Ordovician Graptolites of the Basin Ranges in California, Nevada Utah, and Idaho

GEOLOGICAL SURVEY BULLETIN 1134

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By REUBEN J. ROSS, JR., *and* WILLIAM B. N. BERRY

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A compilation, with descriptions and illustrations, of the more common species and genera of graptolites in the Great Basin

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ORDOVICIAN GRAPTOLITES OF THE BASIN RANGES IN CALIFORNIA, NEVADA, UTAH, AND IDAHO

By Reuben J. Ross, Jr., and William B. N. Berry

ABSTRACT

In the Basin Ranges, Ordovician graptolites have been found in two contrasting lithic facies; the "western" or eugeosynclinal facies is composed of greenstone, shale, siliceous argillite, chert, and quartzite, whereas the "eastern" or miogeosynclinal facies is composed of limestone, dolomite, silty limestone, calcareous shale, and quartzite. Graptolites are the most common fossils in the eugeosynclinal strata and probably far more abundant in the miogeosynclinal facies than is generally supposed.

The ages of graptolites discovered in both the eugeosynclinal and the miogeosynclinal facies range from Tremadoc to Ashgill; however, only a single collection from the eugeosynclinal facies is referred to the Tremadoc and that tentatively. Not a single collection represents the lowest zone of the Llanvirn (zone of *Didymograptus bifidus* and *D. artus*) in the eugeosynclinal beds although *D. artus* is common in the basal shales of the Swan Peak formation to the east.

The composition of the Great Basin fauna is similar to that from the Marathon region of Texas with which very close correlation has been made. There are marked affinities with the graptolite faunas of Australia.

The 133 species described and (or) illustrated, representing 35 genera, probably represent only a fraction of the total fauna present in the area of California, Nevada, Utah, and Idaho. Future searches are expected to produce a much more complete assemblage.

INTRODUCTION

This report presents a summary of the graptolite faunas of the Basin Ranges as known from the collections of the U.S. Geological Survey and the Departments of Geology of the University of California at Los Angeles and Utah State University. The collections were made in the period 1872–1958, but only a very small number of specimens have been described or illustrated in the 80 or so years elapsed.

Most of the collections were obtained since 1950 by various Survey field parties working in Nevada. Since 1953 the senior author has been responsible for identification and correlation of all Geological Survey graptolite collections from the West, and he has worked

with most of the field parties in obtaining collections. The junior author was recruited to assist in the preparation of this paper because of his experience with graptolite faunas of the Marathon region of Texas and his familiarity with type material from New York and Great Britain. He is responsible for all correlations and zonal ranges of species presented here, and he has reviewed the identification of every graptolite previously reported from the Basin Ranges.

In the main body of the report we have discussed very briefly the present geography of contrasting lithic facies of Ordovician age and the shortcomings of our knowledge about Ordovician paleogeography. All known graptolite localities are then listed, in numerical order. Thereafter we have presented faunal lists for each locality arranged by quadrangle or mining district from south-southwest to north-northeast. Descriptions of genera and species terminate the report.

One hundred and twenty-three species are described and illustrated, 6 are described but not illustrated, and 4 illustrated but not described. These species belong to 35 genera, all but 5 of which are described. In addition a great many more species are doubtfully or indefinitely identified or are represented by too few specimens to warrant description. Two new genera, 8 new species, and 6 new varieties are described. The composition and stratigraphic ranges of the genera and species of the fauna are summarized in tables 1 and 2.

PURPOSE AND SCOPE

One of the purposes of this report is to provide the field man without special training in the study of graptolites a means of roughly identifying them. We hope that he may use it to assist his stratigraphic interpretations in the Great Basin without necessarily becoming involved in phylogeny or taxonomy. Specimens are illustrated as nearly as possible as they appear in the rock; not by retouched photographs or drawings of reconstructions.

Definitive dating of strata by means of graptolites requires the use of assemblages, since single species commonly range through several zones. In addition, the major types of graptolites evolved and became extinct according to a fairly set scheme; with a slight knowledge of generic categories and virtual ignorance of species almost any geologist can make surprisingly accurate guesses at the age of graptolite assemblages.

A second purpose is to acquaint others interested particularly in the distribution of graptolites with the rather large and varied fauna of the Basin Ranges. We are just beginning to learn about this

fauna, despite the early discoveries of G. K. Gilbert (1875, p. 36) and descriptions of C. A. White (1874, p. 13; 1877, p. 62–66).

We have dealt only with collections made through 1958 and have not reported on collections from the northern part of the Toquima Range because that area is to be the subject of reports by Columbia University students under the direction of Professor G. Marshall Kay. Descriptions of species and genera have been kept brief; details of morphology important to those interested primarily in graptolites can be obtained from references listed in synonymies.

We have made no effort to report on Silurian graptolites of the Great Basin, of which there are an increasing number of collections. They must await another report.

METHODS OF PREPARING FOSSILS

Preparation of Great Basin graptolities for study depends on a great variety of conditions of preservation.

Classically, collectors find a likely black shale which is then split methodically to reveal the graptolites entombed therein. The shales of the Phi Kappa formation yield to such treatment as do a few localities of the Vinini formation.

In much of Nevada, argillites do not split readily. Graptolites are most easily found on surfaces of chips and small slabs that have been weathered free naturally. The best time of day for such collecting is when the sun's rays strike the particular slope under scrutiny at a low angle. The collector will have little success if he remains standing. Graptolites may appear brownish against a light background, light colored against a darker background, or as a colorless shiny reflection on any surface.

In the last of these circumstances, in particular, a mold may remain over which latex can be spread to produce a rubber cast of the specimen showing three dimensions to some extent. We have taken advantage of this technique for many of the specimens illustrated in this report.

HISTORY OF PREVIOUS EXPLORATION

The earliest report of graptolites in the Basin Ranges concerned collections made by G. K. Gilbert (1875, p. 36) near Belmont, Nev., and identified by C. A. White (1874, p. 12–14; 1877, p. 62–66). Collections were made sparingly until 1942, when the work of C. W. Merriam and C. A. Anderson demonstrated the importance of graptolites in unraveling the structural complexities of central Nevada; since then they have been collected in greater numbers.

The following annotations will serve as a chronologic outline of the study of graptolites in the Basin Ranges. Detailed references may be found under "References cited" at the end of this report.

1870. Emmons, S. F., p. 334—Mentions slates in the Toyabe Range without indication of fossils or age.

1874. White, C. A., p. 12–14—Describes first new species of graptolites collected in Basin Ranges.

1875. Gilbert, G. K., p. 36—Notes the presence of argillaceous slate with Silurian (now considered Ordovician) fossils near Belmont, Nev. These were the graptolites reported by White in 1874 and 1877.

1877. White, C. A., p. 62–66—Describes and illustrates 4 species of graptolites from Ordovician shales, 5 miles north of Belmont, Nev.

1896. Gurley, R. R., p. 66, 76, 84, 294–301—Describes and tabulates graptolites collected at "Summit," Nev., by C. D. Walcott. This is Garden Pass in the Garden Valley quad. according to modern nomenclature.

1902. Turner, H. W., p. 265–266—Names Palmetto formation in Silver Peak quad. Describes interbedded cherts, slates, and occasional limestones. Age of graptolites from slates identified as "Normanskill" and "Quebec horizon."

1903. Spurr, J. E., p. 95—Notes that shales and slates of the Toyabe Range might be the same as those near Belmont in the Toquima Range. p. 185—Notes Turner's discovery of graptolites in the Silver Peak quad. and presence of "Silurian" rocks, particularly north of Benderes Pass, near Palmetto, and on "Montezuma Ridge."

1906. Spurr, J. E., p. 17–18—Discussses Cambrian and Ordovician rocks of the Silver Peak quad. very briefly; mentions graptolites. Geologic map shows undifferentiated Paleozoic.

1907. Ball, S. H., p. 56–57—Doubt cast on Turner's assignment of rocks in east part of Silver Peak quad. (near Montezuma) to Ordovician.

1909. Turner, H. W., p. 243—In Silver Peak quad., describes thin black, gray, and red slates interbedded with layers of black siliceous argillite and sandstone. These beds highly contorted and faulted. Graptolites north and south of Emigrant Pass.

1909. Ransome, F. L., p. 32—Correlates shales and flinty argillites with Cambrian rocks on basis of lithology by referring to Walcott (1886, p. 30) and Ball (1907, p. 57). No reference is made to Turner's work of 1902.

1918b. Kirk, E. *in* Knopf, A., p. 35–36—In the Inyo Range, speculates on possibility that shaly beds in Badger Flat and at head of Mazourka Canyon might be equivalent to the Palmetto formation, although no fossils had been found.

1924. Ferguson, H. G., p. 21–24—Names and describes Zanzibar limestone and Toquima formation of the Manhattan dist., suggesting that one might be in part the facies equivalent of the other. Lists a large graptolite fauna from slates siliceous argillites.

1928. Ferguson, H. G., p. 127, and fig. 10—Map of Gilbert dist. shows extent of Ordovician slates, cherts, and quartzites. p. 130—Compares slates with those of San Antonio Mts., 24 miles to east, and of Miller Mtn., 24 miles to west.

1930. Umpleby, J. B., Westgate, L. G., and Ross, C. P., p. 18–23—Name and describe the Phi Kappa formation in the Hailey quad., Idaho. This unit corresponds nearly perfectly in lithology and graptolite fauna with the Vinini and Valmy formations of Nevada.

1934. Ross, C. P., p. 942–947—Reviews lithology and graptolite fauna of the Phi Kappa formation, including a lower Ordovician unit originally separated by Umpleby, Westgate, and Ross (1930). Names and describes Ramshorn slate in the Bayhorse quad., Idaho, and lists Ordovician and Silurian graptolites found in it.

P. 952–955—Names and describes Saturday Mountain formation in the Bayhorse quad. Idaho, and lists graptolites from one locality on Bruno Creek. (This locality is believed by the senoir author to represent Phi Kappa formation, possibly in tectonic contact with Ordovician carbonates.)

1935. Clark, T. H., Reports graptolites from the Garden City formation in the Logan quad., Utah.

1937. Ross, C. P., p. 14–17, 18–22, pl. 1—Bayhorse region, Idaho. Describes Ramshorn slate, listing graptolites. Describes Saturday Mountain formation with graptolites listed from Bruno Creek.

1942. Merriam, C. W., and Anderson, C. A., p. 1686—List graptolites from the Hanson Creek formation of Late Ordovician age.

P. 1693–1698—Recognize a major thrust plate emplaced from the west—the Roberts Mtn. thrust. Name and describe the Vinini formation, listing graptolites.

P. 1699–1701—Discuss major facies differences between Ordovician argillites and cherts on the west and limestones and quartzites on the east. Suggest connection between western facies of Nevada and that of central Idaho.

1947. Kay, G. M., p. 1291, fig. 1—Proposes term Fraser eugeosynclinal belt and Millard miogeosynclinal belt to correspond with "western" and "eastern facies" of Merriam and Anderson.

1947. Ruedemann, R., p. 106–111—Reviews knowledge of graptolite faunas in Utah, Nevada, Idaho, and California.

1948. Williams, J. Stewart, p. 1135–1136—Lists graptolites from Garden City formation, Logan quad., Utah.

1949. Ferguson, H. G., and Muller, S. W., pl. 1, fig. 10, p. 50—Ordovician cherts and slates thrust onto Triassic rocks in the Monte Cristo Range.

P. 51—Ordovician cherts and slates present in the San Antonio Mts. Correlation based on lithology.

1949. Ross, R. J., Jr., p. 480—Lists a few graptolites from the Garden City formation, northeastern Utah.

1951. Ferguson, H. G., Muller, S. W., and Roberts, R. J., Winnemucca quad. Name, describe very briefly, and map Ordovician (?) Sonoma Range formation. Ordovician Valmy formation mapped.

1951. Roberts, R. J., Antler Peak quad. Names, describes, and maps Ordovician Valmy formation. Stated to be dated on basis of graptolites. Ordovician Comus formation mapped. Both belong to "western facies."

1951. Ross, R. J., Jr., p. 9, 23, 27, 28—Lists graptolites from the Garden City formation in vicinity of Logan, Utah. (These have been reexamined and correctly identified for the present paper; listed below).

1952. Ferguson, H. G., Roberts, R. J., and Muller, S. W., Golconda quad. Name, describe, and map Ordovician Comus formation of "western facies." Dated by graptolites. Also mapped Valmy formation.

1953. Ferguson, H. G., Muller, S. W., and Cathcart, S. H., Coaldale quad. Palmetto formation extended to this area. Mention no fossils.

1954. Ferguson, H. G., Muller, S. W., and Cathcart, S. H., Mina quad. Palmetto formation mapped on Miller Mtn. No fossils.

1954. Ferguson, H. G., and Cathcart, S. H., Round Mountain quad. Map includes Manhattan dist. and southern Toyabe Range. Extend Ordovician Palmetto formation to Toyabe Range; in Manhattan dist. Palmetto formation includes Zanzibar, Mayflower, and Toquima formations of Ferguson (1924). Ample graptolites known in Manhattan dist.

1954. Rinehart, C. D., and Ross, D. C. p. 1297 [abs.]—Report Ordovician argillites bearing graptolites in eastern Sierra Nevada.

1955. Kay, G. M., p. 1582 [abs.]—Northern Toquima range. Toquima formation with abundant graptolites, folded prior to Pennsylvanian deposition. "Western facies" in thrust contact with Ordovician Pogonip group of "eastern facies." Several different Ordovician sequences separated by faults.

1956. Nolan, T. B., Merriam, C. W., and Williams, J. Steele, p. 23—General discussion of Ordovician stratigraphy in vicinity of Eureka, Nev.
P. 32–33—Review Hanson Creek formation and graptolites found in it.
P. 34–36—Review of "western facies" and graptolite-bearing Vinini formation.

1958. Rigby, J. K., Describes and illustrates graptolites obtained from the Garden City formation and Pogonip group in western Utah.

1958. Roberts, R. J., Hotz, P. E., Gilluly, J., and Ferguson, H. G., p. 2830–2833—Discuss relation of Ordovician rocks of "eastern" and "western facies" and show distribution.

1959. Rinehart, C. D., Ross, D. C., and Huber, N. K., p. 941–946—Measure section, map, and describe Ordovician and other Paleozoic units found in roof pendants of the Sierra Nevada batholith. Graptolites present in argillites. Located near Convict Lake in Mt. Morrison quad., California. (This is the most southwesterly known occurrence of the "western facies" of the Ordovician.)

1959. Lovejoy, D. W., Discusses "eastern" and "western facies" of Ordovician on Nannies Peak, Lone Mtn., Elko County, Nev. The cherts and slates bearing graptolites are thrust over "eastern facies." Details of structure not mapped; therefore thickness not certain.

1959. Bick, K. F., p. 1067–1068—Reports *Phyllograptus loringi* and *Phyllograptus* sp. 150 ft below top of Chokecherry dolomite in Deep Creek Range.

Current—To these may be added the current work of several U.S. Geological Survey parties and University geology departments in Nevada and Idaho. It is assumed that the results of their labors will be forthcoming shortly. Many of the collections covered in this report were made by or in cooperation with such parties.

ACKNOWLEDGMENTS

So many people have assisted in the preparation of this report that with difficulty we select those mentioned below for particular thanks, without intending any slight to others.

All type specimens of graptolites from the Basin Ranges in the collections of the U.S. National Museum were made available by G. A. Cooper. Several unusual specimens from the Garden City formation, including a new species of *Clonograptus*, were lent us by Dean J. Stewart Williams, of Utah State University. Prof. C. A. Nelson, of the University of California at Los Angeles, made available collections from the Mineral Hill quadrangle, Nevada. Prof. G. Marshall Kay, Columbia University, provided regional information and a guided tour of his students' thesis areas in the Toquima Range and in the area north of Elko, Nev. Dr. H. O. Fletcher, of the Australian Museum, provided us with photographs of the type specimens of *Climacograptus hastatus* T. S. Hall.

Much of this report is based on collections made by Survey field parties since 1950. In addition to making routine collections in the course of field investigations several persons have assisted us in obtaining additional material, have furnished us with special data, and have discussed special stratigraphic problems with us; they include James Gilluly, R. J. Roberts, Harold Masursky, P. E. Hotz, Jr., P. E. Cloud, Jr., J. F. Smith, K. B. Ketner, T. B. Nolan, C. W. Merriam, and M. R. Mudge. In addition to the technique of photographing graptolites by immersion in glycerine, D. G. Griggs perfected the photography of black latex peels to produce many of the illustrations presented.

STRATIGRAPHIC AND STRUCTURAL SETTING

GEOGRAPHY OF "EASTERN" AND "WESTERN FACIES" NEVADA AND CALIFORNIA

"West of the 117th meridian the Middle Ordovician is represented predominantly by graptolite shales with minor amounts of sandstones, limestones, and calcareous shaly beds," write Kirk (1933, p. 29). His important observation is equally true of much of the Lower Ordovician and of the Upper Ordovician, although the line separating the graptolite-rich beds from the Ordovician carbonates and quartzites to the east is far from straight and only approximates the 117th meridian in a general way.

As a result of Merriam's and Anderson's (1942) account of the geology in the vicinity of the Roberts Mountains, Nev., geologists realized that two very distinct facies of the Ordovician were separated

from each other over much of Nevada by a zone of thrust faults. Ordovician shales, cherts, quartzites, and greenstones such as those of the Vinini formation (Merriam and Anderson, 1942, p. 1693–1698) had been moved eastward over Paleozoic rocks including Ordovician limestones, quartzites, and dolomites.

To the cherty and argillaceous sequence Merriam and Anderson (1942, p. 1699–1701) gave the name "western facies," calling attention to the similar deposits described by Turner, Emmons, Spurr, and Ferguson as noted. The area occupied by this sequence has also been termed the Fraser eugeosynclinal belt by Kay (1947, p. 1291, fig. 1), as opposed to the Millard miogeosynclinal belt, or "eastern facies" of Merriam and Anderson. They have suggested (p. 1701) that the "western facies" extended through central Idaho into British Columbia.

Roberts and others (1958) have given a comprehensive summary of the Paleozoic stratigraphy north of the 39th parallel covering facies changes and structural interpretations. They have indicated the great extent of a major thrust zone separating "eastern" from "western facies" in an area from the vicinity of Eureka, Nev., north to Idaho.

Southward, Kay and numerous students under his supervision (oral communication, August 1958) demonstrate that a graptolite-bearing chert and argillite sequence overrides the Pogonip group near Ikes Canyon in the Toquima Range. Similarly, Kay (1955, p. 15; oral communication, Aug. 18–20, 1958) has shown in the area at and south of Ikes Canyon that the Ordovician is present in several different major thrust slices; within each slice the Ordovician sequence is different, with an orderly change taking place from one to the next. This change in sequence suggests that the modern Toquima Range may be close to the zone of intergradation between "eastern" and "western facies." At the south end of the range Ferguson (1924, p. 21) noted in the Manhattan district that the Ordovician Zanzibar limestone grades laterally into calcareous slate and then into fissile black fine-grained slate. In the Osgood Mountains quadrangle, more than 100 miles to the north, Hotz and Willden (1955, p. 1652) claim that a transitional sequence of Ordovician rocks is composed of a mixture of cherts, shales, greenstones, dolomites, and limestones. On this basis, Roberts and others (1958, p. 2831, fig. 4) postulate a transition area extending north-northeast to south-southwest west of the Mount Lewis quadrangle. No other concrete evidence for intergrading facies has been reported.

South and southwest of the Manhattan district, the relations between the two facies are unknown. "Western facies" Ordovician rocks

are reported in the San Antonio Mountains, north of Tonopah, Nev. (Ferguson and Muller, 1949, pl. 1), and in the Silver Peak quadrangle (Palmetto formation, Turner, 1902, p. 265–266; 1906, p. 17–18). There is some possibility that the cherts and argillites assigned to the Cambrian in the Goldfield district (Ransome, 1909, p. 32) are partly of Ordovician age. Further to the west in the Mount Morrison quadrangle graptolite-bearing argillites are present (Rinehart, Ross, and Huber, 1959).

Southward from the Roberts Mountains area, "eastern facies" limestones, dolomites, and quartzites of the Pogonip group and the Eureka and Ely Springs (Hanson Creek) formations are known in the north end of the Monitor Range, at Tybo (Ferguson, 1933), in the Bare Mountain quadrangle (Cornwall and Kleinhampl, 1960), in the Ubehebe Peak quadrangle (McAllister, 1956), and in the Inyo Range (Kirk, 1918b).

The boundary between the two facies must lie between these two series of localities. Its speculative position is crudely indicated in plate 14. Further investigations are needed in a tract along this speculative boundary to determine facies interrelation. Such investigations should not be limited to southwestern Nevada.

IDAHO

To the north, in central Idaho, graptolite-bearing cherts, siliceous argillites, slaty shales, and quartzites of the Phi Kappa formation are in thrust contact with other rocks (Umpleby, Westgate, and Ross, 1930, pl. 1).

In the Bayhorse quadrangle, the Saturday Mountain formation along Squaw and Bruno Creeks is a structurally complex mixture of dolomite (from which all of the brachiopod fauna has come), cherts, and slaty shales, bearing graptolites. As the senior author has indicated (Ross, R. J., 1959, p. 444), the slaty shales and dolomites may have been juxtaposed tectonically; a few miles away in sections 4, 9, 16, T. 12 N., R. 19 E., the Saturday Mountain formation is composed only of dolomites which are practically indistinguishable from typical Fish Haven dolomites.

In addition to their importance in "western facies" rocks, graptolites may play an increasingly important role in "eastern facies" stratigraphy. Little attention has been given them in the Garden City and Pogonip units where they occur sparingly in calcareous siltstones.

ALASKA AND WESTERN CANADA

Although not covered in this report graptolites have been known for many years north and west of the areas here discussed. In

eastern Washington they occur in the Ledbetter slate (Park and Cannon, 1943, p. 19–22; McLaughlin and Simons, 1951, p. 514–515), a formation lithicly similar to the "western facies" of Nevada. In southern Alaska the graptolite-bearing strata are argillites and cherts associated with greenstones (Kirk, 1918a, p. 143–144; Buddington and Chapin, 1929, p. 74–77), truly a "western facies" assemblage. Although USGS collections from both of these areas are at hand their study at this time is limited to the determination that Early, Middle, and Late Ordovician graptolites are present.

In western Canada, Ordovician sections typical of the "western," "eastern," and mixed facies have been described, along with listings of graptolite fauna, from the vicinity of Banff north to MacKenzie Bay (Lapworth, 1887, p. 320; Walcott, 1924 p. 33–34; Clark, 1926, p. 136–137; Walker, 1926, p. 25–31; Cairnes, 1914, p. 65–66 and table facing p. 38; Cockfield, 1925, p. 7A; Decker and others, 1947, p. 149–158; Decker, 1950, p. 2223–2224, Martin, 1959, p. 2411–2413). The Ordovician system has not been described in sufficient detail in this vast area to ascertain how much it may have in common with correlative rocks in the Western United States. Kay (1947, 1951) has, among others, suggested that the Cordilleran geosyncline of that time curved to include westernmost Canada and Southern Alaska.

Ruedemann (1934, p. 14, fig. 3) shows the positions of North American Paleozoic geosynclines in which graptolite-bearing rocks are known. The graptolite beds of Prince of Wales Island in the southern Alaskan panhandle he excludes from the main Cordilleran trough. In this regard we would disagree, believing that the southern Alaskan rocks may have been continuous with those of western Nevada in Ordovician time.

PALEOGEOGRAPHY

As indicated above, Ordovician graptolites occur in the Great Basin in two contrasting lithofacies. They are most common in a "western" assemblage of rocks composed of argillites, siliceous argillites, cherts, shales, quartzites, and greenstones. Although there are many areas about which little is known, we consider it possible that this assemblage was deposited along a continuous belt from the vicinity of Mount Morrison, Calif., on the south through the Bayhorse area, Idaho, and stretching northwestward through eastern Washington into western Canada and southern Alaska.

Miogeosynclinal deposits of limestone, dolomite, sandstone, and calcareous mudstone were formed to the east of this silica-rich belt. The few occurrences of graptolites in this "eastern facies" corroborate the correlation of two very different rock types, as indicated in table 1.

If these two sets of deposits were formed in a single trough as is commonly believed, they should intergrade horizontally for thousands of miles along the site of the Ordovician geosyncline. In Nevada such intergradation has been suggested only in the Toquima Range and in the Osgood Mountains, as noted above. In Idaho the type area of the Saturday Mountain formation (Ross, C.P., 1934, p. 952–956, 1937, p. 18–22) along Squaw Creek may represent an area of interbedding of argillaceous and calcareous deposits, as C. P. Ross's discussion suggests. However, the senior author has examined the area briefly and believes that detailed mapping will reveal complex structures that may have caused the juxtaposition of different rock types.

Incontrovertible evidence for the intergradation of the "eastern" and "western facies" remains undiscovered in the United States. Although such intergradation probably took place, most of the evidence may have been buried by thrust faulting. But it is also possible that the two facies were deposited in discrete basins and brought into juxtaposition only by later tectonic activity. In determining the Ordovician paleogeography of the Great Basin both possibilities must be considered.

In British Columbia, the graptolite-bearing Glenogle shale in the Windermere map area (Walker, 1926, p. 22–34) and in the Brisco-Dogtooth map area (Evans, 1933, p. 126A–135A) is reported to be interbedded with carbonates and quartzites. The region north and north-northwestward from those areas may represent the zone of intergradation between the two facies. Intergradation may explain the discontinous nature of outcrop of the Glenogle shale (Walker, 1926, geol. map.; Evans, 1933, geol. map). A fuller understanding of Canadian Ordovician stratigraphy should aid our understanding of paleography of correlative rocks in the Great Basin.

Careful studies of sedimentary structures may assist in determining source areas for the sediments of both facies. In addition, the relation, if any, between the abundant quartzites of the Phi Kappa, Valmy, and Vinini formations and those of the Eureka, Swan Peak, and Kinnikinic formations in the United States and the Wonah quartzite in Canada requires consideration. Did these have a common source? What currents of water or air gave them their present distribution?

Thus, although two distinct rock successions of Ordovician age can be delimited, with the "western" the more siliceous and the "eastern" the more carbonate rich, the nature of their depositional sites is still a matter of conjecture. Further research is needed to obtain a full comprehension of the size, shape, and orientation of the seaways, the chemistry of the water in which thousands of feet of cherts and siliceous argillites were deposited, and the kinds of life they supported.

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BIOSTRATIGRAPHIC DATA

ORDOVICIAN LOCALITIES, LISTED NUMERICALLY

The following list gives locality data for all collections mentioned in the systematic descriptions, correlation chart, and illustrations. Although similar information is given in the faunal lists, arranged geographically, collections are here arranged in numerical order.

Numbers with suffix (OS) refer to old series numbers used in a catalog of collections established by Walcott and used by Walcott, Resser, Ulrich and others until 1940. Numbers with the suffix (CO) refer to a catalog established after 1940 by Josiah Bridge for Cambrian and Ordovician collections. The suffix (SD) refers to a catalog established by Edwin Kirk and used mostly for Silurian and Devonian collections; however, Kirk's catalog includes many Ordovician collections.

Numbers without prefix are assigned to collections in Washington, D.C.; those with prefix D are assigned to collections in Denver.

In addition to the U.S. Geological Survey collections, several collections of the Department of Geology of the University of California at Los Angeles are included. We have prefixed these numbers with UCLA for purposes of this report. Two specimens from the collections of Utah State University are shown on plate 2, figures 2, 8.

A few very old collections from the Belmont district were never assigned collection numbers.

USGS collection

222 (OS). "Summit," Nev. From Garden Pass, T. 22 and 23 N., R. 52 E., Garden Valley quad., Nevada.

444z (OS). From the general vicinity of Mt. Moriah, 1½ miles west of Manhattan. Manhattan dist., Nevada.

1072 (CO). Barite quarry, east edge NW¼SE¼ sec. 12, T. 37 N., R. 41 E., Osgood Mtn. quad., Nevada.

1292 (CO). Valmy formation. South side of North Fork of Trout Creek at range front, SW¼ sec. 6, T. 32 N., R. 42 E., Antler Peak quad., Nevada.

1293 (CO). Valmy formation. NE¼ sec. 8, T. 32 N., R. 43 E., Antler Peak quad., Nevada.

1373 (CO). Below crest of ridge in southeast part of SE¼SE¼ sec. 30, T. 39 N., R. 42 E., Osgood Mts. quad., Nevada.

1949 (CO). Valmy formation? On ridge at alt of 8,250 ft., SW¼ sec. 3, T. 32 N., R. 43 E., Antler Peak quad., Nevada.

1950 (CO). SE¼ sec. 3, T. 32 N., R. 43 E., Antler Peak quad., Nevada.

1952 (CO). Valmy formation. NE¼ sec. 20, T. 32 N., R. 43 E., alt 6,850 ft. northeast side of Cottonwood Creek about 200 ft above road. Antler Peak quad., Nevada.

1953 (CO). Valmy formation. SW¼ sec. 21, T. 32 N., R. 43 E., alt 7,050 ft on knoll south of road. Antler Peak quad., Nevada.

308 (SD). 600 ft west-southwest of Monument 189 on Mt. Moriah, approximately 9,000 ft west of Manhattan. Manhattan dist., Nevada.

311 (SD). 200 ft northwest of the summit of hill 6735 in northern part of Palo Alto Hill, about 3 miles west-northwest of Manhattan. Manhattan dist., Nevada.

315 (SD). 750 ft south of Palo Alto well and about 3,000 ft west of Palo Alto Hill. Manhattan dist., Nevada.

316 (SD). Approximately 2,800 ft northeast of the settlement of Central, and west of Black Mammoth Hill, 400 ft west-northwest of top of hill 7077. Manhattan dist., Nevada.

320 (SD). Near top of hill 7077, west of Black Mammoth Hill. Manhattan dist., Nevada.

