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Late Triassic cyrtinoid spiriferinacean brachiopods
from western North America and their
biostratigraphic and biogeographic implications

by

Peter R. Hoover

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LATE TRIASSIC CYRTINOID SPIRIFERINACEAN BRACHIOPODS
FROM WESTERN NORTH AMERICA
AND THEIR BIOSTRATIGRAPHIC AND BIOGEOGRAPHIC IMPLICATIONS

By

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ABSTRACT

Cyrtinoid spiriferinacean brachiopods in samples from over fifty Late Triassic marine fossil localities in western North America include examples of three species of *Spondylospira* Cooper, 1942, one of which (*S. tricosta*) is new; one new species of *Zugmayerella* Dagens, 1963; and four new monotypic genera, represented by *Dagyspirifer fascicostata*, *Phenacozugmayerella mimunicinata*, *Pseudospondylospira perplexa*, and *Vitimetula parva*, all new species. In North America, all of these genera are limited to the Karnian and/or Norian. One species, *Spondylospira tricosta*, n. sp. appears to be a good indicator of the early Norian. The family Laballidae of earlier workers is divided into the family Laballidae and the new family Spondylospiridae, based on absence or presence, respectively, of functional pedicle foramina; the latter family is divided into two new subfamilies, Spondylospirinae and Dagyspiriferinae, based on the form of those foramina.

Two features of cyrtinoid spiriferinacean species biogeography have tectonostratigraphic implications. First, there are no "Tethyan" species among them, and second, the nine species of cyrtinoid spiriferinaceans reported here are predominantly confined to the Americas, including both cratonal and terrane belt localities. Biogeographic evidence from the cyrtinoids, therefore, does not support close links between terranes of the present-day eastern and western Pacific.

Cyrtinoid spiriferinaceans provide abundant evidence of biogeographic "stitching" of various terranes. For example, *Pseudospondylospira perplexa*, *Spondylospira lewesensis*, and *Spondylospira tricosta* occur in localities that are craton-bound as well as in parautochthonous and allochthonous localities.

ACKNOWLEDGEMENTS

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Drs. J. Thomas Dutro, Jr. (U. S. Geological Survey, Washington, DC, and my advisor in the post-doctoral study which led to this paper), Norman J. Silberling, (U. S. Geological Survey, Denver, CO), Algirdas S. Dagens (Institute of Ecology, Vilnius, Lithuania), and Derek Ager (Swansea, Wales) reviewed the manuscript and made valuable comments, many of which have been incorporated into the manuscript.

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The illustrations in this study came from a variety of sources. The photographs on all the plates were produced in 1975 by R. H. McKinney and H. E. Mochizuki of the U. S. Geological Survey's Paleontology and Stratigraphy Branch in Washington, DC. I drafted Text-figure 1; the photographs in Text-figure 2A and B were shot by McKinney and Mochizuki, and Jorge Valdes, of S. T. Pees and Associates, Meadville, PA, respectively; Text-figures 3 and 4 come from the talented pen of Jude Louviere of Toledo, OH; and the photographs that comprise Text-figure 5 were expertly shot and printed by David Tuttle, of the Department of Geological Sciences at the State University of New York at Binghamton.

INTRODUCTION

Late Triassic cyrtinoid spiriferinacean brachiopods from western North America historically have been poorly known. This is partially due to their rarity (compared with other Late Triassic invertebrate fossils) and partially due to the comparatively greater biostratigraphic utility of other forms (e.g., ammonites and flat clams, and, more recently, conodonts; see discussion

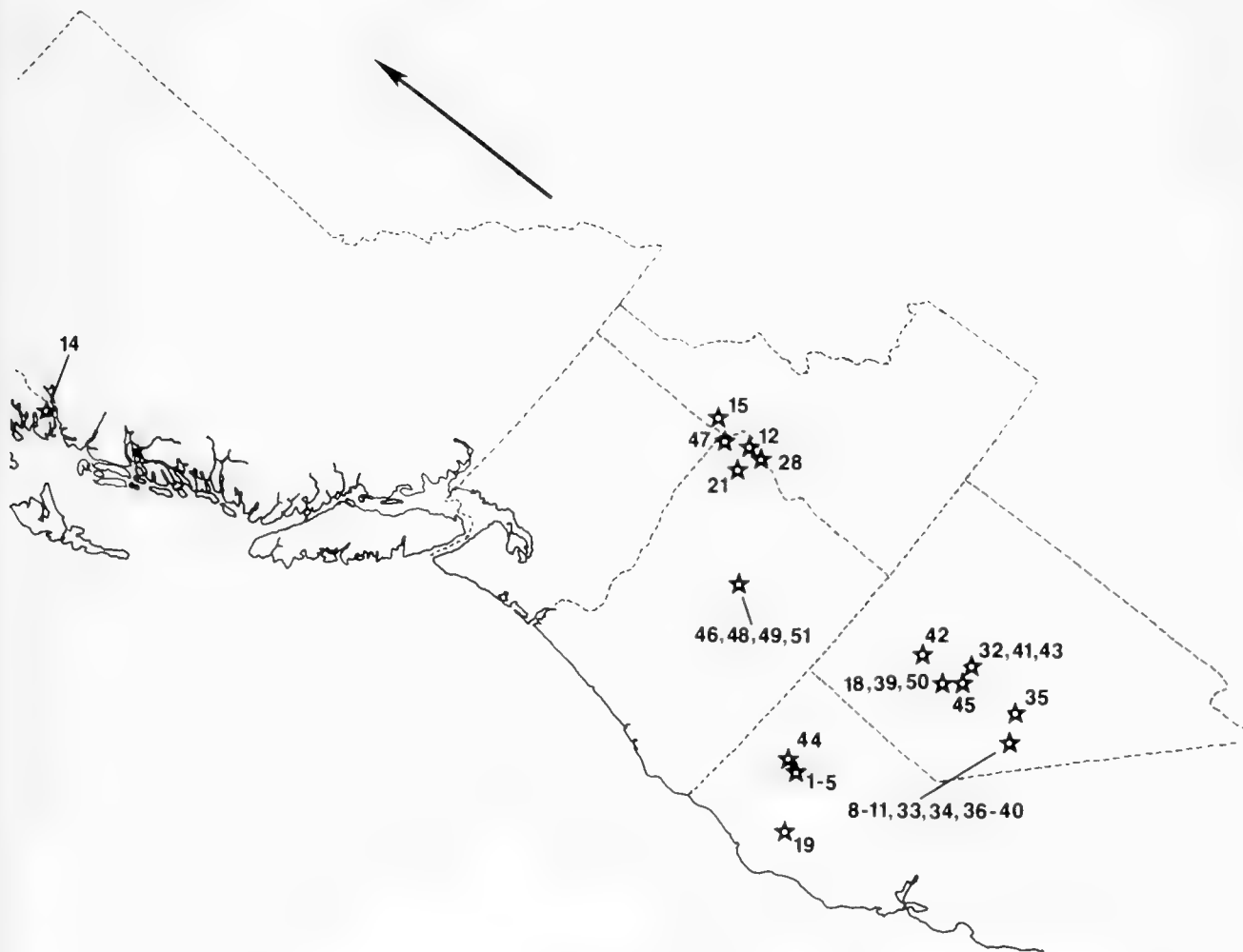


Text-figure 1.—Sketch map showing location of North American collecting localities cited in this report (arrows point North).

below). Although there were sporadic reports under the guise of *Cyrtina* Davidson, 1858 and *Spiriferina* d'Orbigny, 1847 during the late nineteenth and early twentieth centuries, not until Cooper's work of 1942 and 1944, which defined *Spondylospira*, were these forms studied in appropriate detail. In 1944, in Shimer and Shrock's *Index Fossils of North America*, Cooper illustrated a specimen he assigned to *Psioidea* sp. (p. 359, pl. 140, figs. 52–55). This specimen was differentiated from the species of *Spondylospira* illustrated by having a smooth fold and sulcus. The illustration shows a very smooth surface, and examination of the specimen (USNM 106250) reveals it to be the internal mold of a cyrtinoid spiriferinacean of a size and form similar to *Spondylospira lewesensis* (Lees, 1934). Because it lacks any remaining vestige of the shell, it cannot confidently be assigned to any known cyrtinoid spiriferinacean genus or species. These stud-

ies were followed in short order by the Vokes and Haas (1944) compendium of information on American species of *Spondylospira*, which incorporated available information from the Triassic of Peru (Körner, 1937; Tilmann, 1917). Since then most North American Late Triassic cyrtinoid spiriferinacean brachiopods have been referred to *Spondylospira*, including some forms that were not even spiriferinaceans (e.g., *Spondylospira alia* Hall and Whitfield, 1877; see discussion under *Spondylospira lewesensis*). In recent years, some cyrtinoid forms that lack a costate fold and sulcus have been assigned to *Zugmayerella* Dagys, 1963 [see e.g., *Zugmayerella uncinata* (Schafhäütl, 1851), cited in Stanley, 1979, p. 14, pl. 8, figs. 10–13], but none has been formally described.

In 1976, as part of a post-doctoral project, I began a study of Late Triassic articulate brachiopods, based primarily on materials deposited in the stratigraphic



Text-figure 1.—[continued].

collections of the U. S. Geological Survey in Washington, DC, and Menlo Park, CA. This eventually involved over 50 collecting localities, spread over an area from central Nevada north to southwestern Alaska (Text-fig. 1). It became immediately apparent that time and equipment were inadequate to do justice to the terebratulids and rhynchonellids, both of which require elaborate preparation of many specimens to adequately understand the variation in expression of taxonomically significant characters. The spiriferoids were commonly better preserved, and their usable taxonomic characters more readily accessible. Of these, the cyrtinoid spiriferinaceans were a convenient group to work on, as they contain a variety of structures that are of great interest in terms of functional interpretations. Indeed, these puzzling functional interpretations are one of several important factors that have delayed publication of this monograph (see Hoover, 1983; 1990).

Fourteen years later, in March of 1990, having become increasingly aware of the many fine Late Triassic marine fossil localities that had been collected from by Canadian workers, I visited the Geological Survey of Canada in Ottawa, and surveyed its Triassic biostratigraphic collections. At the Canadian Survey, as in the U. S., fossils are most commonly collected by workers engaged in mapping, and chiefly interested in those forms that have biostratigraphic significance. Because most biostratigraphically significant Triassic invertebrate macrofossils are not brachiopods, but rather ammonites or flat clams, there were few brachiopods in the collections. Indeed, the only Canadian localities represented in the GSC biostratigraphic collections that contained cyrtinoid spiriferinaceans were: (1) Nicola, British Columbia [no further information available], which yielded a single ventral valve questionably referable to *Pseudospondylospira*, n. gen.; (2) the type

Table 1.—Upper Triassic Series, Stages, Substages, and Zones (after Tozer, in House and Senior, 1980).

Norian (No)	Upper Norian (Sevastian)(UNo)	<i>Choristoceras crickmayi</i> Zone (UNo3) <i>Cochloceras amoenum</i> Zone (UNo2) <i>Gnomohalorites cordilleranus</i> Zone (UNo1)
	Middle Norian (Alaunian)(MNo)	<i>Himavatites columbianus</i> Zone (MNo2) <i>Drepanites rutherfordi</i> Zone; <i>Cyrtopleurites bicrenatus</i> Zone (MNo1)
	Lower Norian (Lacian)(LNo)	<i>Juvavites magnus</i> Zone (LNo3) <i>Malayites dawsoni</i> Zone; <i>Malayites paulckeii</i> Zone (LNo2) <i>Mojsisovicsites kerri</i> Zone; <i>Guembelites jandianus</i> Zone (LNo1)
Karnian (C)	Upper Karnian (Tuvalian)(UC)	<i>Klamathites macrolobatus</i> Zone (UC3) <i>Tropites welleri</i> Zone; <i>Tropites subbullatus</i> Zone (UC2) <i>Tropites dilleri</i> Zone (UC1)
	Lower Karnian (Julian)(LC)	<i>Sirenites nanseni</i> Zone (LC3) <i>Austrotrachyceras austriacum</i> Zone (LC2) <i>Trachyceras desatoyense</i> Zone; <i>Trachyceras aonoides</i> Zone (LC1)

area for *Spondylospira lewesensis* (Lees, 1934) [Lake Laberge region, Yukon Territory]; (3) another area in similar strata about 10 km to the east that also yielded *S. lewesensis* [Lime Peak, Yukon Territory (Reid, 1985)]; (4) the Karnian of Cameron Island in the Canadian Arctic [GSC loc. 25872]; (5) Trout Lake, Yukon Territory [GSC loc. 86206], which yielded isolated specimens that may be referable to *Zugmayerella* Dagens, 1963; and (6) the Halfway River area of British Columbia [GSC loc. 47016], which yielded isolated specimens questionably referable to the genus *Spondylospira* Cooper, 1942. This should in no way be construed as a gauge of the rarity of cyrtinoid spiriferinaceans in Canada, any more than U. S. collections are a gauge of their comparative rarity in the U. S. Rather, they are rarely collected. Because this paper demonstrates the biostratigraphic utility of some of these forms, they may be better sampled in the course of future studies.

Here, then, are six genera of spiriferinacean brachiopods that may prove useful in future paleoecological and biostratigraphic studies of the Triassic System.

BIOSTRATIGRAPHY

All specimens discussed herein were recovered from institutional collections, and their occurrence in the field was documented by workers whose primary interest was not necessarily biostratigraphic, or even paleontologic. Thus, much of the information relating to collecting localities themselves is interpretive and was derived in part from evidence recovered subsequent to the discovery of the fossils themselves (see *Appendix*, material in brackets). Probable age assignments for the rocks recovered from the localities discussed herein vary in their precision; some are made on the basis of stratigraphic position, and others on the basis of associated fauna.

Dagyspirifer fascicostata, n. gen. and n. sp., and *Vimmetula parva*, n. gen. and n. sp., each known from a single locality, occur, respectively, in the earliest Norian and late Norian [zones LNo1, and UNo1 through

UNo3 of Tozer (1980); see Table 1]. Their full biostratigraphic ranges are not known.

Pseudospondylospira perplexa, n. gen. and n. sp. occurs in beds that range from early late Karnian to latest Norian in age [zones UC1 through UNo3 of Tozer (1980)], but most occurrences are in the early Norian. The precision of dating of these localities is, for the most part, insufficiently high to make this form a reliable biostratigraphic indicator.

Spondylospira Cooper, 1942 has commonly been used as an indicator for the Late Triassic, and with one possible exception (Hoover, 1990), that is still true. *S. lewesensis* (Lees, 1934), the best known species of the genus, has been recovered in this study alone from 22 localities ranging in probable age from earliest Karnian through latest Norian [zones LC1 through UNo3 of Tozer (1980)]. The precision of the age assignments on the early end of this range is unknown. Only a single locality (loc. 26, Alexander terrane) includes rocks that may be older than late Karnian [zone UC1 of Tozer (1980)]. This date is based on analysis of associated fauna by Silberling (written commun., 1989). Dagens (written commun., 1990) states that the "distribution [herein] of *S. lewesensis* through all Late Triassic is quite unusual for Triassic cyrtinoid brachiopods. In Tethys, as well as in Boreal region, they are indicators only of part of one stage. Very suspect is distribution of *lewesensis* in Carnian." It may be: (1) that the ages presented here are correct; (2) that age assignments of some of the localities included herein are too broad or incorrect; or (3) that some of the material may belong to other taxa. I believe alternative (3) to be unlikely. *S. parmata* Hoover, 1983 is known from only two localities, but seems such a distinctive form that it could be a reasonable indicator for the middle to late Norian [zones MNo1 through UNo3 of Tozer (1980)]. *S. tricosta*, n. sp. qualifies as a very good index fossil. In this study it occurs at six localities in three different terranes, and nowhere is found earlier than the earliest Norian nor later than the late early Norian [zones LNo1

through LNo3 of Tozer (1980)]. Because it is morphologically highly distinctive and easily recognizable, it should find great utility as an index for the early Norian.

Zugmayerella Dagys, 1963 as a genus does not appear to occur earlier than the early late Karnian [zone UC1 of Tozer (1980)] nor later than the late middle Norian [zone MNo2 of Tozer (1980)], and there are interesting patterns within the species recognized herein. *Z.?* sp. A is known from only two specimens, from two localities, one of which is of unknown age, and the other of which is dated as middle late Karnian [zone UC2 of Tozer (1980)] on the basis of associated fauna. *Z.* sp. is known from a single specimen recovered from beds that are dated from early late Karnian through middle early Norian [zones UC1 through LNo2 of Tozer (1980)], based on stratigraphic position. Neither can be considered as a good index based on this small information base. *Z. americana*, n. sp., however, is known from four localities representing three terranes, all dated on the basis of associated fauna and covering the relatively short time range of from middle late Karnian through early early Norian [zones UC2 through LNo1 of Tozer (1980)].

Phenacozugmayerella mimuncinata, n. gen. and n. sp. is a particularly interesting story. It has a completely disjunct distribution. Four localities, representing the Alexander (loc. 6) and Izee (locs. 48, 49, 51) terranes, give an age spanning the Late Karnian [zones UC1 through UC3 of Tozer (1980)], based on associated fauna in the former and on stratigraphic position in the latter, but these ages may not be so well constrained as represented. Eight other localities, representing the Paradise and Jungo terranes, and rocks overlying the Golconda allochthon, give an age mostly in the early Norian, with one locality each from the Paradise and Jungo terranes extending the range up through the middle Norian [through zone MNo2 of Tozer (1980)].

EVOLUTIONARY RELATIONSHIPS OF THE BRACHIOPODS

All of the brachiopods described herein are representatives of the families Spondylospiridae or Laballidae of the Superfamily Spiriferinacea. With the possible exception of a single species of *Spondylospira* Cooper, 1942 from Peru (Hoover, 1990), none is known from strata older than Karnian or younger than Norian. Where these two structurally bizarre spiriferinacean families came from is a matter of conjecture. After many years of pondering this problem I am no nearer to a solution. How evolution proceeded within the group is somewhat easier to postulate. The two families are differentiated largely on the basis of the apparent presence in the Spondylospiridae of a large functional pedicle in the adult stage, while this feature is only

rarely reported in the Laballidae. Dagys (1974) has reported a small pedicle foramen in *Thecocyrtella* Bittner, 1892, and in *Thecocyrtelloidea* Yang and Xu, 1966 (pp. 113, 114, pl. 9, figs. 1–14; pl. 10, figs. 2–3), multiple pedicle tubules that pierce the deltidium have been described. Although Yang and Xu state [p. 113] that *Thecocyrtelloidea* is typified “by . . . lack of dental plates (hence no spondylium),” Dagys (written commun., 1990) feels that a true spondylium is present. Thus it appears that if the descent of multiple-foramen cyrtinoid spiriferinaceans is monophyletic, this occurrence in the Ladinian of Gueizhou, China is a logical precursor to *Spondylospira* and related forms in the later Triassic.

Dagys (1974, p. 284) demonstrates that the Spiriferinacea, like other groups of Paleozoic brachiopods that survived the great reorganization near the Permian–Triassic boundary, continued to diversify throughout the Triassic. In the Early Triassic (Induan and Olenekian), the superfamily consisted of only a single genus; in the Anisian, it had eight genera; in the Ladinian, nine; in the Karnian, 19; and in the Norian 12. Studies since 1974 have increased these numbers, but the pattern remains the same. Dagys (1974, Table 3, pp. 287–289) indicated that *Zugmayerella* had a fossil record covering the entire Norian, while *Spondylospira* was known only in the Upper Norian. From evidence developed herein, I think it is safe to extend the lower boundaries of both ranges, because good examples of the families Spondylospiridae (typified by *Spondylospira*) and Laballidae (typified herein by *Zugmayerella*) exist in the Karnian. Dagys (1974, p. 228) cites the obvious homeomorphy between Paleozoic Cyrtinidae (which extend from the Late Silurian through the Early Carboniferous) and the Late Triassic laballids [= Laballidae + Spondylospiridae herein], but points out that there is no direct phylogenetic connection between the two lineages. Dagys (1974, p. 228) also discounts the possibility that punctae developed more than once in the spiriferids (*i.e.*, that these forms were polyphyletic), and believes that the Late Triassic spiriferinaceans (including those discussed herein) evolved from spiriferinacean ancestors, not directly from homeomorphically-similar cyrtinids. He further suggests that, although the jugal structures of Late Paleozoic spiriferinids have been insufficiently studied, one detail of these forms stands out — the jugum is V-shaped and has its apex directed toward the anterior margin; that is, its structure is intermediate between the jugum of cyrtinids and the jugum of younger spiriferinaceans.

Within the Late Triassic spiriferinaceans that have ridges on part or all of the interarea, the course of evolution is clearer (Hoover, 1990). *Dagysprifer fascicostata*, n. gen. and n. sp. (Pl. 9, figs. 1–9), with its globose form and small ridged portion of the interarea,

appears a likely precursor morphology to that of *Spondylospira*; it is known only from a single locality in the late Karnian of southeastern Alaska. Forms like *Pseudospondylospira perplexa*, n. gen. and n. sp. (Pl. 10, figs. 14–24) from the late Karnian to late Norian of Nevada, Oregon, and Alaska, have a slightly less globose form and relatively larger ridged portion of the interarea, and they seem likely intermediates in this lineage. This leads through increased relative height of the ventral valve, broadening of the “interarea”, increased development of multiple “honeycomb” foramina at the ventral valve apex, and decreasing shell thickness, to forms like *Spondylospira parmata* Hoover, 1983 (Pl. 10, figs. 8–13) in the late Norian.

BIOGEOGRAPHY OF THE BRACHIOPODS AND IMPLICATIONS FOR TERRANE COMPARISONS

The nine clearly recognizable species of cyrtinoid spiriferinaceans occur in a wide array of different tectonic blocks within the western Cordillera. Therefore they provide a new data set for biogeographic comparisons among various Cordilleran terranes. This is the first such data set published for Early Mesozoic brachiopods of the Cordillera.

Of the six spiriferinacean genera in two families of cyrtinoid brachiopods described in this paper, only two (*Spondylospira* Cooper, 1942, and *Zugmayerella* Dagys, 1963) appear to be known outside North America, and of these, only *Zugmayerella* is cosmopolitan. In addition to North American occurrences, *Spondylospira* is also known from South America and the northeasternmost U. S. S. R. (Bychkov and Dagys, 1984; Dagys, written commun., 1990). The two spondylospirid genera *Pseudospondylospira*, n. gen. and *Vitimetula*, n. gen., are known from but a single locality each, in southeastern Alaska [zones UC1–UNo1 of Tozer (1980); Alexander terrane] and Idaho [zones UNo1–UNo3 of Tozer (1980); Wallowa terrane], respectively. *Zugmayerella*, when first described by Dagys (1963), was reported from the Norian and Rhaetian of the Alps, the Carpathians, the Crimea, the Caucasus, northwestern Turkey, and the northeastern U. S. S. R. (see Bychkov *et al.*, 1976). It has since been recognized in Alaska (Wrangellia terrane), California (Eastern Sierramesa terrane), Utah (Cathlamet terrane) and Oregon (Wallowa terrane) [this last two from unpublished data], Chile (Chong D. and Hillebrandt, 1985), Peru (unpublished data), Papua New Guinea (Coffin, 1976), New Zealand (McColl and Campbell, 1976), China (Ching and Wang, 1977), Tibet (Sun, 1981), and New Zealand (Campbell, 1990). Stanley's (1979) report of *Zugmayerella* in the Late Triassic of Nevada was based on my own erroneous preliminary identifications; in the light of the present report, these forms are probably better assigned to *Phenacozugmayerella*, n. gen. *Phenaco-*

zugmayerella, n. gen., in many respects a homeomorph of *Zugmayerella*, is known from 12 localities in Alaska (Alexander terrane), Nevada (Paradise terrane, Jungo terrane, and Triassic cover on the Golconda Allochthon), and Oregon (Izee terrane).

