Early Silurian Graptolites From Southeastern Alaska and Their Correlation With Graptolitic Sequences in North America and the Arctic

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By MICHAEL CHURKIN, JR., *and* CLAIRE CARTER

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Descriptions and illustrations of 59 species of Graptoloidea and correlation of the assemblages with other graptolitic successions in North America, the Soviet Arctic, and Great Britain

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By MICHAEL CHURKIN, JR., and CLAIRE CARTER

ABSTRACT

A succession of graptolite faunas across the Ordovician-Silurian boundary has been discovered in North America. The earliest Silurian graptolite zones, characterized by the association of the biserial graptolites *Climacograptus*, *Glyptograptus*, and *Orthograptus*, established much earlier in the Ordovician—together with the first Silurian monograptids, *Akidograptus* and *Dimorphograptus*—are described for the first time in North America. These new collections of Lower Silurian graptolites are from dark shales in southeastern Alaska and Nevada. The occurrence of Silurian graptolites in western North America is reviewed, and the Alaskan graptolite faunas are correlated with other graptolitic successions in North America and the Soviet Arctic. The Alaskan graptolite species and zonal succession are remarkably similar to that in the Birkhill Shales of Scotland, the type section for the standard Lower Silurian graptolite zones. From Alaska, graptolite assemblages equivalent to the zones of *Akidograptus acuminatus*, *Monograptus cyphus*, and *Monograptus gregarius* are recognized and illustrated. In addition, the following new graptolite species are established: *Climacograptus indivisus esquibelensis*, *C. innotatus obesus*, *C. medius brevicaudatus*, *C. stenotelus*, *C. rectangularis abbreviatus*, *Diplograptus mucroterminatus*, *D. elongatus*, *Glyptograptus tamariscus magnus*, *G. lanpherei*, *G. laciniosus*, *G. gnomus*, *G. kayi*, *Orthograptus eberleini*, *O. insectiformis minutus*, *Dimorphograptus physophora alaskensis*, *Monograptus calamistratus*, *M. buddingtoni*, *M. noyesensis*, *M. kerri*, *M. hamatus*, *Rastrites orbitus*.

INTRODUCTION

Graptolite faunas, especially from black shale sequences bordering North America, show a remarkable similarity in species and faunal succession to the British graptolites made famous first by Charles Lapworth, then by Elles and Wood (1901–18). In Australia (Thomas, 1960), Asia (Sun, 1933; Hsü, 1934; Obut, 1959, 1960), and North Africa (Waterlot, 1945), where good graptolite sections are known, the similarity in species and succession of faunas above the initially somewhat provincial Lower Ordovician faunas is again remarkable. Despite the cosmopolitan character of graptolites, the lowest Silurian graptolite zones are relatively unknown outside of Great Britain. The lowest Silurian graptolite zones characterized by the association of biserial genera—such as the long-established Ordovician *Climacograptus*, *Glyptograptus*, and *Orthograptus* and the appearance of the new *Dimorphograptus* (proximally uniserial and distally biserial)—together with the first monograptids were not reported in Ruedemann's (1947) cataloging of North American graptolites.

More recently, Ross, (1962) described several lower Silurian species from Illinois, but they are fragmentary and poorly preserved. Another lower, but not lowest, Silurian graptolite collection that has beautifully preserved specimens was recently made from talus in a mine dump in Nevada (Kerr, 1962; Churkin and Kay, 1967). These graptolites are illustrated for the first time in this paper.

The senior author in the company of G. D. Eberlein and M. A. Lanphere made several discoveries of considerably older Silurian graptolite faunas in southeastern Alaska during the 1964 field season. Subsequently in 1965, new lower Silurian graptolite localities were found by Eberlein, A. T. Ovenshine, and Churkin. The most important of these localities was revisited by Churkin in 1968, and the highest Ordovician graptolites were found just below the previously known lowest Silurian faunas, thus establishing the Ordovician-Silurian boundary. The earliest Silurian graptolite zones are present in some of these localities—the first record of their occurrence in North America. The purpose of this paper is to describe this new material, briefly review the occurrence of Lower Silurian graptolites in western North America and the Soviet Arctic, correlate the Alaskan graptolites within these areas, and show the differences in associations of certain critical graptolite species that most likely reflect changes in their stratigraphic range from one region to another.

The biostratigraphic section is by Michael Churkin, and the systematic descriptions are largely by Claire Carter, who also did all of the camera lucida drawings of the graptolites.

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The authors are indebted to the collecting zeal of G. D. Eberlein, A. T. Ovenshine, M. A. Lanphere, and Charles Carter, without whose help this report would

not be possible; to G. D. Eberlein for much stratigraphic data on southeastern Alaska; to Marshall Kay for helping to collect the Nevada graptolites; to O. M. B. Bulman for pointing out literature on the British succession; to A. M. Obut for Soviet graptolite literature and helpful comments regarding comparisons with Asian species; to Dennis Jackson for the latest references covering western Canadian Silurian graptolite localities; to William Kerr and Hans Trettin for the latest Canadian Arctic graptolite locations; to W. B. N. Berry for examining the New species *Orthograptus eberleini* and for several helpful suggestions; to Kenji Sakamoto for tackling the difficult task of graptolite photography, and especially to Peter Toghill for making available his thesis covering the graptolites of the Birkhill Shales, for carefully examining the Alaskan and Nevadan graptolites, and for making numerous suggestions on their comparison with British graptolites, especially those from the Birkhill Shales.

GRAPTOLITES OF THE DESCON FORMATION, SOUTHEASTERN ALASKA

DESCRIPTION OF THE DESCON FORMATION

Silurian graptolites have long been known to occur in various parts of southeastern Alaska (Buddington and Chapin, 1929; Ruedemann, 1947; Muffler, 1967, p. C10). Most of these collections were made from isolated exposures of graptolitic shale during rapid reconnaissance mapping. These earlier field investigations, supported mainly by the paleontological studies of Edwin Kirk, Rudolf Ruedemann, and G. H. Girty, showed the completeness of the Paleozoic sequence in the vicinity of Craig on the northwest coast of Prince of Wales Island.

Eberlein and Churkin (1969) selected this area indicated in figure 1 for detailed geologic mapping and biostratigraphic study. The Lower Silurian graptolites that are described in this paper were collected during this mapping of the Craig B–4, C–4, C–5, C–6, and parts of the D–4 and D–5 quadrangles that are now being prepared for publication. All the Ordovician and Silurian graptolites within the Craig area occur in the Descon Formation of Early Ordovician through Early Silurian age (Eberlein and Churkin, 1969). In exception, graptolites of earliest Devonian age associated with vascular plants are known to occur in the lower part of the Karheen Formation on northeastern Noyes Island (Churkin and others 1969).

The Descon Formation is a thick sequence composed of marine predominantly graywacke-type coarse- and fine-grained rocks interbedded with basaltic volcanics that is the oldest known rock sequence exposed in the northwest coastal area of Prince of Wales Island (Eberlein and Churkin, 1969). The general distribution of these rocks is shown in figure 1, but they are known to extend much farther to the north and east on Kosciusko and Prince of Wales Island. Their extension to the south is imperfectly known, but it is likely that their metamorphic equivalents have been included in the Wales Group as mapped by Buddington and Chapin (1929).

Geologic mapping has demonstrated the practicality of informally subdividing the Descon Formation into five general lithofacies:

1. Graywacke sandstone and banded mudstone.
2. Conglomerate and sedimentary breccia.
3. Black chert and siliceous shale with minor lenses of limestone.
4. Basaltic volcanic rocks, including pillow basalt flows, breccia, volcanic conglomerate, and agglomerate.
5. Quartzo-feldspathic arenite.

These are interbedded and some of the clastic lithologies can be demonstrated to be distal or proximal equivalents of one another. Their designation as formal members may be called for eventually, but outcrop limitations have made it impossible to extend the units with sufficient confidence.

GRAYWACKE SANDSTONE AND BANDED MUDSTONE

These are the most widespread and quantitatively important lithologies of the Descon Formation. The graywacke is typically dark-greenish-gray massive medium- to coarse-grained compact poorly sorted sandstone composed mainly of relatively fresh mineral and intraformational rock fragments set in a chloritic matrix that has generally undergone some degree of mimetic recrystallization. Much of the graywacke is essentially a volcanic sandstone with the texture of a microbreccia that is composed mainly of intraformational basaltic debris and subordinate chert and mudstone fragments. Although beds of graywacke as much as 20 feet thick are common, they may range from a few inches to 150 feet or more in thickness. In many outcrops no bedding is apparent, but locally a crude stratification is manifest by interbeds and pebble strings of intraformational siltstone and banded mudstone. At some places even the coarser grained and thicker beds exhibit large-scale vertical grading. Cross laminae, when developed, are confined within parallel-bedded sets that rarely exceed 3 inches in thickness.

The banded mudstone interbedded with the graywacke occurs as thin-bedded intervals of olive-gray to grayish-black thin-layered siltstone and very fine to medium-grained dusky-yellow sandstone. Individual beds seldom exceed a few inches in thickness and most are less than 1 inch thick. Contacts between adjacent

beds are normally sharp and may show evidence of penecontemporaneous erosion. Cross laminations, confined to single beds, are not uncommon and many of the sets show excellent graded bedding. These rocks generally are indurated and lack fissility. The textural features and sedimentary structures of this lithofacies in the Descon Formation are similar to those in turbidites, which are commonly attributed to deposition from turbidity currents.

CONGLOMERATE AND SEDIMENTARY BRECCIA

Although quantitatively subordinate to graywacke, conglomerate and sedimentary breccia are just as widely distributed as the finer grained equivalents with which they are interbedded. Their composition is quite variable and ranges all the way from wholly volcaniclastic material to polymictic varieties with megaclasts of varicolored chert, limestone, felsic volcanics, and granitic to gabbroic rock types.

A common variety of conglomerate and breccia consists predominantly of porphyritic basaltic detritus rich in euhedral pyroxene crystals that is petrologically identical to the flows in the Descon Formation. Subordinate amounts of mudstone, graywacke, gray-green chert, and rare limestone make up the remaining megaclasts. In most places, 40 percent or less of indurated matrix is present, and the megaclasts tend to be in contact with one another. Sizing is poor and there tends to be a complete gradation from the coarsest to finest grained detritus, especially in oligomictic varieties. Locally, however, the largest fragments are completely separated by sand-size matrix. This is especially common in the basaltic sedimentary breccias.

BLACK CHERT AND SILICEOUS SHALE

An important, albeit comparatively minor, lithologic assemblage within the Descon Formation consists of thin-bedded black to dark-gray chert and siliceous siltstone with black shale partings. The importance of this facies derives mainly from the fact that it occurs interbedded with all the other lithologies, and its shaly interbeds have proved to be a good source of well-preserved graptolites excellent for dating and correlation. Individual chert beds range in thickness from a fraction of an inch to as much as 6 inches, but most are ½–1 inch thick. Locally, lenses of laminated medium-dark-gray limestone as much as 3 feet thick and beds of graywacke and chert arenite several inches thick are also present.

Because these fine-grained rocks commonly preserve graptolites, it is fortunate they have such a large areal, as well as stratigraphic, distribution. On the southwest shore of Heceta Island, good exposures occur 2.3 and 3.3 miles northwest of Point Desconocida (fig. 1). Excellent exposures also occur on the islands at the north and south entrances to Big Salt Lake, where the chert and siliceous shale are interbedded with fragmental basaltic volcanics and graywacke. Other occurrences that have yielded useful graptolite collections are on the east shore of Steamboat Bay (Noyes Island), the northeast shore of Noyes Island, Esquibel Island, the west coast of Anguilla Island, and in the Harmony Islands.

QUARTZO-FELDSPATHIC ARENITE

Gritstone and medium- to fine-grained sandstone, rich in feldspar and commonly containing 5–10 percent of detrital quartz, locally occur interbedded with graywacke and banded mudstone of the Descon Formation.

Typically, these rocks are poorly sized, massive, compact, quartzo-feldspathic arenites that tend to weather to orange brown within the tidal zone. Fresh surfaces are medium gray to various shades of pistachio green, due mainly to the development of epidote in the matrix. Individual beds range in thickness from several inches to 20 feet or more. The thicker beds in some places exhibit a poorly developed parallel internal stratification and may show very crude grading. The principal constituents are angular grains of pale-green and gray chert, broken crystals of twinned plagioclase, and broken, partly rounded euhedra of clear quartz, which are ubiquitous but rarely exceed 15 percent of the rock by volume.

VOLCANIC ROCKS

Flows and associated fragmental volcanics, in the form of agglomerate and flow breccia, appear sporadically throughout the Descon Formation. The interbedded graptolite shales imply that repeated volcanism occurred from different centers during Early Ordovician through Early Silurian time.

The lavas are predominantly medium-olive-gray porphyritic, vesicular, and amygdaloidal basalts. Stubby phenocrysts of diopsidic augite, locally as much as 10 mm in diameter, are set in a groundmass of small granular augite, plagioclase microlites (generally in the range An_{35}–An_{48}), and chloritic alteration products, probably derived in part from former glass. Thus, these rocks have the petrographic characteristics of basalts except that the plagioclase normally is andesine rather than labradorite or bytownite (G. D. Eberlein, oral commun., 1968).

STRATIGRAPHIC RELATIONS TO OTHER UNITS AND AGE

The base of the Descon Formation is not exposed in the area studied. In the Heceta-Tuxekan Islands area,

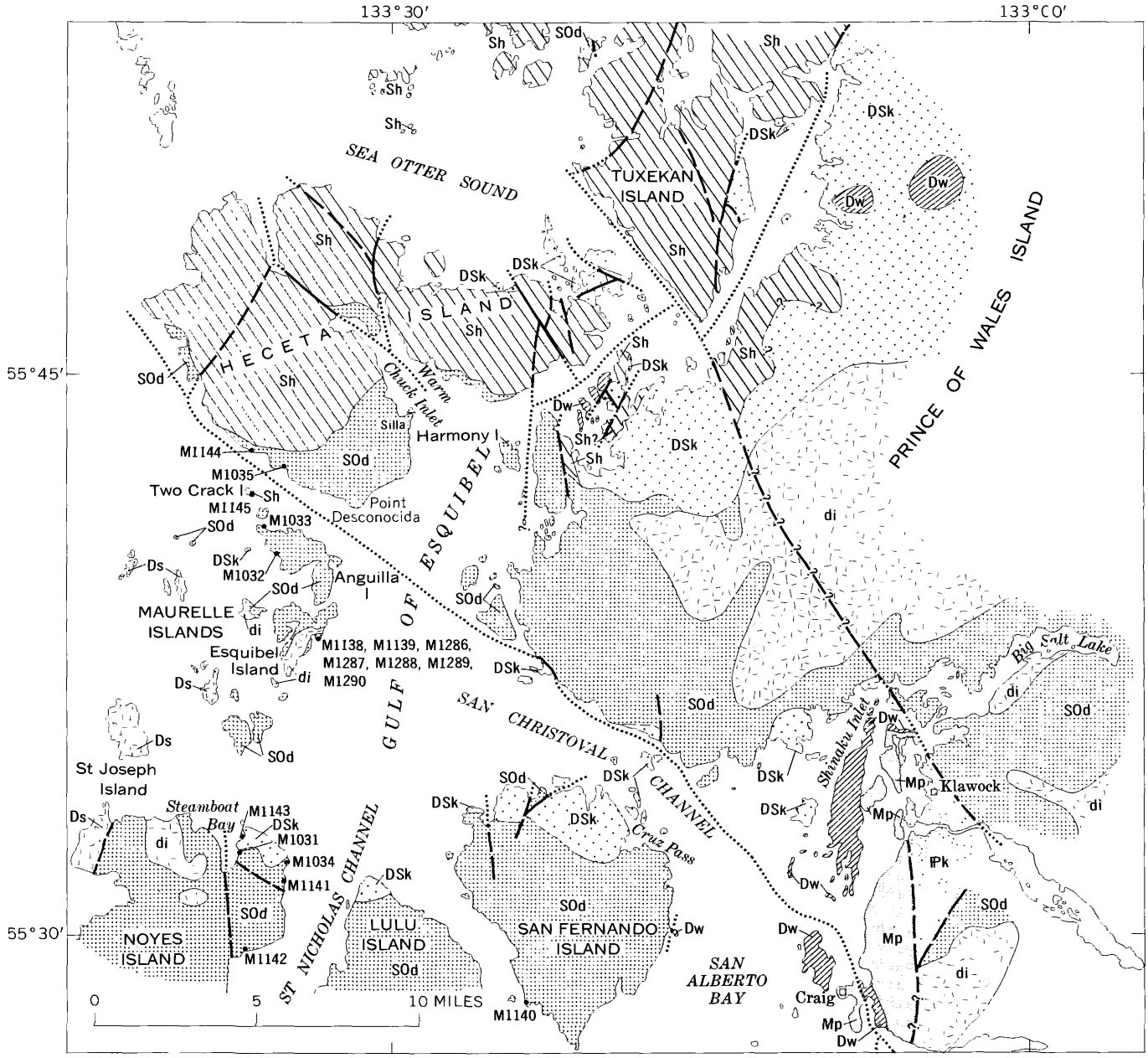
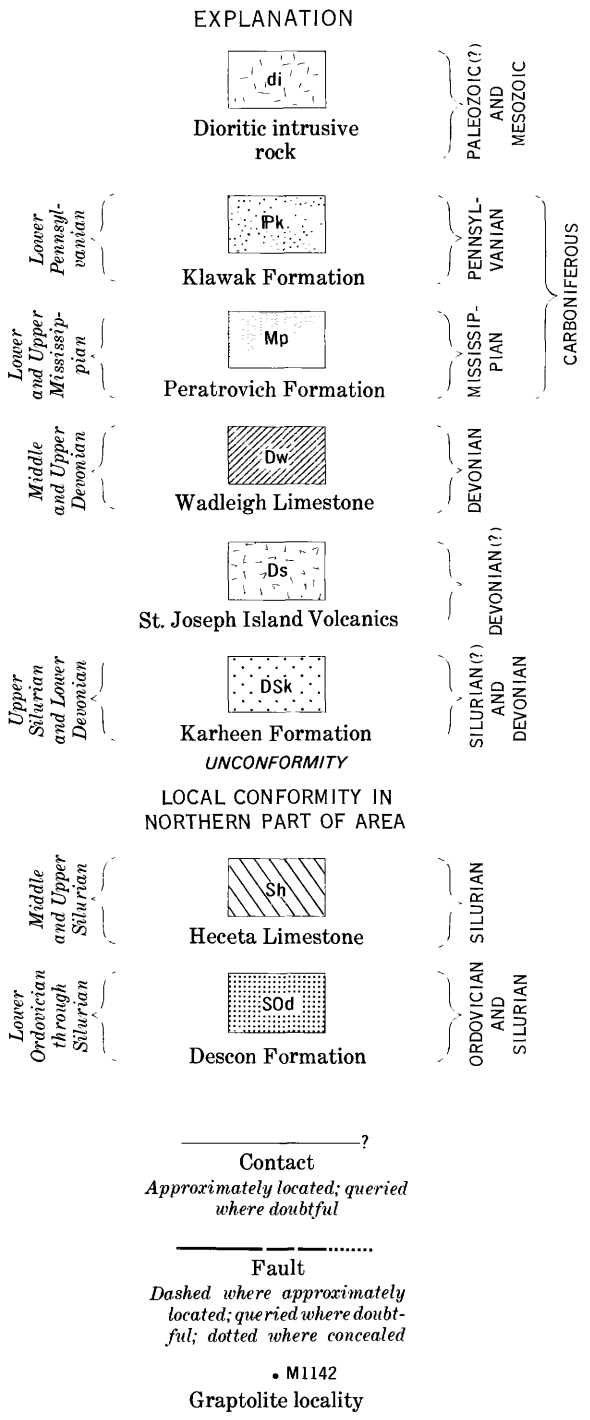


FIGURE 1.—Northwest coastal area of Prince of Wales Island (modified from Eberlein and Churkin, 1969).

Descon conglomerate and graywacke are overlain conformably by the Heceta Limestone (Eberlein and Churkin, 1969). At the south end of Two Crack Island, the Heceta Limestone rests upon deformed dark-gray calcareous siltstone and siliceous shale with thin interbeds of fine-grained graywacke and silty limestone. South of the Harmony Islands, where the Heceta Limestone is missing, clastic rocks of the Karheen Formation rest unconformably upon the Descon Formation. There is no evidence for major discontinuities within the formation. In fact, numerous graptolite collections indicate virtually continuous deposition from Early Ordovician into Early Silurian time, with episodes of volcanism in the late Early and late Middle Ordovician, and locally in the Early Silurian.

Beds as old as Early Ordovician have been recognized at several rather widely separated places. On the east shore of Steamboat Bay, Noyes Island (see fig. 1, loc. USGS M1031–CO), black shale partings interbedded with thin-bedded dark-gray chert and chert arenite contain *Tetragraptus* cf. *T. serra*, *Cardiograptus*?, and *Didymograptus*? indicative of a late Early Ordovician (Arenigian) age. On the west side of Anguilla Island (fig. 1, loc. USGS M1032–CO), about the same Lower



Ordovician stratigraphic position is indicated by *Didymograptus protobifidus*, *Didymograptus* sp., and *Phyllograptus anna* in gray siltstone interbedded with volcanic graywacke and basaltic sedimentary breccia.

The most widespread and richest graptolite faunas are, however, Middle Ordovician, equivalent to the lower Caradocian zones 9 and 10 of Elles and Wood (1901–18). Very large collections from this horizon, which is well developed from the Big Salt Lake area, commonly have the following species:

Glossograptus spp.
Cryptograptus tricornis
Dicellograptus sextans
Climacograptus bicornis
Didymograptus sp.
Glyptograptus teretiusculus
Orthograptus calcaratus vars.
Retiograptus geinitzianus

Other Middle Ordovician collections have been obtained from the west shore of Warm Chuck Inlet 0.5 mile south of triangulation station Silla, the Harmony Islands, the east side of Cruz Pass, and the north shore of Shinaku Inlet. In practically all places the fossil control has come from shaly partings in thin-bedded black to dark-gray-green chert and cherty siltstone with minor laminated limestone.

A slightly higher horizon, lower Upper Ordovician, about Caradocian zone 13 of Elles and Wood, is indicated by collection USGS M1033–CO from the north tip of Anguilla Island, which contains *Orthograptus truncatus*, *Dicellograptus* sp., and *Leptograptus flaccidus*, in addition to certain of the more common Ordovician genera listed above. About the same horizon is represented by *Orthograptus truncatus*, *Lasiograptus* sp., and *Orthoretiolites*? from northeastern Noyes Island, locality USGS M1034–CO. The highest Ordovician graptolites occur on Esquibel Island directly below the earliest Silurian graptolite collections (USGS M1286–SD, M1287–SD, M1288–SD, M1289–SD, M1290–SD, M1138–SD, M1139–SD) described here. The association of *Dicellograptus complanatus* var. *ornatus*, *Climacograptus hastatus*, *Climacograptus supernus*, and *Orthograptus truncatus* in beds directly below a good Early Silurian fauna with *Akidograptus* indicates correlation with the zone of *Dicellograptus anceps* (*D. complanatus ornatus* zone of Jackson and Lenz, 1962) at the top of the Ashgillian. The highest Ordovician graptolites, *Climacograptus* cf. *C. hastatus*, *Dicellograptus complanatus*?, and *Orthograptus truncatus*, were also found at locality USGS M1035–CO on the south shore of Heceta Island.

The exceptionally rich earliest Silurian graptolites described here (see also fig. 1) were collected on the east shore of Esquibel Island (USGS M1286–SD, M1287–SD, M1288–SD, M1289–SD, M1290–SD, M1138–SD, M1139–SD), the west shore of San Fernando Island (USGS M1140–SD), east coast of Noyes Island (USGS M1142–SD), and on the east shore of Steamboat Bay of Noyes Island (USGS M1143–SD). These are among the first discoveries of Early Silurian graptolites in western North America and are further described in detail in this paper.

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The youngest known beds of the Descon Formation are conformably overlain by the Middle and Upper Silurian Heceta Limestone (Eberlein and Churkin, 1969) 3.6 miles northwest of Point Desconocida on southwestern Heceta Island and on the south end of Two Crack Island. Thin-bedded siliceous siltstone with interbedded graywacke occurs approximately 1,500 feet stratigraphically beneath the contact (loc. USGS M1144–SD) and contains *Petalograptus* cf. *P. palmeus* var. *tenuis, Monograptus triangulatus predecipiens, M. sedgwickii, M.* cf. *concinnus* or *nudus*, and *M.* ex gr. *lobiferus*. This assemblage suggests a late Llandoverian age about equivalent to the zone of *M. sedgwickii* (middle Early Silurian). At the south end of Two Crack Island (loc. USGS M1145–SD), approximately 50 feet of deformed siltstone, shale, and silty limestone, with thin graywacke interbeds, occurs beneath the Heceta Limestone. The shales contain the graptolites, *Monograptus* ex gr. *M. priodon* and *Monograptus* cf. *M. elongatus*,[1] indicative of about the same position in the Llandoverian as those on southwestern Heceta Island.

STANDARD GRAPTOLITE ZONES FOR THE LOWER SILURIAN

The most complete and undeformed section of the lowest Silurian graptolitic shales in the British Isles is the Birkhill Shales of Dobb's Linn in the Moffat area of Scotland.

Lapworth's careful stratigraphic studies here in the 1870's led to the establishment of the lowest Silurian graptolite zonal succession that with minor modification is the world standard used today. Toghill, (1965, 1968) provides a modern description of the stratigraphy and graptolite succession of the Birkhill Shales of Dobb's Linn with special emphasis on the basal beds that show variations in *Akidograptus* and *Dimorphograptus* and their relation to *Monograptus* evolution. The Birkhill Shales have in their basal 20 feet a unique purely biserial graptolite fauna characterized by beds with *Glyptograptus persculptus* in the first 4 feet and by species of *Akidograptus* in the remaining 16 feet. The first *Monograptus, Dimorphograptus*, and *Rhaphidograptus* make their appearance exactly together at the base of the *Orthograptus vesiculosus* zone, 20 feet above the base of the Birkhill Shales. The earliest dimorphograptids in the lower 2 feet of the *O. vesiculosus* zone have unusually long uniserial parts. Only 4 feet above the first monograptids the next higher zone of *Monograptus cyphus* is characterized by dimorphograptids with shorter uniserial parts such as *D. confertus swanstoni* and *D. physophora* (Toghill, 1965).

[1] Thecae as in *elongatus*, but Alaska specimens seem to be more tightly coiled.

The possible development of *Monograptus* by progressive lengthening of the uniserial part of *Dimorphograptus* is therefore inconsistent with the stratigraphical succession of its earliest species, *D. elongatus*, which possesses long uniserial parts, and with several of the later species, for example *D. confertus swanstoni* and *D. physophora*, which have short uniserial parts (Bulman, 1960; Toghill, 1965, 1968). The Birkhill Shales at Dobb's Linn represent extremely attenuated graptolite zones measuring only several to tens of feet thick. Despite their thinness, no unsuspected stratigraphic breaks can be postulated on the basis of more complete graptolite succession known elsewhere. In fact the same lowest Silurian graptolite zones that are reported here for the first time in North America are similarly attenuated. On Esquibel Island in southeastern Alaska, for example, *Akidograptus acuminatus* lies only about 7 feet above highest Ordovician graptolites and only 6 or less feet stratigraphically below a good *Orthograptus vesiculosus* zone fauna. The first *Monograptus* occurs together with *vesiculosus* only a few feet higher. Another place in North America where graptolite zones are relatively thin is in the vicinity of Trail Creek, Idaho, where more than seven graptolite zones occur in a 300-foot section of nearly pure shale (Churkin, 1963).

Questions concerning the placement of the Ordovician-Silurian boundary in the graptolitic shale sequences of North America and the succession of Lower Silurian graptolite faunas (across the boundary) must be referred to the classical Birkhill Shales which can then be compared with the Esquibel Island section described here.

The basal beds of the Birkhill Shales, the zones of *G. persculptus* and *Akidograptus acuminatus* that lie between the highest Ordovician strata (Hartfell Shales) with purely biserial graptolites below and strata with the earliest uniserial *Monograptus* above, could be included in the Ordovician (Elles, 1922; Davies, 1929) because of their biserial graptolites. The base of the Llandovery, however, was taken by Lapworth at the base of the Birkhill Shales to coincide with a marked change in lithology, thereby placing the first appearance of *Monograptus* some 20 feet above the base of the Silurian.

LOWER SILURIAN GRAPTOLITES IN WESTERN NORTH AMERICA

Silurian graptolites in western North America are known largely from the dark shales formed in parts of the Cordilleran geosyncline from California and Nevada in the south to British Columbia, southeastern Alaska, and southern Yukon Territory on the north (fig. 2). Another belt with graptolitic shales, the Franklinian geosyncline, is exposed in the Canadian Arctic Islands

(fig. 2). In east-central Alaska and parts of northern Yukon Territory, Silurian graptolites are known from the thin shales of the Yukon shelf and from thicker shale sections in the Richardson Basin. Despite the rather extensive distribution of Silurian graptolitic shales and an even better known development of Ordovician graptolitic shales, especially in the Cordilleran geosyncline, no succession of graptolites across the

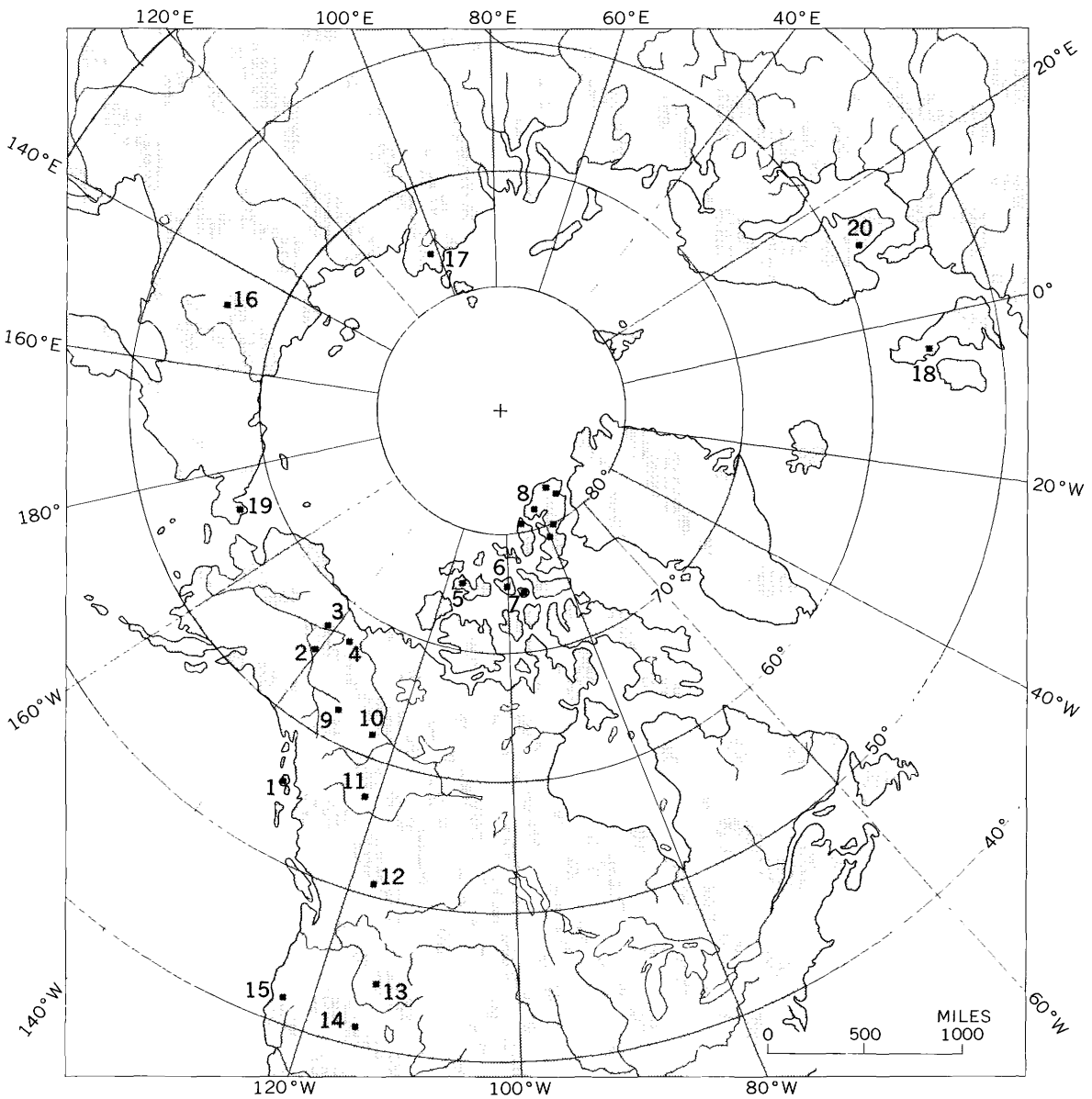


FIGURE 2.—Silurian graptolite localities of western North America and the Arctic region. 1. Prince of Wales Island area, southeastern Alaska (this paper). 2. Yukon River, east-central Alaska (Churkin and Brabb, 1965). 3. Porcupine River, east-central Alaska (Churkin and Brabb, 1967). 4. Richardson Mountains, Yukon Territory (Jackson and Lenz, 1962). 5. Melville Island (Tozer and Thorsteinsson, 1964). 6. Bathurst Island (Thorsteinsson and Glenister, p. 589, and McLaren, p. 601, in Fortier and others, 1963). 7. Cornwallis Island (Thorsteinsson, 1958). 8. Ellesmere and Axel Heiberg Island (J. W. Kerr and H. P. Trettin, written communs., 1968). 9. Pelly River area, Yukon Territory (Wheeler and others, 1960a, b). 10. South Nahanni River area, Northwest Territory (Lenz and Jackson, 1964). 11. Northern Rocky Mountains, northeastern British Columbia (Jackson and others, 1965). 12. Rocky Mountains, southeastern British Columbia (Walcott, 1924; Walker, 1926). 13. Trail Creek, central Idaho (Churkin, 1963). 14. Nevada: northeastern (Churkin and Kay, 1967); central (Gilluly and Masursky, 1965; Kay and Crawford, 1964). 15. Klamath Mountains, Calif. (Churkin, 1965). 16. Kolyma Massif, northeastern U.S.S.R. (Obut and others, 1967). 17. Taimyr Peninsula (Obut and others, 1965). 18. Birkhill Shales, Scotland (Toghill, 1968). 19. Chukotsk Peninsula (A. M. Obut, oral commun., 1967). 20. Sweden (Törnquist, 1899).