325 (SD). Exact locality data not known. Manhattan dist., Nevada.

328 (SD). 500 ft west of Monument 189 on Mt. Moriah, approximately 9,000 ft west of Manhattan. Manhattan dist., Nevada.

335 (SD). Vicinity of Salisbury Peak, Manhattan dist., Nevada.

336 (SD). Located north of Belmont Road, 2,000 ft southeast from East Manhattan, from breccia exposed beneath Tertiary rhyolite. Possibly an old talus slope. Manhattan dist., Nevada.

1367 (SD). From along Trail Creek road between Ketchum and Chilly, about 1.5 miles south of pass over Sawtooth Range, Hailey quad., Idaho.

1368 (SD). "On the west bank of Trail Creek, about a mile south of the point where the creek swings abruptly west." This is at the mouth of the fifth tributary from the west, north of lat 43°50′. Hailey quad., Idaho.

1370 (SD). From near the head of Fall Creek, approximately 3 miles due north of the mouth of Park Creek (designated Basin Creek on 30 min Hailey quad. map), north of divide between Trail Creek and Summit Creek, Blaine County, Idaho. Hailey quad., Idaho.

2347 (SD). Palmetto formation, Pablo Canyon, east side of Toyabe Range, T. 10 N., R. 42 E., Round Mtn. quad., Nevada.

2349 (SD). Vinini formation, east of small hill 2 miles west of Mt. Hope, Garden Valley quad., Nevada.

2352 (SD). This collection was made by Edwin Kirk "about 1 mile west of the Weepah Road along south front of range." This information indicates that the collection was made somewhere in the northeast part of the Silver Peak quad., Nevada.

2353 (SD). "Summit," Nev. (Garden Pass, sec. 31, T. 23 N., R. 51 E., Garden Valley quad., Nevada.)

2519 (SD). NW¼NW¼SE¼NE¼ sec. 8, T. 11 N., R. 17 E., northwest of the junction of Squaw and Bruno Creeks, Bayhorse quad., Idaho.

D93 (CO). Southwest of Altenburg Hill, alt 5,720 ft, Nevada footage coordinates, central zone, 489,000 E., 2,019,080 N., Crescent Valley quad., Nevada.

D95 (CO). Peak 7,297 ft, 1 mile northwest of cabin in Corral Canyon. Nevada footage coordinates, 483,000 E., 2,069,450 N., Crescent Valley quad., Nevada.

D96 (CO). 1 mile west of Lander (site), near turn off to King Gulch barite mine, alt 5,600 ft. Nevada footage coordinates, central zone, 481,650 E., 2,029,250 N., Crescent Valley quad., Nevada.

D97 (CO). On round-topped hill about 2,000 ft due south of Lander (site), alt 6,080 ft. Nevada footage coordinates, 488,200 E., 2,029,650 N., Crescent Valley quad., Nevada.

D98 (CO). Alt 6,000 ft. On spur northeast of mouth of Mule Canyon, Cortez Range. Nevada footage coordinates 543,500 E., 2,008,450 N., Crescent Valley quad., Nevada.

D102 (CO). West of Gold Acres, alt 6,200 ft. Nevada footage coordinates, central zone, 467,175 E., 2,008,750 N., Mt. Lewis quad., Nevada.

D103 (CO). South of Gray Eagle mine, in cherty black shale associated with quartzite, alt 6,860 ft. Nevada footage coordinates, 474,300 E., 2,044,550 N., Mt. Lewis quad., Nevada.

D104 (CO). Gray shale associated with tuff and quartzite, 1,000 ft north of Indian Creek and about 1 mile west of Lander. Nevada footage coordinates, central zone, 484,000 E., 2,032,250 N., Crescent Valley quad., Nevada.

D106 (CO). Southwest of Altenburg Hill, alt 5,640 ft. Nevada footage coordinates, central zone, 489,200 E., 2,016,800 N., Crescent Valley quad., Nevada.

D107 (CO). West side of quartzite ridge in valley, due north of Gold Acres, alt 5,740 ft. Nevada footage coordinates, 481,300 E., 2,018,750 N., Crescent Valley quad., Nevada.

D110 (CO). Alt 6,500 ft. West of center sec. 21, T. 29 N., R. 46 E., Mt. Lewis quad., Nevada.

D111 (CO). NW. Cor., sec. 34, T. 29 N., R. 46 E., Mt. Lewis quad., Nevada.

D112 (CO). Alt 8,200 ft. South fork, Cook Creek divide, east of Mill Creek summit, NE¼ sec. 14, T. 28 N., R. 45 E., Mt. Lewis quad., Nevada.

D113 (CO). Alt 5,860 ft. 1,500 ft north from BM 5584 at junction of Ferris and Indian Creeks, Mt. Lewis quad., Nevada.

D114 (CO). South of Ferris Creek junction with Indian Creek, east of center of sec. 2, T. 28 N., R. 46 E., Mt. Lewis quad., Nevada.

D115 (CO). West head of Lewis Canyon, extreme south center of sec. 35, T. 30 N., R. 45 E. Mt. Lewis quad., Nevada.

D116 (CO). Above road in Lewis Canyon, NW¼NW¼SE¼ sec. 23, T. 30 N., R. 45 E., Mt. Lewis quad., Nevada.

D117 (CO). 600 ft east of SW. Cor. sec. 23, T. 29 N., R. 46 E., Mt. Lewis quad, Nevada.

D118 (CO). Alt 6,080 ft. On spur southwest of BM 5740 on road 2 miles southeast of Utah mine camp, Mt. Lewis quad., Nevada.

D119 (CO). Alt 6,480 ft, near barite mine, center sec. 28, T. 28 N., R. 45 E., Mt. Lewis quad., Nevada.

D120 (CO). Alt 7,080 ft. North side of Horse Canyon, NE¼ sec. 4, T. 29 N., R. 45 E., Mt. Lewis quad., Nevada.

D121 (CO). Alt 6,480 ft, 1½ miles east-southeast of Utah mine camp, on southeast spur of hill 6838, Mt. Lewis quad., Nevada.

D122 (CO). Alt 7,680 ft north side of Crippen Canyon, SE¼NW¼ sec. 9, T. 29 N., R. 45 E. Nevada footage coordinates, 429,250 E., 2,057,100 N., Mt. Lewis quad., Nevada.

D123 (CO). Alt 6,160 ft on northeast spur of hill 6821, 3,500 ft west-southwest of BM 5740 on road southeast of Utah mine, Mt. Lewis quad., Nevada.

D124 (CO). Alt 7,100 ft, south side of middle fork, Mill Creek, northeast edge of sec. 10, T. 28 N., R. 45 E., Mt. Lewis quad., Nevada.

D125 (CO). Alt 6,200 ft. On spur west of border of sec. 27, T. 29 N., R. 46 E., Mt. Lewis quad., Nevada.

D127 (CO). 800 ft south, 3,600 ft west of NE. cor. of sec. 31, T. 28 N., R. 46 E., Mt. Lewis quad., Nevada.

D128 (CO). Alt 8,200 ft, north of head of south fork, of Mill Creek, NW¼ sec. 12, T. 28 N., R. 45 E., Mt. Lewis quad., Nevada.

D129 (CO). Alt 8,600 ft, middle fork of Ferris Creek divide, SE¼ sec. 1, T. 28 N., R. 45 E., Mt. Lewis quad., Nevada.

D130 (CO). Alt 7,320 ft, divide between middle and south forks of Mill Creek, NE¼ sec. 10, T. 28 N., R. 45 E., Mt. Lewis quad., Nevada.

D131 (CO). Alt 8,260 ft. NW¼ sec. 6, T. 28 N., R. 46 E., Mt. Lewis quad., Nevada.

D135 (CO). Mill Creek, 1,600 ft. north, 100 ft. west of SE. cor. sec. 31, T. 29 N., R. 45 E., Mt. Lewis quad., Nevada.

D137 (CO). Gray shales on ridge south of road on west side of Emigrant Pass, alt. 6,400 ft., about 1 mile south-southeast of Emigrant Pass summit. T. 1 N., R. 37 E., Silver Peak quad, Nevada.

D149 (CO). NW¼ sec. 9, T. 24 N., R. 49 E., alt. 6,600 ft. On northwest side of valley at upper spring. Simpson Park Range. Roberts Creek Mtn. quad., Nevada.

D150 (CO). Alt 7,400 ft. Nevada footage coordinates, east zone, 268,000 E., 1,997,000 N., Horse Creek Valley quad., Nevada.

D157 (CO). Alt 6,780 ft. Nevada footage coordinates, east zone, 264,800 E., 1,998,100 N. At head of north fork of Brock Canyon, Horse Creek Valley quad., Nevada.

D158 (CO). Approximately 11.5 miles northwest of Carlin, Nev. Sec. 26, T. 34 N., R. 50 E., Tuscarora Mts. No quad. surveyed.

D159 (CO). Near the head of James Creek, 1½ miles west-southwest from point lat 40°45′ N., long 116°15′ W., NW¼NW¼ sec. 17, T. 33 N., R. 51 E., Beowawe quad., Nevada.

D160 (CO). Center sec. 21, T. 33 N., R. 51 E., half a mile northwest of Cherry Spring at alt. 6,600 ft., Carlin quad.

D161 (CO). At crest of range, a quarter of a mile north of saddle, SE¼SW¼ sec. 20, T. 33 N., R. 51 E., Beowawe quad., Nevada.

D162 (CO). Near head of Marys Creek, one-third of a mile east of creek, N½NW¼NE¼ sec. 25, T. 33 N., R. 50 E., Beowawe quad., Nevada.

D163 (CO). On Marys Creek, half a mile southwest of D162 (CO), highest collection of Vinini. S½NW¼NW¼ sec. 25, T. 33 N., R. 50 E., Beowawe quad., Nevada.

D164 (CO). Center, T. 34 N., R. 50 E., Tuscarora Mts. No quadrangle surveyed.

D165 (CO). Sec. 18, T. 35 N., R. 51 E., Tuscarora Mts. No quadrangle surveyed.

D166 (CO). Sec. 12, T. 35 N., R. 50 E., Tuscarora Mts. No quadrangle surveyed.

D204 (CO). Southwest side of top of Gold Mine Hill, northeast of Round Hill. NE¼NE¼SW½SE¼ sec. 10, T. 9 N., R. 1 W., Mt. Pisgah quad., 1:24,000, Utah (loc. 13, Ross, 1951, p. 22–23). Basil shales of Swan Peak formulation 15 ft below quartzite.

D206 (CO) and D206a (CO). Twin Bridges dugway, north end, southwest side of U.S. Highway. SE¼NE¼NE¼ sec. 33, T. 13 N., R. 3 E., Logan quad, Utah. Garden City formation.

D227 (CO). East side of Hilyards Canyon, 1.8 miles north of head of canyon. SE¼ sec. 17, T. 15 S., R. 41 E., Preston quad., Idaho (same as loc. 5, Ross 1951, p. 14). Garden City formation.

D229 (CO) and D230 (CO). East side of Hilyards Canyon, about 300 yds south of D227 (CO) and 150 ft lower in alt. In a separate fault slice. Garden City formation.

D247 (CO). From float on lower 30 ft of slope masking the Hanson Creek formation. NE¼ sec. 36, T. 16 N., R. 49 E., Horse Heaven Mtn. quad., Nevada.

D317h (CO). Approximately 1 mile north of Tooele-Juab County boundary, for half a mile running east from peak 6342. Utah footage coordinates, central zone, 1,559,150 E., 581,750 N., Dugway Range quad., 1:62,500, Tooele County, Utah.

D342 (CO). From float on lower 50 ft of slope masking the Hanson Creek formation. NE¼ sec. 36, T. 16 N., R. 49 E., Horse Heaven Mtn. quad., Nevada.

D359 (CO). North side of Willow Creek. Center E½SE¼NW¼ sec. 36, T. 29 N., R. 52 E., Pine Valley quad., Nevada.

D359a (CO). At easternmost colln. of D359.

D359b (CO). 75 ft west of D359a (CO).

D359c (CO). 200 ft west of D359b (CO).

D360 (CO). Sec. 1, T. 27 N., R. 52 E., Sulfur Springs Range, Pine Valley quad., Nevada.

D389 (CO). Valmy and Vinini formation, sec. 36, T. 28 N., R. 52 E. in saddle south of highest knob, Pine Valley quad., Nevada.

D392 (CO). Vinini formation. Alt. 7,650 ft, 200 ft north, 400 ft west of NE. cor. sec. 3, T. 26 N., R. 48 E. Nevada footage coordinates, central zone, 534,250 E., 1,969,750 N., Cortez quad., Nevada.

D393 (CO). Vinini formation. Alt. 6,000 ft. 1,700 ft. north, 4,400 ft. east of SW. cor., sec. 33, T. 26 N., R. 48 E., Nevada footage coordinates, central zone, 528,800 E., 1,939,500 N., Cortez quad., Nevada.

D394 (CO). Vinini formation. Alt. 6,325 ft. 700 ft. north, 3,400 ft. east, SW. cor., sec. 28, T. 26 N., R. 48 E., Nevada footage coordinates, central zone, 527,600 E., 1,943,900 N., Cortez quad., Nevada.

D395 (CO). Vinini formation. Alt. 5,625 ft. 2,700 ft. north, 7,200 ft. west of SE. cor., T. 27 N., R. 47 E., Nevada footage coordinates, 507,000 E., 1,972,300 N., Cortez quad., Nevada.

D434 (CO). South side of North Fork of Trout Creek at Range Front. SW¼ sec. 6, T. 32 N., R. 42 E., Antler Peak quad., Nevada.

D442 (CO). Valmy and Vinini formations. Northeast "corner" of draw on north side of Willow Creek. Center SE¼NW¼ sec. 36, T. 29 N., R. 52 E., Pine Valley quad., Nevada.

D442a (CO). Valmy and Vinini formations. 15 ft. west of coll. D442, Pine Valley quad., Nevada.

D442b (CO). Valmy and Vinini formations. 15 ft. west of coll. D442a, Pine Valley quad., Nevada.

D442c (CO). Valmy and Vinini formations. 15 ft. west of D442b, Pine Valley quad., Nevada.

D442d (CO). Valmy and Vinini formations. Most westerly 20 ft. along north side of gully to its northwest "corner." Otherwise same as D442, Pine Valley quad., Nevada.

D442e (CO). Valmy and Vinini formations. About 25 ft. west of D442d, Pine Valley quad., Nevada.

D442f (CO). Valmy and Vinini formations. About 30 ft. southwest of D442e, Pine Valley quad., Nevada.

D442g (CO). Valmy and Vinini formations. About 60 ft. southwest of coll. D442f, Pine Valley quad., Nevada.

D442h (CO). Valmy and Vinini formations. About 50 ft. west of D442g, Pine Valley quad., Nevada.

D442i (CO). Valmy and Vinini formations. On southwest-facing shoulder of next draw to west. About 200 ft. west of D442h, Pine Valley quad., Nevada.

D443 (CO). Valmy and Vinini formations. NE¼NE¼SE¼SE¼NW¼ sec. 1, T. 27 N., R. 52 E., Pine Valley quad., Nevada.

D444 (CO). Valmy formation. SW¼SE¼NW¼NE¼ sec. 22, T. 25 N., R. 47 E., alt. 6,525 ft., Cortez quad., Nevada.

D445 (CO). Valmy formation. Center S½NW¼NW¼NE¼ sec. 22, T. 25 N., R. 47 E., Cortez quad., Nevada.

D446 (CO). Valmy formation. Center of west boundary of NW¼NW¼NE¼, sec. 22, T. 25 N., R. 47 E. Alt 6,650 ft, Cortez quad., Nevada.

D447 (CO). Valmy formation. In small saddle at alt 6,725 ft on boundary between NE¼ and SE¼ of SW¼SW¼, sec. 15 T. 25 N., R. 47 E., Cortez quad., Nevada.

D453 (CO). Vinini formation. NE¼SW¼SE¼NE¼ sec. 31, T. 33 N., R. 53 E., Carlin quad., Nevada.

D454 (CO). Vinini formation. Center SW¼NW¼ sec. 31, T. 33 N., R. 53 E., Carlin quad., Nevada.

D456 (CO). NW¼NW¼SE¼NE¼ sec. 8, T. 11 N., R. 17 E., northwest of the junction of Squaw and Bruno Creeks, Bayhorse quad., Idaho. Same locality as 2519 (SD).

D473 (CO). East of Lone Mountain, alt 6,245 ft, S. 85° W. from the peak of Lone Mountain and about 3,000 ft west of Roberts Creek Mtn. road. Nevada footage coordinates, east zone, 320,850 E., 1,744,200 N., Whistler Mtn. quad., Nevada.

D474a (CO). From base of exposure, mostly float; 1.5 miles from the north end of Martin Ridge, SE¼NE¼NE¼ and NE¼SE¼NE¼ sec. 36, T. 15 N., R. 49 E., Horse Heaven Mtn. quad., Nevada.

D474b (CO). From float 6 ft above colln. D474a (CO); 1.5 miles from the north end of Martin Ridge, SE¼NE¼NE¼ and NE¼SE¼NE¼ sec. 36, T. 15 N., R. 49 E., Horse Heaven Mtn. quad., Nevada.

D474c (CO). 14 ft above colln. D474a (CO); 1.5 miles from the north end of Martin Ridge, SE¼NE¼NE¼ and NE¼SE¼NE¼ sec. 36, T. 15 N., R. 49 E., Horse Heaven Mtn. quad., Nevada.

D474d (CO). 47 ft above colln. D474a (CO) partly from float; 1.5 miles from the north end of Martin Ridge, SE¼NE¼NE¼ and NE¼SE¼NE¼ sec. 36, T. 16 N., R. 49 E., Horse Heaven Mtn. quad., Nevada.

D474e (CO). From float 68 ft above colln. D474a (CO); 1.5 miles from the north end of Martin Ridge, SE¼NE¼NE¼ and NE¼SE¼NE¼ sec. 36, T. 16 N., R. 49 E., Horse Heaven Mtn. quad., Nevada.

D477 (CO). Vinini formation. South side of U.S. Highway 40 at Emigrant Pass, about 100 ft west of sign for summit. West of Carlin, Nev., Beowawe quad., Nevada.

D478a (CO). Valmy and Vinini formations. Marys Creek, 4.5 miles north of U.S. Highway 40. West side of creek, Beowawe quad., Nevada.

D480a (CO). In draw, west of Marys Creek, SW¼SE¼NW¼NW¼ sec. 25, T. 33 N., R. 50 E., Beowawe quad., Nevada. Ordovician beds dip steeply with Silurian beds on east and west; separated on east by fault; 150 ft west of fault over Silurian argillaceous sandy beds.

D480b (CO). In draw, west of Marys Creek, SW¼SE¼NW¼NW¼ sec. 25, T. 33 N., R. 50 E., Beowawe quad., Nevada. Ordovician beds dip steeply with Silurian beds on east and west; separated on east by fault; 104 ft west of fault over Silurian argillaceous sandy beds.

D480c (CO). In draw, west of Marys Creek, SW¼SE¼NW¼NW¼ sec. 25, T. 33 N., R. 50 E., Beowawe quad., Nevada. Ordovician beds dip steeply with

Silurian beds on east and west; separated on east by fault. From beds 57–84 ft west of fault over Silurian argillaceous sandy beds.

D480d (CO). In draw, west of Marys Creek, SW¼SE¼NW¼NW¼ sec. 25, T. 33 N., R. 50 E., Beowawe quad., Nevada. Ordovician beds dip steeply with Silurian beds on east and west; separated on east by fault. From beds 35–57 ft west of fault over Silurian argillaceous sandy beds.

D480e (CO). In draw, west of Marys Creek, SW¼SE¼NW¼NW¼ sec. 25, T. 33 N., R. 50 E., Beowawe quad., Nevada. Ordovician beds dip steeply with Silurian beds on east and west; separated on east by fault. From interval, 15–35 ft west of fault over Silurian argillaceous sandy beds.

D482 (CO). East of Bald Mtn. and south of Copper Canyon, slightly north of center NE¼SW¼, sec. 10, T. 25 N., R. 47 E., Cortez quad., Nevada.

D483 (CO). Valmy formation. East of Bald Mtn., alt 8,050 ft. Center N½SW¼NW¼ sec. 9, T. 25 N., R. 47 E., Cortez quad., Nevada.

D484 (CO). Southwest side of Bald Mtn., alt 8,450 ft. SW¼NE¼SE¼NE¼ sec. 8, T. 25 N., R. 47 E., Cortez quad., Nevada.

D485 (CO). Valmy formation. Near Bald Mtn., alt 6,675 ft. Center S½NW¼SW¼ sec. 10, T. 25 N., R. 47 E., Cortez quad., Nevada.

D486 (CO). Vinini formation. Alt 6,525 ft. SW¼SW¼NE¼ sec. 30, T. 25 N., R. 48½ E., Cortez quad., Nevada.

D487 (CO). Vinini formation. Alt 6,300 ft. NE¼SE¼NE¼ sec. 24, T. 25 N., R. 48 E., Cortez quad., Nevada.

D488 (CO). Vinini formation. Alt 6,675 ft. SW¼NW¼SW¼ sec. 31, T. 25 N., R. 48½ E., Cortez quad., Nevada.

D489 (CO). Southwest side of North Fork of Trout Creek, alt 6,350 ft. SW¼SW¼ sec. 5, T. 32 N., R. 43 E., Antler Peak quad., Nevada.

D495 (CO). South shoulder of North Peak, 700 ft east of quarter corner between secs. 3 and 4, T. 32 N., R. 43 E., alt 8,150 ft, Antler Peak quad., Nevada.

D496 (CO). South Fork of Trout Creek, nose running northwest. SW¼NE¼-SW¼ sec. 9, T. 32 N., R. 43 E., alt 7,675 ft, Antler Peak quad., Nevada.

D498 (CO). On boundary between secs. 7 and 18, 300 ft above Cottonwood Creek, on east side of canyon, Antler Peak quad., Nevada.

D499 (CO). North side of North Fork of Trout Creek. SE¼SW¼SW¼SW¼ sec. 5, T. 32 N., R. 43 E., Antler Peak quad., Nevada.

D500 (CO). North Fork of Trout Creek, northeast side. Center N½NE¼NE¼ sec. 8, T. 32 N., R. 43 E., Antler Peak quad., Nevada.

D501 (CO). E½ sec. 31, T. 33 N., R. 53 E., Carlin quad., Nevada.

D502 (CO). W½ sec. 31, T. 33 N., R. 53 E., Carlin quad., Nevada.

D504 (CO). Alt 7,700 ft, on ridge west from peak 7900, SW¼ sec. 9, T. 32 N., R. 43 E., Antler Peak quad., Nevada.

D505 (CO). Vinini formation. SW¼ sec. 3, T. 23 N., R. 48 E., alt 6,800 ft on west side of Simpson Park Range, 1.5 miles southeast of Walti Ranch, Walti Hot Springs quad., Nevada.

D507 (CO). Valmy or Vinini formation. Same locality as D163 (CO), Beowawe quad., Nevada.

D513 (CO). NE¼ sec. 31, T. 4 S., R. 29 E., Mt. Morrison 15-min quad., California.

D514 (CO). SW¼SW¼ sec. 23, T. 4 S., R. 28 E., Mt. Morrison 15-min quad., California.

D514a (CO). Mt. Morrison quad., California.

D515 (CO). N½SE¼SE¼ sec. 32, T. 4 S., R. 29 E., Mt. Morrison 15-min quad., California.

D516 (CO). SE¼SE¼ sec. 32, T. 4 S., R. 29 E., Mt. Morrison 15-min quad., California.

D530 (CO). "6.7 km (4.2 miles) southwest of Cow Camp Springs." (This locality was probably in secs. 7, 17, or 18, T. 4 S., R. 38 E.) Silver Peak quad., Nevada.

D531 (CO). "4 km (2.5 miles) southwest of Cow Camp Springs." (Probably in sec. 8, T. 4 S., R. 38 E.) Silver Peak quad., Nevada.

D532 (CO). "5.5 km (3.8 miles) south of west from Cow Camp Springs." (Probably in secs. 7, 17, or 18, T. 4 S., R. 38 E.) Silver Peak quad., Nevada.

D533 (CO). "Southwest of Piper lava flow." (Probably in the area southwest of Piper Peak, T. 3 S., R 36 and 37 E.) Silver Peak quad., Nevada.

D534 (CO). East side of McGee Mtn., SE¼ sec. 30, T. 4 S., R. 29 E., Mt. Morrison quad. This collection is probably equivalent to D513 (CO), above.

D535 (CO). SE¼SW¼ sec. 24, T. 4 S., R. 28 E., Mt. Morrison quad., California.

D536 (CO). NW¼NW¼ sec. 4, T. 5 S., R. 29 E., Mt. Morrison quad., 1:62,500, California.

D537 (CO). 600 ft east and 200 ft south of NW. cor. of sec. 19, T. 28 N., R. 47 E. in Crescent Valley quad. Nevada footage coordinates 480,750 E., 2,017,600 N.

D538 (CO). Alt 6,040 ft. West spur of mountain, south of Horse Canyon. 300 ft E., 2,500 ft north of SW. cor. sec. 5, T. 29 N., R. 45 E., Mt. Lewis quad. Nevada footage coordinates 423,800 E., 2,061,900 N.

D539 (CO). Vinini formation. Alt 6,600 ft; 1,200 ft N., 5,600 ft E. of SW. cor. sec. 28, T. 26 N., R. 48 E. Nevada footage coordinates, central zone, 529,800 E., 1,944,300 N., Cortez quad., Nevada.

D540 (CO). Emigrant Pass, U.S. Highway 40, SW¼NW¼ sec. 14, T. 32 N., R. 50 E., Beowawe quad., Nevada.

D541 (CO). Sec. 9, T. 34 N., R. 50 E., Tuscarora Mts., Nev. No quadrangle surveyed.

Collections of the Department of Geology, the University of California at Los Angeles. Locality data are listed below. Collections are deposited at the Museum of Paleontology, University of California, Berkeley.

UCLA 1–1. Alt 5,775 ft. Center N½NE¼SE¼ sec. 11, T. 27 N., R. 52 E., Mineral Hill quad., 1:62,500, Nevada.

UCLA 6–2. Alt 6,650 ft. Nevada footage coordinates, east zone, 375,000 E., 1,969,100 N., Mineral Hill quad., 1: 62,500, Nevada.

UCLA 6–5. Alt 7,025 ft. Tops of small hill, NW¼SW¼SW¼, sec. 2, T. 26 N., R. 52 E., Mineral Hill quad., 1:62,500, Nevada.

UCLA 6–7. Alt 6,575 ft. On south side of Grassy Canyon. E½NW¼SW¼ sec. 35, T. 27 N., R. 52 E., Mineral Hill quad., 1:62,500, Nevada.

UCLA 52N–7. Alt 6,675 ft. On ridge northwest of Chokecherry Spring. SW. cor., NE¼SE¼ sec. 30, T. 27 N., R. 53 E., Mineral Hill quad., 1:62,500, Nevada.

UCLA 52N8A. Alt 6,850 ft. On southwest-facing slope, center S½NE¼SE¼ sec. 30, T. 27 N., R. 53 E., Mineral Hill quad., 1:62,500, Nevada.

UCLA C–1. Alt 6,700 ft. 300 ft. southwest of Chokecherry Spring. NW¼ SE¼SE¼ sec. 30, T. 27 N., R. 53 E., Mineral Hill quad., 1:62,500, Nevada.

UCLA E–2. Alt 6,560 ft. Nevada footage coordinates, east zone, 375,100 E., 1,968,000 N., Mineral Hill quad., 1:62,500, Nevada.

UCLAE2–1. Alt 6,925 ft. On northeast side of small hill in SE¼NW¼NW¼ SW¼ sec. 2, T. 26 N., R. 52 E., Mineral Hill quad., 1 : 62,500, Nevada.

UCLA E–7. Alt 6,950 ft. On ridge in SW. cor., NW¼SW¼ sec. 2, T. 26 N., R. 52 E., Mineral Hill quad., 1 : 62,500, Nevada.

UCLA E–11. Alt 6,750 ft. Center W½SW¼NE¼ sec. 10, T. 26 N., R. 52 E., Mineral Hill quad., 1 : 62,500, Nevada.

UCLA E–12. Alt 7,275 ft. East border SE¼SE¼NE¼ sec. 10, T. 26 N., R. 52 E., Mineral Hill quad., 1 : 62,500, Nevada.

UCLA M4–1. Alt 6,500 ft. On north side of Williams Canyon, Nevada footage coordinates, east zone, 374,400 E., 1,961,600 N., Mineral Hill quad., 1 : 62,500, Nevada.

UCLA R–6. Alt 6,275 ft. 1,200 ft south of Willow Spring, NW¼SW¼ sec. 19, T. 27 N., R. 53 E., Mineral Hill quad., 1 : 62,500, Nevada.

UCLA R–7. Alt 6,250 ft. SW¼SW¼NW¼ sec. 19, T. 27 N., R. 53 E., Mineral Hill quad., 1 : 62,500, Nevada.

UCLA R–8. Alt 6,050 ft. On north side of small valley, center NE¼SW¼ sec. 13, T. 27 N., R. 52 E., Mineral Hill quad., 1 : 62,500, Nevada.

UCLA S–21. Alt 6,575 ft. Nevada footage coordinates, east zone, 375,400 E., 1,967,800 N., Mineral Hill quad., 1 : 62,500, Nevada.

UCLA V–8. Alt 6,390 ft. Center north side of NE¼SW¼ sec. 16, T. 27 N., R. 53 E., Mineral Hill quad., 1 : 62,500, Nevada.

GRAPTOLITE COLLECTIONS BY DISTRICT AND QUADRANGLE

Graptolite collections are listed below by mining districts and by quadrangles. In general these areas are dealt with from the southwest toward the northeast. Graptolites of the "eastern" or shelf facies—Garden City and Hanson Creek formations—are listed last.