Three features of cyrtinoid spiriferinacean species biogeography are particularly striking and offer insight into terrane comparisons and paleogeography. First, true “Tethyan” species are absent. Indeed, only one of the six genera reported here (*Zugmayerella*) includes species that occur in Tethys, but the closest Tethyan relative of an American species is from China, at the eastern end of Tethys. Dagys (written commun., 1990) suggests that “*Zugmayerella* is [a] cosmopolitan genus, but species are different in remoted [*sic*] regions — western Tethyan, eastern Tethyan (China), Boreal (Siberia), eastern Pacific, and perhaps Notal. North American species were connected with Tethyan rather via boreal regions. True Tethyan species of cyrtinoid brachiopods (as well as other characteristic Tethyan species of this group — koninkinids, thecospirids, etc.) were absent in East Pacific region.”

Second, some of the forms endemic to North America occur in several different types of terranes. *Phenacozugmayerella*, n. gen. occurs not only in the allochthonous Alexander, Paradise, and Izee terranes, but also in parautochthonous terranes such as the Jungo, and in rocks associated with blocks such as the Golconda Allochthon, which were linked with North America and “autochthonous” by the Late Triassic.

The distribution of *Zugmayerella* parallels that of the Late Triassic rhynchonellid brachiopod *Halorella* Bittner, 1884, whose geographic occurrences have been summarized by Ager (1964). *Halorella* occurs over a broad geographic range within the Tethyan seaway, and also has been recognized both in allochthonous Cordilleran terranes of eastern Oregon (Ager, 1964), and in rocks of the parautochthonous Jungo terrane (Burke and Silberling, 1973).

The nine species of cyrtinoid spiriferinaceans reported herein are mostly confined to North and South America, including the terrane belt. The only taxonomic overlap with Western Pacific Norian assemblages is with the species of *Spondylospira* from the Koryak Range of the northeasternmost U. S. S. R. Cyrtinoid spiriferinacean brachiopods show little biogeographic evidence for linkages among terranes of the present-day eastern and western Pacific.

Abundant evidence does exist for biogeographic “stitching” among the North American terranes — including biogeographic links among allochthonous, parautochthonous, and craton-related terranes. Among the spiriferinaceans, several species illustrate these complex, overlapping distribution patterns particularly well.

(1) *Pseudospondylospira perplexa*, n. gen. and n. sp.

is known from the allochthonous Alexander and Wallowa blocks. However, it also occurs in the Triassic cover on the Golconda Allochthon, which is thought by most workers to have been tectonically emplaced against the North American craton during Permian to Early Triassic time (Miller *et al.*, 1984; Brueckner and Snyder, 1985; Silberling *et al.*, 1987; Babaie and Speed, 1990). New structural and stratigraphic data (Ketner, 1990) indicate that parts of the Golconda Allochthon overthrust Lower Triassic strata as a result of Mid- or Late Mesozoic tectonism. However, the youngest time of initial emplacement is mid- to Late Triassic (Silberling *et al.*, 1987; see discussion under "Triassic cover on the Golconda Allochthon", p. 71). Thus, occurrences of *P. perplexa* in rocks overlying the Golconda Allochthon represent localities whose paleogeographic position was either on or very near the Late Triassic North American continent.

Pseudospondylospira perplexa also occurs in the parautochthonous Jungo terrane of Nevada. Triassic strata of the Jungo terrane have been identified by some workers as basal equivalents of the Auld Lang Syne Group of the Golconda terrane, which was craton-bound by latest Triassic time (Silberling *et al.*, 1987). The depositional cyclicity within the Auld Lang Syne Group in turn has been correlated with that of the North American Chinle Formation (Lupe and Silberling, 1985). An alternative recent interpretation by Oldow, Bartel, and Gelber (1990) is that the basal Early Mesozoic rocks of the Jungo terrane ("Lovelock assemblage" of Oldow, Bartel, and Gelber) are allochthonous relative to the neighboring craton-related platform sediments of the Golconda terrane. However, Oldow (1984) has interpreted the Jungo-Lovelock Early Mesozoic sediments as having been thrust eastward during closure of a marginal basin behind the Sierra Nevada arc, and thus, even this "allochthonous" interpretation of Jungo strata does not involve large-scale longitudinal displacement of Jungo rocks. Therefore, the Jungo terrane is probably parautochthonous. Note that the occurrence of *P. perplexa* in the Jungo lithotectonic block is significant in bridging the boundary between the craton-related Golconda terrane and the more outboard, truly allochthonous Cordilleran blocks such as the Alexander terrane. In summary, then, *P. perplexa* is here reported from occurrences that represent craton-bound North American rocks, parautochthonous rocks, and allochthonous rocks.

(2) *Spondylospira lewesensis* (Lees, 1934) is known from a broad range of allochthonous terranes within the North American Cordillera, including Eastern Klamath, Alexander, Paradise, Wrangellia, Wallowa, and Chulitna. It also occurs in the parautochthonous Jungo terrane (see discussion above), and is found in rocks overlying the Golconda allochthon, which by

Late Triassic time was likely bound to the North American craton (see discussion above). In addition, *S. lewesensis* is known from the Stikine terrane (where it was first described), which is inferred to have amalgamated with Cache Creek by Late Triassic time and may have accreted to North America during Jurassic time (Monger, Price, and Templeman-Kluit, 1982; Cordey *et al.*, 1987). Paleomagnetic data from Permian and Triassic strata of the Stikine block initially were thought to indicate significant northward latitudinal displacement of Upper Triassic and younger rocks. Late Triassic reefs described by Reid (1985) further suggest an origin for Stikine far south of the terrane's present position. However, May and Butler (1986) have shown that when revised North American Upper Triassic poles are used, the Stikine Triassic results are in agreement with expected cratonal inclinations. Comparable results have been obtained for Permian rocks of the Stikine block (Irving and Monger, 1987). Thus, paleomagnetic data show no indication of major post-Permian translational motion for Stikine, leading some workers to speculate that Stikine may have "evolved near, but seaward of, the margin of North America" (Samson *et al.*, 1989, p. 705). The presence of *S. lewesensis* in the Stikine block and in the Golconda terrane shows that this species inhabited North American parautochthonous and cratonal habitats as well as occurring in more distant allochthonous terranes. Thus, *S. lewesensis* provides yet another biogeographic tie between cratonal North America and the allochthonous terranes.

(3) *Spondylospira tricosta*, n. sp. also occurs in terranes of diverse origins. It is known from the craton-bound Triassic strata overlying the Golconda allochthon, but it is also represented in the Paradise terrane of Nevada and the Wallowa terrane of northeastern Oregon and Idaho. The distribution of *S. tricosta* compares with that of *Pseudospondylospira perplexa*, n. gen. and n. sp. and *S. lewesensis* in that this species also occurs in both craton-bound (Golconda) and "suspect" terrane localities.

In summary, the absence of "Tethyan" species and the complex, overlapping biogeographic patterns of spiriferinacean brachiopods in this study compare favorably with patterns previously described for Cordilleran bivalves by Newton (1987). The most significant pattern documented in this study is the biogeographic "stitching" of North American craton-bound brachiopod faunas with those of the parautochthonous and allochthonous Cordilleran terranes. These shared brachiopod species suggest that either many terranes originated close to the North American continent, or that there was large-scale dispersal of faunas within the proto-Pacific ocean basin. Evidence for the latter is also suggested by apparent species co-

occurrences in *Spondylospira* in North America and in the northeasternmost U. S. S. R., and similarities between North American and Chinese species of *Zugmayerella*.

TECTONOSTRATIGRAPHIC SETTING OF LOCALITIES

The following discussions of North American terranes are ordered geographically, from south to north, and are followed by a brief discussion of the marine sedimentary rocks of the Cerro de Pasco region of Peru, from which Late Triassic cyrtinoid spiriferinacean brachiopods have also been recovered. In these discussions, a terrane is a descriptive unit having no inherent genetic implications (*sensu* Dover, 1990).

JUNGO TERRANE

[Churchill and Pershing counties, Nevada]
(locs. 18, 39, 45)

The Jungo terrane of northwestern Nevada preserves an Early Mesozoic stratigraphy of deformed Upper Triassic–Lower Jurassic fine clastic strata that represent basinal facies (Silberling, 1990). This terrane, as defined by Silberling *et al.* (1987) and Silberling (1990), is the equivalent of the “Lovelock assemblage” discussed by Oldow (1984) and Oldow, Bartel, and Gelber (1990). Lupe and Silberling (1985) and Silberling *et al.* (1987) infer that these basinal Jungo strata are the distal equivalents of the Auld Lang Syne Group sediments that overlie the Golconda Allochthon. Oldow, Bartel, and Gelber (1990) infer that the Late Mesozoic Fencemaker thrust, which separates the Early Mesozoic rocks of these two terranes, coincides approximately with the sedimentological transition between equivalent platformal (Golconda) and basinal (Jungo) strata. The Upper Triassic sedimentary units of the Jungo terrane include the lower Norian Hollywood Formation and overlying Antelope Springs Formation, the middle Norian Lori Formation, and the upper Norian to Lower Jurassic Packard Wash Formation (Oldow, Bartel, and Gelber, 1990).

PARADISE TERRANE

[locs. 8–11, 33–38, 40]

(Mineral and Nye counties, Nevada)

The western Nevada terrane was initially assigned to the Jungo terrane within the Walker Lake terrane of Silberling *et al.* (1987), but recently Silberling (1990) elevated the Paradise to terrane status. This terrane, as recognized by Silberling (1990) and Silberling *et al.* (1987), is equivalent to the Sand Springs, Pamlico, Luning, and Gold Range lithotectonic assemblages of Oldow (1984). The Paradise terrane consists of Permo-

Triassic volcanogenic rocks, overlain by Upper Triassic to Lower Jurassic platformal carbonates that also include clastic and volcanogenic components (Silberling, 1990). Upper Triassic formations within the Paradise terrane include the Luning and Gabbs formations, both of which yield cyrtinoid spiriferinacean brachiopods. The stratigraphy of the Luning–Gabbs sequence was first described by Muller and Ferguson (1936; 1939) and, in part, has most recently been reviewed by Taylor *et al.* (1983). The Luning, principally of Norian age, represents a carbonate platform with interspersed clastic sediments; it is overlain by clastic sediments of the upper Norian Gabbs Formation, which is overlain in turn by lowermost Jurassic clastics of the Sunrise Formation (Taylor *et al.*, 1983; Silberling *et al.*, 1987). Much biostratigraphic work has been done on rocks of the Gabbs and Sunrise formations, because the Triassic–Jurassic boundary coincides approximately with the formational contact (Guex and Taylor, 1976; Hallam, 1981; Laws, 1982; Taylor *et al.*, 1983; Tozer, 1988).

The Paradise terrane is clearly, in the strict sense, allochthonous with respect to cratonal North America, because it is bounded by thrust faults (*e.g.*, Silberling and John, 1989). Exposures of Paradise terrane described by Silberling and John (1989) occur west of the $Sr_1=0.706$ isopleth, which is interpreted as the westernmost extent of Precambrian continental basement (Levy and Christie-Blick, 1989, and references therein). However, the magnitude of post-Early Mesozoic displacement relative to the North American continent is not known, and the Mesozoic rocks of the Paradise are often interpreted as paraautochthonous rather than allochthonous; for example, Speed, Elison, and Heck (1988) infer that the Paradise rocks were deposited atop an allochthonous Paleozoic basement *after* suturing to North America. Some tectonic studies (*e.g.*, Silberling, 1990) have also preferred a fringing-arc interpretation of the volcanogenic sediments of this and related terranes, in which these Nevada terranes originated close to the American continental margin but were tectonically reshuffled later in the Mesozoic. One specific variant on this theme was proposed by Oldow (1984), who inferred that the thrusting of the Luning–Fencemaker and other western Nevada allochthons reflects closure of a back-arc basin behind (eastward of) the Sierra Nevada arc. In this last view, although there may have been hundreds of kilometers of southeast-directed thrusting, the western Nevada terranes would essentially be paraautochthonous with respect to cratonal North America. More recent work by Oldow, Bartel, and Gelber (1990) has shown that, although there are lithostratigraphic differences among the western Nevada terranes (including the Paradise terrane), provenance linkages between stratigraphic units do exist —

for example, between the platformal Triassic sediments of the Golconda terrane and correlative submarine fan deposits of the Jungo terrane. Biogeographic evidence from ammonoid cephalopods supports the idea that the Triassic Paradise strata originated near North America (Tozer, 1982).

TRIASSIC COVER ON THE GOLCONDA ALLOCHTHON

[locs. 32, 41–43]

(Lander and Pershing counties, Nevada)

The Golconda Allochthon is a Carboniferous to mid-Permian package of sedimentary and volcanic rocks in thrust contact with an older, more eastern Paleozoic allochthon (the Roberts Mountains Allochthon) or its Upper Paleozoic cover. Triassic strata overlying the Golconda Allochthon rest in unconformable contact on a deformed Carboniferous to mid-Permian package of deep-water pelagic rocks, turbidites, and pillow lavas (Silberling *et al.*, 1987) variously interpreted as a collapsed back-arc basin or an accretionary prism (see Miller *et al.*, 1984; and Brueckner and Snyder, 1985, for discussions of each model).

Cyrtinoid spiriferinaceans occur within the Upper Triassic Cane Spring Formation of the Star Peak Group and the Osobb, Dun Glen, and (possibly) Winnemucca formations of the Auld Lang Syne Group (as restricted by Oldow, Bartel, and Gelber, 1990). The Cane Spring includes carbonates that represent a range of shallow-water environments (Nichols and Silberling, 1977), whereas the overlying Auld Lang Syne clastic sediments were deposited in partly deltaic, to shallow sedimentary environments (Burke and Silberling, 1973).

Three lines of evidence suggest that the Golconda Allochthon was emplaced against cratonal North America during Late Permian to Early Triassic time. First, stratigraphic evidence presented by Lupe and Silberling (1985) suggests that cratonal, nonmarine sediments of the Chinle Formation in the Great Basin show sedimentary cycles correlative with those of the marine Auld Lang Syne Group, which overlies the Golconda Allochthon.

Second, the age of the youngest sediments in several areas of the Golconda terrane has been used to constrain the timing of emplacement of the allochthon, an event generally referred to as the Sonoma orogeny (Silberling and Roberts, 1962; Snyder and Brueckner, 1983). In the Schoonover sequence, for instance, the youngest basinal Paleozoic deposits are of Early Permian age, leading Miller *et al.* (1984) to conclude that thrust-faulting of the basin occurred in post-Early Permian time. Burke and Silberling (1973) suggest that emplacement occurred during the Late Permian or Early Triassic, a conclusion that has been supported by numerous other workers (*e.g.*, Speed, 1977; Brueckner

and Snyder, 1985; Brueckner, Snyder, and Boudreau, 1987; Speed, Elison, and Heck, 1988). However, there is considerable evidence that deformation of sediments within the Golconda terrane may have been diachronous (*e.g.*, Brueckner and Snyder, 1985) and also that the emplacement itself may have occurred at slightly different times in various areas of Nevada. There is also evidence for some post-Triassic movement of rocks in both the Golconda and Roberts Mountains terranes during later orogenic episodes (Ketner, 1984, 1990; Ehman, 1985, p. 145; Little, 1987; Thorman *et al.*, 1990).

A third, and more compelling line of evidence for a Triassic or earlier emplacement of the Golconda terrane is that the Upper Triassic Auld Lang Syne clastics were derived from an eastern, low-lying continental source — possibly in the Colorado Plateau or Rocky Mountain regions (Compton, 1960; Silberling and Wallace, 1969; Burke and Silberling, 1973). The composition of these clastics differs from that expected for western Nevada terranes derived from local sources (Burke and Silberling, 1973). Thus, even if the timing of emplacement was diachronous and spanned somewhat more than the Permian–Early Triassic range usually assigned to the Sonoma orogeny, an eastern source for Upper Triassic Auld Lang Syne Group clastics (Burke and Silberling, 1973) suggests that by Late Triassic time the Golconda terrane adjoined the North American craton (Lupe and Silberling, 1985).

EASTERN KLAMATH TERRANE

[locs. 1–5, 44]

(Shasta county, California)

The Eastern Klamath terrane, which represents a Paleozoic–Early Mesozoic island-arc sequence in northern California, preserves a Triassic through Middle Jurassic sedimentary section of carbonate, shale, and coarse volcanoclastic sediments (Sanborn, 1960; Silberling *et al.*, 1987). Cyrtinoid spiriferinacean brachiopods occur in two formations within the Triassic part of the section in Shasta County: the Hosselkus Limestone and the Devil's Canyon Member of the Modin Formation. The Hosselkus consists of limestones and shales and is probably in conformable contact with the Pit Shale below, while it is only questionably conformable with the lithologically similar, but more shaly, Brock Shale above. The Brock appears to be in conformable contact with the Modin Formation above. Sanborn (1960) divided the Modin into three subunits, from oldest to youngest, the Hawkins Creek Member (volcanics and conglomerate), the Devil's Canyon Member (tuffaceous limestone, limestone, and calcareous sandstone), and the Kosk Member (argillites, sandstones, and volcanics).

IZEE TERRANE
[locs. 48, 49, 51]

(Suplee area, east-central Oregon)

Triassic strata in the Suplee area of east-central Oregon are assigned to the Begg and Brisbois formations and the Rail Cabin Argillite (Dickinson and Vigrass, 1965). The Begg Formation, including mudstone, conglomerate, volcanoclastic rocks, lava, and rare bioclastic limestone, rests unconformably on unnamed Paleozoic rocks. The Begg contains possibly redeposited mollusks and corals of probable early Karnian age and has a conformable contact with the overlying Brisbois Formation, in part of late Norian age. The Brisbois, lithologically similar to the Begg, has produced all the spondylospirid brachiopods recovered from the area. It is unconformably overlain by the Rail Cabin Argillite, of middle to late Norian age, which is overlain concordantly by the Lower Jurassic Graylock Formation. Hettangian fossils in the basal strata of the Graylock suggest that the uppermost beds of the Rail Cabin could extend upward into the earliest Jurassic. Silberling (written commun., 1990) suggests that "most of the Late Triassic shelly fossils in the Begg and Brisbois are reworked," and that "the Rail Cabin is evidently a facies of part of the Brisbois, as interpreted by Dave Taylor."

WALLOWA TERRANE
[locs. 12, 15, 21, 28, 47]

(Wallowa County, Oregon, and Nez Perce and Lewis counties, Idaho)

The Wallowa terrane, a Late Paleozoic–Early Mesozoic volcanic arc with overlying Triassic–Jurassic limestones and clastic sediments, contains cyrtinoid spiriferinacean brachiopods of both early and late Norian ages. Within this terrane, early Norian brachiopod localities occur in Hells Canyon and in the Wallowa Mountains, whereas the only late Norian locality is an isolated limestone quarry, often called the Lewiston locality (Stanley, 1979, p. 25), which is far to the northeast of the other Triassic carbonate outcrops. The various Wallowa localities are discussed in further detail below.

Early Norian (locs. 12, 21, 28, 47).—In the Wallowa Mountains of northeastern Oregon, Triassic strata include the Martin Bridge and Hurwal formations, and is informally designated the Lower Sedimentary Sequence [LSS] (Smith and Allen, 1941). The LSS in part lies, and in part may be equivalent to the largely Permian Clover Creek Greenstone. The LSS is commonly unconformably overlain by the Martin Bridge Formation; and several hundred feet below that contact the LSS contains fossils suggestive of the middle upper Karnian *Tropites welleri* Zone. The Martin Bridge Formation as the name is applied in Hells Canyon and

the northeastern Wallowa Mountains, consists largely of shelf carbonates and includes typical early Norian faunas. It contains the only spondylospirid brachiopods recovered from the area, and it is apparently conformably overlain by the Hurwal Formation. The Hurwal, in the northern Wallowa Mountains, contains several ammonoid faunas of from early to middle Norian age (Silberling and Tozer, 1968), and it is overlain unconformably by Tertiary volcanics (Reeside *et al.*, 1957).

Late Norian (loc. 15).—An isolated limestone quarry on the Nez Perce Reservation east of Lewiston, Idaho, probably representing a roof pendant in the Wallowa Batholith, contains scleractinian coral patch reefs with an associated fauna of brachiopods, bivalves, and gastropods. The coral-associated invertebrates represent an epifauna-dominated assemblage; bivalves from this locality consist of cemented and epibyssate (primarily nestling) species (Newton, *in prep.*). The paleoecology and structure of the scleractinian reefs has been documented by Stanley (1979).

The age of the carbonates at this locality is not well documented. Although no ammonoids have yet been recovered from this site, the reef-associated fauna seems to indicate a late Norian age. Haas (1953) noted, in particular, that the undescribed gastropod fauna at Lewiston closely resembles late Norian gastropods from Peru. Bivalves from the Lewiston site include no age-diagnostic species. A diverse fauna of largely undescribed brachiopods has been recovered from this site. Two species of cyrtinoid spiriferinaceans are present, one of which, *S. lewesensis* (Lees, 1934), is of some biostratigraphic utility. The other, so far as is known, occurs only at this locality.

The spatial isolation of this limestone block makes correlation with units in Hells Canyon (loc. 28) or the Wallowa Mountains (locs. 12, 21, 47) difficult. Indeed, if the late Norian age is correct, there are no time-equivalent rocks of comparable lithology in Hells Canyon. Stanley (1979) has tentatively compared the Lewiston sequence with the late Norian Hurwal Formation, though the lithofacies are not identical. Based on its location, most workers have presumed that the Lewiston locality belongs to the Wallowa terrane, which encompasses nearby parts of the Wallowa Mountains and Hells Canyon areas (Silberling *et al.*, 1987).

STIKINE TERRANE
[locs. 29–31]

(Lake Laberge region, Yukon Territory, Canada)

The Stikine terrane is a Paleozoic through Early Mesozoic volcanic-arc terrane characterized by volcanic and sedimentary strata (Monger and Berg, 1987). The Mesozoic rocks of the Lake Laberge region, Yukon Territory, Canada, are divided into the Lewes River

Group (Triassic), the Laberge Group (Jurassic), and the Tantalus Formation (Upper Jurassic or Lower Cretaceous). They are underlain by Permian limestones of the Braeburn Formation. The Lewes River Group, defined in this area by Lees (1934), has been divided into seven formations, from oldest to youngest designated "A" through "G" (Tozer, 1958). These range in age from Karnian through Norian. Formations "C", "E", and "G" consist mostly of limestone; "B" and "D" are composed mostly of clastic rocks; and "A" and "F" contain both carbonate and clastic strata. Spondylospirid brachiopods have been recovered only from formations "F" and "G".

ALEXANDER TERRANE

[locs. 6, 7, 22–27]

(Gravina, Keku, Kuiu, and Screen Islands and Cornwallis Peninsula, southeastern Alaska)

The Alexander terrane of southeastern Alaska represents a composite terrane with a complex Paleozoic history that suggests that the three major subterrane — Admiralty, Craig, and Annette — experienced disparate tectonic regimes in pre-Late Paleozoic time (Monger and Berg, 1987). Nonetheless, Pennsylvanian plutons common to both the Alexander and Wrangellia terranes indicate that at least part of the Alexander terrane (and perhaps the entire composite terrane) was united with the Wrangellia terrane at least by Late Carboniferous time (Gardner *et al.*, 1988). A further geographic constraint on the Alexander terrane comes from paleomagnetic evidence that the terrane was located far to the south in Pennsylvanian time (Van der Voo *et al.*, 1980), but had arrived at its present latitude relative to North America by at least Triassic time (Hillhouse and Grommé, 1980).