Ordovician-Silurian boundary has been reported anywhere in North America. This apparent absence of lowest Silurian graptolite faunas coincides with an unconformity above the highest Ordovician zone of *Dicellograptus complanatus ornatus* in northern British Columbia (Jackson and others, 1965). However, in east-central Alaska (Churkin and Brabb, 1965) and in northern Yukon Territory (Jackson and Lenz, 1962; Lenz and Churkin, 1966) nongraptolitic and in places largely covered intervals of shale separate the *D. complanatus ornatus* zone from middle and upper Llandoverian graptolites (fig. 3).

Probably more graptolite localities of widely varying age are known in the Great Basin (locs. 13 and 14, fig. 2) than in any other comparable area in North America. However, because of intense structural deformation, details of the stratigraphy in the graptolite shale and chert facies are known only in local areas. In the Toquima Range area of central Nevada (Kay and Crawford, 1964), there seems to be an unconformity separating Ordovician rocks from Silurian, whereas at Trail Creek, Idaho, the boundary falls in a small covered interval with no sign of a stratigraphic break (Churkin, 1963).

The oldest Silurian graptolite collection in the Great Basin was recently made from large slabs of slate in a mine dump in northeastern Nevada (Kerr, 1962). Most of the species are found together on the individual rock slabs. This distribution indicates that only a single fossil horizon was mined. These beautifully preserved, three-dimensional pyritized specimens were re-collected and a more extensive fossil list was published (Churkin and Kay, 1967, p. 663). The graptolite assemblages found together on individual rock slabs are characterized by coiled monograptids that indicate correlation with the interval of the zone of *Monograptus gregarius* to *M. convolutus* of middle Llandoverian age. The revised fossil list given in table 1 is the result of reexamination of the material reported in Churkin and Kay and comparison with the new Alaskan graptolites described in this paper. Several of these pyritized specimens are also formally described and illustrated for the first time in this paper.

The new graptolite collections (USGS M1286–SD, M1287–SD, M1288–SD, M1289–SD, M1290–SD, M1138–SD, M1139–SD, and M1141–SD) from southeastern Alaska described in this paper represent the oldest Silurian graptolite faunas known in North America (Table 2). *Akidograptus acuminatus* in collections USGS M1286–SD, M1287–SD, M1141–SD, and M1139–SD indicates correlation with the zone of *Akidograptus acuminatus*, virtually the lowest graptolite zone in the standard graptolite succession of the British Isles. In Great Britain the zone of *Glyptograptus persculptus* has been recognized below the *Akidograptus* zone and the Ordovician-Silurian boundary has been drawn at the base of the *G. persculptus* zone (Toghill, 1968). The *G. persculptus* beds, however, are only 3.5 feet thick, and the fauna is not as readily distinguished as is the *Akidograptus* zone fauna. Nevertheless, *G. persculptus* was found in the Esquibel Island section in several feet of beds separating the *Akidograptus acuminatus* zone from the highest Ordovician graptolites of the *Dicellograptus anceps* zone (Churkin and others, 1969). *Akidograptus* in the Alaskan collections is associated only with biserial graptolites as it is in the Birkhill Shales of Scotland. The presence of *Dimorphograptus*, *Orthograptus vesiculosus*, and several species of *Monograptus* including *M. cyphus* together with *Akidograptus* in collection USGS M1139–SD suggested that this original collection, made only over an interval of some 10 feet, is a mixture of several

TABLE 1.—*Partial list of graptolites from northeastern Nevada showing British ranges and associations on single talus slabs.*
[Range in Toghill (1965) ——; Range in Elles and Wood (1901–18) ------]

Genus and species	Zone [1]							Slab No.				
	16	17	18	19	20	21	22	1	11, 12	13, 14	66	57, 68
Climacograptus cf. *C. scalaris*									×	×		
Pseudoclimacograptus (*Metaclimacograptus*) *hughesi* [2]								×	×	×	×	×
Glyptograptus kayi n. sp [2]								×	×		×	×
ex. gr. *G. sinuatus*—*G. persculptus*								×	×	×	×	×
tamariscus								×			×	
Petalograptus palmeus var. *tenuis* [2]											×	
Monograptus cf. *M. denticulatus*									×			×
hamatus n. sp [2]								×	×	×	×	×
cf. *M. jaculum*									×	×		×
kerri n. sp [2]								×	×		×	×
lobiferous [2]								×	×	×	×	×
cf. *M. millepeda*												×
cf. *M. nobilis*								×		×		
Rastrites sp										×		

[1] Zone 16, *A. acuminatus* zone; 17, *O. vesiculosus* zone; 18, *M. cyphus* zone; 19, *M. gregarius* zone; 20, *M. convolutus* zone; 21, *M. sedgwicki* zone; 22, *R. maximus* zone.
[2] Described in this paper.

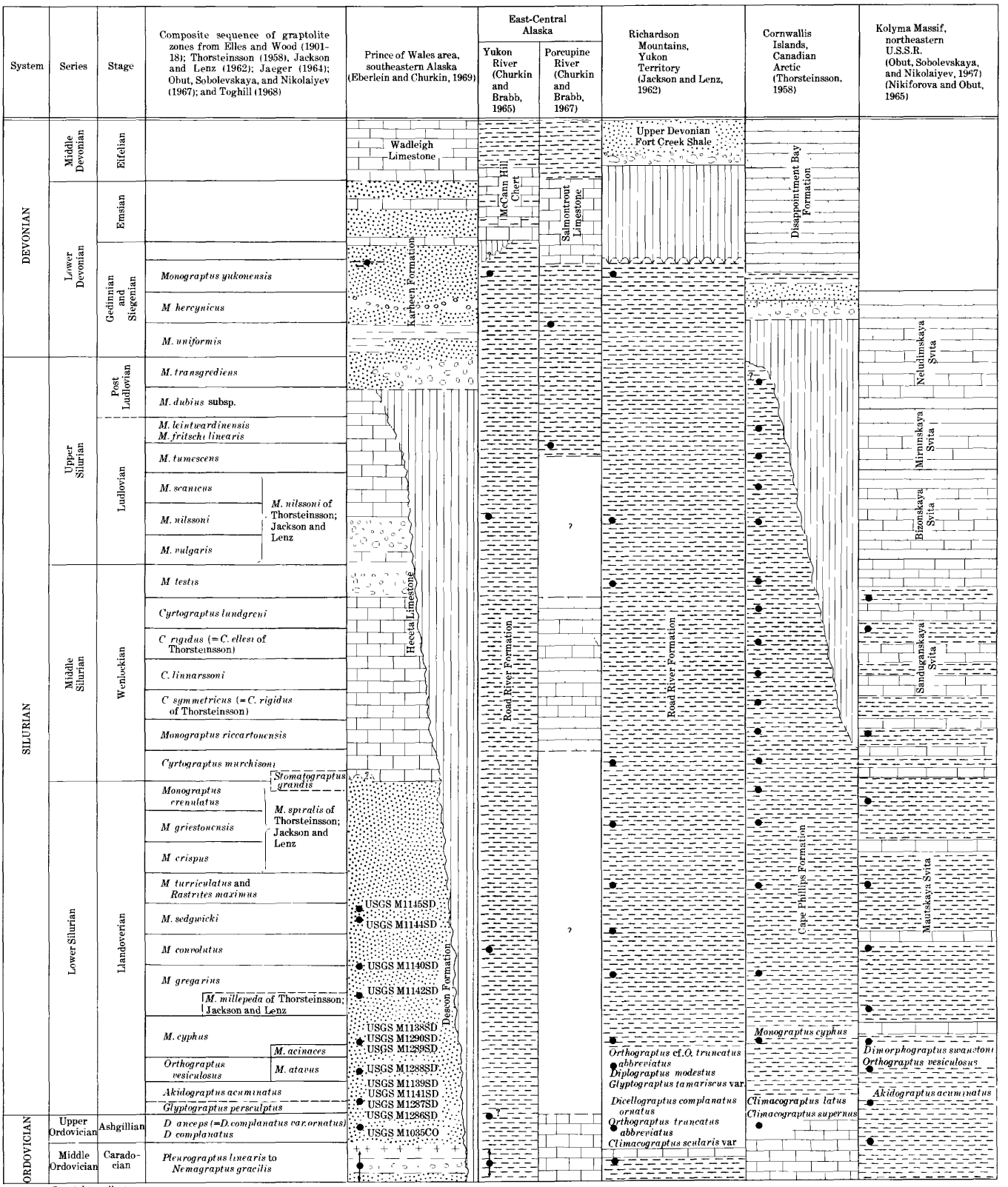


FIGURE 3.—Correlation of graptolitic sequences in western North America and the Arctic.

graptolite zones. A careful examination of the shale slabs on which *Akidograptus* occurs did not reveal any monograptids or biserial graptolite species characteristic of any zone above that of *A. acuminatus*. Collection USGS M1138–SD, which contains a somewhat different fauna, was made only 10 feet above M1139–SD (fig. 4). Thus the cherty black shale section here represents several extremely attenuated graptolite zones not unlike those in the Birkhill Shales of Scotland.

The association of the biserial genera, *Climacograptus*, *Pseudoclimacograptus*, *Diplograptus*, *Glyptograptus*, and *Orthograptus* together with *Dimorphograptus* and *Monograptus* in collection USGS M1138–SD implies correlation with zone (18) of *Monograptus cyphus* of Lapworth

TABLE 2.—*Silurian graptolite faunas from Prince of Wales Island area, Alaska*

[Frequency: a, abundant; c, common; f, frequent; r, rare]

Genus and species	USGS M1286–SD	USGS M1287–SD	USGS M1288–SD	USGS M1289–SD	USGS M1290–SD	USGS M1138–SD	USGS M1139–SD	USGS M1140–SD	USGS M1141–SD	USGS M1142–SD
Climacograptus indivisus esquibelensis n. subsp						r				
innotatus Nicholson				f		c	f			
obesus n. subsp						r				
cf. *C. medius* Törnquist	c	c	c			r	c		c	
medius brevicaudatus n. subsp										a
minutus? Carruthers						r				
cf. *C. rectangularis* (M'Coy)						c	r			r
rectangularis abbreviatus n. subsp						r	f			
scalaris (Hisinger)				a	c?	a	a			
stenotelus n. sp								c		
trifilis Manck	f						r			
Pseudoclimacograptus (*Metaclimacograptus*) *hughesi* (Nicholson)				f		f	r			
cf. *P.* (*M.*) *undulatus* (Kurck)								c		
Diplograptus elongatus n. sp						f				
modestus var. *diminutus* Elles and Wood		r	r?						a	
mucroterminatus n. sp										c
n. sp						r				
n. sp						r				
Glyptograptus cf. *G. enodis* var. *enodis* Packham			f?			r				
cf. *G. enodis* var. *latus* Packham										a
gnomus n. sp						r				
incertus Elles and Wood						f				
laciniosus n. sp							a		r	f
lanpherei n. sp							f			
tamariscus magnus n. subsp						f	r			
cf. *G. tamariscus tamariscus* (Nicholson)								f	r?	r
? n. sp										r
Orthograptus bellulus Törnquist										r
eberleini n. sp						r	r			
insectiformis minutus n. subsp								r		r
cf. *O. mutabilis* Elles and Wood						r				
vesiculosus Nicholson			f	c	c	a	r			
? n. sp	a	f					f			
Petalograptus minor Elles										f
palmeus (Barrande)								f		
Dimorphograptus confertus swanstoni (Lapworth)				f		c	r			
physophora alaskensis n. subsp					r	r				
Akidograptus acuminatus (Nicholson)	f	r?					r		f	
Monograptus acinaces Törnquist				f	c	f	r			
atavus Jones						f	r			?r
buddingtoni n. sp								f		
calamistratus n. sp										c
cf. *M. crenularis* Lapworth									a	
cyphus Lapworth				r?		r	r			r
cf. *M. difformis* Törnquist										r
gregarius Lapworth										c
cf. *M. incommodus* Törnquist				f		f	r			
noyesensis n. sp										a
revolutus Kurck										f
tenuis (Portlock)						a				
aff. *M. undulatus* Elles and Wood								f		
Rastrites cf. *R. longispinus* (Perner)										r
orbitus n. sp										f
aff. *R. peregrinus* (Barrande)								f		

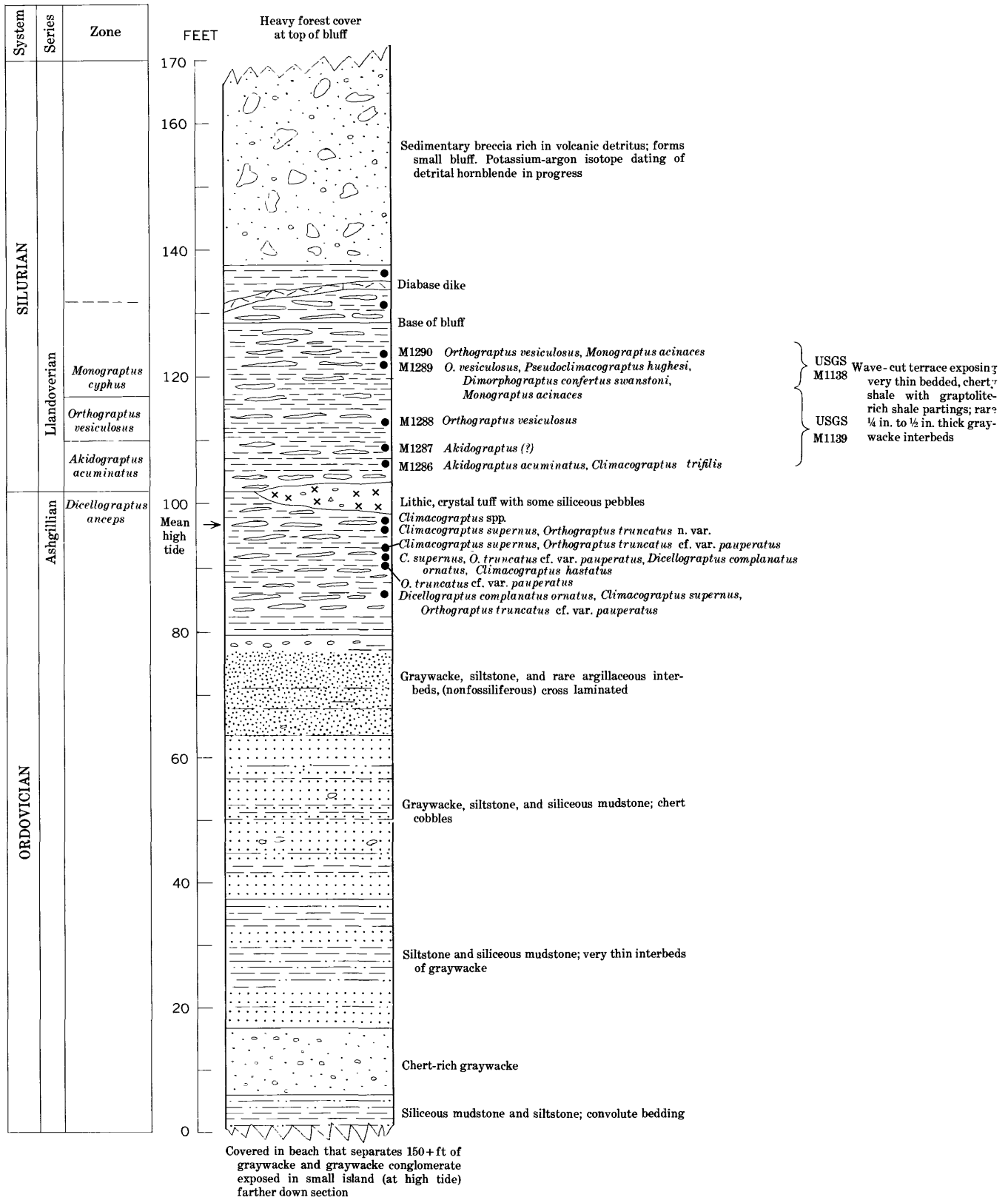


FIGURE 4.—Succession of graptolite localities across the Ordovician-Silurian boundary; east shore Esquibel Island, southeastern Alaska.

(Elles and Wood, 1901–18) and the identically named zone of Toghill (1968). The presence of *Dimorphograptus confertus swanstoni* and a variety of *D. physophora*, both easily recognizable forms characteristic of the *cyphus* zone, further supports this correlation. Although the overall aspect of the fauna is definitely most like that of the Birkhill's *M. cyphus* zone, individual species listed below, most of which are difficult to identify, are found elsewhere only in the overlying zone of *Monograptus gregarius* and higher:

Climacograptus scalaris
Glyptograptus cf. *G. enodis* var. *enodis*
Glyptograptus incertus
Monograptus tenuis

On the other hand, *Orthograptus vesiculosus*, easily recognized by the conspicuous vane structure (Jones and Rickards, 1967), is the guide to the underlying *O. vesiculosus* zone but is also known from the *M. cyphus* zone in the Birkhill Shales (Toghill, 1968). In Yukon Territory, Canada (Jackson and Lenz, 1962), and in the Kolyma Massif region of northeastern U.S.S.R. (Obut and others, 1967), *Orthograptus vesiculosus* occurs biostratigraphically higher and in association with *Dimorphograptus* ex gr. *D. confertus* as it does in Alaska.

The graptolite collections (USGS M1138–SD and M1139–SD) from Esquibel Island were found during a rapid reconnaissance of the area. The original collecting was done during high tide from two approximately 10-foot-thick intervals of graptolitic shale. Although the early Silurian age of the graptolites was realized during the time of collecting, the presence of several extremely thin graptolite zones over the interval collected was not appreciated until the faunas were studied in the laboratory. In 1968, Churkin returned to Esquibel Island to check the interpretation that collection USGS M1139–SD is a mixture of *Akidograptus acuminatus* and *Orthograptus vesiculosus* zones and to search for graptolites of Ordovician age at the base of the section. Accordingly, the entire section was re-collected bed by bed. More than 15 stratigraphically separate graptolite collections were made. This more detailed examination proves that *Akidograptus* in the Esquibel Island section occurs together only with biserial graptolites as it does in collection USGS M1141–SD from Noyes Island and in the British Isles. *Orthograptus vesiculosus*, the guide to the next higher graptolite zone, lies 3 feet above the highest occurrence of *Akidograptus*. Beds rich in species of *Monograptus* and *Dimorphograptus* are still stratigraphically higher in the section. Not only was it possible to stratigraphically follow the same faunal succession as in the standard *Akidograptus acuminatus*, *Orthograptus vesiculosus*, and *Monograptus cyphus* zones but in the underlying few feet of beds, exposed only at low tide, graptolites of the highest Ordovician zone of *Dicellograptus anceps* were found. The position of the Silurian-Ordovician boundary and the exact stratigraphic position of key graptolite species based on this new data is shown in figure 4. The main Silurian species identified at each locality are listed in table 2. A detailed account of the Ordovician species and a discussion of the Ordovician-Silurian boundary is being separately prepared (Churkin and others, 1969).

Slightly younger Silurian graptolites from the upper part of the Descon Formation are represented by collection USGS M1142–SD from Noyes Island and by collection USGS M1140–SD (fig. 5) from San Fernando Island. In collection USGS M1142–SD (table 2) the common occurrence of *Monograptus* together with abundant species of the biserial genera—*Climacograptus*, *Diplograptus*, *Glyptograptus*, and *Orthograptus*—implies in itself a position in the Llandovery equivalent to the *vesiculosus* zone (lower Llandovery) or higher.

The presence of species of *Petalograptus* and *Rastrites* further restricts the age of collection USGS M1142–SD to the next higher zone of *Monograptus gregarius* or younger. Finally, numerous specimens of *M. gregarius* in association with *M. revolutus*, *M.* cf. *M. clavus* and a new variety of *Orthograptus insectiformis* implies correlation with the zone of *M. gregarius*.

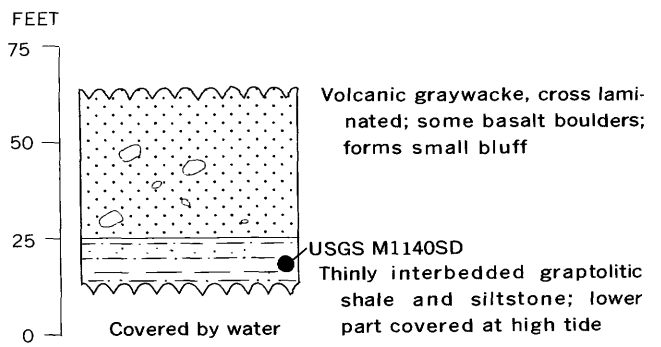


FIGURE 5.—Lower Silurian graptolite locality (USGS M1140–SD) about 800 feet northwest of Sword Point on the southwest shore of San Fernando Island, southeastern Alaska.

Graptolite collection USGS M1140–SD (table 2; and fig. 5) is an assemblage similar to USGS M1142–SD, but USGS M1140–SD has *Pseudoclimacograptus* cf. *P. extremus*, *Monograptus* cf. *M. crenularis*, and *M.* aff. *M. undulatus* that suggest the slightly younger horizon of the zone of *Monograptus convolutus*. Collection USGS M1140–SD is provisionally assigned to the interval between the upper part of the *M. gregarius* zone and the lower part of the *M. convolutus* zone.

SYSTEMATIC DESCRIPTIONS[2]

Class GRAPTOLITHINA
Order GRAPTOLOIDEA
Family DIPLOGRAPTIDAE
Subfamily CLIMACOGRAPTINAE

Genus CLIMACOGRAPTUS Hall, 1865

Climacograptus Hall. Bulman, 1955, Geol. Soc. America, treatise on invertebrate paleontology, pt. V, p. V85, fig. 63, 1a–d.

Rhabdosome biserial, scandent. Thecae with angular sigmoidal curvature, so that ventral wall is nearly parallel to axis of rhabdosome and apertures are situated in narrow excavations. Lower Ordovician to Lower Silurian, worldwide.

Climacograptus indivisus esquibelensis n. subsp.

Text figure 6*A*; plate 1, figure 1

Description.—According to Waern (in Waern and others, 1948, p. 456–457), the rhabdosome of *C. indivisus* is slender and straight, without a visible septum. It widens from an initial width of 0.6–0.7 mm to a maximum of 1.0–1.1 mm at theca 6 which is thereafter maintained. The virgella can attain a considerable length (2.8 mm) and is forked at a distance of approximately 1 mm from the aperture of the sicula. The two branches form an angle of 40°–60° with each other. Thecae number 11 per centimeter.

The Alaskan form is similar to *C. indivisus* in general appearance. It differs by (1) being wider distally, 1.6–1.9 mm (this could be due partly to flattening), (2) having a distinctly tapering appearance, (3) having a longer virgella, and (4) having a smaller angle of divergence between the two branches of the virgella.

Discussion.—The extremely long virgella is very distinctive. On the best specimen (fig. 6*A;* and pl. 1, fig. 1), the virgella is 16 mm long, and it forks approximately 3 mm below the aperture of the sicula. The two branches are more or less parallel, and one of the branches has apparently forked about 8 mm below the first fork. The virgella of the second specimen is broken off so that it only measures 5.0 mm. It forks 1.2 mm below the sicular aperture, and the angle between branches is approximately 15°.

The Alaskan specimens resemble *Rhaphidograptus toernquisti* in having a slender proximal end but differ from it by having theca 1[2] present and not missing as in *Rhaphidograptus*. They also resemble *C. medius* but differ by being wider and having a split virgella.

[2] Bulman's (1955) terminology and classification have been used in the following descriptions.

Occurrence.—M1138–SD.

Range.—*C. indivisus* occurs in the lower part of the zone of *Akidograptus acuminatus* at Kinnekulle, Sweden (Waern, in Waern and others, 1948, p. 456–457), and in the zone of *Glyptograptus persculptus* in Great Britain (Davies, 1929). The Alaskan variety occurs considerably higher in the zone of *Monograptus cyphus* (table 3).

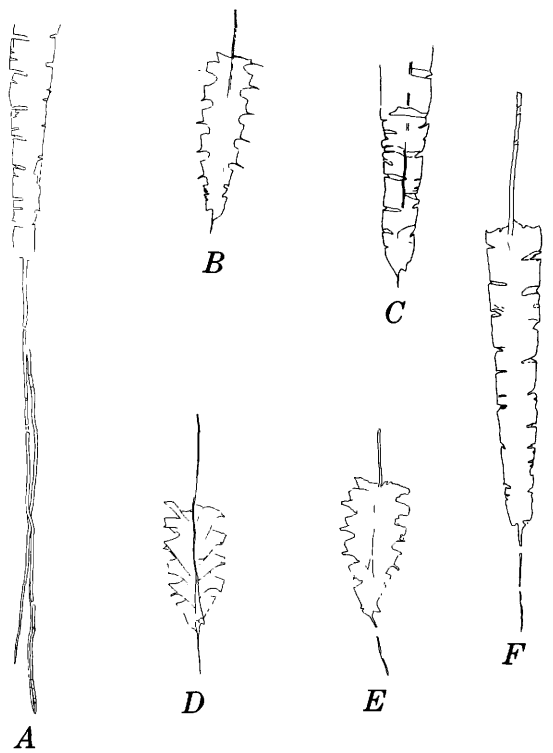


FIGURE 6.—*Climacograptus. A, C. indivisus esquibelensis* n. subsp., holotype (USNM 161604) (same as pl. 1, fig. 1), × 4. *B, C. innotatus* Nicholson (USNM 161606), × 5. *C, C. minutus?* Carruthers (USNM 161627) (same as pl. 1, fig. 6), × 5. *D, E, C. innotatus obesus* n. subsp. *D,* Holotype (USNM 161611) with spines broken off, showing sicula, × 5. *E,* (USNM 161610) × 5. *F, C.* cf. *C. medius* Törnquist (USNM 161614), × 5.

Dimensions (in millimeters).—

Specimen No.	Length of rhabdosome[1]	Width		Thecae per centimeter	Length of virgella
		Theca 1[1]	Maximum		
USNM–161604[2]--	>15	0.7	1.6	10	16
161605---	>13.7	.6	1.9	11	[3] 5

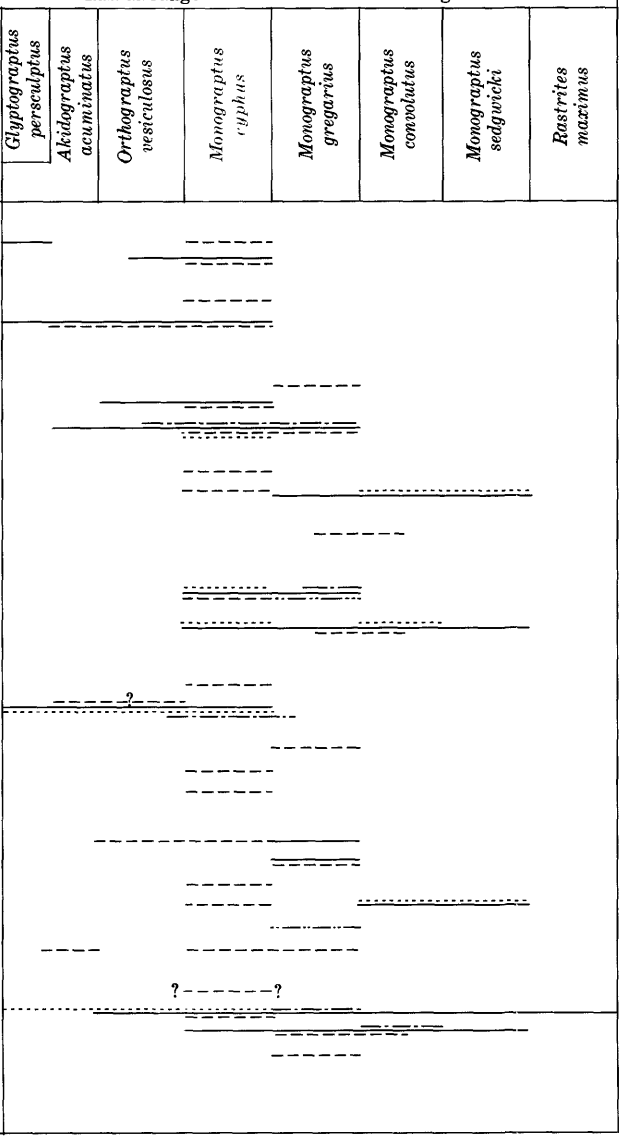
[1] Exclusive of virgella length.
[2] Figured specimen.
[3] Broken.