GRAPTOLITES OF THE "WESTERN FACIES"

MOUNT MORRISON QUADRANGLE, CALIFORNIA

The most southwesterly exposure of graptolite-bearing strata and one of the most significant has been reported by Rinehart, Ross, and Huber (1959, p. 941–945) from the Mount Morrison quadrangle of California. There Paleozoic rocks are preserved as roof pendants within one of the Sierra Nevada batholiths near Convict Lake. Graptolites from black slates range in age from Arenig to Caradoc, although younger zones may be present. The presence of these rocks along with other Paleozoic strata within the bounds of the present Sierra Nevada batholiths indicates that the belt of Paleozoic geosynclinal deposits must have stretched further to the southwest than previous evidence indicated. This discovery also raises hopes that similar Ordovician rocks may be found in the area of the Idaho batholith.

Fossil localities and faunas are:

USGS D513 (CO). NE¼ sec. 31, T. 4 S., R. 29 E., Mt. Morrison 15-min. quad., California.

Climacograptus cf. *C. parvus* J. Hall

Glyptograptus cf. *G. euglyphus* Lapworth
cf. *G. teretiusculus* Hisinger
Orthograptus cf. *O. calcaratus* var. *acutus* Lapworth
Age: Probably zone of *Climacograptus bicornis;* possibly zone of *Nemagraptus gracilis.*

USGS D514 (CO). SW¼SW¼ sec. 23, T. 4 S., R. 28 E., Mt. Morrison 15-min. quad., California.
Glossograptus cf. *G. hincksii* Hopkinson
Dicranograptus nicholsoni var. *whitianus* (Miller)
Climacograptus bicornis J. Hall
cf. *C. bicornis* var. *tridentatus* Lapworth
Glyptograptus? sp.
Orthograptus cf. *O. calcaratus* var. *acutus* Lapworth
sp.
Hallograptus cf. *H. mucronatus* J. Hall
Age: Probably zone of *Climacograptus bicornis;* possibly zone of *Nemagraptus gracilis.*

USGS D515 (CO). N½SE¼SE¼ sec. 32, T. 4 S., R. 29 E., Mt. Morrison 15-min. quad., California.
Climacograptus bicornis J. Hall
Glyptograptus euglyphus Lapworth
cf. *G. teretiusculus* (Hisinger)
Orthograptus calcaratus var. Lapworth?
sp.
Age: Probably zone of *Climacograptus bicornis,* possibly zone of *Orthograptus truncatus* var. *intermedius.*

USGS D516 (CO). SE¼SE¼ sec. 32, T. 4 S., R. 29 E., Mt. Morrison 15-min. quad., California.
Tetragraptus fruticosus J. Hall (3- and 4-branched forms.)
Didymograptus cf. *D. ensjøensis* Monsen
Age: Zone of *Tetragraptus fruticosus* (3- and 4-branched forms.) May be zone of *Didymograptus protobifidus.*

USGS D534 (CO). East side of McGee Mtn., SE¼ sec. 30, T. 4 S., R. 29 E., Mt. Morrison quad., California.
Climacograptus parvus J. Hall
Orthograptus sp.
Age: Probably zone of *Climacograptus bicornis;* possibly zone of *Nemagraptus gracilis.*

USGS D535 (CO). SE¼SW¼ sec. 24, T. 4 S., R. 28 E., Mt. Morrison quad., California.
Diplograptus? sp.
Glyptograptus? sp.
Age: This collection is probably Ordovician although the listed genera occur also in Silurian strata.

USGS D536 (CO). NW¼NW¼ sec. 4, T. 5 S., R. 29 E., Mt. Morrison quad., 1:62,500, California.
Tetragraptus pendens Elles
Didymograptus sp. (Extensiform type.)
Age: Probably zone of *Didymograptus protobifidus.*

SILVER PEAK QUADRANGLE, NEVADA

Turner (1902, p. 265–266) reported graptolites in cherts and slates in the Silver Peak Range, Palmetto Mountains, and in country north of Clayton Valley (Silver Peak quad., 30-min., 1898). To the graptolite-bearing beds he gave the name Palmetto formation. Spurr (1903, p. 185) noted the occurrence of graptolitic strata in the Silver Peak Range as reported by Turner and in his report on the Silver Peak quadrangle (1906, p. 17–18) mentioned the Ordovician briefly; unfortunately his map did not differentiate between the Paleozoic systems.

Turner (1902, p. 266) quoted Schuchert as stating that two horizons were represented by the Palmetto graptolites, "one, the Normanskill * * * and the other the Quebec horizon. Nearly all of the graptolites, however, belong to the Normanskill zone. In the Quebec horizon, Mr. Schuchert found two characteristic genera *Didymograptus* and *Tetragraptus*."

Turner described the Ordovician rocks as, "dark thin bedded cherts with layers of gray graptolite slates, and smaller amounts of reddish slates, and an occasional limestone layer."

We have examined four collections of graptolites made by Turner from his Palmetto formation and apparently the basis for part of his paper of 1902. The material is not well preserved. Collections may be located on the geologic map of the Silver Peak quadrangle (Spurr, 1906, pl. 1). Original locality descriptions written in 1899 are repeated here in quotations.

USGS D530 (CO). "6.7 km (4.2 miles) southwest of Cow Camp Springs." (This locality was probably in secs. 7, 17, or 18, T. 4 S., R. 38 E.).

Cryptograptus sp.
Glossograptus hincksii Hopkinson
Dicranograptus spinifer Elles and Wood
Climacograptus parvus Hall
sp.
Orthograptus calcaratus Lapworth
calcaratus var. *acutus* Lapworth

Age: Zone of *Climacograptus bicornis*.

USGS D531 (CO). "4 km (2.5 miles) southwest of Cow Camp Springs." (Probably in sec. 8, T. 4 S., R. 38 E.).

Glyptograptus cf. *G. teretiusculus* (Hisinger)

Age: Ranges from zone of *G. teretiusculus* to zone of *C. bicornis*.

USGS D532 (CO). "5.5 km (3.8 miles) south of west from Cow Camp Springs." (Probably in secs. 7, 17 or 18, T. 4 S., R. 38 E.).

Glyptograptus? cf. *G. teretiusculus* (Hisinger)

Age: Ranges from zone of *G. teretiusculus* to zone of *C. bicornis*.

USGS D533 (CO). "Southwest of Piper lava flow." (Probably in the area southwest of Piper Peak, T. 3 S., R. 36 and 37 E.).

Isograptus caduceus var. *maxima* Harris
forcipiformis var. *latus* Ruedemann
caduceus var. *victoriae* Harris

Age: Zone of *Isograptus*.

Two collections are more recent than Turner's. One (2352 [SD]) was made by Kirk in the 1930's; the other (D137 [CO]) was made by A. R. Palmer in 1954.

USGS 2352 (SD). This collection was made by Edwin Kirk, "about 1 mile west of the Weepah Road along south front of range." This information indicates that the collection was made somewhere in the northeast part of the Silver Peak quad.

Dicellograptus cf. *D. intortus* Lapworth
cf. *D. sextans* J. Hall
sextans var. *exilis* Elles and Wood
Climacograptus cf. *C. eximius* Ruedemann
parvus J. Hall
Glyptograptus? sp.

Age: Probably zone of *Nemagraptus gracilis* but may be zone of *Climacograptus bicornis*.

USGS D137 (CO). Gray shales on ridge south of road on west side of Emigrant Pass, alt 6,400 ft, about 1 mile south-southeast of Emigrant Pass summit. T. 1 N., R. 37 E., Silver Peak quad., Nevada.

?*Cryptograptus tricornis* (Carruthers)
Dicellograptus divaricatus var. *salopiensis* Elles and Wood
gurleyi Lapworth
intortus Lapworth
sextans? (J. Hall)
sp.
Dicranograptus sp.
Leptograptus cf. L. flaccidus (J. Hall)

Age: Probably zone of *Nemagraptus gracilis*.

GOLDFIELD DISTRICT, NEVADA

Ordovician argillites may be present in the Goldfield district although none have been reported there to date.

In his account of the stratigraphy of the Goldfield district, Ransome (1909, p. 32) describes "Cambrian shales" as dark, fine-grained thin-bedded, with a dense flinty texture, locally interbedded with quartzites. The description would do well for many of the Ordovician strata of the "western facies."

Without fossils, Ransome was forced to compare lithologies with beds of known age. Cambrian fossils were known in the Silver Peak Range (Walcott, 1886, p. 30). Similar comparisons were made with Lida and Cuprite. However, no mention was made of the fact that Ordovician graptolites were also known in the Silver Peak Range

(Turner, 1902, p. 265; 1909, p. 243) in similar rocks. Ball (1907, p. 57) had noted his inability to locate Ordovician rocks reported near Montezuma by Turner, and Ransome may have been influenced by Ball's report to which he refers.

COALDALE QUADRANGLE, NEVADA

The Palmetto formation is mapped in the Coaldale quadrangle (Ferguson, Muller, and Cathcart, 1953), but no information on Ordovician faunas is given. The lithology is reported as dark slate and chert with subordinate limestone. Ferguson (1928, p. 130) previously had reported the same lithologic types with the addition of some dark quartzites in the Gilbert district. This area was also covered by the work of Ferguson and Muller (1949, pl. 1, and fig. 10, p. 50); they indicated that the Ordovician beds had been overthrust onto Triassic strata in the Monte Cristo Range.

MINA QUADRANGLE, NEVADA

Ferguson, Muller, and Cathcart (1954) drew a close comparison between the lithology of the Palmetto formation as mapped in the Mina quadrangle with that of the Vinini formation of Merriam and Anderson (1942) and with that of the Comus formation (Ferguson, Roberts, and Muller, 1952), and the Toquima formation of Ferguson (1924, p. 20–25). The lower part of the unit was stated to contain graptolites of Normanskill age.

Ferguson and Muller (1949, fig. 7) had previously indicated that the Ordovician was overlain with angular unconformity by Permian and Triassic rocks.

SAN ANTONIO MOUNTAINS, NEVADA

About 8 miles north of Tonopah in the San Antonio Mountains, Ordovician cherts and slates are present with a minor amount of limestone; these rocks are similar to those of the Toquima Range (Ferguson and Muller, 1949, p. 51, pl. 1). No fossils have been reported from them, however.

ROUND MOUNTAIN QUADRANGLE AND THE MANHATTAN DISTRICT, NEVADA

In 1924, Ferguson (p. 20–25) named three Ordovician formations in the Manhattan district. Of these the Mayflower schist and Zanzibar limestone were questionably referred to the Ordovician. The Toquima formation contained numerous graptolites that made its age certain. The Mayflower schist was considered to be the oldest of the three.

The Zanzibar consists of blue-gray limestone interbedded in most places with dense black jaspillite, according to Ferguson. Laterally it grades into dark calcareous slate and then into fissile black very fine grained slate containing problematical graptolite remains. This

gradation suggests that the Zanzibar is in part equivalent to and in part overlain by the Toquima formation.

The Toquima formation includes quartzites, slates, and limestones identical with those of the Zanzibar, and schists like those of the Mayflower as well as argillites and black cherts. Graptolites from the slates were identified by Kirk and included species of *Dicranograptus*, *Diplograptus*, *Climacograptus*, *Didymograptus*, *Dicellograptus*, *Nemagraptus*, *Glossograptus*, and *Retiolites* (Ferguson, 1924, p. 22–23). Most of the species had no reported occurrences outside of southern Nevada and have needed reexamination.

Faunal lists based on Ferguson's original collections in the Manhattan district have been prepared for this paper. All localities may be located on his geologic map (Ferguson, 1924, pl. 1, scale 1:24,000).

USGS 308 (SD). 600 ft west-southwest of Monument 189 on Mt. Moriah, approximately 9,000 ft west of Manhattan.

Dicellograptus cf. *D. sextans* var. *exilis* Elles and Wood
Dicranograptus cf. *D. nicholsoni* var. *whitianus* (Miller)
Glyptograptus cf. *G. teretiusculus* Hisinger
Orthograptus cf. *O. calcaratus* var. *acutus* Lapworth
sp.

Age: Zone of *Climacograptus bicornis*.

USGS 311 (SD). 200 ft northwest of the summit of hill 6735 in the northern part of Palo Alto Hill, located about 3 miles west-northwest of Manhattan.

Dicellograptus sextans J. Hall
Cryptograptus tricornis Carruthers
Glyptograptus? sp.

Age: Zone of *Climacograptus bicornis*.

USGS 315 (SD). 750 ft. south of Palo Alto well and about 3,000 ft. west of Palo Alto Hill.

Dicranograptus nicholsoni Hopkinson
nicholsoni var. *geniculatus* Ruedemann and Decker
(Note Ruedemann's fig. 5, pl. 66 is not *D. nicholsoni* but probably *D. n.* var. *geniculatus*.)
Glyptograptus? sp.
Orthograptus cf. *calcaratus* (Lapworth)

Age: Zone of *Orthograptus truncatus* var. *intermedius*.

USGS 316 (SD). Approximately 2,800 ft. northeast of the settlement of Central, and west of Black Mammoth Hill, 400 ft. west-northwest of the top of hill 7077. The exact zone represented cannot be ascertained.

Orthograptus sp.

USGS 320 (SD). Near top of hill 7077, west of Black Mammoth Hill.

Climacograptus sp.
Orthograptus calcaratus var. *basilicus* (Lapworth)

Age: Probably zone of *Orthograptus quadrimucronatus*.

USGS 325 (SD). Locality data not known.

Climacograptus bicornis var. *peltifer* Lapworth

Age: Zone of *Climacograptus bicornis*.

USGS 328 (SD). 500 ft. west of Monument 189 on Mt. Moriah, approximately 9,000 ft. west of Manhattan.

Glyptograptus? sp.
Cryptograptus tricornis Carruthers
Dicellograptus intortus Lapworth
cf. *D. sextans* J. Hall
Nemagraptus gracilis J. Hall (Fragments.)
Glyptograptus? sp.
Orthograptus calcaratus var. *acutus* (Lapworth)

Age: Zone of *Climacograptus bicornis*.

USGS 335 (SD). Vicinity of Salisbury Peak.

Orthograptus sp.

USGS 336 (SD). North of Belmont Road, 2,000 ft. southeast from East Manhattan, from breccia exposed beneath Tertiary rhyolite. Possibly an old talus slope.

Didymograptus? sp. (Stipes and fragments.)
Dicranograptus sp.
Climacograptus bicornis J. Hall
Orthograptus calcaratus var. *acutus* (Lapworth)

Age: Zone of *Climacograptus bicornis*.

USGS 444z (OS). From the general vicinity of Mt. Moriah, 1½ miles west of Manhattan. This collection should be considered in conjunction with 308 (SD) and 328 (SD).

Cryptograptus tricornis Carruthers
Glossograptus cf. *G. ciliatus* Gurley
Nemagraptus gracilis J. Hall.
gracilis var. *surcularis* (J. Hall)
Dicellograptus gurleyi Lapworth
intortus Lapworth
sextans J. Hall
var. *exilis* Elles and Wood
Dicranograptus cf. *D. furcatus* (J. Hall)
nicholsoni var. *ichitianus* (Miller)
Climacograptus bicornis J. Hall
cf. *C. eximius* Ruedemann
Glyptograptus aff. *G. teretiusculus* (Hisinger)
sp.
Orthograptus calcaratus var. *acutus* (Lapworth)
cf. *calcaratus* var. *incisus* (Lapworth)
Lasiograptus sp.
Retiograptus geinitzianus (J. Hall)

Age: Zone of *Climacograptus bicornis*.

In mapping the Round Mountain quadrangle Ferguson and Cathcart (1954) did not use the threefold break down of the Ordovician rocks that the former mapped in the Manhattan district; they mapped all Ordovician rocks as Palmetto formation, noting that the black cherts of the upper part of the section were missing in the Toyabe Range. Estimated thickness of the Ordovician rocks in the Manhattan district is about 5,000 feet (T. 8 N., R. 43–44 E.), but to the north-

west between Pablo and Wall Canyons in the Toyabe Range (T. 10 N., R. 42 E.) it is estimated as 2,500 feet thick (Ferguson and Cathcart, 1954).

A collection by Kirk from the Toyabe Range supplements the information from the Manhattan district.

USGS 2347 (SD). Palmetto formation, Pablo Canyon, east side of Toyabe Range, T. 10 N., R. 42 E.

Dicellograptus sp.
Orthograptus calcaratus Lapworth var?
cf. *O. calcaratus* var?
truncatus Lapworth
var. *intermedius*? Elles and Wood
n. sp.
Lasiograptus eucharis (Hall)

Age: Probably zone of *Dicranograptus clingani* but possibly zone of *Orthograptus truncatus* var. *intermedius*.

The nearest "eastern facies" exposures are at Tybo (Ferguson, 1933, p. 16–20) where limestones of the Pogonip group and the Eureka quartzite are present, but the Ely Springs dolomite is reportedly absent.

North of the Round Mountain quadrangle, in the extension of the Toyabe Range, Emmons in 1870 (p. 334) had reported the presence of slates but without any fossil evidence for their age.

BELMONT DISTRICT, NEVADA

As early as 1875, Gilbert (p. 36) noted that the rocks of the Toquima Range in the vicinity of Belmont included much argillaceous slate * * * "somewhat metamorphosed, but not so much as to destroy its fossils, which are of Silurian forms." Today these are known to be Ordovician. White (1874, p. 12–14; 1877, p. 62–66) later identified graptolites collected by Gilbert, describing two new species. According to White the four forms collected were:

Graptolithus (*Climacograptus*) *ramulus* White
(*Diplograptus*) *hypniformis* White
(*Diplograptus*) *pristis* J. Hall (?)
quadrimucronatus J. Hall(?)

These identifications need considerable revision. "*Climacograptus*" *ramulus* (USNM 8555) is really *Dicranograptus* and a synonym of *D. nicholsoni* var. *parvangulus* Gurley. *Diplograptus pristis* Hall (USNM 8558) is better assigned to *Orthograptus calcaratus* cf. var. *incisus* Lapworth, and *G. quadrimucronatus* (USNM 8557) is an indeterminate species, probably of *Glyptograptus*?. *Diplograptus hypniformis* (USNM 8556) seems to be a *Glyptograptus* and probably belongs to the species, *G. teretiusculus* (Hisinger). On the same piece

of rock is a specimen of a large orthograptid similar to *Orthograptus* cf. *O. truncatus intermedius* Lapworth. This assemblage probably correlates with the fauna of the *Climacograptus bicornis* zone but may equal the zone of *O. truncatus intermedius*.

Another specimen collected near Belmont by Gilbert (USNM 54337) we have identified as *Glyptograptus euglyphus* var. *pygmaeus* Ruedemann.

NORTHERN TOQUIMA RANGE, NEVADA

The northern part of the Toquima Range has held a fascination for most students of the Ordovician system in the Basin Ranges. Ikes Canyon in particular figures in many of the early paleontologic discussions. Many of the brachiopods from the Pogonip limestone described by Ulrich and Cooper (1938) came from there, as did the sponges described by Bassler (1941, p. 91–102, pl. 19–24). Kirk visited the area in 1928 and very briefly described its stratigraphy in 1933 (p. 34); he believed that the limestones of the Pogonip were overlain disconformably by Silurian graptolite-bearing shale.

In recent years, G. M. Kay of Columbia University has supervised a summer geology camp at the mouth of Ikes Canyon. His students have done extensive geologic mapping on planimetric and photographic bases under his close supervision. As a result (Kay, 1955, p. 1592; oral communication, August 1958) it has been demonstrated that rocks of the graptolite shale and chert facies of Ordovician age override the Pogonip sequence on a thrust fault. Furthermore, to the south and west there are successive thrust faults, above each of which is an Ordovician and Silurian sequence differing from the sequence beneath each thrust. Kay expects to describe the graptolite faunas of the overriding sequences shortly (oral communication, August 1958).

The structure of the Toquima Range is too complex to be appreciated without geologic maps. Therefore age determinations of the few collections at hand have little meaning out of the structural context. Suffice it to say that in the northern part of the Toquima Range graptolites range in age at least from Llanvirn well into the Caradoc. It may further be noted that although a change of facies is indicated from one thrust sequence to the next, the contact between the graptolite shales and cherts and the Ordovician carbonates of the Pogonip group is also a thrust fault. In these respects the graptolitic strata of the Toquima Range are similar to those of the Vinini and Valmy formations to the north.

ROBERTS CREEK MOUNTAINS, WALTI HOT SPRINGS, AND HORSE CREEK VALLEY QUADRANGLES, NEVADA

In the areas of the Roberts Creek Mountains and Walti Hot Springs quadrangles very little collecting has been done to date. Roberts and Lehner, in the course of compiling a geologic map of Eureka County, Nev., made 2 collections, 1 in each quadrangle. They are listed as follows:

USGS D149 (CO). NW¼ sec. 9, T. 24 N., R. 49 E. Alt 6,600 ft. On northwest side of valley at upper spring. Simpson Park Range. Roberts Creek Mts. quad., Nevada.

Dicellograptus? sp.
Dicranograptus? sp.
Climacograptus caudatus Lapworth
minimus (Carruthers)
typicalis J. Hall
sp.
Amplexograptus cf. *A. perexcavatus* Lapworth
sp. (4 mm wide.)

Age: Zone of *Orthograptus quadrimucronatus*.

USGS D505 (CO). Vinini formation. SW¼ sec. 3, T. N., R. 48 E. Alt 6,800 ft on west side of Simpson Park Range; 1½ miles southeast of Walti Ranch, Walti Hot Springs quad., Nevada.

Corynoides calicularis Nicholson
incurvus Hadding
Dicranograptus contortus? Ruedemann
Glyptograptus tercticusculus? (Hisinger)

Age: Probably late Middle Ordovician. Possibly zone of *Climacograptus bicornis* or of *Orthograptus truncatus* var. *intermedius*.

ROBERTS MOUNTAINS AND GARDEN PASS, NEVADA

In 1942, Merriam and Anderson published their account of the geology of the Roberts Mountains in an area now covered by four 15-minute topographic quadrangles (Roberts Creek Mountain, Garden Valley, Bartine Ranch, and Whistler Mountain). As noted, it was here that the concept of the Roberts Mountains and similar thrusts in the area was first stated (Merriam and Anderson, 1942, p. 1701). The core of the Roberts Mountains is composed of Paleozoic rocks (including the Ordovician Pogonip, Eureka, and Hanson Creek formations) of the "eastern" or shelf facies. Around this core lies the Vinini formation of Ordovician age and of the "western facies."

Graptolites have been known from these beds since 1896 when Gurley (p. 66, 76, 84, 294–301) published descriptions of and discussed graptolites collected by C. D. Walcott in the "Piñon Range, at the crossing of the Eureka and Palisades Railroad, at Summit, Nevada." Today the locality is known as Garden Pass (T. 22 and 23 N., R. 52 E.) in the Garden Valley quadrangle and lies only a few

miles northeast of the type section of the Vinini formation on Vinini Creek. Gurley's list of species included:

Phyllograptus anna J. Hall
sp. indet.
Didymograptus perflexus Gurley
Climacograptus caelatus Lapworth
Diplograpsus sp.
Cryptograptus tricornis Carruthers
Glossograptus ciliatus (Lapworth)
Thamnograptus anna
Dendrograptus cf. *serpens* Hopkinson
Caryocaris wrightii Salter
curvilatus Gurley

Ruedemann (1947, p. 107) examined Gurley's and other collections from "Summit" (Garden Pass) and concluded that late Deepkill (Llanvirn) and early Normanskill (Early Caradoc) were indicated. Ruedemann's faunal lists are a little more extensive than Gurley's.

Collections made by Walcott and identified by Gurley have been reexamined for this report. Twenty-five species are present. Two-thirds of these are known in or originally reported from Victoria (Australia), where most are found in the Middle Ordovician (Harris and Thomas, 1938b).

Ten species are common to Britain. Four are found there only in Arenig-Lower Llanvirn rocks. The other six are found in Llandeilan to Mid-Caradoc strata.

The collections from "Summit" represent two zones. By taking separate pieces of shale or groups of pieces, it has been possible to separate the included fossils into two faunal assemblages.

A fauna representing the zone of *Hallograptus etheridgei* has been assembled from specimens USNM 54249, 54331, 54344, and 54347.

Didymograptus compressus Harris and Thomas
gracilis Törnquist
cf. D. *cognatus* Harris and Thomas
Isograptus dumosus Harris
forcipiformis Ruedemann
cf. I. *manubriatus* T. S. Hall
Cryptograptus schäferi Lapworth
Glossograptus hincksii Hopkinson
horridus Ruedemann
Climacograptus sp.
Diplograptus decoratus var. *amplexograptoideus* n. var.
decoratus var. *multus* n. var.
Amplexograptus cf. *A. arctus* Elles and Wood
Glyptograptus? cf. *G. euglyphus* Lapworth
sp.

The following composite fauna represents the zone of *Glyptograptus teretiusculus* and was assembled from specimens USNM 54332, 54333, 54334, 54335, 54342.

Phyllograptus nobilis Harris and Keble
Cryptograptus schäferi Lapworth
tricornis Carruthers
Glossograptus acanthus Elles and Wood
hincksii Hopkinson
horridus Ruedemann
Climacograptus riddellensis Harris
Climacograptus sp. (0.15 mm wide proximally; widens to 1.1 mm. Strong median septum. Virgella 2.8 mm long. Thecae 18–20 in 10 mm. Excavations deep, almost to median septum.)
Diplograptus decoratus var. *multus* n. var.
Amplexograptus cf. *A. arctus* Elles and Wood
confertus
Glyptograptus teretiusculus Hisinger

A fauna that may be intermediate between the zones *H. etheridgei* and *G. teretiusculus* is found on specimen USNM 54341:

Phyllograptus nobilis Harris and Keble
Cryptograptus schäferi Lapworth
Glossograptus acanthus Elles and Wood
hincksii Hopkinson
horridus Ruedemann
Climacograptus riddellensis Harris
sp.
Diplograptus decoratus Harris and Thomas
decoratus subsp. *amplexograptoideus* n. subsp.
var. *multus* n. var.
decoratus -D. decoratus var. *amplexograptoideus* transients
Amplexograptus confertus Lapworth
differtus Harris and Thomas
modicellus Harris and Thomas
Glyptograptus euglyphus Lapworth

Most of the species listed belong to the zone of *G. teretiusculus*, but in Australia *Amplexograptus differtus* and *A. modicellus* occur in a fauna like that of our zone of *Hallograptus etheridgei*. In Nevada these two species may have lived somewhat longer than in Australia; in that case the above faunal assemblage would belong in the zone of *G. teretiusculus*.

In addition to these early collections Kirk made several in the vicinity of Garden Pass in the 1930's. Of these, collection 2353 (SD) was made at "Summit" and is important for its inclusion of *Cardiograptus*, a genus not represented in the previous collections for some reason. Kirk's collections are listed.

USGS 2349 (SD). East of Small Hill, 2 miles west of Mt. Hope, Garden Valley quad., Nevada.

Amplexograptus confertus Lapworth
Glyptograptus sp.

Age: Zone of *Glyptograptus teretiusculus.*

USGS 2350 (SD). South bank of Vinini Creek, Garden Valley quad., Nevada.

Glyptograptus sp.

USGS 2351 (SD). South bank Vinini Creek, 1½ miles west of the Eureka-Palisade road, Garden Valley quad., Nevada.

Cryptograptus tricornis Carruthers
Glossograptus hincksii Hopkinson
horridus Ruedemann
Climacograptus? sp.
Diplograptus decoratus var. *amplexograptoideus* n. var.
Amplexograptus confertus Lapworth
modicellus Harris and Thomas
Glyptograptus cf. G. *euglyphus* Lapworth

Age: Probably zone of *Glyptograptus teretiusculus*, possibly zone of *Hallograptus etheridgei;* same as USNM 54341.

USGS 2353 (SD). "Summit," Nev. (Garden Pass, sec. 31, T. 23 N., R. 51 E., Garden Valley quad., Nevada.)

Cardiograptus crawfordi Harris
Cryptograptus tricornis Carruthers
Cryptograptus? *antennarius* J. Hall
Glossograptus hincksii Hopkinson
Climacograptus riddellensis Harris
sp.
Amplexograptus confertus Lapworth
Diplograptus decoratus–D. decoratus var. *amplexograptoideus* transient
Glyptograptus euglyphus Lapworth
Retiograptus n. sp. (Like *R. speciosus* Harris but thecae number 10 in 10 mm. instead of 14 in 10 mm.)

Age: Probably zone of *Glyptograptus teretiusculus.*

Ruedemann examined collections from the type section of the lower part of the Vinini formation (Merriam and Anderson, 1942, p. 1695; Ruedemann, 1947, p. 108) and identified:

Dictyonema n. sp.
Tetragraptus similis (J. Hall) (Probably *T. serra* Brogniart or *T. bigsbyi* J. Hall.)
quadribrachiatus (J. Hall)
Phyllograptus cf. *P. angustifolius* (J. Hall)
Didymograptus nitidus (J. Hall)
Isograptus gibberulus Nicholson (Probably *caduceus* var.)
Cardiograptus folium Ruedemann (Probably *morsus* Harris and Keble.)

He called attention to the presence of *Cardiograptus* in Australia as well as in Idaho and British Columbia. The assemblage is probably mixed, being Llanvirn and Arenig in age.

From the upper beds of the Vinini Ruedemann (1947, p. 108; Merriam and Anderson, 1942, p. 1697) listed:

Leptograptus flaccidus var. *spinifer* Elles and Wood mut. *trentonensis* Ruedemann
Dicranograptus spinifer Lapworth
Diplograptus angustifolius (J. Hall) [=*Glyptograptus teretiusculus* (Hisinger)].
Orthograptus calcaratus var. *acutus* Lapworth
Climacograptus bicornis (J. Hall)
modestus Ruedemann
Retiograptus geinitzianus (J. Hall)

Ruedemann noted that this fauna occurs also in Idaho in the Bayhorse and Hailey quadrangles and in British Columbia. It correlates with the zone of *Climacograptus bicornis*.