The Admiralty Subterrane, which contains the cyrtinoid spiriferinacean brachiopod localities herein discussed, includes Triassic strata of the Hyd Group and the Keku Volcanics. The Hyd Group is divided into the Burnt Island Conglomerate, Cornwallis Limestone, Hamilton Island Limestone, and Hound Island Volcanics (Muffler, 1967). The Keku Volcanics consist of felsic and mafic volcanic rock and intercalated clastic units, which unconformably overlie the Permian Pybus Formation. The upper part of the Keku Volcanics includes rare fossiliferous limestones, which contain early to late Karnian faunas. The Burnt Island Conglomerate may be a lateral equivalent of the upper part of the Keku Volcanics and at one locality contains [in allochthonous pebbles] an early Karnian fauna. The Cornwallis Limestone, of late Karnian to earliest Norian age, apparently overlies the Keku Volcanics conformably and the Burnt Island Conglomerate unconformably. The Cornwallis is a gray oolitic limestone containing faunas of late Karnian to earliest Norian

age, and it is considered the shallow-water facies equivalent of the deep-water Hamilton Island Limestone (Muffler, 1967). Fossils from the Hamilton Island Limestone suggest ages equivalent to that of the Cornwallis. Both the Cornwallis and Hamilton Island formations are apparently conformably overlain by the Hound Island Volcanics. This unit consists largely of basaltic pillow breccia and pillow lava, andesitic volcanic breccia, and aquagene tuff, but includes some thin-bedded limestone. Fossils from these limestones suggest a late Karnian to late middle Norian age. The Hyd Group is unconformably overlain by unnamed Cretaceous lithic mudstones and sandstones. Silberling (written commun., 1990) suggests that "the complex facies relations implied by all of this probably indicate some substantial tectonic disruption of these rocks." Cyrtinoid spiriferinacean brachiopods have been recovered from the Cornwallis Limestone and from the Keku and Hound Island volcanics.

WRANGELLIA TERRANE

[locs. 13, 20]

(Wrangell Mountains, southern Alaska and Nabesna quadrangle, south-central Alaska)

Triassic strata in the Wrangell Mountains of south-central Alaska include the Nikolai Greenstone, the Chitistone and Nizina limestones, and the McCarthy Formation (Silberling and Tozer, 1968). Faunas from shaly beds near the base of the Nicolai indicate a late Ladinian to early Karnian age, while conformably overlying the Nicolai, the Chitistone Limestone contains *Tropites* faunas near its base that are indicative of an early late Karnian age. Fossils from beds transitional between the Chitistone and the overlying Nizina Limestone suggest a latest Karnian to earliest Norian age. Fossils from the highest beds in the Nizina suggest the *Juvavites magnus* Zone of late early Norian age. Fossils in the lower part of the overlying McCarthy Formation are typical of the *Rhabdoceras suessi* Zone of late Norian age. Spondylospirid brachiopods have been recovered in this area from beds transitional between the Chitistone and Nizina limestones and are thus early Norian in age.

In the Nabesna quadrangle of south-central Alaska, Triassic fossils are reported from three horizons. The "Upper Triassic limestone" of Richter (1976) contains *Monotis subcircularis* Gabb, 1864, suggesting an early late Norian age for that unit. Lying unconformably below this unit, the "Lower Triassic limestone" of Richter has yielded spondylospirid brachiopods referable to *Spondylospira* and has been assigned a late Karnian age. This unit is bounded unconformably below by the Nikolai Greenstone, an unfossiliferous unit consisting of volcanics and volcanogenic sediments.

The Nikolai is in turn bounded unconformably below by the Eagle Creek Formation. The "Upper Triassic limestone" is unconformably overlain by beds of Late Jurassic to Cretaceous age which are assignable to the "Nutzotin Mountains sequence" of Berg, Jones, and Richter (1972).

Wrangellia is demonstrably an allochthonous Cordilleran terrane, as attested by its distinctive internal stratigraphy of Paleozoic arc rocks overlain by Triassic basalt and Upper Triassic sedimentary strata (Jones, Silberling, and Hillhouse, 1977; Jones *et al.*, 1987), and by its anomalous paleomagnetic signatures. Paleomagnetic data suggest Triassic paleolatitudes of 14–18°, whereas for the Alaska segment of Wrangellia the expected Triassic paleolatitude would be approximately 35–37° (Hillhouse, 1977; Yole and Irving, 1980; Hillhouse and Grommé, 1984; see compilations in Stone and McWilliams, 1989). Recent paleomagnetic modelling of the Jurassic and later motions of known oceanic plates suggests that if Wrangellia accreted to North America during Cretaceous time, Jurassic and younger longitudinal displacement of Wrangellia within the proto-Pacific ocean basin may have been as much as 60° (Debiche, Cox, and Engebretson, 1987).

CHULITNA TERRANE

[loc. 53]

(Alaska Range, south-central Alaska)

The Chulitna terrane consists of Upper Devonian ophiolite, overlain by Upper Paleozoic volcanic and sedimentary rocks, Triassic carbonate, terrigenous clastic, and basaltic rocks, and Jurassic clastic sedimentary rocks and chert (Jones *et al.*, 1980; Jones *et al.*, 1987). Within a complex Upper Triassic unit of interstratified pillow basalt and limestone, *Spondylospira lewesensis* (Lees, 1934) has been recovered in association with large (up to 20 cm) megalodontid bivalves. Megalodontids are typical of shallow-water platformal facies.

CERRO DE PASCO REGION

[loc. 16]

(Peru)

Spiriferina steinmanni Tilmann, 1917 and *Spiriferina* sp. of Tilmann, 1917 (the latter here referred to *Spondylospira tricosta*, n. sp.), are both referable to the spondylospirid genus *Spondylospira* Cooper, 1942 and were recovered from beds in the Triassic–Jurassic section of Peru that Tilmann (1917, p. 644) and Lees and Haas (1944, p. 284) referred to the Middle Lias. Szekeley and Grose (1972), in a detailed re-examination of these beds at three localities in the same region (Ninacaca; old trail connecting Carhuamayo and Pasco; Yanamarca), suggest that most of the Jurassic Aramachay and Condorsinga formations are

missing here. Thus, the fossil-bearing sequence sampled by Tilmann is probably best referred to the Chambara Formation of the Pucará Group, which, on paleontological grounds, is of Norian age. Lower Jurassic (Sinemurian) ammonites recovered by Tilmann from the nearby San Blas area were not found in association with any spondylospirid brachiopods. At one set of localities south of Cerro de Pasco, however, an undescribed species of *Spondylospira* is associated with a sponge fauna that suggests a Jurassic age (Hoover, 1990). Thus, South America may be the only place spondylospirids are not limited to the Upper Triassic.

SYSTEMATIC PALEONTOLOGY

INTRODUCTION

Abbreviations of Repository Institutions

The material discussed and described in this report comes from several sources and collections. These bear locality and/or catalogue numbers with acronyms as follows:

CASG: California Academy of Sciences, Geology Collections, San Francisco, CA.

GSC: National Type Collection of Fossil Invertebrates and Plants, Geological Survey of Canada, Ottawa, Ontario, Canada.

LSJU: Leland Stanford Junior University, Stanford, CA.

USGS: United States Geological Survey, U. S. National Museum of Natural History, Washington, DC.

USGS M: United States Geological Survey, Menlo Park, CA.

USNM: U. S. National Museum of Natural History, Smithsonian Institution, Washington, DC.

(other): Various collections, identified only by field number, currently housed in the collections of the U. S. Geological Survey, Denver, CO.

Measurement Abbreviations and Subscripts

In the tables of measurements: a.v. = articulated valves; d.v. = dorsal valve; v.v. = ventral valve. Several subscripts are used to qualify measurements. The subscript _e indicates that the measurement was estimated and is probably correct only to the nearest millimeter. The subscript _c indicates that the specimen was crushed in such a way as to render the measurement non-representative; if _e is also present, the value given was estimated to correct this deficiency. The subscript _b indicates that the specimen is broken and implies that the missing portion is necessary to that measurement; this may also be accompanied by the subscript _e with the same meaning as given above. A measure across a structure with bilateral symmetry

(e.g., brachiopod hinge width) may be estimated by doubling the half-measure [distance from symmetry plane to distal extremity]. Use of this procedure is indicated by the subscript $_h$.

Terminology of Types

The terminology of types used in this report follows that of Frizzell (1933). Of the types defined therein, only the *chorotype* is likely to be unfamiliar to the reader. Frizzell (p. 646) defined it as: "A fossil specimen collected from the same stratum as the type, but from a neighboring locality."

Size as a Taxonomic Character

Two samples of a continuous species population, taken from temporally or spatially disjunct localities, may exhibit different mean and range in individual size. With such material, there is no way, *a priori*, to determine whether one is dealing with two genetically-distinct species or with a single size-variable one. Individuals that differ *only* in size are here considered conspecific; and that size as a basis for specific discrimination, taken alone, is considered invalid. In many monotypic *new* genera, however, the diagnosis of the type species indicates the mean size of the individuals. This implies that size *is* of significance in specific discrimination.

Specific discrimination by size, however unrealistic, is a necessary approximation (as are many paleontological species) in the initial stages of paleontological investigation. The advantage of biological and paleontological taxonomy is that it is not static, but is cumulative, and may be emended as more data become available. Thus, in this report, the type species of a monotypic new genus may be diagnosed as "small", based solely on the subjective opinion that other, larger, possibly distinct congeneric species populations remain to be sampled and described.

"Lumpers" and "Splitters"

I do not think of myself as either a "splitter", a manufacturer of perhaps unnecessary new taxa, nor as a "lumper", including new forms within the broad potential morphological variation of a given taxon. Several of the taxa reported herein are new genera represented by single new species, and several of these are represented by relatively few specimens from a small number of localities. The relatively bizarre morphological characters of many of these forms suggest to me that they are distinct at the generic level, but the thought remains that I do not have much material on which to base this suggestion. I am left with the task, which is the task of all taxonomists, of determining the closeness of relationship of the forms under consideration to each other and to previously-de-

scribed ones, and have reluctantly decided that they are indeed new, and not just on the fringes of variation of existing forms. I am comforted by the belief that taxonomic names, whatever else they are in genetic terms, are "handles" for discussion of a definite group of specimens, and that their correspondence to genetic groups becomes increasingly vague as the temporal distance from the Recent increases.

This would not be a problem if all I was doing was describing morphology and making morphological comparisons. I am, however, making paleobiogeographic inferences based on these taxonomic assignments, and the taxonomic assignments favor the paleogeographic arguments presented. I feel it necessary to state that the taxonomic assignments presented herein were made on morphologic grounds, with no *a priori* thought to their paleobiogeographic consequences, but also that I take full responsibility for those assignments.

SYSTEMATICS

Order SPIRIFERIDA Waagen, 1883

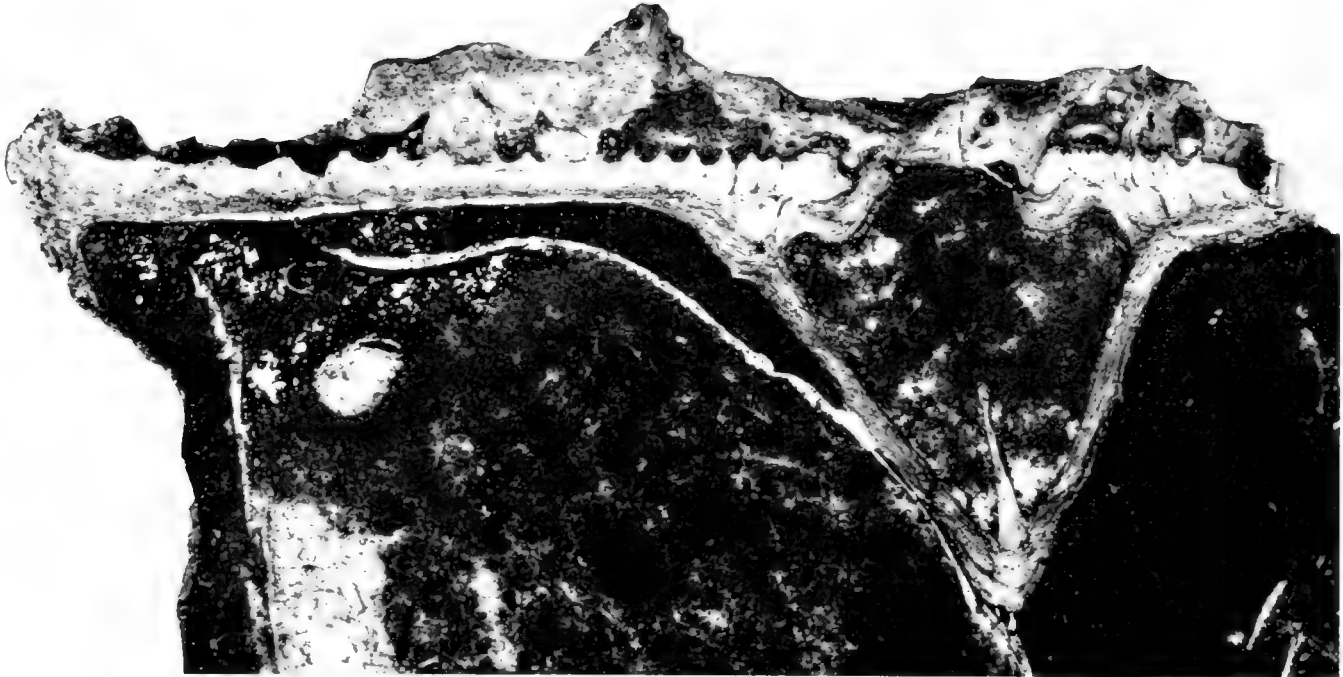
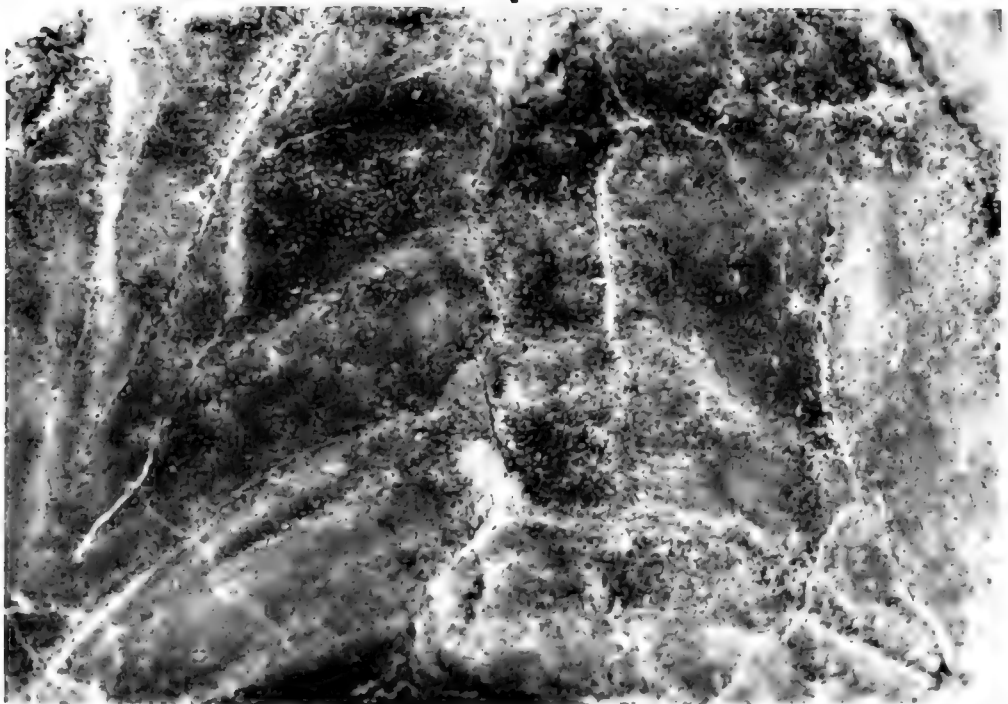
Suborder SPIRIFERIDINA Waagen, 1883

Superfamily SPIRIFERINACEA Davidson, 1884

Family SPONDYLOSPIRIDAE, new family

Diagnosis.—Cyrtiniform spiriferinaceans with large functional pedicle in the adult. Delthyrium open or closed by deltidial structures. Additional posterior covering plates (collectively the *cooperculum*; see Text-fig. 2) rarely preserved. Dental plates converging anteriorly to join strong median septum as spondylium; septum continuing posterior to junction of dental plates. Jugal supports attached to valve floor. Spires of brachidium directed posterolaterally or ventrally.

Remarks.—The genera *Spondylospira* Cooper, 1942 and *Vitimetula*, *Dagyspirifer*, and *Pseudospondylospira*, new genera, are included in the new family Spondylospiridae. The erection of a new family is justified by evidence that all four genera possessed a comparatively large functional pedicle in the adult stage, a feature rare in other non-Paleozoic cyrtinoid spiriferinaceans. The size of the structure is indicated by the area taken up by inferred pedicle foramina. A foramenate condition has not been reported in the related family Laballidae, except for the two types of foramina cited for the Thecocyrtellinae. Among the genera assigned to the Thecocyrtellinae (*Thecocyrtella* Bittner, 1892; *Thecocyrtelloidea* Yang and Xu, 1966; *Klipsteinella* Dagys, 1974), only *Thecocyrtelloidea* appears to possess other than the normal single pedicle opening. In *Thecocyrtelloidea* numerous "pedicle tubules" (Yang and Xu, 1966, pl. 9, fig. 14, and pl. 10, fig. 2) appear to pierce the deltidium throughout its length, a scheme different from that seen in the Spondylospiridae.

**A****B**

Views of the cooperculum of *Spondylospira lewesensis* (Lees, 1934). **A**, thin-section, $\times 12$, 11.7 mm dorsad of ventral beak, dorsal plane, of ventral valve, GSC 69374D (chorotype, from loc. 30), showing ridged interarea, dental plates, and median suture along anterior portion of the spondylium, deltidial plates, and severely distorted cooperculum. Note that the shell structure of all parts of the shell is fibrous and laminar, while the cooperculum is clearly punctate externally and laminar internally, as is the spondylium (shown only as fragment at extreme upper left of figure), except for the ridged portion of the interarea; **B**, posterior view, $\times 14.5$, of ventral valve, GSC 69373 (chorotype, from loc. 30), showing punctate surface of cooperculum, its irregular mesial suture (ticks and bottom), and the lateral rugae and vertical furrows on its surface. [enlargement, upside down, of Pl. 9, fig. 21].

The proximal portions of the pedicle in the Spondylospiridae are of two types, which form the basis for definition of two new subfamilies, the Dagyspiriferinae and the Spondylospirinae. Each subfamily is represented by two or more genera and species, which in other respects exhibit considerable homeomorphy. Individuals of genera currently assigned to the Laballidae may, on closer examination, prove to be spondylospirids rather than laballids.

Subfamily **DAGYSPIRIFERINAE**, new subfamily

Included genera.—*Dagyspirifer*, n. gen.; *Pseudospondylospira*, n. gen.

Diagnosis.—Spondylospirid spiriferinacean brachiopods with paired pedicle foramina; foramina ovate, internally rimmed by callus thickening. Shells commonly globose, inflated, rarely pyramidal. Deltoidal or additional posterior covering plates not observed.

Remarks.—The Dagyspiriferinae may be distinguished from the Laballidae by their pedicle foramina, from the Thecocyrtellinae by the number and size of these pedicle openings, and the apparent lack of posterior covering or deltidial plates in these forms, and from the Spondylospirinae by the paired, rather than multiple pedicle foramina, and the globose, rather than pyramidal shell habit.



Text-figure 3.—Dorsoposterolateral view (prepared using a camera lucida), $\times 13$, of ventral valve of *Dagyspirifer fascicostata*, n. gen. and n. sp., USNM 450274 (paratype, from loc. 23), showing one of the two small, paired, ovate pedicle foramina that pierce the apices of both the ridged portion of the interarea and the dental plates. The thin ridge that appears to bisect the foramen is the edge of a very narrow deltidial plate. The dorsal edges of the spondylium are broken.

Genus **DAGYSPIRIFER**, new genus

Etymology of name.—Honoring A. S. Dagys, Lithuanian student of Triassic brachiopods.

Description.—Globose shells with subpentagonal outline. Surface macro-ornament pauciplicate. Micro-ornament of co-marginal growth lamellae and fine pustules.

Ventral valve deep, swollen in lateral view, with distinct sulcus bounded by largest costae. Sulcus produced anterodorsally as tongue producing W-shaped commissure in anterior view. Beak produced considerably posterior to hingeline, commonly incurved strongly, reaching to commissural plane. Interarea low, small, narrow, vertically ridged, bordered anteriorly by row of hinge denticles. Delthyrium wide for the subfamily, open, rimmed by narrow apparent deltidial plates. Spondylium as for subfamily. Paired pedicle foramina at delthyrial apex piercing apical portions of both ridged interarea and dental plates (*i.e.*, spondylium) and opening into shell interior cavity on either side of median septum (see Text-fig. 3).

Ventral interior surface radially plicate, reflecting exterior ornament. Muscle impressions indistinct.

Dorsal valve unknown.

Type Species.—*Dagyspirifer fascicostata*, n. sp.

Diagnosis.—Globose Dagyspiriferinae with paucicostate radial macro-ornament, distinct ventral sulcus floored by costae, and narrow ridged portion of interarea, and small, oval, paired pedicle foramina.

Occurrence.—As for species.

Comparison.—*Dagyspirifer*, n. gen. is superficially most similar to *Orientospira* Dagys, 1965, from which it differs in its costate, rather than smooth ventral sulcus, its delicate internal structures and its paired apical pedicle foramina. It differs from other cyrtinoid spiriferinaceans in its markedly globose, rather than pyramidal form. It differs from the other known dagyspiriferine, *Pseudospondylospira*, n. gen., in this respect, in the much narrower ridged portion of its interarea, and in its coarser macroornament.

Dagyspirifer fascicostata, new species

Plate 9, figures 1–9

new genus and new species of Early Norian brachiopod. Hoover, 1991, p. 394, fig. 2.

Etymology of name.—*L. fascis* = bundle + *L. costata* = ribbed.

Description.—Medium-sized globose shells; outline subpentagonal in dorsal view. Surface macro-ornament of four to six coarse costae on each flank, anteriorly broadening from apex to commissure; low broad smaller costae arising from flanks of larger costae, broadening anteriorly. Micro-ornament of co-marginal growth lamellae and fine pustules.

Table 2.—Measurements (in mm) of type specimens of *Dagyspirifer fascicostata*, n. gen. and n. sp. See p. 74 for explanations of abbreviations and subscripts.

	hinge width	maximum width	length	depth	specimen type
locality 23					
USNM 450274 (paratype)	9.3	18.4	14.7 _{bc}	8.6	v.v.
USNM 450275 (paratype)	10.6	24.2	19.1 _{bc}	10.7	v.v.
USNM 450276 (holotype)	13.3	25.0	25.0	13.2	v.v.

Ventral valve deep, swollen in lateral view; having prominent flat-bottomed sulcus, floored by several very weakly rounded broad costae, bordered by two most prominent costae, these running distinctly from apex to anterior commissure, there produced dorsally as tongue. Commissure in anterior view W-shaped. Beak produced considerably posterior to hingeline, commonly incurved to commissural plane. Interarea low, small, about one-half maximum shell width, vertically ridged, marginally rimmed by low, anteromesially-directed hinge denticles. Delthyrium wide, open, rimmed by narrow apparent deltidial plates. Small spondylium formed by ventral convergence of dental plates; plates ridged on mesial surfaces, ridges reflecting previous positions of anterior edges of dental plates during ontogeny. Low median septum emergent from bottom

furrow of spondylium, produced a short distance anterodorsal of dental plates. Paired oval pedicle foramina at apex of delthyrium opening into shell interior.

Ventral interior with thin median septum extending about one-half valve length. Surface radially costate, reflecting exterior macro-ornament. Thin, small, horizontal plate joining apical dental plate to lateral shell wall (Text-fig. 4). Muscle impressions indistinct.

Dorsal valve unknown.

For measurements, see Table 2.

