not clear if closed by plate. Cardinal extremities rounded with angle of 110°, maximum width of shell at midvalve. Sulcus starts at beak, with subangular base and sulcal angle of 15-17°. Two faint lateral sinal costae appear 12-20mm from umbonal tip. Lateral plicae number 5-7 pair, first pair bifurcate for most of length, interspaces wide.

Dorsal valve less convex than ventral valve; beak incurved, umbonal angle of 100°, moderately elevated. Fold low, divided by median groove, which is narrow posteriorly, wide and deep anteriorly; each flank of fold bears 1-2 costae. Strong simple plicae in 6-8 pair, first pair bifurcate for most of length. Micro-ornament on both valves consists of broad concentric growth laminae, 5-6 per mm on anterior dorsal valve, and finer longitudinal lirae; pustules broad, along single growth laminae on anterior dorsal valve; full pattern not preserved. On a fragment of lateral shell of dorsal valve, 10-12 growth increments occur per mm, with large pustules crossing 5-6 increments.

Ventral interarea with dental plates, concave inwards, supported by adminicula buried in shell. Muscle scars subquadrate, broad, myophragm thin or absent, adductors broad, striate. Dorsal interior with thin long septum about one-third of shell length, socket plates and small crural plates, spires directed laterally. Adductor scars submedianly placed, narrow, elongate, marked by irregular ridges. Cardinal process laminate.

Measurements in mm

No.	Width	Length	Dorsal length	Height	Hinge width	Umbonal angle
CCGBH135	36	52.5	39	27.5	31	90°
CCGBH136	33	51	40.5	19.5	31.4	90°
CCGBH137	32	39	30	19.5	24.5	–
CCGBH138	20	34.5	27.5	17.2	15	75°
CCGBH139	16.5	25	20.5	13.5	14	75°
CCGBH140	25.5	34	22	15.5	18.5	80°
CCGBH141	18.5	22	15.5	14	15	80°

Comparison. This new species is characterized by its elongate-oval outline, narrow sulcus with bicurcate bounding plications and simple lateral plicae and, especially its broad groove in the dorsal fold. It resembles *Spiriferella qubuensis* Chang from the Selong Group of Tibet in Chang & Ching (1976, pl. 18, fig. 1-5) in outline and sculpture, but differs in having a wider sulcus with median costae and narrower bounding plicae. *S. unicostata* Chang in Chang & Ching (1976, pl. 16, fig. 1-2) from the same group is similar to our species in its simple lateral plications and smooth sulcus, but differs in its large broad oval outline with tricostate bounding plications. These Tibetan species cannot be fully compared because their dorsal valves are not described.

The dorsal groove of the present species is only slightly wider than that of *Spiriferella loveni* (Diener) of early mid-Permian deposits in the Arctic, as revised by Waterhouse & Waddington (1982). Apart from this difference, specimens of *S. loveni* are not as elongate as those of the new species. *Spiriferella leviplica* Waterhouse & Waddington, 1982 from Kungurian deposits of Arctic Canada has a similar groove in the dorsal fold, and smooth plicae, but is transverse and lacks costae.

Spiriferella antefurcata Liu & Waterhouse from the mid-Permian Zhesi Formation of Zhesi, Damao County, Neimongol, is close in the nature of its furrow along the dorsal fold, but is less elongate with higher fold and more costae, and more incurved ventral umbo.

Spiriferella aff. *antefurcata* Liu & Waterhouse
Pl. 8, fig. 6, 9-12

Locality. $P_{12}H_4$.

Diagnosis. Shell of average size, ventral sulcus broad, shallow, with bifurcated lateral sinal costae, no medium sinal costae; plicae with up to 3 costae; dorsal fold low, groove well defined anteriorly.

Description. Ventral valve moderately convex, strongly incurved with angle of 80°. Interarea moderately concave, delthyrium obscured by incurved umbo, hinge wide, maximum width of shell at midvalve. Sulcus narrow, shallow, sulcal angle about 25°, no median sinal costa; 2 pairs of lateral costae within sinus of a few shells on inner flanks of plicae, bifurcate anteriorly. Some 5-7 pairs of plicae, fine laterally, plical crests and interspaces subangular, inner 2 pair of plicae have 3-4 costae.

Dorsal valve less convex than ventral valve, beak incurved, fold low, divided by well developed median groove from apex, flanks of fold bear 3 costae. Four pairs of plicae, inner bearing 3 costae, next pair with 2 costae. Micro-ornament not preserved.

Ventral interior with strong dental plates, short adminicula, mostly buried. Adductor scars narrow, diductor scars wide with longitudinal ridges and oblique growth lines. Pallial markings well shown laterally.

Measurements in mm

No.	Width	Length	Dorsal length	Height	Hinge width
CCGBH142	39	44	34	23.5	31.5
CCGBH143	35	40	31	22	28.5
CCGBH144	32.5	34.5	35	28	33
CCGBH145	38	45	35	32.5	33

Comparison. These specimens resemble *Spiriferella antefurcata* Liu & Waterhouse from the Zhesi Formation at Zhesi, Damao County, Neimongol in general appearance and particularly in the nature of the dorsal furrow along the fold. There are differences, in that the present specimens tend to be more inflated with a lower dorsal fold and fewer costae. In these respects the present shells come close to *S. wangi* from the same beds, but have more costae, slightly more transverse shape, greater inflation, and more incurved ventral umbo. They have much the same low fold with wide median groove.

Spiriferella sp.
Pl. 8, fig. 13-15

Locality. $P_{12}H_1$.

Diagnosis. Shell small, subrhomboidal in outline, greatest width at hinge. Sulcus well developed, smooth, plicae simple. Fold with wide median groove.

Description. Ventral valve moderately inflated, subrhomboidal in outline. Beak incurved, interarea low, cardinal extremities rounded, hinge 80-85°, maximum width of shell near midlength. Sulcus well developed, smooth, with low costa each side suggested in one shell, sinal angle 15°. Plicae simple, high, with rounded crests, 4 pairs.

Dorsal valve less convex than ventral valve, fold prominent with conspicuous median groove, plicae simple, 3 pairs.

Ventral valve with dental plates. Umbonal cavity thickened by secondary shelly deposits. Dorsal interior not observed.

Measurements in mm

No.	Width	Length	Dorsal length	Height	Hinge width
CCGBH146	26.5	24.4	22	16	26.5
CCGBH147	24	22	17	8	24

Comparison. These specimens are close to *Spiriferella wangi* sp. nov. described above, but are suboval in outline, not elongate, and have fewer plicae.

Genus *Elivina* Frederiks, 1924
Elivina sinensis sp. nov.
Pl. 9, fig. 1-4, 6, 7; pl. 10, fig. 1, 4, 5, 7, 9

Locality. $P_{12}H_6$.

Holotype. CCGBH148, pl. 9, fig. 1, 3.

Diagnosis. Shell triangular in outline, hinge short, cardinal extremities obtuse. Sulcus broad and shallow, smooth or with faint sinal costae; dorsal fold with wide simple median groove. Plicae simple, costae few.

Description. Ventral valve moderately convex, beak strongly incurved over delthyrium, with angle of 32°, interarea high. Hinge about half or less than half width of shell, and maximum width placed at anterior fourth of shell length. Sulcus well defined with sinal angle of 25°, smooth or bearing faint median and lateral costae. Plicae in 6-7 pairs, without costae.

Dorsal valve gently convex, beak incurved, fold low, divided by broad simple median groove which begins from beak. Six pairs of plicae, simple, or rarely with weak additional rib on inner side, interspaces wide. Surface of both valves marked by irregular concentric growth lines, 5-8 in 1mm, with radial pustules in interspaces, but detail poor.

Ventral interior with short adminicula and high dental plates, large muscle field. Dorsal interior with median ridge, spiralium points posterolaterally, adductor impressions faint, subrectangular.

Measurements in mm

No.	Width	Length	Dorsal length	Height	Hinge width
CCGBH148	37	35	26	17	18
CCGBH149	36	32	22.5	17.5	19
CCGBH150	44	35?	22.5	20	–
CCGBH151	29.5	34	25	20	22
CCGBH152	30	21	16.5	12.5	14.5
CCGBH153	40	39	33	16	19
CCGBH154	29	28.5	22.5	17	15.5

Comparison. These specimens are close in general appearance to *Elivina tibetana* (Diener, 1897) from Kazanian or early Punjabian beds in south Tibet, though tending to be slightly more elongate and more triangular in shape with maximum width placed well forward. Costae are much less conspicuous, and, more significantly, the groove along the dorsal fold is much more pronounced in the present species. *Elivina tschernyschewi* Waterhouse & Waddington, 1982 from early Permian beds of the Urals is more inflated with posterior walls straight in outline, and with the dorsal fold bearing a narrow though distinct furrow. *Elivina cordiformis* Waterhouse & Waddington, 1982 from Kungurian beds of the Canadian Arctic also has a narrow groove along the dorsal fold, and is closely costate with massive ventral umbonal shoulders and deep ventral sulcus.

Family Spiriferidae King, 1846

Genus *Neospirifer* Frederiks, 1924

Neospirifer sulcoprofundus sp. nov.

Pl. 9, fig. 5, 8, 11; pl. 10, fig. 2, 3, 6, 8; pl. 11, fig. 2, 3, 5, 6, 9; pl. 12, fig. 1,3

Locality. $P_{12}H_6$.

Diagnosis. Shell large in size, transversely trapezoidal in outline with maximum width at hinge. Ventral sulcus with mostly angular to anteriorly rounded floor; fold high, narrow, costae coarse.