TABLE 3.—*Lower Silurian graptolites of Alaska and Nevada showing a comparison of their zonal ranges to the same or similar species in Canada, Great Britain, and the Soviet Arctic*

Data largely from: Elles and Wood (1901–18); Toghill (1968), Jackson and Lenz (1962), Thorsteinsson (1958), Packham (1962), Obut, Sobolevskaya, and Bondarev (1965), Obut, Sobolevskaya and Nikolaiyev (1967)

British range ———— Canadian range ····· Russian range —·—·— Alaskan range – – – – Nevadan range —·—·—·

Genus and species	Illustrations: Plate; figure	Illustrations: Text figure	USGS Collection No.
Climacograptus			
indivisus esquibelensis n. subsp.[1]	1; 1	6*A*	M1138
innotatus Nicholson	1; 2	6*B*	M1138, M1139 M1289
obesus n. subsp.	1; 3	6*D, E*	M1138
cf. *C. medius* Törnquist	1; 4, 5	6*F*	M1138, M1139 M1141, M1286 M1287, M1288
medius brevicaudatus n. subsp.	1; 12	7*D*	M1142
minutus? Carruthers	1; 6	6*C*	M1138
cf. *C. rectangularis* (M'Coy)	1; 7–9	7*A, B*	M1138, M1139, M1142
rectangularis abbreviatus n. subsp.	1; 15	8*C*	M1138, M1139
scalaris (Hisinger)	1; 10, 11	7*C*	M1138, M1139 M1289, M1290(?)
stenotelus n. sp.	1; 13, 14	8*A, B*	M1140
Pseudoclimacograptus (*Metaclimacograptus*)			
hughesi (Nicholson)	1; 16, 17	8*E*	M1138, M1139, Nev., M1289
cf. *P. (M.) undulatus* (Kurck)	1; 18	8*D*	M1140
Diplograptus			
elongatus n. sp.	1; 19, 20	9*C, D*	M1138
modestus var. *diminutus* Elles and Wood	2; 19	10*G*	M1141, M1287 M1288 (?)
mucroterminatus n. sp.	1; 21	9*A, B*	M1142
n. sp. *A*	2; 1	9*E, F*	M1138
n. sp. *B*			M1138
Glyptograptus			
cf. *G. enodis* var. *enodis* Packham	2; 2	10*A*	M1138, M1288(?)
cf. *G. enodis* var. *latus* Packham	2; 3, 4	10*B, C*	M1142
gnomus n. sp.	2; 16	11*E, F*	M1138
incertus Elles and Wood	2; 5, 6	10*D, E*	M1138
kayi n. sp.	2; 15	12*E, F*	Nevada
laciniosus n. sp.	2; 17, 18	11*D*	M1139, M1141, M1142
lanpherei n. sp.	2; 9, 10	11*C*	M1139
tamariscus magnus n. subsp.	2; 7, 8	11*A, B*	M1138, M1139
cf. *G. tamariscus tamariscus* (Nicholson)		10*F*	M1140, M1142
? n. sp.		12*D*	M1142



[1]Ranges of new subspecies are compared with ranges for the old species

Material.—Two compressed, somewhat poorly preserved specimens. Named after Esquibel Island, Alexander Archipelago, Alaska.

Holotype.—USNM 161604.

Climacograptus innotatus Nicholson

Text figure 6*B*; plate 1, figure 2

Climacograptus innotatus Nicholson. Elles and Wood, 1901–18, Mon. British Graptolites, Palaeontographical Soc., p. 212–213, text fig. 143, pl. 27, fig. 10a–e.

Climacograptus innotatus Nicholson. Hundt, 1924, Grapt. d. deutsch. Silurs, p. 57, pl. 1, figs, 5–7.

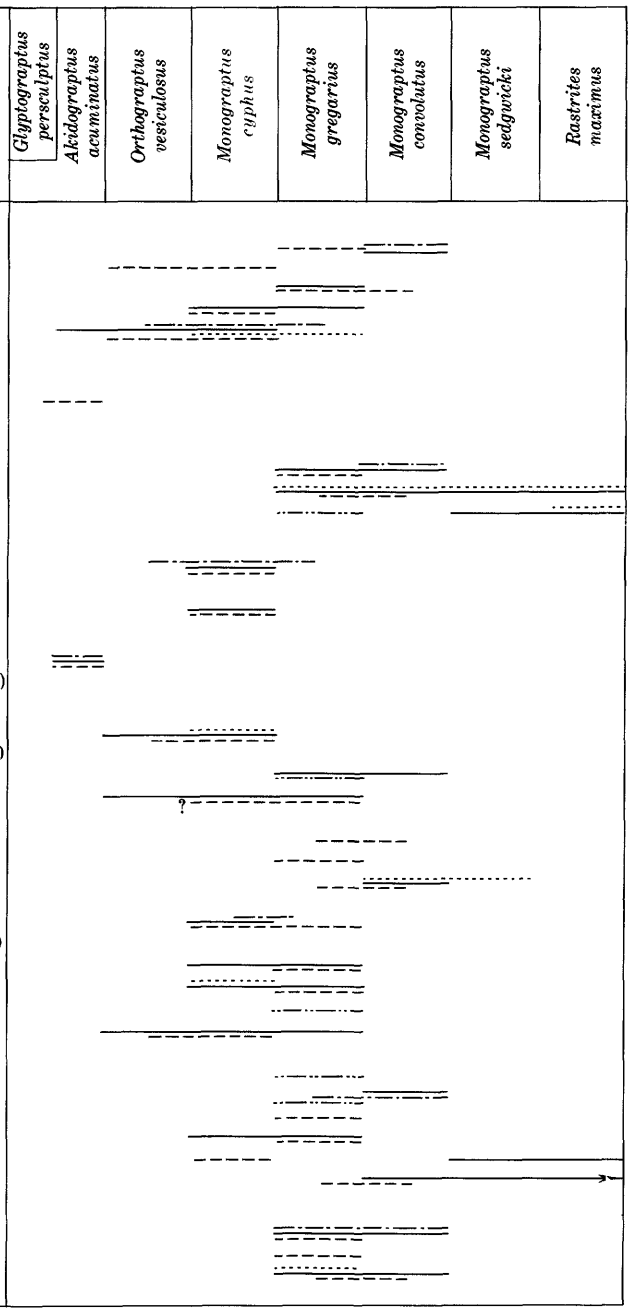
Discussion.—The specimens under study have more closely set thecae (16–18 thecae per centimeter) than those described by Elles and Wood (1901–18).

Occurrence.—M1138–SD, M1139–SD, M1289–SD.

Range.—Llandoverian zones (17 and 18) of *Orthograptus vesiculosus* and *Monograptus cyphus* (Birkhill Shales) in Great Britain (Toghill, 1968). Lower

TABLE 3.—*Lower Silurian graptolites of Alaska and Nevada showing a comparison of their zonal ranges to the same or similar species in Canada, Great Britain, and the Soviet Arctic*—Continued

Genus and species	Illustrations: Plate; figure	Illustrations: Text figure	USGS Collection No.
Orthograptus			
bellulus Törnquist	3; 1	12*G*	M1142
eberleini n. sp.	3; 2	12*A, B*	M1138, M1139
insectiformis minutus n. subsp.		12*C, H, I*	M1140, M1142
cf. *O. mutabilis* Elles and Wood	2; 14		M1138
vesiculosus Nicholson	2; 11-13		M1138, M1139 M1288, M1289 M1290
? n. sp.	3; 4	13*D*	M1139, M1286 M1287
Petalograptus			
minor Elles	3; 5	13*E, F*	M1142
palmeus (Barrande)	3; 6	13*G*	M1140
var. *tenuis* Barrande	3; 3	13*A*	Nevada
Dimorphograptus			
confertus swanstoni (Lapworth)	3; 8-10	14 *C, D*	M1138, M1139, M1289
physophora alaskensis n. subsp.	3; 7	13*H, I*	M1138, M1290
Akidograptus acuminatus (Nicholson)	3; 16, 17	13*B, C*	M1139, M1141 M1286, M1287(?)
Monograptus			
acinaces Törnquist	3; 13-15	14*A*	M1138, M1139, M1289, M1290
argutus Lapworth	4; 16	14*B*	Nevada
atavus Jones	3; 11	14*E*	M1138, M1139 M1142 (?)
buddingtoni n. sp.	4; 7, 8	15*D, E*	M1140
calamistratus n. sp.	4; 12	15*A-C*	M1142
cf. *M. crenularis* Lapworth	3; 18, 23-25	16*A, B, D, E*	M1140
cyphus Lapworth	4; 5, 6	16*F*	M1138, M1139 M1142, M1289(?)
cf. *M. difformis* Törnquist	3; 22	18*E*	M1142
gregarius Lapworth	4; 1	16*C*	M1142
hamatus n. sp.	4; 15	17*D, E*	Nevada
cf. *M. incommodus* Törnquist	3; 20	18*A*	M1138, M1139 M1289
kerri n. sp.	4; 11	17*F*	Nevada
lobiferus (M'Coy)	3; 12, 21		Nevada
noyesensis n. sp.	4; 9, 10	17*A-C*	M1142
revolutus Kurck	3; 19	18*G*	M1142
tenuis (Portlock)	4; 2, 3	18*D*	M1138
aff. *M. undulatus* Elles and Wood	4; 4	18*B,C, F*	M1140
Rastrites			
cf. *R. longispinus* (Perner)	4; 17	19*C*	M1142
orbitus n. sp.	4; 18, 19	19*A, B*	M1142
aff. *R. peregrinus* (Barrande)	4; 13, 14		M1140



Keilorian (lower) Llandovery in Australia (Thomas, 1960). Also reported in the zone of *Demirastrites triangulatus* from Bohemia, Czechoslovakia, by Pribyl (1948). Varieties reported from the following formations in North America: Road River Formation, Yukon Territory, Canada, in Ashgillian zone of *Dicellograptus complanatus* var. *ornatus* (Jackson and Lenz, 1962); Phi Kappa Formation, Trail Creek, Idaho, in Caradocian zones (12 and 13) of *Dicranograptus clingani* and *Pleurograptus linearis* (Churkin, 1963); Williamsburg, Ohio, (Fairmount Limestone Member of the Fairview Formation) (Ruedemann, 1947).

Dimensions (in millimeters).—

Specimen No.	Length of rhabdosome	Width of rhabdosome	Thecae per centimeter
USNM–161606	4.5	1.3	16
161607 [1]	6.0	1.25	16
161608	5.5	1.25	16
161609g	6.0	1.2	17
161609h	6.2	1.25	18

[1] Figured specimens.

Material.—About 28 compressed, well-preserved specimens.

Figured specimens.—USNM 161606, 161607.

Climacograptus innotatus obesus n. subsp.

Text figure 6*D*, *E*; plate 1, figure 3

Description.—The rhadbosome widens very rapidly from an intial width of 0.4 mm to a maximum of 1.5–2.0 mm, at theca 4 or 5, which is thereafter maintained, making the margins approximately parallel. The thecae are like those of *C. innotatus*, numbering 15–16 per centimenter. The sicula is 1.6 mm long with a virgella as much as 1.4 mm long. The apex of the sicula extends to the level of the aperture of theca 2^2.

Discussion.—The features that distinguish this subspecies from *C. innotatus* are its greater width and its more sharply tapering proximal end.

Occurrence.—M1138-SD.

Range.—Zone of *M. cyphus* in Alaska.

Dimensions (in millimeters).—

Specimen No.	Length of rhabdosome	Width			Thecae per centimeter
		Theca 1^1	Theca 4^1	Maximum	
USNM–161610 [1]	3.5	0.8	1.7	1.7	15
161611 [1]	5.0	.8	1.6	1.7	16
161612	5.9	.9	1.75	2.0	16
161613 [1]	5.5	.8	1.5	1.6	16

[1] Figured specimens.

Material.—About six compressed, well-preserved specimens. Named after Latin "obesus"=fat, corpulent.

Figured specimens.—USNM 161610, 161611, 161613.

Holotype.—USNM 161611.

Climacograptus cf. C. medius Törnquist

Text figure 6*F*; plate 1, figures 4, 5

Climacograptus medius Törnquist. Elles and Wood, 1901–18, Mon. British Graptolites, Palaeontographical Soc., p. 189–190, text fig. 122, pl. 26, fig. 4a–f.

Climacograptus medius Törnquist. Hundt, 1924, Grapt. d. deutsch. Silurs, p. 56, pl. 1, figs. 22, 23, 35, 36.

Climacograptus medius Törnquist. Sun, 1933, Palaeont. Sinica, ser. B, v. 14, pt. 1, p. 23, pl. 4, fig. 2a, b.

Climacograptus medius Törnquist. Obut, 1949, Polyevoi Atlas, Rukovodyashchich graptolitov vyerkhnyevo Silura Kirgizskoi SSR, p. 13, pl. 1, fig. 3a, b.

Climacograptus medius Törnquist. Stein, 1965, Neues Jahrb. Geologie u. Paläontologie Abh., p. 163–165, text fig. 16a–g.

Discussion.—In the general shape of the rhabdosome, character and number of thecae, and long virgella, our specimens closely resemble *C. medius* and *Rhaphidograptus toernquisti*. The Alaskan species is, however, narrower (maximum width 1.8 mm) than either *C. medius* (maximum width 2.5 mm) or *R. toernquisti* (maximum width 2.0 mm). In addition, theca 1^2 is characteristically missing in *R. toernquisti* but is present in our specimens.

Occurrence.—M1138–SD, M1139–SD, M1141–SD, M1286–SD, M1287–SD, M1288–SD.

Range.—Llandoverian zones (16–18) of *Glyptograptus persculptus* to *M. cyphus* (Birkhill Shales) in Great Britain (Toghill, 1968). Llandoverian zones of *G. persculptus* to *M. cyphus* in the Frankenwald (northeast Bavaria) (Stein, 1965). Llandoverian zones of *Demirastrites pectinatus* to *D. triangulatus* in Bohemia, Czechoslovakia (Pribyl, 1948). Also reported from Malaya (Kobayashi and others, 1964) and China (Sun, 1933).

Dimensions (in millimeters).—

Specimen No.	Length of rhabdosome [1]	Width			Thecae per centimeter	Length of virgella
		Theca 1^1	Theca 5^1	Maximum		
USNM—161614 [2]	14	0.7	1.1	1.25	12	2.6
161615 [2]	23	.5	1.2	1.5	11	9.7
161616	15	.9	1.5	1.8	11	5.0
161617	21	.6	1.1	1.5	11	6.0
161619	11.5	.5	1.0	1.1	11	1.8
161618 [2]	28	.5	1.0	1.4	10–11	1.9
161620	19.5	.6	1.3	1.6	10–11	2.2

[1] Exclusive of virgella length.
[2] Figured specimens.

Material.—Approximately 15 compressed, moderately well preserved specimens, some of which are fragmentary.

Figured specimens.—USNM 161614, 161615, 161618.

Climacograptus medius brevicaudatus n. subsp.

Text figure 7*D*; plate 1, figure 12

Description.—The rhabdosome is as much as 2.5 cm long, widening rapidly from a width of 0.8–0.9 mm at the first pair of thecae to a maximum of as much as 2.3 mm, so that it has a parallel-sided appearance for most of its length. The thecae number 10–11 per centimeter, with the free edge of the ventral wall approximately straight and vertical, and the apertural margin horizontal. The proximal end is wide, with a short, robust virgella (0.5–0.6 mm long).

The rhabdosome widens rapidly and measures 1.3–1.6 mm wide at the fifth thecal pair. It resembles *C. medius* in this respect. The excavations are very small

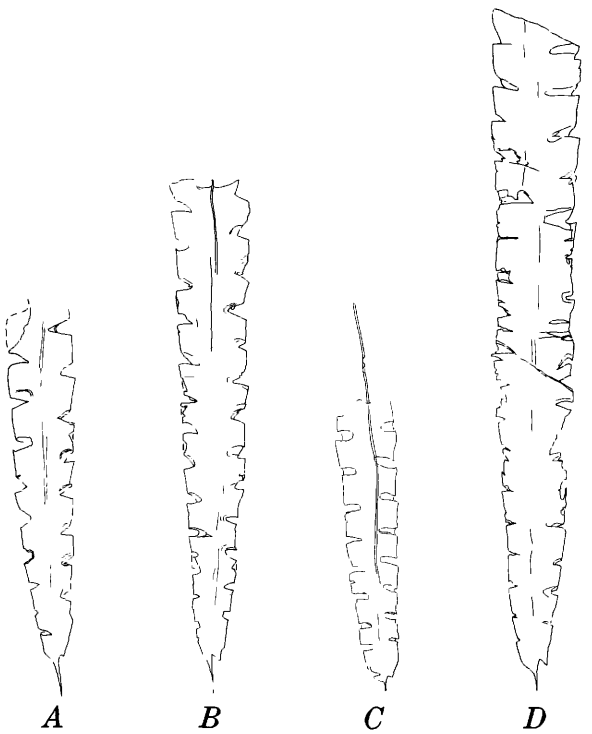


FIGURE 7.—*Climacograptus*. *A*, *B*, *C*. cf. *C. rectangularis* (M'Coy): *A*, (USNM 161631), × 5; *B*, (USNM 161632) (same as pl. 1, fig. 8), × 5. *C*, *C. scalaris* (Hisinger) (USNM 161653), × 5. *D*, *C. medius brevicaudatus* n. subsp., holotype (USNM 161621) (same as pl. 1, fig. 12), × 5.

in the proximal part, occupying less than a fifth of the width of the rhabdosome. They increase in depth distally to about a third of the width of the rhabdosome.

Discussion.—This form resembles *C. medius* very closely except that the Alaskan variety has a much shorter virgella. It has a much broader proximal end and is less tapering than *C. rectangularis* as depicted by Elles and Wood (1901–18) in their plate 26, figure 5a, b, c, and e. It does, however, resemble their figure 5d on plate 26.

Occurrence.—M1142–SD.

Range.—Zone of *M. gregarius* in Alsaka.

Dimensions (in millimeters).—

Specimen No.	Length of rhabdosome	Width			Thecae per centimeter
		Theca 1[1]	Theca 5[1]	Maximum	
USNM–161621[1]	>18	0.9	1.6	2.3	10
161622a	15.5	.8	1.3	1.8	10–11
161622b	>8.6	.8	1.6	1.8	11
161623	>10	.8	1.4	1.9	10
161624e	>17			2	10
161625	>18			2.2	10
161626	11.5	.8	1.5	2.1	11

[1] Figured specimens.

Material.—About 18 compressed specimens. About five are well preserved; the rest are fragmentary. Named after the Latin "brevis"=short and "caudatus"=tailed.

Holotype.—USNM 161621.

Climacograptus minutus? Carruthers

Text figure 6*C*; plate 1, figure 6

Climacograptus minutus Carruthers. Elles and Wood, 1901–18, Mon. British Graptolites, Palaeontographical Soc., p. 211–212, text fig. 142, pl. 27, fig. 12a–c.

Climacograptus minutus Carruthers. Hsü, 1934, Graptolites of the Lower Yangtze Valley, p. 61, pl. 4, fig. 10.

Discussion.—Our specimens closely resemble *C. minutus* but are too poorly preserved for positive identification and are questionably referred to this species.

Occurrence.—M1138–SD.

Range.—Llandoverian zones (17, 18) of *O. vesiculosus* and *M. cyphus* (Birkhill Shales) in Great Britain (Elles and Wood, 1901–18). Ruedemann (1947) reports a *minutus*-like form from the Ordovician Phi Kappa Formation in Idaho. Also reported in the basal part of the Kaochiapien Shale (zone with *A. ascensus*) in China (Hsü, 1934).

Dimensions (in millimeters).—

Specimen No.	Length of rhabdosome	Width		Thecae per centimeter (approximate)
		Theca 1[1]	Maximum	
USNM 161627[1]	>6.5	0.8	1.25	14
161628	5.3	.8	1.0	
161629	9	.7	1.25	12

[1] Figured specimen.

Material.—About four compressed, poorly preserved specimens.

Figured specimen.—USNM 161627.

Climacograptus cf. C. rectangularis (M'Coy)

Text figure 7*A*, *B*; plate 1, figures 7–9

Climacograptus rectangularis (M'Coy). Elles and Wood, 1901–18, Mon. British Graptolites, Palaeontographical Soc., p. 187–188, text fig. 121, pl. 26, fig. 5a–e.

Climacograptus rectangularis (M'Coy). Hundt, 1924, Grapt. d. deutsch. Silurs, p. 56, pl. 1, figs. 14, 15, 24, 25.

Climacograptus rectangularis (M'Coy), Obut, 1949, Polyevoi Atlas, Rukovodyashchich graptolitov vyerkhnyevo Silura Kirgizskoi SSR, p. 12, pl. 1, fi. 2a b.

Climacograptus rectangularis (M'Coy). Stein, 1965, Neues Jahrb. Geologie u. Paläontologie Abh., p. 160–163, text figs. 15a–c, 16 h.

Hedrograptus rectangularis (McCoy). Obut, Sobolevskaya, and Bondarev, 1965, Graptolity Silyura Taimyra, p. 29, pl. 1, figs. 7–9.

Hedrograptus rectangularis (McCoy). Obut and Sobolevskaya, 1966, Graptolity rannyevo Silyura v Kazakhstanye, p. 10–11, text fig. 3, pl. 3, fig. 4.

Discussion.—The Alaskan specimens are mostly narrower than those described by Elles and Wood (1901–18), and the sigmoidal curvature of their thecae becomes more gentle distally. Also, their siculae are free on one side for only about 0.4 mm. The gradual widening, short virgella, and number of thecae per centimeter are like *C. rectangularis*.

Occurrence.—M1138–SD, M1139–SD, M1142–SD.

Range.—Llandoverian zones (16–19) of *A. acuminatus* to *M. gregarius* (lower part of Birkhill Shales and equivalents) in Great Britain (Elles and Wood, 1901–18; Toghill, 1968). Zone of *M. cyphus* (middle part of Road River Formation) in Yukon Territory, Canada (Jackson and Lenz, 1962). Reported from the Edgewood Limestone, zone (17) of *D. modestus*, of northeast Illinois by Ross (1962). Llandoverian zone of *O. vesiculosus* (approximate) in Pulau Langgon, Langkawi Island, Malaya (Kobayashi and others, 1964). Also reported from: Portugal (Romariz, 1962), Germany (Hundt, 1924), Russia (Obut, 1949; Obut and others, 1965; Obut and Sobolevskaya, 1966), Bohemia (Pribyl, 1948).

Dimensions (in millimeters).—

Specimen No.	Length of rhabdosome	Width			Thecae per centimeter
		Theca 1[1]	Theca 5[1]	Maximum	
USNM–161631 [1]	21. 5	0. 7	1. 2	2. 0	11–12
161632 [1]	13. 8	. 7	1. 3	2. 0	10–11
161633	15. 0	. 6	1. 3	1. 8	11–12
161634	>16	. 7	1. 0	1. 5	10
161635 [1]	12. 5	. 8	1. 5	2. 2	11
161636	8. 5	. 7	1. 3	1. 7	12
161637	>13. 5	. 7	1. 3	1. 8	10–11
161638	9. 8	. 7	1. 1	1. 6	10
161639 [1]	>16. 5	. 7	1. 2	2. 0	10
161640	9. 6	. 6	1. 2	1. 7	10
161641	>7. 5	. 7	1. 25	1. 5	11
161642	8. 0	. 6	1. 3	1. 6	12

[1] Figured specimen.

Material.—Approximately 30 compressed, fairly well preserved specimens (about half are fragmentary).

Figured specimens.—USNM 161631, 161632, 161635, 161639.

Climacograptus rectangularis abbreviatus n. subsp.

Text figure 8*C*; plate 1, figure 15

Description.—The short, robust rhabdosome is 1–2 cm long and increases gradually in width throughout its length from 0.8 to 0.9 mm at theca 1[1] to a maximum of 2.0–2.5 mm. The thecae are markedly alternate and number 10–12 per centimeter with an overlap about a third of their length. The apertural margins are horizontal and are in deep excavations occupying fully a third of the width of the rhabdosome. The geniculum is very sharp, and the free ventral wall above it is slightly inclined to the axis of the rhabdosome. The characters of the sicula are unknown, but a short, fine virgella is present.

Discussion.—This form closely resembles *C. rectangularis* but has a generally shorter rhabdosome. (*C. rectangularis* measures 1–4 cm in length). It also has a smaller, less conspicuous virgella than *rectangularis*. It is wider than *Climacograptus* cf. *C. rectangularis*, described in this paper. This variety also resembles *C. latus*, but lacks the basal spines and has deeper excavations. It is characterized by relatively great width in proportion to its length, and by the markedly alternate thecae, especially in the proximal part.

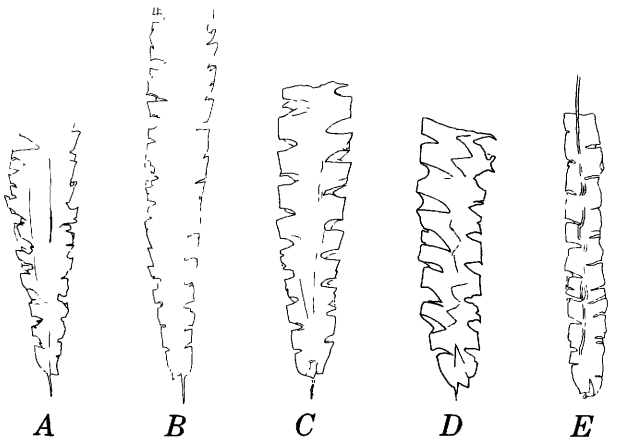


FIGURE 8.—*Climacograptus* and *Pseudoclimacograptus*. *A, B, C. stenotelus* n. sp.: *A* (USNM 161673), × 5; *B*, Holotype (USNM 161666) (same as pl. 1, fig. 14), showing slight distortion, × 5; *C, C. rectangularis abbreviatus* n. subsp., Holotype (USNM 161643), × 5. *D, P.* (*Metaclimacograptus*) cf. *P.* (*M.*) *undulatus* (Kurck) (USNM 161690) (same as pl. 1, fig. 18) showing some distortion, × 9. *E, P.* (*Metaclimacograptus*) *hughesi* (Nicholson) (USNM 161674) (same as pl. 1, fig. 16), × 5.

Occurrence.—M1138–SD, M1139–SD.

Range.—Zone of *M. cyphus* in Alaska.

Dimensions (in millimeters).—

Specimen No.	Length of rhabdosome	Width		Thecae per centimeter
		Theca 1[1]	Maximum	
USNM–161643 [1]	8. 5	0. 9	2. 0	12
161645	>18. 5	. 8	2. 3	10–11
161646 [1]	8. 0	. 9	1. 8	12–13
161647	16. 0	. 8	2. 3	10–12
161648	15. 0	. 9	2. 5	9–11
161649	11. 5	. 9	2. 2	11
161650	>7	. 9	1. 7	10
161651c	>5. 6	1. 0	1. 7	11
161652e	>6	. 9	2. 0	11
161652f	4. 5	. 8	1. 3	

[1] Figured specimen.

Material.—Approximately 10 compressed, well-preserved specimens.

Holotype.—USNM 161643.

Figured specimens.—USNM 161643, 161646.

Climacograptus scalaris (Hisinger)

Text figure 7*C*; plate 1, figures 10, 11

Climacograptus scalaris (Hisinger) (Linné?). Elles and Wood, 1901–18, Mon. British Graptolites, Palaeontographical Soc., p. 184–185, text fig. 118, pl. 26, fig. 1a–c.

Climacograptus scalaris (Hisinger). Hundt, 1924, Grapt. d. deutsch. Silurs, p. 55, pl. 1, figs. 27–31.

Climacograptus scalaris scalaris (Hisinger). Stein, 1965, Neues Jahrb. Geologie u. Paläontologie Abh., p. 149–150, 157, text fig. 13a-h, pl. 14, figs. a, b.

Discussion.—The Alaskan specimens agree closely with the description of *C. scalaris* by Elles and Wood (1901–18). However, some specimens have a few more thecae per centimeter (11–14 vs. nine to 11 for Elles and Wood, 1901–18).

Occurrrence.—M1138–SD, M1139–SD, M1289–SD, M1290–SD(?).

Range.—Llandoverian zones of *M. convolutus* to *M. sedgwickii* (middle part of Road River Formation) in Yukon Territory, Canada. Varieties reported from same area in Ashgillian zone of *Dicellograptus complanatus* var. *ornatus* and Llandoverian zone of *M. millepeda* (Jackson and Lenz, 1962), Llandoverian zones (19–22) of *M. gregarius* to *M. turriculatus* (upper Birkhill Shales, lower Gala Beds) in Great Britain (Elles and Wood, 1901–18; Toghill, 1968). Also found in: Germany (zones 10–15) (Hundt, 1924); Portugal (zone 19–22) (Romariz, 1962); Bohemia, Czechoslovakia (Llandoverian zones of *Demirastrites convolutus* to *M. sedgwickii*) (Pribyl, 1948); Australia (Bolindian to lower Keilorian) (Thomas, 1960). Varieties are reported from Maine (Clinton? age) and Arkansas (Lower Silurian Blaylock Sandstone) by Reudemann (1947), and from Russia by Obut (1949). Apparently *C. scalaris* in southeastern Alaska ranges down into the zone of *M. cyphus*, a zone lower than it occurs in the British Isles.

Dimensions (in millimeters).—

Specimen No.	Length of rhabdosome	Maximum width	Thecae per centimeter
USNM–161653 [1]	7.5	1.5	12
161654	10.5	1.5	12
161655	6.5	1.3	12
161656	7.2	1.5	12
161657	20.8	1.5	11
161658 [1]	9.3	1.4	14
161659	9	1.5	12
161660	13.3	1.3	12
161661	21.5	1.5	12
161662	17.5	1.5	12
161663 [1]	>8	1.5	12
161664	11.5	1.5	13
161665	>8	1.5	12

[1] Figured specimens.

Material.—About 63 compressed, well-preserved specimens.

Figured specimens.—USNM 161653, 161658, 161663.

Climacograptus stenotelus n. sp.

Text figure 8 *A, B;* plate 1, figures 13, 14

Description.—The rhabdosome is as much as 3 cm long and 0.5–0.6 mm wide initially, reaching a maximum width of approximately 2.0 mm. The thecae are of the general climacograptid type, numbering 14–16 per centimeter. The proximal end is gently tapering in appearance, with a virgella about 1 mm long.

Discussion.—Because the specimens are somewhat deformed, it is difficult to say what their true appearance was. Generally, this is a long form with closely set thecae and a tapering proximal end. It is larger than *C. scalaris*, narrower and with more closely set thecae than *C. rectangularis* and *C. medius* and also with a shorter virgella than *C. medius*. It has a narrower and more tapering proximal end than *C. minimus*. Its most distinctive feature is the narrow proximal end with its closely set thecae.

Occurrence.—M1140–SD.

Range.—Zone of *M. gregarius* to *M. convolutus* in Alaska.

Dimensions (in millimeters).—

Specimen No.	Length of rhabdosome	Width			Thecae per centimeter
		Theca 1[1]	Theca 5[1]	Maximum	
USNM–161666 [1]	>11.3	0.6	1.4	1.9	16
161668f	>12	.5	1.25	1.5	16
161668g	5	.6	1.4	1.5	20
161669	>27.5	.5	1.1	1.5	14–15
161670	5	.5	1.2		14
161671	24	.5	1.1	1.5	15
161672	>14	.6	1.4	1.9	14
161673 [1]	11	.6	1.4	1.8	16
161667 [1]	>15.5	.6	1.2	1.7	13–16

[1] Figured specimens.

Material.—Approximately 50 compressed, distorted specimens, somewhat poorly preserved. Named after the Greek "stenos"=narrow and "telus"=end.

Holotype.—USNM 161666.

Figured specimens.—USNM 161666, 161667, 161673.

Genus PSEUDOCLIMACOGRAPTUS Pribyl, 1947

Pseudoclimacograptus Pribyl, 1947, Bull. internat. de l'Acad. tchèque Sci., v. 48, p. 21

Pseudoclimacograptus Pribyl, Bulman and Rickards, 1968, Palaeontology, v. 11, pt. 1, p. 2

Rhabdosome diplograptid, with zigzag, angular, or undulating median septum. Thecae of "Glypto-climacograptus" type; apertural excavations short and deep, often introverted. A genicular hood present in some

late representatives. Lower Ordovician to Lower Silurian; Europe, Asia, Australia, and North America.

Subgenus P. (METACLIMACOGRAPTUS) Bulman and Rickards 1968

P. (*Metaclimacograptus*) Bulman and Rickards, 1968, Palaeontology, v. 11, pt. 1, p. 3.

Climacograptids with gently convex or nearly straight supragenicular walls; apertural excavations short, deep, and introverted and partly covered by a hood growing from the geniculum of the succeeding theca. Angular to undulating median septum. Lower Silurian; Europe, Asia, Australia, and North America.

P. (Metaclimacograptus) hughesi (Nicholson)

Text figure 8 *E*; plate 1, figures 16, 17

Climacograptus Hughesi (Nicholson). Elles and Wood, 1901–18, Mon. British Graptolites, Palaeontographical Soc., p. 208–210, text fig. 140, pl. 27, fig. 11a–e.

Climacograptus Hughesi Nicholson. Hundt, 1924, Grapt. d. deutsch. Silurs, p. 56, pl. 1, figs. 8–10.

Climacograptus hughesi (Nicholson). Hsü, 1934, Graptolites of the lower Yangtze Valley, p. 67–68, pl. 5, fig. 7a–c.

Climacograptus hughesi (Nicholson). Harris and Thomas, 1937, Victoria Dept. of Mines, Mining and Geol. Jour., July 1937, p. 69, pl. i, fig. 1.