Occurrence.—*Dagyspirifer fascicostata*, n. sp., has been recovered only from locality 23 (Alaska, Cornwallis Limestone, Alexander terrane), from beds assigned to zone LNo1 of Tozer (1980), based on associated fauna [Silberling, written commun., 1989].

Diagnosis.—Fascicostate *Dagyspirifer*.

Types.—Holotype, USNM 450276; paratypes, USNM 450274, USNM 450275.

Comparison.—*Dagyspirifer* is at present monotypic. The fasciculate macro-ornament of *D. fascicostata* is assumed to be of significance only at the species level. *D. fascicostata* is probably more closely related to species of *Pseudospondylospira*, n. gen. than to those of *Orientospira* Dagys, 1965, even though it is superficially homeomorphic with the latter. It differs from species of *Orientospira* in its paired pedicle foramina, its more complex macro-ornament and its more delicate internal structures.

Genus PSEUDOSPONDYLOSPIRA, new genus

Etymology of name.—L. *pseudo* = false + *Spondylospira*.

Description.—Subglobose, unequally biconvex, costate shells with modestly developed dorsal fold and ventral sulcus. Ornament weaker on mesial than on lateral shell surfaces. Outline subsemicircular in dorsal view, with rounded dorsal umbo and pointed ventral beak. Valves meeting at acute angles on flanks, at right angles in mesial regions.

Ventral valve high. Costae broadening distally. Interarea duplex: laterally smooth, punctate, mesially vertically ridged, impunctate; inner ridged portion laterally rimmed by low serrate ridge in some specimens, anteriorly bordered by hinge denticles that terminate vertical ridges. Delthyrium high, narrow, open, with narrow, marginal, disjunct apparent deltidial plates. Paired ovate apical pedicle foramina piercing both



FIG. 4.—Anterodorsolateral (interior) view (prepared using camera lucida). $\times 13\frac{1}{2}$, of ventral valve of *Dagyspirifer fascicostata*, n. gen. and n. sp., USNM 450275 (paratype, from loc. 23), showing horizontal bar (at right) that connects the dental plates and lateral wall. The opening above the bar connects to one of the two paired pedicle foramina that pierce both the ridged portion of the interarea and the dental plate (see Text-fig. 3). The Y-shaped structure at lower left is the posterior portion of the spondylium.

ridged interarea and apical portions of dental plates. Low extensions of median septum protruding posteriorly from floor of spondylium.

Dorsal valve ornamented as for ventral. Umbo low, broad.

Ventral interior surface reflecting exterior ornament. Spondylium elements very thin, delicate. Paired ovate apical pedicle foramina bearing raised callus rims.

Dorsal interior with bilobate anteroposteriorly striate cardinal process, flanked by anteriorly produced articulatory shelf. Broad inner socket ridges flanking wide, open notothyrium. Descending branches of spire arising from dorsal margins of socket ridges, joined to valve floor by narrow ridge. Smooth ovate paired adductor muscle scars. Surface reflecting external ornament.

Type species.—*Pseudospondylospira perplexa*, n. sp.

Diagnosis.—Subglobose Dagyspiriferinae with costate radial ornament, and large duplex interarea, and relatively large, paired, oval apical pedicle foramina.

Occurrence.—As for species.

Comparison.—*Pseudospondylospira*, n. gen., outwardly resembles *Spondylospira* Cooper, 1942, very closely. In specimens that preserve the apex of the ventral valve, however, it may easily be distinguished from *Spondylospira*, by its paired, ovate, rather than multiple, slit-like pedicle foramina. It is otherwise distinguished from *Spondylospira* by its more delicate shells, more globose, less pyramidal shape, and by the limitation of the ridged portions of its interarea to a smaller portion of the posterior face of the ventral valve. Some specimens of two species of *Spondylospira* [*S. lewesensis* (Lees, 1934) and *S. parmata* Hoover, 1983] preserve both deltidial plates and cooperculum, and the shell structure of the ridged portion of the interarea in *Pseudospondylospira* leads me to suggest that a cooperculum was present in the latter genus as well. *Pseudospondylospira* is distinguished from *Dagyspirifer*, n. gen., by its less globose form, its costate, rather than paucicostate macro-ornament, its relatively large, paired, oval pedicle foramina, and by its less pronounced fold and sulcus development. It differs from laballid spiriferinaceans by having pedicle foramina, and from thecocyrtelline spiriferinaceans by these foramina being paired, rather than single or multiple, and by having an open delthyrium.

***Pseudospondylospira perplexa*, new species**

Plate 10, figures 14–24

new genus and new species of Late Karnian to Late Norian brachiopod. Hoover, 1991, p. 394, fig. 3.

Etymology of name.—*L. perplexus* = obscure, ambiguous.

Description.—Subglobose, inequibiconvex, costate shells with modest development of dorsal fold and

ventral sulcus. Costae weaker, narrower, more closely spaced on fold and sulcus than on flanks. Shell outline subsemicircular in dorsal view, with rounded dorsal umbo and pointed ventral beak. Commissural angle acute on flanks, about 90° mesially.

Ventral valve transverse, wider than long; high, rounded, with tongue-like semicircular dorsal extension of mesial sulcus. Costae low, rounded, gradually broadening distally. Small, pointed beak hooked posterior to hingeline. Interarea duplex; laterally smooth, mesially vertically ridged; in some specimens rimmed by low serrate ridge on lateral margins of mesial ridged portion; anteriorly bordered by articulatory hinge denticles. Delthyrium high, narrow, open, with narrow, marginal, disjunct apparent deltidial plates. Paired elongate oval pedicle foramina piercing ridged interarea and apical portions of dental plates. Spondylium floored mesially by thin posterior extension of median septum; septum projecting somewhat dorsad of edges of dental plates.

Dorsal valve bearing moderately strong to weak macro-ornament of radial costae; costae more narrow, weak, and closely spaced on fold than on flanks, increasing in number anteriorly by bifurcation, median costa rarely broader or higher than adjacent costae. Anterior commissure in dorsal view mesially resected by sulcal tongue of opposite valve. Umbo low, broad, produced slightly posterior to hinge; incurved only slightly ventrad to hingeline.

Ventral interior surface reflecting exterior ornament of costae, smooth distal interarea and ridged mesial interarea. Elements of spondylium (dental plates, median septum) thin, delicate. Pedicle foramina bearing raised callus rims; muscle impressions otherwise indistinct.

Dorsal interior with bilobate, anteroposteriorly striate cardinal process, flanked by anteriorly-produced articulatory shelf. Shelf bearing denticulate dorsad step at about mid-length; narrow lengthwise furrows posterior to step; deep, oval articulatory fossae just anterior to step. Broad inner socket ridges flanking wide, open notothyrium. Descending branches of spire arising from dorsal margins of socket ridges, joined to valve floor in narrow ridge at about one-half valve length. Median myophragm separating smooth, ovate, paired adductor scars; myophragm variably developed, low; may extend anteriorly about one-fifth valve length. Interior surface radially striate, reflecting exterior ornament.

For measurements, see Table 3.

Occurrence.—*Pseudospondylospira perplexa*, n. sp., has been recovered in the present collections from localities 7 [Alaska, Cornwallis Limestone, Alexander terrane, zones UC1–LNo1(?) of Tozer (1980), based on associated fauna], 18 [Nevada, Jungo terrane, zone

Table 3.—Measurements (in mm) of type specimens of *Pseudospondylospira perplexa*, n. gen. and n. sp. See p. 74 for explanations of abbreviations and subscripts.

	striate hinge width	interarea width	maximum width	length	thickness	specimen type
locality 22						
USNM 450277 (paratype)	—	12 _c	20	24	15.3	a.v.
USNM 450278 (holotype)	11.0	15.6	28 _b	24	22.5	a.v.

LNo3 of Tozer (1980), based on associated fauna], 22 [Alaska, Cornwallis Limestone, Alexander terrane, zones UC1–UNo1 of Tozer (1980), based on associated fauna], 23 [Alaska, Cornwallis Limestone, Alexander terrane, zone LNo1 of Tozer (1980), based on associated fauna], 24 [Alaska, Cornwallis Limestone, Alexander terrane, zones UC1–LNo2 of Tozer (1980), based on stratigraphic position], 25 [Alaska, limestone bed in Hound Island Volcanics, Alexander terrane, zones UC2–LNo1 of Tozer (1980), based on associated fauna], 27 [Alaska, Cornwallis Limestone, Alexander terrane, zones UC1–UNo1 of Tozer (1980), based on stratigraphic position], 28 [Oregon, Martin Bridge Formation, Wallowa terrane, zone LNo1 of Tozer (1980), based on associated fauna], and 41 [Nevada, Osobb Formation, Triassic cover on the Golconda Allocthon, zones LNo2–LNo3 of Tozer (1980), based on stratigraphic position]. See Table 1 for Tozer's (1980) zonal scheme.

Diagnosis.—Transverse *Pseudospondylospira* with low dorsal fold and shallow ventral sulcus.

Types.—Holotype, USNM 450278; paratypes, USNM 450277, USNM 450279, USNM 450280, USNM 450281, USNM 450282.

Comparison.—*Pseudospondylospira perplexa*, n. sp., is at present the only species in the genus. The assumption is made that the outline and strength of fold and sulcus development are specific rather than generic characters. Mean size may also prove to be significant, but no conclusions can be made in the absence of large population samples of *P. perplexa* or specimens of other congeneric species. Several specimens from a single locality in Oregon have been tentatively assigned to this species (see below). Their stronger macro-ornament and more pronounced fold and sulcus development are near the limit of what I would consider non-specific variation.

Pseudospondylospira perplexa, n. sp., is preserved from silicified material, which commonly preserves the subfamilially diagnostic apex of the ventral valve. Calcareous "crackout" specimens, however, commonly lack this portion of the shell, and development of such specimens from matrix involves lengthy and complex preparation. I have not identified specimens as *P. perplexa* unless, in addition to other criteria, the diforamenate condition could be ascer-

tained. Hence, many individuals that may be *P. perplexa* have been assigned to less restrictive taxonomic categories, and the cited occurrence of the species may not be representative of its true geographic and stratigraphic range.

***Pseudospondylospira* aff. *P. perplexa*, new species**
Plate 10, figures 25–27

Remarks.—A small partial ventral valve and a larger complete dorsal valve of a form closely related to *P. perplexa* were recovered from locality 28 (Oregon, Martin Bridge Formation, Wallowa terrane) in beds assigned, on the basis of associated fauna, to zone LNo1 of Tozer (1980) by Silberling (written commun., 1989). The paired pedicle foramina clearly place these specimens within the Dagyspiriferinae, and the subglobose form and comparatively subdued macro-ornament suggest *Pseudospondylospira*. The macro-ornament is, however, stronger than that in *P. perplexa*, and is accompanied by more pronounced development of the fold and sulcus. The range of variation in macro-ornament observed in *P. perplexa* (see Pl. 10, figs. 20, 21) suggests this form may also lie within *P. perplexa*, but too few specimens are present to permit more conclusive identification than the above.

Types.—Figured specimens, USNM 450283, USNM 450284.

Subfamily **SPONDYLOSPIRINAE**, new subfamily

Included genera.—*Spondylospira* Cooper, 1942; *Vitimetula*, n. gen.

Diagnosis.—Spondylospirid spiriferinacean brachiopods with more than two pedicle openings. Deltidial plates and coopercula may be present. Shells commonly subpyramidal, apically hooked, rarely globose or inflated.

Remarks.—The Spondylospirinae may be distinguished from the Laballidae by their pedicle opening, from the Thecocyrtellinae by the size of that opening, from the Dagyspiriferinae by their multiforamenate rather than diforamenate pedicle opening, and in some species of *Spondylospira* from all others by the preservation of two distinct kinds of coopercula (see Hoover, 1983; and Text-fig. 2 and Plate 10, figs. 10–13 herein).

Genus SPONDYLOSPIRA Cooper, 1942

Type species.—*Spondylospira reesidei* Cooper, 1942, p. 232; Cooper, in Shimer and Shrock, 1944, p. 359, pl. 140, figs. 43–47.

Diagnosis.—Spondylospirine spondylospirids with weak to strong dorsal fold and ventral sulcus, bearing ornament of strong costae on flanks and weaker costae on fold and sulcus. Interarea vertically ridged; deltidium commonly preserved as open, in some specimens covered by deltidial plates or deltidium; interarea in some specimens shielded by multipartite shield (cooperculum). Hinge denticulate. Ventral interior with spondylium basally bisected by median septum; dorsal interior with descending branches of spire jugate anteriorly, supported dorsally by meshwork connected to valve floor.

Occurrence.—*Spondylospira* occurs in beds of from Karnian to Norian age in North and South America. *Spondylospira* cf. *S. lewesensis* (Lees, 1934) is the only species referred to the genus reported from outside the Western Hemisphere [by Dagys (written commun., 1990) from the Koryak mountains of the northeasternmost U. S. S. R.]. This species was originally referred to *Spondylospira alia* (Hall and Whitfield, 1877) by Bychkov and Dagys (1984, p. 13).

Comparison.—Well-preserved specimens of *Spondylospira* may be distinguished from other non-spondylospirine cyrtinoid spiriferinaceans by their multiple apical pedicle foramina. Less well-preserved specimens may be distinguished from *Zugmayerella* Dagys, 1963, *Laballa Moisseiev* in Dagys, 1962, *Pseudolaballa* Dagys, 1974, *Spinolepismatina* Dagys, 1974, and *Orientospira* Dagys, 1965, by their costate fold and sulcus. The latter characters also distinguish *Spondylospira* from the other known spondylospirine, *Vitimetula*, n. gen.

Discussion.—Vokes and Haas (1944) referred the following species to *Spondylospira*: *Cyrtina lewesensis* Lees, 1934, *Spiriferina acrotamboensis* Körner, 1937, *Spirifera* (*Spiriferina*) *alia* Hall and Whitfield, 1877, *Spiriferina canavarica* Tommasi var. *robusta* Körner, 1937, *Spiriferina koessenensis* Zugmayer, 1882, *Spiriferina steinmanni* Tilmann, 1917, *Spiriferina* sp. of Tilmann, 1917, *Spiriferina*(?) sp. indet. of Körner, 1937, and *Spondylospira reesidei* Cooper, 1942.

Cyrtina lewesensis Lees, 1934 is the name first applied to the form which typifies *Spondylospira*. Widely variable in size, strength of costation, and number of costae, this species is the senior synonym of both *Spiriferina acrotamboensis* [Pl. 9, figs. 27–29], and *Spondylospira reesidei* [Pl. 9, figs. 22–26]. Hoover (1983) reported that preparation of the ventral valve which is the holotype of *S. (S.) alia* Hall and Whitfield, 1877 [USNM 12671; Pl. 10, figs. 4–7] reveals a shell that may not even be punctate, a low, non-ridged interarea,

non-denticulate hinge, and absence of the “cyrtinoid” spondylium that is the uniting characteristic of the laballids and spondylospirids. *S. (S.) alia* cannot be placed within either family, and only questionably fits in the Spiriferinacea. The specimen figured by Cooper (in Shimer and Shrock, 1944, pl. 141, figs. 48–51) as *Spondylospira alia* (Hall and Whitfield, 1877) is here placed in synonymy with *S. lewesensis* (Lees, 1934). Specimens of *S. canavarica robusta*, *S. steinmanni*, and *S. (?)* sp. indet. of Körner, were not available for comparison, but from the published illustrations suggest assignment to *Spondylospira*. *Spiriferina* sp. of Tilmann (1917) is herein referred to *Spondylospira tricola*, n. sp. *Spiriferina koessenensis* was removed from *Spondylospira* by Dagys (1963), who defined it as the type species of *Zugmayerella*.

***Spondylospira lewesensis* (Lees, 1934)**

Plate 9, figures 10–38; Plate 10, figures 1–3

Cyrtina lewesensis Lees, 1934, p. 35, pl. 1, figs. 14–16.

Spiriferina acrotamboensis Körner, 1937, p. 168, pl. 11, figs. 5–8.

Spondylospira reesidei Cooper, 1942, p. 232; Cooper, in Shimer and Shrock, 1944 [part], p. 359, pl. 140, figs. 43–47 [USNM 103468a–c, e–g only; not USNM 103468d (= *Vitimetula parva*, n. gen. and n. sp.)]; Dagys, 1974, pl. 54, figs. 5–8; Hoover, 1983, figs. 3G–3K.

Spondylospira alia (Hall and Whitfield). Cooper, in Shimer and Shrock, 1944, p. 359, pl. 140, figs. 48–51 [not *Spirifera* (*Spiriferina*) *alia* Hall and Whitfield, 1877, p. 281, pl. 6, fig. 17].

Spondylospira aff. *S. alia* Hall and Whitfield [sic]. Rangel Z., 1978, p. 25, pl. 1, figs. 3–5 [not *Spirifera* (*Spiriferina*) *alia* Hall and Whitfield, 1877, p. 281, pl. 6, fig. 17].

Spondylospira lewesensis Lees. Tozer, 1962, p. 27, pl. 12, figs. 11–13; Dagys, 1974, pl. 51, figs. 9a–b; Hoover, 1983, pp. 1026–1028, figs. 3L–3S, 4E, 4F, 5.

Spondylospira aff. *S. acrotamboensis* Körner [sic]. Rangel Z., 1978, p. 25, pl. 1, fig. 6, pl. 2, figs. 1–4.

Spondylospira cf. *S. acrotamboensis* Körner [sic]. Rangel Z., 1978, p. 24, pl. 1, figs. 1, 2.

Description.—*Spondylospira lewesensis* (Lees) has been amply described in the above accounts. Its differences from related species are detailed under *Comparison* below. For measurements, see Table 4.

Occurrence.—*Spondylospira lewesensis* (Lees) has been recovered from deposits of from early Karnian to late Norian age. In the present collections, it is recognized from localities 5 [California, ?Modin Formation, Eastern Klamath terrane, zones LNo1–UNo3 of Tozer (1980), based on associated fauna], 6 [Alaska, Alexander terrane, zones UC1–UC3 of Tozer (1980), based on associated fauna], 10 [Nevada, middle member of Gabbs Formation, Paradise terrane, zones UNo2–UNo3 of Tozer (1980), based on associated fauna], 13 [Alaska, Wrangellia terrane, age unknown], 15 [Idaho, Wallowa terrane, zones (?)UNo1–UNo3 of Tozer (1980), based on associated fauna (see *Appendix* for discussion of age uncertainty at this locality)], 16 [Peru, zones UC1–UNo3 of Tozer (1980), based on associated fauna], 21 [Oregon, Martin Bridge Forma-

Table 4.—Measurements (in mm) of specimens of *Spondylospira lewesensis* (Lees, 1934). See p. 74 for explanations of abbreviations and subscripts.

	<i>hinge width</i>	<i>maximum width</i>	<i>length</i>	<i>thickness</i>	<i>dorsal costae on fold/flank</i>	<i>specimen type</i>
locality 15						
USNM 103468a ¹	9.1	13.7	8.4 _c	9.0 _c	—	v.v.
USNM 103468b ²	14.0 _h	15.0 _h	9.0 _b	3.0 _c	6/6	d.v.
USNM 103468c ²	14.1	14.1	6.1	3.0	4/6	d.v.
USNM 103468d ²	10.1	12.4	8.8	6 _c	—	v.v.
locality 29						
GSC 9619 (lectotype)	17.9	22.6	18.5	20.7	4/6	a.v.
GSC 9619a (paralectotype)	17.0	22.7	20.7	21	6/6	a.v.
locality 30						
GSC 69373 (chorotype)	14.9	22.4	23.8	17.8	6/6	a.v.
locality 39						
CASG 66253.02	6.8	7.9	6.4	6.3	4/6	a.v.
CASG 66253.03	8.3	11.0	8.5	9.0 _c	4/6	a.v.
CASG 66253.04	10.4 _h	12.3	9.1	9.2	4/6	a.v.
CASG 66253.01	11.3	14.0	10.0	9.5	6/7	a.v.
locality 45						
CASG 66258.05	6.8	8.3	7.7	5.8	4/4	a.v.
CASG 66258.01	7.6	8.6	5.4	6.2	4/4	a.v.
CASG 66258.06	6.8	8.4	5.6	5.0	4/4	a.v.
CASG 66258.07	8.0	9.2	7.5	6.3	4/7	a.v.
CASG 66258.08	7.9	9.7	6.8	8.3	—	a.v.
CASG 66258.03	8.6	10.2	8.0	7.7	4/6	a.v.
CASG 66258.02	10.4	10.5	6.5	6.9	4/6	a.v.
CASG 66258.09	10.4	11.5	8.2	8.0	4/6	a.v.
CASG 66258.10	10.8	12.8	8.9	8.0	4/8	a.v.
CASG 66258.04	13.2	13.8	8.5	9.8	6/6	a.v.

¹ Holotype of *Spondylospira reesidei* Cooper, 1942.

² Paratype of *Spondylospira reesidei* Cooper, 1942.

tion, Wallowa terrane, zone UC3 of Tozer (1980), based on associated fauna], 26 [Alaska, limestone bed in Keku Volcanics, Alexander terrane, zones LC1–UNo2 of Tozer (1980), based on associated fauna], 27 [Alaska, Cornwallis Limestone, Alexander terrane, zones UC1–UNo1 of Tozer (1980), based on stratigraphic position], 29 [Yukon, Formation “F” of Lewes River Group, Stikine terrane, zone UNo2 of Tozer (1980), based on associated fauna], 30 [Yukon, Formation “F” of Lewes River Group, Stikine terrane, zone UNo2 of Tozer (1980), based on associated fauna], 31 [Yukon, Formation “F” of Lewes River Group, Stikine terrane, zone UNo2 of Tozer (1980), based on associated fauna], 33 [Nevada, lower member of Luning Formation, Paradise terrane, zone LNo1 of Tozer (1980), based on fauna at this stratigraphic level], 35 [Nevada, Luning Formation, Paradise terrane, zone LNo3 of Tozer (1980), based on associated fauna], 36 [Nevada, Luning Formation, Paradise terrane, zone LNo1 of Tozer (1980), based on fauna at this stratigraphic level], 37 [Nevada, lower Luning Formation, Paradise terrane, zones LNo1–LNo2 of Tozer (1980), based on fauna at this stratigraphic level], 39 [Nevada, Jungo terrane,

zone LNo3 of Tozer (1980), based on associated fauna], 40 [Nevada, Luning Formation, Paradise terrane, zone LNo3 of Tozer (1980), based on stratigraphic position], 41 [Nevada, Osobb Formation, Triassic cover on the Goldconda allochthon, zones LNo2–LNo3 of Tozer (1980), based on stratigraphic position], 45 [Nevada, Jungo terrane, zone MNo2 of Tozer (1980), based on associated fauna], 47 [Oregon, Martin Bridge Formation, Wallowa terrane, zones LNo1–MNo2 of Tozer (1980), based on associated fauna], and 53 [Alaska, Chulitna terrane, zone UC3 of Tozer (1980), based on associated fauna]. This indicates a range of zones LC1 through UNo3 of Tozer (1980), with ages in the older end of the range most common in the Alexander terrane. The early and middle Karnian extension of the range is supported by only a single locality (loc. 26), and Dagys (written commun., 1990) doubts that the species really ranges down into the Karnian at all. Occurrences that may be Karnian are limited to the Alexander and Chulitna terranes of Alaska.

Diagnosis.—*Spondylospira* with strong dorsal fold costae that increase initially by equal bifurcation, subsequently by equal or unequal bifurcation; widest at or

slightly anterior to hingeline; fold and sulcus moderately to strongly developed; bears posterior cooperulum on interarea, but cooperulum rarely preserved.

Types.—Lectotype, GSC 9619; paralectotype, GSC 9619a; chorotype, GSC 69373; chorotype of *S. acrotamboensis* Körner, 1937, USNM 450285; figured specimens, CASG 66248.01, CASG 66248.02, CASG 66251.01, CASG 66253.01, CASG 66258.01–CASG 66258.04, USNM 103468a, USNM 103468b, USNM 103468f, USNM 106521, USNM 450286, USNM 450287; measured specimens, CASG 66253.01–CASG 66253.04, CASG 66258.01–CASG 66258.10, GSC 9619, GSC 9619a, GSC 69373, USNM 103468a–USNM 103468d.