Unfortunately these collections have not been available to us for the present study.

During the summer of 1958, Merriam (oral communication, August 1958) was able to show that the Vinini formation lies around the flanks of Lone Mountain in the Whistler Mountain quadrangle. A collection of graptolites (D473 [CO]) made by him and Ross from the east side of the mountain is probably of Ordovician age. As a result, the extent of the Vinini is greater than shown on the original map of Merriam and Anderson (1942, pl. 4), and Lone Mountain is mainly a window.

MINERAL HILL QUADRANGLE, NEVADA

Mapping of the Mineral Hill quadrangle has been undertaken by the geology summer camp of the University of California at Los Angeles under the supervision of Donald Carlisle, E. L. Winterer, and others. There graptolite-bearing rocks of the Vinini facies are involved in major thrust faulting, probably a continuation of the Roberts Mountains thrust; the thrust zone runs northward into the Pine Valley quadrangle.

Graptolites collected in the Mineral Hill quadrangle range in age from equivalents of the zone of *Didymograptus protobifidus* to equivalents of the zone of *Orthograptus truncatus* var. *intermedius*. UCLA collections are listed below:

Collection from the zone of *Didymograptus protobifidus:*

UCLA 1–1. Alt 5,775 ft. Center N½NE¼SE¼ sec. 11, T. 27 N., R 52 E., Mineral Hill quad., 1:62,500, Nevada.
Dictyonema sp.
Didymograptus protobifidus Elles

Collections from the zone of *Isograptus:*

UCLA E–11. Alt 6750 ft. Center W½SW¼NE¼ sec. 10, T. 26 N., R. 52 E., Mineral Hill quad., 1:62,500, Nevada.

Isograptus caduceus var. *victoriae* Harris
caduceus var. *maxima* Harris

UCLA E–7. Alt 6,950 ft. On ridge in SW. cor., NW¼SW¼ sec. 2, T. 26 N., R. 52 E., Mineral Hill quad., 1:62,500, Nevada.

Isograptus caduceus var. *divergens* Harris (May be from zone of *Hallograptus etheridgei.*)

Collection from the zone of *Hallograptus etheridgei:*

UCLA R–7. Alt 6,250 ft. SW¼SW¼NW¼ sec. 19, T. 27 N., R. 53 E., Mineral Hill quad., 1:62,500, Nevada.

Phyllograptus sp. (2.8 cm long, 7 mm wide, 11 thecae in 10 mm).
Didymograptus sp.
Isograptus forcipiformis var. *latus* Ruedemann
Cryptograptus schäferi Lapworth
Glossograptus hincksii (Hopkinson)
Climacograptus sp.
Diplograptus decoratus var. *amplexograptoideus* Ross and Berry n. var.
decoratus var. *multus* Ross and Berry n. var.
Amplexograptus confertus (Lapworth)
Glyptograptus euglyphus (Lapworth)
intersitus (Harris and Thomas)

Collection from the zone of *Nemagraptus gracilis:*

UCLA S–21. Alt 6,575 ft. Nevada footage coordinates, east zone, 375,400 E., 1,967,800 N., Mineral Hill quad. 1:62,500, Nevada.

Dicellograptus divaricatus (J. Hall)
divaricatus var. *salopiensis* Elles and Wood
Climacograptus sp.
Glyptograptus cf. *G. teretiusculus* (Hisinger)

Collections from either the zone of *Nemagraptus gracilis* or the zone of *Climacograptus bicornis:*

UCLA R–6 (?). Alt 6,276 ft. 1,200 ft south of Willow Spring, NW¼SW¼ sec. 19, T. 27 N., R. 53 E., Mineral Hill quad., 1: 62,500, Nevada.

Didymograptus?
Glossograptus?
Glyptograptus sp.

UCLA V–8. Alt 6,390 ft. Center north side of NE¼SW¼ sec. 16, T. 27 N., R. 53 E., Mineral Hill quad., 1: 62,500, Nevada.

Didymograptus? sp.
Climacograptus eximius Ruedemann?
Glyptograptus sp.
Caryocaris sp. (A ceratiocarid crustacean.)

UCLA C–1. Alt 6,700 ft. 300 ft southwest of Chokecherry Spring. NW¼ SE¼SE¼ sec. 30, T. 27 N., R. 53 E., Mineral Hill quad., 1: 62,500, Nevada.

Dicellograptus divaricatus var. *salopiensis* Elles and Wood
sextans var. *exilis* Elles and Wood
Glyptograptus euglyphus var. *pygmaeus* (Ruedemann)

UCLA E–2. Alt 6,560 ft. Nevada footage coordinates, east zone, 375, 100 E., 1,968,000 N., Mineral Hill quad., 1 : 62,500, Nevada.

Leptograptus sp.
Dicellograptus sp.
Climacograptus cf. *C. modestus* Ruedemann
cf. *C. parvus* J. Hall
sp.
Amplexograptus? sp.
Glyptograptus teretiusculus (Hisinger)
Hallograptus cf. *H. mucronatus* (J. Hall)

Collections from the zone of *Climacograptus bicornis:*

UCLA R–6. Alt 6,275 ft. 1,200 ft south of Willow Spring, NW¼SW¼ sec. 19, T. 27 N., R. 53 E., Mineral Hill quad., 1 : 62,500, Nevada.

Didymograptus sagitticaulis Gurley
Glossograptus hincksii (Hopkinson)
Climacograptus eximius Ruedemann
sp.
Glyptograptus teretiusculus (Hisinger)
Orthograptus calcaratus var. *acutus* Lapworth
Orthograptus? sp.
Hallograptus bimucronatus (Nicholson)

UCLA 6–5. Alt 7,025 ft. Top of small hill, NW¼SW¼SW¼, sec. 2, T. 26 N., R. 52 E., Mineral Hill quad., 1 : 62,500, Nevada.

Cryptograptus tricornis (Carruthers)
Climacograptus bicornis (J. Hall)
Diplograptus multidens Elles and Wood

UCLA 52 N–7. Alt. 6,675 ft. On ridge northwest of Chokecherry Spring. SW. cor. NE¼SE¼ sec. 30, T. 27 N., R. 53 E., Mineral Hill quad., 1 : 62.500. Nevada.

Cryptograptus tricornis (Carruthers)
Dicranograptus sp.
Climacograptus bicornis (J. Hall)
sp.
Diplograptus multidens Elles and Wood
Amplexograptus perexcavatus (Lapworth)
Glyptograptus euglyphus var. *pygmaeus* (Ruedemann)
sp.
Orthograptus whitfieldi (J. Hall)

UCLA R–8. Alt. 6,050 ft. On north side of small valley. Center NE¼SW¼ sec. 13, T. 27 N., R. 52 E., Mineral Hill quad., 1 : 62,500, Nevada.

Glyptograptus teretiusculus (Hisinger)
Orthograptus whitfieldi (J. Hall)
sp.
Hallograptus? sp.
Caryocaris sp.

UCLA 6–2. Alt. 6,650 ft. Nevada footage coordinates, east zone, 375,000 E. 1,969,100 N., Mineral Hill quad., 1 : 62,500, Nevada.

Crytograptus tricornis (Carruthers)
Dicellograptus sp.
Climacograptus bicornis (J. Hall)
Orthopgraptus cf. *O. whitfieldi* (J. Hall)

UCLA E–12. Alt. 7,275 ft. East border SE¼SW¼NE¼ sec. 10, T. 26 N., R. 52 E., Mineral Hill quad. 1:62,500, Nevada.

Cryptograptus tricornis Carruthers
Dicellograptus sextans (J. Hall)
Dicranograptus nicholsoni var. *diapason* Gurley
Climacograptus bicornis (J. Hall)

UCLA E 2–1. Alt. 6,925 ft. On northeast side of small hill in SE¼NW¼SW¼ sec. 2, T. 26 N., R. 52 E., Mineral Hill quad., 1:62,500, Nevada.

Dicranograptus ramosus var. *longicaulis* Lapworth
Climacograptus sp. (New?, 5 cm long, widens from 1.0 mm proximally to a maximum of 1.8 mm in 2.5 cm and then narraws distally. 9 thecae in 10 mm. Apertural margins slightly introverted.)

UCLA 6–7. Alt. 6,575 ft. On south side of Grassy Canyon. E½NW¼SW¼ sec. 35, T. 27 N., R. 52 E., Mineral Hill quad., 1:62,500, Nevada.

Climacograptus sp. (Poorly preserved, may be same as *C.* n.? sp. in E2–1.)
Orthograptus cf. *O calcaratus* var.?
(May be from zone of *Orthograptus truncatus* var. *intermedius.*)

Collections from the zone of *Orthograptus truncatus* var. *intermedius:*

UCLA M 4–1. Alt. 6,500 ft. On north side of Williams Canyon, Nevada footage coordinates, east zone, 374,400 E., 1,961,000 N., Mineral quad., 1:62,500, Nevada.

Climacograptus antiquus Lapworth
sp.
Orthograptus cf. *O. truncatus* Lapworth

UCLA 6–2. Alt. 6,650 ft. Nevada footage coordinates, east zone, 375,000 E., 1,969,100 N., Mineral Hill quad., 1:62,500, Nevada.

Cryptograptus tricornis Carruthers
Dicranograptus nicholsoni Hopkinson
Dicranograptus n. sp. (Biserial part 2.1 mm long, spines on first 2 thecae only; uniserial branches diverge initially at 80° then bend outward and are 3.5 cm long, 0.7 mm wide. Thecae 12 in 10 mm.)
Orthograptus cf. *O. calcaratus* var.?
quadrimucronatus var.? (May be new var.)
truncatus cf. var. *intermedius* Elles and Wood
cf. *O. truncatus* var.?
Retiograptus pulcherrimus Keble and Harris
Orthoretiolites sp.

UCLA 52 N–8A. Alt. 6,580 ft. On southwest-facing slope. Center S½NE¼SE¼ sec. 30, T. 27 N., R. 53 E., Mineral Hill quad., 1: 62,500, Nevada.

Climacograptus parvus (Hall?)
Orthograptus truncatus cf. var. *intermedius* (Elles and Wood)
sp.

PINE VALLEY AND CARLIN QUADRANGLES, NEVADA

Over large areas of the Pine Valley and Carlin quadrangles Smith and Ketner have been mapping lithic and faunal equivalents of the Vinini and Valmy formations. They have not been entirely success-

ful in distinguishing the Ordovician from the Silurian in the "western facies" on a lithic basis. A very similar problem has been met by Gilluly and Masursky in the Cortez quadrangle where distinction would not have been possible without faunal evidence.

The graptolite beds, ranging in age from early Arenig to late Caradoc, are in thrust relation with rocks of the "eastern facies" along a north-south belt through both quadrangles.

Graptolites identified by localities are:

USGS D359 (CO). North side of Willow Creek. Center E½SE¼NW¼ sec. 36, T. 29 N., R. 52 E. Pine Valley quad., Nevada. This collection, made in 1956, is clearly mixed.

Didymograptus aff. *D. euodus* Lapworth
nicholsoni Lapworth
Isograptus caduceus var. *divergens* Harris
caduceus var. *maxima* Harris
n. sp. aff. *I. norvegicus* Monsen
Glossograptus cf. *G. hincksii* var. *fimbriatus* (Hopkinson)
Dicellograptus n. sp. (Like *D. angulatus.*)
Climacograptus n. sp. (aff. *C. caudatus* Lapworth.)
Glyptograptus? sp.
Orthograptus aff. *O. quadrimucronatus* (J. Hall) (1.4 mm wide, 20 thecae in 10 mm, periderm thin.)

This collection is a mixture of Llanvirn, Llandeilo, and Caradoc elements. As a result repeated efforts were made over the next 2 years to collect within intervals, close enough to delimit the cause of mixing. This effort was not entirely successful, as shown by USGS collection D442h (CO), but enough was learned to indicate considerable structural complexity in a very short distance along the side of Willow Creek.

USGS D359a–c (CO) were collected in 1957 from virtually the same place, but an effort was made to divide the locality into three zones to eliminate mixed faunas.

USGS D359a (CO)—easternmost collection.

Climacograptus aff. *C. tubuliferus* Lapworth
sp.
Amplexograptus cf. *A. arctus* Elles and Wood
Glyptograptus cf. *G. teretiusculus* (Hisinger)
sp.
Orthograptus aff. *O. truncatus* Lapworth
quadrimucronatus whitfieldi (J. Hall)
Retiolites? sp.

Age: This fauna is mixed but no species is older than Llandeilo.

USGS D359b (CO). 75 ft west of D359a (CO).

Dichograptus octobrachiatus (J. Hall)
Tetragraptus serra (Brogniart)
Phyllograptus anna J. Hall

Didymograptus extensus? J. Hall
aff. *D. nicholsoni* Lapworth
cf. *D. nicholsoni* var. *planus* Elles and Wood
Isograptus caduceus var. *divergens* Harris
caduceus mut. *nanus* Ruedemann
var. *victoriae* Harris
Climacograptus sp.

Age: Most of this fauna is Llanvirn (*Isograptus* zone). Some Arenig elements are present (Didymograptids).

USGS D359c (CO). 200 ft west of D359b (CO).
Dichograptus octobrachiatus (J. Hall)
Didymograptus cf. *D. gracilis* Törnquist
Didymograptus? cf. *D. spinosus* Ruedemann
Didymograptus sp. (Extensiform type.)
Isograptus caduceus var. *maxima* Harris
caduceus cf. *I. c.* var. *victoriae* Harris
sp.
Dicellograptus or *Dicranograptus* sp.
Climacograptus typicalis var. *crassimarginalis* Ruedemann and Decker
Glyptograptus sp.
Orthograptus calcaratus? var.
aff. *O. quadrimucronatus* (J. Hall)

Age: Part of this collection is Arenig, part Llanvirn (*Isograptus* zone), and part Caradoc (zone of *Orthograptus truncatus intermedius* or higher). It is clearly mixed.

In 1958, further efforts were made to study this locality in much smaller stratigraphic intervals in the attempt to obtain unmixed collections. The attempt was almost completely successful; the following USGS collections indicate complex structure (colln. D442–442i [CO]).

USGS D442 (CO). Valmy and Vinini formations. NE. "corner" of draw on north side of Willow Creek. Center SE¼NW¼ sec. 36, T. 29 N., R. 52 E. Pine Valley quad., Nevada.
Isograptus caduceus nanus Ruedemann
Glossograptus hincksii (Hopkinson)
Diplograptus decoratus? Harris and Thomas

Age: early Middle Ordovician zone of *Hallograptus etheridgei.*

USGS D442a (CO). Valmy and Vinini formations; 15 ft west of colln. D442. Pine Valley quad., Nevada.
Glossograptus hincksii (Hopkinson)
Amplexograptus? sp.
Glyptograptus cf. *G. intersitus* Harris and Thomas
sp.

Age: Middle Ordovician; possibly zone of *Hallograptus etheridgei.*

USGS D442b (CO). Valmy and Vinini formations; 15 ft west of colln. D442a (CO). Pine Valley quad., Nevada.
Leptograptus sp.
A nemagraptid?

Climacograptus aff. *C. scharenbergi* Lapworth
sp. (Tapering form which widens to 1.5 mm distally, has 13 thecae in 10 mm.)
Amplexograptus? sp.
Glyptograptus (Tapering form which widens to 2.5 mm distally and has 12 thecae in 10 mm.)

Age: Middle Ordovician—probably zone of *Climacograptus bicornis*, but may be next older—*Nemagraptus gracilis* zone.

USGS D44c (CO). Valmy and Vinini formations. 15 ft west of D442b. Pine Valley quad., Nevada.

Tetragraptus approximatus (Nicholson)
aff. *T. quadribrachiatus* (J. Hall)

Age: middle Early Ordovician approximately correlative with the Jefferson City dolomite. The fauna is that of the zone of *T. approximatus*.

USGS D442d (CO). Valmy and Vinini formations. Most westerly 20 ft along north side of gully to its northwest "corner." Otherwise same as D442 (CO). Pine Valley quad., Nevada.

Dichograptus sp. (Probably new.)
Didymograptus sp.
Isograptus caduceus var. *divergens* Harris (Small forms like Harris, 1933, fig. 16.)
caduceus var. *maxima* Harris
mut. *nanus*? Ruedemann
Isograptus? sp.
Trigonograptus ensiformis (J. Hall)

Age: Early Middle Ordovician zone of *Isograptus*.

USGS D442e (CO). Valmy and Vinini formations. About 25 ft west of D442d. Pine Valley quad., Nevada.

Climacograptus cf. *C. styloideus* Lapworth
Climacograptus? sp.
Orthograptus (Form widens from 1.5 mm proximally to 2.5 mm distally, has 12–13 thecae in 10 mm, and thecae have distinct apertural mucros.)
An archiretioletid?

Age: Probably Late Ordovician zone of *Orthograptus quadrimucronatus*.

USGS D442f (CO). Valmy and Vinini formations. About 30 ft. southwest of D442e. Pine Valley quad., Nevada.

Didymograptus sp. (Extensiform type.)
Dichograptus n. sp. (Funicle 2 mm long and 0.2 mm wide, second order stipes 1 mm long and 0.3 mm wide, third order stipes 0.5 mm wide proximally and widen gradually to 0.8 mm. Thecae number 11 in 10 mm. Second order stipes enclose a 110° angle and third order stipes enclose a 60° angle.)
Didymograptus n. sp. (Stipes diverge initially at 140° from the sicula then curve and become nearly horizontal. The stipes are 1 mm wide. The sicula is 0.5 mm long. The thecae number 14 in 10 mm and are inclined at a 30° angle to the stipe.)
Isograptus caduceus var. *divergens* Harris (Small form like Harris, 1933, fig. 16.)
caduceus var. *maxima* Harris.

Glossograptus n. sp. (This form is somewhat like *G. ciliatus* var. *debilis* Ruedemann but is longer and has a pointed proximal end.)
Ramulograptus surcularis n. gen. and n. sp.
Age: Early Middle Ordovician-*Isograptus* zone.

USGS D442g (CO). Valmy and Vinini formations. About 60 ft. southwest of colln. D442f. Pine Valley quad., Nevada.
Trichograptus immotus Harris and Thomas
Tetragraptus approximatus (Nicholson)
Didymograptus n. sp. (Extensiform-type stipes diverge at 180° angle from sicula and remain horizontal. They are 1.3 mm wide. The thecae number 10 in 10 mm and are inclined at a 35° angle to the stipe.)
Glossograptus? sp.
Climacograptus sp.
Age: With the exception of *T. approximatus*, this fauna is probably that of the zone of *Hallograptus etheridgei*. *T. approximatus* is the characteristic fossil of the mid-Early Ordovician zone which bears its name.

USGS D442h (CO). Valmy and Vinini formations. About 50 ft. west of D442g. Pine Valley quad., Nevada.
Didymograptus sp.
Isograptus caduceus var. *maxima* Harris
Climacograptus cf. *C. styloideus* Lapworth
sp.
Orthograptus quadrimucronatus (J. Hall)
An archiretiolitid
Age: This assemblage is a mixture of two zones. *Isograptus caduceus* var. *maxima* and *Didymograptus* sp. are early Middle Ordovician in age and represent the *Isograptus zone*. The other forms indicate the *Orthograptus quadrimucronatus* zone which is Late Ordovician in age.

USGS D442i (CO). Valmy and Vinini formations. On southwest-facing shoulder of next draw to west. About 200 ft. west of D442h. Pine Valley quad., Nevada.
Glyptograptus sp.
Orthograptus? sp.
Age: Probably late Middle Ordovician or possibly Late Ordovician.

Other collections that have been made in the Pine Valley and Carlin quadrangles are listed as follows:

USGS D360 (CO). Sec. 1, T. 27 N., R. 52 E., Sulfur Springs Range. Pine Valley quad., Nevada.
Climacograptus bicornis J. Hall
Glyptograptus sp.
Age: Probably zone of *Climacograptus bicornis*.

USGS D389 (CO). Sec. 36, T. 28 N., R. 52 E., in saddle south of highest knob. Pine Valley quad., Nevada.
Climacograptus scharenbergi Lapworth
sp.
Amplexograptus sp.
Age: Probably zone of *Climacograptus bicornis*.

USGS D443 (CO). Valmy and Vinini formations NE¼NE¼SE¼SE¼NW¼ sec. 1, T. 27 N., R. 52 E. Pine Valley quad., Nevada.

Climacograptus bicornis (J. Hall)
sp.
Glossograptus? sp.
Dicranograptus? sp.
Dicellograptus? sp.

Age: Middle Ordovician zone of *Climacograptus bicornis*.

USGS. D453 (CO). Valmy formation. NE¼SW¼SE¼NE¼ sec. 31, T. 33 N., R. 53 E. Carlin quad., Nevada.

Dicellograptus pumilus Lapworth
sp.
Climacograptus cf. *C. tubuliferus* Lapworth
sp.
sp. (2+mm wide, 10 thecae in 10 mm, long virgella.)
sp. (1.5 mm wide, 11 thecae in 10 mm.)
Diplograptus sp.
Glyptograptus sp.
sp. (2.5 mm wide as a maximum and form tapers proximally, 12–14 thecae in 10 mm.)
sp. (1.5 mm wide, 13–14 thecae in 10 mm.)
Orthograptus calcaratus subsp.?
of the *calcaratus* type
cf. *O. quadrimucronatus* (J. Hall)
quadrimucronatus cf. *O. q. postremus* Ruedemann
subsp.? (2.7 mm wide; 10 thecae in 10 mm.)
var.? (2.4 mm wide, 12 thecae in 10 mm.)
of the *truncatus* type with 17 thecae in 10 mm.
n. sp. cf. *O. whitfieldi* Elles and Wood [not *O. whitfieldi* (J. Hall)].
sp. (Form widens from 1.5 mm proximally to 2.5 mm distally, has 9–13 thecae in 10 mm, and has distinct but short mucros at the distal edges of the thecae.)
sp.

Age: Probably Late Ordovician, zone of *Orthograptus quadrimucronatus*. The fauna of colln. D453 (CO) appears to be slightly younger than D454 (CO).

USGS D454 (CO). Valmy formation. Center SW¼NW¼ sec. 31, T. 33 N., R. 53 E. Carlin quad., Nevada.

Leptograptus sp.
Dicellograptus? sp.
Dicranograptus cf. *D. brevicaulis* Elles and Wood
Climacograptus cf. *C. caudatus* Lapworth
aff. *C. modestus* Ruedemann
spiniferus Ruedemann
aff. *C. styloideus* Lapworth
sp.
sp. (2+ mm wide, 10 thecae in 10 mm, long virgella.)
sp. (1.5 mm wide, 13–14 thecae in 10 mm.)
Diplograptus? sp.

Glyptograptus aff. *G. euglyphus* var. *pygmaeus* Ruedemann
sp. of coll. 453?
sp. (2.2 mm wide, 14–15 thecae in 10 mm.)
sp.
Orthograptus sp. of the *O. quadrimucronatus* type
Orthograptus? sp.

Age: Late Middle Ordovician. The general aspect of this fauna is that of the zone of *Orthograptus truncatus* var. *intermedius* (=zone of *Climacograptus wilsoni* of Elles and Wood).

USGS D501 (CO). E½ sec. 31, T. 33 N., R. 53 E. Carlin quad., Nevada.
Climacograptus sp.
Amplexograptus cf. *A. perexcavatus* (Lapworth)
Glyptograptus cf. *G. teretiusculus* (Hisinger)
sp.
Orthograptus calcaratus var?
aff. *O. quadrimucronatus* (J. Hall)

Age: Zone of *Climacograptus bicornis* or of *Orthograptus truncatus intermedius*.

USGS D502 (CO). W½ sec. 31, T. 33 N., R. 53 E. Carlin quad., Nevada.
Dicranograptus or *Dicellograptus* sp.
Climacograptus sp.
Glyptograptus cf. *G. teretiusculus* (Hisinger)

Age: Late Middle or Late Ordovician.

USGS D160 (CO). Center sec. 21, T. 33 N., R. 51 E., half a mile northwest of Cherry Spring at alt. 6,600 ft., Carlin quad., Nevada. Collected by R. E. Lehner.
Dicranograptus sp.

Age: Probably late Middle Ordovician.

NORTHERN EUREKA COUNTY, INCLUDING BEOWAWE QUADRANGLE, NEVADA

A considerable number of graptolites have been collected from the Beowawe quadrangle, which has not been mapped in detail. R. J. Roberts and R. E. Lehner, in connection with their work on the geology of Eureka County, obtained most of them. Collections along Marys Creek proved of such interest that these stratigraphically high Ordovician and Silurian localities were revisited in 1958 by Roberts, accompanied by P. E. Cloud, J. F. Smith, and us.

Ordovician collections are listed as follows:

USGS D158 (CO). Approximately 11.5 miles northwest of Carlin. Sec. 26, T. 34 N., R. 50 E., Tuscarora Mts., Nev.
Didymograptus? sp. [If this really is a *Didymograptus* (large fragment without proximal part) it probably is *D. superstes*.]
Dicellograptus cf. *D. divaricatus* (J. Hall)
Diplograptus cf. *D. multidens* var. *diminutus* Ruedemann
Amplexograptus sp.

Age: Probably zone of *Climacograptus bicornis*.

USGS D159 (CO). Near the head of James Creek. NW¼NW¼ sec. 17, T. 33 N., R. 51 E., Tuscarora Mts., Nev.

Amplexograptus aff. *A. confertus* (Lapworth)
Orthograptus sp. (cf. *O. truncatus* type?)
Age: Probably late Middle Ordovician.

USGS D161 (CO). At crest of range, a quarter of a mile north of saddle, SW¼SW¼ sec. 20, T. 33 N., R. 51 E. Beowawe quad., Nevada.
Leptograptus cf. *L. annectans* var.?
Climacograptus cf. *C. tubuliferus* Lapworth
Glyptograptus sp. (1.5 mm wide, 13–14 thecae 10 mm; same sp. in D453 (CO), Carlin quad.)
Orthograptus calcaratus Lapworth.
quadrimucronatus (J. Hall)
truncatus var. *pertenuis* (Ruedemann)
sp. (Widens from 1.5 mm proximally to 2.5 mm distally, 9–13 thecae 10 mm, distinct but short mucros at distal edges of thecae; same sp. in D453 (CO), Carlin quad.)
Retiograptus n. sp. (Like *R. pulcherrimus* of Keble and Harris, 1934, except Australian form is thicker and lacks distinct thecal spines.)
Age: Zone of *Orthograptus quadrimucronatus.*

USGS D162 (CO). Near head of Marys Creek, one-third of a mile east of creek, N½NW¼NE¼ sec. 25, T. 33 N., R. 50 E. Beowawe quad., Nevada.
Dicranograptus kirki Ruedemann
Climacograptus cf. *C. spiniferus* Ruedemann
Orthograptus of the *quadrimucronatus* type (3.5 mm wide, 12 thecae in 10 mm.)
Orthoretiolites hami Whittington
Age: Zone of *Orthograptus truncatus* var. *intermedius.*

USGS D163 (CO). On Marys Creek, half a mile southwest of D162 (CO), highest collection of Vinini. South side of draw west of Marys Creek, S½NW¼NW¼ sec. 25, T. 33 N., R. 50 E. Beowawe quad., Nevada.
Dicellograptus cf. *D. complanatus* Lapworth
Climacograptus bicornis var. *longispina* T. S. Hall
hastatus var. *americanus* Ruedemann
tubuliferus Lapworth
Orthograptus cf. *O. calcaratus* Lapworth
Arachniograptus laqueus n. sp.
Age: Mixed fauna from zone of *Dicellograptus complanatus* and from zone of *Orthograptus quadrimucronatus.*

USGS D164 (CO). Center T. 34 N., R. 50 E., Tuscarora Mts., Nev.
Climacograptus caudatus Lapworth
Climacograptus? sp.
Age: Late Middle or Late Ordovician.

USGS D165 (CO). Sec. 18, T. 35 N., R. 51 E., Tuscarora Mts., Nev.
Climacograptus cf. *C. bicornis* (J. Hall)
Glyptograptus cf. *G. teretiusculus* (Hisinger)
Age: Probably zone of *Climacograptus bicornis*

USGS D166 (CO). Sec. 12, T. 35 N., R. 50 E., Tuscarora Mts., Nev.
Glossograptus cf. *G. hincksii* (Hopkinson)
Amplexograptus cf. *A. macer* Ruedemann

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Glyptograptus sp. [May be same sp. as in D161 (CO) and D453 (CO).]
Orthograptus cf. *O. truncatus* var. *intermedius* Elles and Wood sp.
Age: Zone of *O. truncatus* var. *intermedius*.

USGS D477 (CO). Vinini formation. South side of U.S. Highway 40 at Emigrant Pass, about 100 ft west of sign for summit. West of Carlin Nev.
Dicellograptus sp. (Spinose form? same as in D540.)
Climacograptus tubuliferus? Lapworth
sp. (Same *C.* sp. as in D540.)
Age: Zone of *Orthograptus quadrimucronatus*.

USGS D478a (CO). Valmy and Vinini formations. Marys Creek, 4.5 miles north of U.S. Highway 40. West side of creek. Beowawe quad., Nevada.
Dicellograptus gurleyi Lapworth
Dicranograptus aff. *D. spinifer* Elles and Wood
Climacograptus bicornis (J. Hall)
sp.
Glyptograptus tercticusculus (Hisinger)
Orthograptus calcaratus cf. *O.c.* var. *acutus* Lapworth
Age: Zone of *Climacograptus bicornis*.

USGS D480a–e (CO). In tributary draw west of Marys Creek, SW¼SE¼-NW¼NW¼ sec. 25, T. 33 N., R. 50 E., Beowawe quad., Nevada. Ordovician beds dip very steeply westward, between faulted Silurian on the east and Silurian on the west. Positions of collections measured from fault separating argillaceous sandy Silurian beds on east, at mouth of draw on south side.