Pseudoclimacograptus hughesi (Nicholson). Pribyl, 1948, Knihovna Stát. geol. úst. Čsk. Republiky, sv. 22, p. 18.

Pseudoclimacograptus hughesi (Nicholson). Obut and Sobolevskaya, 1966, Graptolity rannyevo Silyura v Kazakhstanye, p. 12–13, text fig. 4, pl. 3, figs. 5, 6.

Pseudoclimacograptus (*Metaclimacograptus*) *hughesi* (Nicholson). Bulman and Rickards, 1968, Palaeontology, v. 11, pt. 1, p. 3–6, text figs. 1a–c.

Discussion.—The pyritized specimens from Nevada agree very closely with the description and dimensions given by Bulman and Rickards (1968, p. 3–5) except for the shape of the median septum. The Nevada specimens have a more angulate septum, similar to that of *P.* (*M*). *undulatus*, as described by Bulman and Rickards (text fig. 1d). In their discussion (p. 5), they state that in some of the earlier specimens of *hughesi* (from the *acinaces* zone) "there are traces of the angularity characteristic" of the median septum in *P.* (*M.*) *undulatus*. However, our (pyritized) specimens are from a higher horizon (*gregarius* zone). Traces of the genicular hoods are visible in some of the pyritized specimens.

Occurrence.—M1138–SD, M1139–SD, M1289–SD. Nevada: Central Independence Range, locality 4 of Kerr (1962).

Range.—Zone of *M. cyphus* (Cape Phillips Formation) in Canadian Arctic (Thorsteinsson, 1958). Questionably from Silurian black slate at Houlton, Maine (Ruedemann, 1947). Llandoverian zones of *M. cyphus* and *M. gregarius* (Birkhill Shales) in Great Britian (Toghill, 1968). Llandoverian zone of *M. gregarius* in New South Wales, Australia (Sherrard, 1954). Upper Bolindian through Keilorian in Victoria, Australia (Thomas, 1960). Also reported from Germany (Hundt, 1924), Bohemia (Pribyl, 1948), Portugal (Romariz, 1962), Russia (Obut and Sobolevskaya, 1966), and China (Hsü, 1934).

Dimensions (*in millimeters*).—

Specimen No.	Flattened (F) or in relief (R)	Length of rhabdosome	Width		Thecae per centimeter	Length of sicula
			Theca 1[1]	Maximum		
USNM–161674 [1]	F	9.5	0.8	1.0	14	----------
161675	F	5.7	.7	.9	14	----------
161676	F	9.1	.7	1.0	14	----------
161677	F	7.0	.7	1.0	15	----------
161678	F	12.5	.8	1.0	12	----------
161679	F	6.3	.8	1.0	16	----------
161680	R	11.0	----------		12	.5
161681	R	7.8	.6	1.0	14	.7
161682	R	2.8	.5	.7	13	.5
161683	R	7.3	----------	.7	14	----------
161684	R	8.4	.5	.8	12	.6
161685	R	6.0	----------		13	----------
161686	R	5.0	.4	.6	12	----------
161687 [1]	R	11.3	.7	.9	14	.5
161688	R	7.6	.6	.75	14	.6
161689	R	16.3	.6	1.0	10–12	----------

[1] Figured specimens.

Material.—About 20 compressed, well-preserved specimens and 10 pyritized specimens preserved in relief.

Figured specimens.—USNM 161674, 161687.

P. (Metaclimacograptus) cf. P. (M.) undulatus (Kurck)

Text figure 8*D*; plate 1, figure 18

Climacograptus extremus H. Lapworth. Elles and Wood, 1901–18, Mon. British Graptolites, Palaeontographical Soc., p. 210–211, text fig. 141, pl. 27, fig. 13a, b.

Pseudoclimacograptus (*Metaclimacograptus*) *undulatus* (Kurck). Bulman and Rickards, 1968, Palaeontology, v. 11, pt. 1, p. 6–8, text figs. 1d–j, 3e.

Discussion.—Because our specimens are distorted, identification is difficult. The zigzag septa, large number of thecae per centimeter, and small rhabdosomes of our specimens indicate that they are probably *P.* (*M.*) *undulatus*. One specimen (text fig. 8*D*) has a sicula 0.65 mm long.

Occurrence.—M1140–SD.

Range.—Llandoverian zones of *M. cyphus* and *M. millepeda* (Cape Phillips Formation) in the Canadian Arctic (Thorsteinsson, 1958). Questionably from Ordovician shale, Mount Joli, Percè, Quebec (Ruedemann, 1947). Llandoverian zones of *M. cyphus* to *M. sedgwickii* and possibly *M. turriculatus* in Great Britain and Sweden (Bulman and Rickards, 1968).

Dimensions (in millimeters).—

Specimen No.	Length of rhabdosome	Width		Thecae per centimeter
		Theca 1[1]	Maximum	
USNM–161690 [1]	4.5	0.65	1.1	20
161691	5.0	.8	.8	18
161692	8.5	.5	.9	18
161693	5.0	.5	1.0	16
161694	>9.0	----	1.0	20
161695	9.0	.7	1.1	19–20
161696	9.0	.5	1.0	17–18

[1] Figured specimen.

Material.—About 40 compressed specimens (some show slight relief), which have been moderately distorted.

Figured specimen.—USNM 161690.

Subfamily DIPLOGRAPTINAE

Genus DIPLOGRAPTUS M'Coy, 1850

(= MESOGRAPTUS Elles and Wood, 1901–18)

Diplograptus M'Coy. Bulman, 1955, Geol. Soc. America, Treatise on invertebrate paleontology, pt. V, p. V85, fig. 63, 2a, b.

Rhabdosome biserial, scandent. Thecae strongly sigmoidal with apertures in broad semicircular excavations at proximal end, gradually becoming more gently sigmoid and almost straight distally. Periderm attenuated and with apertural lists proximally. Middle Ordovician to Lower Silurian; Europe, North America, Australia, and Asia.

Diplograptus elongatus n. sp.

Text figure 9*C, D;* plate 1, figures 19, 20

Description.—The rhabdosome is about 2.5 mm long, or longer, widening gradually from an initial width of approximately 0.8 mm to a maximum of 2.5 mm. The thecae number eight to 13 per centimeter and are of the climacograptid type (thecae with angular sigmodial curvature, free ventral wall subparallel to rhabdosome axis, apertures in semicircular excavations) up to about the fifth thecal pair, above which they change gradually to the glyptograptid type (thecae with gentle sigmoidal curvature). The characters of the sicula are unknown. A short virgella, measuring approximately 0.8 mm, is commonly present.

Discussion.—The whole rhabdosome has a tapering appearance. This form is characterized by its relative narrowness in comparison to other species of *Diplograptus,* by the tapering shape of the rhabdosome, and by the small number of climacograptid-type thecae. In general appearance it resembles *D. multidens* var. *compactus* but lacks the basal spines and the more closely set thecae (12–14 per centimeter) of that form.

Occurrence.—M1138–SD.

Range. —Zone of *M. cyphus* in Alaska.

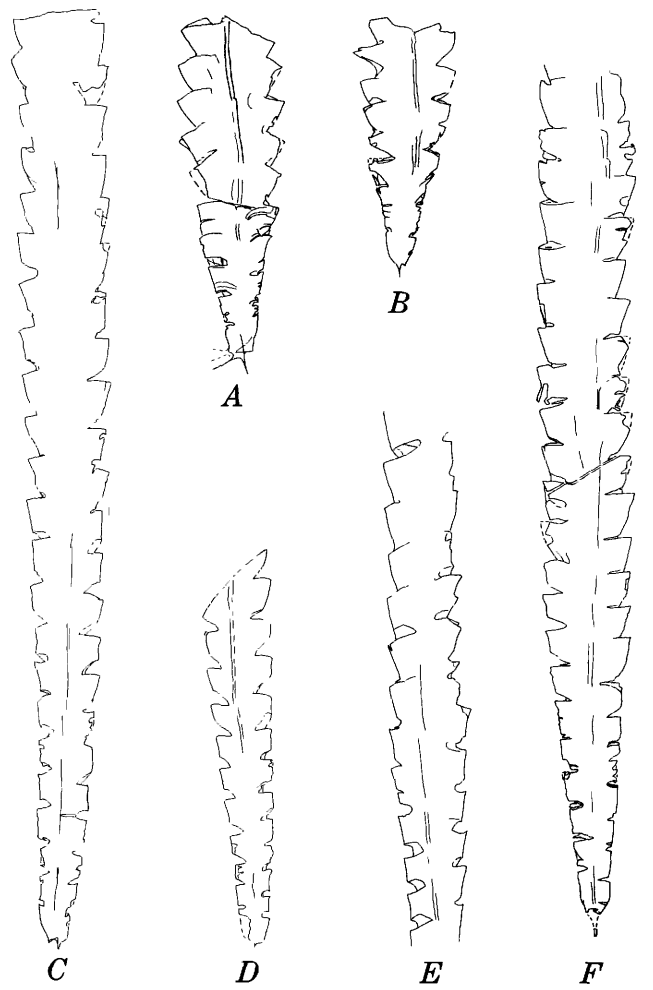


FIGURE 9.—*Diplograptus. A, B, D. mucroterminatus* n. sp.: *A,* Holotype (USNM 161707) showing proximal spines, × 5; *B,* Immature specimen (USNM 161705), × 5. *C, D, D. elongatus* n. sp.: *C,* Holotype (USNM 161698) (same as pl. 1, fig. 20), × 4; *D,* (USNM 161697) × 5. *E, F, Diplograptus* n. sp.: *E,* fragmentary specimen (USNM 161711) (same as pl. 2, fig. 1), × 5; *F,* (USNM 161712), × 5.

Dimensions (in millimeters).—

Specimen No.	Length of rhabdosome	Width			Thecae per centimeter
		Theca 1[1]	Theca 5[1]	Maximum	
USNM–161697 [1]	10.5	----	1.3	1.75	11–13
161698 [1]	25.2	0.8	1.3	2.0	8–10
161699	22.6	.7	1.3	1.75	10–13
161732	25.7	.7	1.3	2.0	9
161700 [1]	18.0	.8	1.3	2.4	9–11

[1] Figured specimens.

Material.—Approximately 16 compressed specimens; about four are well preserved, the others are fragmentary. Named after the Latin "elongatus"=prolonged.

Holotype.—USNM 161698.

Figured specimens.—USNM 161697, 161698, 161700.

Diplograptus modestus var. diminutus Elles and Wood

Text figure 10*G*; plate 2, figure 19

Diplograptus (Mesograptus) modestus var. *diminutus* Elles and Wood, 1901–18, Mon. British Graptolites, Palaeontographical Soc., p. 265, text fig. 182, pl. 31, fig. 13a–c.

Discussions.—This variety resembles *D. modestus* very closely but differs by its smaller size and more closely set thecae. The rhabdosome is not more than 1.5 cm long, and its width increases quickly from 0.6 mm initially to about 1.5 mm distally. The thecae are the same as in *D. modestus* s.s. but number 14–16 per centimeter.

Occurrence.—M1141–SD, M1287–SD, M1288–SD (?).

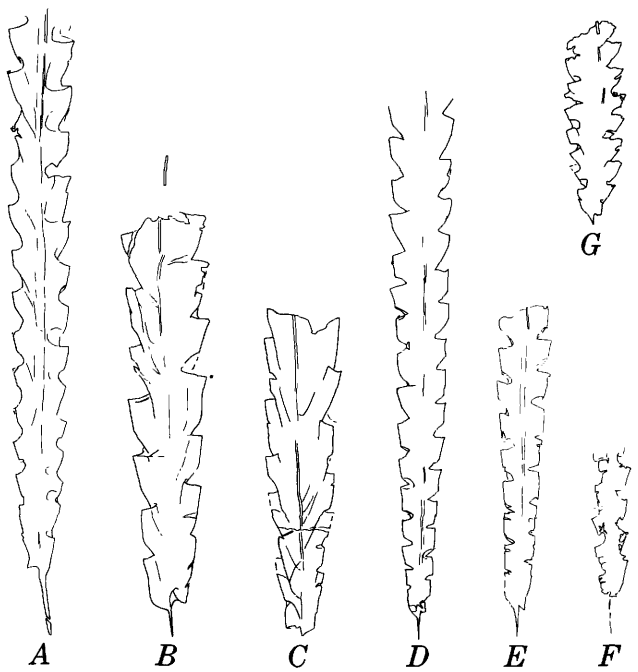


FIGURE 10.—*Glyptograptus* and *Diplograptus*. *A*, *G.* cf. *G. enodis enodis* Packham (USNM 161715) (same as pl. 2, fig. 2), × 5. *B, C, G.* cf. *G. enodis latus* Packham: *B,* (USNM 161718) (same as pl. 2, fig. 3), × 8; *C,* (USNM 161717) (same as pl. 2, fig. 4), × 8. *D, E, G. incertus* Elles and Wood: *D,* (USNM 161730) (same as pl. 2, fig. 5), × 5; *E,* (USNM 161731), × 5. *F, G.* cf. *G. tamariscus tamariscus* (Nicholson) (USNM 161986), × 5. *G, Diplograptus modestus* var. *diminutus* Elles and Wood (USNM 161701a) (same as pl. 2, fig. 19), × 5.

Range.—D. modestus diminutus is found in the Llandoverian zones (16–18) of *A. acuminatus* to *M. cyphus* (Birkhill Shales) in Great Britain (Elles and Wood, 1901–18). *D. modestus* is found in: The Llandoverian zone of *D. modestus* (Road River Formation) in Yukon Territory, Canada (Jackson and Lenz, 1962); the zone of *M. cyphus* (Cape Phillips Formation) in the Canadian Arctic (Thorsteinsson, 1958); the Llandoverian zones of *D. acuminatus* and *M. cyphus* in the Frankenwald (northeastern Bavaria) (Stein, 1965); the lower Llandovery in Portugal (Romariz, 1962); the lower Llandovery (Parhsa-pye graptolite beds) in the Langkawi Islands, Malaya (Kobayashi and others, 1964); the zones of *Cystograptus vesiculosus* and *Pristiograptus cyphus* in Russia (Obut and others, 1965); the Lower Silurian of China (Sun, 1933; Hsu, 1934); the Keilorian of Australia (Thomas, 1960).

Dimensions (in millimeters).—

Specimen No.	Length of rhabdosome	Width		Thecae per centimeter
		Theca 1[1]	Maximum	
USNM–161701a[1]	5. 3	1. 0	1. 7	16
161701b	5. 4	. 9	1. 4	16
161702	5. 0	. 9	1. 8	18
161703	>3. 8	. 9	1. 6	20(?)

[1] Figured specimens.

Material.—Approximately 12 compressed, fairly well preserved specimens.

Figured specimen.—USNM 161701a.

Diplograptus mucroterminatus n. sp.

Text figure 9*A, B*; plate 1, figure 21

Description.—The rhabdosome is wide and relatively short; none exceed about 1.5 cm in length. The maximum width ranges from 2.3 to 3.0 mm with the average specimen being approximately 2.5 mm wide. The proximal end is greatly tapered, widening rapidly from a width of 0.6–0.9 mm at the first pair of thecae to 2.0–2.6 mm at the fifth thecal pair. The thecae number 11–12 per centimeter, strongly climacograptid proximally, then changing rapidly to orthograptid-type thecae distally. The sicula is free for a part of its length on one side and has a short virgella (0.5–0.8 mm long). Frequently the virgula extends for a distance (18.5 mm maximum) above the distal end of the rhabdosome.

Discussion.—The characteristic feature of this form is the strongly tapered proximal end. The first three pairs of thecae are climacograptid, with excavations occupying approximately one-fourth to one-third the width of the rhabdosome. The fourth thecal pair is more or less intermediate in type and the orthograptid-type thecae appear in the fifth thecal pair. The rhabdosome tapers to about the fifth pair; above this point the margins of the rhabdosome are nearly parallel. The orthograptid-type thecae are short, wide, straight tubes, inclined to the rhabdosome axis, with everted apertural margins. In some specimens, the rhabdosome narrows slightly distally. From a maximum width of 2.8 mm, 3.0 mm, and 2.6 mm, three specimens narrow

to 2.0 mm, 2.3 mm, and 2.0 mm wide, respectively, at the last pair of thecae. One specimen (fig. 9*A*) seems to have a proximal spine (possibly three spines) growing out almost horizontally from the first theca near its change of growth direction. There appear to be traces of two other spines close by. No other specimen had spines preserved.

This species resembles *D. modestus* somewhat, but it widens more rapidly and is smaller than *modestus*. The distal part resembles *Orthograptus bellulus*, but the proximal end of *O. bellulus* has no climacograptid thecae.

Occurrence.—M1142–SD.

Range.—Zone of *M. gregarius* in Alaska.

Dimensions (in millimeters).—

Specimen No.	Length of rhabdosome	Width			Thecae per centimeter
		Theca 1[1]	Theca 5[1]	Maximum	
USNM–161704	11. 1	0. 9	2. 6	2. 8	12
161705 [1]	7. 0	. 8	2. 0	2. 6	12
161706 [1]	12. 5	. 7	2. 3	3	12
161707 [1]	9. 5	. 8	2. 1	2. 5	12
161708c	15	. 8	2. 1	2. 3	11
161708d	5	. 6	1. 9	2	
161709	12. 5		2. 2	2. 6	12
161710	3. 5	. 9	2. 4	2. 4	

[1] Figured specimens.

Material.—Twelve compressed, fairly well preserved specimens. Named after the Latin "mucro"=sharp point, and "terminatus"=end.

Holotype.—USNM 161707.

Figured specimens.—USNM 161705–161707.

Diplograptus n. sp. A

Text figure 9*E*, *F*; plate 2, figure 1

Description.—The rhabdosome is more than 2 cm long, widening from an initial width of 0.9 mm at the first thecal pair to a maximum width of about 2.5 mm. The thecae number nine to 11 per centimeter, and are of the climacograptid type proximally, becoming orthograptid type thecae distally.

Discussion.—Only two specimens are known and one of these is fragmental. This species has a distinctively long and slender rhabdosome. The proximal end tapers from a width of 0.9 mm at the first pair of thecae to a width of 1.5 mm at the fifth thecal pair. The thecae are climacograptid up to about the tenth pair. Then they change to the orthograptid type, with straight ventral walls and horizontal or slightly everted apertural margins. The characteristics of the sicula are unknown.

This form differs from other species of *Diplograptus* by being narrower and having fewer thecae per centimeter. It differs from *Diplograptus elongatus* in having distal thecae of the orthograptid type, whereas *Diplograptus elongatus* has distal thecae of the glyptograptid type. This new species is not named because of the scarcity and poor preservation of specimens.

Occurrence.—M1138–SD.

Range.—Zone of *M. cyphus* in Alaska.

Dimensions (in millimeters).—

Specimen No.	Length of rhabdosome	Width			Thecae per centimeter
		Theca 1[1]	Theca 5[1]	Maximum	
USNM–161711 [1]	>19			2. 0	9–10
161712 [1]	>23	0. 9	1. 5	2. 5	10–11

[1] Figured specimens.

Material.—Two compressed specimens.

Figured specimens.—USNM 161711, 161712.

Diplograptus n. sp. B

Discussion.—A diplograptid of great length and relative narrowness, distally resembling a large glyptograptid such as *G. serratus*. Only two specimens of this species are present in our collection, and on both the proximal end is missing.

Occurrence.—M1138–SD.

Range.—Zone of *M. cyphus* in Alaska.

Dimensions (in millimeters).—

Specimen No.	Length of rhabdosome	Width		Thecae per centimeter
		Minimum	Maximum	
USNM–161713	>53	1. 1	3. 0	8–10
161714	>60	1. 3	3. 0	8–9

Genus GLYPTOGRAPTUS Lapworth, 1873

Glyptograptus Lapworth. Bulman, 1955, Geol. Soc. America, Treatise on invertebrate paleontology, pt. V, p. V86 fig. 4a, b.

Rhabdosome biserial, scandent. Thecae with gently sigmoidal curvature, apertural margins frequently undulate. Lower Ordovician to Lower Silurian, worldwide.

Glyptograptus cf. G. enodis var. enodis Packham

Text figure 10*A*; plate 2, figure 2

Glyptograptus enodis enodis Packham, 1962, Palaeontology, v. 5, p. 517, pl. 71, figs. 18, 19, 21; pl. 72, fig. 1, text fig. 4g–j.

Description.—According to the original description, the rhabdosome is nearly 4 cm long, increasing rapidly in width until the fifth pair of thecae from whence it is parallel sided or slowly widening. The thecae number 8½–11 per centimeter, have gentle sigmoidal curvature and everted apertures and overlap approximately a third of their length. The virgella is stout.

At theca 1[1], the rhabdosome is about 0.6 mm wide, at theca 5[1] it is about 0.9–1.2 mm wide, and its maximum

width is 1.7 mm. Above the geniculum the free ventral walls of the thecae are inclined to the axis of the rhabdosome. The common canal is approximately uniform in width beyond the fifth pair of thecae and occupies about half the width of the rhabdosome in that region and less proximally.

Discussion.—According to Packham (1962), *G. enodis* can be distinguished from *G. tamariscus* by the more gentle curvature of the thecae, the longer and less definite excavations occupying a smaller proportion of the rhabdosome width, and by a greater overlap of the thecae."

Only two specimens are present in our collections, and one is wider than the specimens described by Packham (1962). Both of our specimens look like Packham's flattened specimen (1962, text fig. 4j) with nonalternating thecae, and both have a good stout virgella.

Occurrence.—M1138–SD, M1288–SD(?).

Range.—Llandoverian zone of *M. gregarius* in Great Britain (Packham, 1962). The occurrences of *G. enodis enodis* in Alaska with assemblages that otherwise indicate correlations with the zones of *M. cyphus* and *O. vesiculosus* suggests it ranges lower in western North America.

Dimensions (in millimeters).—

Specimen No.	Length of rhabdosome	Width			Thecae per centimeter	Length of virgella
		Theca 1^1	Theca 5^1	Maximum		
USNM–161715 [1]	>20.5	0.8	1.2	1.6	8–11	2.0
161716	28.0	.8	1.5	2.0	10	2.0

[1] Figured specimens.

Material.—Two compressed, moderately well preserved specimens.

Figured specimen.—USNM 161715.

Glyptograptus cf. G. enodis var. latus Packham

Text figure 10*B, C;* plate 2, figures 3, 4

Glyptograptus enodis latus, Packham, 1962, Palaeontology, v. 5, p. 518, pl. 71, fig. 20, text fig. 4e.

Description.—According to Packham (1962), this is a long form of *G. enodis* that increases in width throughout its length and reaches a maximum width of 1.4 mm distally. The common canal widens steadily throughout the rhabdosome and occupies about half the width at the distal end. The thecae have a gentle sigmoidal curvature, everted apertures, and an overlap of about a third. The excavations occupy about a third of the width of the rhabdosome.

Discussion.—Packham's (1962) only specimen measures 0.65 mm wide at th1^1, 1.1 mm wide at th5^1, and 1.4 mm wide maximum. It has nine to 11 thecae per centimeter and is preserved in relief. The Alaskan specimens are wider proximally and have one more theca per centimeter, but this may be due in part to the fact that the Alaskan material is flattened.

Occurrence.—M1142–SD.

Range.—Llandoverian zone of *M. gregarius* in Great Britain (Packham, 1962).

Dimensions (in millimeters).—

Specimen No.	Length of rhabdosome	Width			Thecae per centimeter	Length of Theca 1^1	Length of sicula free on one side
		Theca 1^1	Theca 5^1	Maximum			
USNM–161717 [1]	>5.5	0.8	1.1	1.2	11–12	1.0	0.4
161718 [1]	8.0	.8	1.3	1.4	11	.9	.35
161719	7.2	.8	1.3	1.3	12	----	----
161720	5.0	.75	1.4	1.4	10	.9	.5
161721	8.0	.75	1.3	1.3	11	.8	.45
161722	5.0	.8	1.4	1.5	11–12	.9	.35
161723	4.0	.7	----	1.4	----	1.0	----
161724	>8.0	.8	1.4	1.6	11	1.0	----
161624L	>6.0	.8	1.4	1.5	12	.8	----
161801m	4.0	.7	1.4	1.4	12	----	----
161725b	>7.0	.75	1.4	1.5	12	----	----
161726	5.3	.8	1.4	1.4	12	----	----

[1] Figured specimens.

Material.—About 17 compressed, fairly well preserved specimens.

Figured specimens.—USNM 161717, 161718.

Glyptograptus gnomus n. sp.

Text figure 11*E, F;* plate 2, figure 16

Description.—The rhabdosome is less than 2 cm long, widening from a width of about 0.6 mm at theca 1^1 to a maximum of about 1.8 mm. The thecae number 11–14 per centimeter, overlap approximately a third of their length, and have relatively long free ventral walls above the geniculum which are inclined to the rhabdosome axis. The apertural margins are horizontal or slightly everted. The excavations are moderately deep and approximately the same size throughout the length of the rhabdosome, so that the common canal increases in width as the rhabdosome increases in width. The geniculum becomes more gentle distally. The sicula is about 1 mm long, extending up to the level of the aperture of theca 1^2, and free on one side for about half of its length. The virgella is conspicuous and about 0.6 mm long.

Discussion.—This form differs from *G. tamariscus* (Packham, 1962) by having inclined free ventral walls above the geniculum, shallower excavations, and a more tapering shape. It looks somewhat similar to Obut and Sobolevskaya's (1966) *G. tamariscus nikolayevi,* but the positions of theca 1^1 and theca 1^2 are different. Obut and Sobolevskaya (1966, text fig. 6) show the aperture of theca 1^1 to be slightly above the aperture of theca 1^2. In the Alaskan specimens, the situation is reversed. It might possibly be

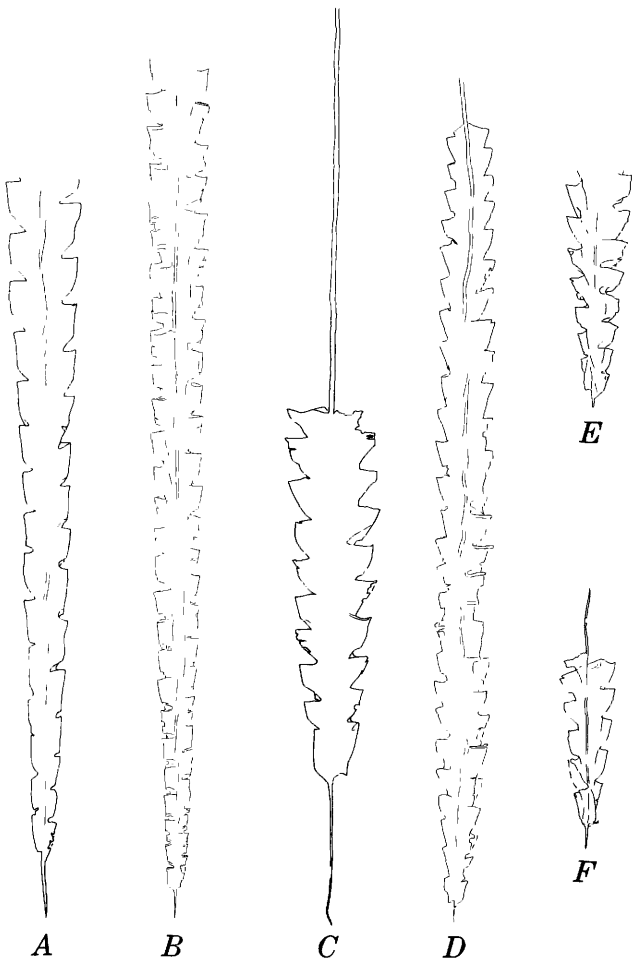


FIGURE 11.—*Glyptograptus. A, B, G. tamariscus magnus* n. subsp.: *A*, Holotype (USNM 161765), proximal part (same as pl. 2, fig. 7), × 5; *B*, (USNM 161771), × 4. *C, G. lanpherei* n. sp., holotype (USNM 161759), × 5. *D, G. laciniosus* n. sp., holotype (USNM 161746) (same as pl. 2, fig. 18), × 5. *E, F, G. gnomus* n. sp.: *E*, holotype (USNM 161644) (same as pl. 2, fig. 16), detail of the proximal part, × 5; *F*, (USNM 161727), × 5.

the proximal part of *G. serratus*, but Elles and Wood (1901–18) do not give a sufficiently detailed description for comparison.

Occurrence.—M1138–SD.

Range.—Zone of *M. cyphus* in Alaska.

Dimensions (in millimeters).—

Specimen No.	Length of rhabdosome	Width			Thecae per centimeter	Length of Theca 1[1]
		Theca 1[1]	Theca 5[1]	Maximum		
USNM–161644[1]	12.5	0.7	1.5	1.7	11–14	0.75
161727[1]	6.5	.6	1.3	------	13	.8
161728	15.5	.7	1.2	1.4	12	.8
161729	4.2	.6	>1.0	------	13	1.0

[1] Figured specimens.

Material.—Four compressed, well-preserved specimens. Named after New Latin "gnomus" = diminutive fabled being, dwarf.

Holotype.—USNM 161644.

Figured specimens.—USNM 161644, USNM 161727.

Glyptograptus incertus Elles and Wood

Text figure 10*D, E;* plate 2, figures 5, 6

Diplograptus (Glyptograptus) tamariscus var. *incertus* Elles and Wood, 1901–18, Mon. British Graptolites, Palaeontographical Society, p. 249, text fig. 168a, b, pl. 30, fig. 9a–d.

Glyptograptus incertus Elles and Wood. Packham, 1962, Palaeontology, v. 5, p. 518–519, pl. 72, figs. 6, 7, text fig. 4a–d.

Description.—According to Packham (1962), the rhabdosome is about 2 cm long and is virtually parallel sided, with a broad proximal end. The thecae have distinct sigmoidal curvature that is more pronounced proximally than distally. They number 11–14 per centimeter and overlap approximately a third of their length.

The rhabdosome is 0.6–0.8 mm wide at the first pair of thecae, widens gradually to about 1.4 mm at 5 mm from the proximal end and reaches a maximum width of about 1.6 mm. Thecal shape varies throughout the rhabdosome; proximally the sigmoidal curvature is very strong but decreases in intensity distally. There is a resulting lengthening of the excavations toward the distal end. The excavations occupy a half or more of the rhabdosome width proximally and slightly more than a third distally. The apertural margins are horizontal or slightly everted, and the free ventral walls above the geniculum are inclined to the rhabdosome axis.

Discussion.—The Alaskan specimens fit the above description very closely except for being somewhat narrower proximally. Also, the proximal thecae on our specimens are more nearly climacograptid in shape than those figured by Packham (1962).

Occurrence.—M1138–SD.

Range.—Llandoverian zones of *M. convolutus* to *M. sedgwickii* (Road River Formation) in Yukon Territory, Canada (Jackson and Lenz, 1962). Zones (20 and 21) of *M. convolutus* to *M. sedgwickii* (Birkhill Shales, Skelgill Beds) in Great Britain (Elles and Wood, 1901–18; Toghill, 1968; Packham, 1962). Also reported from Portugal by Romariz (1962), in the zones of *M. gregarius* to *M. turriculatus*. This species in Alaska seems to range lower, into the zone of *M. cyphus*.

Dimensions (in millimeters).—

Specimen No.	Length of rhabdosome	Width			Thecae per centimeter
		Theca 1[1]	Theca 5[1]	Maximum	
USNM–161730[1]__	23. 5	0. 5	1. 1	1. 7	10–12
161731[1]__	8. 5	-------	1	1. 4	12
161733___	12	. 5	1. 2	1. 7	11–13
161734[1]__	14	. 5	1. 2	1. 4	12
161735___	>13	. 5	1. 3	1. 8	11–13

[1] Figured specimens.

Material.—About 10 compressed specimens, five of which are well preserved.

Figured specimens.—USNM 161730, 161731, 161734.

Glyptograptus kayi n. sp.

Text figure 12*E*, *F*; plate 2, figure 15

Description.—The rhabdosome tapers from an initial width of 0.5–0.6 mm at theca 1[1] to a maximum width of 1.5–2.0 mm, which is attained at about the seventh thecal pair. Thereafter the sides of the rhabdosome are approximately parallel. The thecae number 10–13 per centimeter and are of the glyptograptid type, overlapping one-third to one-half of their length. The sigmoid curvature of the thecae is much more pronounced distally than proximally; the proximal thecae exhibit very little sigmoid curvature. The apertural margins are mostly everted, though in some specimens they are horizontal or slightly introverted. The proximal end tapers to a short virgella. The sicula is hidden on both sides of the rhabdosome, and there is no visible septum.