Holotype. CCGBH124, pl. 10, fig. 2, 6, 8; pl. 11, fig. 5, 6, 9.

Description. Ventral valve moderately convex; umbo incurved with apical angle of 120–145°, interarea low, at maximum width of shell, marked by

vertical and horizontal striations. Cardinal extremities usually alate, angles varying from 45° to 80–85°. Sulcus narrow with rounded or subangular floor, and sulcal angle of 20°. Costae coarse, with rounded crests, 6-7 costae in 5mm posteriorly near sulcus, 4-5 costae in 5mm anteriorly, bundles ill-formed, irregular in strength, with 3 ribs, the strongest one in the middle, splitting anteriorly. Concentric growth lines poorly preserved.

Dorsal valve more inflated than ventral valve, beak strongly incurved over low triangular interarea, high acute fold begins at umbo. Costae and plicae as in ventral valve.

Dental plates scapula-shaped, converging at 100° on high short adminicula diverging at 105-110° ; delthyrium under beak closed by series of growth ridges passing on to dental plates, no large umbonal callosity. Muscle field wide, divided for almost full length by prominent myophragm, adductors broad, raised, with light longitudinal markings, separated by groove from wide diductor scars bearing growth undulations and ridges radiating like thumb prints. Posterior floor thickened, marked by pallial lines and pits.

Cardinal process laminated, adjoined by very small crural plates and strong thick socket plates; crest of fold damaged, obscuring presence or absence of median ridge, muscle scars not clearly defined.

Measurements in mm

No.	Width	Length	Height
CCGBH124	130+	60+	35
CCGBH125	100+	63	40
CCGBH126	100	55	46
CCGBH127	78	42	22

Comparison. An elongate specimen is shaped somewhat like *Neospirifer striatoparadoxus* (Toula, 1873, 1875) from early mid-Permian beds of Spitsbergen and the other Arctic areas (see Gobbett, 1964), and has similar coarse costae and poorly defined plicae, but is distinguished by its narrow V-shaped sulcus. Some Mongolian specimens are further distinguished by their very transverse outline. The ribs are much coarser than in most species of *Neospirifer.*

Neospirifer adpressum sp. nov.
Pl. 12, fig. 5-10

Localities. $P_{12}H_6$.

Holotype. CCGBH131, pl. 12, fig. 5, 7.

Diagnosis. Shell large, subrectangular, beaks adpressed, interareas low. Sulcus well developed with subangular floor, fold high with angular crest. Costae fine, inner pair of plicae along and within anterior sulcus large, other plicae inconspicuous.

Description. Ventral valve moderately inflated, umbo strongly incurved, angle 130-140°, interarea low. Hinge at greatest width of shell, cardinal extremities acute, cardinal angle 70-80°. Sulcus well developed, with sulcal angle of 25°, forming prominent tongue anteriorly, deep angular base posteriorly, rounded cross-profile anteriorly. Costae fine, 6-7 in 5mm at midlength, slightly finer within sulcus, bundled in threes posteriorly near beak and sulcus. Inner pair of plicae very broad, 2 or 3 outer pairs more subdued. Concentric laminae well developed on anterior part.

Dorsal valve more inflated than ventral valve, umbo incurved, touching ventral umbo, area very low, fold high and angular. Costae with faint fasciculations near beak but indistinct laterally. Micro-ornament not preserved.

Dental plates scapula-shaped, strongly thickened, inclined inwards at low angle, and diverging forwards, leaving low ridge along inner side of delthyrium; adminicula inclined outward at high angle to floor of valve, substantially buried in secondary shell. Adductors broad, slightly raised, marked by irregular longitudinal striae; diductors wide, also with longitudinal grooves and ridges; pallial markings strong over posterior lateral shell; floor bearing small pustules, 2-5 per mm, some elongate.

Cardinal process with some 50 fine vertical laminae, marked by a few strong growth pauses; socket plates low, crural plates vertical, diverging widely forward at 110°, hinge not denticulate. Median septum and muscle scars obscured by damage, and spire not revealed. Posterior shell moderately thickened, with fine pustules and pits over floor.

Measurements in mm

No.	Width	Length	Height
CCGBH128	75	56	37
CCGBH129	74	40	44
CCGBH130	72	38	23
CCGBH131	78	52	49

Comparison. This species is like *Neospirifer marcoui* (Waagen, 1883) from the upper part of the Lower Productus Limestone (=Amb Formation – pre-Katta beds) to Middle Productus limestone (Wargal Formation) in the Salt Range, Pakistan. Waagen's species is characterized by its subrectangular outline, deep and subangular sulcus, high acute fold and strong costae as well as indistinct fasciculations with a large inner pair of plicae. Chernyshev (1902, pl. 6, fig. 9; pl. 12, fig. 3) recorded this species from the Omphalotrochus bed in the Urals and Timan, of Upper Carboniferous age, but his specimens are smaller than Waagen's or our specimens, and have well defined plicae and generally very different appearance. Lee *et al.* (1980, p. 412, pl. 177, fig. 4) reported the species *marcoui* from the Sijiashan Formation of Lower Permian age in Heilongjiang Province, North-east China (= upper Chihsia Formation of south China) but their specimen is very incomplete.

The variety *N. marcoui undata* Reed (1944) from the Amb Formation of the Salt Range has well defined but low plicae, and *N. trimuensis* Reed, 1944 has very fine costae but may be allied. *Neospirifer ravana* (Diener) from the Himalayas has been generally accepted as a descendent species from *marcoui* (Reed, 1944; Waterhouse, 1966, 1978) with stronger plicae and a comparable pronounced sulcus and fold and massive inner pair of ventral plicae, leading in turn to the younger species *N. ravaniformis* Waterhouse, 1978. Of present specimens only one shows the massive inner plicae, and on others plicae are limited to the posterior shell, perhaps as in Waagen's figures which do not indicate any strong degree of plication. The main difference of present specimens is that the beaks are more adpressed, and the umbonal regions of both valves thus somewhat different, with lower interareas and more incurved beaks in the Neimongol specimens.

Specimens ascribed to *marcoui* by Etheridge (1914) from the Byro Group of Western Australia appear to be close to Waagen's species, as noted by Waterhouse (1978), although referred to *N. ravana* by Stepanov (1937).

Family Elythidae Frederiks, 1919, 1924
Genus *Kitakamithyris* Minato, 1951
Kitakamithyris ovata sp. nov.
Pl. 11, fig. 8; pl. 12, fig. 2, 4

Locality. $P_{12}H_1$.

Diagnosis. Shell transversely oval to subcircular in outline, subequally biconvex. Sulcus begins on umbo, broad and shallow anteriorly.

Holotype. CCGBH155, pl. 11, fig. 8; pl. 12, fig. 2, 4.

Description. Ventral valve gently to moderately convex, beak incurved, apical angle of about 45°. Interarea moderately high, weakly defined, slightly concave, broad delthyrium with angle of 75°. Umbonal shoulders rounded, hinge shorter than maximum width, cardinal extremities rounded. Sulcus narrow over umbo, shallow and broad anteriorly with angle of 35°. Surface marked by numerous concentric laminae, about 7 in 5mm at anterior margin, with crowded biramous spines along each margin, 2 in 1mm anteriorly.

Dorsal valve gently inflated, beak incurved, fold ill-defined, surface ornamented by crowded concentric laminae with spines.

Interior of ventral valve with short dental plates resting on vertical adminicula, diverging forward. Ventral median septum long, extending over posterior fourth of shell, high ridge projects into delthyrium between dental and adminicular plates but apparently no complete deltidial plate. Muscle scars impressed, striate, adductors sited on septum. Dorsal interior with low socket plates and faint median ridge, about one third of shell length, with ridge each side, probably delimiting long subrectangular posteriorly placed faintly impressed adductor scars.

Measurements in mm

No.	Width	Length	Dorsal length	Height	Hinge width
CCGBH155	33	19.5	26	16.5	17
CCGBH156	35.5	28	26	10	14

Comparison. *Kitakamithyris tyoanjiensis* Minato, 1951 from Early Carboniferous beds of Japan, is a more inflated less oval shell. *K. septata* (Chronic 1949, 1953) from the early Permian Copacabana Group of Lake Titicaca is a more transverse and somewhat more inflated species. *K. buravasi* Hamada, 1960 from the pebbly beds of the Phuket Group in south Thailand, as revised by Waterhouse, 1981, is close in general appearance but its posterior walls are less concave in outline and the ventral umbo less extended posteriorly. The species *K. krystofovichi* (Zavodowsky, 1970; see Sarytcheva *et al.* 1977) from the Paren (basal Permian) and Chahadan beds Kolyma-Omolon Massif is moderately close but has a well formed ventral sulcus. *K. magna* (Miloradovich, 1936 – see Sarytcheva *et al.* 1977) from Early Permian beds of Novaya Zemlya also has a shallow ventral sulcus, a little better defined than in the present species. There is considerable similarity to a specimen from the Callytharra Formation (Sterlitamakian, Sakmarian) of Western Australia that was figured as *Phricodothyris lineata* by Prendergast (1935), but the posterior walls are less concave in outline.

Genus *Squamularia* Gemmellaro, 1899
?*Squamularia* sp.
Pl. 11, fig. 4

Locality. $P_{12}H_4$.