Comparison.—*Spondylospira lewesensis* (Lees, 1934) includes forms that vary considerably in most of the characters which define the species. It may most easily be distinguished from *S. tricosta*, n. sp., by the manner of initial increase in number of costae on the dorsal fold. *S. tricosta* adds a single subordinate costa on either side of a single initial costa, so that bilateral trifurcation takes place. *S. lewesensis* simply bifurcates the initial costa, and at least in the early ontogenetic stages, bears an even number of dorsal fold costae, as new ones are added symmetrically. *S. parmata* Hoover, 1983 may fall within the range of *S. lewesensis*. It was identified as a distinct species primarily because (1) it is close to the limits of variation of *S. lewesensis* and (2) it exhibits features of particular interest that are not well shown in *S. lewesensis*, although they may be present in some individuals of that species. *S. parmata* may be distinguished by its weak development of the median fold and sulcus, and by its very numerous, thin, closely spaced costae. It bears a cooperulum that appears to be tripartite, as opposed to the bipartite set of elements seen in some specimens of *S. lewesensis*. *S. lewesensis* includes multicostate forms referred by Cooper to *S. alia* (Hall and Whitfield, 1877). Hoover (1983) recognized that the type of Hall and Whitfield's species was not a spondylospirid.

In *Spondylospira* the dorsal interior spire support meshwork memorialized by the generic name is not always well-preserved. The beautiful silicification seen in the types of *S. acrotamboensis* (Körner, 1937) and *S. reesidei* Cooper, 1942 is the exception rather than the rule. Thus specific characters have tended to be external. The types of *S. reesidei* (USNM 103468a–c, e–g) however, suggest how variable such external characters may be. In addition, it seems subjectively reasonable that individuals of this elusive genus from such geographically widely-separated regions as Peru, Idaho, and the Yukon Territory of Canada might, in the absence of other collections, belong to distinct species. Thus, *S. lewesensis* (Lees) from the Yukon Territory of Canada was considered distinct from the Peruvian

species *S. acrotamboensis* (Körner, 1937), and both of those were considered distinct from *S. reesidei* Cooper. These three species can only be differentiated as follows: *S. acrotamboensis* and *S. lewesensis* are larger, and have more lateral costae, than does *S. reesidei*. This distinction, as suggested above, is insufficient basis for specific discrimination when a large database is available. *S. lewesensis* and *S. acrotamboensis* have more (4–6 vs. 4–5) lateral costae than does *S. reesidei*. The latter phenomenon can be related directly to size. Discounting these differences, the three species above must be considered to form a single, externally variable, hemispherically cosmopolitan species, *Spondylospira lewesensis* (Lees).

Discussion.—The type material of *S. reesidei* includes individuals with two distinct types of ornament. Most bear strong, commonly sinuous costae, that bifurcate anteriorly. A single ventral valve [USNM 103468d] bears only simple, very weak costae, and is comparatively smooth. Examination of topotypic material [loc. 15] has produced further specimens of this smooth form. As no transitional forms occur, the smooth form is here assigned to a distinct taxon. As it lacks a costate fold or sulcus, it cannot be assigned to *Spondylospira* [*sensu stricto*], and is therefore here placed in the new genus *Vitimetula*. Ventral valves of both forms show the multiple apical foramina characteristic of the new subfamily Spondylospirinae.

***Spondylospira parmata* Hoover, 1983**

Plate 10, figures 8–13

Spiriferina cf. *S. suessi* Winkler. Sanborn, 1960, pp. 20–21, pl. 2, figs. 7, 8 [not *Spiriferina suessi* Winkler, 1859 = *Laballa Moisseiev* in Dagys, 1962].

Spondylospira parmata Hoover, 1983, pp. 1025, 1026, text-figs. 3A–3F; Hoover, 1991, p. 395, fig. 4.

Description.—Pyramidal, inequibiconvex costate shell, with weak dorsal fold and ventral sulcus. Costae increasing in number distally by bifurcation. Interarea about half-covered by multipartite cooperulum, exposed apically and basally.

Ventral valve about equal in length, width, and depth. Outline triangular in lateral, anterior, posterior, or ventral aspects. Surface macro-ornament of closely spaced fine costae; at 10 mm from beak, about 15 on each flank, and six narrower ones in shallow sulcus. Interarea mostly planar, but beak strongly hooked posteriorly at apex. Interarea surface vertically finely ridged; about 17 ridges in a 5 mm distance at base. Hingeline denticulate; denticles serving articulatory function. Delthyrium high, open, narrow.

Cooperulum of single basal and two lateral plates, together covering entire width of basal two-thirds of interarea, exposing only oval apical mesial and low, transverse slitlike basal areas. Surface rugose, with ap-

Table 5.—Measurements (in mm) of the holotype of *Spondylospira parmata* Hoover, 1983. See p. 74 for explanations of abbreviations and subscripts.

	hinge width	maximum width	interarea height	length	thickness	specimen type
locality 44						
CASG 60975.01 (holotype)	21 _{bc}	21 _{bc}	20.3	23 _c	29.2	a.v.

parent suture-lines demarcating basal one or two plates, and disjunct right and left lateral plates. Basal plate relatively smooth, lateral plates co-marginally rugose around pedicle opening, bearing coarse rounded vertical grooves on lateral plates. Lateral plates thickest (ca. 2 mm) around pedicle opening, thinning distally and toward the hingeline.

Dorsal valve with costate ornament in number and character like that of opposite valve. Low mesial fold developed. Hinge area bearing longitudinally-ridged articular shelf and striate cardinal process.

Ventral interior with spondylium of dental plates, supported and divided longitudinally by median septum. Interiors of either valve not otherwise observed.

For measurements, see Table 5.

Occurrence.—Only a single specimen confidently identifiable as *S. parmata* Hoover, 1983, is known. It was recovered from locality 44 (California, Devil's Canyon Member of the Modin Formation, Eastern Klamath terrane), in beds assigned to zones UNo1–UNo3 of Tozer (1980) on the basis of associated fauna (Silberling, written commun., 1989). Several other specimens which appear conspecific but have not preserved the cooperulum characteristic of *S. parmata* have been recovered from locality 44, and from locality 2 (California, ?Modin Formation, Eastern Klamath terrane). Beds at the latter locality may be assigned to zones MNo1 through UNo2 of Tozer (1980) based on associated fauna (Silberling, written commun., 1989).

Diagnosis.—Equidimensional *Spondylospira* with numerous fine costae, weak fold/sulcus development, and a tri-partite cooperulum covering portions of the ventral interarea.

Types.—Holotype: CASG 60975.01.

Comparison.—*S. parmata* may fall within the extremely broad range of variation of *S. lewesensis* (Lees), as discussed above. It is, however, near the limits of the range of that variation, and its numerous fine costae and weak fold and sulcus development distinguish it from specimens of *S. acrotamboensis*, *S. lewesensis*, and *S. perplexa*. It is more similar in exterior ornament to *S. perplexa* and *Spondylospira perplexa*, n. sp., but differs from the latter form in having an interarea that covers the maximum width of the shell, and in having multiple rather than paired pedicle foramina. Its tripartite cooperulum distinguishes it from all previously described species of the genus. Topotypic specimens of *S. lewesensis* (Lees) also bear a cooperulum, which in that species

appears to be comprised of only two paired lateral plates.

Spondylospira tricosta, new species Plate 11, figures 1–15

Spiriferina sp. Tilmann, 1917, p. 689, pl. 25, figs. 12a, 12b.

Etymology of name.—*L. tri* = three + *L. costa* = rib.

Description.—Small, inequibiconvex, paucicostate shells with distinct, costate dorsal fold and ventral sulcus; commonly high, thicker than long; transverse, wider than long.

Ventral valve outline subsemicircular in ventral aspect, dorsally tongued in anterior aspect; pointed beak commonly projecting posteriorly. Distinct median sulcus commonly bearing two weak radial costae; flanks bearing four to five stronger costae; mesial costae only originating at beak; others originating further dorsad on flanks of posterior margin. Interarea planar to concave posteriorly, bounded laterally by raised rim; vertically finely ribbed, ribs terminating dorsally in fine hinge denticles. Delthyrium narrow, open. Micro-ornament of fine co-marginal growth lines and radial striae.

Dorsal valve anteriorly truncate in lateral aspect; hinge width commonly slightly less than maximum width, subequal to length. Broad median fold commonly bearing three costae on crest; mesial costa strongest, all arising about four mm anterior to beak by trifurcation. Flanks commonly bearing fine costae.

Ventral interior with spondylium and posteriorly-produced median septum. Hinge teeth low, feeble, articulation chiefly by hinge denticles.

Dorsal interior unknown.

For measurements, see Table 6.

Occurrence.—*Spondylospira tricosta*, n. sp., is known only from the early Norian [zones LNo1 through LNo3 of Tozer (1980)]. It has been recognized in the present study at localities 8 [Nevada, lower member of Luning Formation, Paradise terrane, zone LNo1 of Tozer (1980), based on associated fauna], 28 [Oregon, Martin Bridge Formation, Wallowa terrane, zone LNo1 of Tozer (1980), based on associated fauna], 32 [Nevada, Osobb Formation, Triassic cover on the Golconda Allochthon, zones LNo1–LNo3 of Tozer (1980), based on stratigraphic position], 40 [Nevada, Luning Formation, Paradise terrane, zone LNo3 of Tozer (1980), based on stratigraphic position], 41 [Nevada, Osobb

Table 6.—Measurements (in mm) of specimens of *Spondylospira tricosta*, n. sp. See p. 74 for explanations of abbreviations and subscripts.

	<i>hinge width</i>	<i>maximum width</i>	<i>length</i>	<i>thickness</i>	<i>costae on dorsal fold/flank</i>	<i>specimen type</i>
locality 8						
USNM 450288	17.0	22.3 _c	17.6 _c	21.3 _c	5/5	a.v.
locality 32						
CASG 66247.01 (holotype)	11.2	13.8	11.4	11.5	3/5	a.v.
CASG 66247.02 (paratype)	10.6	15.4	11.5 _b	12.6	3/5	a.v.
CASG 66247.03 (paratype)	10.2	17.3	13.0 _b	13.8	3/5	a.v.
CASG 66247.04 (paratype)	14 _c	18.5	13.9	15.8	4/5	a.v.
locality 40						
CASG 66254.01	11.1	14.8	12.0	15.0	5/5	a.v.
locality 41						
CASG 66255.01	11.1	16.0	13.2	15.6	3/5	a.v.
CASG 66255.03	11.5	16.5	16.6	14.0 _b	3/5	a.v.
CASG 66255.04	14.1	16.5 _b	14.8	14.3	3/5	a.v.
CASG 66255.05	14.2	18.1	14.5	16.8 _b	3/5	a.v.
CASG 66255.06	19.7	21.6	15.0	18 _c	3/5	a.v.
CASG 66255.02	18.3 _c	18.8 _c	19.7 _c	24.0 _c	3/5	a.v.
locality 42						
CASG 66256.01	7.7	10.5 _h	8 _{be}	8.4	3/4	a.v.
locality 43						
CASG 66257.01	13.8	16.9	14.0	14.0	3/5	a.v.
CASG 66257.02	14.8	17.6	17.0	16.6	3/5	a.v.

Formation, Triassic cover on the Golconda Allochthon, zones LNo2–LNo3 of Tozer (1980), based on stratigraphic position], 42 [Nevada, Dun Glen Formation, Triassic cover on the Golconda Allochthon, zone LNo3 of Tozer (1980), based on associated fauna], and 43 [Nevada, ?Winnemucca Formation, Triassic cover on the Golconda Allochthon, zones LNo2–LNo3 of Tozer (1980), based on stratigraphic position]. It also appears to be present in rocks assigned to the "Middle Triassic" of Peru by Tilmann (1917), where it was reported as *Spiriferina* sp. The dorsal valve exterior figured by Tilmann (1917, pl. 25, fig. 12a), shows the trifurcate costae on the fold that are characteristic of this species.

Diagnosis.—Paucicostate *Spondylospira* bearing an odd number of costae on the dorsal fold, which arise from bilateral trifurcation of a single initial mesial costa.

Types.—Holotype, CASG 66247.01; paratypes, CASG 66247.02–CASG 66247.04; figured specimens, CASG 66255.01, CASG 66255.02, CASG 66256.01, USNM 450289; measured specimens, CASG 66255.01–CASG 66255.06, CASG 66256.01, CASG 66257.01, CASG 66257.02, USNM 450288.

Comparison.—*S. tricosta*, n. sp. may be distinguished from most species of *Spondylospira* by its paucicostate macro-ornament. Among paucicostate cyrtinoid spiriferinacean species, it may be distinguished from *S. lewesensis* (Lees) by the odd number of costae borne on its dorsal fold. It may be distinguished from

Vitimetula parva, n. sp. by its more pronounced ornament, and presence of a dorsal fold. It may be distinguished from species of *Zugmayerella* Dagys, 1963, which it resembles in form and outline, by its costate fold and sulcus.

Discussion.—*S. tricosta*, n. sp. is probably closest in overall appearance to *S. lewesensis*, although no transitional forms have been observed. As is the case in *S. lewesensis*, sporadic bifurcation of mesial and lateral costae results in both paucicostate and multicostate phenotypes, although the transition from one to the other is not so well-represented by samples as is the case with *S. lewesensis*. Samples of *S. tricosta* from Nevada most resemble species of *Zugmayerella* Dagys, 1963, differing most obviously in bearing costae on the fold and sulcus.

Genus VITIMETULA, new genus

new genus aff. *Spondylospira*. Hoover, 1983, p. 1026.

Etymology of name.—*L. vietus* = wrinkled + *L. metula* = conical or pyramidal figure.

Description.—Strongly inequibiconvex shells with high spire-like ventral and shallow bowl-like dorsal valves. Both valves may bear faint simple costae; costae more pronounced distally. Distinct, shallow, very narrow ventral sulcus, extending from apex to anterior commissure; no corresponding dorsal fold.

Ventral valve outline variable in ventral aspect. Interarea margins laterally rimmed; interarea surface planar, bearing coarse, sinuous vertical ridges, which may

bifurcate commissurally, ridges terminating at hinge in prominent simple denticles. Delthyrium high, narrow, open. Apical pedicle foramina multiple, "honeycombed" as typical of subfamily.

Dorsal valve quite shallow, commonly widest at hinge. Surface smooth or distally faintly costate.

Ventral interior with shallow spondylium. Articulation by hinge denticle and by anterior portions of dental plates that apparently match hinge sockets of opposite valve. Surface smooth or faintly reflecting exterior ornament. Muscle scars indistinct.

Dorsal interior posteriorly bearing short articulatory shelf; shelf bearing anteroposteriorly elongate fossae that accommodate articulatory hinge denticles of opposite valve. Shallow hinge sockets present. Median septum absent, but low median myophragm separating muscle scars. Umbo poorly developed, not produced posterior to hinge line. Descending branches of spire produced anteriorly from anterior margins of hinge sockets, anteriorly forming a jugum. All elements joined to valve floor by complex meshwork.

Type species.—*Vitimetula parva*, n. sp.

Diagnosis.—Faintly costate Spondylospirinae with high ventral and shallow dorsal valves, narrow shallow ventral sulcus but no dorsal fold. Interior as for *Spondylospira* Cooper.

Occurrence.—*Vitimetula*, n. gen. is at present known only from locality 15 (Idaho, Wallowa terrane), where it co-occurs with *Spondylospira lewesensis* (Lees, 1934). The fauna at this locality is probably of late Norian age (Stanley, 1979) [zones UNo1–UNo3 of Tozer (1980). See *Appendix* for discussion of problems with the age of this locality].

Comparison.—*Vitimetula*, n. gen. is easily distinguished from *Spondylospira* by the absence of a dorsal fold and the absence of costae on the mesial portions of either valve. It is distinguished from other laballids and spondylospirids that have smooth mesial portions by its narrow sulcus and comparatively smooth surface overall. It is distinguished from *Psioidea* Hector, 1879 by the absence of a dorsal fold and its relatively short hingeline and non-transverse outline.

Discussion.—A single specimen of the type lot of *Spondylospira reesidei* Cooper [USNM 103468d] is here assigned to *Vitimetula*, n. gen.

Vitimetula parva, new species

Plate 11, figures 16–32

Spondylospira reesidei Cooper, 1942, p. 232 [part: unfigured paratype (USNM 103468d)]; Cooper, in Shimer and Shrock, 1944, p. 102 [part: unfigured paratype (USNM 103468d)].

Etymology of name.—*L. parvus* = small.

Description.—Small, strongly inequibiconvex shells with high conical ventral and shallow bowl-like dorsal valves. Both valves bearing faint simple costae; costae

more pronounced distally. Distinct, very narrow, shallow ventral sulcus, but no corresponding dorsal fold.

Ventral valve commonly four times as deep as dorsal; outline in ventral aspect variable. Margins of interarea commonly produced posteriorly as low rim; posterodorsal hinge margins commonly flared distally. Interarea bearing coarse, sinuous, dorsally bifurcate vertical ridges; ridges terminating at hinge in prominent simple denticles. Apical portion of area pierced by several posteroventrally oriented slitlike openings (see Pl. 11, fig. 18). Delthyrium long, narrow, open.

Dorsal valve quite shallow, commonly widest at hinge; surface smooth or marginally faintly costate.

Ventral interior with shallow spondylium formed by junction of short dental plates and median septum; septum length variable in terms of spondylium support, invariably projecting posteriorly into spondylium. No functional paired hinge teeth, but anterior portions of dental plates apparently articulating with hinge sockets of opposite valve. Articulation mostly by hingeline denticles. Muscle scars not evident. Interior surface smooth or faintly reflecting subdued exterior costation.

Dorsal interior posteriorly bearing short articulatory shelf. Shelf bearing anteroposteriorly elongate fossae which accommodate articulatory hinge denticles of opposite valve. Shallow hinge sockets present. No median septum, but low rounded myophragm separating striate muscle scars. Umbo poorly developed, not produced posterior to hinge line. Descending branches of spire produced anteriorly from anterior margins of hinge sockets, anteriorly forming a jugum, all elements joined to valve floor by complex meshwork.

For measurements, see Table 7.

Occurrence.—*Vitimetula parva*, n. sp. is at present known only at locality 15 (Idaho: Wallowa terrane), where it co-occurs with *Spondylospira lewesensis* (Lees, 1934). The fauna there suggests a late Norian age [Stanley (1979); zones UNo1–UNo3 of Tozer (1980), based on associated fauna, but see *Appendix* for discussion of problems with this age].

Diagnosis.—Small *Vitimetula*.

Types.—Holotype, USNM 450290; paratypes, USNM 103468d, USNM 450291–USNM 450298.

Comparison.—*Vitimetula*, n. gen. is monotypic. *V. parva*, n. sp. may be distinguished from species of *Spondylospira* by its smooth narrow ventral sulcus and its lack of a dorsal fold, and from other spondylospirids and laballids by its high ventral valve, smooth exterior, and narrow ventral sulcus. Its internal details indicate that it is probably most closely related to *Spondylospira*. Its ventral valve somewhat resembles that of *Zugmayerella americana*, n. sp., but consistently bears a narrower sulcus, while the dorsal valves of the two forms are markedly dissimilar.

Table 7.—Measurements (in mm) of type specimens of *Vitimetula parva*, n. gen. and n. sp. See p. 74 for explanations of abbreviations and subscripts.

	hinge width	maximum width	length	height/depth or thickness	specimen type
locality 15					
USNM 450290 (holotype)	4.8	6.3	6.0	10.2	a.v.
USNM 450291 (paratype)	5.5	5.5	8.2	6.2	v.v.
USNM 450292 (paratype)	5.4	5.4	3.8	4.5	v.v.
USNM 450293 (paratype)	6.0 _{he}	6.0 _{he}	3.5 _{bc}	6.3	v.v.
USNM 450294 (paratype)	3.6 _{he}	3.6 _{he}	3.7	4.2	v.v.
USNM 450295 (paratype)	5.5	5.5	5.0	1.0	d.v.
USNM 450296 (paratype)	7.0	7.0	4.8	1.5 _e	d.v.
USNM 450297 (paratype)	6.0 _b	7.2 _b	4.5 _c	2.2 _c	d.v.
USNM 450298 (paratype)	9.0 _b	9.0 _b	— _b	1.6	d.v.
USNM 103468d (paratype)	8.0	8.0	6.0 _e	4.8	v.v.

Family LABALLIDAE Dagys, 1962

Subfamily LABALLINAE Dagys, 1962

Genus ZUGMAYERELLA Dagys, 1963

Type species.—*Spiriferina koessenensis* Zugmayer, 1882, p. 28, pl. 3, figs. 2, 3, 5, 13.

Diagnosis.—Small to medium-sized laballines with high ventral valve, smooth, sharply differentiated fold and sulcus, and paucicostate flanks. Interior as for *Spondylospira* Cooper, 1942. Microornament of densely packed spines.

Occurrence.—*Zugmayerella* has been recovered from Norian strata in the Alps, the Carpathians, the Balkans, the Dinarides, Crimea, the Caucasus, northeastern U. S. S. R., Papua New Guinea, China, Tibet, New Zealand, and South America. In the present collections, *Zugmayerella* and a species questionably referred to that genus have been recovered from seven localities in Alaska, California, and Oregon, ranging in age from late Karnian to early Norian.

Comparison.—*Zugmayerella* may be distinguished externally from *Spondylospira* Cooper, 1942, by its smooth, rather than costate fold and sulcus. It differs from *Vitimetula*, n. gen. in its more transverse outline, broader sulcus, and presence of a dorsal fold. It differs from *Spinolepismatina* Dagys, 1974, and *Pseudolaballa* Dagys, 1974, in having a longitudinally ridged, rather than smooth interarea. It differs from *Klipsteinella* Dagys, 1974, in its denticulate hinge, and absence of a deltidium, and from *Laballa* Moisseiev in Dagys, 1962, by its denticulate hinge and by the strong plication of both valves. It differs from *Orientospira* Dagys, 1965, in its subpyramidal rather than globose shell form, and its comparatively high, narrow interarea. It differs from *Phenacozugmayerella*, n. gen. in its spinose, rather than capillate-cancellate microornament.

Discussion.—Placement of the genus *Zugmayerella* in the Laballidae rather than the Spondylospiridae is tentative. It was so assigned by Dagys (1962), and the critical characters of the ventral apex necessary to dis-

tinguish between the two families are not well-shown in any of the specimens of *Zugmayerella* available for this study. It is, however, possible that better preservation in specimens recovered in the future may dictate that this genus be placed in the Spondylospiridae with the other genera described in this paper. *Zugmayerella* was originally distinguished from *Lepismatina* Wang, 1955 (Dagys, 1963, pp. 99–100) on the basis of its ridged interarea and resultant denticulate hinge, features which Dagys believed were not shared by *Lepismatina*. Later examination by Sun (1981) of topotypic material of *Lepismatina* revealed that *Lepismatina* does not belong in the Laballidae, but rather in the Spiriferinidae.

One character common to known species of *Zugmayerella* is spinose microornament (Dagys, written commun., 1990). This character, though mentioned in the original diagnosis of the genus (Dagys, 1963), was not there accorded the importance brought out by later observations (Dagys, written commun., 1990). The spines in *Zugmayerella* are small and easily broken, and a pustulose surface microornament is commonly the result. Pearson (1977, p. 23), in one of the few comprehensive discussions of the genus in English, states that the shell surface is "pustulose, possibly spinose." It is this character that, among others, sets this genus apart from the new genus *Phenacozugmayerella*, in which the cancellate microornament is formed by beaded capillae.