Discussion.—This form is unique among Lower Silurian glyptograptids in having a hidden sicula and no visible median septum. It resembles *G. sinuatus* somewhat but lacks the septum and the rapid widening of the rhabdosome above a slender proximal region characteristic of *sinuatus*.

Occurrence.—Nevada: Central Independence Range, locality 4 of Kerr (1962).

Range.—Zone of *M. gregarius* in Nevada.

Dimensions (in millimeters).—

Specimen No.	Length of rhabdosome	Width			Thecae per centimeter	Thecal overlap
		Theca 1[1]	Theca 5[1]	Maximum		
USNM–161736___	3. 0	0. 5	------	1. 1	13	>½
161737___	13. 5	. 6	1. 1	2. 0	10–12	½
161738___	6. 3	. 6	. 9	1. 5	14	>½
161739b__	9. 6	. 5	1. 3	1. 7	12–13	½
161739c__	4. 0	. 6		1. 2	13	⅓
161740___	6. 5	. 5	1. 3	1. 5	10	⅓
161741[1]__	12. 5	. 6	1. 1	1. 8	10–12	½
161742___	8. 2	. 5	1. 2	1. 5	14	½
161743[1]__	7. 3	. 6	1. 2	1. 5	9–10	½
163744___	10. 7	. 5	1. 1	1. 5	12	½
161745___	12. 0	. 4	. 9	1. 4	10–11	⅓–½

[1] Figured specimens.

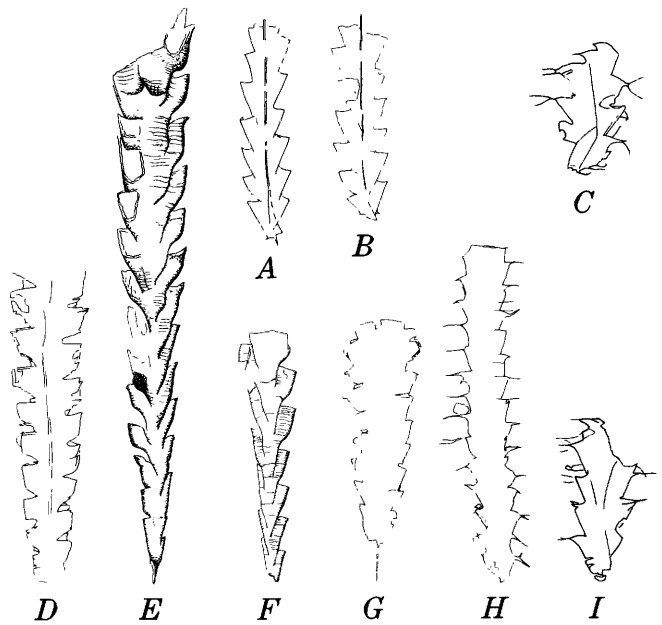


FIGURE 12.—*Glyptograptus* and *Orthograptus*. *A*, *B*, *O. eberleini* n. sp.: *A*, Holotype (USNM 161783) (same as pl. 3, fig. 2), × 5; *B*, (USNM 161782), × 5. *C*, *H*, *I*, *O. insectiformis minutus* n. subsp.: *C*, Small, immature specimen showing sicula (USNM 161624b), × 8; *H*, Holotype (USNM 161785), × 5; *I*, Small, immature specimen (USNM 161624a), × 8. *D*, *?Glyptograptus* n. sp. (USNM 161776), × 5. *E*, *F*, *G. kayi* n. sp.: *E*, Holotype (USNM 161741) (same as pl. 2, fig. 15), preserved in relief, × 5; *F*, Proximal fragment (USNM 161743) preserved in partial relief, × 5. *G*, *O. bellulus* Törnquist (USNM 161779) (same as pl. 3, fig. 1), × 5.

Material.—Eleven pyritized specimens preserved in relief. Named in honor of Professor Marshall Kay of Columbia University.

Holotype.—USNM 161741.

Figured specimens.—USNM 161741, 161743.

Glyptograptus laciniosus n. sp.

Text figure 11*D*; plate 2, figures 17,18

Description.—The rhabdosome is long and slender, measuring as much as 2.5 cm in length. It widens quickly from a width of 0.6–0.7 mm to a maximum of about 1.5 mm and is approximately parallel sided for most of its length. The thecae number 10–14 per centimeter, exhibit only slight sigmoidal curvature, and overlap about a third of their length. The apertural margins are nearly horizontal and are situated in excavations occupying approximately a fourth of the width of the rhabdosome. A short virgella is present on some specimens.

Discussion.—The distinctive feature of this species is the shape of the thecae. The free ventral wall is nearly straight. Some thecae show more curvature

than others, but it is never very pronounced as in *G. tamariscus*. The thecae resemble those of *G. serratus*, but the rhabdosome is considerably narrower and shorter than that of *G. serratus*. The occurrence of a number of subscalariform views (pl. 2, fig. 17) indicates that the rhabdosome must have been nearly circular in cross section.

Occurrence.—M1139–SD, M1141–SD, M1142–SD.

Range.—Zones of *A. acuminatus*, *M. cyphus*, and *M. gregarius* in Alaska.

Dimensions (in millimeters).—

Specimen No.	Length of rhabdosome	Width			Thecae per centimeter
		Theca 1[1]	Theca 5[1]	Maximum	
USNM–161746 [1]	23. 7	0. 6	1. 2	1. 5	12–14
161747	25	. 7	1. 2	1. 7	12–13
161748	>20. 5			1. 5	11
161749	>13			1. 5	12
161750	>17			1. 5	12
161751 [1]	21. 6	. 6	1. 1	1. 4	11–14
161752	>19	. 7	1. 1	1. 5	10–14
161753	14	. 6	1. 1	1. 5	11–13
161754	10. 5	. 8	1. 2	1. 5	12
161755	8	. 6	1. 2	1. 5	11–13
161756	13			1. 5	10
161757e	9	. 6	1. 3	1. 5	10
161757f	>8. 5			1. 5	12

[1] Figured specimens.

Material.—About 35 compressed, fairly well preserved specimens. Named after the Latin "*laciniosus*"= jagged, full of indentations.

Holotype.—USNM 161746.

Figured specimens.—USNM 161746, 161751.

Glyptograptus lanpherei n. sp.

Text figure 11*C*; plate 2, figures 9, 10

Description.—The rhabdosome is approximately 1 cm long and as much as 2 mm wide. It is wide at its origin and may gain close to its maximum width by the fifth thecal pair, so that the margins are subparallel for most of its length. Most specimens continue to widen slightly beyond the fifth thecal pair. The thecae number 10–12 per centimeter, overlap about a third of their length and have horizontal or slightly everted apertural margins situated in excavations which occupy about a fourth of the width of the rhabdosome. The virgella is very long, measuring as much as 11.8 mm. The virgula is frequently distally prolonged.

Discussion.—The thecae exhibit gentle sigmoidal curvature. The geniculum is smoothly rounded, and the excavations are long. The rhabdosome has a robust appearance. It is about 1 mm wide at theca 1^1 and from 1.4 mm to 2.0 mm wide at the fifth thecal pair. The characteristic features of this species are: (1) The long virgella, (2) the wide proximal end, (3) the gentle sigmoidal curvature of the thecae. In its wide width and general shape it resembles *Diplograptus modestus*, but all its thecae are glyptograptid. It is also similar in appearance to *G. kaochiapienensis* Hsü (1934), being approximately the same size, with the same number of thecae per centimeter and the same amount of thecal overlap, a third. Both have a distally prolonged virgula and excavations occupying a fourth of the width of the rhabdosome. It differs from *G. kaochiapienensis* by having a wider proximal end, a slightly narrower rhabdosome, a longer virgella, and apertural margins that are horizontal or slightly everted instead of horizontal or introverted.

Occurrence.—M1139–SD.

Dimensions (in millimeters).—

Specimen No.	Length of rhabdosome [1]	Width			Thecae per centimeter	Length of virgella
		Theca 1[1]	Theca 5[1]	Maximum		
USNM–161758 [2]	10. 2	1. 0	1. 8	2. 0	11	2. 3
161759 [2]	9. 0	1. 0	1. 9	2. 0	11	3. 4
161760 [2]	10. 5	. 9	1. 4	1. 6	10–12	11. 0
161761	9. 2	. 9	1. 4	1. 7	12	>1. 0
161762	7. 0	1. 0	1. 5	1. 6	12	11. 3
161763	>7. 0	1. 1	2. 0	2. 0	11	6. 0
161764	17. 7	1. 0	1. 7	2. 0	10	>11. 8

[1] Exclusive of virgella.
[2] Figured specimens.

Material.—Seven compressed, well-preserved specimens. Named in honor of Marvin A. Lanphere of the U.S. Geological Survey.

Holotype.—USNM 161759.

Figured specimens.—USNM 161758–161760.

Glyptograptus tamariscus magnus n. subsp.

Text figure 11*A*, *B*; plate 2, figure 7, 8

Description.—The rhabdosome is as much as 5 cm long, smoothly tapering from 0.7 mm wide at theca 1^1 through 1.0 mm wide at theca 5^1 to a maximum width of about 2.2 mm distally. The thecae vary in shape throughout the rhabdosome and number seven to 11 per centimeter. The apertural margins are even and horizontal. The excavations occupy approximately a fourth of the width of the rhabdosome. The virgella is stout and measures as much as 2.0 mm long.

Proximally, the thecae number 10–11 per centimeter. The geniculum is abrupt, and the free ventral wall above the geniculum is approximately vertical and much longer than the margin below the geniculum. As the rhabdosome widens, so do the excavations, so that they always occupy about a fourth of the width of the rhabdosome. Distally, the geniculum becomes less abrupt and more rounded, the excavations become longer and more open, and the free ventral wall above the geniculum becomes relatively shorter and more

nearly equal in length to the margin below the geniculum.

Discussion.—The characteristic features of this form that distinguish it from *G. tamariscus* are: (1) The long smoothly tapering rhabdosome, (2) the narrow, elongated appearance of the proximal end, (3) the varying shapes of the thecae, (4) the long, stout virgella and (5) the greater width of the rhaddosome.

Occurrence.—M1138–SD, M1139–SD.

Range.—Zone of *M. cyphus in Alaska.*

Dimensions (in millimeters).—

Specimen No.	Length of rhabdosome	Width			Thecae per centimeter
		Theca 1[1]	Theca 5[1]	Maximum	
USNM–161765[1]	42	0.7	1.0	2.25	8–10
161766[1]	25.5	.7	1.0	1.8	10
161767	20.0	.7	1.0	1.75	9–11
161768	24.2	.7	1.0	1.2	10
161769	16.5	.6	1.0	1.7	11
161770	37.5	.7	-------	2.0	7–11
161771[1]	>49	.7	1.0	2.1	8–11
161772	34.5	.7	1.0	2.2	8½–11
161773	8.5	.7	1.0	1.2	13
161774	>12.7	.7	.9	1.5	12–12½
161775	17	.7	1.0	1.6	12

[1] Figured specimens.

Material.—Approximately 15 compressed, well-preserved specimens. Named after the Latin "magnus"= large, great.

Holotype.—USNM 161765.

Figured specimens.—USNM 161765, 161766, 161771.

Glyptograptus cf. G. tamariscus var. tamariscus (Nicholson)

Text figure 10*F*

Diplograptus (Glyptograptus) tamariscus Nicholson. Elles and Wood, 1901–18, Mon. British Graptolites, Palaeontographical Soc., p. 247, text fig. 167a–c, pl. 30, fig. 8a.

Glyptograptus tamariscus tamariscus (Nicholson). Packham, 1962, Palaeontology, v. 5, p. 504–506, pl. 71, figs. 1–4, 11, 13, text fig. 1g-j, m–u.

Description.—According to Packham (1962), the rhabdosome is narrow and tapering, reaching a width of 1.3 mm in flattened specimens. The thecae are alternating, numbering eight to 14 per centimeter and having a small amount of overlap. The excavations occupy approximately half the width of the rhabdosome, and the apertural margins are horizontal to slightly everted. The free ventral wall above the geniculum is nearly perpendicular and longer than the length of the excavation. The geniculum is rounded.

Discussion.—*G. tamariscus* s.s. as described by Packham (1962) differs from *G. tamariscus* as described by Elles and Wood (1901–18) in the following ways: (1) It is wider (2 mm wide vs. 1 mm wide in Elles and Wood), (2) it has horizontal or everted apertural margins instead of horizontal or introverted apertural margins as in Elles and Wood, (3) it has seven to 14 thecae per centimeter instead of the 12–14 thecae per centimeter reported by Elles and Wood.

G. tamariscus var. *tamariscus* is a tapering form of *G. tamariscus*, reaching 1.3 mm in width and having deep and relatively long thecal excavations. The specimens from locality M1140–SD have been distorted and are questionably referred to this species.

Occurrence.—M1140–SD, M1142–SD.

Range.—Llandoverian zones (18–21) of *M. cyphus* to *M. sedgwickii* (Birkhill Shales) in Great Britain (Packham, 1962). *G. tamariscus* is reported from the following localities: Llandoverian zones of *D. modestus* and *M. cyphus* (Road River Formation) in Yukon Territory, Canada (Jackson and Lenz, 1962); the zone of *M. cyphus* (Cape Phillips Formation) in the Canadian Arctic (Thorsteinsson, 1958); Llandoverian zones of *M. cyphus* to *M. sedgwickii*, in Portugal (Romariz, 1962); Llandoverian zone of *Demirastrites convolutus* in Bohemia, Czechoslovakia (Pribyl, 1948); Germany (Hundt, 1924); Russia (Obut, 1949; Obut and others, 1965); Llandoverian zone with *M. leei* (lower Kaochiapien Shale) in China (Hsü, 1934); Middle Polindian to Middle Keilorian stages in Australia (Thomas, 1960; Sherrard, 1954; Harris and Thomas, 1949).

Dimensions (in millimeters).—

Specimen No.	Length of rhabdosome	Width			Thecae per centimeter
		Theca 1[1]	Theca 5[1]	Maximum	
USNM–161630	7.0	----------		1.0	12
161985	3.0	0.5	---------	.7	15
161986[1]	>4.0	.5	.8	---------	12
161987	9.0	----------		1.0	14

[1] Figured specimen.

Material.—About 23 compressed specimens; the two undeformed specimens are fragmentary, and the rest are distorted.

Figured specimen.—USNM 161986.

?Glyptograptus n. sp.

Text figure 12*D*

Description.—The rhabdosome is approximately 1 cm long, increasing gradually in width from about 0.9 mm at the first thecal pair to a maximum of about 2 mm. The thecae number 11–12 per centimeter and have a large amount of sigmoid curvature so that they are almost climacograptid in appearance. The geniculum is rather abrupt, and the free ventral wall above it is nearly vertical. The apertural margins are approximately horizontal.

Discussion.—This species is intermediate in appearance between *Glyptograptus* and *Climacograptus*. The excavations are deep and narrower than usual for a glyptograptid. They occupy about a third of the width

of the stipe. The characteristic features of this form are: (1) The wide proximal part and (2) the shape of the thecae. Because of the scarcity and poor quality of preservation of the specimens, this form has not been named.

Occurrence.—M1142–SD.

Range.—Zone of *M. gregarius* in Alaska.

Dimensions (in millimeters).

Specimen No.	Length of rhabdosome	Width			Thecae per centimeter	Length of Theca 1[1]
		Theca 1[1]	Theca 5[1]	Maximum		
USNM–161776[1]	>9.3	0.9	1.7	2.0	11½–12	------
161777	4.3	.9	1.5?	-----	12	1.0
161778	>10.0	1.0?	1.6?	1.7	12	------

[1] Figured specimen.

Material.—About five compressed, poorly preserved specimens.

Figured specimen.—USNM 161776.

Genus ORTHOGRAPTUS Lapworth, 1873

Orthograptus Lapworth. Bulman, 1955, Geol. Soc. America, Treatise on invertebrate paleontology, pt. V, p. V87, fig. 63, 5a–c.

Rhabdosome biserial, scandent. Thecae nearly straight or slightly curving. Large basal spines fairly common. Some species have paired apertural spines. Middle Ordovician to Lower Silurian, worldwide.

Orthograptus bellulus Törnquist

Text figure 12*G*; plate 3, figure 1

Diplograptus (Orthograptus) bellulus Törnquist. Elles and Wood, 1901–18, Mon. British Graptolites, Palaeontographical Soc., p. 231–232, text fig. 152, pl. 29, fig. 2a–e.

Diplograptus bellulus Törnquist. Hundt, 1924, Grapt. d. deutsch., Silurs, p. 60, pl. 2, figs. 14–16.

Diplograptus (Orthograptus) bellulus Törnquist. Stein, 1965, Neues Jahrb. Geologie u. Paläontologie Abh., p. 170–171, text fig. 19a, b.

Discussion.—Elles and Wood (1901–18) state that *O. bellulus* has 10–14 thecae per centimeter. However, their figured specimens (pl. 29, fig. 2a–d) have 16–18 thecae per centimeter proximally, as do the Alaskan specimens. (Note: The table of dimensions below gives the number of thecae extrapolated to 1 cm even though none of the specimens are that long.) The virgellas on the Alaskan specimens are shorter than the 8-mm virgellas cited by Elles and Wood (1901–18), but this may be due to poor preservation.

Occurrence.—M1142–SD.

Range.—Llandoverian zones (19–21) of *M. gregarius* to *M. sedgwickii* (upper Birkhill Shales) in Great Britain (Elles and Wood, 1901–18). Toghill (1968) limits the range of *O. bellulus* in the Birkhill Shales to the zone of *M. convolutus*. Llandoverian zones of *Demirastrites convolutus* to *M. sedgwickii* in Bohemia, Czechoslovakia (Pribyl, 1948). Also found in Germany (Hundt, 1924). Thorsteinsson (1958) reported an *O. bellulus*-like form from the zone of *M. cyphus* (Cape Phillips Formation in the Canadian Arctic.

Dimensions (in millimeters).—

Specimen No.	Length of rhabdosome	Width			Thecae per centimeter	Length of virgella
		Theca 1[1]	Theca 5[1]	Maximum		
USNM–161779[1]	5.7	0.9	1.6	2.0	16	1.2
161780	>5	.8	1.6	1.8	16	5.4
161725c	>4	.8	1.5	1.7	20	1.0
161781	6	.7	1.5	1.6	16	1.0

[1] Figured specimen.

Material.—About five compressed, fairly well preserved specimens.

Figured specimen.—USNM 161779.

Orthograptus eberleini n. sp.

Text figures 12*A*, *B*; plate 3, figure 2

Description.—The rhabdosome is small and slender, being less than 7 mm in length and 1.5 mm in width. The sicula is about 1.5 mm long. The thecae are narrow, numbering 12 per centimeter and overlapping one-third to one-half their length. The apertural margins are horizontal and very slightly undulate, occupying about one-fourth the width of the rhabdosome.

The rhabdosome is gently curved. Theca 1^1 has a short spine near its origin, which is near the aperture of the sicula. The sicula is free on one side for about 0.3 mm and the virgella is very short (about 0.25 mm). The thecae average about 1 mm long, but some are as much as 1.3 mm long.

Discussion.—This species resembles *O. cyperoides* and differs from it by having: (1) Greater width, (2) a shorter sicula, (3) a shorter theca 1^1 and, (4) a shorter free edge on the sicula. In general appearance, *O. eberleini* resembles *Akidograptus*. However, *Akidograptus* is characterized by loss or reduction of theca 1^2 and a slender, elongate-looking proximal part in which the apex of the sicula is well below the level of the aperture of theca 1^1. The apex of the sicula in *O. eberleini* extends to approximately the level of the aperture of theca 1^1, and the proximal region is relatively wide.

Occurrence.—M1138–SD, M1139–SD.

Range.—Zones of *M. vesiculosus* and *M. cyphus* in Alaska.

Dimensions (in millimeters).—

Specimen No.	Length of rhabdosome	Width		Thecae per centimeter	Length of Sicula
		Theca 1[1]	Maximum		
USNM-161782[1]	6.0	----	1.5	12	1.3
161783[1]	6.4	1.0	1.3	12	1.5
161784	2.3	1.0	1.2	----	1.5

[1] Figured specimens.

Material.—Five compressed, fairly well preserved specimens. Named in honor of G. Donald Eberlein of the U.S. Geological Survey.

Holotype.—USNM 161783.

Figured specimens.—USNM 161782, 161783.

Orthograptus insectiformis minutus n. subsp.

Text figure 12*C, H, I*

Description.—This is a small variety of *O. insectiformis*. The rhabdosome reaches 1.5 cm in length and is about 1 mm wide (exclusive of spines). There are 16–20 thecae per centimeter (in contrast to 10–12 thecae per centimeter reported by Elles and Wood, 1901–18). The apertural margins are prolonged into apertural spines, some of which are paired. The sicula is about 0.8 mm long with one-half to one-third of its length free on one side.

The rhabdosome reaches its maximum width by about the fourth thecal pair. It is 0.8–0.9 mm wide at theca 1[1] and about 1.0 mm wide at theca 3[1], thereafter being approximately parallel sided. The apertural spines have a maximum length of about 0.7 mm, and often, two spines per theca can be seen.

Discussion.—Because all the specimens are flattened, it is not possible to determine with certainty if the apertural spines actually are two separate spines or if a single spine is forked near its base.

The features that distinguish this subspecies from *O. insectiformis* are: (1) Its smaller size, (2) its more closely set thecae, (3) its shorter sicula, and (4) its paired spines.

Occurrence.—M1140–SD, M1142–SD.

Range.—Toghill (1968) gives the range of *O. insectiformis* s.s. in Great Britain (Birkhill Shales) as the zone of *M. gregarius*. In southeastern Alaska, the new subspecies occurs in the zones of *M. gregarius* and *M. convolutus*.

Dimensions (in millimeters).—

Specimen No.	Length of rhabdosome	Width (exclusive of spines)			Thecae per centimeter	Length of spines
		Theca 1[1]	Theca 3[1]	Maximum		
USNM-161785[1]	9	0.8	1.0	1.1	16	0.7
161624a[1]	2.8	.8	1.0	1.0	20	----
161624b[1]	2.0	.9	1.0	1.0	20	----
161786a	>14	----	----	.8	16	.75
161786b	>14	----	----	.8	16	.3

[1] Figured specimens.

Material.—About eight compressed, fragmentary specimens. Named after the Latin "minutus"=little, small.

Holotype.—USNM 161785.

Figured specimens.—USNM 161785, 161624a, 16124b.

Orthograptus cf. O. mutabilis Elles and Wood

Plate 2, figure 14

Diplograptus (Orthograptus) mutabilis Elles and Wood, 1901–18, Mon. British Graptolites, Palaeontographical Soc., p. 232–233, text fig. 153, pl. 29, fig. 1a–d.

Description.—According to Elles and Wood (1901–18), the rhabdosome of *O. mutabilis* is large, 4–5 cm long, widening rapidly from the origin until a maximum width of 3–3.5 mm is reached, after which the margins are nearly parallel. The thecae number nine to 12 per centimeter and overlap one-half to two-thirds of their length. The apertural margins are slightly lobate and have a fairly conspicuous rim or flange. The sicula is large.

Discussion.—Three incomplete specimens are present in the collections under study. All are about 2.5 cm long, and range in width from 2.8 to 3.1 mm. The thecae have lobate apertural margins similar to those of *O. mutabilis* and number eight to 10 per centimeter. These specimens agree with *O. mutabilis* in every respect, but the absence of any proximal ends prohibits positive identification.

Occurrence.—M1138–SD.

Range.—Llandoverian zones of *M. cyphus* and *M. gregarius* in Great Britain (Elles and Wood, 1901–18).

Figured specimen.—USNM 161787.

Orthograptus vesiculosus Nicholson

Plate 2, figures 11–13

Diplograptus (Orthograptus) vesiculosus Nicholson. Elles and Wood, 1901–18, Mon. British Graptolites, Palaeontographical Soc., p. 229–230, text fig. 151, pl. 28, fig. 8a–d.

Diplograptus vesiculosus Nicholson. Hundt, 1924, Grapt. d. deutsch. Silurs, p. 60, pl. 18, figs. 1, 12.

Cystograptus vesiculosus (Nicholson). Obut, Sobolevskaya, and Bondarev, 1965, Graptolity Silyura Taimyra, p. 34–35, pl. 2, figs. 1–4.

Discussion.—The Alaskan specimens have apertural margins that are distinctly more lobate than those figured by Elles and Wood (1901–18). The most characteristic feature of this species is the conspicuous, "three-vaned" membranous body within the rhabdosome (see Jones and Rickards, 1967).

Occurrence.—M1138–SD, M1139–SD, M1288–SD, M1289–SD, M1290–SD.

Range.—Llandoverian zones of *M. cyphus* to *M. millepeda* (Road River Formation) in Yukon Territory, Canada (Jackson and Lenz, 1962). Llandoverian zones

of *A. acuminatus* to *M. cyphus* (Birkhill Shales) in Great Britain (Toghill, 1968). Llandoverian zones of *O. vesiculosus* and *M. cyphus* in Portugal (Romariz, 1962). Llandoverian zone of *Pristiograptus cyphus* in Bohemia, Czechoslovakia (Pribyl, 1948). Lower Llandovery in Pulau Langgon, Langkawi Island, Malaya (Kobayashi and others, 1964). Lower Silurian (basal part of Fuchih Shale) in Hupei, China (Sun, 1933). Also reported from Germany (Hundt, 1924, 1953) and Russia (Obut and others, 1965).

Dimensions (in millimeters).—

Specimen No.	Length of rhabdosome	Width		Thecae per centimeter
		Theca 1[1]	Maximum	
USNM–161788 [1]	>15. 5	1. 9	3. 5	12
161789	7. 5	1. 8	3. 5	14
161790 [1]	22. 0	2. 2	4. 3	8–10
161791	20. 0	------	2. 5	8½
161792	>15. 0	1. 7	3. 6	10
161793	13. 0	1. 8	3. 2	10
161794	>25. 0	------	4. 0	10

[1] Figured specimens.

Material.—Approximately 40 compressed, well-preserved specimens, some of which are fragmentary.

Figured specimens.—USNM 161788, 161790, 161794.

?Orthograptus n. sp.

Text figure 13*D*: plate 3, figure 4

Description.—The rhabdosome is small, measuring as much as 2 cm long with a width of 0.5–0.7 mm at theca 1[1] and a maximum width of 1.5 mm (including apertural lobes). There are usually 10 thecae per centimeter although one specimen has 12–14 per centimeter. The proximal end bears five to six long, slender spines that measure not more than 1.5 mm in length. The rhabdosome is smoothly tapering for about the first 5 mm of its length, after which it becomes approximately parallel sided.

Discussion.—The most characteristic features of this species are the proximal spines and the fact that it is always preserved in what appears to be a subscalariform view. In this view, the thecae appear to have straight, nearly parallel, vertical walls. The rhabdosome is crossed at regular intervals by the traces of the apertural margins. Short, thick lobes developed at the ends of the apertures project beyond the outline of the rhabdosome. The arrangement of the proximal spines is slightly variable. Generally, there are three to four slender, some what flexed spines grouped very closely together and growing from the extreme end of the rhabdosome. At the same time, one to two spines are a short distance from the main cluster. Because of the subscalariform preservation, the thecal character is uncertain, and therefore this species has not been named. However, the lobed apertural margins and the spined proximal end suggest *Orthograptus*.

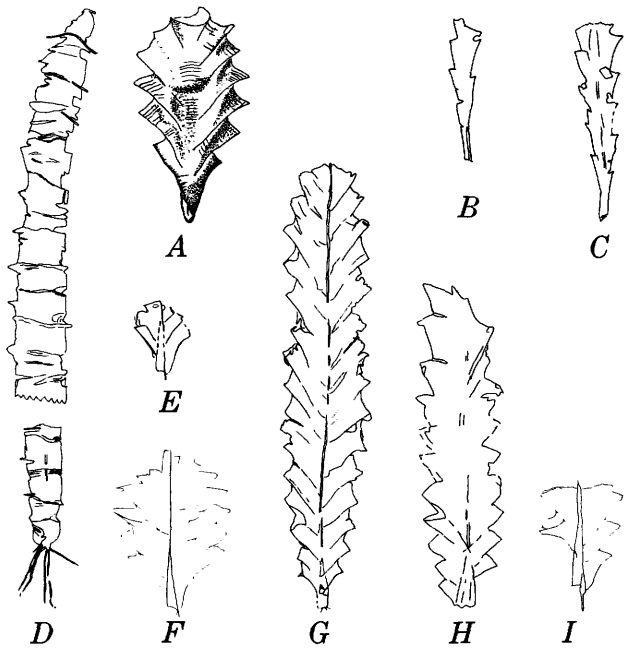


FIGURE 13.—*Orthograptus, Petalograptus, Dimorphograptus,* and *Akidograptus. A, P. palmeus* var. *tenuis* Barrande, (USNM 161811), reverse view, preserved in relief, × 5. *B, C, Akidograptus acuminatus* (Nicholson): *B,* (USNM 161832) (same as pl. 3, fig. 17) × 5; *C,* (USNM 161833), × 5. *D, ?Orthograptus* n. sp. (USNM 161796b), proximal and distal parts, in subscalariform view, × 5. *E, F, P. minor* Elles: *E,* Immature specimen showing sicula, × 5; *F,* (USNM 161800) (same as pl. 3, fig. 5), × 5. *G, P. palmeus* (Barrande) (USNM 161808) (same as pl. 3, fig. 6), × 5. *H, I, D. physophora alaskensis* n. subsp.: *H,* Holotype (USNM 161826), showing sicula (same as pl. 3, fig. 7), × 5; *I,* Proximal fragment (USNM 161827), showing long sicula, × 5.

Occurrence.—M1139–SD, M1286–SD, M1287–SD.

Range.—Zone of *A. acuminatus* in Alaska.

Dimensions (in millimeters).—

Specimen No.	Length of rhabdosome	Width (including spines)		Thecae per centimeter
		Theca 1[1]	Maximum	
USNM–161795 [1]	7. 5	0. 5	1. 2	12–14
161796b[1]	17. 3	. 7	1. 4	10
161796a	14	--------	1. 5	10
161797	19	. 5	1. 5	10
161798	7	. 6	1. 5	----------

[1] Figured specimens.

Material.—Five compressed, fairly well preserved specimens, all in subscalariform view.

Figured specimens.—USNM 161795, 161796b.

Subfamily PETALOGRAPTINAE

Genus PETALOGRAPTUS Suess, 1851

Petalograptus Suess. Bulman, 1955, Geol. Soc. America, Treatise on invertebrate paleontology, pt. V, p. V87, figs. 63, 6a, b.

Rhabdosome tabular, leaf shaped. Thecae long, nearly straight or with gentle ventral curvature, at a considerable angle to the rhabdosome axis, with large overlap. Septum partial or absent, sicula largely exposed. Lower Silurian; Europe, Australia, China, North Africa, and North America.

Petalograptus minor Elles

Text figure 13*E*, *F*; plate 3, figure 5

Petalograptus minor Elles. Elles and Wood, 1901–18, Mon. British Graptolites, Palaeontographical Soc., p. 279–281, text fig. 193, pl. 32, fig. 5a–e.

Petalograptus minor Elles. Sun, 1933, Palaeont. Sinica, ser. B, v. 14, pt. 1, p. 33, pl. 5, fig. 5a, b.

Discussion.—The Alaskan specimens agree with the description of *P. minor* by Elles and Wood (1901–18) except for the number of thecae per centimeter. Elles and Wood state that *P. minor* has 12 thecae per centimeter, and their figures (pl. 32, fig. 1a–c) show 14–16 thecae per centimeter. The Alaskan specimens have about 20 thecae per centimeter, and in this respect they resemble *P. posterus* Ruedemann (1947), which was found in the same area of Alaska. However, Ruedemann's figures are rather indistinct and prevent positive identification. The long sicula, small size, and protracted proximal end of the Alaskan specimens indicate that they are *P. minor*.

Occurrence.—M1142–SD.