Description. Shell small, subcircular in outline. Ventral valve strongly convex with high interarea and narrow delthyrium, beak small, incurved. Umbonal slopes steep, hinge shorter than the maximum width, sited at midlength. No sulcus. Ornament of concentric bands, prominent and broad posteriorly, fine and crowded anteriorly. Micro-ornament obscure. Specimen, 19mm wide, 17mm long, hinge 16.5mm wide.

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	Section 1	Section 2	Section 3	Section 12			
	H20	H7	H4	H1	H3	H4	H6
Derbyia dorsosulcata						X	
Dyoros lamellosa				X			
chonetid gen. & sp. indet.			X				
Waagenoconcha sp. A				X			
Waagenoconcha sp. B						X	
Waagenoconcha sp. C							X
Kochiproductus aff. *sinensis*					X	X	X
Kochiproductus sp.					X		
Magniplicatina sp.				X			
Muirwoodia mammata?				X	X		X
Muirwoodia sp.							X
Yakovlevia borealis						X	
Y. convexus						X	
Stenoscisma sp. A							X
Stenoscisma sp. B				X			
Stenoscisma sp. C							X
S. cf *paucisulcata*						X	
S. cf. *timorensis*						X	X
S. ovalia				X	X		
Camerisma rhomboidea						X	X
Spirigerella sp.						X	
Attenuatella orientalis	X						
Syringothyris sp. A		X	X				
Syringothyris sp. B			X				
?*Pseudosyringothyris* sp.			X				
Spiriferella wangi						X	X
S. aff. *antefurcata*						X	
Spiriferella sp.				X			
Elivina sinensis							X
N. sulcoprofundus							X
N. adpressum							X
Kitakamithyris ovata				X			
?*Squamularia* sp.						X	

Table 2. Faunal list of brachiopods from Xiujimqinqi.

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PLATE 1

Derbyia dorsosulcata sp. nov.

Fig. 1, 7, 10 Dorsal, ventral and posterior views, holotype CCGBH55.

Fig. 8 Dorsal view of internal mould, CCGBH56.
Specimens x 1, $P_{12}H_4$, Zhesi Formation.

Dyoros lamellosa sp. nov.

Fig. 2, 3 Ventral valve, x 2, x1, CCGBH59.

Fig. 9 Ventral view CCGBH58, x2.

Fig. 4, 5, 6 Ventral and dorsal views of holotype CCGBH57. (xl, x2)

Specimens from $P_{12}H_1$, Houtoumiao Formation.

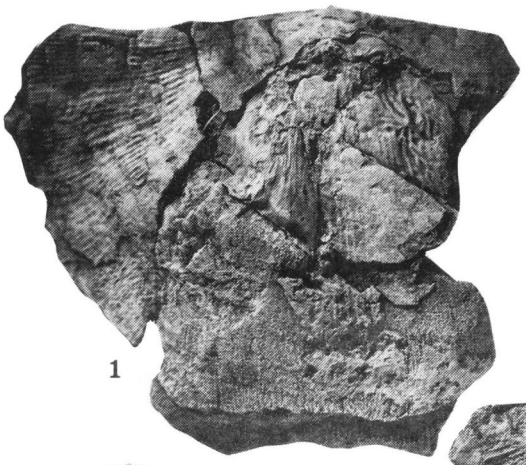
Magniplicatina sp.

Fig. 11 Ventral view CCGBH73, x1, from $P_{12}H_1$, Houtoumiao Formation.

Waagenoconcha sp. A

Fig. 12, 13 Ventral and dorsal views, CCGBH64 x1, from $P_{12}H_1$, Houtoumiao Formation.

PLATE 1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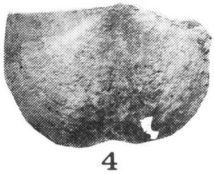
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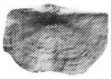
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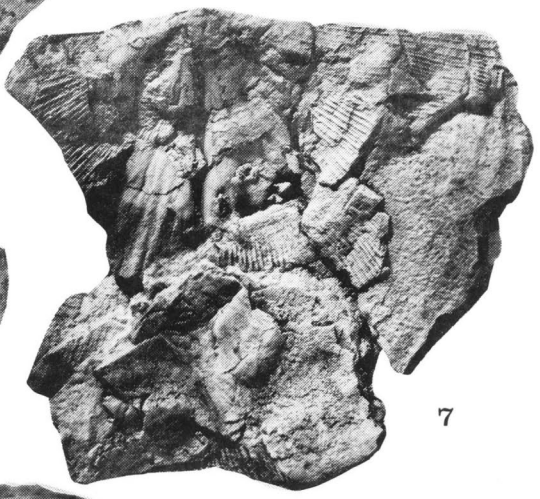
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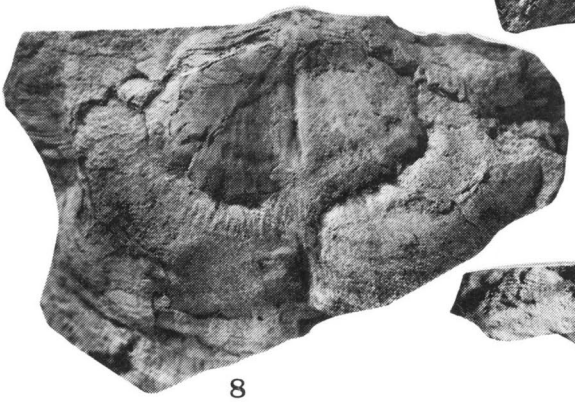
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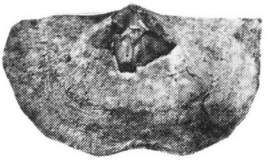
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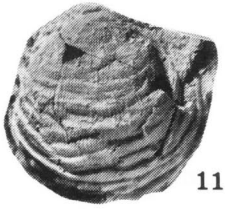
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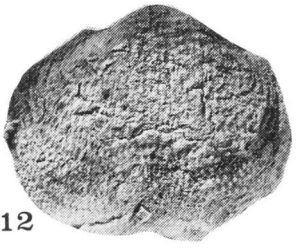
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PLATE 2

Chonetid gen. & sp.

Fig. 1 Slab with internal moulds of dorsal and ventral valves. CCGBH63, x3, from P_3H_4, Houtoumiao Formation.

Waagenoconcha sp. B.

Fig. 3, 4 Ventral views of valves CCGBH67, 68, x 1, from $P_{12}H_4$, Zhesi Formation.

Waagenoconcha sp. C.

Fig. 5 Ventral view of CCGBH69, x1, from $P_{12}H_6$, Zhesi Formation.

Kochiproductus aff. *sinensis* Liu & Waterhouse

Fig. 6 Ventral valve CCGBH72 x 1, from $P_{12}H_3$, Houtoumiao Formation.

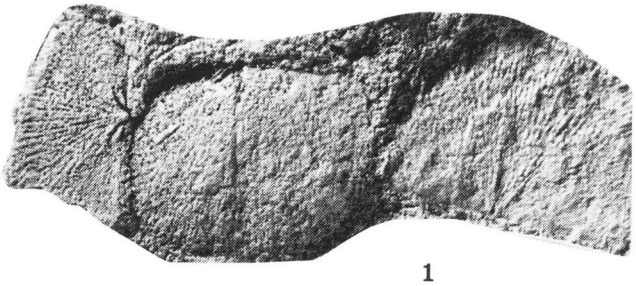
Fig. 7, 8 Ventral and lateral views x1, from $P_{12}H_6$, Zhesi Formation.

Waagenoconcha sp. A

Fig. 2, 9 Ventral and dorsal views CCGBH65.

Specimens x 1, from P_{12},H_1, Houtoumiao Formation.

PLATE 2



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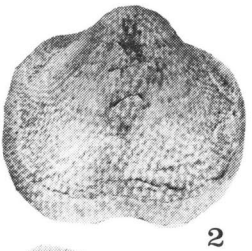

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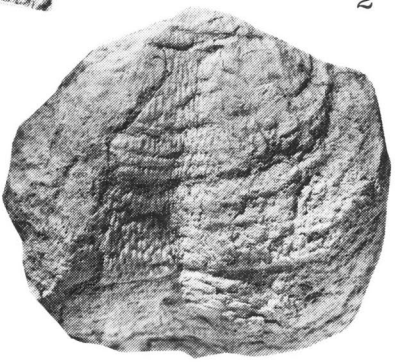

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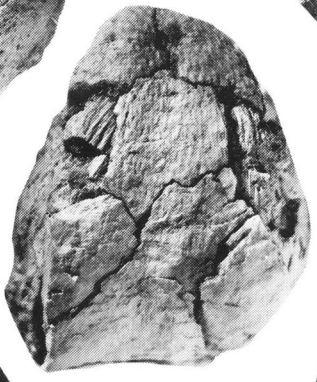

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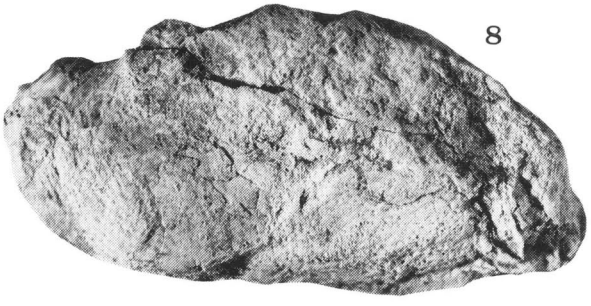

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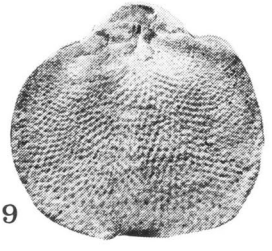

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PLATE 3

Kochiproductus aff. *sinensis* Liu & Waterhouse

Fig. 1-2 Ventral and lateral views of internal mould CCGBH71, x1, from $P_{12}H_4$, Zhesi Formation.