USGS D480a (CO). 150 ft west of fault.
Specimens from bedrock:
Leptograptus sp.
Dicellograptus complanatus var. *ornatus* Elles and Wood
Climacograptus bicornis (Hall) var. *longispina* T. S. Hall
hastatus T. S. Hall
var. *angustus* n. var. Ross and Berry
tubuliferus? Lapworth
sp. (With spines.)
Diplograptus sp.
Glyptograptus? n. sp. [Possibly n. sp. described from loc. 1368 (SD).]
Orthograptus truncatus var. *socialis* Lapworth
sp. (12 thecae in 10 mm, 3.5 mm wide.)
sp.?
Orthograptus of *truncatus* type or *Glyptograptus* sp. (12 thecae in 10 mm, 3 mm wide.)
Arachniograptus? sp.
Specimens from float:
Dicellograptus complanatus Lapworth
complanatus var. *ornatus* Elles and Wood
cf. *D. complanatus* var. *ornatus* Elles and Wood
Climacograptus bicornis var. *longispina* T. S. Hall
hastatus T. S. Hall
var. *angustus* n. var.
sp. (small.)
sp.?

Diplograptus sp.? (Small.)
Glyptograptus altus n. sp.
Orthograptus sp.
Age: Zone of *Dicellograptus complanatus*.

USGS D480b (CO). 104 ft west of fault.
Climacograptus hastatus var. *angustus* n. var.
mississippiensis Ruedemann
cf. *C. mississippiensis* Ruedemann
Climacograptus? cf. *C. tubuliferus* Lapworth
Diplograptus sp.?
Orthograptus aff. *O. truncatus* var. *socialis* Lapworth
sp.?
Age: Zone of *Dicellograptus complanatus*.

USGS D840c (CO). 57–84 ft west of fault.
Specimens from bedrock:
Dicellograptus? sp.
Climacograptus sp.
Diplograptus? sp.
Glyptograptus? sp.
Orthograptus? sp.
Specimens from overlying float:
Dicellograptus cf. *D. complanatus* Lapworth
Climacograptus hastatus T. S. Hall
sp. (With spines.)
Diplograptus sp.
Orthograptus truncatus var. *socialis* Lapworth
Orthograptus? sp.
Age: Of bedrock uncertain; of float, zone of *Dicellograptus complanatus*.

USGS D480d (CO). 35–57 ft west of fault.
Glyptograptus altus Ross and Berry n. sp.
Glyptograptus? sp.
Orthograptus? sp.
Age: Zone of *Dicellograptus complanatus* or of *Orthograptus quadrimucronatus*.

USGS D480e (CO). 15–35 ft west of fault over Silurian.
Specimens from bedrock:
Didymograptus? sp. (Fragments.)
Pleurograptus? sp. (Stipes.)
Climacograptus sp. (With spines.)
sp.
Climacograptus? sp.
Diplograptus? sp.
Amplexograptus? sp. or *Diplograptus*? sp.
Glyptograptus altus Ross and Berry n. sp.
sp.
Glyptograptus? sp.
sp. (Or might be distal end of *Diplograptus* sp.)
Orthograptus quadrimucronatus (J. Hall)
cf. *O. quadrimucronatus* (J. Hall)
quadrimucronatus (J. Hall) var?
sp.

Orthograptus? sp.
Retiograptus pulcherrimus Keble and Harris
(Like *R. pulcherrimus* Keble and Harris but has spines.)
Age: Zone of *Orthograptus quadrimucronatus*.

Specimens from float:
Dicellograptus cf. *D. angulatus* Elles and Wood (Cannot see thecae but shape of axil, uniform width of stipe the same. Has lateral spines and sicula is long as in *D. angulatus*.)
sp.
sp. (Fragments.)
Climacograptus cf. *C. brevis* Elles and Wood
mississippiensis Ruedemann
sp. (Small with three spines.)
sp. (1+ cm long, widens from 0.8 mm to 2.0 mm deep thecal excavations, 12 thecae in 10 mm.)
sp. (3 mm wide, parallel sided, 9 thecae in 10 mm.)
Diplograptus n. sp.
Diplograptus sp.?
Glyptograptus sp. (Widens from 1 mm wide proximally to 3+ mm distally.)
sp.
Orthograptus quadrimucronatus (J. Hall)
cf. *O. truncatus* Lapworth type
sp.
Retiograptus pulcherrimus Keble and Harris
(Like *R. pulcherrimus* Keble and Harris but with spines.)

USGS. D507 (CO). Valmy or Vinini formation.
Same locality as D163 (CO).
Leptograptus sp.
Dicellograptus cf. *D. complanatus* var. *ornatus* Elles and Wood
Climacograptus hvalross Ross and Berry, n. sp.
supernus Elles and Wood
Glyptograptus sp.
Orthograptus quadrimucronatus (J. Hall)
truncatus (two different varieties not definitely identifiable.)
Retiograptus n. sp. (Like *R. pulcherrimus* but this form is thinner and has thecal spines.)
Age: Mixture of *D. complanatus* and *O. quadrimucronatus* zones

USGS. D540 (CO). Emigrant Pass, U.S. Highway 40, SW¼NW¼ sec. 14, T. 32 N., R. 50 E. Beowawe quad., Nevada.
Dicellograptus sp.
Climacograptus sp. (Large.)
sp. (Small.)
Orthograptus quadrimucronatus (J. Hall)
Age: Zone of *Orthograptus quadrimucronatus*.

USGS. D541 (CO). Sec. 9, T. 34 N., R. 50 E., Tuscarora Mts., Nev. This is a mixed collection and may therefore indicate the position of a fault.
Cryptograptus schäferi (Lapworth)
Age: Zone of *Hallograptus etheridgei*
Monograptus sp. (A robust form with hooked thecae.)
Age: Probably Wenlock-Middle Silurian.

54–F–72 NE¼, T. 35 N., R. 50 E., Tuscarora Mts., Nev.
Climacograptus sp.
Age: Probably Ordovician.

CORTEZ AND FRENCHIE CREEK QUADRANGLES, NEVADA

J. Gilluly and H. Masursky have mapped the Cortez quadrangle where Cambrian to Devonian rocks of the "eastern shelf" facies form an imposing cliff above the site of the old mining camp of Cortez. Over these rocks Ordovician and Silurian cherts and argillites have been thrust from the west.

Graptolites so far collected in the quadrangle range in age from Early Ordovician to Silurian. Silurian forms have been obtained from rocks of both "eastern" and "western facies."

Two collections were made by Lehner and Roberts from the Frenchie Creek quadrangle in the course of mapping Eureka County (D150 [CO]), D157 [CO]).

Ordovician collections from quadrangles are listed as follows:

USGS D392 (CO). Vinini formation. Alt 7,650 ft, 200 ft north, 400 ft west of NE. cor. sec. 3, T. 26 N., R. 48 E. Nevada footage coordinates, central zone, 534,250 E., 1,969,750 N., Cortez quad., Nevada.
Didymograptus? sp.
Cryptograptus? sp.
Glossograptus hincksii Hopkinson
Climacograptus sp.
Glyptograptus cf. *G. teretiusculus* (Hisinger)
Age: Somewhere in the range between zone of *Hallograptus etheridgei* and of *Orthograptus truncatus* var. *intermedius*.

USGS D393 (CO). Vinini formation. Alt 6,000 ft, 1,700 ft north, 4,400 ft east of SW. cor., sec. 33, T. 26 N., R. 48 E. Nevada footage coordinates, central zone, 528,800 E., 1,939,500 N., Cortez quad., Nevada.
Dicellograptus or *Dicranograptus* sp.
Climacograptus cf. *C. spiniferus* Ruedemann
sp.
Glyptograptus cf. *G. teretiusculus* (Hisinger)
Orthograptus calcaratus var.?
Age: Probably zone of *Orthograptus truncatus* var. *intermedius*.

USGS D539 (CO). Vinini formation. Alt 6,600 ft 1,200 ft north, 5,600 ft east of SW. cor. sec. 28, T. 26 N., R. 48 E. Nevada footage coordinates, central zone, 529,800 E., 1,944,300 N., Cortez quad., Nevada.
Orthograptus aff. *O. whitfieldi* (J. Hall)
Age: Late Middle Ordovician.

USGS D394 (CO). Vinini formation. Alt 6,325 ft 700 ft north, 3,400 ft east SW. cor., sec. 28, T. 26 N., R. 48 E. Nevada footage coordinates, central zone, 527,600 E., 1,943,900 N., Cortez quad., Nevada.
Dicellograptus sp.
Climacograptus bicornis J. Hall
sp.

Glyptograptus sp.
Orthograptus? sp.
Age: *Climacograptus bicornis* zone.

USGS D395 (CO). Vinini formation. Alt 5,625 ft 2,700 ft north, 7,200 ft west of SE. cor., T. 27 N., R. 47 E. Nevada footage coordinates, 507,000 E., 1,972,300 N., Cortez quad., Nevada.
Climacograptus sp.
Amplexograptus cf. *A. perexcavatus* Lapworth
Glyptograptus? sp.
Orthograptus? sp.
Age: Probably zone of *Climacograptus bicornis.*

USGS D444 (CO). Valmy formation. SW¼SE¼NW¼NE¼ sec. 22, T. 25 N., R. 47 E. Alt 6,525 ft Cortez quad., Nevada.
Glossograptus cf. *G. hincksii* (Hopkinson)
Dicellograptus aff. *D. divaricatus* var. *salopiensis* Elles and Wood
Climacograptus cf. *C. scharenbergi* Lapworth
sp. (Small.)
sp. (Twisted.)
Glyptograptus? sp.
Age: Probably zone of *Nemagraptus gracilis;* possibly zone of *Climacograptus bicornis.*

USGS D445 (CO). Valmy formation. Center S½NW¼NW¼NE¼, sec. 22, T. 25 N., R. 47 E. Cortez quad., Nevada.
Cryptograptus schäferi (Lapworth)
Climacograptus? sp.
Trigonograptus ensiformis (J. Hall)?
Probably age: Llanvirn. Zone of *Hallograptus etheridgei.*

USGS D446 (CO). Valmy formation. Center of west boundary of NW¼NW¼ NE¼ sec. 22, T. 25 N., R. 47 E. Alt 6,650 ft. Cortez quad., Nevada.
Cryptograptus tricornis Carruthers
Glossograptus hincksii (Hopkinson)
Glyptograptus? sp.
Age Middle Ordovician. Zone of *Hallograptus etheridgei* to zone of *Climacograptus bicornis.*

USGS D447 (CO). Valmy formation. In small saddle with alt 6,725 ft on boundary between NE¼ and SE¼ of SW¼SW¼ sec. 15, T. 25 N., R. 47 E. Cortez quad., Nevada.
Climacograptus sp. (Small.)
Glyptograptus? sp. or *Orthograptus*? sp.
Age: Probably zone of *Climacograptus bicornis* or zone of *Orthograptus truncatus* var. *intermedius.*

USGS D482 (CO). East of Bald Mtn., and south of Copper Canyon, slightly north of center NE¼SW¼ sec. 10, T. 25 N., R. 47 E. Cortez quad., Nevada.
Cryptograptus? sp.
Glossograptus hincksii (Hopkinson)
Climacograptus? sp.
Amplexograptus? sp.
Glyptograptus aff. *G. euglyphus* var. *pygmaeus* Ruedemann
sp.
Age: Middle Ordovician. Zone of *Hallograptus etheridgei* to zone of *Climacograptus bicornis.*

USGS D483 (CO). Valmy formation. East of Bald Mtn. Alt 8,050 ft, center N½SW¼NW¼ sec. 9, T. 25 N., R. 47 E. Cortez quad., Nevada.

Clonograptus sp.? or *Didymograptus* sp.?

Tetragraptus sp?

n. sp.? (Type of *T. quadribrachiatus*, possibly same new species as is present in Garden City formation, with short funicle.)

?*Climacograptus* sp.

Age: Early Ordovician, except for questionable *Climacograptus*.

USGS D484 (CO). Southwest side of Bald Mtn. Alt 8,450 ft, SW¼NE¼ SE¼NE¼ sec. 8, T. 25 N., R. 47 E. Cortez quad., Nevada

Fragment of *Dicellograptus*? sp.

Glyptograptus sp.

Age: Ordovician.

USGS D485 (CO). Valmy formation. Near Bald Mtn. Alt 6,675 ft, center S½NW¼SW¼ sec. 10, T. 25 N., R. 47 E. Cortez quad., Nevada.

Tetragraptus fruticosus (J. Hall)

Didymograptus extensus (J. Hall)?

sp. or *Tetragraptus* sp.

Age: Late Canadian (post Jefferson City equivalent).

USGS D486 (CO). Vinini formation. Alt 6,525 ft, SW¼SW¼NE¼ sec. 30, T. 25 N., R. 48½ E. Cortez quad., Nevada.

Dicellograptus? sp. (Fragment.)

Climacograptus cf. *C. phyllophorus* Gurley (See pl. 8, fig. 17.)

sp.

Amplexograptus? sp.

Orthograptus of the *O. calcaratus* type.

Caryocaris sp. (A ceratiocarid crustacean.)

Age: Late Middle or Late Ordovician.

USGS D487 (CO). Vinini formation. Alt 6,300 ft, NE¼SE¼NE¼, sec. 24, T. 25 N., R. 48 E. Cortez quad., Nevada.

Climacograptus cf. *C. phyllophorus* Gurley

Age: Probably zone of *Nemagraptus gracilis* or of *Climacograptus bicornis*.

USGS D488 (CO). Vinini formation. Alt 6,675 ft, SW¼NW¼SW¼ sec. 31, T. 25 N., R. 48½ E. Cortez quad., Nevada.

Climacograptus? sp.

Amplexograptus aff. *A. arctus* Elles and Wood

Glyplograptus? sp.

Age: Probably Middle Ordovician. Zone of *Hallograptus etheridgei* to zone of *Climacograptus bicornis*.

USGS D150 (CO). Alt 7,400 ft. Nevada footage coordinates, east zone, 268,000 E., 1,997,000 N., Horse Creek Valley quad., Nevada. Collected by R. J. Roberts and R. E. Lehner.

Glossograptus hincksii (Hopkinson)

Orthograptus aff. *O. truncatus* Lapworth

Age: Probably zone of *Climacograptus bicornis*.

USGS D157 (CO). Alt 6,780 ft. Nevada footage coordinates, east zone, 264,800 E., 1,998,100 N., At head of north fork of Brock Canyon, Horse Creek Valley quad., Nevada. Collected by R. E. Lehner and R. J. Roberts.

Orthograptus cf. *O. truncatus* Lapworth
aff. *O. truncatus* Lapworth
Climacograptus caudatus Lapworth
sp.
Dicranograptus sp.

Age: Probably zone of *Orthograptus truncatus* var. *intermedius* but possibly zone of *Orthograptus quadrimucronatus*.

MOUNT LEWIS AND CRESCENT VALLEY QUADRANGLES, NEVADA

James Gilluly and assistants have spent several years mapping the geology of Mount Lewis and Crescent Valley quadrangles in which at least two windows of "eastern facies" rocks are surrounded by cherts and argillites of Ordovician and (or) Silurian age. The structure is extremely complex.

Graptolites from these quadrangles have been identified as follows. They range in age from Arenig to Ashgill; collections from the Mount Lewis quadrangle are listed first.

USGS D102 (CO). West of Gold Acres, alt 6,200 ft, Nevada footage coordinates, central zone, 467,175 E., 2,008,750 N., Mt. Lewis quad., Nevada.

Dicellograptus sextans (J. Hall)
Climacograptus aff. *C. scharenbergi* Lapworth
sp.
Glyptograptus euglyphus var.?
euglyphus var. *pygmaeus* Ruedemann
aff. *G. teretiusculus* (Hisinger)
Glyptograptus? sp.
Orthograptus quadrimucronatus var. *whitfieldi* (J. Hall)
cf. *O. calcaratus* Lapworth
Trigonograptus martellii n. sp.

Age: Zone of *Climacograptus bicornis*, except for *Trigonograptus* which has previously been reported no higher than zone *Glyptograptus teretiusculus*. This may be anomalous.

USGS D103 (CO). South of Gray Eagle mine, in cherty black shale associated with quartzite. Alt 6,860 ft. Nevada footage coordinates, 474,300 E., 2,044,550 N., Mt. Lewis quad., Nevada.

Dicellograptus gurleyi? Lapworth
intortus Lapworth

Age: Zone of *Nemagraptus gracilis* or *Climacograptus bicornis*.

USGS D110 (CO). Alt 6,500 ft, west of center, sec. 21, T. 29 N., R. 46 E., Mt. Lewis quad., Nevada.

Climacograptus cf. *C. brevis* Elles and Wood

Age: Zone of *Nemagraptus gracilis* or *Climacograptus bicornis*.

USGS D111 (CO). N.W. cor., sec. 34, T. 29 N., R. 46 E., Mt. Lewis quad., Nevada.

Didymograptus cf. *D. serratulus*
Glossograptus hincksii var. *fimbriatus* Hopkinson
Dicranograptus? sp.
Climacograptus cf. *C. eximius* Ruedemann
scharenbergi Lapworth

Glyptograptus euglyphus var. *pygmaeus*? Ruedemann
Orthograptus? sp.
Age: Probably zone of *Climacograptus bicornis*.

USGS D112 (CO). Alt 8,200 ft south fork, Cook Creek divide, east of Mill Creek summit, NE¼ sec. 14, T. 28 N., R. 45 E., Mt. Lewis quad., Nevada.
Dicellograptus sextans (J. Hall)
sextans var. *exilis* Elles and Wood
sp.
Glyptograptus euglypus var. *pygmaeus*? Ruedemann
Age: Probably zone of *Nemagraptus gracilis*.

USGS D113 (CO). Alt 5,860 ft 1,500 ft north from BM 5584 at junction of Ferris and Indian Creeks, Mt. Lewis quad., Nevada.
?*Didymograptus* sp.
Glossograptus hincksii Hopkinson
Climacograptus riddellensis Harris
Diplograptus sp.
Amplexograptus aff. *A. arctus* Elles and Wood
Amplexograptus? sp.
Glyptograptus cf. *G. euglyphus* Lapworth
cf. *G. teretiusculus* Hisinger
Trigonograptus cf. *T. ensiformis* (J. Hall)
Age: Probably zone of *Glyptograptus teretiusculus* (Llandeilo) but may be zone lower.

USGS D114 (CO). South of Ferris Creek junction with Indian Creek, east of center of sec. 2, T. 28 N., R. 46 E., Mt. Lewis quad., Nevada.
Didymograptus? sp.
Age: Early Ordovician.

USGS D115 (CO). West head of Lewis Canyon, extreme south center of sec. 35, T. 30 N., R. 45 E., Mt. Lewis quad., Nevada.
Dichograptus sp.
Dichograptid, possibly a *Didymograptus*
Caryocaris? sp. (A ceratiocarid crustacean.)
Age: Early Ordovician.

USGS D116 (CO). Above road in Lewis Canyon, alt 5,900 ft just southeast of center of sec. 23, T. 30 N., R. 45 E.
Didymograptus cf. *D. serratulus* (J. Hall)
Cryptograptus tricornis (Carruthers)
Glossograptus hincksii var. *fimbriatus* Hopkinson
Nemagraptus aff. *N. exilis* Lapworth
Dicellograptus divaricatus var. *salopiensis* Elles and Wood
sextans (J. Hall)?
var. *exilis* Elles and Wood
Climacograptus cf. *C. scharenbergi* Lapworth
sp.
Glyptograptus cf. *G. teretiusculus* (Hisinger)
Retiograptus geinitzianus (J. Hall)
Age: Zone of *Nemagraptus gracilis*.

USGS. D117 (CO). 600 ft east of SW. cor. sec. 23, T. 29 N., R. 46 E., Mt. Lewis quad., Nevada.
Didymograptus? sp.

Climacograptus eximius Ruedemann
Diplograptus? sp.
Glyptograptus cf. *G. euglyphus* var. *pygmaeus* Ruedemann
sp.

Age: Probably zone of *Climacograptus bicornis*, may be zone of *Nemagraptus gracilis*.

USGS. D118 (CO). Alt 6,080 ft on spur southwest of BM 5740 on road 2 miles southeast of Utah mine camp. Mt. Lewis quad., Nevada.

Didymograptus? sp.
Cryptograptus tricornis Carruthers
Glossograptus aff. *G. hystrix* Ruedemann
Nemagraptus exilis var. *linearis* Ruedemann
Dicellograptus aff. *D. divaricatus* var. *salopiensis* Elles and Wood
cf. *D. sextans* var. *exilis* Elles and Wood
Dicellograptus? sp. or *Dicranograptus*? sp.
Glyptograptus teretiusculus (Hisinger)?
Glyptograptus? sp.
Retiograptus geinitzianus (J. Hall)

Age: Probably the zone of *Nemagraptus gracilis*.

USGS. D119 (CO). Alt 6,480 ft, near barite mine, center sec. 28, T. 28 N., R. 45 E., Mt. Lewis quad., Nevada.

Dicranograptus contortus Ruedemann?

Age: Probably zone of *Nemagraptus gracilis* or *Climacograptus bicornis*.

USGS. D120 (CO). Alt 7,080 ft, north side of Horse Canyon, NE¼ sec. 4, T. 29 N., R. 45 E., Mt. Lewis quad., Nevada.

Cryptograptus tricornis (Carruthers)
Glossograptus cf. *G. hincksii* (Hopkinson)
Climacograptus aff. *C. scharenbergi* Lapworth
sp.
Glyptograptus cf. *G. teretiusculus* (Hisinger)
Glyptograptus? sp.

Age: Zone of *Nemagraptus gracilis* or *Climacograptus bicornis*.

USGS. D121 (CO). Alt 6,480 ft, 1.5 miles east-southeast of Utah mine camp, on southeast spur of hill 6838, Mt. Lewis quad., Nevada.

Didymograptus? sp.
Glossograptus cf. *G. hincksii* Hopkinson
Dicranograptus? sp. or *Dicellograptus*? sp.
Climacograptus sp. (Possibly a minute species of type of *C. scharenbergi.*)
Climacograptus? sp.

Age: Probably zone of *Nemagraptus gracilis*, but could be zone of *Climacograptus bicornis*.

USGS. D123 (CO). Alt 6,160 ft on northeast spur of hill 6821, 3,500 ft west-southwest of BM 5740 on road southeast of Utah mine, Mt. Lewis quad., Nevada.

Tetragraptus fruticosus (J. Hall) (Three-branched form.)
Didymograptus? sp.

Age: Late Canadian. Equivalent to high Garden City but older than basal shale of the Swan Peak. Zone of *Tetragraptus fruticosus* (3- and 4-branched forms) or zone of *Didymograptus protobifidus*.

USGS D124 (CO). Alt. 7,100 ft, south side of middle fork, Mill Creek, northeast edge of sec. 10, T. 28 N., R. 45 E., Mt. Lewis quad., Nevada.

Climacograptus? sp.

?*Glyptograptus* sp.

Age: Probably zone of *Nemagraptus gracilis* or *Climacograptus bicornis*, but may be older.

USGS D125 (CO). Alt. 6,200 ft., on spur west of border of sec. 27, T. 29 N., R. 46 E., Mt. Lewis quad., Nevada.

Climacograptus? sp.

Age: Probably Ordovician, but might be Silurian.

USGS D127 (CO). 800 ft. south, 3,600 ft. west of NE. cor. of sec. 31, T. 28 N., R. 46 E., Mt. Lewis quad., Nevada

Dicellograptus? sp.

Climacograptus sp. (1.5 mm wide, 1.5 cm long, 12 thecae in 10 mm.)

Glyptograptus sp.

Age: Probably zone of *Nemagraptus gracilis* or *Climacograptus bicornis*.

USGS D128 (CO). Alt. 8,200 ft., north of head of south fork of Mill Creek, NW¼ sec. 12, T. 28 N., R. 45 E., Mt. Lewis quad., Nevada.

Glyptograptus sp.

Orthograptus of the type of *O. quadrimucronatus*

Age: Probably zone of *Climacograptus bicornis* or *C. wilsoni*.

USGS D129 (CO). Alt. 8,600 ft. middle fork of Ferris Creek divide, SE¼ sec. 1, T. 28 N., R. 45 E., Mt. Lewis quad., Nevada.

Cryptograptus tricornis (Carruthers)

Glossograptus hincksii (Hopkinson)

Climacograptus aff. *C. scharenbergi* Lapworth

sp. (Long and thin; 4.5 cm long, 1.3 mm wide, deeply pouched thecae.)

Diplograptus multidens var.?

Glyptograptus cf. *G. euglyphus* (Lapworth)

aff. *G. tercticusculus* (Hisinger)

Orthograptus calcaratus var.?

Age: Zone of *Climacograptus bicornis*.

USGS D130 (CO). Alt. 7,320 ft., divide between middle and south forks of Mill Creek, NE¼ sec. 10, T. 28 N., R. 45 E., Mt. Lewis quad., Nevada.

Glossograptus cf. *G. hincksii* var. *fimbriatus* (Hopkinson)

Climacograptus of type of *C. scharenbergi* Lapworth

sp.

Amplexograptus? sp.

Glyptograptus cf. *G. euglyphus* (Lapworth)

cf. *G. teretiusculus* (Hisinger)

Glyptograptus? sp.

Age: Probably zone of *Climacograptus bicornis*, but may equal zone of *Nemagraptus gracilis*.

USGS D131 (CO). Alt. 8,260 ft., NW¼ sec. 6, T. 28 N., R. 46 E., Mt. Lewis quad., Nevada.

Dicellograptus sextans (J. Hall)

Dicranograptus? sp.

Age: Zone of *Nemagraptus gracilis* or *Climacograptus bicornis*.

USGS D135 (CO). Mill Creek, 1,600 ft north, 100 ft west of SE. cor., sec. 31, T. 29 N., R. 45 E., Mt. Lewis quad., Nevada.

Nemagraptus? sp.
Dicellograptus intortus Lapworth
sextans var. *exilis* Elles and Wood
sp.
Climacograptus sp.
Glyptograptus cf. *G. teretiusculus* (Hisinger)

Age: This collection represents the zone of *Nemagraptus gracilis*.

USGS D538 (CO). Alt 6,040 ft. West spur of mountain south of Horse Canyon. 300 ft east, 2,500 ft north of SE. cor. sec. 5, T. 29 N., R. 45 E. Mt. Lewis quad. Nevada footage coordinates, 423,800 E., 2,061,900 N.

Amplexograptus? sp.
Glyptograptus teretiusculus? (Hisinger)
Orthograptus quadrimucronatus var. *whitfieldi*? J. Hall
Orthograptus? of the *O. calcaratus* type

Age: Zone of *Climacograptus bicornis*.

USGS D93 (CO). Southwest of Altenburg Hill. Alt 5,720 ft. Nevada footage coordinates, 489,000 E., 2,019,080 N., Crescent Valley quad., Nevada.

Orthograptus calcaratus cf. *O.C.* var. *acutus* Lapworth

Age: Probably zone of *Climacograptus bicornis* or possibly *Orthograptus truncatus* var. *intermedius*.

USGS D95 (CO). Peak 7,297 ft, 1 mile northwest of cabin in Corral Canyon. Nevada footage coordinates, 483,000 E., 2,069,450 N., Crescent Valley quad., Nevada.

Phyllograptus cf. *P. anna* J. Hall

Age: Late Early Ordovician or early Middle Ordovician.

USGS D96 (CO). 1 mile west of Lander (site), near turn off to King Gulch barite mine. Alt 5,600 ft. Nevada footage coordinates, 481,650 E., 2,029,250 N., Crescent Valley quad., Nevada.

Dichograptus cf. *D. separatus* Elles
Tetragraptus quadribrachiatus (J. Hall)
sp. (Dependent type.)
Phyllograptus anna J. Hall
ilicifolius J. Hall

Age: Late Early Ordovician.

USGS D97 (CO). On round-topped hill about 2,000 ft due south of Lander (site). Alt 6,080 ft. Nevada footage coordinates, 488,200 E.; 2,029,650 N., Crescent Valley quad., Nevada.

Climacograptus bicornis var. *tridentatus* of Ruedemann, but not the same as Lapworth's original species.

Age: Zone of *Climacograptus bicornis*.

USGS D98 (CO). Alt 6,000 ft. On spur northeast of mouth of Mule Canyon, Cortez Range. Nevada footage coordinates, 543,500 E., 2,008,450 N., Crescent Valley quad., Nevada.

Dicellograptus sp.
Climacograptus raricaudatus Ross and Berry n. sp.

Age: Late Middle or Late Ordovician.

USGS D104 (CO). Gray shale associated with tuff and quartzite; 1,000 ft north of Indian Creek and about 1 mile west of Lander. Nevada footage coordinates, 484,000 E., 2,032,250 N., Crescent Valley quad., Nevada.

Glossograptus hincksii var. *fimbriatus* Hopkinson
Climacograptus sp.
Diplograptus? sp. or *Glyptograptus*? sp.

Age: Probably zone of *Climacograptus bicornis*.

USGS D106 (CO). Southwest of Altenburg Hill. Alt 5,640 ft. Nevada footage coordinates, 489,200 E., 2,016,800 N., Crescent Valley quad., Nevada.

Glossograptus? aff. *G. hincksii* Hopkinson
Climacograptus cf. *C. eximius* Ruedemann
riddellensis Harris
Orthograptus calcaratus var.?

Age: Probably zone of *Climacograptus bicornis*.

USGS D107 (CO). West side of quartzite ridge in valley due north of Gold Acres. Alt 5,740 ft. Nevada footage coordinates, 481,300 E., 2,018,750 N., Crescent Valley quad., Nevada.

?*Dicellograptus* sp.

Age: Probably Ordovician.