Range.—Llandoverian zones (19 and 20) of *M. gregarius* to *M. convolutus* (Birkhill Shales) in Great Britain (Elles and Wood, 1901–18). Llandoverian zones of *Demirastrites pectinatus* to *D. triangulatus* in Bohemia, Czechoslovakia (Pribyl, 1948). Lower Silurian (Fuchih Shale) in Changyang district, Hupei, China (Sun, 1933). Also, *Petalograptus* cf. *P. minor* reported from Llandoverian zone (20) of *M. convolutus* (Phi Kappa Formation) in Idaho (Churkin, 1963).

Dimensions (in millimeters).—

Specimen No.	Length of rhabdosome	Maximum width of rhabdosome	Thecae per centimeter	Length of sicula
USNM–161799	4.8	3.6	20	----
161800[1]	4.5	3.2	20	1.5
161801c	3.0	2.6	20?	1.2
161802	6.3	3.3	----	1.6

[1] Figured specimen.

Material.—Approximately seven compressed, moderately well preserved specimens.

Figured specimen.—USNM 161800.

Petalograptus palmeus (Barrande)

Text figure 13*G*; plate 3, figure 6

Petalograptus palmeus s. s. (Barrande). Elles and Wood, 1901–18 Mon. British Graptolites, Palaeontographical Soc., p. 274–275, text fig. 188, pl. 32, fig. 1a–d.

Diplograptus palmeus Barrande. Hundt, 1924, Grapt. d. deutsch. Silurs, p. 58, pl. 2, figs. 24–26.

Petalograptus palmeus (Barrande). Sun, 1933, Palaeont. Sinica, ser. B, v. 14, pt. 1, p. 31–32, pl. 5, fig. 4a–b.

Diplograptus (*Petalograptus*) *palmeus* (Barrande). Obut, 1949, Polyevoi Atlas, Rukovodyashchich graptolitov vyerkhnyevo Silura Kirgizskoi SSR, p. 15, pl. 1, fig. 7a, b.

Discussion.—The specimens under study compare closely with the description and illustrations of *P. palmeus* s.s. by Elles and Wood (1901–18).

Occurrence.—M1140–SD.

Range.—Llandoverian zones of *M. millepeda* to *M. turriculatus* (Road River Formation) of Yukon Territory, Canada (Jackson and Lenz, 1962). Zone of *M. turriculatus* (Cape Phillips Formation) in the Canadian Arctic (Thorsteinsson, 1958). Llandoverian zones (19–22) of *M. gregarius* to *M. turriculatus* (Birkhill-Gala) in Great Britain (Elles and Wood, 1901–18). Lower Silurian Fuchih Shale at Lungma, Ichang, Hupei, China (Sun, 1933). Also reported from Germany (Hundt, 1924, 1953), Portugal (Romariz, 1962), and Russia (Obut,1949).

Dimensions (in millimeters).—

Specimen No.	Length of rhabdosome	Width 1st thecal pair	Width 3d thecal pair	Width Maximum	Thecae per centimeter	Length of sicula	Length of thecae
USNM–161803	9.0	1.4?	2.0?	2.5	14	----	----
161804	7.0	1.0?	2.0	2.0	14	1.8	0.5–1.5
161805b	6.5	----	1.7	2.5	15	1.5	.5–1.7
161806	>9	----	----	2.5	14	----	1.6
161807	8.5	----	----	2.5	15?	----	1.5
161808[1]	13	1.1	1.7	2.5	13	2.0	.5–1.5
161809	9	1.0	1.6	2.5	13	2.0	.5–1.5

[1] Figured specimen.

Material.—Approximately 10 compressed distorted specimens, half of which are fragmentary.

Figured specimen.—USNM 161808.

Petalograptus palmeus var. tenuis Barrande

Text figure 13*A*; plate 3, figure 3

Petalograptus palmeus var. *tenuis* Barrande. Elles and Wood, 1901–18, Mon. British Graptolites, Palaeontographical Soc., p. 276–277, text fig. 190, pl. 32, fig. 3a–d.

Description.—According to Elles and Wood (1901–18, p. 276), this variety differs from *P. palmeus* s.s. in (1) its extreme narrowness, (2) the smaller number of thecae per centimeter, and (3) the relative proportions of the thecae and the general absence of curvature of their walls.

The Nevadan specimens are somewhat wider than those described by Elles and Wood (1901–18). They exhibit a partial septum—there is no trace of a median septum on the reverse side.

Discussion.—*P. palmeus tenuis* differs from *P. minor*, the other small petalograptid in our collection, by having a much smaller angle of inclination of its thecae. Also *P. minor* has more thecae per centimeter (about 20) than does *P. palmeus tenuis*.

Occurrence.—Nevada: Central Independence Range, locality 4 of Kerr (1962).

Range.—Llandoverian zone of *M. turriculatus* (Road River Formation) in Yukon Territory, Canada (Jackson and Lenz, 1962). Llandoverian zones of *M. sedgwickii* and *R. maximus* (Birkhill Shales) in Great Britain (Toghill, 1968). Zones of *R. linnaei* to *M. griestoniensis* in Bohemia, Czechoslovakia (Pribyl, 1948).

Dimensions (in millimeters).—

Specimen No.	Length of rhabdosome	Maximum width of rhabdosome	Thecae per centimeter	Length of sicula
USNM-161810	3.5	1.5	----	2.0?
161811 [1]	5.5	2.8	13–14	----
161812 [1]	5.0	2.0	12	2.8

[1] Figured specimen.

Material.—About five pyritized specimens preserved in relief.

Figured specimens.—USNM 161811, 161812.

Family DIMORPHOGRAPTIDAE

Genus DIMORPHOGRAPTUS Lapworth, 1876

Dimorphograptus Lapworth. Bulman, 1955, Geol. Soc. America, Treatise on invertebrate paleontology, pt. V, p. V90–91, fig. 67, 2a, b.

Proximal part of rhabdosome uniserial, becoming biserial distally. Thecae of orthograptid or glyptograptid type. Uniserial part of varying length. Lower Silurian; Europe, China, North America.

Dimorphograptus confertus var. swanstoni (Lapworth)

Text figure 14*C, D;* plate 3, figure 8–10

Dimorphograptus confertus var. *swanstoni* (Lapworth). Elles and Wood, 1901–18, Mon. British Graptolites, Palaeontographical Soc., p. 350–352, text fig. 228, pl. 35, fig. 4a–f.

Dimorphograptus swanstoni Lapworth, Hundt, 1924, Grapt. d. deutsch. Silurs, p. 78, pl. 7, figs. 13–21.

Discussion.—There is considerable variation in the Alaskan species. The specimens under study range from as much as 2.2 mm in width, through all gradations to a narrow form measuring as little as 1.25 mm in width. The number of thecae per centimeter ranges from nine to 13. The sicula is approximately 2 mm long, extending up to the level of the aperture of theca 1, and bears a short virgella. Theca 1 originates slightly above the aperture of the sicula so that the sicula alone forms the proximal termination of the rhabdosome. The Alaskan specimens are generally narrower than those described by Elles and Wood (1901–18). Also, the abrupt widening of the rhabdosome where it becomes biserial is less pronounced in the Alaskan material.

Occurrence.—M1138–SD, M1139–SD, M1289–SD.

Range.—Llandoverian zone of *M. cyphus* (Birkhill Shales) in Great Britain (Toghill, 1968). Also reported from Germany (Hundt, 1924, 1953) and Russia (Obut and others, 1967).

Dimensions (in millimeters).—

Specimen No.	Length of rhabdosome	Width of biserial part	Uniserial part		Thecae per centimeter
			Length	Width	
USNM-161813	11.5	2.2	6.5	0.5	13
161814 [1]	16.5	2.0	6.0	.5	12
161815	15.5	2.0	5.0	.5	12
161816 [1]	15.1	1.8	5.8	.5	12
161817d	16.5	1.7	4.75	.5	11
161817e	9.7	1.3	5	.3	----
161817f	10.5	1.5	4.5	.5	14
161818	13.5	1.5	5	.4	11
161819	21	1.25	6.1	.3	9
161820	13	1.4	6.5	.4	11
161821	9.5	1.7	4.6	.4	11
161822	9.2	1.5	4.5	.3	12
161823 [1]	10.0	1.5	5.7	.5	12
161824 [1]	>12	1.5	7	.25	10
161825	>15	1.8	5	.4	12

[1] Figured specimens.

Material.—Approximately 30 compressed, fairly well preserved specimens, some of which are fragmentary.

Figured specimens.—USNM 161814, 161816, 161823, 161824.

Dimorphograptus physophora alaskensis n. subsp.

Text figure 13*H, I;* plate 3, figure 7

Description.—The rhabdosome is less than 1 cm long and has a maximum width of about 2.3 mm. The uniserial part is very short and straight, and the biserial part is also straight. The sicula is long and conspicuous. The thecae number 12–14 per centimeter and overlap one-half to two-thirds of their length. The apertural margins are approximately horizontal.

The uniserial part of the rhabdosome is composed of only one theca. At the aperture of theca 1[1], the rhab-

dosome measures 1.0 mm in width; it increases to as much as 1.9–2.0 mm at the commencement of the biserial part. The maximum width is attained shortly thereafter, and the margins of the rhabdosome are approximately parallel for most of their length. The sicula is about 2.0 mm long. The free ventral margins of the thecae are nearly straight; the apertural margins show a tendency to eversion at the proximal end of the rhabdosome but quickly become horizontal distally.

Discussion.—This subspecies differs from *D. physophora* in (1) having a wider proximal end with only one uniserial theca, (2) having more closely set thecae, (3) having a longer sicula, (4) showing little or no evidence of a proximal disc, and (5) having a shorter rhabdosome (maybe due to immaturity).

Occurrence.—M1138–SD, M1290–SD.

Range.—Zone of *M. cyphus* in Alaska.

Dimensions (in millimeters).—

Specimen No.	Length of rhabdosome	Width			Thecae per centimeter	Length of sicula
		Theca 1[1]	Theca 1[2]	Maximum		
USNM–161826 [1]	8.5	1.0	1.9	2.2	12	2.0
161827 [1]	3.6	1.0	2.1	2.3	14	2.0
161828	5.0	1.0	1.9	2.1	14	2.0
161829	3.0	1.0	2.0	2.0	14	2.0

[1] Figured specimens.

Material.—Four compressed, well-preserved specimens. Named after Alaska, the 49th state of the Union and North America's last major frontier.

Holotype.—USNM 161826.

Figured specimens.—USNM 161826, 161827.

Genus AKIDOGRAPTUS Davies, 1929

Akidograptus Davies. Bulman, 1955, Geol. Soc. America, Treatise on invertebrate paleontology, pt. V, p. V91, fig. 67, 1.

Rhabdosome mostly biserial; thecae climacograptid or orthograptid; proximal end characteristically exhibits loss or reduction of theca 1^2, but there is no apparent uniserial part due to the shortening of theca 2^2; initial bud downwardly directed at origin. Lower Silurian; Europe, northeastern USSR, China, and Alaska.

Akidograptus acuminatus (Nicholson)

Text figure 13*B*, *C*; plate 3, figures 16, 17

Cephalograptus(?) acuminatus (Nicholson). Elles and Wood, 1901–18, Mon. British Graptolites, Palaeontographical Soc. p. 289–295, text fig. 199, pl. 32, fig. 11a–d.

Diplograptus acuminatus Nicholson. Hundt, 1924, Grapt. d. deutsch. Silurs, p. 59, pl. 2, figs. 9, 10, 17.

Diplograptus (Akidograptus) acuminatus acuminatus Nicholson. Stein, 1965, Neues Jahrb. Geologie u. Paläontologie Abh., 121, 2; p. 174–175, text fig. 22e, f, pl. 15, fig. c.

Akidograptus acuminatus (Nicholson). Obut, Sobolevskaya, and Nikolaiyev, 1967, Graptolity i stratigraphiia nizhnego Silura okrainnykh podniatii kolymskogo massiva, p. 74–75, pl. 6, figs. 10–13.

Akidograptus acuminatus (Nicholson). Toghill, 1965 (unpub. thesis) p. 61–65, figs. 7–4, 7–5, 7–6.

Description.—According to Elles and Wood (1901–18), the rhabdosome is 1–3 cm long and straight or slightly curved. It increases gradually in width from a narrow protracted proximal end to a maximum width of 1.5 mm, which is thereafter maintained. The sicula is very long (2.5 mm) and slender. The thecae are of the orthograptid type, numbering about 10 per centimeter, and overlapping one-half their length. The outer walls of the thecae may exhibit gentle sigmoid curvature; the apertural margins are introverted and develop an acute denticle when compressed.

Discussion.—*Akidograptus acuminatus* is a fairly distinctive form. The narrow, protracted proximal end serves to distinguish it from the diplograptids. The orthograptid-type thecae distinguish it from other species of *Akidograptus*.

Occurrence.—M1139–SD, M1141–SD, M1286–SD, M1287–SD(?).

Range.—Llandoverian zone of *A. acuminatus* (Birkhill Shales) in Great Britain (Elles and Wood, 1901–18; Toghill, 1968). Llandoverian *acuminatus* zone in the Frankenwald (Northeastern Bavaria) (Stein, 1965). Zone of *A. acuminatus—A. ascensus* in Russia (Kolyma Massif) (Obut and others, 1967).

Dimensions (in millimeters).—

Specimen No.	Length of rhabdosome	Width of rhabdosome		Thecae per centimeter	Sicula length
		Theca 1[1]	Maximum		
USNM–161830 [1]	13.0	----	1.5	12	----
161831	7.5	0.4	----	----	1.8(?)
161832 [1]	3.7	.5	----	[2] 13	----
161833 [1]	5.2	.5	1.5	[2] 12	----

[1] Figured specimens.
[2] Approximate.

Material.—Four compressed, fragmentary specimens.

Figured specimens.—USNM 161830, 161832, 161833.

Family MONOGRAPTIDAE

Subfamily MONOGRAPTINAE

Genus MONOGRAPTUS Geinitz, 1852

Monograptus Geinitz. Bulman, 1955, Geol. Soc. America, Treatise on invertebrate paleontology, pt. V, p. V92, fig. 68, 1a-g.

Rhabdosome scandent, uniserial, straight or curved. Thecae highly variable in form, straight, curved, or distally isolate. Many species with at least two thecal types in same rhabdosome. Silurian, worldwide.

Monograptus acinaces Törnquist

Text figure 14*A*; plate 3, figures 13–15

Monograptus acinaces Törnquist. Elles and Wood, 1901–18, Mon. British Graptolites, Palaeontographical Soc., p. 364–365, text fig. 237, pl. 36, fig. 2a–d.

Monograptus acinaces Törnquist. Hsü, 1934, Graptolites of the Lower Yangtze Valley, p. 91–92, pl. 7, fig. 1a–d.

Discussion.—The Alaskan specimens are mostly the arcuate proximal ends with long, slender thecae that characterize this species. Numerous distal fragments with less curvature of the rhabdosome and greater thecal overlap are also present (pl. 3, fig. 14).

Occurrence.—M1138–SD, M1139–SD, M1289–SD, M1290–SD.

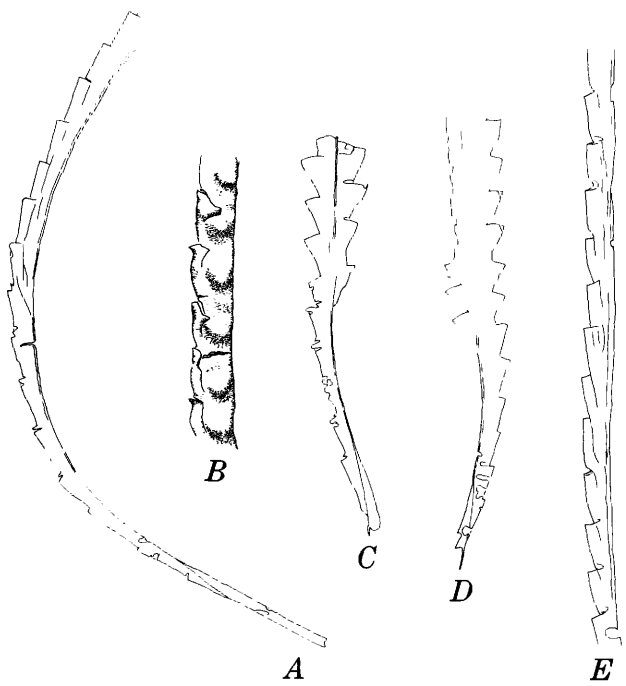


FIGURE 14.—*Dimorphograptus* and *Monograptus*. *A. M. acinaces* Törnquist (USNM 161835), proximal fragment showing sicula (same as pl. 3, fig. 13), × 5. *B, M. argutus* Lapworth (USNM 161841) (same as pl. 4, fig. 16), × 6. *C* and *D, D. confertus swanstoni* (Lapworth): *C,* Narrow form showing sicula (USNM 161823), × 5; *D,* (USNM 161814) (same as pl. 3, fig. 10) showing sicula, × 5. *E, M. atavus* Jones (USNM 161842) (detail of pl. 3, fig. 11), × 5.

Range.—Llandoverian zone of *M. cyphus* (Road River Formation) in Yukon Territory, Canada (Jackson and Lenz, 1962). Llandoverian zones of *O. vesiculosus* and *M. cyphus* (Birkhill Shales) in Great Britain (Toghill, 1968). Llandoverian zone of *Pristiograptus cyphus* in Bohemia, Czechoslovakia (Pribyl, 1948). Lower part of Kaochiapien Shale (zone with M. *leei*) near Nanking and central Anhui, China (Hsü, 1934).

Dimensions (in millimeters).—

Specimen No.	Length of rhabdosome	Width		Thecae per centimeter	Length of sicula
		Initial	Maximum		
USNM–161834	14	0. 3?	0. 7	9	--------
161835 [1]	21	. 2	. 75	9	4. 5
161836 [1]	15. 5	. 3?	. 75	9	--------
161837	17. 5	. 3?	. 7	8	--------
161838	14	. 25	. 5	9	>1. 6
161839	24	--------	. 5	8	--------

[1] Figured specimens.

Material.—About 11 compressed, fairly well preserved specimens, mostly fragmental.

Figured specimens.—USNM 161835, 161836, 161840.

Monograptus argutus Lapworth

Text figure 14*B*; plate 4, figure 16

Monograptus argutus Lapworth. Elles and Wood, 1901–18, Mon. British Graptolites, Palaeontographical Soc., p. 408–409, text fig. 274, pl. 40, fig. 3a–e.

Monograptus argutus Lapworth. Sun, 1933, Palaeont. Sinica, ser. B, v. 14, pt. 1, p. 44, pl. 7, fig. 4a, b.

Monograptus argutus Lapworth. Hsü, 1934, Graptolites of the Lower Yangtze Valley, p. 97, pl. 7, fig. 8a–e.

Description.—According to Elles and Wood (1901–18, p. 409), *M. argutus* is characterized by thecae that show conspicuous sigmoidal curvature and have introverted and introtorted apertural regions. The thecae thus resemble those of *Dicellograptus*. The rhabdosome has a maximum width of 1.5 mm, and the thecae are as much as 3 mm long and number eight per centimeter.

Discussion.—Only one specimen (a distal fragment) has been found, but it is well preserved and shows the characteristic thecal form noted by Elles and Wood (1901–18, p. 409). The width of the distal fragment is 1.3 mm and the thecae are 2.5 mm long. The thecae overlap two-thirds and number eight to nine per centimeter. The protheca shows a conspicuous expansion at the junction with the metatheca, but the metatheca is then immediately constricted and continues at a diameter of 0.2 mm. The metatheca shows conspicuous sigmoidal (convex) curvature, and the apertural region is introverted with a slight hook developed. The aperture points directly inwards, and the apertural region is slightly introtorted.

Occurrence.—Central Independence Range, Nev., locality 4 of Kerr (1962).

Range.—Llandoverian zones (19 and 20) of *M. gregarius* and *M. convolutus* (Birkhill Shales) in Great Britain (Elles and Wood, 1901–18) (Toghill, 1968). Zone of *Demirastrites convolutus* in Bohemia, Czechoslovakia (Pribyl, 1948). Lower Silurian (Sintan Shale) at Lunshan, Kiangsu, China (Sun, 1933). Lower part of the Kaochiapien Shale (zone with *M. leei*) at Lunshan,

near Nanking, China (Hsü, 1934). Reported from the Blaylock Sandstone of Blaylock Mountain, Montgomery County, Ark. (Ruedemann, 1947).

Material.—One pyritized specimen, preserved in relief. Identified by P. Toghill (oral commun., 1968).

Figured specimen.—USNM 161841.

Monograptus atavus Jones

Text figure 14*E;* plate 3, figure 11

Monograptus atavus Jones. Elles and Wood, 1901–18, Mon. British Graptolites, Palaeontographical Soc., p. 403–404, text fig. 270, pl. 39, fig 1a–d.

Discussion.—The collection consists of fragments varying widely in width. The rhabdosomes are straight or with slight dorsal or ventral curvature. The thecae overlap less than one-half their length and have varying amounts of sigmoidal curvature.

Occurrence.—M1138–SD, M1139–SD, M1142–SD(?).

Range.—Llandoverian zones (17–19) of *O. vesiculosus* to M. *gregarius* (Birkhill Shales) in Great Britian (Elles and Wood, 1901–18) (Toghill, 1968). Lower part of the Kaochiapien Shale (zone with *M. leei*) in China (Hsü, 1934). *Monograptus* cf. *atavus* reported from slate at Waterville, Maine (Ruedemann, 1947).

Dimensions (in millimeters).—

Specimen No.	Length of rhabdosome	Width of rhabdosome	Thecae per centimeter
USNM–161842 [1]	>48	0. 7–0. 8	7½–8
161843a	>20	. 8	8
161843b	>25	. 7–0. 8	8
161844	>10	. 75	8
161845	>15	. 4–0. 5	9
161846	>30	. 6–0. 7	8
161847	>19	. 6	8
161848	>23	. 6–0. 7	9
161849	>30	1. 0–1. 1	8

[1] Figured specimen.

Material.—Approximately 20 compressed, fairly well preserved, fragmentary specimens.

Figured specimen.—USNM 161842.

Monograptus buddingtoni n. sp.

Text figure 15*D, E;* plate 4, figures 7, 8

Description.—The rhabdosome is small, approximately straight distally, and more or less abruptly curved proximally so that it has a J-shape. The rhabdosome widens from an initial with of about 0.3 mm to a maximum of 0.6 mm. The thecae number 12–18 per centimeter and are simple tubes with only slight overlap and even horizontal or everted apertural margins.

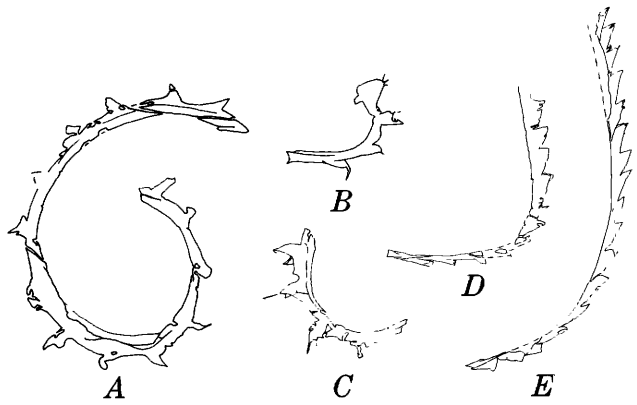


FIGURE 15.—*Monograptus. A–C, M. calamistratus* n. sp.: *A,* Holotype (USNM 161865), proximal end missing, × 8; *B,* Proximal fragment (USNM 161864) with sicula(?) and apertural spines, × 8; *C,* Proximal frgament (USNM 161624c), showing apertural spines and hornlike apertural projections, × 8. *D* and *E, M. buddingtoni* n. sp.: *D,* Specimen showing sicula (USNM 161853a), × 5; *E,* Holotype (USNM 161850) (same as pl. 4, fig. 8), × 5.

The characteristic features of this species are the strong dorsal curvature, the closely set, simple thecae, and the small amount of overlap of the thecae. Because of distortion of the specimens, some exhibit a rather abrupt bend at about th6–7, on either side of which they are fairly straight (fig. 15*D*), and some exhibit a more gently curving rhabdosome (fig. 15*E*). The thecal apertures range from everted to inverted due to distortion, but all thecae show the characteristically slight overlap, which ranges from almost none to about a third of the total thecal length. The sicula measures about 1.0 mm long and reaches to approximately the level of the aperture of th1.

Discussion.—This species resembles the monograptids of the *M. cyphus-M. acinaces-M. gregarius* group in the character of its thecae (straight, simple, overlapping tubes) and the dorsal curvature of its rhabdosome. However, it has far less thecal overlap than *M. cyphus* or *M. acinaces* and differs from *M. gregarius* by having a much shorter sicula and a more sharply curved rhabdosome. In thecal shape and the small amount of thecal overlap, it resembles *M. jaculum,* but the rhabdosome of *M. jaculum* is approximately straight and that of the Alaskan species is always curved.

Occurrence.—M1140–SD.

Range.—Zones of *M. gregarius* to *M. convolutus* in Alaska.

Dimensions (in millimeters).—

Specimen No.	Length of rhabdosome	Width		Thecae per centimeter
		Minimum	Maximum	
USNM–161850 [1]	11	0. 3	0. 5	16
161851 [1]	>10	. 5	. 55	14
161853a [1]	>10	. 3	. 55	13–15
161854	15	. 25	. 5	13
161855	13	. 5	. 65	18
161853b	15	. 4	. 5	16
161853c	>8	. 5	. 5	14
161856	>8	. 4	. 6	15
161857	>11	. 5	. 6	14
161858	9	. 5	. 5	12
161805a	>13	. 5	. 6	14
161859	>15	. 3	. 4	12
161860c	>10	. 5	. 5	16
161861	>11	. 4	. 5	12
161862a	12	. 2	. 6	18
161863a	>8	. 4	. 5	18
161852	>20	. 3	. 6	18

[1] Figured specimens.

Material.—Approximately 30 compressed, distorted specimens. Named in honor of A. F. Buddington, whose reconnaissance geologic mapping in southeastern Alaska laid a good basic framework for subsequent geologic investigations.

Holotype.—USNM 161850.

Figured specimens.—USNM 161850, 161851, 161853a.

Monograptus calamistratus n. sp.

Text figure 15*A–C*; plate 4, figure 12

Description.—The rhabdosome is small and coiled into a flat spiral. The thecae number approximately 14 per centimeter and are long and narrow with the outer end of the apertural margin retroverted so as to appear beaklike. They have relatively long prothecae, short triangular metathecae, apertural spines, and little or no overlap. The sicula is at most 0.9 mm long.

The rhabdosome is tightly coiled initially, becoming more loosely coiled distally, so that the overall shape is an irregular spiral. The spiral has about 2½ whorls and measures about 5 mm in diameter.

The protheca (proximal part of graptoloid theca before differentiation of the succeeding theca (Bulman, 1955, p. V6)) measures from 0.5 mm long at the proximal end of the rhabdosome to about 0.9 mm long at the distal end. The metatheca (distal part of a graptoloid theca (Bulman, 1955, p. V6)) is approximately triangular in outline and measures 0.25–0.5 mm high. Spines on the tips of the metathecae are frequently preserved and may measure as much as about 0.3 mm long. One specimen (fig. 15*C*) shows two metathecal projections, which may indicate that the apertural region is divided into two hornlike projections. Th1 appears to originate near the aperture of the sicula and grows upward from there.

Discussion.—The characteristic features of this form are: (1) the coiled rhabdosome, (2) the elongated prothecae, and (3) the apertural spines. It resembles *M. involutus* in its spiral rhabdosome, but the new species has a wider proximal end and more thecae per centimeter.

Occurrence.—M1142–SD.

Range.—Zone of *M. gregarius* in Alaska.

Dimensions (in millimeters).—

Specimen No.	Width of rhabdosome	Thecae per centimeter
USNM–161624c [1]	0. 3–0. 5	14
161864 [1]	. 25–0. 5	16–20
161865 [1]	. 4–0. 5	11–14
161866	. 3–0. 5	14
161867	. 5	14
161868	. 5	12½–14
161869l	. 4–0. 5	11–14
161869m	. 3–0. 5	12–16
161869n	. 5	14

[1] Figured specimens.

Material.—Approximately 10 compressed, poorly preserved specimens.

Named after the Latin "calamistratus" = curled.

Holotype.—USNM 161865.

Figured specimens.—USNM 161624c, 161864, 161865, 161988.

Monograptus cf. M. crenularis Lapworth

Text figure 16*A, B, D, E;* plate 3, figures 18, 23–25

Monograptus crenularis Lapworth. Elles and Wood, 1901–18, Mon. British Graptolites, Palaeontographical Soc., p. 414–415, text fig. 281, pl. 41, fig. 7a–e.

Monograptus crenularis Lapworth. Sun, 1933, Palaeont. Sinica, ser. B, v. 14, pt. 1, p. 42–43, pl. 7, fig. 1a–e.

Description.—According to Elles and Wood (1901–18, p. 414), the rhabdosome is long and slightly arcuate throughout, widening very gradually from 0.5 mm to a maximum of 1 mm. The thecae number 10–12 per centimeter and overlap two-thirds of their length. The apertural margins are slightly everted and occasionally are situated in distinct excavations (fig. 16*B*).

The rhabdosome is characteristically slender, and the maximum width is attained some distance from the proximal end. It is nearly straight distally and curved dorsally at the proximal end. The thecae show an apparent narrowing in the apertural region and in some, as a result of compression, the twisted apertural region shows a tendency to isolation and retroversion.

Discussion.—Elles and Wood's figures (1901–18, pl. 41, fig. 7a–e) show a form very similar to the specimens under study: fairly straight rhabdosome with a curved proximal part, and with the proximal thecae hooked or lobate in appearance. Some of the Alaskan specimens

show a greater amount of dorsal curvature in the proximal end (pl. 3, fig. 18) than do Elles and Wood's (1901–18) specimens. Because of its tighter curvature and broaden proximal end, the specimen illustrated on plate 3, figure 18, appears to have affinities with *M. argenteus* and is only provisionally grouped with *crenularis*. In this respect, the Alaskan specimens resemble Sun's (1933, pl.7, fig. 1a–e) specimens. Our specimens have between 11 and 13 hooked proximal thecae. The sicula was probably about 1.0 mm long (the specimens are distorted) and extends above the highest region of theca 1 but below the highest region of theca 2.

Occurrence.—M1140–SD.

Range.—Llandoverian zone (20) of *M. convolutus* (Birkhill Shales) in Great Britain (Elles and Wood, 1901–18; Toghill, 1968). Llandoverian zone of *Demirastrites convolutus* in Bohemia, Czechoslovakia (Pribyl, 1948). Lower Silurian Fuchih Shale from Hupei, China (Sun, 1933).

Dimensions (in millimeters).—

Specimen No.	Proximal (P) or distal (D) fragment	Length	Width		Thecae per centimeter	Number hooked thecae	Length of sicula
			Minimum	Maximum			
USNM–161870 [1]	D	27.5	----	0.55	10½–11	----	----
161871a [1]	P	17	[2] 0.5	.9	13–14	11	0.8
161872 [1]	P	54	.7	1.1	12–13	7	----
161873 [1]	D	29	----	.5	11–12	----	----
161874 [1]	P	55	.5	1.1	12–13	10	----
161875	P	10	.7	.8	10?	11	----
161876	P	12	[2] .5	.9	----	12	1.5
161877	P	15	.5	.9	12?	13	1.2
161878	P	15	.8	.7	10	12	1.0
161879	P	14	.5	.7	13	11	----
161880	P	5	[2] .5	----	----	----	1.2
161881	P	11	[2] .5	.9	13	12	.8?
161860a	D	30	----	1.5	13–14	----	----
161860b	D	103	----	1.5	----	----	----
161882	D	13	.5	.6	10	----	----
161693d	D	15.5	----	.5	10	----	----
161883	D	12	.7	.8	10	----	----
161871c	D	14	----	.7	7	----	----
161871d	D	6	----	1.0	10	----	----
161884	D	9.5	.6	.7	13	----	----

[1] Figured specimens.
[2] Theca 1.

Material.—A large number are compressed and distorted; most are poorly preserved specimens. Two nearly complete specimens are present; the rest are fragments.