Zugmayerella americana, new species

Plate 11, figures 33–50; Plate 12, figures 1–5

Description.—Small, unequally biconvex shells having high, pyramidal ventral and shallow bowl-like dorsal valves. Ventral sulcus and dorsal fold only slightly developed. Microornament of densely-packed spines.

Ventral valve semicircular in ventral aspect, triangular in anterior aspect. Depth commonly subequal to shell width, slightly less than height. Median sulcus shallow, rounded, bounded laterally by large plicae.

Table 8.—Measurements (in mm) of type specimens of *Zugmayerella americana*, n. sp. See p. 74 for explanations of abbreviations and subscripts.

	<i>hinge width</i>	<i>maximum width</i>	<i>length</i>	<i>thickness</i>	<i>specimen type</i>
locality 3					
USNM 450305 (paratype)	5.8 _h	5.8 _h	4.1	4.0	v.v.
locality 20					
USNM 450299 (paratype)	4.8 _h	6.0 _h	4.1	3.9	v.v.
USNM 450300 (paratype)	6.2	6.8	4.4	4.5 _{be}	v.v.
USNM 450301 (paratype)	11.8	13.2	10.0	9.1	v.v.
USNM 450302 (paratype)	10.5	14.1	10.3	3.4	d.v.
USNM 450303 (paratype)	8.8	13.3	12.3	3.2	d.v.
locality 21					
USNM 450304 (paratype)	7.5	8.4	6.5	4.3	v.v.
locality 28					
USNM 450306 (holotype)	5.4	5.4	5.1	4.4	a.v.
USNM 450307 (paratype)	7.9 _h	7.9 _h	4.6	4.7	v.v.
USNM 450308 (paratype)	4.6	7.6	6.1	4.6	v.v.
USNM 450309 (paratype)	9.6 _b	12.0	10.0	9.8	v.v.
USNM 450310 (paratype)	12.1	14.1	10.0	9.7	v.v.
USNM 450311 (paratype)	10.0	11.3	7.6	3.2	d.v.
USNM 450312 (paratype)	7.9 _c	11.6	8.8	2.3	d.v.
USNM 450313 (paratype)	10.6	11.6	10.0	2.6	d.v.

Flanks bearing four to six prominent plications. Interearea sharply recurved posteriorly at apex, otherwise flat; entire surface vertically ridged, ridges terminating as denticles at hinge. Delthyrium open, narrow. Hinge denticulate; primary teeth absent, anterior portions of dental plates may be marginally functional in articulation.

Dorsal valve quadrate to transverse or semicircular in dorsal aspect, broadly rounded in anterior or lateral aspects. Umbo tiny, not produced posterior to hingeline. Median fold low, square-shouldered, medially depressed; bordered laterally by four to six prominent rounded plications; fold commonly lower than adjacent plicae. Plicae originating from central portion of hingeline, but not from mesially-located "point-source" beak.

Ventral interior generally reflecting exterior macroornament. Thin median septum extending one-half to two-thirds valve length, may be asymmetric with respect to sulcus. Dental plates united with median septum just below its crest, forming small spondylium. Muscle scars indistinct.

Dorsal interior with simple, anteroposteriorly striate surface. Median septum present. Hingeline anteroposteriorly elongate, may be slightly curved mesially. Hinge sockets present, probably marginally functional in articulation. Low median myophragm present or absent, if present extending about one-half valve length. Descending branches of spire joined to valve floor at about mid-length of valve, united anteriorly to that point by simple jugum.

For measurements, see Table 8.

Diagnosis.—Small *Zugmayerella* with pyramidal,

comparatively high ventral valve, shallow, flat-bottomed ventral sulcus and low, mesially depressed dorsal fold, and four to six lateral plications. Dorsal umbo not produced posterior to hingeline.

Occurrence.—*Z. americana*, n. sp. has been recovered in this study from rocks ranging in age from middle late Karnian [zone UC2 of Tozer (1980)] to earliest Norian [zone LNo1 of Tozer (1980)], at localities 3 (California, ?Hosselkus Formation, Eastern Klamath terrane, ≈zone UC2 of Tozer (1980), based on associated fauna), 13 (Alaska, Wrangellia terrane, age unknown), 20 (Alaska, beds transitional between Chitstone and Nizina formations, Wrangellia terrane, zone LNo1 of Tozer (1980), based on associated fauna), 21 [Oregon, Martin Bridge Formation, Wallowa terrane, zone UC3 of Tozer (1980), based on associated fauna], and 28 (Oregon, Martin Bridge Formation, Wallowa terrane, zone LNo1 of Tozer (1980), based on associated fauna). All specimens recovered are silicified. The fine preservation of this form wherever it is found and its comparatively wide distribution, coupled with its relatively short stratigraphic range, combine to make it a fine potential biostratigraphic index. Etching of material in suitable matrix should provide usable specimens of this small but important form.

Types.—Holotype, USNM 450306; figured paratypes, USNM 450300–450302, USNM 450305, USNM 450308, USNM 450309, USNM 450311, USNM 450313; measured paratypes, USNM 450299–USNM 450313.

Comparison.—*Zugmayerella americana*, n. sp. may be distinguished from most known species of the genus by its lower fold and shallower sulcus, and by lacking

a dorsal umbonal bulge that projects posterior to the hingeline. It is smaller and less globose than *Z. eurea* Dagys, 1965, *Z. inaequiplicata* Dagys, 1965, or *Z. koessenensis* Zugmayer, 1882. It is smaller and has more lateral plications than does *Z. hemipyramida* Sun, 1981, and is smaller, and has plications that are less angular than those of *Z. uncinata* (Schafhäutl, 1851). It is smaller, narrower, and lacks the characteristic rib in the sulcus and furrow on the fold that are characteristic of *Z. osmana* (Bittner, 1902).

Among the other North American cyrtinoid spiriferinaceans, it is easily distinguished from specimens of *Phenacozugmayerella mimuncinata*, n. sp., by its smaller size and less acute plications and by the lack of spinose ornament in the latter form. From all the species of *Spondylospira* Cooper, 1942, and from *Pseudospondylospira perplexa*, n. gen. and n. sp., *Dagyspirifer fascicostata*, n. gen. and n. sp., and *Vitimetula parva*, n. gen. and n. sp., it is distinguished by its apparent lack of pedicle foramina in the ventral valve.

The small shell of *Zugmayerella americana*, n. sp. is most similar to *Z. yueliangpingica* Ching and Feng, 1977 from the Upper Triassic of Gueizhou, China, from which it differs in size. The latter form, described on the basis of only four specimens, two ventral external molds, and one dorsal external mold, and one dorsal internal mold, ranges from 15 to 20 mm wide, while the largest known specimen of *Z. americana* is just over 14 mm wide.

Discussion.—*Zugmayerella americana*, n. sp. belongs to the only cosmopolitan cyrtinoid genus among those described in this report. Its close similarity to the Chinese *Z. yueliangpingica* Ching and Feng, 1977 may suggest origin via trans-Pacific dispersal.

Zugmayerella species

Plate 12, figure 34

Discussion.—A single silicified dorsal valve [USNM 450317] assignable to *Zugmayerella*, but not confidently associated with any species, shows the supporting structures of the brachidium in best detail. The descending branches of the spire extend anterodorsally from the hingeline and contact the valve floor at about midlength. A simple jugum unites the branches anteriorly. It was recovered from locality 1 [California, ?Hosselkus Formation, Eastern Klamath terrane, zones UC1–LNo2 of Tozer (1980), based on stratigraphic position].

Measurements (in mm)*.—Hinge width, 10.6_{he}; valve width, 10.6_{he}; valve length, 8.8_{be}; valve height, 5.0.

Type.—Figured specimen, USNM 450317.

Table 9.—Measurements (in mm) of specimens of *Zugmayerella?* sp. A. See p. 74 for explanations of abbreviations and subscripts.

	hinge width	maxi- mum width	length	height	speci- men type
locality 3					
USNM 450315	11.2 _c	17.6 _h	15 _c	— _b	v.v.
locality 12					
USNM 450314	10.5	14.2	12.7	11.6	v.v.
USNM 450316	17.5 _c	24.1 _c	13.7 _c	11.3 _c	v.v.

Zugmayerella? species A

Plate 12, figures 25–33

Discussion.—Three partial ventral valves (one silicified, two calcareous) of a new species here questionably assigned to *Zugmayerella* were recovered from localities 3 [California, ?Hosselkus Formation, Eastern Klamath terrane, ≈zone UC2 of Tozer (1980), based on associated fauna] and 12 (Oregon, ?Martin Bridge Formation, Wallowa terrane, age unknown). All appear to have been somewhat decorticated, but represent a pauciplicate form with a smooth broad sulcus and very faint lateral plications. The rarity and the poor preservation of this form make formal species designation unwarranted here, and the lack of unequivocally preserved microornament make generic identification questionable.

For measurements, see Table 9.

Types.—Figured specimens, USNM 450314, USNM 450315; measured specimens, USNM 450314–USNM 450316.

Genus **PHENACOZUGMAYERELLA**, new genus

Etymology of name.—Gr. *phenax* = cheat, impostor, + *Zugmayerella*.

Type species.—*Phenacozugmayerella mimuncinata*, n. sp.

Diagnosis.—Medium-sized laballines with high ventral valve, smooth, sharply differentiated fold and sulcus, narrow denticulate hinge, and paucicostate flanks. Surface microornament cancellate, with capillae broken into transverse bars by growth increments (Text-fig. 5).

Occurrence.—As for species.

Comparison.—*Phenacozugmayerella* is perhaps most easily confused with *Zugmayerella* Dagys, 1963, from which it differs in its microornament, which is capillate–cancellate rather than densely spinose. In this respect it also differs from most other laballids, except aspinose forms like *Yanospira* Dagys, 1977, which differs in having a duplex interarea, with the central portion ridged, and the outer part smooth, and by being more transverse. It may be distinguished from *Spondylospira* Cooper, 1942, by its smooth, rather than

* see p. 74 for explanations of abbreviations and subscripts.

Table 10.—Measurements (in mm) of type specimens of *Phenacozugmayerella mimuncinata*, n. gen. and n. sp. See p. 74 for explanations of abbreviations and subscripts.

	hinge width	maximum width	dorsal valve length	total length	thickness	interarea height	specimen type
locality 31							
CASG 66248.03 (paratype)	14.5	19	15	19.5	18.5	11.5	a.v.
CASG 66248.04 (paratype)	19	21.5	15	20	18	12	a.v.
CASG 66248.06 (paratype)	13	15	10	12.5	13 _c	10.5 _c	a.v.
locality 32							
CASG 66249.01 (paratype)	9.5	9.5	5.5	7.5	6.5	6.0 _c	a.v.
CASG 66249.02 (paratype)	11.5	13.5	10.5	10.5	11.0 _b	10.0 _c	a.v.
locality 34							
CASG 66250.01 (paratype)	15	17	16	21	17	9	a.v.
CASG 66250.02 (holotype)	18.5	20	12.5	21.5	17	12.5	a.v.
locality 35							
CASG 66251.02 (paratype)	19	19	14	17	15.5	10	a.v.
CASG 66251.03 (paratype)	17	20	18.5	20 _c	19	12 _c	d.v.
locality 36							
CASG 66252.01 (paratype)	20	21	15	18.5	16.5	13	a.v.

costate fold and sulcus, and from *Vitimetula*, n. gen., *Dagyspirifer*, n. gen., and *Pseudospondylospira*, n. gen., by its equidimensionally pyramidal plicate shell, and from all of these by its apparent lack of a functional pedicle.

Discussion.—Assuming (with Dagys, 1974) that the nature of the microornament in cyrtinoid spiriferinaceans is relatively important in distinguishing among the various genera, *Phenacozugmayerella* is probably most closely related to *Yanospira* Dagys, 1977, from the Norian of Okhotsk, U. S. S. R.

Phenacozugmayerella mimuncinata, new species

Plate 12, figures 6–24

Zugmayerella uncinata (Schafhäütl). Stanley, 1979, p. 14 [as *Z. incinata*], pl. 8, figs. 10–12] (non *Spirifer uncinata* Schafhäütl, 1851, p. 135, pl. 24, fig. 33).

Etymology of name.—Gr. *mimos* = actor + *uncinata*.

Description.—Shell small- to medium-sized, unequally biconvex, with pronounced dorsal fold and ventral sulcus. Fold height about two to four, commonly two, times the height of adjacent plicae. Flanks of both valves corrugated by radial plicae that expand distally; plicae of less magnitude laterally. Fold and sulcus subrounded to subrounded in section; commonly shallowly plicated, rarely interrupted mesially by one or two faint radial plicae. Valve outline in ventral aspect quadrate, with straight lateral margins that converge slightly anteriorly, and mesially incurved anterior margin. Outline in dorsal aspect transverse with rounded anterior margin in small specimens, becoming quadrate in larger, apparently more mature individuals. Outer shell layer commonly not preserved; where pre-

served, surface micro-ornament of radial capillae, composed of obliquely-disposed transverse bars formed by the intersection of capillae with growth lines, the two elements of microornament together presenting a finely cancellate surface. Three to five, most commonly three plicae on either side of fold on dorsal valve, one or more on ventral. Hinge width subequal to maximum shell width.

Ventral valve deep, varying from about one-half to four-fifths of hinge width in height. Valve length and width, and shell thickness all subequal, but variable. Interarea high, triangular, with narrow to moderately broad triangular delthyrium; interarea surface longitudinally ridged, ridges fine, extending dorsal to hinge as fine denticles; denticles fitting into articulatory recesses along hinge of opposite valve. Interarea flat, catacline to apsacline, angle to commissural plane measured through shell 90° to about 110°, most commonly about 100°. Ventral apex of ventral beak commonly hooked posteriorly in last few mm.

Dorsal valve comparatively shallow, with fold providing curved quadrate section in lateral view. No interarea exposed, but short low beak extending about 1 mm beyond the hinge line in well-preserved specimens. Lateral plicae not straight, but gently curved and concave distally.

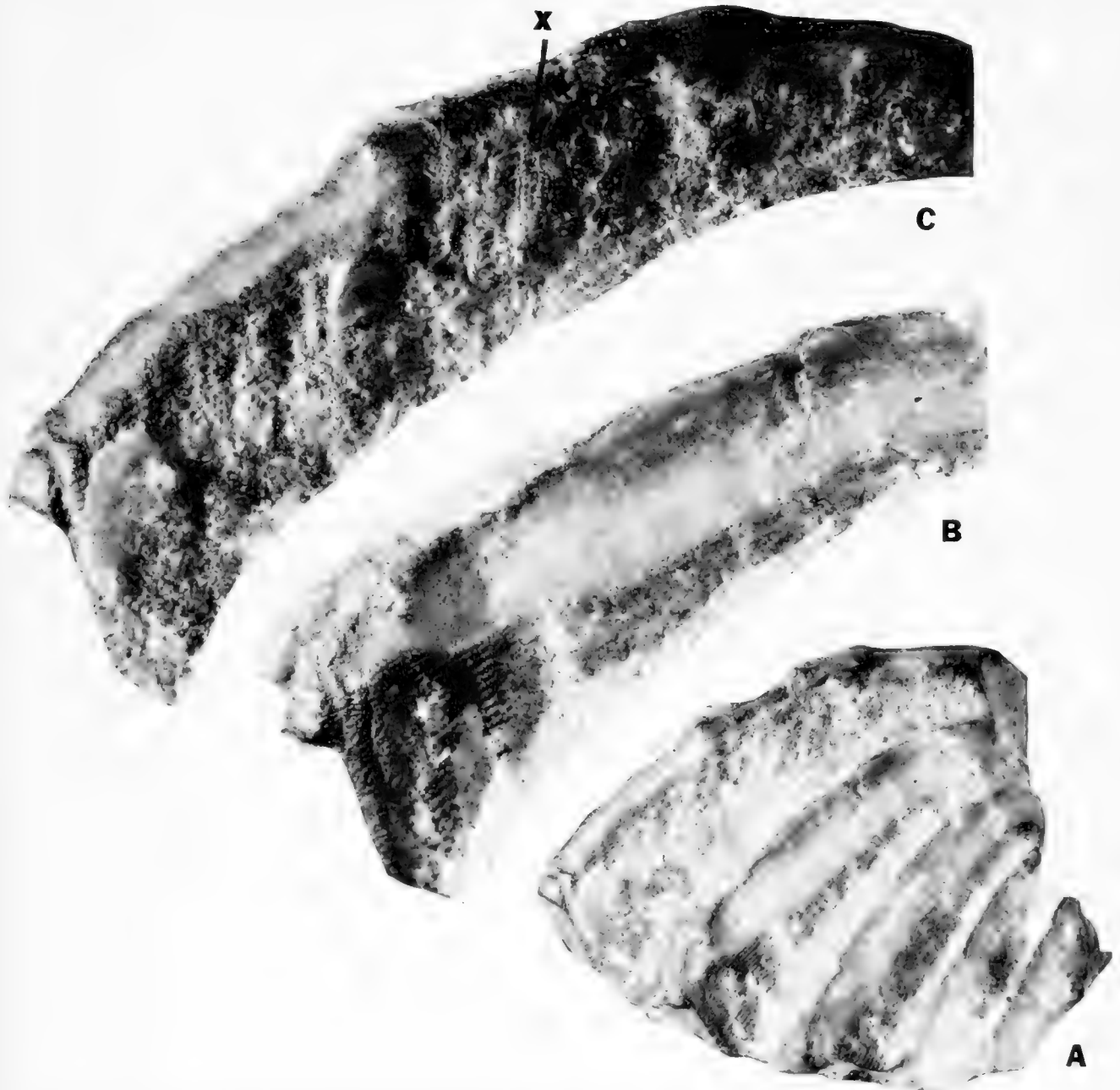
Ventral interior with strong median septum extending along valve floor about one-half valve length, rising anteriorly as a thin blade. Apparent dental plates joining inner margins of delthyrium to about mid-height of median septum, to form spondylium; median septum continuing posterior to spondylium as thin blade not quite reaching plane of interarea surface. Muscle scars indistinct. Interior surface plicate, reflecting exterior macro-ornament.

Dorsal interior with minute notothyrium and hinge-line bearing row of anteroposteriorly elongate fossae that accommodate ventral valve hinge denticles.

For measurements, see Table 10.

Occurrence.—*Phenacozugmayerella mimuncinata*, n. sp. is apparently endemic to North America. In the present collections it has been recovered from rocks ranging in age from late Karnian to middle Norian [zones UC1 through MNo2 of Tozer (1980)], at localities 6 [Alaska, Alexander terrane, zones UC1–UC3 of Tozer (1980), based on associated fauna], 32 [Nevada,

Osobb Formation, Triassic cover on the Golconda Allochthon, zones LNo1–LNo3 of Tozer (1980), based on stratigraphic position], 33 [Nevada, lower member of Luning Formation, Paradise terrane, zone LNo1 of Tozer (1980), based on fauna at this stratigraphic level], 34 [Nevada, upper member of Luning Formation, Paradise terrane, zone LNo3 of Tozer (1980), based on stratigraphic position], 35 [Nevada, Luning Formation, Paradise terrane, zone LNo3 of Tozer (1980), based on associated fauna], 36 [Nevada, Luning Formation, Paradise terrane, zone LNo1 of Tozer (1980),



Text-figure 5.—Posterodorsolateral views of portions of a dorsal valve of *Phenacozugmayerella mimuncinata*, n. gen. and n. sp., CASG 66250.02 (holotype, from loc. 36), showing (a) the five folds on one flank, $\times 8$; (b) the surface microornament of beaded capillae on the next-to-the-top fold, $\times 17$; and (c) the capillate and capillate-cancellate (x) surface microornament on the top fold.

based on fauna at this stratigraphic level], 37 [Nevada, lower Luning Formation, Paradise terrane, zones LNo1–LNo2 of Tozer (1980), based on fauna at this stratigraphic level], 38 [Nevada, Luning Formation, Paradise terrane, zones LNo1–MNo2 of Tozer (1980), based on stratigraphic position], 45 [Nevada, Jungo terrane, zone MNo2 of Tozer (1980), based on associated fauna], 48 [Oregon, Brisbois Formation, Izee terrane, zones UC1–UC3 of Tozer (1980), based on stratigraphic position], 49 [Oregon, Brisbois Formation, Izee terrane, zones UC1–UC3 of Tozer (1980), based on stratigraphic position], and 51 [Oregon, Brisbois Formation, Izee terrane, zones UC1–UC3 of Tozer (1980), based on stratigraphic position].

Diagnosis.—Small to medium-sized pauciplicate

Phenacozugmayerella with acute-angled plications and distinct, comparatively large fold and sulcus.

Types.—Holotype, CASG 66250.02; figured paratypes, CASG 66248.03–CASG 66248.05, CASG 66249.01, CASG 66249.02, CASG 66250.01, CASG 66251.02, CASG 66252.01; measured paratypes, CASG 66248.03, CASG 66248.04, CASG 66248.06, CASG 66249.01, CASG 66249.02, CASG 66250.01, CASG 66251.02, CASG 66251.03, CASG 66252.01.

Comparison.—*Phenacozugmayerella mimuncinata*, n. sp. is the only species of the genus, and is most easily confused with *Zugmayerella uncinata* (Schafhäütl, 1851), from which it differs in its capillate–cancellate surface micromerit, and in lacking the duplex interarea that is characteristic of that species.

APPENDIX

LOCALITIES CITED IN THIS REPORT

Locality information from specimen labels (not enclosed in square brackets) in many cases has been enhanced by comparison of original register entries, field labels, maps, notebooks, more recent topographic maps, and geologic maps and reports. Such additions appear in brackets. Zonal abbreviations refer to the zonation for the Triassic presented by Tozer (1980, Table II; see Table 1 herein) and have been assigned by N. J. Silberling (written commun., 1989). Terrane assignments were made by comparison of map position with those in the “Folio of the Lithotectonic Terrane Maps of the North American Cordillera” [U. S. Geological Survey, Miscellaneous Field Studies Maps, MF-1874-A (Jones *et al.*, 1987), MF-1874-B (Monger and Berg, 1987), and MF-1874-C (Silberling *et al.*, 1987)], and by consultation with N. J. Silberling (written commun., 1989). Locality numbers as used in this report (see also Text-fig. 1) are followed by the field number, in parentheses.

Locality 1 (USGS loc. 2309).—California, [Shasta Co., Bollibokka Mtn. 15' quad.]; E. line of sec. 30, T. 34 N., R. 1 W.; on both sides of Little Cow Creek [= Little Cedar Ck.], just below mouth of Bear Gulch; Collectors: [J.] Storrs and [C.] Washburne, August 8, 1901. [formation not given, probably Hosselkus Fm.; zones UC1–LNo2 of Tozer (1980), based on stratigraphic position; Eastern Klamath terrane].