Kochiproductus sp.

Fig. 3 Ventral valve CCGBH72, x1 from $P_{12}H_3$, Houtoumiao Formation.

Yakovlevia borealis sp. nov.

Fig. 4, 5 Ventral and dorsal aspects of holotype, CCGBH81.

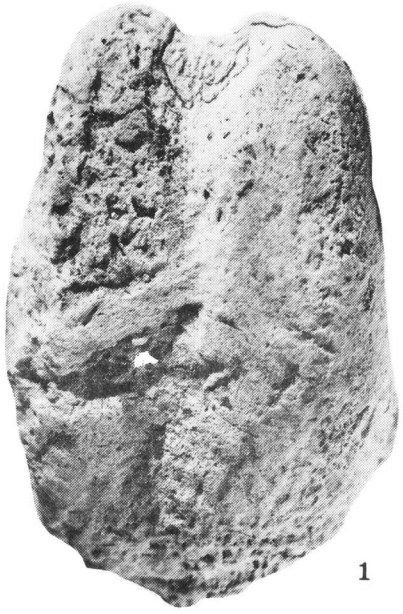
Fig. 6 Ventral valve CCGBH80.

Specimens x1, from $P_{12}H_4$, Zhesi Formation.

Yakovlevia convexus sp. nov.

Fig. 7 Internal mould, ventral valve CCGBH88, x1, from $P_{12}H_3$, Houtoumiao Formation.

PLATE 3



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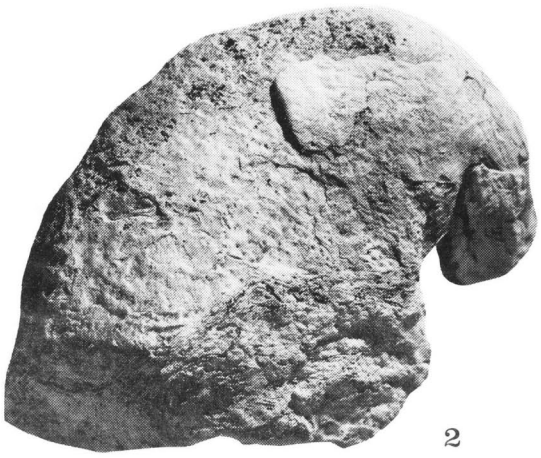

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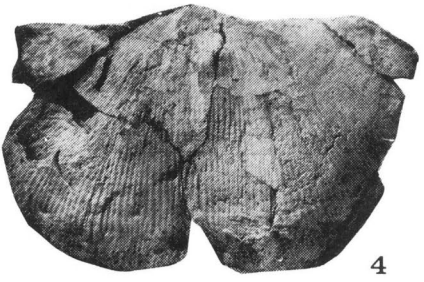

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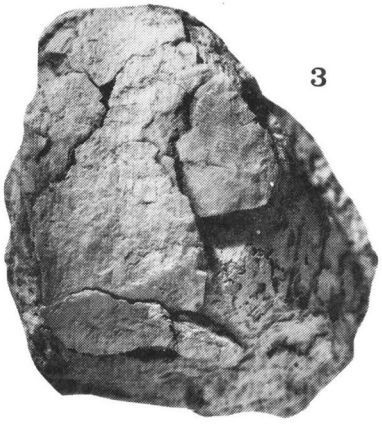

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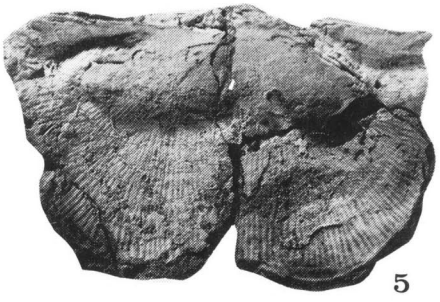

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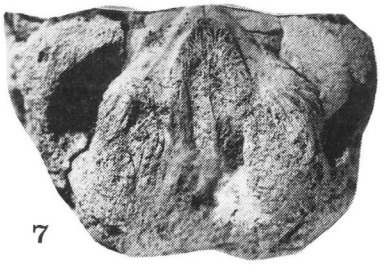

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PLATE 4

Yakovlevia convexus sp. nov.

Fig. 1-3 Ventral, anterior, and lateral views of holotype, CCGBH87, x 1, from $P_{12}H_4$, Zhesi Formation.

Muirwoodia mammata (Keyserling)

Fig. 4 Dorsal view, CCGBH74.

Fig. 5 Anterior ventral view, CCGBH76.

Fig. 6 Ventral valve CCGBH75.

Specimens x1, from $P_{12}H_1$, Houtoumiao Formation.

Muirwoodia sp.

Fig. 7 Ventral valve CCGBH77, x 1, from $P_{12}H_6$, Zhesi Formation.

Stenoscisma cf. *paucisulcata* Liu & Waterhouse

Fig. 8, 9, 11 Ventral, dorsal and lateral views (dorsal valve on top) of CCGBH82.

Fig. 10 Ventral view of CCGBH84.

Fig. 12 Interior of ventral valve CCGBH87.

Specimen x1, from $P_{12}H_4$, Zhesi Formation.

Stenoscisma cf. *timorense* (Hayasaka & Gan)

Fig. 13, 14 Dorsal and ventral views of internal mould CCGBH89, x 1, from $P_{12}H_6$, Zhesi Formation.

PLATE 4

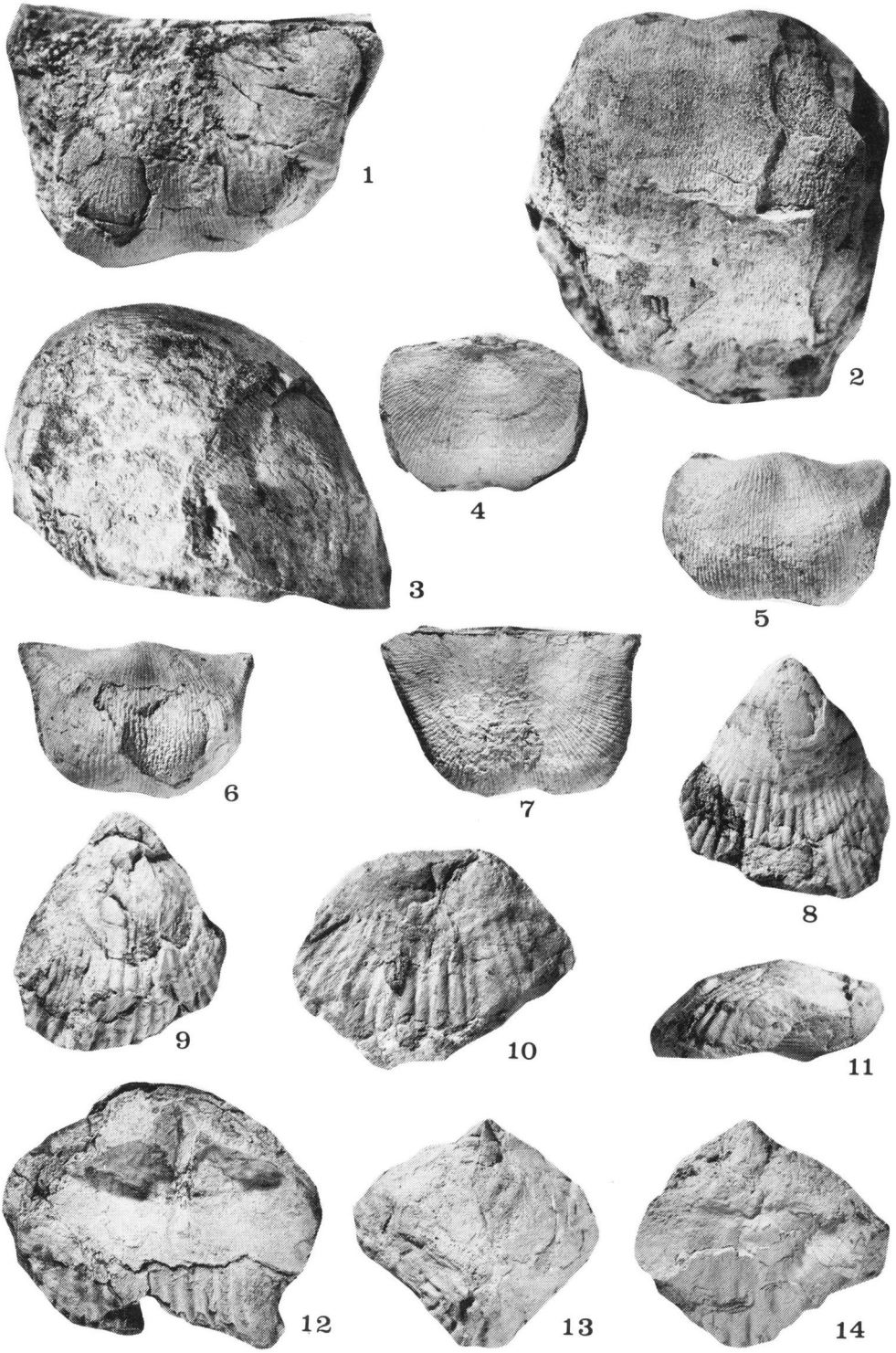


PLATE 5

Stenoscisma cf. *timorense* (Hayasaka & Gan)

Fig. 1-3 Ventral, anterior and dorsal views of internal mould CCGBH90, x 1.