Figured specimens.—USNM 161870, 161871a, 161872–161874.

Monograptus cyphus Lapworth

Text figure 16*F*; plate 4, figures 5, 6

Monograptus cyphus Lapworth. Elles and Wood, 1901–18, Mon. British Graptolites, Palaeontographical Soc., p. 362–364, text fig. 236, pl. 36, fig. 1a–e.

Pristiograptus cyphus (Lapworth). Obut, Sobolevskaya, and Bondarev, 1965, Graptolity Silyura Taimyra, p. 66, pl. 11, figs. 1, 2.

Description.—The rhabdosome is more than 4 cm long, with a maximum width of 1.8–1.9 mm. The thecae number seven to 10 per centimeter and are simple, straight, or slightly curving tubes, broad in relation to their length. They overlap about one-half their length and are inclined to the rhabdosome axis. The apertural margins are even and everted.

Discussion.—All of the specimens under study are fragmentary and none have proximal ends preserved. Some have approximately straight rhabdosomes, and some have very gentle dorsal curvature. One specimen has broad ventral curvature.

M. cyphus is distinguished from similar forms by the width of its distal part, the simple character of its thecae, and the curvature of its rhabdosome.

Occurrence.—M1138–SD, M1139–SD, M1142–SD, M1289–SD(?).

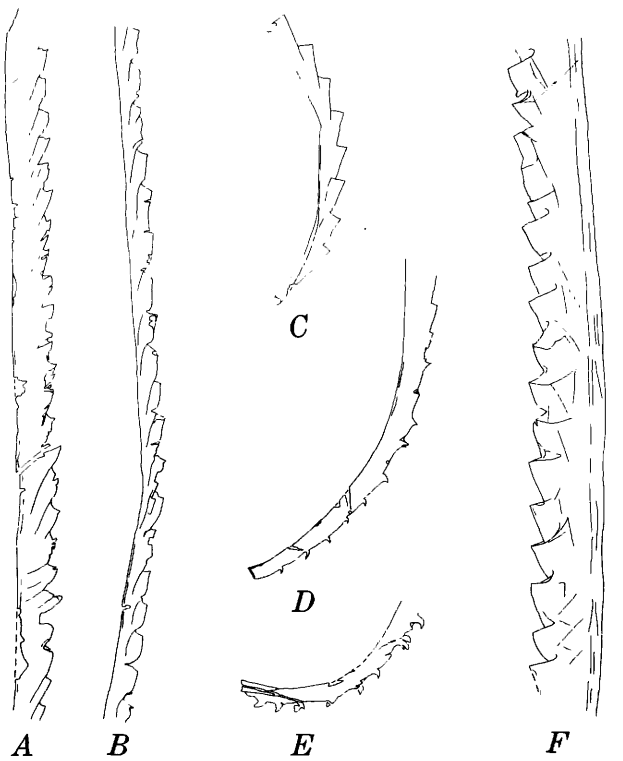


FIGURE 16.—*Monograptus. A, B, D,* and *E, M.* cf. *M. crenularis* Lapworth: *A, D,* Distal and proximal ends of specimen (USNM 161874) (same as pl. 3, fig. 23), × 5; *B,* Distal part (USNM 161870) showing apertural margins in distinct excavations, × 5; *E,* (USNM 161871a) detail of proximal end of pl. 3, fig. 18, showing sicula, × 5. *C, M. gregarius* Lapworth (USNM 161894) showing long sicula (same as pl. 4, fig. 1), × 5. *F, M. cyphus,* distal fragment (USNM 161885) (detail of pl. 4, fig. 5), × 5.

Range.—Llandoverian zone of *M. cyphus* (Birkhill Shales) in Great Britain (Toghill, 1968). Zone of *Pristiograptus cyphus* in Russia (Obut and others, 1965). Lower Keilorian in Australia (Thomas, 1960).

Dimensions (in millimeters).—

Specimen No.	Length of rhabdosome	Width of rhabdosome	Thecae per centimeter
USNM–161885 [1]	36	1. 9	9
161886	9	1. 8	9
161887	33	1. 8	8
161888	17	1. 7	7
161889d	28	1. 5	8
161889e	35	1. 6	10
161890 [1]	29	1. 7–1. 8	7½–7
161891	29	1. 5	8
161892	40	1. 9	8

[1] Figured specimens.

Material.—Approximately 10 compressed, fairly well preserved specimens. Identified by P. Toghill (oral commun., 1968).

Figured specimens.—USNM 161885, 161890.

Monograptus cf. M. difformis Törnquist

Text figure 18*E*; plate 3, figure 22

Monograptus difformis Törnquist. Elles and Wood, 1901–18. Mon. British Graptolites, Palaeontographical Soc., p. 386–387, text fig. 256a, pl. 38, fig. 4a–c.

Description.—According to Elles and Wood (1901–18, p. 386), the rhabdosome of *M. difformis* is several centimeters long, is arcuate distally, and has an involute proximal part. It widens gradually to a maximum width of about 1 mm. There are 10–12 thecae per centimeter, and they are of two types: the proximal thecae have a tendency to sigmoidal curvature and have conspicuously retroverted apertural regions; the distal thecae are simple tubes with even and somewhat everted apertural margins and overlap one-half their length.

Discussion.—Our only specimen is more than 2 cm long, has a maximum width of 1.0 mm, and has 10 thecae per centimeter. It closely resembles *M. difformis*, which is very rare in Great Britain. *M. difformis* is somewhat similar to *M. revolutus* but differs by having a more robust proximal end and greater retroversion of the proximal thecae than *revolutus*.

Occurrence.—M1142–SD.

Range.—Llandoverian zones (18 and 19) of *M. cyphus* and *M. gregarius* (Birkhill Shales) in Great Britain (Elles and Wood, 1901–18; Toghill, 1968). Zone of *Pristiograptus cyphus* in Bohemia, Czechoslovakia (Pribyl, 1948).

Material.—One compressed rather poorly preserved fragmentary specimen.

Figured specimen.—USNM 161893.

Monograptus gregarius Lapworth

Text figure 16*C*; plate 4, figure 1

Monograptus gregarius Lapworth. Elles and Wood, 1901-18, Mon. British Graptolites, Palaeontographical Soc., p. 365-366, text fig. 238, pl. 36, fig. 3a–d.

Monograptus gregarius Lapworth. Hundt, 1924, Grapt. d. deutsch. Silurs, p. 73, pl. 5, fig. 4.

Monograptus gregarius Lapworth. Ruedemann, 1947, Graptolites of North America, Geol. Soc. America Mem. 19; p. 481, pl. 84, fig. 1.

Discussion.—The main characteristics of this species according to Elles and Wood (1901–18, p. 366) are: (1) The stiffly curved rhabdosome, (2) the robust proximal end, and (3) the relatively gigantic sicula reaching up to theca 5. The Alaskan specimens closely agree with the dimensions of *M. gregarius* given by Elles and Wood (1901–18, p. 366). The length of the siculas in the Alaskan species, however, seems considerably less, and the sicula may extend only to theca 3. Unfortunately, poor preservation and scarcity of specimens make it difficult to make comparisons in sicular structure.

Occurrence.—M1142–SD.

Range.—Zone of *M. cyphus* (Cape Phillips Formation) in Canadian Arctic (Thorsteinsson, 1958). Reported, with doubt, from the Silurian Blaylock Sandstone, Arkansas (Ruedemann, 1947). Llandoverian zones of *M. cyphus* and *M. gregarius* (Birkhill Shales) in Great Britain (Toghill, 1968). Llandoverian zone of *M. gregarius* in the Frankenwald (northeastern Bavaria) (Stein, 1964, 1965). Llandoverian zones of *M. cyphus* to *M. convolutus* in Portugal (Romariz, 1962). Llandoverian zones of *Demirastrites pectinatus* (=*fimbriatus*) to *Rastrites approximatus geinitzi* (=*M. argenteus* in England) in Bohemia, Czechoslovakia (Pribyl, 1948). Llandoverian zone of *M. gregarius* at Four Mile Creek, New South Wales, Australia (Sherrard, 1954).

Dimensions (in millimeters).—

Specimen No.	Length of rhabdosome	Width of rhabdosome	Thecae per centimeter	Sicula	
				Length	Maximum width
USNM–161894 [1]	8	0. 7	11	3. 0	0. 25
161895	5	. 6	12	3. 0?	. 25
161896	5	. 55	10	3. 3	. 2
161897	7. 7	. 5	11	3. 5	. 3
161898	>7. 5	. 6	10	----	----

[1] Figured specimen.

Material.—Approximately 10 compressed, rather poorly preserved specimens, about half of which are fragmentary.

Figured specimen.—USNM 161894.

Monograptus hamatus n. sp.

Text figure 17*D*, *E*; plate 4, figure 15

Description.—The rhabdosome is very long and straight and increases gradually in width from about 0.3 mm wide proximally to a maximum of about 1.0 mm wide distally. The thecae number about eight per centimeter and are long, very slender, gently

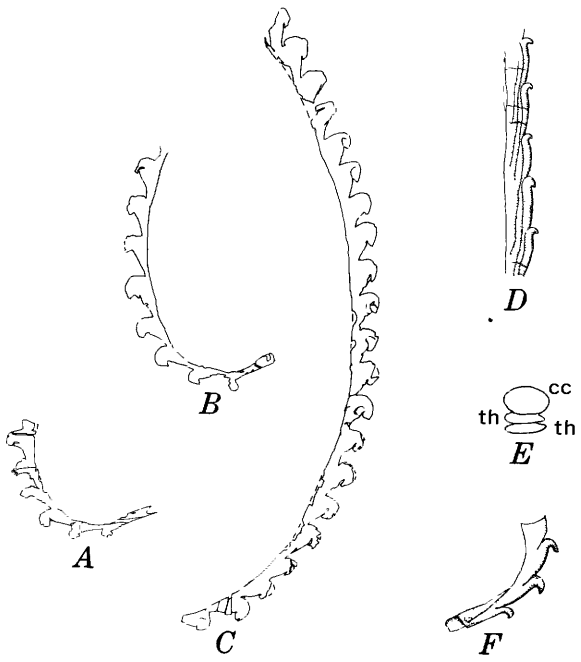


FIGURE 17.—*Monograptus. A–C, M. noyesensis* n. sp.: *A*, Proximal fragment (USNM 161930), × 5; *B*, Proximal fragment (USNM 161929) (same as pl. 4, fig. 10), × 5; *C*, Holotype (USNM 161928), distal fragment (same as pl. 4, fig. 9), × 5. *D, M. hamatus* n. sp., (USNM 161902) distal fragment preserved in relief, × 5. *E*, Schematic cross section of *M. hamatus* n. sp., showing common canal (cc) and thecae (th). *F*, *M. kerri* n. sp., (USNM 161910) proximal fragment showing sicula (broken), preserved in relief × 7.

curving tubes. They grow nearly parallel to the rhabdosome axis and have hooked apertural regions. They overlap about two-thirds of their length. The characters of the sicula are unknown.

Discussion.—This form has a very distinctive appearance. The free ventral wall of each theca forms a gentle convex curve, so that in outline, the ventral margin of the rhabdosome is a series of shallow convex curves, each curve between two hooked apertural regions. The thecae, in cross section, have the shape of a flattened oblong (fig. 17*F*). Only a small fraction of the thecal length is involved in the apertural hook.

Occurrence.—Nevada: Central Independence Range, locality 4 of Kerr (1962).

Range.—Zone of *M. gregarius* in Nevada.

Dimensions (in millimeters).—

Specimen No.	Length of rhabdosome	Width	Thecae per centimeter
USNM–161899	5	1. 0	8
161900	45	. 8–1. 0	7½–8½
161901 [1]	21	. 3–0. 8	8
161902 [1]	17. 5	1. 0	8
161903	13	. 25–0. 6	7½

[1] Figured specimens.

Material.—Five pyritized specimens preserved in relief. Named after the Latin "hamatus" = with hooks, hooked.

Holotype.—USNM 161901.

Figured specimens.—USNM 161901, 161902.

Monograptus cf. M. incommodus Törnquist

Text figure 18*A*; plate 3, figure 20

Monograptus incommodus Törnquist. Elles and Wood, 1901–18, Mon. British Graptolites, Palaeontographical Soc., p. 406, text fig. 272, pl. 40, fig. 1a–e.

Monograptus incommodus Törnquist. Ruedemann, 1947, Graptolites of North America, Geol. Soc. America Mem. 19, p. 481, pl. 85, fig. 26.

Pribylograptus incommodus (Törnquist). Obut and Sobolevskaya, 1966, Graptolity rannyevo Silyura v Kazakstanye, p. 34–35, pl. 6, fig. 9, text fig. 25.

Description.—According to Elles and Wood (1901–18, p. 406), the rhabdosome is long and slender, with irregular curvature. It widens from a slender, slightly arcuate, or straight proximal part to a flexed distal part with an average width of 0.5–0.6 mm. The thecae number seven to eight per centimeter, are inclined at a very small angle, and overlap one-third to one-half of their length. The apertural margins are even and slightly introverted.

The curvature of the rhabdosome is generally dorsal. The sicula is fully 3 mm long and reaches to the level of the aperture of theca 1, which originates at a point about halfway up the sicula. The thecae show slight sigmoidal curvature.

Discussion.—Some of the Alaskan specimens have more strongly curved rhabdosomes than those figured by Elles and Wood (1901–18, pl. 40, fig. 1a–e). Poor preservation makes determination of thecal characters difficult. The thecae appear to overlap about a third of their length, and some have slightly introverted apertures.

Occurrence.—M1138–SD, M1139–SD, M1289–SD.

Range.—Llandoverian zones of *O. vesiculosus* to *M. gregarius* (Birkhill Shales) in Great Britain (Toghill, 1968). Reported from the Silurian Blaylock Sandstone of Arkansas (Ruedemann, 1947). Llandoverian zones of *Pristiograptus cyphus* to *Demirastrites pectinatus* (=

fimbriatus) in Bohemia, Czechoslovakia (Pribyl, 1948). Distal fragment reported from the Lower Silurian

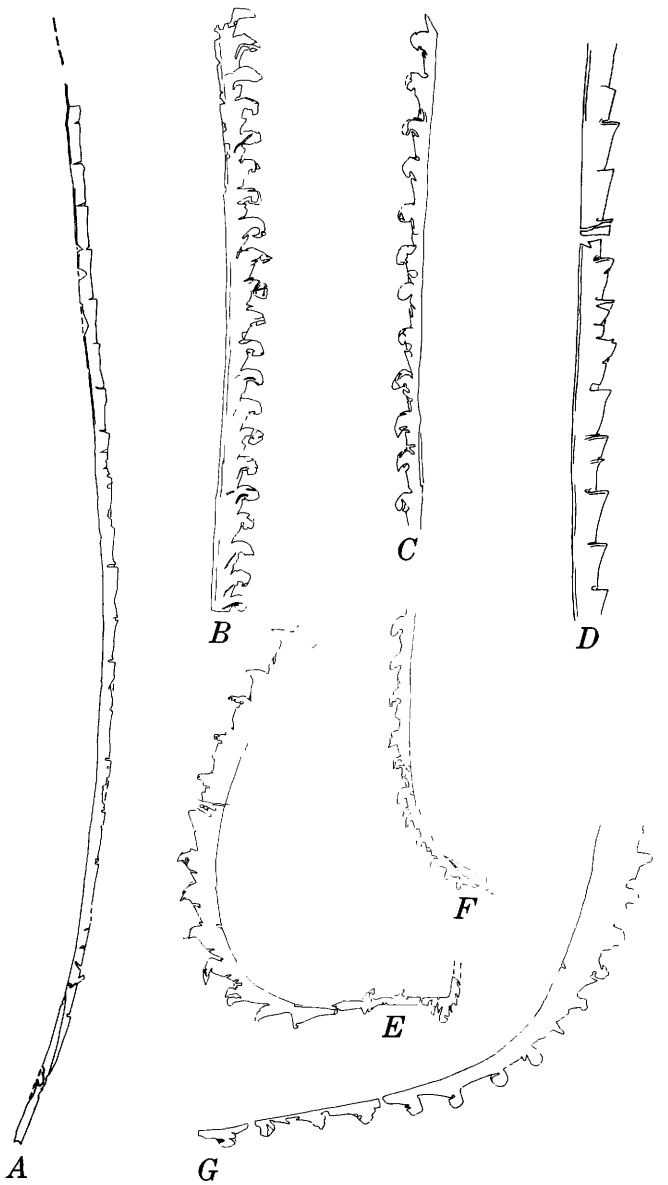


FIGURE 18.—*Monograptus*. *A*, *M.* cf. *M. incommodus* Törnquist (USNM 161904), showing long sicula, × 5. *B*, *C*, and *F*, *M.* aff. *M. undulatus* Elles and Wood: *B*, Distorted distal fragment (stretched widthwise) (USNM 161955), × 5; *C*, Distal part of pl. 4, fig. 4 (USNM 161862b), × 5; *F*, Proximal fragment (USNM 161957), slightly distorted, × 5. *D*, *M. tenuis* (Portlock) distal fragment (USNM 161940), × 5. *E*, *M.* cf. *M. difformis*, incomplete specimen (USNM 161893) (same as pl. 3, fig. 22), × 5. *G*, *M. revolutus* Kurck, incomplete specimen (USNM 161937) (same as pl. 3, fig. 19), × 5.

Kaochiapien Shale, Kiangsu, China (Sun, 1933). Also reported from Russia (Obut and Sobolevskaya, 1966).

Dimensions (in millimeters).—

Specimen No.	Length of rhabdosome	Width of sicula	Maximum width of rhabdosome	Thecae per centimeter	Length of sicula
USNM–161904[1]	30	0.25	0.4	9	3.7
161905[1]	14	------	.3	9	------
161906b	20	------	.4	8	------
161906c	17	.2	.3	------	4.1
161907	20	.2	.5	6	3.5
161908	35	------	.5	7½–8	------
161909	11	------	.4	6	------

[1] Figured specimens.

Material.—About 10 compressed, poorly preserved specimens.

Figured specimens.—USNM 161904, 161905.

Monograptus kerri n. sp.

Text figure 17*F*; plate 4, figure 11

Description.—The rhabdosome is very small and slender, with strong dorsal curvature. The proximal part is relatively robust and abruptly recurved. The thecae number 10–12 per centimeter and are hooked, with about a third of the thecal length involved in the hook. They resemble the thecae of *M. irfonensis* and *M. scanicus*, and they overlap about a fourth of their length. The sicula is as much as 1.4 mm long, and theca 1 starts one-fourth to one-third of the way up its length.

Discussion.—This form resembles *M. leei* Hsü (1934, p. 97–98) very closely in size and shape of the rhabdosome. The thecae and details of the sicula are entirely different, however. The sicula of *M. leei* is 2 mm long, and its apex reaches to the level of the aperture of theca 3. The sicula on this form is, at most, 1.4 mm long and reaches no higher than midway between theca 1 and theca 2. The thecae of *M. leei* have apertures that are wide, even, and perpendicular to the general trend of the rhabdosome. The thecae on this form have distinctly hooked apertural regions.

The characteristic features of this species are: (1) The hooked thecae, (2) the small size of the rhabdosome, (3) the strong dorsal curvature of the rhabdosome.

Occurrence.—Nevada: Central Independence Range, locality 4 of Kerr (1962).

Range.—Zone of *M. gregarius* in Nevada.

Dimensions (in millimeters).—

Specimen No.	Length of rhabdosome	Width		Thecae per centimeter	Length of sicula
		Theca 1	Maximum		
USNM–161910[1]	3.0	0.5	0.65	13	1.4
161911[1]	7	.3	.6	10	1.2
161912	4.3	------	.75	10–12	------
161913	2.5	.3	.3	11	1.0
161914	5	------	.7	10–12	------
161915	12	------	1.0?	10	------

[1] Figured specimens.

Material.—Six pyritized specimens preserved in relief. Named in honor of J. William Kerr of the Canadian Geological Survey.

Holotype.—USNM 161911.

Figured specimens.—USNM 161910, 161911.

Monograptus lobiferus (M'Coy)

Plate 3, figures 12, 21

Monograptus lobiferus (M'Coy). Elles and Wood, 1901–18, Mon. British Graptolites, Palaeontographical Soc., p. 448–450 text fig. 308, pl. 45, fig. 1a–f.

Monograptus (Streptograptus) lobiferus (M'Coy). Obut, 1949, Polyevoi Atlas, Rukovodyashchich graptolitov vyerkhnyevo Silura Kirgizskoi SSR. Akademiia Nauk SSSR, p. 23, pl. 4, fig. 6a–c.

Monograptus lobiferus (M'Coy). Romariz, 1962, Revista da Faculdade de Ciencias, Lisbon Univ., ser. 2, C, v. 10, pt. 2, p. 251, pl, 18, fig. 8.

Monograptus lobiferus (McCoy). Obut, Sobolevskaya, and Nikolaiyev, 1967, Graptolity i stratigrafiia nizhnego Silura okrainnykh podniatii kolymskogo massiva (severovostok SSSR), Akademiia Nauk SSSR, p. 93–94, pl. 10, figs. 3, 4.

Discussion.—Most of the Nevada specimens are proximal or near-proximal fragments. They compare very closely with the dimensions given by Elles and Wood (1901–18, p. 448). They have the lobed thecae and dorsally recurved proximal end characteristic of *M. lobiferus*. They also resemble *Globosograptus wimani* (Obut and others, 1967, pl. 13, fig. 2) but lack its ventral proximal curvature.

Occurrence.—Nevada: Central Independence Range, locality 4 of Kerr (1962).

Range.—Llandoverian zone (20) of *M. convolutus* (Phi Kappa Formation) in Idaho (Churkin, 1963). Llandoverian zone (20) of *M. convolutus* (Birkhill Shales) in Great Britain (Elles and Wood, 1901–18; Toghill, 1968). Llandoverian zones of *M. gregarius* to *M. turriculatus* in Portugal (Romariz, 1962). Also reported from Russia (Obut, 1949; Obut and others, 1967).

Dimensions (in millimeters).—

Specimen No.	Length of rhabdosome	Width	Thecae per centimeter
USNM–161916	8. 5	1. 3	6
161917	17. 5	. 5–1. 1	8–10
161918	4. 5	. 5–0. 6	8–10
161919 [1]	11. 5	1. 2	7
161920a	12. 5	1. 0–1. 2	7
161920b	11. 5	1. 4–1. 5	7
161920c	9. 0	1. 1	8
161920d	13. 7	2. 0	6½
161921	11. 5	1. 8	8
161922	32	1. 5–1. 7	9
161923 [1]	10	. 8	9
161924	3. 5	. 4–0. 5	10
161925	11. 5	. 8	9
161926	14	1. 5	7
161927	27	1. 5–1. 7	7

[1] Figured specimens.

Material.—About 30 pyritized specimens preserved in relief.

Figured specimens.—USNM 161919, 161923.

Monograptus noyesensis n. sp.

Text figure 17*A–C;* plate 4, figures 9, 10

Description.—The rhabdosome is broadly arched, with the proximal end moderately curved and the thecae on the convex side with little or no overlap. The early thecae are somewhat elongated. The distal thecae are bluntly triangular, widening from the beginning of the protheca to the apertural region, which is hooked.

The rhabdosome is curved throughout, with the amount of curvature greatest in the proximal region (first four to five thecae). The sicula measures 1.0–1.2 mm long and 0.2–0.3 mm wide. It extends up to about the level of the aperture of theca 1 and usually exhibits a very short virgella. Theca 1 has a slender protheca, and the hooked metatheca is about 0.4 mm high. Up to about theca 6, the thecae have an elongated appearance because of their relatively slender, slowly widening prothecae. Above theca 5 and 6 the thecae become more and more bluntly triangular. They widen from the beginning of the protheca and attain a maximum height of about 1.0 mm. There are 11–12 thecae per centimeter distally. The thecae are curved into a prominent hooked shape in the apertural region, with the apertural margin on some specimens approximately parallel to the axis of the rhabdosome. The dorsal outline of the thecae has a rounded hunchback appearance.

Discussion.—Distally, this form is very similar in appearance to *Monograptus pseudoplanus* Sudbury (1958, p. 523–524, text fig. 22a, pl. 22, figs. 94–96). The thecae have almost exactly the same shape in the flattened condition. It differs from *M. pseudoplanus* by being somewhat smaller and by having a much different proximal end. The proximal thecae of *M. pseudoplanus* are greatly elongated, with very small hooked metathecal parts, and the proximal region itself is broadly arched. The proximal region of the Alaskan species exhibits a greater amount of curvature, and its proximal thecae are much larger and much less elongated than those of *M. pseudoplanus.*

Monograptus noyesensis resembles *M. communis* in the proximal region, but the distal thecae of *M. communis* have less of an apertural hook than those of the Alaskan species.

It also resembles *M. millipeda* and *M. lobiferus* but is more slender than *M. millipeda* and has a more strongly recurved proximal end than *M. lobiferus.* It also differs in the characters of the distal thecae, the

hook, or lobe, being less conspicuous and involving a smaller part of the thecal length.

Occurrence.—M1142–SD.

Range.—Zone of *M. gregarius* in Alaska.

Dimensions (in millimeters).—

Specimen No.	Length of rhabdosome	Width					Thecae per centimeter	Length of sicula
		Maximum	Theca 1	Theca 2	Theca 4	Theca 5		
USNM–161928 [1]	18	1.0					12	
161929 [1]	8	.7	0.4	0.5	0.7	0.7	10	1.0
161930 [1]	5	.7	.4	.5	.6	.7		1.2
161931	5	.6					12	
161932	14	.8					11	
161933	9	.75					10	
161934	9	.75					9	
161935	2.5		.4	.6				1.2
161936c	9	.7	.4	.6	.6	.7		1.2
161936d			.3	.5	.6			1.2

[1] Figured specimens.

Material.—Approximately 20 compressed fragmentary fairly well preserved specimens. Named after Noyes Island in southeastern Alaska.

Holotype.—USNM 161928.

Figured specimens.—USNM 161928–161930.

Monograptus revolutus Kurck

Text figure 18*G*; plate 3, figure 19

Monograptus revolutus Kurck. Elles and Wood, 1901–18, Mon. British Graptolites, Palaeontographical Soc., p. 384–385, text fig. 254, pl. 38, fig. 1a–e.

Monograptus revolutus Kurck. Sudbury, 1958, Royal Soc. London, Philos. Trans. ser., B, no. 685, v. 241, p. 533–536, text figs. 26, 27a, 28, table 4.

Pernerograptus revolutus (Kurck). Obut and Sobolevskaya, 1966, Graptolity rannyevo Silyura v Kazakhstanye, p. 32–33, text fig. 23, pl. VI, figs. 5–7.

Description.—According to Elles and Wood (1901–18, p. 384–385), the rhabdosome is several centimeters long, with an involute or broadly recurved proximal part. It widens from a threadlike initial part to a maximum width of about 1 mm. The thecae number eight to 10 per centimeter and are long narrow tubes of two types. The early thecae have the outer end of the apertural margin retroverted so as to appear beaklike or rostellate; the mature thecae are simple tubes with even apertural margins, and overlap two-thirds of their length.

Discussion.—Our largest specimen (fig. 18*G*) has a maximum width of 1.4 mm and compares closely with the "B"-form of Sudbury (1958, p. 534, fig. 26b). The others are about 1 mm wide and resemble form "A" of Sudbury (1958, p. 534, fig. 26a). Distally the thecae number 10–11 per centimeter and proximally, six to nine per centimeter. The narrow part of the proximal end is approximately straight, and the rhabdosome starts to curve at the point where it starts to widen.

Occurrence.—M1142–SD.

Range.—Llandoverian zones (18 and 19) of *M. cyphus* and *M. gregarius* (Birkhill Shales) in Great Britain (Elles and Wood, 1901–18; Toghill, 1968). Llandoverian zone of *Pristiograptus cyphus* in Bohemia, Czechoslovakia (Pribyl, 1948). A proximal fragment reported from the Lower Kaochiapien Shale near Nanking, China (Hsü, 1934). Also reported from Germany (Hundt, 1924) and Russia (Obut and Sobolevskaya, 1966).

Dimensions (in millimeters).—

Specimen No.	Length of rhabdosome	Width		Thecae per centimeter (distal)	Thecae per centimeter (proximal)
		Initial	Maximum		
USNM 161937 [1]	22	0.2?	1.4	10	7–8
161938	17	.2	.7	10	6
161939	20	.2	1.0	11	7–8

[1] Figured specimens.

Material.—Approximately seven compressed rather poorly preserved fragmentary specimens.

Figured specimen.—USNM 161937.

Monograptus tenuis (Portlock)

Text figure 18*D*; plate 4, figures 2, 3

Monograptus tenuis (Portlock). Elles and Wood, 1901–18, Mon. British Graptolites, Palaeontographical Soc., p. 407–408, text fig. 273, pl. 40, fig. 2a–e.

Pristiograptus tenuis (Portlock). Romariz, 1962, Revista da Faculdade de Ciencias, ser. 2, v. 10, pt. 2, p. 286, pl. 2, fig. 4; pl. 3, fig. 4; pl. 4, fig. 3.

Discussion.—The Alaskan specimens possess the general characters of *M. tenuis*. The thecae have distinctly sigmoidal curvature and overlap one-third to one-half of their length. The rhabdosomes reach a maximum width of 1 mm and are straight or very slightly curved. The apertural margins are even and slightly introverted. The thecae exhibit an abrupt expansion in the apertural region that tends to produce an acute denticle on the apertural margin. The Alaskan specimens have more thecae per centimeter than those described as five to seven per centimeter by Elles and Wood (1901–18, p. 407).

Occurrence.—M1138–SD.

Range.—Llandoverian zones of *M. sedgwickii* and *Rastrites maximus* (Birkhill Shales) in Great Britain (Toghill, 1968). The same zones in Portugal (Romariz, 1962). Reported from the lower Llandoverian Panlasapye beds at Pulau Langgon, Langkawi Islands, northwestern Malaya (Kobayashi and others, 1964).

Dimensions (in millimeters).—

Specimen No.	Length of rhabdosome	Width of rhabdosome	Thecae per centimeter
USNM–161940 [1]	20	0. 8	8
161941	20	. 8	7
161942	9. 5	. 5	7
161943a [1]	20	. 7–0. 8	7
161944	21	1. 0	8
161945	15	1. 0	8
161943e [1]	15	. 7	8
161946	34	. 7–0. 75	8
161947	15	. 6	8
161948	20	. 5–0. 6	10
161949	36. 5	. 6–0. 75	7
161950	13	. 4–0. 5	7
161951	17	. 5	8
161952	12. 6	. 3–0. 4	8
161953	62	. 4–0. 7	8

[1] Figured specimens.

Material.—A large number of compressed, fairly well preserved, fragmentary specimens.

Figured specimens.—USNM 161940, 161943a, 161943e; *M.* cf. *M. tenuis*, USNM 161954.

Monograptus aff. M. undulatus Elles and Wood

Text figure 18*B, C, F;* plate 4, figure 4

Monograptus undulatus Elles and Wood, 1901–18, Mon. British Graptolites, Palaeontographical Soc., p. 432, text fig. 295, pl. 45, fig. 5.

Description.—The rhabdosome is long and slender, with gentle dorsal curvature and a recurved proximal end. It increases very gradually in width, so that it appears to be about the same width throughout its length. The thecae have their apertural regions coiled into lobes involving about a third of the thecal length. The lobes occupy approximately a half of the total width of the rhabdosome. The sicula extends almost to the level of the highest region of theca 3 (fig. 18*F*).

Discussion.—The Alaskan specimens resemble *M. undulatus* in general appearance. Because all our specimens are distorted, it is difficult to state what their true dimensions were. In comparison to *M. undulatus*, they seem to have generally more thecae per centimeter. *M. undulatus* is ventrally flexed in its distal part, where as all our specimens are nearly straight or are dorsally curved. The apex of the sicula of *M. undulatus* is on a level with the highest region of theca 1, and the sicula on our specimens reaches to theca 3.

The Alaskan specimens also resemble *M. runcinatus* var. *pertinax*, but it has a nearly straight rhabdosome, and the lobed part of the thecae occupies only about a third of the width of the rhabdosome.