Locality 2 (USGS loc. 2314).—California, Shasta Co., [Burney 30' quad.] near ctr., sec. 20, T. 34 N., R. 1 W.; 5 mi NE of Furnaceville; Collectors: [J.] Storrs and [C.] Washburne, August 8, 1901. [formation not given, probably Modin Fm.; zones MNo1–UNo2 of Tozer (1980), based on associated fauna; Eastern Klamath terrane]

Locality 3 (USGS loc. 2446).—California, Shasta Co., [?Millville 15' quad.] on Toll Road by Cedar Creek, 10½ mi [?] below [west of] Round Mtn.; Collectors: J. S. Diller and J. Storrs, June, 1892. [formation not given, probably Hosselkus Fm.; about zone UC2 of Tozer (1980), based on associated fauna; Eastern Klamath terrane]

Locality 5 (USGS loc. 2769).—California, Shasta Co., [?Big Bend 15' quad.] 5 mi. E. of Grizzly Peak, W. face of Table; bed of s. s. d cong.; Collector: J. Storrs, June 19, 1903. [Formation not given, Luning Formation (based on lithology); zones LNo1–UNo3 of Tozer (1980), based on associated fauna; Eastern Klamath terrane]

Locality 6 (USGS loc. 10548).—Alaska, Southeast, Screen Islands, [?1:63,360 quad.]; Clarence Strait, west coast of Etolin Island, 35' of dark gray limestone 400' thick; Collector: E. M. Anderson, 1905. [Formation not given; zones UC1–UC3 of Tozer (1980), based on associated fauna; Alexander terrane]

Locality 7 (USGS loc. 11406).—Alaska, Southeast, [Port Alexander D-1 1:63,360 quad.]; west side of Keku Straits, 7 mi NW of Pup Island, Kuiu Islands; Collector: A. F. Buddington, 1922. [Cornwallis Limestone; zones UC1–LNo1(?) of Tozer (1980), based on associated fauna (Muffler, 1967, p. C34); Alexander terrane]

Locality 8 (USGS loc. 11814).—Nevada, [Mineral Co.,] Hawthorne [1° quad., T. 7 N., R. 35 E., N. 65° E. from Mina, first limestone exposure in Dunlap Gulch; Collectors: [H. G.] Ferguson, [S. H.] Cathcart, Heiges and [T. W.] Stanton, July 13, 1923. [Lower member of the Luning Formation, zone LNo1 of Tozer (1980), based on associated fauna (sponges); Paradise terrane]

Locality 10 (USGS loc. 13354).—Nevada, [Mineral Co.,] Hawthorne 1° quad.; Gabb's Valley Range, S. of Mayflower Ball Mill E. of Road, 100'–200' above top of blue limestone with small amount of brown sandy material; Collector: H. G. Ferguson, September 2, 1925. [Middle member of Gabb's Formation, zones UNo2–UNo3 of Tozer (1980), based on associated fauna; Paradise terrane]

Locality 12 (USGS loc. 15550).—Oregon, [Wallowa Co.,] Imnaha River, [Harl Butte 15' quad.]; NE¼, sec. 15, T. 2 S., R. 48 E., isolated outcrop over more or less ½ square mile area; Collectors: [R. W.] Richards and [B. N.] Moore, August 14, 1930. [formation not given, ??Martin Bridge Fm.; no information on stratigraphic position; Wallowa terrane]

Locality 13 (USGS loc. 16266).—Alaska, South Central, Nutzotin Mtns., [Nabesna C-5 1:63,360 quad.]; Long. 143°10' W.; Lat. 62°35' N.; head of tributary of Jack Creek that lies directly S. of Bear Ck. glacier, Copper River Region; Collector: F. H. Moffitt, August 30, 1931. [formation not given; Wrangellia terrane]

Locality 15 (USGS loc. 17424).—Idaho, [Nev Perce–Lewis Co. line, Culdesac 15' quad.]; about 6 mi up Mission Ck. from Jaques R. R. Station, past St. Joseph's Mission and Slickpoo Settlement, at first narrows of Mission Creek, collection from black limestone abt. 70' above water, E. side of ck.; Collectors: J. Reed and J. S. Williams, June 17, 1936. [formation not assigned, zones UNo1–UNo3 of Tozer (1980), based on associated fauna [the brachiopods (Cooper, 1942) and gastropods (Haas, 1953) suggest a Norian–Rhaetian age. Stanley (1979) notes that many of the coral species are not known elsewhere]

in North America, but have been reported from the Zlambach beds (Norian) of Fischerweise, Austria. He states (p. 27) that he has "chosen tentatively to regard the Lewiston locality as Upper Norian," but that "no diagnostic ammonites have been discovered, and the age of the known fauna is equivocal."; Wallowa terrane]

Locality 16 (USGS loc. 24387).—Peru, Atacocha Dist.; Dept. of Pasco; Machican Mine area; Collectors: R. F. Johnson and R. W. Lewis, 1952. [formation not given, = Chambara Fm. of Pucará Gp.; zones UC1–UNo3 of Tozer (1980), based on associated fauna; terrane unknown]

Locality 18 (USGS loc. M96).—Nevada, Pershing Co., [Buffalo Mtn. 15' quad.;] NE¼, sec. 5, T. 26 N., R. 34 E., and sec. 32, T. 27 N., R. 34 E.; along strike of beds at base of limestone cliffs, approx. ¾ mi S. to ½ mi W. of Nevada Quicksilver [= Juniper] mine; Collectors: N. J. Silberling, R. E. Wallace, W. P. Irwin, 1956. [formation not given, but = Antelope Springs Fm. of Oldow, Bartel, and Gelber (1990); zone LNo3 of Tozer (1980), based on associated fauna; Jungo terrane]

Locality 20 (USGS loc. M1708).—Alaska, Wrangell Mtns., McCarthy B–5 1:63,360 quad.; on west side of East Fork Valley just E. of largest patch of Cretaceous capping Green Butte Ridge; Collector: N. J. Silberling, July 7, 1962. Transitional beds between Chitstone and Nizina formations. [zone LNo1 of Tozer (1980), based on associated fauna; Wrangellia terrane]

Locality 21 (USGS loc. M1749).—Oregon, [Wallowa Co.,] Wallowa Mtns., Enterprise 15' quad.; ctr. of W½ of boundary line bet. sec. 3, T. 3 S., R. 44 E., and sec. 34, T. 2 S., R. 44 E.; elev. ca. 6240' on W. side of Hurricane Ck., about 1 mi N. of Little Granite Ck.; Collector: B. Nolf [Oregon State Univ.], 1962. Martin Bridge Formation. [zone UC3 of Tozer (1980), based on associated fauna; Wallowa terrane]

Locality 22 (USGS loc. M1906).—Alaska, Southeast, Keku Strait, Port Alexander [D–1 1:63,360] quad.; NE side of Cornwallis Peninsula ca. 1 mi E. of Point 5600' S. 85° E. from triangulation station Corn; silicified fauna in medium to thick-bedded limestone; Collector: L. J. P. Muffler, June, 1963. Cornwallis Limestone. [Silberling, written commun., 1963 (cited by Muffler, 1967, p. C30, table 2) dates this locality as of "uncertain age in the Late Triassic," based on "scleractinian corals and (or) the spiriferid brachiopod *Spondylospira*; arcestd or clydonitacid ammonites." He later (written commun., 1989) assigned it to zones UC1–UNo of Tozer (1980), based on associated fauna; Alexander terrane]

Locality 23 (USGS loc. M1911).—Alaska, Southeast, [Keku Strait, Port Alexandria D–1 1:63,360 quad.]; S. side of small cove of E. shore, Kuiu Island, 1.5 mi SSE, or 8300' S. 19° E. from triangulation station "Low"; silicified fauna from 185' above base of limestone; Collector: N. J. Silberling, June, 1963. Cornwallis Limestone. [Silberling, written commun., 1963 (cited by Muffler, 1967, p. C30, table 2) dated this locality as "latest Karnian or earliest Norian," based on the occurrence of species of *Halobia* and *Mojsisovicites*. He later (written commun., 1989) assigned it to zone LNo1 of Tozer (1980), based on associated fauna; Alexander terrane]

Locality 24 (USGS loc. M1917).—Alaska, Southeast, Keku Strait; Port Alexander D–1 1:63,360 quad.; NE shore of Kuiu Island ca. 3½ mi SE of Pt. Cornwallis; 17,950' S. 69° E. from triangulation station CORN; impure limestone 20–30' above base of limestone; Collectors: N. J. Silberling, L. J. P. Muffler, June 27, 1963. [Cornwallis Limestone; Silberling (written commun., 1963, cited by Muffler, 1967, p. C28, table 1) dated this locality as of "uncertain age within the Late Triassic," based on "scleractinian corals and (or) the spiriferid brachiopod *Spondylospira*, [and] arcestd or clydonitacid ammonites". He later (written commun., 1989) assigned it to zones UC1–LNo2 of Tozer (1980), based on stratigraphic position; Alexander terrane]

Locality 25 (USGS loc. M1919).—Alaska, Southeast, Keku Strait, Port Alexander D–1 1:63,360 quad.; E. shore Kuiu Island 0.5 mi

SSE, or 2500' S. 23° E. from triangulation station LOW; impure limestone interstratified with mafic tuff, but below main body of Triassic volcanics; Collector: N. J. Silberling, June 29, 1963. Hound Island Volcanics. [Silberling (written commun., 1963, cited by Muffler, 1967, p. C30, table 2) dated this locality as "latest Karnian or earliest Norian," based on species of *Halobia* or *Mojsisovicites*. He later (written commun., 1989) assigned it to zones UC2–LNo1 of Tozer (1980), based on associated fauna; Alexander terrane]

Locality 26 (USGS loc. M2135).—Alaska, Southeast, Keku Strait, Port Alexander D–1 1:63,360 quad.; easternmost tip of islet in NW Keku Islets, 4.41 mi S. 78.5° E. from triangulation station CORN; dense thick-bedded limestone at tidal level; Collector: L. J. P. Muffler, 1963. Keku Volcanics; Silberling (written commun., 1963, cited by Muffler, 1967, p. C28, table 1) dated this locality as of "uncertain age within the Late Triassic," based on scleractinian corals and (or) the spiriferid brachiopod *Spondylospira*, and arcestd or clydonitacid ammonites. He later (written commun., 1989) assigned it to zones LC1–UNo2 of Tozer (1980), based on associated fauna; Alexander terrane]

Locality 27 (USGS loc. M2136).—Alaska, Southeast, Keku Strait, Port Alexander D–1 1:63,360 quad.; on S. side of islet in SE Keku Straits, 1 mi SE of triangulation station THUM, 1.03 mi N. 34° E. from triangulation station LOW; Collector: [L. J. P.] Muffler, 1963. Cornwallis Limestone. [Silberling (written commun., 1963, cited by Muffler, 1967, p. C30, table 2) dated this locality as of "uncertain age in the Late Triassic," based on "scleractinian corals and (or) the Spiriferid brachiopod *Spondylospira*; [and] arcestd or clydonitacid ammonites." He later (written commun., 1989) assigned it to zones UC1–UNo of Tozer (1980), based on stratigraphic position; Alexander terrane]

Locality 28 (USGS loc. M2672).—Oregon, [Wallowa Co.,] Homestead 1:62,500 quad.; Oregon side of Snake River Canyon, elev. 2970' on N. side McGraw Ck., abt. 0.85 mi NW from its mouth, abt. 200' about base of limestone unit; Collector: T. L. Vallier, June 25, 1964. [Martin Bridge Fm.; Silberling (cited in Vallier, 1967, pp. 246–247) assigned this locality to zone LNo1 of Tozer (1980), based on the occurrence of the ammonoid *Tropiceltites* cf. *T. columbianus*; Wallowa terrane]

Locality 29 (GSC loc. 10229).—Canada, Yukon Territory, Lake Laberge area ca. 61° N. lat.; 135° W. long.; High ridge of banded appearance 4 mi NE of Braeburn road house; from interbedded coral reef; Collector: E. J. Lees, 1930. [probably Formation "F", Lewes River Gp.; see note under loc. 31, below; Stikine terrane]

Locality 30 (GSC loc. 23418).—Canada, Yukon Territory, Lake Laberge area. East side of Lake Laberge (Loc. 11 of G. S. C. Bull. 43) [61°15'25" N. lat.; 135°12'9" W. long.]; Formation "F", Lewes River group; Collector: E. T. Tozer, 1953. [See note under loc. 31, below; Stikine terrane]

Locality 31 (GSC loc. 23462).—Canada, Yukon Territory, Lake Laberge area; East side of Lake Laberge (Loc. 10 of G. S. C. Bull. 43) [61°14'55" N. lat., 135°11'26" N. long.]; Formation "F", Lewes River group; Collector: E. T. Tozer, 1953. [Tozer (1958, p. 19) assigns this and other localities in Formation "F" of the Lewes River group in the Lake Laberge area to "late Norian (mid-Upper Triassic) [sic]" and cites the occurrence there of several species of pelecypods in association with *Spondylospira lewesensis* (Lees, 1934). This age call is apparently based on general similarity of the fauna to an assemblage "widely distributed in southern Yukon and in British Columbia west of the Rocky Mountain Trench." He specifically cites similarities to the fauna of the Tyaughton group of southern British Columbia, which occurs on the west coast of Vancouver Island in "beds overlying shales with *Monotis subcircularis*." Silberling (written commun., 1989) assigns this locality to zone UNo2 of Tozer (1980), based on associated fauna; Stikine terrane]

Locality 32 (LSJU loc. 720-C).—Nevada, Lander Co., [Cain Mountain 15' quad.; Augusta Mountains] "W. slope of S. end of

Lone Peak [Cane or Boundary Peak of 40th Parallel Survey], immed. beyond the divide of the first deep canyon S. of Jenkins Ranch; beds lie conformably on Carboniferous? limestone [= Upper Triassic Cane Spring Formation]; fossils from top of 500' thick zone, beginning 60' above ?Carb. [Upper Triassic] lst.]; Collector: S. W. Muller, September, 1928. [Osobb Formation; zones LNo1-LNo3 of Tozer (1980), based on stratigraphic position; Triassic cover on the Golconda Allochthon]

Locality 33 (LSJU loc. 724).—Nevada, Mineral Co., Hawthorne [1° quad., Pilot Mtns.; Dunlap Canyon, 3 mi up from the mouth of the canyon on the W. side of the canyon; Collector: S. Muller, April, 1928; September, 1934; September, 1935. [lower member of Luning Fm.; zone LNo1 of Tozer (1980), based on fauna at this stratigraphic level; Paradise terrane]

Locality 34 (LSJU loc. 764).—Nevada, Mineral Co., Hawthorne [1° quad.; Pilot Mtns.; E. of Mina, abt. 1 mi S. of the mouth of Dunlap Canyon, abt. 1750' due S. of a rhyolite knob; impure limestones faulted against slates; Collector: S. Muller, May, 1932. Upper member of Luning Formation. [zone LNo3 of Tozer (1980), based on stratigraphic position; Paradise terrane]

Locality 35 (LSJU loc. 800-B).—Nevada, Nye Co., [Ione 15' quad., T. 12 N., R. 39 E. (unsurveyed)]; about 1 mi from the mouth of Union Canyon, E. side; Collector: S. Muller, September, 1930. Luning Formation. [zone LNo3 of Tozer (1980), based on associated fauna; Paradise terrane]

Locality 36 (LSJU loc. 844).—Nevada, Mineral Co., Hawthorne and Tonopah [1° quads.; Pilot Mtns., Dunlap Canyon; lower limestone near coral bed; Collector: S. Muller, September 12, 1934. Luning Formation. [zone LNo1 of Tozer (1980), based on fauna at this stratigraphic level; Paradise terrane]

Locality 37 (LSJU loc. 872).—Nevada, Mineral Co., Hawthorne and Tonopah [1° quads.; Pilot Mtns., between Cinnabar and Dunlap Canyons at the boundary of the two quads.; low hills between the two canyons N. of the prominent, andesite, rhyolitic hill; Collector: S. Muller, September, 1934. [lower Luning Formation; zones LNo1-LNo2 of Tozer (1980), based on fauna at this stratigraphic level; Paradise terrane]

Locality 38 (LSJU loc. 1014).—Nevada, Mineral Co., Tonopah [1° quad., Pilot Mtns.; Cinnabar Canyon, near mouth of first tributary from the east, above the "Slate Gorge"; Collector: S. Muller, 1936. Luning Formation. [zones LNo1-MNo2 of Tozer (1980), based on stratigraphic position; Paradise terrane]

Locality 39 (LSJU loc. 1377).—Nevada, Pershing Co., "Lovelock [1° quad. [Buffalo Mountain 15' quad.]; abt. 16 mi E. of Lovelock, abt. 1 mi SW of Nevada Quicksilver Mine; brownish thinly laminated shales and gray limestones"; Collectors: Muller, Bush, Johnston, [E. T.] Schenk and [H. E.] Wheeler, June-July, 1930. [same as loc. 18, formation not given, but = uppermost Hollywood Fm. of Oldow, Bartel, and Gelber (1990); zone LNo3 of Tozer (1980), based on associated fauna; Jungo terrane]

Locality 40 (LSJU loc. 1517).—Nevada, Mineral Co., Hawthorne and Tonopah [1° quads.; Pilot Mtns., Cinnabar Gulch, abt. 1½ mi above the Slate and Cg. Gorge, last exposure of Upper Triassic limestone before getting back into Slate and Congl.; Collector: S. W. Muller, September, 1934. Luning Formation. [zone LNo3 of Tozer (1980), based on stratigraphic position; Paradise terrane]

Locality 41 (LSJU loc. 2336-A).—Nevada, Lander Co., Sonoma Range [1° quad. [Cain Mountain 15' quad.]; Augusta Mtns., 2½ mi SE of Jenkins Ranch, T. 25 N., R. 39 E., 400-500' above base of

unit; Collector: S. W. Muller, date unknown. [Osobb Formation, zones LNo2-LNo3 of Tozer (1980), based on stratigraphic position; Triassic cover on the Golconda Allochthon]

Locality 42 (LSJU loc. 2348).—Nevada, Pershing Co., Sonoma Range [1° quad. [Rose Creek 15' quad.]; East Range, N. end, at the head of Rose Ck., elev. 100' above base of limestone; Collector: S. W. Muller, August, 1940. [Dun Glen Formation; zone LNo3 of Tozer (1980), based on associated fauna; Triassic cover on the Golconda Allochthon]

Locality 43 (LSJU loc. 2546).—Nevada, Pershing Co., Sonoma Range [1° quad. [Cain Mountain 15' quad.]; Augusta Mtns., 2½ mi SE of Jenkins Ranch, abt. 400-500' above base of the unit; Collector: S. W. Muller, date unknown. ?Winnemucca Formation [on strike with loc. 41; zones LNo2-LNo3 of Tozer (1980), based on stratigraphic position; Triassic cover on the Golconda Allochthon]

Locality 44 (LSJU loc. 2970).—California, Shasta Co., Big Bend 15' quad.; [NE¼NE¼SW¼, sec. 25, T. 38 N., R. 1 W.; Alder Creek Trail, abt. ½ mi N. of confluence with Devil's Canyon] Collector: A. F. Sanborn, 1950. Modin Formation, Devil's Canyon Member. [zones UNo1-UNo3 of Tozer (1980), based on associated fauna; Eastern Klamath terrane]

Locality 45 (LSJU loc. 3148).—Nevada, Churchill Co., [Shoshone Meadows 15' quad.]; N. end of Clan Alpine Range, Shoshone Ck., ¼ mi N. of the road at a point 1.8 mi down the creek from Shoshone Springs; coral bed abt. 200' below the limestone ledge; Collectors: [E.] Blackwelder, Sahni, [N. J.] Silberling, August 8, 1952. [formation not given; zone MNo2 of Tozer (1980), based on associated fauna; Jungo terrane]

Locality 47 (Field No. HC341).—Oregon, Wallowa Co., Jim Creek Butte [15' quad.; NE cor., sec. 1 [unsurveyed], T. 5 N., R. 47 E.; 45°56'38" N., 116°52'55" W.; crest of ridge on N. side of Coon Creek; limestone lens in Seven Devils volcanics; Collector: G. C. Simmons, 1974. [Martin Bridge Formation; zones LNo1-MNo2 of Tozer (1980), based on associated fauna; Wallowa terrane]

Locality 48 (Field No. 56-133).—Oregon, [Crook Co.,] Suplee area, NE¼NE¼, sec. 2, T. 18 S., R. 25 E.; isolated limestone knob 750' WNW of road cut 2700' N. of Camp Ck. crossing; limestone conglomerate stratigraphically below point estimated 1800' above base of Brisbois Formation; Collectors: S. W. Muller, [W. R.] Dickinson, [L. H.] Vigrass, 1956. Brisbois Formation. [zones UC1-UC3 of Tozer (1980), based on stratigraphic position; Izee terrane]

Locality 49 (Field No. 56-135).—Oregon, [Crook Co.,] Suplee area; NW cor., NE¼, sec. 1, T. 18 S., R. 25 E.; limestone outcrop 1000' E. of Camp Creek on summit of short arcuate E/W ridge; prob. same horizon as 56-133 [loc. 48]; Collectors: [S. W.] Muller, [W. R.] Dickinson, [L. W.] Vigrass, 1956. Brisbois Formation. [zones UC1-UC3 of Tozer (1980), based on stratigraphic position; Izee terrane]

Locality 51 (Field No. 57-417).—Oregon, [Crook Co.,] Suplee area; W boundary, SE¼NE¼, sec. 23, T. 17 S., R. 25 E., 100' SE of "Paulina telephone" located at junction of Paulina-Suplee road with road to A. Bernard Ranch house; about 700' above base of unit; Collector: L. W. Vigrass, 1957. Brisbois Formation. [zones UC1-UC3 of Tozer (1980), based on stratigraphic position; Izee terrane]

Locality 53 (Field No. 77-S-111).—Alaska, South Central, Alaska Range, Upper Chulitna district, Healy (A-6) quad.; limestone and pillow basalt unit on crest of secondary spur on SW side of valley of the W. fork of the Chulitna River, 3.80 km S. 89° E. from VABM Joyce (6363); Collector: N. J. Silberling, 1977. [zone UC3 of Tozer (1980), based on associated fauna; Chulitna terrane]