USGS D537 (CO). 600 ft east and 200 ft south of NW. cor. of sec. 19, T. 28 N., R. 47 E. in Crescent Valley quad., Nevada footage coordinates, 480,750 E., 2,017,600 N., Crescent Valley quad., Nevada.

Didymograptus? sp.
Dicellograptus sp.

Age: Possibly zone of *Nemagraptus gracilis* or *Climacograptus bicornis*.

ANTLER PEAK QUADRANGLE, NEVADA

The geology of the Antler Peak quadrangle by R. J. Roberts was published in 1951 showing the extent of Ordovician formations in an area much disturbed by thrust faulting. Originally the Comus formation was thought to be of Early Ordovician age and the Valmy of Middle. Because of Robert's continued work and refinement of information, it is now certain that the Valmy formation ranges at least from Early through Middle Ordovician in age.

Collections from this quadrangle are listed below:

USGS 1293 (CO). Valmy formation NE¼ sec. 8, T. 32 N., R. 43 E., Antler Peak quad., Nevada.

Climacograptus cf. *C. scharenbergi* var. *stenostoma* Bulman
Diplograptus cf. *D. multidens* var. *diminutus* Ruedemann
Glyptograptus cf. *G. teretiusculus* (Hisinger)

Age: Probably zone of *Climacograptus bicornis*.

USGS 1953 (CO). Valmy formation SW¼ sec. 21, T. 32 N., R. 43 E., alt 7,050 ft on knoll south of road. Antler Peak quad., Nevada.

Dicellograptus sextans (J. Hall)
sp.

Age: Zone of *Nemagraptus gracilis* or of *Climacograptus bicornis*.

USGS 1952 (CO). Valmy formation. NE¼ sec. 20, T. 32 N., R. 43 E. Alt 6,850 ft. Northeast side of Cottonwood Creek about 200 ft above road. Antler Peak quad., Nevada.

Dicellograptus sextans var. *exilis* Elles and Wood
smithi Ruedemann

Age: Zone of *Nemagraptus gracilis* or of *Climacograptus bicornis*.

USGS 1949 (CO). Valmy formation? On ridge at alt of 8,250 ft, SW¼ sec. 3, T. 32 N., R. 43 E. Antler Peak quad., Nevada.

Dicellograptus sextans? Hall

Age: Possibly zone of *Nemagraptus gracilis* or of *Climacograptus bicornis* but may not be this restricted.

USGS 1950 (CO). SE¼ sec. 3 T. 32 N., R. 43 E. Antler Peak quad., Nevada.

Climacograptus sp.
Glyptograptus sp.
Orthograptus quadrimucronatus var. *angustus* Ruedemann
truncatus cf. *O. t.* var. *intermedius* Elles and Wood
truncatus cf. *O.t.* var. *pertenuis* Ruedemann
Orthoretiolites hami Whittington
An archiretioletid

Age: Zone of *O. truncatus* var. *intermedius*.

USGS 1292 (CO). Valmy formation. South side of north fork of Trout Creek at range front, SE¼ sec. 6, T. 32 N., R. 43 E. Antler Peak quad., Nevada.

Tetragraptus fruticosus (J. Hall) (3- and 4-branched forms.)
?*Tetragraptus* [If a *Tetragraptus* this may be *T. denticulatus* (Hall).]
Didymograptus sp. (Extensiform type.)

Age: Probably zone of *Tetragraptus fruticosus* (3- and 4-branched forms) but may be zone of *Didymograptus protobifidus*.

USGS 1293 (CO). Valmy formation NE¼ sec. 8, T. 32 N., R. 43 E., Antler Peak quadrangle, Nevada.

Diplograptus cf. *D. multidens* var. *diminutus* Ruedemann
Glyptograptus cf. *G. teretiusculus* (Hisinger)
Climacograptus cf. *C. scharenbergi* var. *stenostoma* Bulman

Age: Probably zone of *Climacograptus bicornis*.

USGS D434 (CO). South side of north fork of Trout Creek at range front. SW¼ sec. 6, T. 32 N., R. 43 E. Antler Peak quad., Nevada. (This collection is from the same locality as USGS colln. 1292 [CO].)

Tetragraptus fruticosus (J. Hall) (Four-branched form.)
Didymograptus cf. *D. similis* (J. Hall) (Immature.)

Age: Zone of *Tetragraptus fruticosus* (four-branched form) or zone of *T. fruticosus* (3- and 4-branched forms).

USGS D489 (CO). North side of north fork of Trout Creek. Alt 6,350 ft. SW¼SW¼ sec. 5, T. 32 N., R. 43 E. Antler Peak quad., Nevada. The fauna from this collection is mixed.

Adelograptus sp.
Tetragraptus fruticosus (J. Hall)
Didymograptus patulus J. Hall?
sp. (Extensiform type.)

These species indicate a probable age equivalent to the zone of *Tetragraptus fruticosus* (4-branched form or 3- and 4-branched forms).

Cryptograptus tricornis (Carruthers)
Nemagraptid?
Dicellograptus sextans (J. Hall)
sp.
Climacograptus sp.
Lasiograptus cf. *L. pusillus* Ruedemann
Retiograptus geinitzianus J. Hall

The latter group of species is from the zone of *Nemagraptus gracilis* or of *Climacograptus bicornis.*

Because all these species came from one outcrop it is extremely likely that there is a tectonic cause for the lack of intervening faunas.

USGS D495 (CO). South shoulder of north peak, 700 ft east of quarter corner between secs. 3 and 4, T. 32 N., R. 43 E. Alt 8,150 ft. Antler Peak quad., Nevada.

Dicellograptus intortus Lapworth
sextans J. Hall
Corynoides aff. *C. curtus* Lapworth

Age: Zone of *Nemagraptus gracilis* or of *Climacograptus bicornis.*

USGS D496 (CO). South of north fork of Trout Creek, nose running northwest. SW¼NE¼SW¼ sec. 9, T. 32 N., R. 43 E. Alt 7,675 ft. Antler Peak quad., Nevada.

Climacograptus aff. *C. scharenbergi* Lapworth
sp. (New?)
Glyptograptus? sp.

Age: Early to middle Caradoc. Zone of *Nemagraptus gracilis* to zone of *Orthograptus truncatus intermedius.*

USGS D498 (CO). On boundary between secs. 7 and 18, 300 ft above Cottonwood Creek, on east side of Canyon. Antler Peak quad., Nevada.

Glyptograptus? sp.

Possible age range: Middle Ordovician to Silurian.

USGS D499 (CO). North side of north fork of Trout Creek, SE¼SW¼SW¼ SW¼ sec. 5, T. 32 N., R. 43 E. Antler Peak quad., Nevada. Same locality as for USGS colln. D489 (CO) but limited to lowest part of slope.

Tetragraptus fruticosus (J. Hall) (Three-branched forms.)

Age: Zone of *Tetragraptus fruticosus* (3- and 4-branched forms) or zone of *Didymograptus protobifidus.*

USGS D500 (CO). North fork of Trout Creek, northeast side, center N½NE¼ NE¼ sec. 8, T. 32 N., R. 43 E. Antler Peak quad., Nevada.

Orthograptus aff. *O. quadrimucronatus*?
Glyptograptus? sp.
Glossograptus hincksii (Hopkinson)

Age: Possibly zone of *Climacograptus bicornis* may be zone of *Orthograptus truncatus* var. *intermedius.*

USGS D504 (CO). Alt 7,700 ft, on ridge west from peak 7,900, SW¼ sec. 9, T. 32 N., R. 43 E. Antler Peak quad., Nevada.

Climacograptus aff. *C. scharenbergi* Lapworth
Glyptograptus cf. *G. euglyphus* (Lapworth)

Age: Probably in range from zone of *Glyptograptus teretiusculus* to zone of *Orthograptus truncatus* var. *intermedius*.

OSGOOD MOUNTAINS QUADRANGLE, NEVADA

Only two collections of graptolites from the Osgood Mountains quadrangle have come to our attention. They were collected by P. E. Hotz, Jr., and C. R. Wilden in the course of mapping.

USGS 1072 (CO). Barite quarry, east edge, NW¼SE¼ sec. 12, T. 37 N., R. 41 E., Osgood Mountains quad., 1:62,500, Nevada.

Climacograptus bicornis J. Hall
sp.
Diplograptus? sp.
Orthograptus aff. *O. calcaratus* Lapworth

Age: Probably the zone of *Climacograptus bicornis*.

USGS 1373 (CO). Just below crest of ridge in southeast part of SE¼SE¼ sec. 30, T. 39 N., R. 42 E.

Dicellograptus cf. *D. divaricatus* var. *bicurvatus* Ruedemann
cf. *D. sextans* (J. Hall)
Unidentifiable scandent form

Age: Probably zone of *Climacograptus bicornis*.

BULL RUN QUADRANGLE, NEVADA

Robert Decker has mapped the Bull Run quadrangle although his work has not yet been published. He reports (written communication, December 1958) that the "western facies" rocks are in thrust contact with the shelf sequence over much of the quadrangle and that the contact with the shelf sequence is best exposed on the west flank of Wilson Peak. In this quadrangle, fossils have not yet been found in the cherts and siliceous argillites and they may not be Ordovician. However, Decker claims that they are very similar lithologically to Ordovician and Silurian units to the south.

PHI KAPPA FORMATION, HAILEY QUADRANGLE, IDAHO

In the Hailey quadrangle, Idaho, Umpleby, Westgate, and Ross (1930, p. 17–23) defined two graptolite-bearing Ordovician units. The older was given no name and was distinguished only by its Early Ordovician fauna (USGS colln. 1367 [SD]) from the formally designated Phi Kappa formation. For purposes of this report the Lower Ordovician strata are included in the Phi Kappa.

Kirk identified 20 species of graptolites from the Lower Ordovician argillites (Umpleby, Westgate, and Ross, 1930, p. 18; Ross, C. P., 1934, p. 943). The collections have been restudied for this report and 19 species recognized, of which 1 is new.

Mixing of faunal zones is evident from this study. Faunal elements are grouped below according to associations on single slabs of shale,

although they were all given the same locality number by the previous collectors.

Zones represented are zone of *Isograptus*, the zone of *Didymograptus protobifidus*, and possibly the zone of *Tetragraptus fruticosus* (3- and 4-branched forms).

All the following are from USGS colln. 1367 (SD), from along Trail Creek road between Ketchum and Chilly, about 1.5 miles south of pass over Sawtooth Range, Hailey quadrangle, Idaho.

Tetragraptus amii Lapworth
serra Brogniart
Phyllograptus ilicifolius J. Hall
Didymograptus protobifidus Elles
Age: Zone of *D. protobifidus*.

Tetragraptus amii? Lapworth
Didymograptus? sp. (Dependent form.)
Isograptus cf. *I. dumosus* Harris
Age: Probably zone of *Isograptus*.

Tetragraptus amii Lapworth
bigsbyi J. Hall
reclinatus Elles and Wood
Phyllograptus ilicifolius J. Hall
Didymograptus protobifidus Elles
Age: Zone of *D. protobifidus*.

Tetragraptus quadribrachiatus (J. Hall)
Phyllograptus angustifolius var.
ilicifolius J. Hall
Didymograptus extensus J. Hall
protobifidus Elles
Age: Zone of *D. protobifidus*.

Cardiograptus folium Harris and Keble
Isograptus caduceus var. *maximo-divergens* Harris
Age: Zone of *Isograptus*.

Individual specimens:
Sigmagraptus? *kirki* (Ruedemann)
Tetragraptus fruticosus J. Hall (Three-branched form.)
Phyllograptus anna J. Hall
Tetragraptus reclinatus Elles and Wood
Didymograptus gracilis Törnquist
cf. *D. indentus* (J. Hall)
aff. *D. murchisoni* var. *geminus* (Hisinger) (zone of *D. bifidus*)
aff. *D. murchisoni* Beck (zone of *D. bifidus*)

The youngest Ordovician fauna obtained from the Hailey quadrangle of Idaho was collected by Kirk (Umpleby, Westgate, and Ross, 1930, p. 23) from Trail Creek, high in the Sawtooth Range. The fauna is listed below (USGS colln. 1368 [SD]).

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The species also found in the British Isles are of Ashgill or Silurian age. Because the contact between strata of his locality and the Silurian immediately to its west is mapped as a fault, the faunas may be mixed tectonically. On the other hand, this may be a transition fauna.

The evidence of this fauna coupled with that from USGS colln. 1367 (SD) indicates that the Phi Kappa strata range in age through almost all of the Ordovician.

Another collection made by Kirk (USGS colln. 1370 [SD]) is of an age equivalent to the zone of *Climacograptus bicornis*.

USGS 1368 (SD). "On the west bank of Trail Creek, about a mile south of the point where the creek swings abruptly west." This is at the mouth of the fifth tributary from the west, north of lat 43°50′.

Leptograptus? cf. *L. flaccidus* var. *macer* Elles and Wood
Dicellograptus complanatus Lapworth
cf. *D. complanatus* var. *ornatus* Elles and Wood
Climacograptus hastatus T. S. Hall
hastatus var. *americanus* Ruedemann
hvalross n. sp.
cf. *C. minutus* Carruthers
putillus (J. Hall)
supernus Elles and Wood
n. sp. (With three-spined blunt proximal end.)
Diplograptus n. sp. (Widens from 0.7 to 1.5 mm, 12 mm long., 9 thecae in 5 mm, 18 in 5 mm, 18 thecae in 10 mm, thecae 1.5 mm long, overlap one-half.)
Glyptograptus altus n. sp.
tamariscus Nicholson
teretiusculus var. *occidentalis* Ruedemann
Orthograptus calcaratus var.
truncatus var. *abbreviatus* (Elles and Wood)
cf. var. *socialis* (Lapworth)
cf. *O. truncatus* var. *socialis* (Lapworth)
truncatus var. *richmondensis* (Ruedemann)
rarithecatus n. var.
n. sp.
Pseudoplegmatograptus n. sp.
Arachniograptus laqueus n. gen. and n. sp.

Age: Zone of *Dicellograptus complanatus*.

USGS 1370 (SD). From near the head of Fall Creek, approximately 3 miles due north of the mouth of Park Creek (designated Basin Creek on 30-min Hailey quad. map), north of divide between Trail Creek and Summit Creek, Blaine County, Idaho.

Dendrograptus sp.
Cryptograptus tricornis (Carruthers)
Glossograptus hincksii (Hopkinson)
horridus Ruedemann
ciliatus Emmons?
Leptograptus sp.

Dicellograptus divaricatus var. *bicurvatus* Ruedemann
divaricatus var. *salopiensis* Elles and Wood
sextans var. *exilis* Elles and Wood
Dicranograptus contortus Ruedemann
nicholsoni Hopkinson?
ramosus var. *longicaulis* Lapworth
var. *spinifer* Lapworth
Climacograptus bicornis J. Hall
bicornis var. *peltifer* Lapworth
n. sp.
n. sp.
Glyptograptus teretiusculus Hisinger
cf. *G. teretiusculus* Hisinger
Orthograptus sp.
Hallograptus bimucronatus (Nicholson)
mucronatus J. Hall

Age: Zone of *Climacograptus bicornis*.

SATURDAY MOUNTAIN FORMATION IN THE BAYHORSE QUADRANGLE, IDAHO

In the Bayhorse quadrangle, Idaho, on the north side of the mouth of Bruno Creek, C. P. Ross and Kirk collected graptolites from black slaty shales that Ross considered part of the Saturday Mountain formation (Ross, C. P., 1937, p. 21). At the present time it is the opinion of the senior author that these slates probably are a northward extension of the Phi Kappa formation. Much detailed geologic mapping needs to be done in this area; when completed it may show that the Saturday Mountain formation should be restricted to carbonates similar in lithology and fauna to the Fish Haven and Hanson Creek formations. It is, in fact, in this sense that the name has been applied everywhere in central Idaho by C. P. Ross except in this its type area. It is further suggested that the slates and shales of the unrestricted Saturday Mountain formation are less metamorphosed equivalents of the Ramshorn slate, and that it also is equivalent to the Phi Kappa formation.

The fauna collected by C. P. Ross and Kirk from Bruno Creek is listed (USGS colln. 2519 [SD]). One sample from the collection is of a different age than the others. Therefore faunal lists are given for separate slabs of argillite.

Dicranograptus kirki Ruedemann
Climacograptus cf. *C. caudatus* Lapworth
raricaudatus n. sp.
sp.
Glyptograptus? sp.
Orthograptus calcaratus var.?
calcaratus n. var.
cf. var. *acutus* Lapworth
truncatus cf. *pauperatus* Lapworth
truncatus n. var.

quadrimucronatus var. *whitfieldi* (J. Hall)
aff. *O. quadrimucronatus* var. *whitfieldi* (J. Hall)
sp.

Age: Zone of *Orthograptus truncatus* var. *intermedius*.

Dicranograptus ramosus var. *spinifer* Lapworth

Age: Possible range from zone of *Climacograptus bicornis* to zone *O. truncatus intermedius*.

Dicranograptus kirki Ruedemann
Climacograptus raricaudatus n. sp.
sp.
Orthograptus calcaratus var. *acutus* Lapworth

Age: Zone of *O. truncatus intermedius*.

Orthograptus quadrimucronatus (J. Hall)
sp.

Age: Zone of *Orthograptus quadrimucronatus*.

This same locality was visited by R. J. Ross, Jr., and Burkholder in 1958 in hopes of duplicating the previous collections. All samples were taken from a thin zone, 2 feet thick. The obtained fauna is listed.

USGS D456 (CO). From the same locality as 2519 (SD). Collected by R. J. Ross, Jr., and Burkholder, 1958. All specimens from a thin unit, not exceeding 2 ft. in thickness.

Conularid=Conularia sp.
Leptograptus sp.
Dicranograptus cf. *D. hians* T. S. Hall
kirki Ruedemann
nicholsoni var. *geniculatus* Ruedemann and Decker
ramosus cf. *D. r.* var. *semispinifer* T. S. Hall
tealei Harris and Thomas
Climacograptus aff. *C. antiquus* var.?
cf. *C. caudatus* Lapworth
raricaudatus Ross and Berry n. sp.
sp. (1.25 mm wide, 10 thecae in 10 mm, virgella 0.5 mm long.)
sp. (1.5 mm wide, 14–15 thecae in 10 mm.)
sp. (Small form of *C. typicalis* type, 1–1.25 mm wide, 12, thecae in 10 mm, small virgella.)
Diplograptus vespertinus Ruedemann
sp.
Glyptograptus? sp.
Orthograptus calcaratus var. *acutus* (Lapworth)
calcaratus cf. *O. c.* var. *incisus* (Lapworth)
cf. *O. c.* var. *vulgatus* (Lapworth)
var.?
quadrimucronatus cf. *O. q.* var. *angustus* Ruedemann
cf. *O. q.* var. *spinifer* T. S. Hall
aff. *O. q.* var. *spinifer* T. S. Hall
var.? (Slightly wider form than typical *O. quadrimucronatus*, 3.5 mm wide.)

of type of *quadrimucronatus* (1¾ mm wide, 11 thecae in 10 mm.)
truncatus Lapworth
intermedius Elles and Wood
cf. *O. t.* var. *pauperatus* Elles and Wood
n. var. (2–2.5 mm wide, 8–9 thecae in 10 mm.)
var.? (Narrow, 1¾ mm wide, 9–10 thecae in 10 mm.)
cf. *O. truncatus* type
sp.

Age: Zone of *Orthograptus truncatus intermedius*.

If future work should prove that these graptolite-bearing black shales are a partial facies equivalent of the carbonates mapped as Saturday Mountain formation to the east and southeast that formation must be considered partly of Trenton age. On the other hand, the carbonate beds and black shales of the type section may have been placed in juxtaposition tectonically and may be of quite different ages.

GRAPTOLITES OF THE "EASTERN" OR SHELF FACIES

Graptolites are fairly common though not much studied in rocks of the "eastern" or shelf facies of the Great Basin. *Phyllograptus loringi* White, represented by a single known specimen, is probably the first species described from the Pogonip group and was collected from the north end of the Fish Springs Range, Utah, by members of the U.S. Geographical Surveys West of the 100th meridian. (White, 1877, p. 51–52).

In 1935, Clark described several genera and species from the Garden City and Swan Peak strata near Logan, Utah. A few species were collected by Ross (1951) during his work on the Garden City formation, and these are included in the present paper. Rigby (1958) has published descriptions of other graptolites from the Pogonip group and the correlative Garden City formation in Utah.

Merriam and Anderson (1942, p. 1686) first reported graptolites from the Hanson Creek formation in central Nevada. Their locality has been revisited and collections therefrom included in this report.

GARDEN CITY AND SWAN PEAK FORMATIONS—NORTHERN UTAH, SOUTHEASTERN IDAHO (LOGAN AND PRESTON QUADRANGLES)

Graptolites are found in calcareous siltstones interbedded with limestone of the Garden City formation and were first reported by Clark (1935, p. 240, 241, pl. 24, figs. 1, 2). Clark made several collections, some from the Garden City formation and some from the lower member of the Swan Peak formation. Unfortunately the positions of his collections are not clear other than that they were near the mouth of Logan Canyon. Williams (1948, p. 1135) states that those from the Garden City were low in the formation. Williams also listed graptolites (1948, p. 1136) that he had collected, but did not locate them

within the formation. Graptolites reported by these two authors were:

Garden City formation

Dendrograptus cf. *D. flexuosus* J. Hall
Desmograptus intricatus Ruedemann
Dictyonema rectilineatum Ruedemann
Didymograptus cf. *D. bifidus* (J. Hall)
Tetragraptus sp.
Didymograptus cf. *D. bifidus* (J. Hall)

Swan Peak formation

Didymograptus bifidus (J. Hall)
nitidus (J. Hall)

Within faunal zones based on trilobites, R. J. Ross (1949, p. 480–481) listed graptolites from the Garden City formation. However, these listings were not complete and identifications were cursory. That list and others presented in 1951 (Ross, R. J., 1951, p. 27–29, 20 [loc. 9]) should be considered in light of new collections made in 1955 and of restudy of the old collections for purposes of this report. For instance the graptolite species listed as *D. bifidus* (J. Hall) from the Swan Peak formation is actually *D. artus*.

The following graptolites have been obtained from the Garden City formation:

USGS D204 (CO). Southwest side of top of Gold Mine Hill, northeast of Round Hill, NE¼NE¼SW¼SE¼ sec. 10, T. 9 N., R. 1 W., Mount Pisgah quad., 1:24,000, Utah (loc. 13, Ross, 1951, p. 22–23.) Basal shales of the Swan Peak formation, 15 ft below quartzite.

Didymograptus artus Elles and Wood

Age: Zone of *Didymograptus bifidus*. Trilobites and brachiopods associated are those of zone M of Ross (1951).

USGS D206 (CO) and D206a (CO). Twin Bridges dugway, north end, southwest side of U.S. Highway. SE¼NE¼NE¼ sec. 33, T. 13 N., R. 3 E. Logan quad., Utah. The associated trilobite is *Asaphelina* sp.

Dendrograptus 2 spp. (1 n. sp.)
Dictyonema 3 spp.
Adelograptus? sp.
Clonograptus n. sp. (See pl. 2, fig. 2; like *C. flexilis* but with greater distance between bifurcations; greater than in *C. persistens*. Funicle 2.8 mm long. Thecal count 11–12 in 10 mm; thecae incline 30°, overlap two-thirds.)
Clonograptus n. sp. (See pl. 2, fig. 8; funicle 5 mm long, stipe 0.7 mm wide.)
Tetragraptus n. sp. (Funicle 1.5 mm long; thecae 10–12 in 10 mm. Similar to *T. decipiens* T. S. Hall in which thecae are 9–11 in 10 mm.)
Didymograptus nitidus (J. Hall)

Age: Probably zone of *Clonograptus-Adelograptus;* may range into zone of *Tetragraptus fruticosus* (3- and 4-branched forms.) Exact trilobite zone not known, although estimated as zone G of Ross (1951).

USGS D227 (CO). East side of Hilyards Canyon, 1.8 miles north of head of canyon. SE¼ sec. 17, T. 15 S., R. 41 E., Preston quad., Idaho (same as loc. 5, Ross, 1951, p. 14). Garden City formation.

Didymograptus nitidus (J. Hall)
patulus? (J. Hall)

Age: Probably zone of *Didymograptus protobifidus*. Possibly as old as the zone of *Tetragraptus fruticosus* (3- and 4-branched forms). This collection is associated with *Trigonocerca typica* Ross of trilobite zone H, about 100 ft below the highest beds containing trilobites of zone J.

USGS D229 (CO). and D230. (CO). East side of Hilyards Canyon, about 300 yards south of D227 (CO) and 150 ft lower in altitude. In a separate fault slice. Garden City formation.

Dictyonema 2 spp.
Adelograptus cf. *A. hunnebergensis* (Moberg)
Clonograptus flexilis (J. Hall)
n. sp. (Funicle 4 mm long, stipes 0.3 mm wide, thecae 10–12 in 10 mm.)
Didymograptus aff. *D. novus* Berry

Age: Possibly zone of *Clonograptus-Adelograptus*. Trilobites associated with these graptolites are asaphids of zone G (low?) of Ross (1951), suggesting a higher stratigraphic position. Graptolites may range into zone of *Tetragraptus fruticosus* (3- and 4-branched forms.)

In the Dugway Range of central Utah, M. H. Staatz collected samples for silicified trilobites from the upper Garden City formation. When etched with formic acid these produced three dimensional *Phyllograptus anna* Hall (pl. 3, fig. 15).

USGS colln. D317h (CO). Approximately 1 mile north of Tooele-Juab County boundary, half a mile east of peak 6342. Utah footage coordinates, central zone, 1,559,150 E., 581,750 N., Dugway Range quad., 1:62,500, Tooele County, Utah. Garden City formation, 1,482 ft above base. Zone J of Ross (1951).

HANSON CREEK FORMATION, NEVADA

Several collections have been made from the Hanson Creek formation on the crest of Martin Ridge, northern Monitor Range.

The locality was originally cited by Merriam and Anderson (1942, p. 1686) and is 1.5 miles from the north end of Martin Ridge (SE¼ NE¼NE¼ and NE¼SE¼NE¼ sec. 36, T. 16 N., R. 49 E., Horse Heaven Mtn. quad., Nevada).

Ross visited the locality in the company of Merriam and MacLachlan in 1955. Collections (D247 [CO]) were made from the lower 30 feet of slope, but no bedrock was exposed. The same is true of a collection made by Ross (D342 [CO]) in 1956. Heavy rains or snow seem to have cleaned the crest of the ridge of much float during early 1958, so that some bedrock was exposed when it was visited by Cloud, Dzulynski, and Ross. However, none of the collections made to date is accurately zoned from bedrock.

The composite fauna indicates a late Caradoc age with a few Ashgill elements.

At this place the contact between the base of the argillaceous limestones of the Hanson Creek and the top of the Eureka quartzite is a fault of unknown displacement. About 225 feet of Hanson Creek strata are exposed, overlain by cherty beds assigned by Merriam to the Silurian. Both Cloud and Dzulynski expressed the opinion that Hanson Creek strata at this locality had been deposited below wave base. The formation lacks the black and gray dolomites that typify it further to the east, north, and south.

Graptolites were collected from a 70-foot unit and are listed as follows from top to bottom.

USGS D474e (CO). From float 68 ft above colln. D474a (CO).
Climacograptus cf. *C. hastatus* T. S. Hall
sp. (12 thecae in 10 mm, widens from 0.7—2.0 mm.)
sp. (Parallel-sided, 2.1 mm wide.)

USGS D474d (CO). 47 ft above colln. D474a (CO); partly from float.
Climacograptus cf. *C. minimus* (Carruthers)
sp.
Glyptograptus n. sp. (Same as D47c.)
Orthograptus calcaratus cf. *O. calcaratus* var. *vulgatus* Lapworth
truncatus var. *pauperatus* Elles and Wood

USGS D474c (CO). 14 ft above coll. D474a (CO).
Climacograptus hastatus T. S. Hall
sp.
Glyptograptus n. sp. (Long (25 mn) tapering, widens from 0.6–1.5 mm; 11 thecae in 10 mm, overlap one-fourth.

USGS D474b (CO). From float 6 ft above coll. D474a (CO).
?*Pleurograptus linearis* (Carruthers) (Fragments.)
Climacograptus hastatus T. S. Hall
tubuliferus Lapworth
Amplexograptus sp. (2.5 mm wide, 4.5 cm long; 9 thecae in 10 mm. Apertural excavations four-tenths width of rhabdosome.)
Glyptograptus sp. (May be long tapering n. sp. of coll. D247 [CO].
Orthograptus calcaratus var.? (3–3.5 mm wide; 8 thecae in 10 mm.)
calcaratus var.? (4 mm wide; 8 thecae in 10 mm.)

USGS D474a (CO). From base of exposure, mostly float.
Climacograptus cf. *C. minimus* (Carruthers)
cf. *C. tubuliferus* Lapworth
cf. *C. hastatus* T. S. Hall
sp.

USGS D247 (CO). From float on lower 30 ft of slope masking the formation.
Climacograptus hastatus (T. S. Hall)
hastatus var. *martini* n. var.
tridentatus maximus Decker
typicalis J. Hall
sp.
Diplograptus? cf. *Diplograptus minutus* Berry
Amplexograptus? sp.

Glyptograptus sp. (2 cm long, widens from 1 mm proximally to 1.8 mm distally. Thecae number 11 in 10 mm. Virgula enclosed in tube which extends 0.8 mm beyond rhabdosome.)
Glyptograptus n. sp. (Long and tapering form, 6 cm long, widening from 0.7 mm proximally, to 2.2 mm distally. Thecae number 12 in 10 mm.)
Orthograptus aff. *O. calcaratus* (Lapworth)
sp.
Orthograptus? sp.