Ruedemann (1947, p. 488–89) describes a specimen from Dall Island, in southeastern Alaska, which he calls "*Monograptus* sp. nov. aff. *undulatus*." It is slender and strongly flexed, with the thecae on the convex side. The thecae number 10 per centimeter and are very elongate, with slight ogee curvature. The apertural region is isolate and retroverted, and nearly a third of the thecal length is involved. The lobes thus formed occupy about half the width of the rhabdosome. This description corresponds very closely to ours, but Ruedemann (1947) did not illustrate his specimen.

Occurrence.—M1140–SD.

Range.—M. undulatus is found in the Llandoverian zones (20–23) of *M. convolutus* to *M. crispus* in Great Britain (Elles and Wood, 1901–18). It also occurs in the upper Keilorian of Australia (Thomas, 1960).

Dimensions (in millimeters).—

Specimen No.	Length of rhabdosome	Width	Thecae per centimeter
USNM–161955 [1]	31	1. 0	14
161862b [1]	29	. 5–0. 7	9–10
161956	22	. 5–1. 0	13
161957 [1]	12	. 5	10–13
161958	10	. 5–0. 75	12
161959	21. 5	. 5–0. 8	9–10
161960	21	. 6–0. 7	10–11
161961	14	. 6–0. 75	10–11
161962a	22	. 7–0. 8	9–12
161962b	101	. 7–1. 2	7–13
161962c	55	. 6–0. 7	9–10
161963a	45	. 65–0. 9	10
161964	30	. 5–0. 7	11–12
161965d	22	. 5–0. 6	10–11
161963b	42	1. 0	13
161966	17	1. 0–1. 2	13
161965e	18	1. 0–1. 3	12
161967	97	. 7–1. 0	11

[1] Figured specimens.

Material.—About 30 compressed distorted specimens.

Figured specimens.—USNM 161955, 161862b, 161957.

Genus RASTRITES Barrande, 1850

Rastrites Barrande. Bulman, 1955, Geol. Soc. America, Treatise on invertebrate paleontology, pt. V, p. V93, fig. 68, 2a, b.

Rhabdosome uniserial, curved or hook shaped, with threadlike common canal. Thecae widely spaced, straight, isolated, with tiny hooked apertures, extending from common canal at high angles. Lower Silurian (middle and upper parts); Europe, North Africa, Asia, Australia, Greenland, and North America.

Rastrites cf. R. longispinus (Perner)

Text figure 19*C;* plate 4, figure 17

Rastrites longispinus (Perner). Elles and Wood, 1901–18, Mon. British Graptolites, Palaeontographical Soc., p. 489–490, text fig. 344, pl. 50, fig. 2a–g.

Rastrites longispinus (Perner). Obut, Sobolevskaya, and Bondarev, 1965, Graptolity Silura Taimyra, p. 90–91, pl. 17, figs. 8, 9.

Description.—According to Elles and Wood (1901–18, p. 489–90), the rhabdosome is arcuate, with a proximal part nearly semicircular in shape. The thecae

number seven to eight per centimeter and are very long in proportion to the width of the interspaces between thecae. The thecae are 3–5 mm long, have distinctly reflexed apertural terminations, and are set nearly perpendicularly to the rhabdosome axis. The interspaces are about 1 mm long.

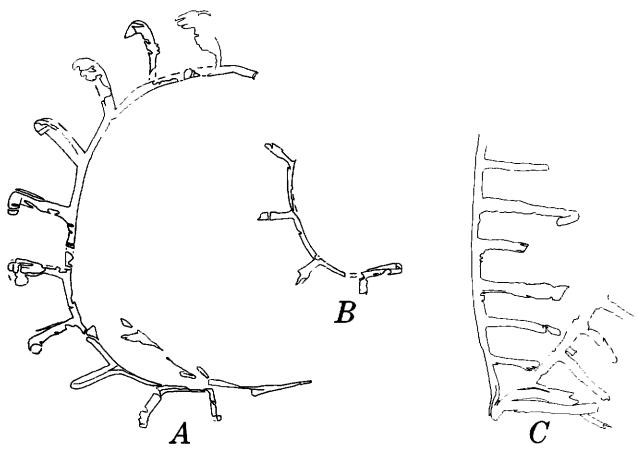


FIGURE 19.—*Rastrites. A and B, R. orbitus* n. sp.: *A*, Holotype (USNM 161969) (same as pl. 4, fig. 18), × 8; *B*, Proximal fragment (USNM 161970) showing sicula, × 8. *C, R.* cf. *R. longispinus* (Perner), broken and bent fragment (USNM 161968) (same as pl. 4, fig. 17), × 5.

Discussion.—The specimens at hand are fragmentary. The largest has thecae as much as about 3.0 mm long, numbering eight to 10 per centimeter. The overall shape and curvature of the Alaskan species is unknown. The long thecae and their general spacing suggests *R. longispinus.*

Occurrence.—M1142–SD.

Range.—Llandoverian zones (19 and 20) of *M. gregarius* and *M. convolutus* (Birkhill Shales) in Great Britain (Elles and Wood, 1901–18) (Toghill, 1968). Llandoverian zones of *M. gregarius* to *M. sedgwickii* in Portugal (Romariz, 1962). Llandoverian zones of *Demirastrites pectinatus* to *D. triangulatus* in Bohemia, Czechoslovakia (Pribyl, 1948). Tentatively identified from the subzone of *M. triangulatus* near Cadia, New South Wales, Australia (Sherrard, 1954). Also reported from Russia (Obut and others, 1965).

Dimensions (in millimeters).—

Specimen No.	Length of thecae	Width of interspaces	Thecae per centimeter
USNM–161968 [1]	As much as 2. 9	1. 0–1. 2	8–10
161869h	1. 0–1. 7	. 8–1. 3	7½–12½

[1] Figured specimen.

Material.—Two compressed fragmentary specimens.

Figured specimen.—USNM 161968.

Rastrites orbitus n. sp.

Text figure 19*A, B;* plate 4, figures 18, 19

Description.—The rhabdosome is small and arcuate to nearly circular in shape. The thecae are on the convex margin; they number seven to 12 per centimeter, and are 0.6–1.8 mm long. They are inclined to the rhabdosome axis and have apertural regions curved into a hook or barb. The interspaces are 0.8–1.4 mm wide.

The rhabdosome is always greatly curved and, in the more nearly complete specimens, forms a circle or spiral. The thecae are relatively short, mostly measuring about 1.0–1.4 mm in length, with the maximum measured at 1.8 mm. The interspace width ranges from 0.7 to 1.4 mm, producing seven to 14 thecae per centimeter. The theca forms an angle with the common canal of anywhere from 90° to 45°, with the average being about 70°–80°. The apertural end of each theca is sharply curved into a barb very similar to that on *R. hybridus.* One fragmentary specimen (fig. 19*B*) bears what appears to be the sicula. This sicula measures about 0.6 mm in length and extends up to the level of the first theca. Theca 1 is 0.2 mm long, theca 2 is 0.5 mm long, and theca 3 is 0.6 mm long. The proximal thecae are thus smaller than the distal thecae, but otherwise very similar to them in appearance.

Discussion.—The characteristic features of this species are the circular or spiral shape of the rhabdosome and the relatively short, inclined thecae. It is similar in general appearance to *M. triangulatus extremus* Sudbury (1958), but *R. orbitus* has shorter thecae and no apparent overlap.

Occurrence.—M1142–SD.

Range.—Zone of *M. gregarius* in Alaska.

Dimensions (in millimeters).—

Specimen No.	Length of thecae	Width of interspaces	Thecae per centimeter
USNM–161969 [1]	0. 7–1. 1	0. 9–1. 0	10–11
161970 [1]	. 2–0. 6	. 9–1. 0	10–11
161971 [1]	. 8–1. 4	1. 0–1. 4	7–10
161972	. 8–1. 3	. 8–0. 9	11–12½
161973d	1. 3–1. 8	1. 0–1. 4	7–10
161973e	1. 0–1. 5	. 8–1. 1	9–12½
161974	. 7–1. 8	. 8–1. 0	10–12½
161975	. 6–1. 4	. 7–0. 9	11–14

[1] Figured specimens.

Material.—Eight compressed somewhat poorly preserved specimens.

Named after the Latin "orbitus"=circular.

Holotype.—USNM 161969.

Figured specimens.—USNM 161969–161971.

Rastrites aff. R. peregrinus (Barrande)

Plate 4, figures 13, 14

Rastrites peregrinus (Barrande). Elles and Wood, 1901–18, Mon. British Graptolites, Palaeontographical Soc., p. 488–489, text fig. 343, pl. 50, fig. 1a–e.

Rastrites peregrinus Barrande. Hundt, 1924 Grapt. d. deutsch Silurs, p. 11, fig. 6–8.

Description.—According to Elles and Wood (1901–18 p. 488–489), the rhabdosome is small and arcuate, appears never to exceed 3 cm in length, and has a short sharply recurved proximal part. The thecae number eight to 10 per centimeter, and are 1.0–2.5 mm long, with narrow interspaces about 1 mm long. They are somewhat club shaped, with apparently rounded extremities due to the very slight apertural reflexion. The proximal part is recurved so as to present the appearance of a small fishhook.

Discussion.—The specimens under study are fragmentary and somewhat distorted. The Alaskan species has more thecae per centimeter than those described by Elles and Wood (1901–18, p. 488–489) but otherwise resembles *R. peregrinus*. The change in thecal direction on specimen USNM 161976 (pl. 4, fig. 14) is definitely due to twisting of the rhabdosome and is not an original character as that described in *Corymbites sigmoidalis* (Obut and others 1967, p. 133).

Occurrence.—M1140–SD.

Range.—Llandoverian zone of *M. millepeda* (Road River Formation) in northern Yukon Territory, Canada (Jackson and Lenz, 1962). Llandoverian zones (19 and 20) of *M. gregarius* and *M. convolutus* (Birkhill Shales) in Great Britain (Elles and Wood, 1901–18; Toghill, 1968). Llandoverian zones of *M. gregarius* to *M. crispus* in Portugal (Romariz, 1962). Llandoverian zones of *Demirastrites convolutus* to *M. sedgwickii* in Bohemia, Czechoslovakia (Pribyl, 1948). Also reported from Germany (Hundt, 1924), *Rastrites* cf. *R. peregrinus* reported from a Silurian shale at Houlton, Maine (Ruedemann, 1947).

Dimensions (in millimeters).—

Specimen No.	Length of rhabdosome	Length of thecae	Width of interspaces	Thecae per centimeter
USNM–161976[1]	17	1.0–1.5	.7–0.9	12
161978[1]	10	1.0–1.3	.7	13
161980	13	1.0–1.5	.7–0.8	10
161979	10	1.1–1.3	.7–0.9	11
161981	7	1.2–1.8	.7–0.8	14
161982	25	.7–1.1	.7–0.8	13
161983	8	.9–1.0	.8–1.0	12
161977	10	1.1	.7–0.9	12
161984	7.5	1.5	.7–0.8	12

[1] Figured specimens.

Material.—About 17 compressed distorted somewhat poorly preserved specimens.

Figured specimens.—USNM 161976, 161978.

REFERENCES CITED

Buddington, A. F., and Chapin, Theodore, 1929, Geology and mineral deposits of southeastern Alaska: U.S. Geol. Survey Bull. 800, 398 p.

Bulman, O. M. B., 1955, Graptolithina, with sections on Enteropneusta and Pterobranchia, Pt. V *of* Moore, P. C., ed., Treatise on invertebrate paleontology: Lawrence, Kans., Geol. Soc. America and Univ. Kansas Press, 101 p.

——— 1960, Some morphologically intermediate genera in graptolite phylogeny: Internat. Geol. Cong. 21st, Copenhagen 1960, Rept., pt. 22, p. 65–70.

Bulman, O. M. B., and Rickards, R. B., 1968, Some new diplograptids from the Llandovery of Britain and Scandinavia: Palaeontology, v. 11, pt. 1, p. 1–15.

Churkin, Michael, Jr., 1963, Graptolite beds in thrust plates of central Idaho and their correlation with sequences in Nevada: Am. Assoc. Petroleum Geologists Bull., v. 47, no. 8, p. 1611–1623.

——— 1965, First occurrence of graptolites in the Klamath Mountains, California, *in* Geological Survey research, 1965: U.S. Geol. Survey Prof. Paper 525–C, p. C72–C73.

Churkin, Michael, Jr., and Brabb, E. E., 1965, Ordovician, Silurian, and Devonian biostratigraphy of east-central Alaska: Am. Assoc. Petroleum Geologists Bull., v. 49, no. 2, p. 172–185.

——— 1967, Devonian rocks of the Yukon-Porcupine Rivers area and their tectonic relation to other Devonian sequences in Alaska, *in* Oswald, D. H., ed., International symposium on the Devonian system, Calgary, 1967, V. 2: Calgary, Alberta Soc. Petroleum Geologists, p. 227–258.

Churkin, Michael, Jr., Carter, Claire, and Eberlein, G. D., 1969, Graptolite succession across the Ordovician-Silurian boundary in southeastern Alaska: Geol. Soc. London Quart. Jour. (In press.)

Churkin, Michael, Jr., Eberlein, G. D., Hueber, F., and Mamay, S. H., 1969, Lower Devonian land plants from graptolitic shale in southeastern Alaska: Paleontology. (In press.)

Churkin, Michael, Jr., and Kay, Marshall, 1967, Graptolite-bearing Ordovician siliceous and volcanic rocks, northern Independence Range, Nevada: Geol. Soc. America Bull., v. 78, no. 5, p. 651–668.

Davies, K. A., 1929, Notes on the graptolite faunas of the Upper Ordovician and Lower Silurian: Geol. Mag. [Great Britain], v. 66, p. 1–27.

Eberlein, G. D., and Churkin, Michael, Jr., 1969, Paleozoic formations in the northwest coastal area of Prince of Wales Island, southeastern Alaska: U.S. Geol. Survey Bull. 1284. (In press.)

Elles, G. L., 1922, The graptolite faunas of the British Isles—a study in evolution: Geol. Assoc. Proc., v. 33, p. 168–200.

Elles, G. L., and Wood, E. M. R., 1901–18, A monograph of British graptolites: Palaeontographical Soc. [London], v. 55–58, 60–62, 64, 66–67, 526 p., 52 pls.

Fortier, Y. O., and others, 1963, Geology of the north-central part of the Arctic Archipelago, Northwest Territories (Operation Franklin): Canada Geol. Survey Mem. 320, 671 p. [With French abstract.]

Gilluly, James, and Masursky, Harold, 1965, Geology of the Cortez quadrangle, Nevada, *with a section on* Gravity and aeromagnetic surveys, by D. R. Mabey: U.S. Geol. Survey Bull. 1175, 117 p.

Harris, W. J., and Thomas, D. E., 1937, Victorian graptolites (new series)—part IV: Victoria Dept. Mines, Mining and Geology Jour., v. 1, pt. 1, p. 68–79, 2 pls.

——— 1949, Victorian graptolites—part XI; Silurian graptolites from Jackson's Creek near Sydenham, Victoria: Victoria Dept. Mines, Mining and Geology Jour., v. 3, no. 5, p. 52–55.

Hsü, S. C., 1934, The graptolites of the lower Yangtze valley: Natl. Research Inst. Geol. (Acad. Sinica), Mon. ser. A., v. 4, 106 p., 7 pls., 37 figs.

Hundt, Rudolf, 1924, Die graptolithen des deutschen Silurs: Leipzig, Verlag Max Weg, 96 p., 18 pls.

——— 1953, Graptolithen; neue Erkenntnisse über die Leitversteinerungen der Silurformation: Leipzig, Akad. Verlagsges. Geest. and Portig, (Die neue Brehm-Bücherei 102), 48 p., 124 pls.

Jackson, D. E., 1966, Graptolitic facies of the Canadian cordillera and Arctic archipelago—A review: Canadian Petroleum Geology Bull., v. 14, p. 469–485.

Jackson, D. E., and Lenz, A. C., 1962, Zonation of Ordovician and Silurian graptolites of northern Yukon, Canada: Am. Assoc. Petroleum Geologists Bull., v. 46, no. 1, p. 30–45.

Jackson, D. E., Steen, G., and Sykes, D., 1965, Stratigraphy and graptolite zonation of the Kechika and Sandpile groups in northeastern British Columbia: Canadian Petroleum Geology Bull., v. 13, no. 1, p. 139–154.

Jaeger, Hermann, 1964, Der gegenwärtige Stand der stratigraphischen Erforschung des Thüringer Silurs, *in* Beiträge zur Regionalen Geologie Thüringens und Angrenzender Gebiete Sowie zu Anderen Problemen: Akad. Wiss. zu Berlin Abh. Deutschen, Kl. Bergban, Huttenwesen und Montangeologie, no. 2, p. 27–51.

Jones, W. D. V., and Rickards, R. B., 1967, *Diplograptus penna* Hopkinson 1869, and its bearing on vesicular structures: Paläont. Zeitschr., Stuttgart, 41 3/4, p. 173–185.

Kay, Marshall, and Crawford, J. P., 1964, Paleozoic facies from the miogeosynclinal to the eugeosynclinal belt in thrust slices, central Nevada: Geol. Soc. America Bull., v. 75, no. 5, p. 424–454.

Kerr, J. W., 1962, Paleozoic sequences and thrust slices of the Seetoya Mountains, Independence Range, Elko County, Nevada: Geol. Soc. America Bull., v. 73, no. 4, p. 439–460.

Kobayashi, Teiichi, Jones, C. R., and Hamada, Takashi, 1964, On the lower Silurian shelly fauna in the Langkawi Islands, northwest Malaya; Contributions to the geology and palaeontology of southeast Asia, XII: Japanese Jour. Geology and Geography, v. 35, no. 1, p. 73–80, 3 pls.

Lenz, A. C., and Churkin, Michael, Jr., 1966, Upper Ordovician trilobites from northern Yukon: Palaeontology, v. 9, pt. 1, p. 39–47.

Lenz, A.C., and Jackson, D. E., 1964, New occurrences of graptolites from the South Nahanni region, Northwest Territories and Yukon: Canadian Petroleum Geology Bull., v. 12, no. 4, p. 892–900.

Muffler, L. J. P., 1967, Stratigraphy of the Keku Islets and neighboring parts of Kuiu and Kupreanof Islands, southeastern Alaska: U.S. Geol. Survey Bull. 1241–C, p. C1–C52.

Nikiforova, D. I., and Obut, A. M., 1965, Stratigrafiya SSSR v chetyrnadtsati tomakh—Silwriyskaya sistema [Stratigraphy of the USSR in 14 volumes—Silurian system]: Moscow, Nedra [publishing organization], 529 p.

Obut, A. M., 1949, Polevoi atlas rukovodyashchikh graptolitov verkhnego silura Kirgizskoi SSR [Field guide to the graptolites characteristic of the Upper Silurian of Kirgiz SSR]: Akad. Nauk SSSR, Kirgiz, Filial, Geol. Inst., Frunze, 59 p., 7 pls.

——— 1959, Zonalnoe raschlenenie Silura v SSSR po graptolitam [Silurian graptolite zones of the USSR]: Sovetskaya Geologiya, no. 2, p. 38–47.

——— 1960, Zonalnoe raschlenenie ordovika v SSSR po graptolitam [Ordovician graptolite zones of the USSR]: Internat. Geol. Cong., 21st, Doklady Sovet. Geol., probl. 7, p. 33–34.

Obut, A. M., and Sobolevskaya, R. F., 1966, Graptolity ranrego Silura v Kazakhstane [Lower Silurian graptolites of Kazakhstan]: Akad. Nauk SSSR, 56 pls., 32 text figs.

Obut, A. M., Sobolevskaya, R. F., and Bondarev, V. E., 1965, Graptolity Silura Taimyra [Silurian graptolites of Taimyr]: Akad. Nauk SSSR, 120 p., 19 pls.

Obut, A. M., Sobolevskaya, R. F., and Nikolaiyev, A. N., 1967, Graptolity i stratigrafiya nizhnego Silura okrainnykh podnyatii kolymskogo massiva (Severovostok SSSR): [Graptolites and stratigraphy of the lower Silurian of the uplifts bordering the Kolyma Massif (Northeast USSR)]: Akad. Nauk SSSR, 162 p., 20 pls.

Packham, G. H., 1962, Some diplograptids from the British lower Silurian: Palaeontology [London], v. 5, pt. 3, p. 498–526, pl. 71–72.

Přibyl, Alois, 1947, Classification of the genus *Climacograptus* Hall, 1865: Internat. Acad. Tchéque d Sci. Bull., v. 48, p. 17–28, pl. 1–2.

——— 1948, Bibliographic index of Bohemian Silurian graptolites: Czechoslovakia, Státní Geol. Ústav, Knihovna, v. 22, 96 p., 1 pl.

Romariz, Carlos, 1962, Graptolitos do Silúrico Português: Lisboa Univ. Fac. Ciênc. Rev., ser. 2, C, v. 10, pt. 2, 305 p., 22 pls.

Ross, C. A., 1962, Early Llandoverian (Silurian) graptolites from the Edgewood Formation, northeastern Illinois: Jour. Paleontology, v. 36, no. 6, p. 1383–1386.

Ruedemann, Rudolf, 1947, Graptolites of North America: Geol. Soc. America Mem. 19, 652 p., 92 pls.

Sherrard, K. M., 1954, The assemblages of graptolites in New South Wales: Royal Soc. New South Wales Jour. and Proc., v. 87, pt. 3, p. 73–101, pl. 10–11.

Stein, Volker, 1964, A section through the Llandovery of N.E. Bavaria, Germany: Geol. Mag. [Great Britain], v. 101, no. 4, p. 322–328.

——— 1965, Stratigraphische und paläontologische Untersuchungen im Silur des Frankenwaldes: Neues Jahrb. Geologie u. Paläontologie Abh., v. 121, p. 111–200, pl. 14–15.

Sudbury, Margaret, 1958, Triangulate monograptids from the *Monograptus gregarius* zone (lower Llandovery) of the Rheidol gorge (Cardiganshire): Royal Soc. London Philos. Trans., ser. B, v. 241, no. 685, p. 485–549, pl. 19–23.

Sun, Y. C., 1933, Ordovician and Silurian graptolites from China: China Geol. Survey, Palaeont. Sinica, ser. B, v. 14, no. 1, 70 p., 7 pls.

Thomas, D. E., 1960, The zonal distribution of Australian graptolites: Royal Soc. New South Wales Jour. and Proc., v. 94, pt. 1, p. 1–40, pl. 1–15.

Thorsteinsson, Raymond, 1958, Cornwallis and Little Cornwallis Islands, District of Franklin, Northwest Territories: Canada Geol. Survey Mem. 294, 134 p., 8 pls.

Toghill, P., 1965, Stratigraphical variations in the lower Silurian of the south of Scotland: Birmingham Univ., England, Ph. D. thesis, 71 p.

Toghill, P., 1968, The graptolite assemblages and zones of the Birkhill Shales (Lower Silurian) at Dobb's Linn.: Palaeontology, v. 11. (In press.)

Törnquist, S. L., 1899, Researches into the Monograptidae of the Scanian *Rastrites*-beds: Lunds Univ. Årsskr., 35, Afd. 2, no. 1, p. 1–26.

Tozer, E. T., and Thorsteinsson, R., 1964, Western Queen Elizabeth Islands, Arctic Archipelago: Canada Geol. Survey Mem. 332, 242 p. [with French abstract and German and Russian summaries].

Waern, Bertil, Thorslund, Per, and Henningsmoen, Gunnar, 1948, Deep boring through Ordovician and Silurian strata at Kinnekulle, Vestergötland: Uppsala Univ., Geol. Inst. Bull., v. 32, p. 337–473, pl. 26.

Walcott, C. D., 1924, Geological formations of Beaverfoot-Brisco-Stanford Range, British Columbia, Canada, No. 1 *of* Cambrian geology and paleontology, v: Smithsonian Misc. Colln., v. 75, no. 1, p. 1–51.

Walker, J. F., 1926, Geology and mineral deposits of Windermere map area, British Columbia: Canada Geol. Survey Mem. 148, 69 p.

Waterlot, Gérard, 1945, Les graptolites du Maroc; premiere partie, Généralités sur les graptolites: Morroco, Serv. Géol., Notes et Mém. 63, 112 p., 70 figs.

Wheeler, J. O., Green, L. H., and Roddick, J. A., 1960a, Geology, Finlayson Lake, Yukon Territory: Canada Geol. Survey Perlim. Ser. Geol. Map 8–1960, scale 1 in. to 4 miles.

——— 1960b, Geology, Quiet Lake, Yukon Territory: Canada Geol. Survey Prelim. Ser. Geol. Map 7–1960, scale 1 in. to 4 miles.

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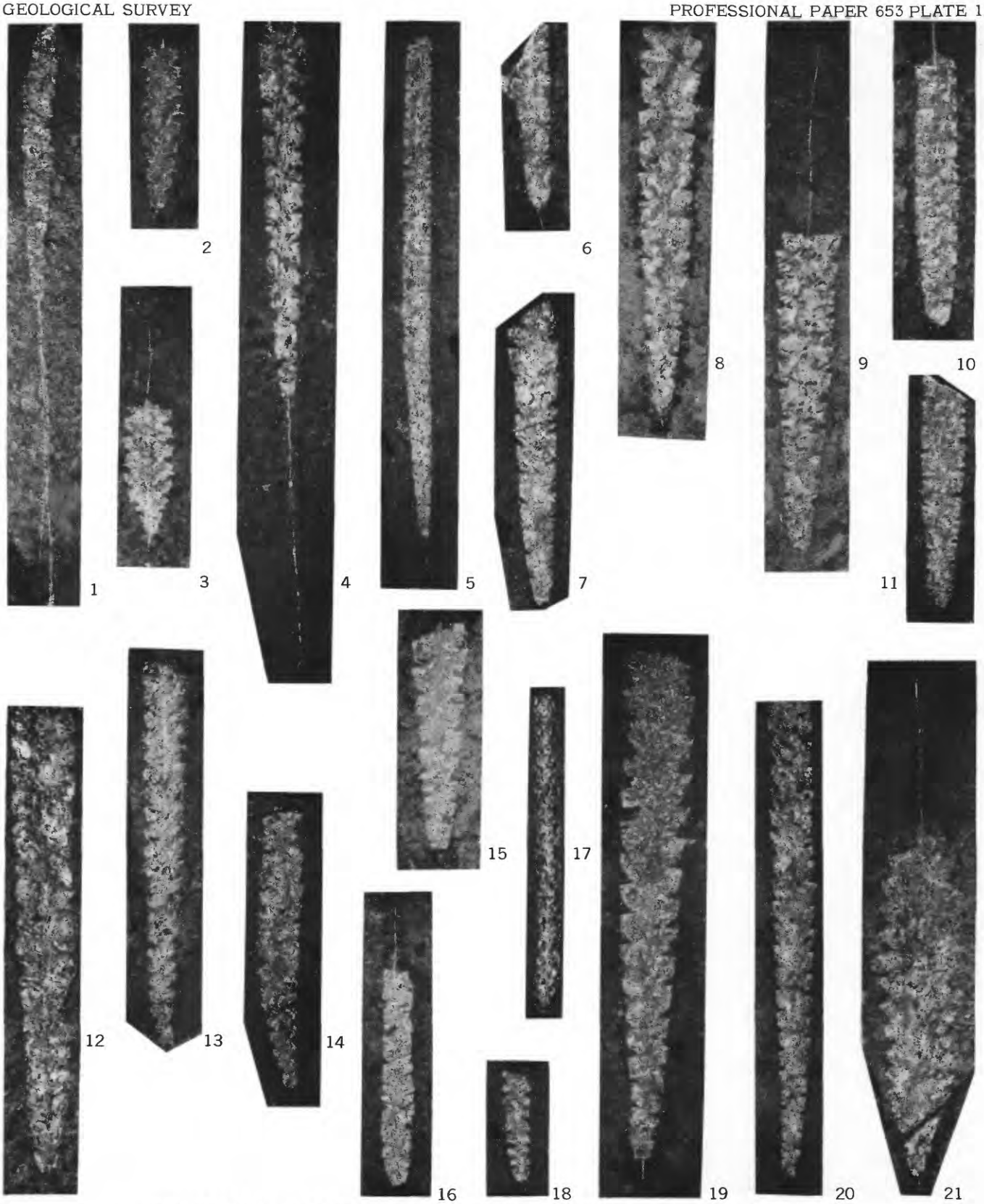

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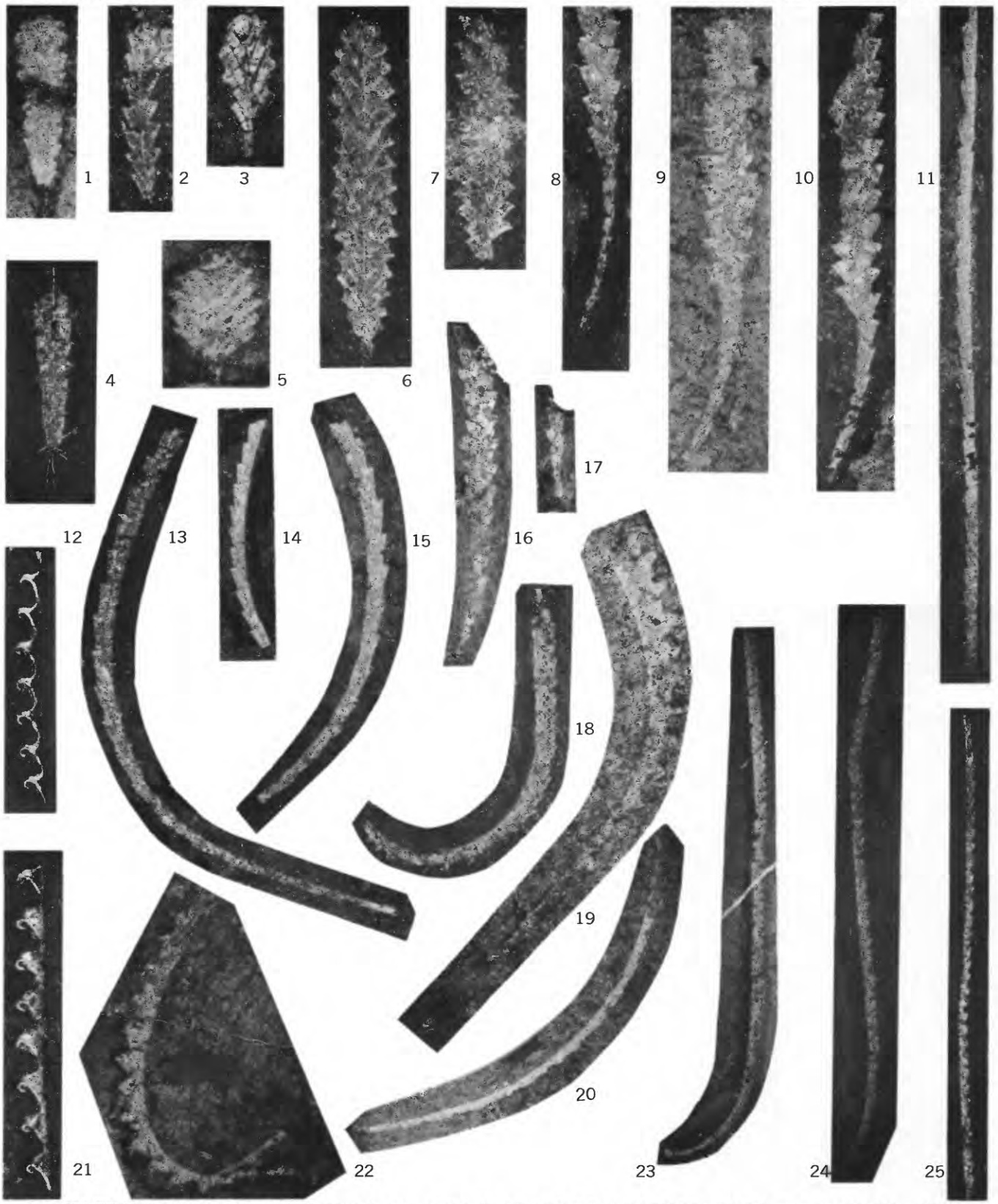

ORTHOGRAPTUS, PETALOGRAPTUS, DIMORPHOGRAPTUS, AKIDOGRAPTUS, and *MONOGRAPTUS*

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MONOGRAPTUS and *RASTRITES*

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