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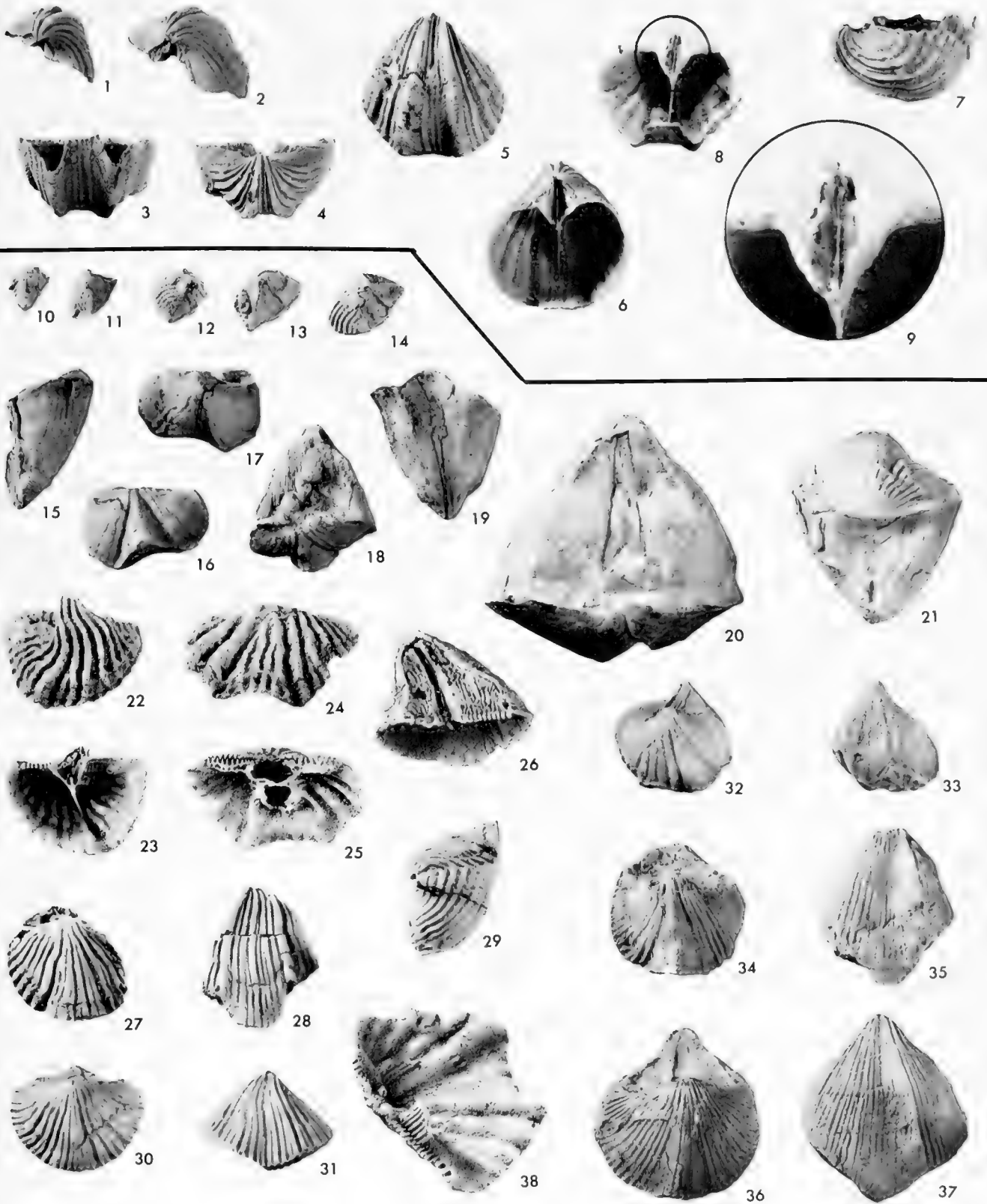
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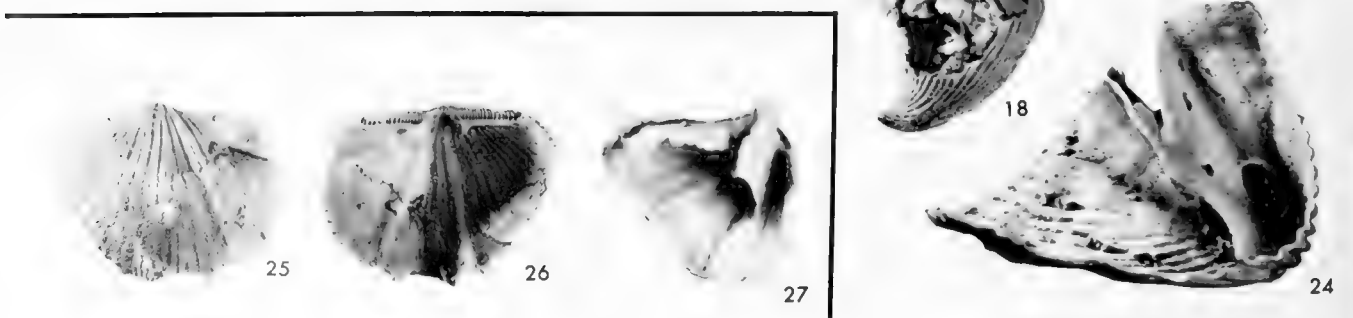
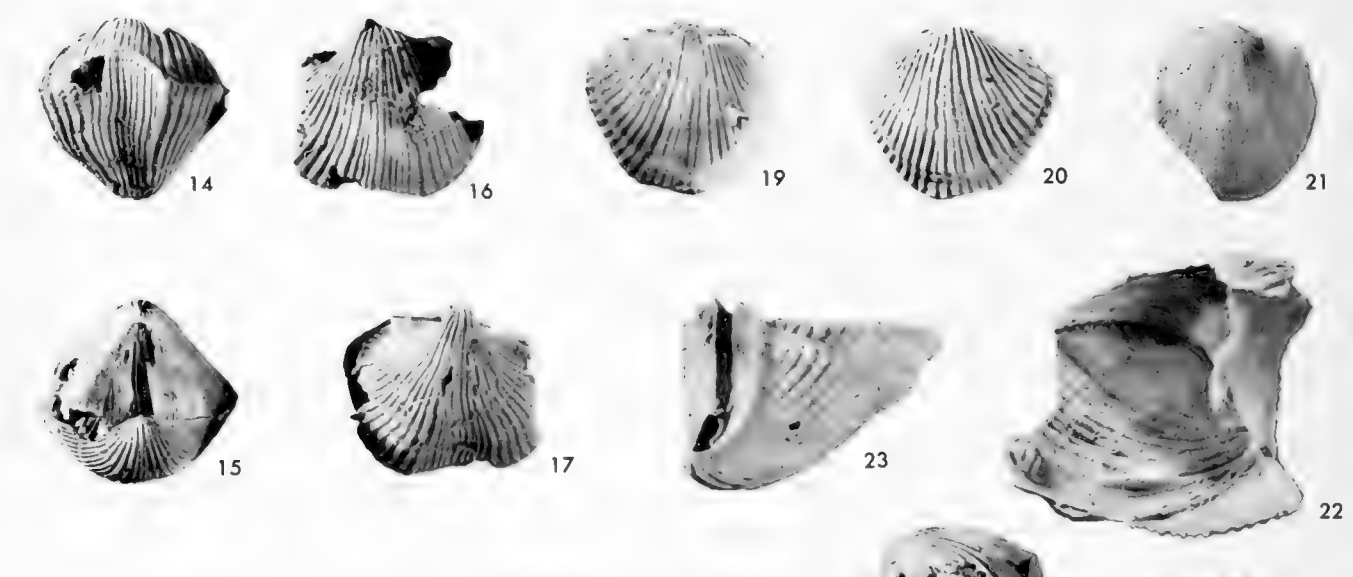
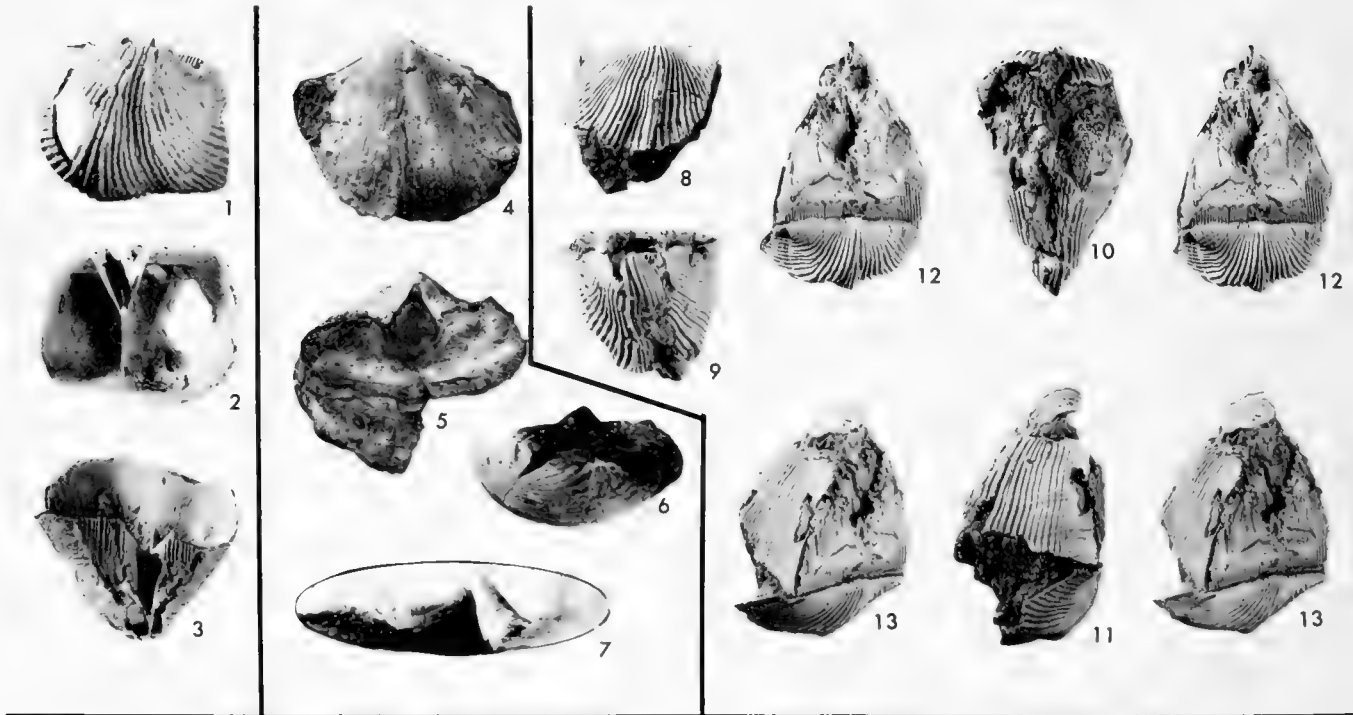
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PLATES

EXPLANATION OF PLATE 9

Figure	Page
1-9. <i>Dagyspirifer fascicostata</i> , new genus and new species	77
1, 2. Paratypes, ventral valves, posteroventrolateral views, $\times 1$, showing size and form of simulated partial ontogenetic series; (1) USNM 450274, and (2) USNM 450275, both from loc. 23.	
3-9. Holotype, ventral valve, (3) anterior, (4) posterior, (5) ventral, (6) dorsal (interior), (7) lateral, and (8) anterior (interior) views, $\times 1$, and (9) anterior (interior) view, $\times 3$, showing fascicostate ornament, globose shell form, small, ridged interarea, spondylospirid spondylium and paired, apical pedicle foramina; USNM 450276, from loc. 23.	
10-38. <i>Spondylospira lewesensis</i> (Lees, 1934)	81
10-14. Figured specimens, articulated valves, posteroventrolateral views, $\times 1$, showing size and form of simulated partial ontogenetic series; (10) CASG 66258.01, (11) CASG 66258.02, (12) CASG 66258.03, and (13) CASG 66258.04, all from loc. 45, and (14) CASG 66253.01, from loc. 39.	
15-19. Lectotype, partially decorticated articulated valves, (15) lateral, (16) dorsal, (17) ventral, (18) posterior, and (19) anterior views, $\times 1$, showing form, outline, and reflection of subdued internal ornament; GSC 9619, from loc. 30 [also figured as <i>Cyrtina lewesensis</i> Lees, 1934, p. 35, pl. 1, fig. 14]	
20. Paralectotype, partially decorticated articulated valves, posterior view, $\times 2$, showing reflection of internal surface of ridged interarea, and impression of mesial junction of cooperulum lateral plates; GSC 9619a, from loc. 30 [also figured as <i>Cyrtina lewesensis</i> Lees, 1934, p. 35, pl. 1, figs. 15, 16].	
21. Chorotype, partially decorticated articulated valves, posterior view, $\times 1$; on dorsal valve showing contrast between strong ornament of shell surface and subdued ornament on cast of internal surface; on ventral valve showing cooperulum of two lateral plates, with ridged interarea exposed adcommissurally, and apical pedicle opening; GSC 69373, from loc. 30.	
22-26. Figured specimens. 22, 23, ventral valve [paratype of <i>Spondylospira reesidei</i> Cooper, 1942], (22) ventral and (23) dorsal (interior) views, $\times 2$, showing strong costae and asymmetric valve, USNM 103468f; 24, 25, dorsal valve [paratype of <i>Spondylospira reesidei</i> Cooper, 1942], (24) dorsal and (25) ventral (interior) views, $\times 2$, showing denticulate hinge, characteristic ornament of costae, weaker on fold than on flanks, increasing anteriorly by bifurcation in the fold, and descending branches of spire, anteriorly jugate, attached to valve floor by calcareous meshwork; USNM 103468b; (26) ventral valve [holotype of <i>Spondylospira reesidei</i> Cooper, 1942], posterior view, $\times 2$, showing ridged interarea, denticulate hinge, and slit-like apical pedicle foramina; USNM 103468a, all from loc. 15.	
27-29. Figured specimen [chorotype of <i>Spiriferina acrotamboensis</i> Körner, 1937], (27) dorsal, (28) anterior, and (29) lateral views, $\times 1$, showing characteristic form and ornament of a Peruvian specimen; USNM 450285, from loc. 16.	
30, 31. Figured specimen, decorticated articulated valves, (30) dorsal and (31) anterior views, $\times 1$, showing effect on ornament and outline of numerous costal bifurcations; CASG 66251.01, from loc. 37.	
32-37. Figured specimens, partially decorticated articulated valves, (32, 34, 36) dorsal and (33, 35, 37) anterior views, $\times 1$, showing variation in form and ornament in three specimens in a partial simulated ontogenetic series; (32, 33) CASG 66248.01, (34, 35) CASG 66248.02, and (36, 37) USNM 106521 [figured as <i>Spondylospira alia</i> (Hall and Whitfield, 1877) by Cooper (<i>in</i> Shimer and Shrock, 1944)], all from loc. 33.	
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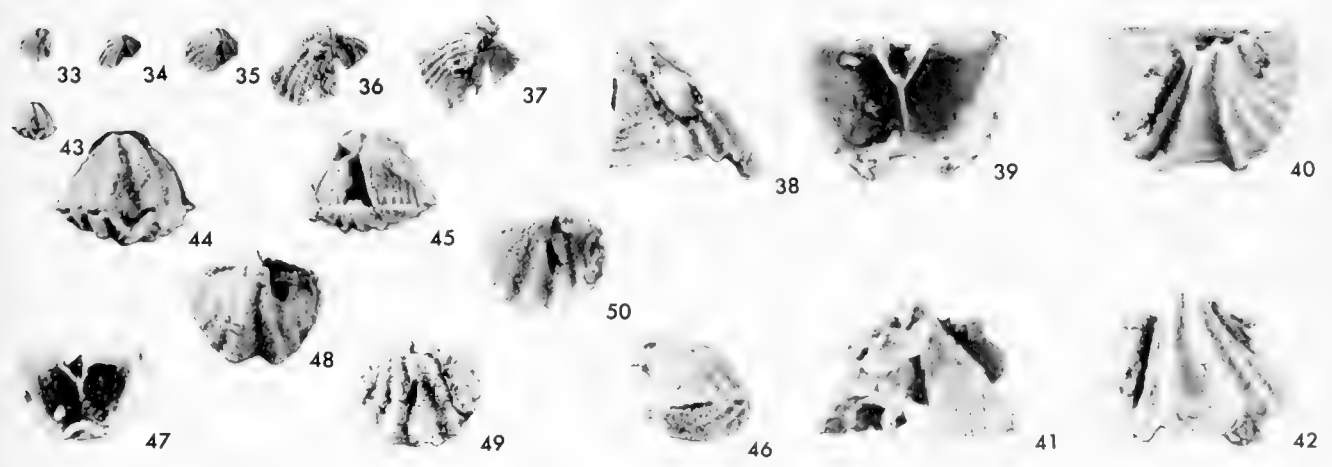
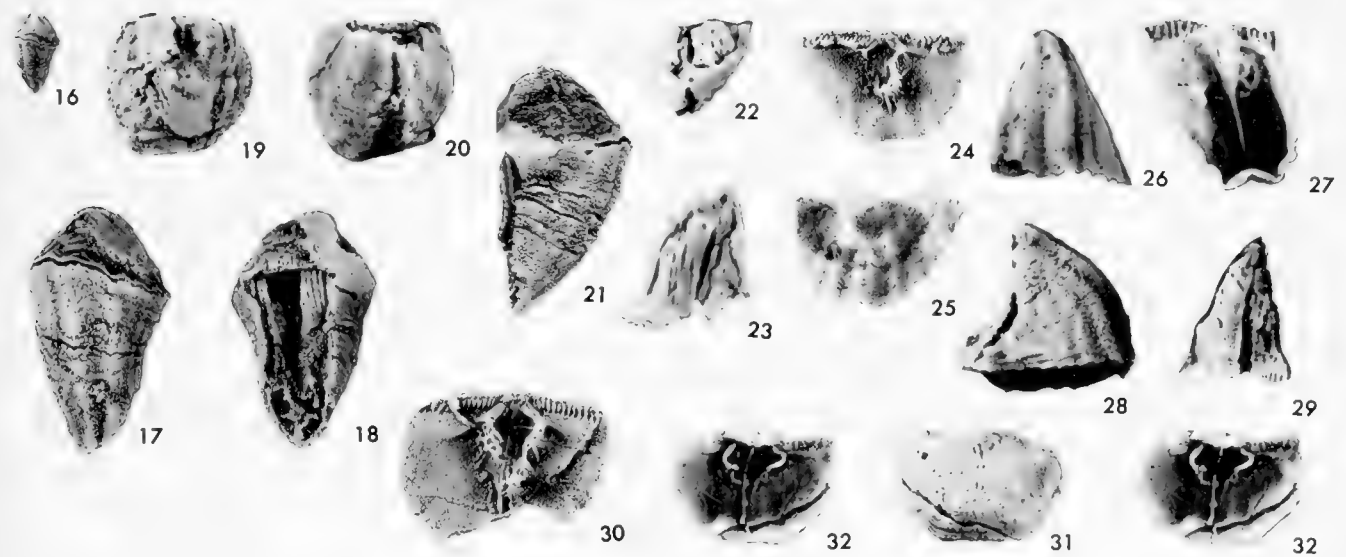
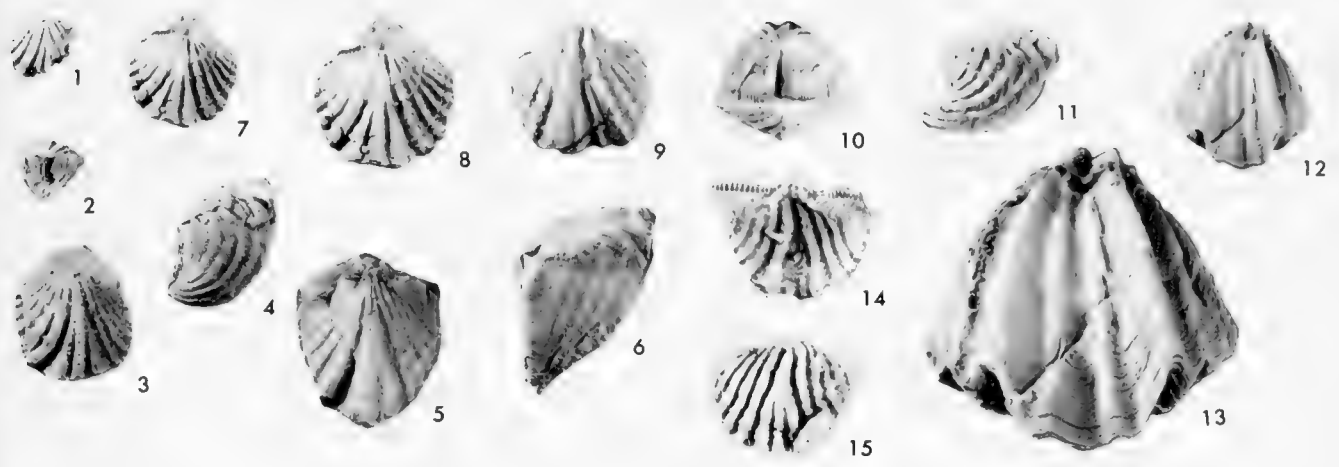


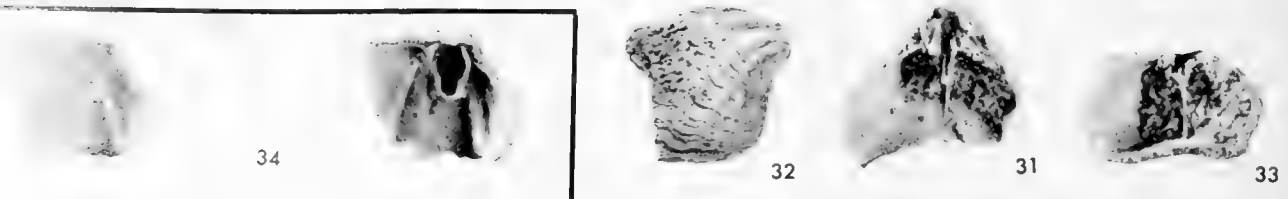
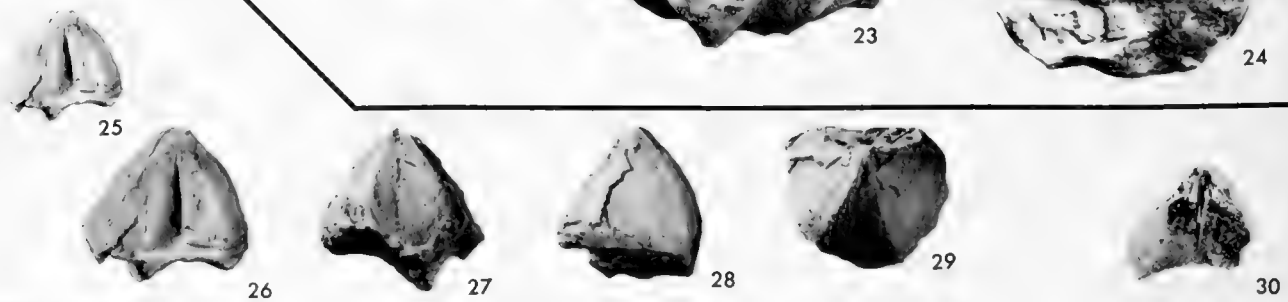
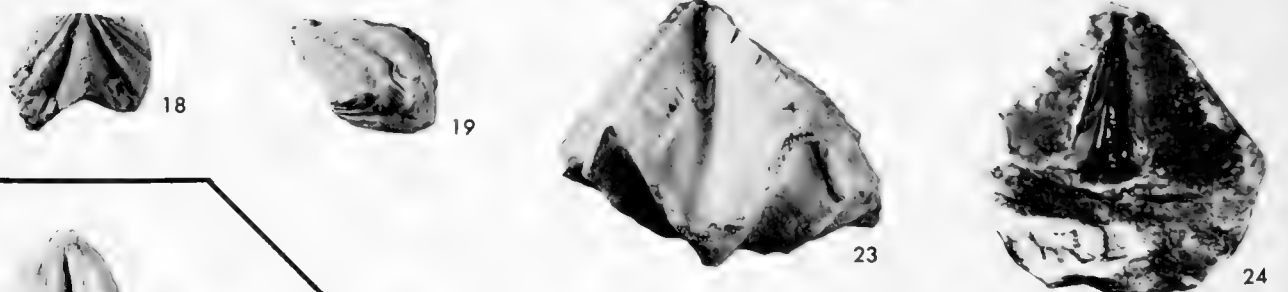
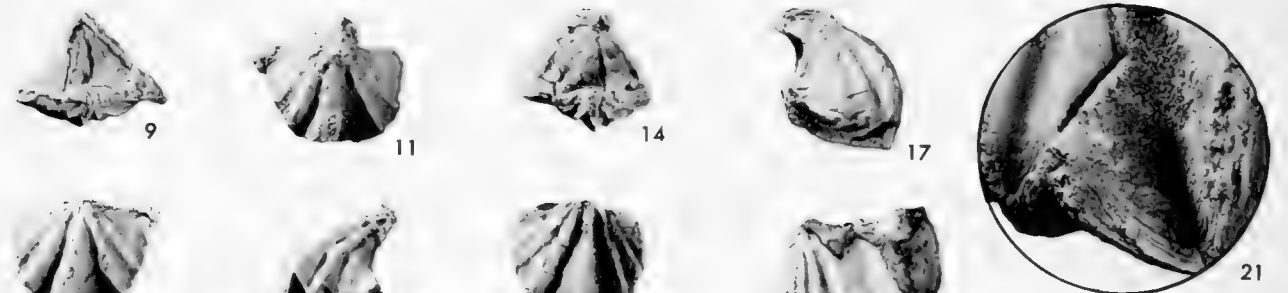
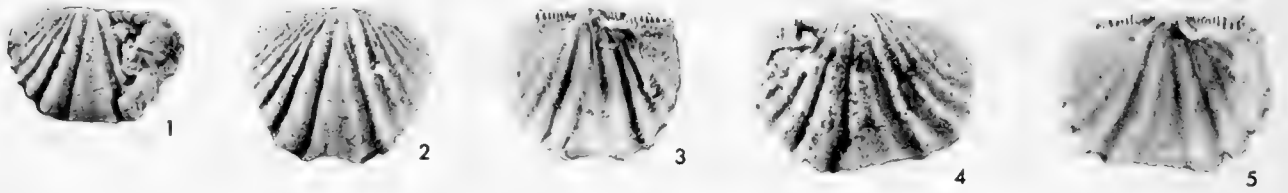
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