Fig. 4 Ventral view of CCGBH91.

Specimens x1, from $P_{12}H_4$, Zhesi Formation.

Stenoscisma ovalia sp. nov.

Fig. 5, 6, 7 Ventral, lateral and dorsal views (ventral valve on top) holotype CCGBH95, x1, $P_{12}H_1$.

Fig. 8, 9, 10 Dorsal, ventral and anterior views (ventral valve on top), CCGBH97, x1, from $P_{12}H_1$.

Fig. 11, 12 Dorsal and ventral views of internal mould CCGBH98, x1, from $P_{12}H_3$.

Fig. 13-16 Ventral and dorsal views of internal mould x1, x2. CCGBH96, $P_{12}H_3$.

All specimens from Houtoumiao Formation.

Stenoscisma sp. B.

Fig. 17, 19 Dorsal and ventral views of CCGBH93.

Fig. 18, 20 Dorsal and ventral views, CCGBH94.

Specimens x1, from $P_{12}H_1$, Houtoumiao Formation.

Stenoscisma sp. C.

Fig. 21, 22 Ventral and dorsal aspects of CCGBH97, x 1, from $P_{12}H_6$, Houtoumiao Formation.

Camerisma rhomboidea sp. nov.

Fig. 23, 24 Ventral and dorsal aspects of internal mould, holotype CCGBH97, x1, from $P_{12}H_6$, Zhesi Formation.

PLATE 5

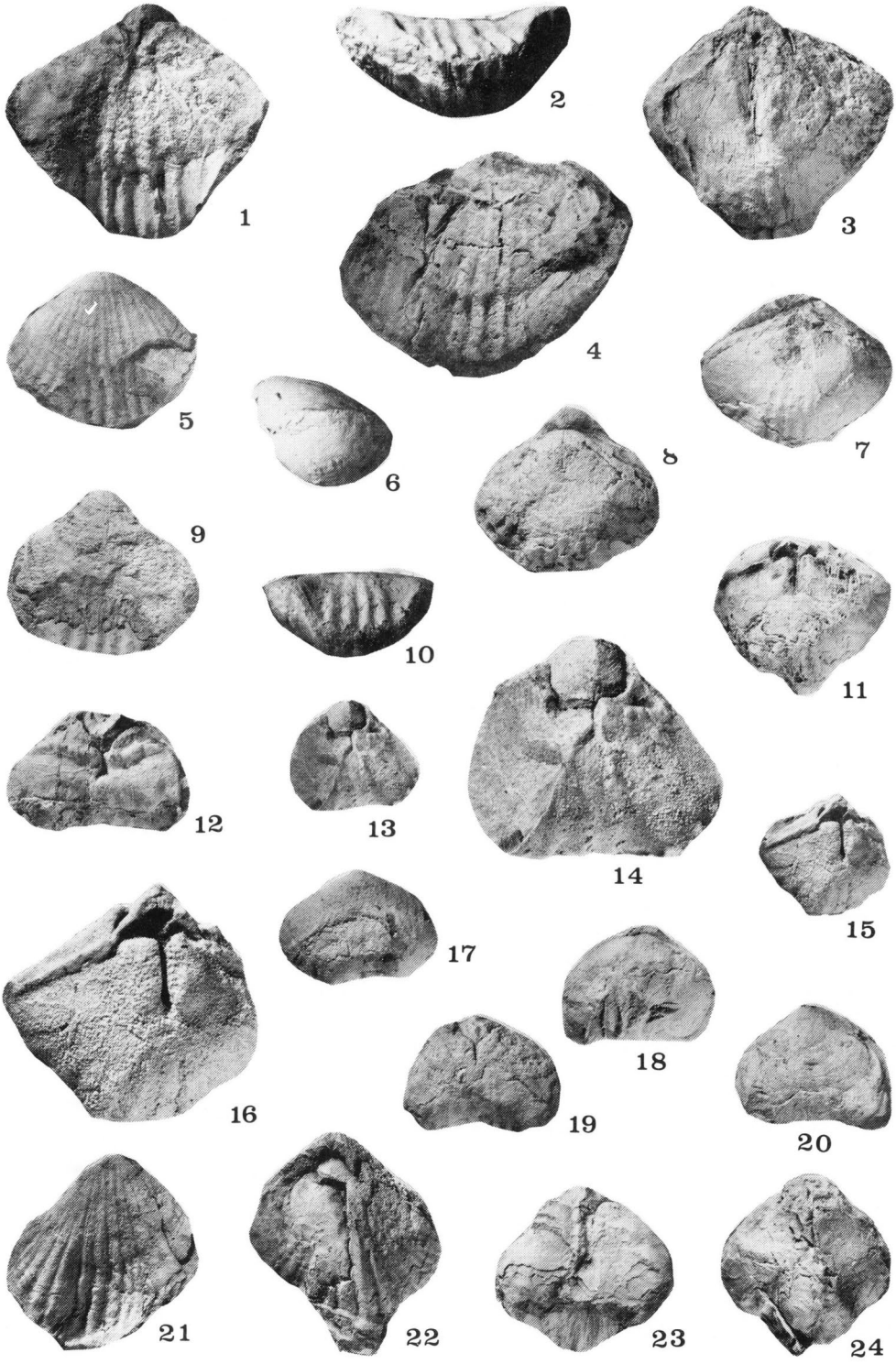


PLATE 6

Camerisma rhomboidea sp. nov.

Fig. 1, 2 Posterior ventral and lateral views (dorsal valve on top), internal mould holotype, CCGBH97, x1, from $P_{12}H_6$.

Fig. 3, 4 Ventral and dorsal views of CCGBH96, x 1, from $P_{12}H_4$.

Specimens from Zhesi Formation.

Spiriferella sp.

Fig. 5, 7 Ventral and lateral views (Tilted, dorsal valve on top), CCGBH98, x1, from $P_{12}H_4$, Zhesi Formation.

Attenuatella orientalis sp. nov.

Fig. 6, 8, 9 Dorsal, ventral and lateral views (dorsal valve on top), internal mould holotype, CCGBH100.

Fig. 12 Posterior ventral view of CCGBH99.

Fig. 15, 16 Lateral views of CCGBH101.

Specimens x3, from P_1H_{20}, Houtoumiao Formation.

Syringothyris sp. A

Fig. 10, 14 Ventral and dorsal views, CCGBH108, from P_3H_4.

Fig. 11, 13 Ventral and dorsal views, CCGBH107, from P_2H_7.

Specimens x1, from Houtoumiao Formation.

PLATE 6

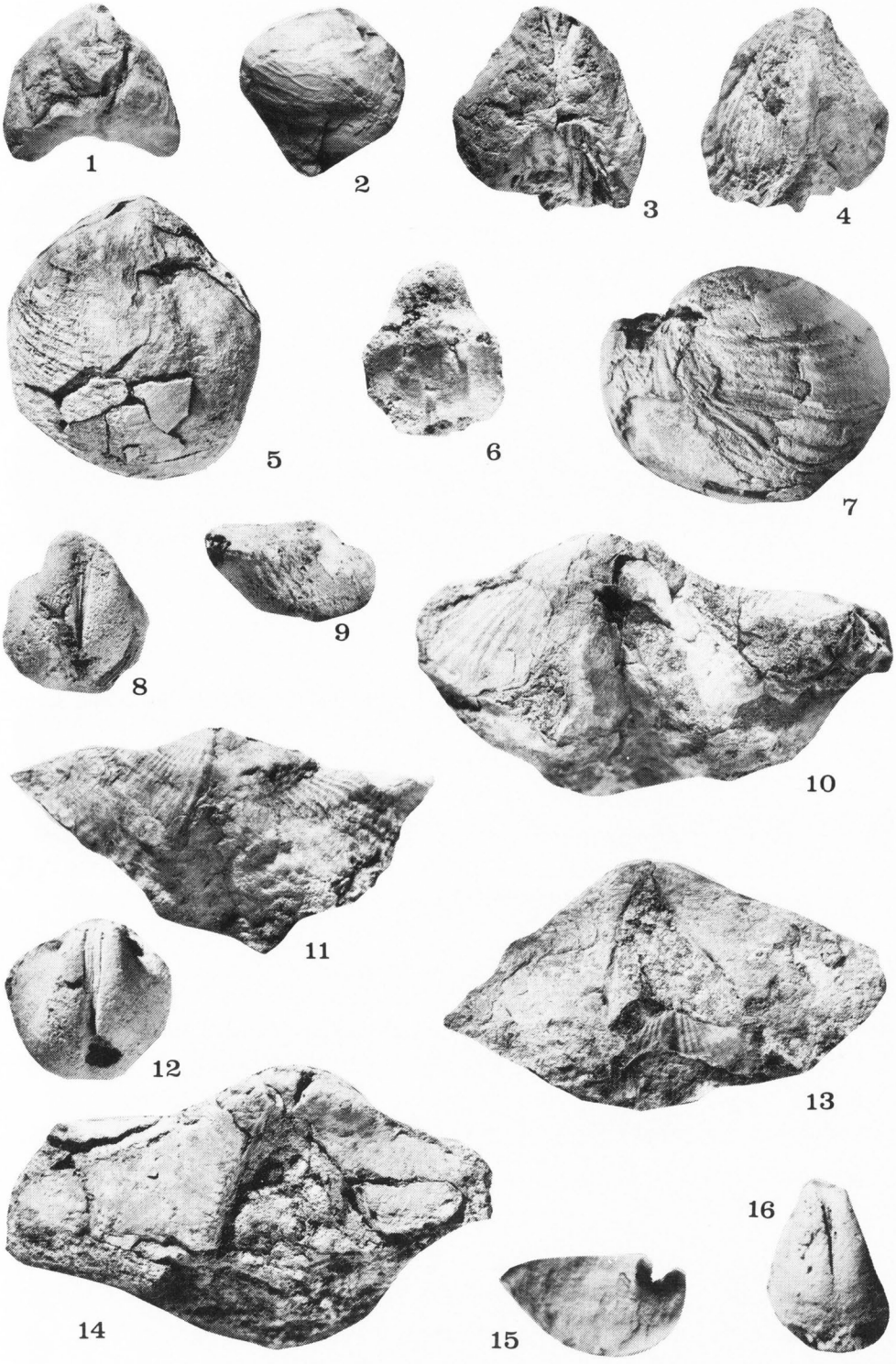


PLATE 7

Syringothyris sp. B

Fig. 1 Dorsal view of ventral valve, CCGBH120.