USGS D342 (CO). From float on lower 50 ft of slope, masking the formation.
Leptograptus flaccidus (J. Hall)
flaccidus var. *macer* Elles and Wood
cf. *L.f.* var. *macilentus* Lapworth
Dicellograptus cf. *D. complanatus* var. *ornatus* Elles and Wood
cf. *D. morrisi* Hopkinson
Climacograptus hastatus T. S. Hall
hastatus var. *martini* n. var.
cf. *C. minimus* (Carruthers)
tridentatus var. *maximus* Decker
sp. (12 thecae in 10 mm, widens from 1.7–2 mm.)
(11–12 thecae in 10 mm, width 0.7–1.5 mm; distal prolongation of virgula.)
Diplograptus minutus?
Diplograptus?
Orthograptus? *O. calcaratus* var.?
Orthograptus?

CORRELATION AND FAUNAL AFFINITIES

The graptolite zonal sequence used in this report is mainly that delimited by Berry in the Marathon region, Texas. (Berry, 1960, p. 7–8, fig. 3). It is given on the correlation chart (table 1) with the suggested correlation of the zones with the series and stages considered standard in the United States. Cooper's (1956, p. 7–9) stages of the Middle Ordovician have been used because reasonably good correlations between them and the Marathon region graptolite zones could be obtained.

All graptolite collections from the Great Basin have been referred to the Marathon region graptolite zonal scheme because the assemblages from the two areas are nearly identical. The correlation of the several Great Basin collections and their zonal position is shown on the correlation chart (table 1). All zones but that of *Anisograptus* have been found in at least one locality in the Great Basin. However, because of structural complexities no complete and only a few very partial successions of zones were found in the area. Those areas which have been studied the most intensively have yielded the greatest range of zones. Some species apparently have slightly different ranges in the Great Basin than in the Marathon region where they appear with different assemblages. Also, additional species, some

new, have been found with the typical zonal assemblages of the zones of *Glyptograptus teretiusculus*, *Orthograptus truncatus* var. *intermedius*, *Orthograptus quadrimucronatus*, and *Dicellograptus complanatus*. Thus the knowledge of the assemblage of species characterizing these zones has been enlarged by the present study.

NEW YORK CORRELATION

Ruedemann's work on the graptolite faunas of the Deepkill and Normanskill shales has remained classic for nearly 60 years. During that time, the names "Deepkill" and "Normanskill" have become almost synonymous with Lower Ordovician and Middle Ordovician when reference was made to graptolite-bearing rocks. However, a comparison of the Ordovician zonal succession of the Marathon region and the like sequence for the Early and early Middle Ordovician recognized by Kindle and Whittington (1958) in western Newfoundland with the zones worked out by Ruedemann in the Deepkill and Normanskill shales reveals that the old interpretation of the age of these formations needs revision. Therefore, Berry has undertaken a reinvestigation of the famous New York formations. As pointed out by him (Berry 1959, p. 1568–1569), four zones are present in the Deepkill shale. The lower three, the zones of *Tetragraptus fruticosus* 3- and 4-branched forms, *Didymograptus protobifidus*, and *Didymograptus bifidus*, are present in the lower part of the formation. The fourth, which is separated structurally from the others, is the zone of *Hallograptus etheridgei*. Thus the formation is latest Early Ordovician and early Middle Ordovician and not entirely Early Ordovician as was previously thought. Also, study of the Normanskill shale and its faunas reveals that all graptolites from it must be included in the zone of *Climacograptus bicornis*.

As is true of the graptolite assemblages from the Great Basin and Newfoundland, those from New York are quite similar to those from the Marathon region, and little difficulty is found in correlating zonal assemblages from area to area. A complete discussion on correlation of other New York State graptolite-bearing formations with the Marathon zonal succession may be found in Berry's publication on the graptolites from the Marathon region (1960, p. 35–38).

INTERCONTINENTAL CORRELATION

Because the Great Basin graptolite assemblages are so like those from the Marathon region and no readily zonable succession has yet been found in the Great Basin, the discussion of intercontinental correlation of the zones is of necessity a comparison of the Marathon sequence with those of Victoria, Australia, the British Isles, and Ka-

zakhstan in Russia. The correlation chart (table 1) indicates the correlation of each Great Basin collection with the Marathon zones, and in addition a correlation of each collection with the stages used in the British Isles and in Victoria. A brief treatment of the correlation of the Marathon, British, and Australian zones has been given by Berry (1956, p. 1670–1671) and a more detailed discussion of the correlations may be found in his study of the Marathon region graptolites (1960, p. 38–44).

AUSTRALIA

As is evident from the chart showing the ranges of the several species in the Great Basin compared with the ranges of the same forms in the British Isles and Victoria, the zonal assemblages in the Great Basin, the Marathon region, and Victoria are closely comparable, although the last has been divided into more zones.

The first three zones of the Marathon succession and the Lancefield may be reasonably well correlated. Many of the same species and most of the same genera occur in nearly identical assemblages in both sequences.

The Bendigonian and most of the Chewtonian contain the same species of multiramous dichograptids, phyllograptids, tetragraptids, and extensiform didymograptids as do zones 4, 5, and 6 of the Marathon succession. Marathon zone 7 is characterized by two dependent didymograptids, *D. bifidus* and *D. artus*, not found in Australia. The upper part of the Chewtonian is correlated with zone 7 on position in the sequence between two zones which can be accurately equated.

The Castlemaine and Yapeen in Victoria bear the same species as are found in the zone of *Isograptus*, in the Marathon region. They have been divided into five zones on the appearance in successively younger strata of the several varieties of *Isograptus caduceus*, then *Oncograptus*, and finally *Cardiograptus*. However, in the Great Basin collections, as well as in the Marathon collections, all these forms occur together. In fact, *Oncograptus*, *Cardiograptus*, and two varieties of *Isograptus caduceus* were found on the same bedding surface in the Marathon region.

The zones of *Hallograptus etheridgei* and *Glyptograptus teretiusculus* in the Marathon region are characterized by the same species that are present in the Victorian Middle Ordovician. In North America only 2 zonal assemblages can be delimited, whereas in Australia 4 have been determined. They are denoted however, by the abundance of the name-bearing species and not by an assemblage of forms.

Beginning with the zone of *Nemagraptus gracilis*, the remainder of the Australian graptolite sequence has not been as intensively studied as the older part. The Gisbornian, Eastonian, and Bolindian

have been divided into two zones each, and the assemblages are said to be similar to those of the British Caradoc and Ashgill (Harris and Thomas, 1938, p. 67). Most of the British zonal names have been used in the Australian succession. Five zones were recognized in the Marathon sequence above the zone of *Glyptograptus teretiusculus*. The assemblages are like those in Australia except that the Marathon zone of *Orthograptus quadrimucronatus* is the approximate correlative of the Australian zones of *Dicranograptus hians* and *Pleurograptus*. The same five zonal assemblages were recognized in the Great Basin as were found in the Marathon region. No further division of the interval represented by them was possible, using the collections available for study.

THE BRITISH ISLES

As Berry pointed out (1956, p. 1670–1671), in contrast to the close similarity of the Australian and Marathon zonal assemblages, those from the British Isles are quite different from the Early and early Middle Ordovician. However, beginning with the base of the Caradoc, the zone of *Nemagraptus gracilis*, all three sequences are closely comparable.

The Lower Tremadoc may be correlated with the lower part of the Lancefield and the first zone in the Marathon succession. The correlation of the upper part of the Tremadoc is questionable, however, because the upper Tremadoc rocks do not bear graptolites.

The zonation of the Arenig as worked out by Elles (1904, 1933) has been widely accepted. Recent reinvestigations of the graptolite-bearing strata of Arenig age have led Bulman (1958, p. 164) to conclude that there is no evidence for the zone of *Dichograptus*, and little for the *Tetragraptus* subzones of the zone of *Didymograptus extensus*. The upper three subzones of the *D. extensus* zone and the *Didymograptus hirundo* zone are readily recognizable. The lower part of the Arenig thus does not have diagnostic graptolites and correlation of it with graptolite-bearing sequences is difficult. Although the assemblages of species which characterize the zones in the upper part of the Arenig are not like those in the Marathon or Victorian successions, the phyllograptids, tetragraptids, and the extensiform didymograptids do reach their zenith in the upper part of the Arenig and in zones 4 through 6 in the Marathon region as well. Thus, these zones are correlated with the upper part of the Arenig.

The *Didymograptus bifidus* zone, zone 7, in the Marathon region, contains the well-known name bearer and the dependent form *D. artus*. These two species characterize the lower zone of the Llanvirn and give the first good tie between the Marathon and British zonal sequences.

The upper zone of the Llanvirn contains few species in common with the Marathon and Australian zones, but the single zone of the Llandeilo, that of *Glyptograptus teretiusculus*, is the probable correlative of the zone of the same name in the Marathon and Australian successions. The upper part of the Llanvirn is approximately equated with the *Isograptus* and *Hallograptus etheridgei* zones on its position in the sequence.

As stated above, starting with the base of the Caradoc and continuing through it and the Ashgill, the British, Australian, and Marathon zonal assemblages are quite similar. Correlation of the Australian Gisbornian, Eastonian, and lower part of the Bolindian, and the correlative zones (11 through 14) of the Marathon region with the Caradoc and the upper part of the Bolindian and Marathon zone 15 with the Ashgill is reasonably sound.

RUSSIA

A Russian graptolite faunal succession has not, as yet, been fully worked out. However, a nearly complete sequence of Ordovician graptolite-bearing strata is known in the Chu-Illiiski Mountains in Kazakhstan. The lower part of this succession, the Kogashikskii beds, bear a fauna that is virtually British Arenig in affinity. The fauna of the Kopalinski and Karakanski beds has been discussed by Keller (1956) and Keller and Lisogor (1954). These beds contain graptolite assemblages that include many forms which from the figures appear to be closely comparable to those from the Australian Castlemaine, Yapeen, and Middle Ordovician and their North American correlatives.

The graptolite faunas of the Anderkenskii, Otarskii, Dulankarinskii, and Chokparskii beds are not so well known as the older units, but the first three are approximately correlative with the Caradoc. The Chokparskii and the Ashgill are probably correlatives.

More work is needed before the affinites of the Russian graptolite faunas can be fully ascertained. However, the appearance of both British and Australian-American forms in the same sequence makes this a region where future work should yield highly interesting results.

DESCRIPTIONS OF GENERA AND SPECIES

We suggest that the reader make himself familiar with, or at least have available, Bulman's (1955) volume on the Graptolithina. We have used his terminology (1955, p. V5–V7) and classification. The reading of pages V43–V69 is particularly recommended. We have referred only to and have paraphrased many of Bulman's descriptions

of genera synonymies except where we felt previous references needed clarification.

Class GRAPTOLITHINA
Order DENDROIDEA
Family DENDROGRAPTIDAE

Representatives of the genera *Dendrograptus*, *Callograptus*, *Desmograptus*, and *Dictyonema* are illustrated (pl. 1, figs. 1, 2, 3, 6, 11) but not described.

Family ANISOGRAPTIDAE

A representative of the genus *Adelograptus* is illustrated (pl. 1, figs. 9, 10) but not described.

Genus CLONOGRAPTUS J. Hall and Nicholson, 1873

Clonograptus J. Hall and Nicholson. Bulman, 1955, Geol. Soc. America, Treatise on invertebrate paleontology, pt. V, p. V32–V33, fig. 16, 1a, b.

The rhabdosome is bilaterally symmetrical as the result of regular bifurcation at increasing intervals, usually producing 5–6 dichotomies, but as many as 8 or 9. The branches diverge markedly in the early stages but become subparallel or flexuous in distal stages. Thecae are usually denticulate with moderate inclination.

In addition to *C. flexilis* (Hall), described below, this genus is represented by several specimens that cannot be assigned to a known species; yet, too few specimens are present to warrant description of new species. They are illustrated on plate 2, figures 2, 8.

Clonograptus flexilis (J. Hall)

Plate 1, figures 5, 7; plate 2, figure 1

Graptolithus flexilis J. Hall, 1865, Canada Geol. Survey, Canadian Organic Remains, Decade 2, p. 103.

Clonograptus flexilis (J. Hall). T. S. Hall, 1898, Royal Soc. Victoria Proc., v. 11, pt. 1, p. 169, pl. 19, fig. 20.

Clonograptus flexilis (J. Hall). Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 280–282, pl. 44, fig. 4, 5.

Clonograptus flexilis (J. Hall). Berry, 1960, Texas Univ. Pub. 6005, p. 47, pl. 6, fig. 4.

The rhabdosome is many branched, with branches arranged bilaterally. The sicula is minute; the short funicle is about 2.5 mm in length. The first-order bifurcation is at about 105°. The second-order bifurcation takes place in 2.5 mm, resulting in 8 branches. Each of these again bifurcates several times.

The slender stipes are flexuous, branching at a lesser angle at successive bifurcations. There are about 64 branches in the entire rhabdosome.

Thecae begin about the second and third bifurcations. They are short, straight, and inclined to the axis at 30°, overlapping about one-half. The thecal count varies from 9–10 in 10 mm.

Figured specimens: USNM 138459, 138460, 138461.
Occurrence: Garden City formation, D230 (CO). Approximately zone G of Ross (1951), based on trilobites.

Discussion.—According to T. S. Hall (1898, p. 169) the third order bifurcation takes place at a variable angle but higher order bifurcation decreases to 30°–40°. In this Ruedemann (1947, p. 280) agrees.

Order GRAPTOLOIDEA

Family DICHOGRAPTIDAE

Genus TRICHOGRAPTUS Nicholson, 1876

Trichograptus Nicholson. Bulman, 1955, Geol. Soc. America, Treatise on invertebrate paleontology, pt. V, p. V76, fig. no. 4.

Two slender branches, springing from sicula in opposite directions. Secondary branches originating at regular intervals from only one side of primaries. Secondaries undivided.

Trichograptus immotus Harris and Thomas

Plate 1, figure 8

Trichograptus immotus Harris and Thomas, 1935, Royal Soc. Victoria Proc., v. 47, new ser., pt. 2, p. 290–291, fig. 1, nos. 2 a–c; fig. 2, nos. 7, 8.

Two primary branches initially diverge at 150°, then at 180° or more. From near the apertures of successive thecae on primary stipes, secondary stipes originate. The thecal count on primaries is 8 in 10 mm, and on secondaries 10–11 in 10 mm. Thecae on the secondaries are inclined about 25° to the axis with slight overlap.

Figured specimen: USNM 138463.
Occurrence: Valmy and Vinini equivalent, D442g (CO) (part).
Range: Zone of *Hallograptus etheridgei.*

Genus DICHOGRAPTUS Salter, 1863

Dichograptus Salter. Bulman, 1955, Geol. Soc. America, Treatise on invertebrate paleontology, pt. V, p. V78, fig. 55.

Eight or fewer stipes, dividing dichotomously to third order only. First two orders usually short, third order long and usually flexuous. Thecae denticulate.

Dichograptus octobrachiatus (J. Hall)

Plate 1, figure 4; plate 2, figure 4

Graptolithus octobrachiatus J. Hall, 1858, Canada Geol. Survey, Rept. Progress for 1857, p. 122–123.

Graptolithus octobrachiatus J. Hall, 1865, Canada Geol. Survey, Canadian Organic Remains, Decade 2, p. 96, pl. 7, fig. 1–7; pl. 8, fig. 1–4.

Dichograptus octobrachiatus J. Hall. Elles and Wood, 1902, Palaeontographical Soc., v. 56, Mon. British Graptolites, pt. 2, p. 77–79, pl. 9, 10, figs. 1a–e.

Dichograptus octobrachiatus J. Hall. Ruedemann, 1904, New York State Mus. Mem. 7, p. 634–639, pl. 8, figs. 1–7; pl. 9, fig. 1, 2.

Dichograptus octobrachiatus J. Hall. Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 288–289, pl. 46, fig. 3–7.

Dichograptus octobrachiatus (J. Hall). Berry, 1960, Texas Univ. Pub. 6005, p. 51, pl. 7, fig. 13; pl. 8, figs. 2, 12.

In his description of this species J. Hall (1865, p. 96) called particular attention to the strong development of a central disk, which is generally but not always regularly octagonal in form, and to the extreme length of the third-order stipes. Proximally these stipes are about 1.3 mm wide and distally about 3.3 mm. Their length may approach 200 mm.

Thecae number 7–8 in 10 mm. Ventral margin of each theca curved, inclined from the axis at an angle of 20° at the base and more than 50° near the aperture.

Ruedemann (1904, p. 635–636) stated that the funicle (two first order branches on either side of the sicula, considered together) is about 2mm long and divides at each end; the second order branches are about 1.5 mm long.

The thecal count was stated by Ruedemann (1947, p. 289) to be 8–10 in 10 mm. Elles and Wood (1902, p. 78) reported as few as 5 thecae in 10 mm.

Figured specimens: USNM 138465, 138466.

Occurrences: Valmy and Vinini equivalent, D359b (CO), D359c (CO), (both mixed collections).

Range: Zone of *Isograptus*. However, in the Marathon region, Texas the range is reported to be from the zone of *Tetragraptus approximatus* to the zone of *D. protobifidus*. It is reported in the Bendigonian of Australia.

Discussion.—All the present specimens are fragmentary and very small; they do not show the species characteristics to good advantage.

Genus TETRAGRAPTUS Salter, 1863

Tetragraptus Salter. Bulman, 1955, Geol. Soc. America, Treatise on Invertebrate paleontology, pt. V, p. V79, fig. 56, 1a–g.

Rhabdosome bilaterally symmetrical, with four second-order stipes, pendent to reclined. Funicle (combined first-order branches from sicula) usually short and composed of only one pair of thecae.

Tetragraptus amii Elles and Wood

Plate 3, figure 1

Tetragraptus amii Lapworth Ms. Elles and Wood, 1902, Palaeontographical Soc., V. 56, Mon. British Graptolites, pt. 2, p. 60, fig. 36; pl. 5, figs. 4a–c.

Tetragraptus amii Elles and Wood. Ruedemann, 1904, New York State Mus. Mem. 7, p. 647–649, pl. 11, figs. 5–7; figs. 53, 54.

Tetragraptus amii Lapworth. Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 301–302, pl. 50, figs. 12–14.

Tetragraptus amii Lapworth. Berry, 1960, Texas Univ. Pub. 6005, p. 52, pl. 6, fig. 10; pl. 7, fig. 9.

The original description, by Elles and Wood (1902), states that the main stipes of this species are usually 25–35 mm long but may reach 55 mm. Proximally they are narrow, widening to about 3 mm and then decreasing slightly toward the tips.

Thecae number 9–10 in 10 mm and are inclined about 45° to the axis; the base of each theca is inclined only 30°, the ventral margin curving. The fully developed thecae are about 3 mm long, overlap three-fourths, and are about 3–4 times as long as wide.

Figured specimen: USNM 138468.

Occurrence: Phi Kappa formation, USGS colln. 1367 (SD).

Range: Zone of *Didymograptus protobifidus*.

Discussion.—The specimens available here are not well preserved. They do show the rapid widening of the stipes and the coarseness of thecal denticulation.

TABLE 3.—*Characteristics of some species of the genus* Tetragraptus

Species	Character of stipe	Maximum width of stipes (mm)	Number of thecae in 10 mm	Angle of inclination of thecae
Horizontal forms				
T. approximatus	At right angles to funicle, like letter H	2.1	10	45°
T. amii	Horizontal, straight	3	10–9	45°
T. quadribrachiatus	do	2.3	10–8	38°
Dependent forms				
T. fruticosus	Pendent, flexed	3.5	10–8 proximal 6 distal	20° proximal 40° distal
T. pendens	Pendent, straight	.6	12–9	15°–20°
Reclined forms				
T. reclinatus	Reclined, straight	2	13–12	45°
T. serra	do	4.0	9–8	40°–45°
T. similis	Reclined, flexed	3.2	14–12	50° initial 70° at aperture

Tetragraptus approximatus Nicholson

Plate 3, figure 7

Tetragraptus approximatus Nicholson, 1873, Annals and Mag. Nat. History, v. 11, 4th ser., p. 136–137, fig. 2.

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Tetragraptus approximatus Nicholson. Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 312–313, pl. 52, figs. 4–6, 17, 18.

Tetragraptus approximatus Nicholson. Bulman, 1955, Geol. Soc. America, Treatise on invertebrate paleontology, pt. V, fig. 56, 1c.

Tetragraptus approximatus (Nicholson). Berry, 1960, Texas Univ. Pub. 6005, p. 52, 53, pl. 6, figs. 1–3.

The outline of this species suggests a long narrow letter H, although Nicholson (1873, p. 137) in the original description preferred to compare it to the letter X.

The funicle is about 2.5 mm long, bifurcating at each end nearly at right angles; the branches curve sharply and then run parallel with each other. Opposite stipes are 5–8 mm apart. Stipes may exceed 45 mm in length.

Thecae number 10 in 10 mm, and are inclined 45° to the axis.

Figured specimen: USNM 138469.

Occurrence: Valmy and Vinini equivalent, USGS colln. D442c (CO), D442g (CO).

Range: Zone of *Tetragraptus approximatus*.

Tetragraptus bigsbyi (J. Hall)

Phyllograptus similis J. Hall, 1858, Canada Geol. Survey, Rept. Progress for 1857, p. 140–141.

Graptolithus bigsbyi J. Hall, 1865, Canada Geol. Survey, Canadian Organic Remains, Decade 2, p. 86–87, pl. 16, figs. 22–30.

Tetragraptus bigsbyi (J. Hall). Elles and Wood, 1902, Paleontographical Soc., v. 56, Mon. British Graptolites, pt. 2, p. 68–69, pl. 6, fig. 6a–e, fig. 42a–b.

Tetragraptus similis (J. Hall) [part] Ruedemann, 1904, New York State Mus. Mem. 7, p. 658–662, pl. 12, fig. 6.

Tetragraptus similis (J. Hall) [part] Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 310–311, pl. 51, figs. 4, 5, 11.

Tetragraptus bigsbyi (J. Hall). Berry, 1960, Texas Univ. Pub. 6005, p. 53–54, pl. 7, fig. 11.

As indicated by Hall's description (1865, p. 86–87) the species is characterized by four semielliptical stipes, the axial edge of each being straight or very slightly curved while the thecal edge is markedly curved. The stipes are strongly reflexed. Hall was unable to discover a sicula. Elles and Wood (1902, p. 69) reported that it was more than 2 mm long as did Ruedemann (1904, p. 659).

Thecae number 12–14 in 10 mm. At their bases they diverge at about 50° from the axis; the ventral wall is curved so that it diverges as much as 70° near the aperture. Apertural angles are mucronate.

Reference specimen: USNM 138470.

Occurrence: Phi Kappa formation USGS colln. 1367 (S.D.).

Range: Zone of *Didymograptus protobifidus* and in Great Britain it is reported from zone 4.

Discussion.—This species when compressed so that only 2 of the 4 stipes are visible can be confused with *Isograptus*. If the stipes are reflexed far enough to touch back to back, it might also be taken for *Phyllograptus*, as it originally was by Hall (1858).

Tetragraptus fruticosus (J. Hall)

Plate 2, figures 5, 7, 9; plate 3, figure 5

Graptolithus fruticosus J. Hall, 1858, Canada Geol. Survey Rept. Progress for 1857, p. 128.

Graptolithus fruticosus J. Hall, 1865, Canada Geol. Survey, Canadian Organic Remains, Decade 2, p. 90, pl. 5, figs. 6–8.

Didymograptus? fruticosus (J. Hall). Etheridge, 1874, Annals and Mag. Nat. History, v. 14, 4th ser., p. 6, pl. 3, fig. 19.

Tetragraptus fruticosus (J. Hall). Elles and Wood, 1902, Palaeontographical Soc., v. 56, Mon. British Graptolites, pt. 2, p. 61–63, fig. 37, pl. 6, fig. 2a, b.

Tetragraptus fruticosus (J. Hall). Ruedemann, 1904, New York State Mus. Mem. 7, p. 649–652, pl. 9, figs. 11–14; pl. 10, figs. 1–10.

Tetragraptus fruticosus (J. Hall). Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 304–305, pl. 51, fig. 25–32.

Tetragraptus fruticosus (J. Hall). Berry, 1960, Texas Univ. Pub. 6005, p. 54–55, pl. 6, figs. 7, 11, 12, pl. 7, fig. 14, pl. 8, figs. 1–3, pl. 9, fig. 3.

This is a pendent species of *Tetragraptus*. The sicula is prominent and about 2 mm long. From it two thecae bud. Each of these produces two branches, gracefully curving to give an outline like that of a bell or of a trumpet. The branches increase in width continuously to as much as 3.5 mm. In some specimens the ends of the branches are reflexed, this taking place 18–50 mm from the sicula.

Thecae number 8 in 10 mm proximally and 6 in 10 mm distally; proximal thecae overlap one-half and diverge 20°; distal ones overlap over three-fourths and diverge 40° from axis.

Two varieties are recognized—those in which 4 branches are produced and those in which 3 branches are formed.

Figured specimens: USNM 138471, 138472, 138473, 138474.

Occurrences of three-branched variety: Unnamed formation, Mt. Morrison quad., California, D516 (CO); Valmy formation, 1292 (CO), D123 (CO), D499 (CO); Phi Kappa formation, 1367 (SD).

Occurrrences of four-branched variety: Unnamed formation, Mt. Morrison quad., California, D516 (CO); Valmy formation, 1292 (CO), D434 (CO), D485 (CO).

Range: Zones of *T. fruticosus*, (4-branched and 3- and 4-branched forms).

Discussion.—This species may be confused with *T. pendens* Elles but differs in spacing of thecae, their inclination, and the continuous increase in width of stripes which in *T. pendens* are of uniform width.

Although Hall figured both varieties, Etheridge (1874, p. 6, pl. 3, fig. 9) seems to have been the first to call attention to the three-branched forms as important in Australia. No British or North

American author seems to have paid much heed to this possible subdivision of the species. Eventually Harris and Keble (1932, p. 30, 32–33, pl. 4, figs. 1, 5) showed that the Australian Bendigo series could be subdivided on the basis of these two varieties, and their scheme was followed by Harris and Thomas (1938b, p. 65–66, 68, pl. I, figs. 18, 19). Berry has found the subdivision useful in the Marathon region of Texas.

Tetragraptus pendens Elles

Tetragraptus pendens Elles 1898, Geol. Soc. London Quart. Jour., v. 54, p. 491, fig. 13.

Tetragraptus pendens Elles. Elles and Wood, 1902, Palaeontographical Soc. v. 56, Mon. British Graptolites, pt. 2, p. 63–64, pl. 6, figs. 3a–d.

Tetragraptus pendens Elles. Berry, 1960, Texas Univ. Pub. 6005, p. 55, pl. 7, fig. 7.

This species is represented by a single poorly preserved specimen in our collections. It is a pendent form, similar to *T. fruticosus.*

The stipes are 12–18 mm long, curving downward, eventually running almost parallel to each other; their width is about 0.6 mm and constant. The sicula is strong. Thecae number 9–12 in 10 mm, and are inclined 15°–20° and are about 3 times as long as wide. They overlap ½–⅔.

Identified specimen: USNM 138475.
Occurrence: Unnamed formation, Mt. Morrison quad., California, D536 (CO).
Range: Zone of *D. protobifidus.*

Discussion.—This species is distinguished from *T. fruticosus* by its smaller size, more slender branches of uniform width, closer spacing of thecae, and subparallelism of branches distally.

Tetragraptus quadribrachiatus (J. Hall)

Plate 3, figure 2

Graptolithus quadribrachiatus J. Hall, 1858, Canada Geol. Survey, Rept. Progress for 1857, p. 125.

Graptolithus quadribrachiatus J. Hall, 1865, Canada Geol. Survey, Canadian Organic Remains, Decade 2, p. 91–92, pl. 5, fig. 1–5; pl. 6, figs. 5, 6.

Tetragraptus quadribrachiatus (J. Hall.) Elles and Wood, 1902, Palaeontographical Soc. v. 56, Mon. British Graptolites, pt. 2, p. 57–58, pl. 5, fig. 1a–d.

Tetragraptus quadribrachiatus (J. Hall). Ruedemann, 1904, New York State Mus. Mem. 7, p. 645–647, pl. 2, fig. 1–4.

Tetragraptus quadribrachiatus (J. Hall). Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 307–308, pl. 50, figs. 15–18.

Tetragraptus quadribrachiatus (J. Hall). Berry, 1960, Texas Univ. Pub. 6005, p. 55–56, pl. 7, fig. 12.

According to Hall's description (1865, p. 91–92) the species is quadriradiate, its stipes very gradually increasing in width from

0.5–1.0 mm proximally to 2.3 mm distally. Thecae are inclined about 38° and are about 4 times as long as wide, overlapping 3/5–2/3. Apertural margins are straight, making an angle of 95°–100° with the axis. There are 8–10 thecae in 10 mm.

To this description Ruedemann (1904, p. 646) added the important information that the funicle is 2.6 mm long and apparently composed of 2 thecae on each side of the sicula.

Figured specimen: USNM 138476a, b.

Occurrence: Valmy formation, D96 (CO); Phi Kappa formation, 1367 (SD).

Range: Zone of *Didymograptus protobifidus*. In Australia it may range as high as the Middle Ordovician (Harris and Keble, 1932, p. 31; Harris and Thomas, 1938b, table on p. 65) or equivalent to the zone of *Hallograptus etheridgei;* the reported occurrence there may be the result of an erroneous identification in the broad sense, however.

Discussion.—Several species very close to *T. quadribrachiatus* are present in the Garden City formation (pl. 3, figs. 8, 9), but all differ in length of funicle and spacing of thecae.

Tetragraptus reclinatus Elles and Wood

Plate 3, figure 3

Tetragraptus reclinatus Elles and Wood, 1902, Palaeontographical Soc., v. 56, Mon. British Graptolites, pt. 2, p. 67, pl. 6, figs. 5a–e.

This is a species with reclined stipes and a conspicuous sicula. The stipes are 12–9 mm long, straight, very narrow proximally, but about 2 mm wide for most of their length. Thecae number 12–13 in 10 mm; they are inclined 45° to the axis, are 3 times as long as wide, and overlap two-thirds.