Fig. 2, 7 Dorsal and ventral views of ventral valve CCGBH115.

Fig. 4 Dorsal view of ventral valve CCGBH121.

Fig. 5 Ventral view CCGBH114.

Specimens from x1, P_3H_4, Houtoumiao Formation, except 5, x1.5.

Syringothyris sp. A

Fig. 3 Transverse section showing delthyrial plate, dental plates and syrinx, CCGBH159, x1, from P_3H_4, Houtoumiao Formation.

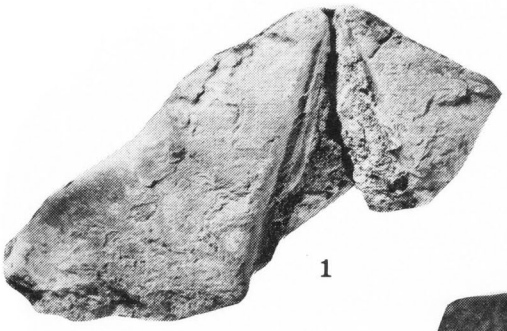
?*Pseudosyringothyris* sp.

Fig. 6, 8 Ventral and dorsal views of ventral valve CCGBH123, x1, from P_3H_4, Houtoumiao Formation.

Spiriferella wangi sp. nov.

Fig. 9 Dorsal view, CCGBH137, x1, from $P_{12}H_4$, Zhesi Formation.

PLATE 7



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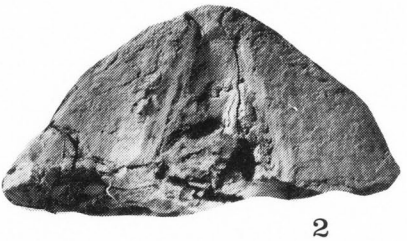

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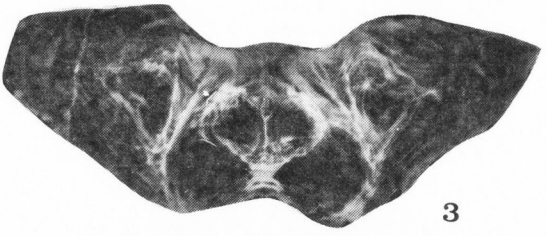

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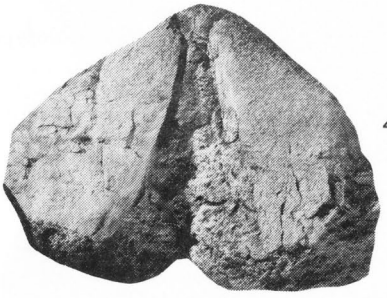

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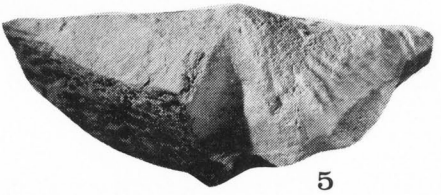

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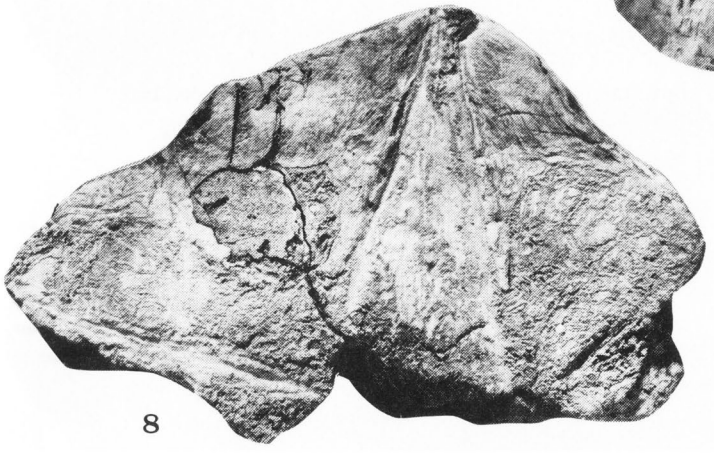

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PLATE 8

Spiriferella wangi sp. nov.

Fig. 1-3 Dorsal, lateral (dorsal valve below) and ventral views, holotype, CCGBH135.

Fig. 4, 5 8 Ventral, dorsal and lateral views (dorsal valve on top) CCGBH136.

Fig. 7 Ventral view, CCGBH137.

Specimens x1, from $P_{12}H_4$, Zhesi Formation.

Spiriferella aff. *antefurcata* Liu & Waterhouse

Fig. 6, 9 Ventral and dorsal views CCGBH145.

Fig. 10, 12 Internal mould, dorsal and ventral views, CCGBH146.

Fig. 11 Dorsal views CCGBH142.

Specimens x1, from $P_{12}H_4$, Zhesi Formation.

Spiriferella sp.

Fig. 13, 14 Dorsal and ventral views of CCGBH146.

Fig. 15 Dorsal view of CCGBH147.

Specimens x1, from $P_{12}H_1$, Houtoumiao Formation.

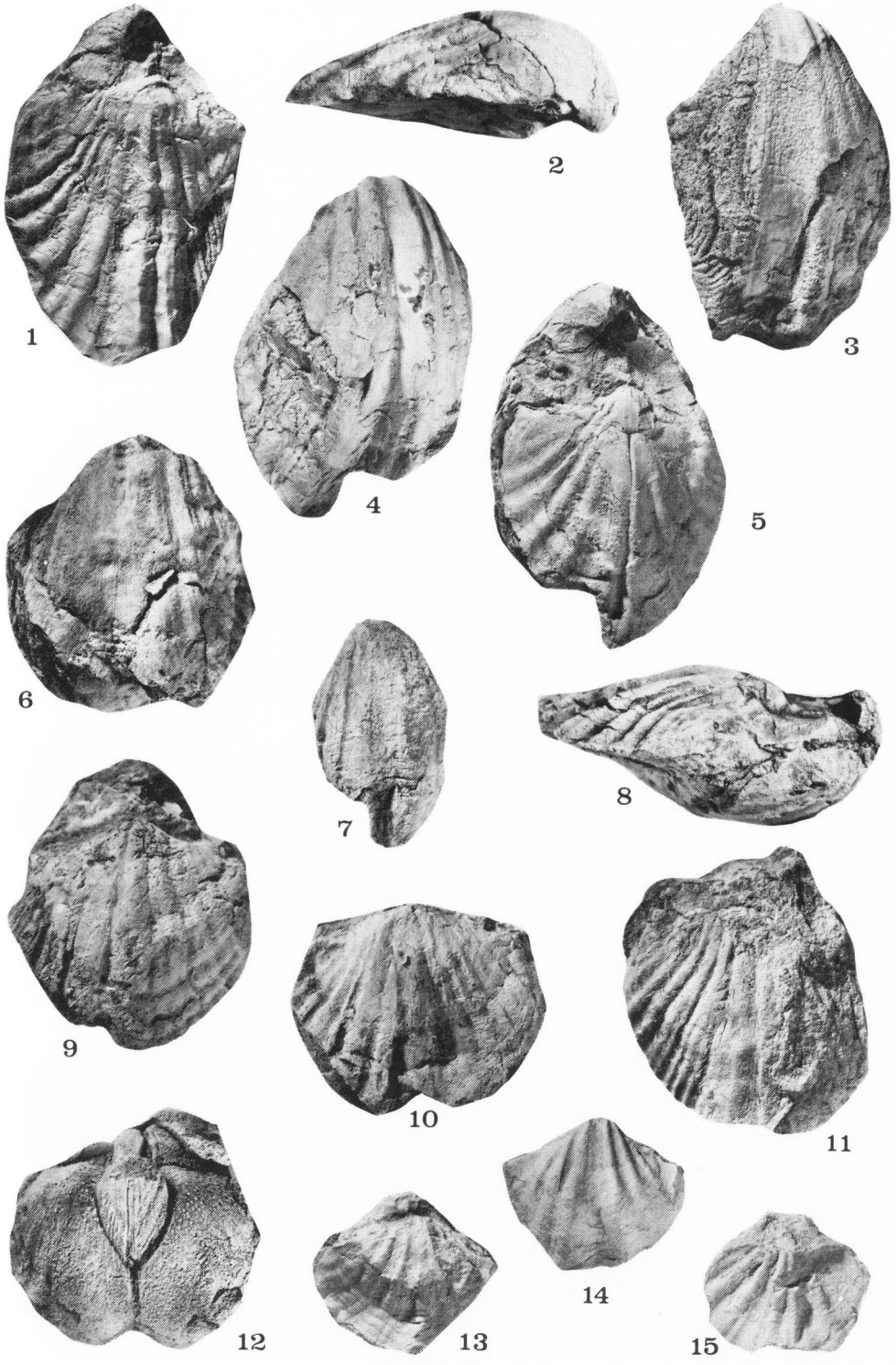
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PLATE 9

Elivina sinensis sp. nov.

Fig. 1, 3 Dorsal and ventral views, holotype, CCGBH148.

Fig. 2, 6 Dorsal and ventral views, CCGBH151.

Fig. 4, 7 Dorsal and ventral views, CCGBH149.

Fig. 9, 10 Dorsal and ventral views CCGBH150.

Specimens x1, from $P_{12}H_6$, Zhesi Formation.

Neospirifer sulcoprofundus sp. nov.

Fig. 5, 8, 11 Ventral, dorsal and posterior views (dorsal valve on top) CCGBH125, x1, from $P_{12}H_6$, Zhesi Formation.

PLATE 9

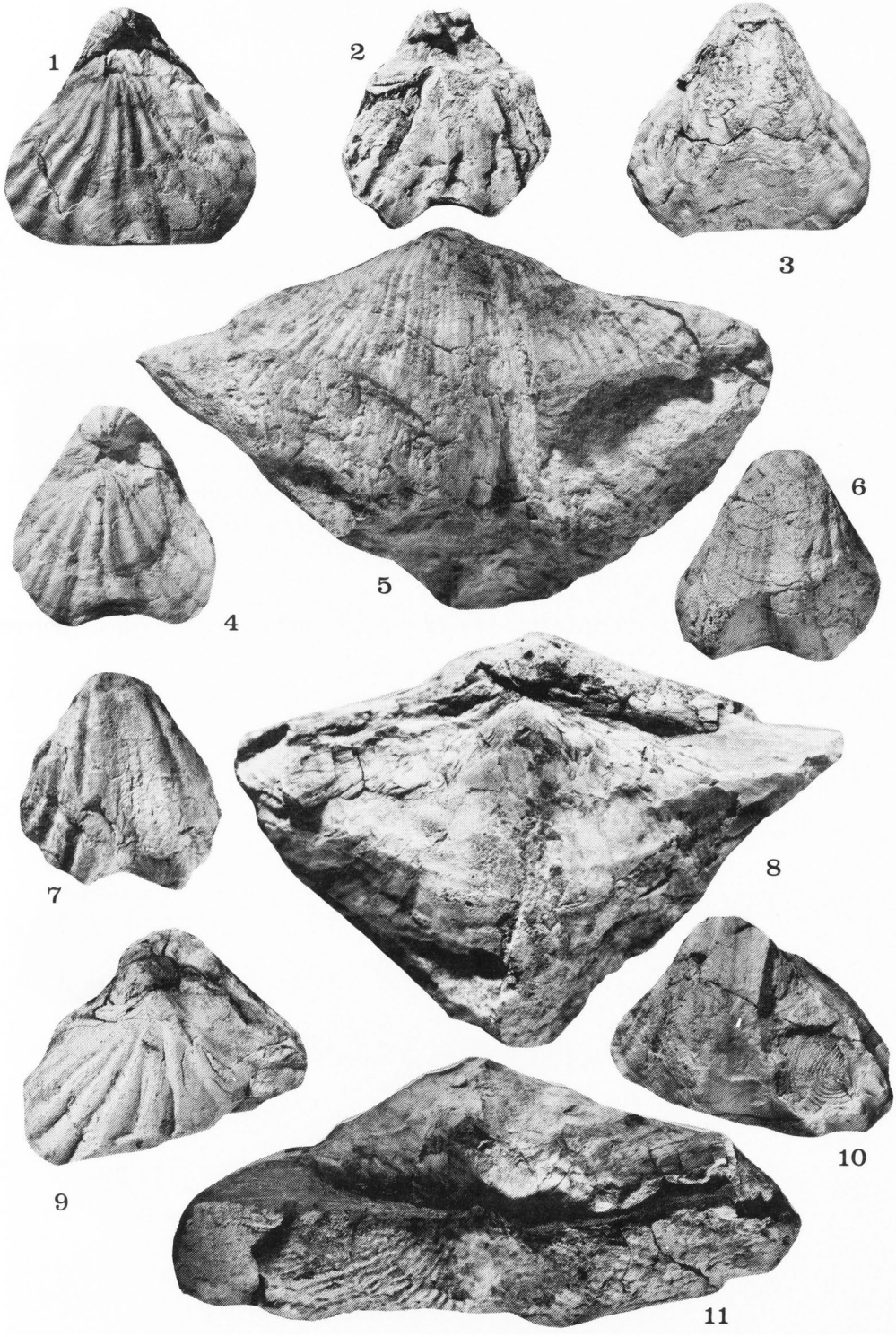


PLATE 10

Elivina sinensis sp. nov.

Fig. 1 Lateral view, dorsal valve on top, CCGBH149.

Fig. 4, 5 Dorsal and ventral views, CCGBH154.

Fig. 7, 9 Dorsal and ventral views, CCGBH152.

Specimens x1, from $P_{12}H_6$, Zhesi Formation.

Neospirifer sulcoprofundus sp. nov.

Fig. 2, 6, 8 Dorsal, posterior (ventral valve on top) and ventral views, holotype, CCGBH124.

Fig. 3 Ventral valve, CCGBH126.

Specimens x1, from $P_{12}H_6$, Zhesi Formation.

Plate 10

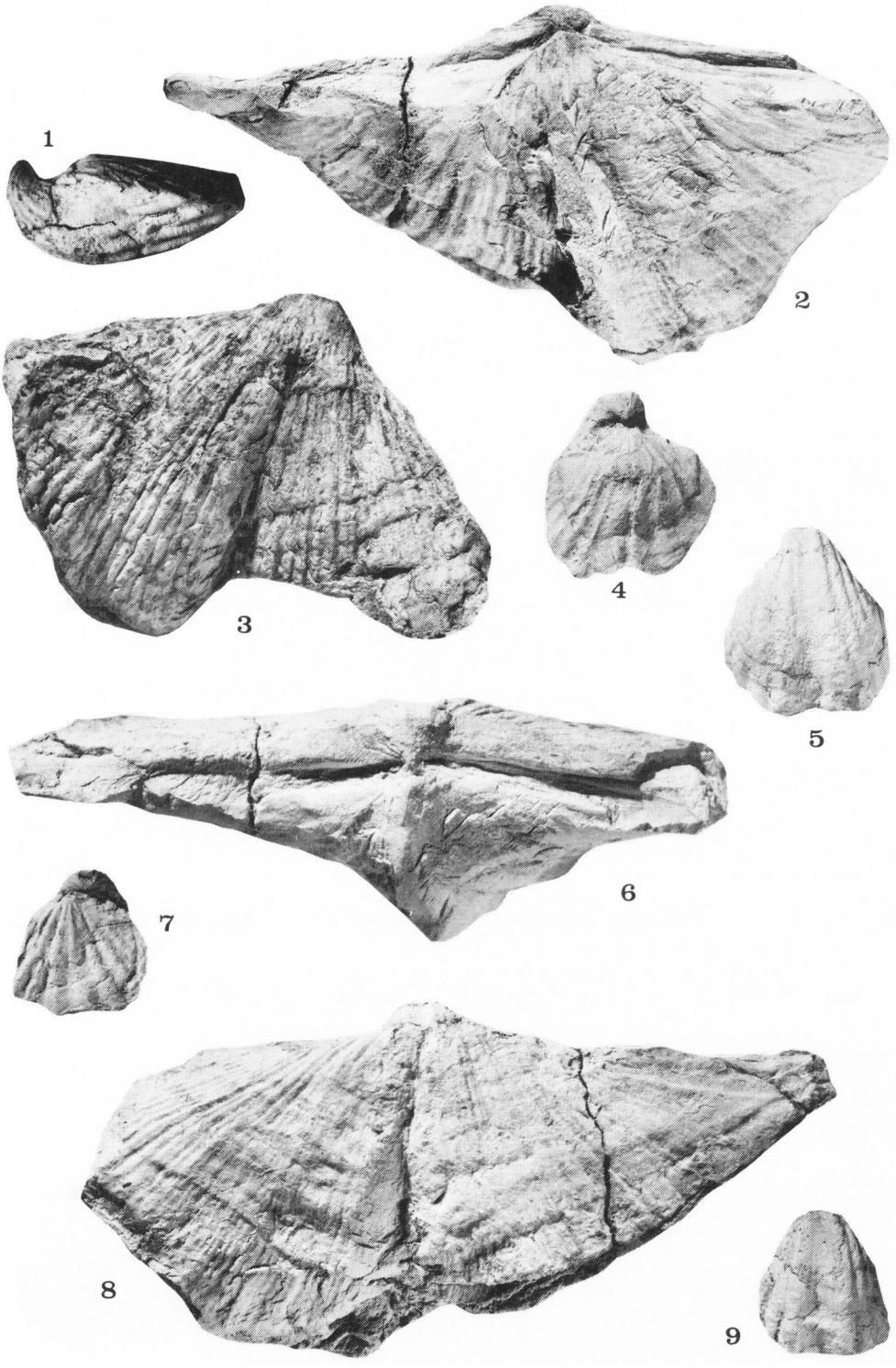


PLATE 11

Elivina sinensis sp. nov.

Fig. 1, 7 Ventral and dorsal views of CCGBH153, x1, from $P_{12}H_6$, Zhesi Formation.

Neospirifer sulcoprofundus sp. nov.

Fig. 2, 3 Ventral and dorsal views, CCGBH127, x 1.

Fig. 5, 9 Internal moulds of dorsal and ventral views, holotype, CCGBH124, xl.

Fig. 6 Detail of internal mould, dorsal valve on top, same specimen, x2.

Specimens from $P_{12}H_6$, Zhesi Formation.

Squamularia sp.

Fig. 4 Ventral view, CCGBH158, x1, from $P_{12}H_4$, Zhesi Formation.

Kitakamithyris ovata sp. nov.

Fig. 8 Ventral view holotype CCGBH155 x 1, from $P_{12}H_1$, Houtoumiao Formation.

Plate 11

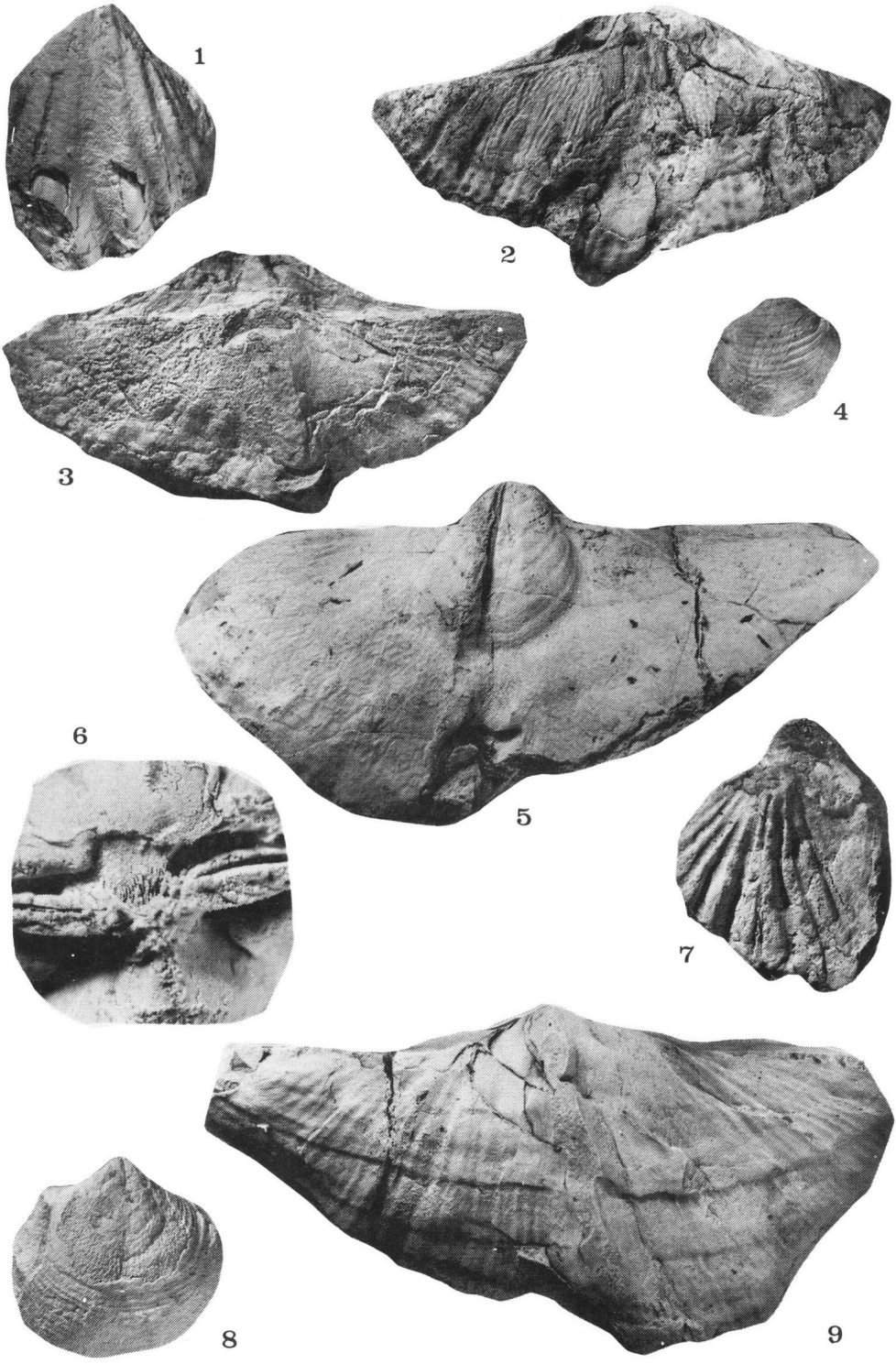


PLATE 12

Neospirifer sulcoprofundus sp. nov.

Fig. 1, 3 Posterior views of internal moulds, dorsal valve on top, CCGBH124 and 126, x1, from $P_{12}H_6$, Zhesi Formation.

Kikakamithyris ovata sp. nov.

Fig. 2, 4 Internal mould, posterior view (dorsal valve on top) and dorsal views, holotype, CCGBH155, x1, from $P_{12}H_1$, Houtoumiao Formation.

Neospirifer adpressum sp. nov.

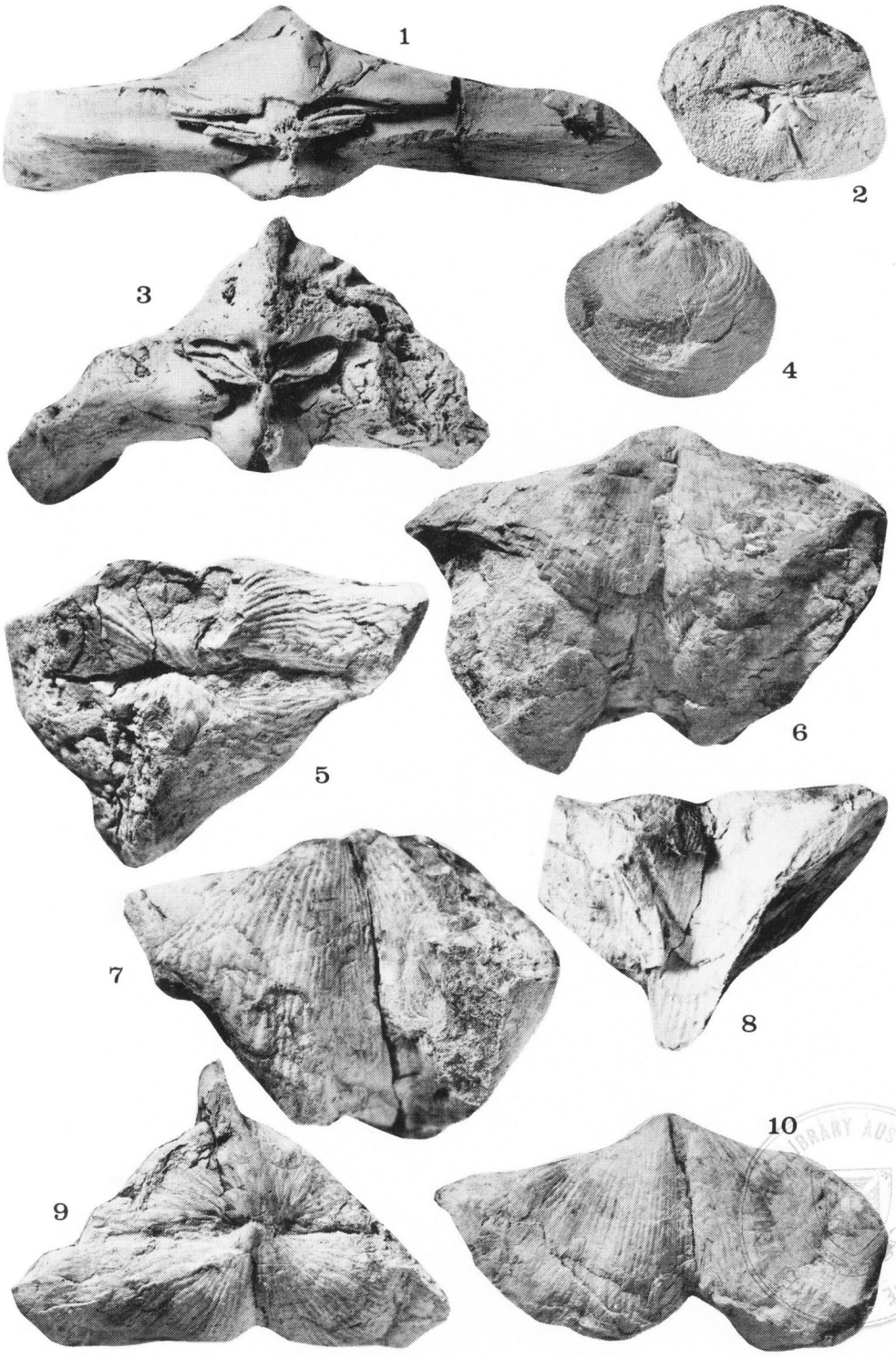
Fig. 5, 7 Posterior dorsal and ventral views, holotype, CCGBH131.

Fig. 6 Ventral view, CCGBH128.

Fig. 8, 9, 10 Anterior, posterior (dorsal valve on top), and ventral views of CCGBH129.

Specimens x1, from $P_{12}H_6$, Zhesi Formation.

PLATE 12



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