Figured specimen: USNM 138477.

Occurrence: Phi Kappa formation, 1367 (SD).

Range: Zone of *Didymograptus protobifidus.*

Discussion.—This species resembles *T. serra*, but it is smaller, with more slender branches, and more closely spaced thecae.

Tetragraptus serra (Brongniart)

Plate 3, figure 6

Tetragraptus serra (Brongniart). Elles and Wood, 1902, Palaeontographical Soc., v. 56, Mon. British Graptolites, pt. 2, p. 65–67, pl. 6, fig. 4a–f.

Tetragraptus serra (Brongniart). Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 309, pl. 50, fig. 19–23.

Tetragraptus serra (Brongniart). Berry, 1960, Texas Univ. Pub. 6005, p. 56, pl. 6, fig. 6; pl. 13, fig. 1.

This is a species with reclined stipes. As indicated by Ruedemann (1947, p. 309), the sicula is about 2 mm long. The funicle, about 2.7 mm long is composed of only 2(?) thecae. Second-order branches

form the main stipes, which are 25–60 mm long, proximally 0.7 mm wide, and distally as much as 4.0 mm wide. Thecae number 8–9 in 10 mm, overlapping ⅔–¾, inclined 40°–45° to axis.

Figured specimen: USNM 138478.

Occurrence: Valmy and Vinini equivalent, D359b (CO); Phi Kappa formation, 1367 (SD).

Range: Zone of *Tetragraptus fruticosus* (3- and 4-branched forms) to *Didymograptus protobifidus*.

Discussion.—The present specimens from Idaho are the largest ever assigned to the species. Ordinarily stipes are not more than 50 mm long or 3.2 mm wide. Preservation leaves much to be desired, however.

Tetragraptus sp.

Plate 3, figures 8, 9

We have illustrated two specimens of this genus that probably represent new species. Unfortunately there are too few specimens on which to base species descriptions. Specimens are therefore merely figured to indicate presence of these forms in the hopes that other examples will be recognized by future investigators. These specimens differ from most known species in the length of funicles, spacing of thecae, and width of stipes.

Figured specimens: USNM 138479, 138480.

Occurrences: Garden City formation, D206 (CO), D206a (CO). Valmy formation, D483 (CO). Valmy and Vinini equivalent, D442c (CO).

TABLE 4.—*Characteristics of some species of the genus* Phyllograptus

Species	Character of rhabdosome	Length (mm)	Width (mm)	Number of thecae in 10 mm	Thecal characteristics
P. anna	Small	3–11	5 (max.)	20–16	Thecae in contact throughout, strongly curved near center of rhabdosome. Apertural margins concave, with mucronate extensions.
P. griggsi	Long, relatively slender.	40–50	9–6	13–11	Apertural margins have mucronate extensions.
P. ilicifolius	Broadly oval	19.5 (max., commonly one-fourth less)	11.3 (max., commonly one-fourth less)	13–11	Thecae strongly curved near sicula, but only slightly bent in middle part. Apertures slightly concave.
P. ilicifolius var. *major.*	Narrowly pointed proximally, widens distally.	25	10	18 proximal 10 distal	Like those of *P. ilicifolius.*
P. loringi	----------	----------	11	14–13	Thecae in contact for most of length. Apertural margins concave with projecting lower lip.
P. nobilis	Shape variable from wide stout forms to slender forms.	----------	----------	11	Thecae in contact for most of length, ventral margins sigmoidal. Apertural margin concave, mucronate with distinct denticle.

Genus PHYLLOGRAPTUS Hall, 1858

Phyllograptus Hall. Bulman, 1955, Geol. Soc. America, Treatise on invertebrate paleontology, pt. V, p. V79, figs. 56, 2a–c.

Four branches, all scandent (back to back). Rhabdosome in cross section forming a right-angled equidimensional cross. In outline, leaf shaped.

Thecae simple, slightly curved, with much overlap.

In the compressed state several forms assigned to this genus can be confused with *Glossograptus*. *Phyllograptus nobilis* described below is such a species. *Glossograptus* is a biserial scandent genus and will never show the cross section of a pair of stipes normal to the plane of compression as is often the case in *Phyllograptus*.

Phyllograptus anna J. Hall

Plate 3, figures 11, 12, 15, 16

Phyllograptus anna J. Hall, 1865, Canada Geol. Survey, Canadian Organic Remains, Decade 2, p. 124, pl. 16, figs. 11–16.

Phyllograptus anna J. Hall. Ruedemann, 1904, New York State Mus. Mem. 7, p. 714–716, pl. 15, figs. 23–27.

Phyllograptus anna J. Hall. Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 316–317, pl. 53, fig. 27–32.

Phyllograptus anna J. Hall. Berry, 1960, Texas Univ. Pub. 6005, p. 57, pl. 8, fig. 14, pl. 10, fig. 4.

According to Hall's original description (1865, p. 124) the length of rhabdosome is 3–11 mm. A specimen 11 mm long is about 5 mm wide. Thecae number 14–15 in 10 mm. Ruedemann (1947, p. 316) reported a higher thecal count of 16–20 in 10 mm, which agrees with our specimens from the Dugway Range, Utah, and from Nevada.

Figured specimens: USNM 138481, 138482, 138485, 138486.

Occurrences: Garden City formation, D317h (CO). Valmy formation, D96 (CO). Valmy and Vinini equivalent, D359b (CO). Phi Kappa formation 1367 (SD).

Range: Zones of *Tetragraptus fruticosus* (3- and 4-branched forms) and *Didymograptus protobifidus*.

Phyllograptus griggsi n. sp.

Plate 4, figures 1, 2

[Part] *Phyllograptus angustifolius* var. *magnificus* Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 316, pl. 53, fig. 7. [Not pl. 90, fig. 20.]

The rhabdosome 40–50 mm long and 6–9 mm wide, expanding rapidly from the proximal end. Thecae number 11–13 in 10 mm. The shape of the thecae cannot be determined in any of the available specimens; their representation by Ruedemann (1947, pl. 53, fig. 7) is entirely interpretive as shown by plate 4, figure 1. The lower lip of

each aperture is mucronate, so that the edges seem to recede toward the top, as in *P. angustifolius* (Ruedemann, 1947, p. 315).

Holotype: USNM 138490.
Paratype: USNM 138489.
Occurrence: Phi Kappa formation, 1367 (SD).
Range: Zones of *Tetragraptus fruticosus* and *Didymograptus protobifidus*.

Discussion.—This species is probably related to *P. angustifolius* from which it differs by a higher thecal count; Hall (1858, p. 139–140; 1865, p. 125) stated clearly that *P. angustifolius* possessed 9–10 thecae in 10 mm despite Ruedemann's (1904, p. 712; 1947, p. 315) assertion that the count was 11–13 in 10 mm. The Idaho specimens are about the same length and width as the largest specimens of *angustifolius* described by Hall (1865, pl. 16, fig. 17–21). Although agreeing in thecal count with specimens figured by Ruedemann (1904, pl. 15, figs. 31–34), they are considerably longer and wider.

Unless specimens can be found showing the shape of the thecae, it will be impossible to relate this species to others.

The specimen illustrated on plate 4, figure 1, was erroneously included in *P. angustifolius* var. *magnificus* Ruedemann (1947, p. 316, pl. 53, fig. 7). The holotype for that variety is from Arkansas and is illustrated by Ruedemann (1947) in his plate 90, figure 20. The explanation of that figure should be corrected to show that that specimen comes from USGS colln. 323i (OS), Hot Springs quadrangle. The specimens from the Phi Kappa formation are quite different.

Phyllograptus ilicifolius J. Hall

Plate 3, figures 4, 10; plate 4, figure 9

Phyllograptus ilicifolius J. Hall, 1858, Canada Geol. Survey, Rept. Progress for 1857, p. 139.
Phyllograptus ilicifolius J. Hall, 1865, Canada Geol. Survey, Canadian Organic Remains, Decade 2, p. 121–123, pl. 16, figs. 1–10.
Phyllograptus ilicifolius J. Hall. Ruedemann, 1904, New York State Mus. Mem. 7 p. 706–708, pl. 15, figs. 15–22.
Phyllograptus ilicifolius J. Hall. Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 317–318, pl. 53, fig. 9–11.
Phyllograptus ilicifolius J. Hall. Berry, 1960, Texas Univ. Pub. 6005, p. 57, pl: 8, fig. 4; pl. 9, figs. 1, 2.

The rhabdosome reaches a length of 19.5 mm and width of 11.3 mm as maxima (Ruedemann, 1904, p. 707). Thecae number 11–13 in 10 mm. At the sicular end they are strongly curved with apertures facing downward, in middle with apertures facing horizontally, and distally with thecal tubes subparallel to axis. The lower margin of each aperture is mucronate.

Figured specimens: USNM 138487, 138488.

Occurrences: Garden City formation, D206a (CO). Valmy formation, D96 (CO). Phi Kappa formation, 1367 (SD).

Range: Zone of *Clonograptus-Adelograptus* probably to zone of *Didymograptus protobifidus.*

Phyllograptus ilicifolius var. major Ruedemann

Plate 3, figure 17

Phyllograptus ilicifolius var. *major* Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 318–319, pl. 53, fig. 21.

The specimen illustrated here and several like it in the present collections have narrowly pointed rhabdosomes proximally, widening distally. The thecae number 18 in 10 mm proximally to 10 in 10 mm distally. The length is about 25 mm but the maximum width does not seem to exceed 10 mm.

The original description of this variety calls for somewhat smaller specimens with much less range in the thecal spacing. It is based furthermore on specimens from Canada, although the specimen figured here was designated the holotype in the plate explanation but not mentioned at all in the text (Ruedemann, 1947, p. 319, pl. 53, fig. 21).

The variety differs from *P. ilicifolius* by the greater length of rhabdosome and by closer proximal spacing of thecae. *P. ilicifolius* var. *grandis* Elles is considerably wider (Elles, 1898, p. 493) but otherwise very similar in general form. The spacing of its thecae is 11–13 in 10 mm.

Holotype: USNM 102468.

Occurrence: Phi Kappa formation, 1367 (SD).

Range: Probably zone of *Didymograptus protobifidus.*

Phyllograptus loringi White

Plate 4, figure 3

Phyllograptus loringi White, 1874, U.S. Geog. and Geol. Explors. and Surveys W. 100th Mer. Prelim. Rept., Invertebrate Fossils, p. 9.

Phyllograptus loringi White, 1877, U.S. Geog. Surveys W. 100th Mer. Rept., v. 4, p. 51; pl. 3, fig. 12.

Phyllograptus loringi White. Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 319–320, pl. 53; fig. 1.

The holotype is a single broken specimen more than 30 mm long and 11 mm wide. The thecae number 13–14 in 10 mm. Lower lip of each aperture is a transverse flange; there are no apertural spines. Rigby (1958, p. 913) has described another specimen 29 mm long and 17 mm wide, but has not illustrated it.

Holotype: USNM 8561.

Occurrence: Precise locality not known. Fish Springs Range, Utah.

Range: Fillmore limestone of Hintze (1951, p. 51–52, according to Rigby, 1958, p. 913). Probably zone H of Ross (1951) based on Hintze's faunal lists

(1952, p. 33, H–28 and H–29). Probably the zone of *Didymograptus protobifidus*; possibly somewhat lower.

Discussion.—This species differs from *P. typus* by the slightly tighter spacing of thecae (maximum of 11 in 10 mm in *P. typus*). Ruedemann (1947, p. 319) has suggested that *P. iliciformis* var. *grandis* may be a synonym.

Phyllograptus nobilis Harris and Keble

Plate 3, figures 13, 14

Phyllograptus nobilis Harris and Keble, 1932, Royal Soc. Victoria Proc., v. 44, new ser., pt. 1, p. 41–42, pl. 6, figs. 3, 4.

Phyllograptus nobilis Harris and Keble. Berry, 1960, Texas Univ. Pub. 6005, p. 57–58, pl. 14, figs. 6, 7.

According to the original description, the outline of this species virtually runs the gamut of shapes found in all species of *Phyllograptus*. Thecae number 11 in 10 mm; their ventral margins are sigmoidal. Thecae in contact for almost full length. Apertural margin concave, mucronate, with distinct denticle.

Figured specimens: USNM 138491 a, b.
Occurrence: Vinini formation, 222 (OS).
Range: Zones of *Hallograptus etheridgei* and *Glyptograptus teretiusculus.*

Discussion.—The only distinguishing feature given in the description of this species seems to be the sigmoid curvature of the thecae, a feature that we have difficulty in distinguishing in either the original illustrations (Harris and Keble, 1932, pl. 6, figs. 3, 4) or the present specimens. In the opinion of the senior author, the validity of the species is doubtful. In the opinion of the junior author the overall shape distinguishes this form from *P. angustifolius* and the shape and mucronate apertures serve to set it apart from other species.

Genus RAMULOGRAPTUS n. gen.

Dichograptid rhabdosome composed of 2 first-order and 2 second-order stipes. One first-order stipe unbranched, whereas the other bifurcates once. Rhabdosome slender and primary stipes of type species diverge from minute sicula at 180°. Thecae simple, inclined at low angle, and have but little overlap.

Type species: Ramulograptus surcularis n. gen., n. sp.

Discussion.—This form resembles the genus *Didymograptus* initially, but 1 of the 2 primary stipes bifurcates.

Ramulograptus surcularis n. sp.

Plate 5, figure 6

The rhabdosome is small and didymograptid initially. The two primary stipes diverge from a minute sicula at a 180° angle. The

unbranched stipe attains a length of at least 10 mm whereas the other stipe is 0.5–0.55 mm in length before bifurcation. The secondary stipes are at least 12 mm in length. All stipes are of uniform width—approximately 0.2 mm. The angle at bifurcation is variable. In the specimens at hand, it ranges from 70° to 90°. The thecae are long and slender, number 7 in 10 mm, and overlap 0.4 mm.

Holotype: USNM 138492.
Paratypes: USNM 138493, 138494.
Occurrence: Valmy and Vinini equivalent, D442f.
Range: Zone of *Isograptus*.

Genus DIDYMOGRAPTUS McCoy, 1851

Didymograptus McCoy, 1851, *in* Sedgwick, Classification of British Paleozoic rocks. Cambridge, p. 9.
Didymograptus McCoy. Bulman, 1955, Geol. Soc. America, Treatise on invertebrate paleontology, pt. V, p. V79–V80.

Rhabdosome composed of one pair of stipes (branches of the first order from sicula), pendent to reclined. Thecae typically simple, straight or slightly curved ventrally; rarely sigmoid or with elaborate apertures.

Didymograptus artus Elles and Wood

Plate 4, figures 10, 11

Didymograptus artus Elles and Wood, 1901, Palaeontographical Soc., v. 55, Mon. British Graptolites, pt. 1, p. 48–49, pl. 4, figs. 6a–d, fig. 30.
Didymograptus artus Elles and Wood. Berry, 1960, Texas Univ. Pub. 6005, p. 58–59, pl. 10, figs. 2, 5, 6.

According to Elles and Wood (1901, p. 48–49) the stipes are pendent, 12–25 mm long, very narrow at their origins (0.4 mm) but expanding continuously to a maximum width of 1.3 mm. Initially the branches diverge at approximately 90°, then curve to run parallel or within 5° of parallel. The distance between the subparallel stipes is 5–6 mm.

The sicula is about 1.3 mm long. Thecae number 18–19 in 10 mm, are inclined 50° to axis of stipe, are 2 to 3 times as long as wide, and overlap 1/2–2/3.

Figured specimens: USNM 138495, 138496.
Occurrence: Swan Peak formation, D204 (CO).
Range: Zone of *Didymograptus bifidus* and *D. artus*.

Didymograptus compressus Harris and Thomas

Plate 4, figures 16–18

Didymograptus compressus Harris and Thomas, 1935, Royal Soc. Victoria Proc., v. 47, new ser., pt. 2, p. 293–294, fig. 1, nos. 6a–c; fig. 2, nos. 20, 21.
Didymograptus compressus Harris and Thomas. Berry, 1960, Texas Univ. Pub. 6005, p. 59.

Harris and Thomas (1935, p. 293) give the following description for *D. compressus:*

Stipes up to 8 cm in length, and from the evidence of detached stipes, probably longer; uniformly slender, diverging from a comparatively long and slender sicula at an angle of about 120° (though sometimes at a greater or less angle), very narrow proximally but widening gradually till a width of 0.6 mm is reached, this width being then maintained. The stipes swing back to a sub-horizontal position. Thecae tubes, 4–5 times as long as wide, in their length, and inclined at an angle as low even as 10°. Ventral margins slightly sigmoid, apertural margins inclined at an angle of a little less than 90°.

The stipes of the specimen illustrated by Harris and Thomas (1935) in figure 2, number 20, are not subhorizontal after an initial angle of divergence of 120°. Also, the slight sigmoid curvature of the thecae is not clearly seen in any of the figures. Thus, more variation is probably present in this species than is given in the description. Some of the specimens from Summit, Nev., labeled by Gurley as cotypes of *Didymograptus perflexus* have the following dimensions: the stipes are at least 6 cm long, very narrow proximally but widening gradually until a maximum width of 0.7 mm is attained and this width is then maintained; the stipes diverge from the sicula at an initial angle of 150° but swing to a subhorizontal position; the thecae number 12 in 10 mm proximally and 9 in 10 mm distally; they are long tubes, 4 times as long as wide, and are in contact one-half their length; the proximal thecae are inclined at an angle of 15° to the stipe and the distal thecae at a 20° angle; the ventral margins are slightly sigmoid, and the apertural margins are inclined at an 80°–85° angle to the stipe. These Nevada specimens fall within the variation of *D. compressus*, with the possible exception of the thecal count, and have been identified as that species.

Figured specimens: USNM 138497, 138498.

Occurrence: Vinini formation, 222 (OS).

Range: Zone of *Hallograptus etheridgei.*

Discussion.—Although Gurley's species name *perflexus* antedates the name *compressus*, Gurley's original description does not match any of the forms with complete rhabdosomes included by him as cotypes of *D. perflexus.* Also, at least four different species are included among those cotypes. Thus, the name *perflexus* should be dropped unless specimens agreeing with Gurley's description can subsequently be found.

Didymograptus ensjøensis Monsen

Plate 4, figure 14

Didymograptus ensjøensis Monsen, 1937, Norsk geol. tidsskr., v. 16, p. 107–108, taf. 1, fig. 40; taf. 7, figs. 12, 14.

Original description translated:

Branches diverging under 180°. Ventral edge concavoconvex or usually quite straight. Outline of the dorsal border slightly curved or straight. Stipes 20–50 mm long, proximally 0.8–1.0 mm wide, quickly reaching a maximum of 2.2 mm, usually between the 8th and 10th thecae; 8–9 thecae in 10 mm. Thecae 2.2–3 mm, not rarely 3.5–4 mm long. Straight or only slightly curved. When not or slightly compressed, thecae are long, narrow tubes, at the aperture only slightly wider. Generally compressed, then at the aperture widened and more or less contrictiform. When strongly constrictiform about 3–3.5 times as long as wide. Proximally overlap is about ½, distally about ⅔–¾. Angle of inclination in the adult part lower than at the aperture, about 20°, on the average 25°–30°. Apertural angle averages 65°–85°, possible varying between 50°–95°. Angle with the dorsal border 90°–120°. Sicula 1.6-about 2 mm long * * *.

Distinguishing features (Monsen, 1937, p. 107):

1. The stiff branches, narrower proximally than distally.
2. The form and number of thecae.
3. The broad, open proximal part.

Figured specimen: USNM 138499.
Occurrence: Unnamed formation, Mt. Morrison quad., California, D516 (CO).
Range: Zone of *Tetragraptus fruticosus* (3- and 4-branched forms).

Discussion.—Our specimens are all poorly preserved and do not reveal the full dimensions of mature specimens.

Didymograptus extensus J. Hall

Plate 5, figure 1

Didymograptus extensus J. Hall, 1858, Canada Geol. Survey, Rept. Progress for 1857, p. 132.
Didymograptus extensus J. Hall, 1865, Canada Geol. Survey, Canadian Organic Remains, Decade 2, p. 80–82, pl. 2, figs. 11–16.
Didymograptus extensus J. Hall. Ruedemann, 1904, New York State Mus. Mem. 7, p. 668–671, pl. 13, figs. 17, 18; pl. 14, figs. 1–4.
Didymograptus extensus J. Hall. Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 331–332, pl. 55, fig. 16; pl. 56, figs. 1, 2.
Didymograptus extensus J. Hall. Berry, 1960, Texas Univ. Pub. 6005, p. 60, 61, pl. 6, fig. 5; pl. 8, fig. 10.

The sicula is inconspicuous. The stipes, diverging at 180°, are proximally 0.5–0.7 mm wide and at a distance of 100 mm 2.5 mm wide. They attain lengths of 400 mm. The thecal count is 10–11 in 10 mm according to Hall (1865, p. 80–81) but 9 in 10 mm according to Ruedemann (1904, p. 669). Length of thecae is twice their width proximally and three times their width distally. Thecal overlap is a half proximally and two-thirds distally. Thecae are inclined at an angle of 35°–40°. Each apertural face is normal to the axis of its theca.

Figured specimen: USNM 138500.
Occurrence: Phi Kappa formation, 1367 (SD).
Range: Zone of *Tetragraptus fruticosus.*

Discussion.—British examples of this species do not attain as great a length or width of stipe as do the American specimens (Elles and Wood, 1901, p. 8).

Didymograptus gracilis Törnquist

Plate 5, figure 11

Didymograptus gracilis Törquist, 1891, Lunds Univ. Arsskr., v. 26, p. 17, pl. 1, figs. 9–12.
Didymograptus gracilis Törnquist. Elles and Wood, 1901, Palaeontographical Soc. V. 55, Mon. British Graptolites, pt. 1, p. 24–25, pl. 2, fig. 2.
Didymograptus gracilis Törnquist. Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 334, pl. 57, figs. 1–6.

This species is characterized by extremely slender almost threadlike stipes that diverge at 180°. One stipe originates near the midlength and the other near the aperture of the sicula. The stipes tend to bend irregularly; their greatest width of 0.2–0.5 mm is reached at the apertures of the thecae, which number 6–8 in 10 mm. Thecae are inclined 15° to axis, each widening toward its aperture.

Figured specimen: USNM 138501.
Occurrence: Vinini formation, 222 (OS). Phi Kappa formation, 1367 (SD).
Range: Known to occur in the zone of *Hallograptus etheridgei* in Nevada. Zone 4 (*Didymograptus extensus*) through zone of *D. bifidus* in Great Britain.

Discussion.—Although the sicula is more than 1 mm long it may be difficult to see because of poor preservation. In that case its position is indicated by the reversal in direction of thecae. It is nearly impossible to distinguish thecae without magnification.

Didymograptus nitidus (J. Hall)

Plate 5, figures 2, 4

Graptolithus nitidus Hall, 1858, Canada Geol. Survey, Rept. Progress for 1857, p. 129.
Graptolithus nitidus Hall, 1865, Canada Geol. Survey, Canadian Organic Remains, Decade 2, p. 69–71, pl. 1, figs. 1–9.
Didymograptus nitidus (Hall). Elles and Wood, 1901, Palaeontographical Soc. v. 55, Mon. British Graptolites, pt. 1, p. 10–11, pl. 1, fig. 2a–c.
Didymograptus nitidus (Hall). Ruedemann, 1904, New York State Mus. Mem. 7, p. 671–674, figs. 66–70; pl. 13, figs. 1–5; pl. 14, figs. 5, 6.
Didymograptus nitidus (Hall). Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 339–340, pl. 55, figs. 11–14; pl. 56, fig. 21.
Didymograptus nitidus (J. Hall). Berry, 1960, Texas Univ. Pub. 6005, p. 61–62, pl. 8, fig. 11.

This species possesses nearly horizontal stipes, that diverge for the proximal 3–5 mm of their length at 100°–180°; thereafter the

angle of divergence is 180°. The sicula is 1.3 mm long. The stipes reach a maximum width of 2.4 mm and attain lengths more than 100 mm. Thecae are spaced 11–13 in 10 mm. At the initial end each is inclined to the axis at about 40°, but because of slight curvature the apertural end is inclinded at about 50°. Apertures are simple, concave. Length 3–4 times breadth; overlap two-thirds proximally to three-fourths distally.

Figured specimen: USNM 138502a,b.

Occurrence: Garden City formation, D227 (CO).

Range: Zones of *Tetragraptus fruticosus* (3- and 4-branched form) and *Didymograptus protobifidus*.

Discussion.—None of our present specimens shows the full length of stipes, all having been broken. The species is associated with trilobites of zone H of Ross (1951).

Didymograptus aff. D. novus Berry

Plate 4, figure 8

Didymograptus novus Berry, 1960, Texas Univ. Pub. 6005, p. 62, pl. 5, fig. 6, 7.

Specimens from the Garden City formation are small, not exceeding 4 mm in length of stipes, which may be very slightly reflexed past 180°. The sicula is 1 mm long. Stipes are 3–4 mm in length, 0.6 mm wide. Thecae number 3 in 2.5 mm (12 in 10 mm). Thecae are about 1.6 mm long and 0.4 mm wide, overlapping about half their lengths.

Figured specimen: USNM 138503.

Occurrence: Garden City formation, D229 (CO).

Range: Zone of *Clonograptus-Adelograptus* or possibly zone *Tetragraptus fruticosus* 3- and 4-branched forms.

Discussion.—According to Berry's (1960, p. 62) description of *D. novus* the stipes are as much as 6 mm long, the sicula only 0.8 mm long, the stipes only 0.4 mm wide. In other respects the Utah and Texas forms are comparable.

Didymograptus perflexus Gurley

Didymograptus perflexus Gurley, 1896, Jour. Geology, v. 4, p. 66–67.

Didymograptus perflexus Gurley. Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 342–343.

As Ruedemann states (1947, p. 343) the cotypes of Gurley's species from "Summit," Nev., present themselves "under very many aspects." They represent so many different species that there is no adequate hypodigm on which to base any one species.

We feel that the species should be suppressed as indicated in our discussion of *Didymograptus compressus*.

Didymograptus protobifidus Elles

Plate 4, figures 6, 12

Didymograptus protobifidus Elles, 1933, Great Britain Geol. Survey Summary of Progress for 1932, p. 98, figs. 1–4.

Didymograptus protobifidus Elles. Berry, 1960, Texas Univ. Pub. 6005, p. 63–64, pl. 8, figs. 5–9.

According to the original description, this is a small species with dependent stipes, ranging from 10–20 mm in length, proximally narrow and widening to 1.3 mm. Stipes diverge about 20°–25° or are subparallel. The sicula is conspicuous. Thecae number 13 in 10 mm, overlapping one-half and inclined at a low but variable angle to the axis of the stipe. They are slightly curved at the distal ends.

Figured specimens: USNM 138505, 138506.
Occurrence: Phi Kappa formation, 1937 (SD).
Range: Zone of *D. protobifidus*.

Discussion.—This species can only be told from *D. artus* by the thecal count, although, commonly the stipes in *D. artus* are more nearly parallel than in this form.

Genus CARDIOGRAPTUS Harris and Keble, 1916

Cardiograptus Harris and Keble. Bulman, 1955, Geol. Soc. America, Treatise on invertebrate paleontology, pt. V, p. V80.

Rhabdosome composed of two stipes, scandent, outline elongate ovate, except that distal end is emarginated in a V-shape between last thecae of each stipe. Thecae long, thin, inclined at high angle to axis, with much overlap.

Cardiograptus crawfordi Harris

Plate 5, figure 9

Cardiograptus crawfordi Harris, 1926, Royal Soc. Victoria Proc., v. 38, new ser., pt. 2, p. 57, pl. 1, figs. 5–7.

Cardiograptus crawfordi Harris. Harris and Thomas, 1935, Royal Soc. Victoria Proc., v. 47, new ser., pt. 2, p. 306, fig. 2, no. 26.

Cardiograptus crawfordi Harris. Harris and Thomas, 1938, Min. and Geol. Jour., v. 1, no. 3, p. 72, pl. 2, fig. 61.

Cardiograptus crawfordi Harris. Berry, 1960, Texas Univ. Pub. 6005, p. 65, pl. 11, fig. 12.

According to Harris (1926, p. 57) the rhabdosome is small, heart shaped, usually about 7 mm long and 5 mm wide. The sicula is 2 mm or more long, but never distinct. Proximal thecae grow parallel to and beyond the sicula; succeeding thecae turn in a distal direction gradually until the most distal are turned at an angle of 165° to the axis. Thecae are trumpet-shaped tubes. Apertures are concave, each

with a strong denticle. Specimens with stronger distal emargination were included later by Harris and Thomas (1935, p. 306).

Figured specimen: USNM 138510.

Occurrence: Vinini formation, 2353 (SD).

Range: Zone of *Hallograptus etheridgei.* The stratigraphic position was originally given as upper Darriwilian (zones of *Glyptograptus intersitus* and *Didymograptus nodosus*) (Harris and Thomas, 1935, p. 306). This zonal position was later modified by Harris (1935, p. 332–333) to the zones of *Glyptograptus intersitus* and *Diplograptus decoratus*, which comprise zones 2 and 3 of the Australian "Middle Ordovician" (Harris and Thomas, 1938b, p. 65).

Cardiograptus folium Ruedemann

Plate 5, figure 7

Cardiograptus folium Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 356, pl. 58, figs. 1–3.

According to the original description of Ruedemann (1947, p. 356) the rhabdosome is medium sized, heart shaped, 14–20 mm long, and 8.5 mm wide. The distal notch is 2–3 mm deep. The sicula is 2 mm long and barely visible from outside. The first 2 or 3 thecae grow downwards, parallel to the sicula, but then the later thecae turn upwards until distally, the initial part is inclined at an angle of 20° – 40° to the stipe. They are curved, outwardly widening tubes that number 11 to 14 in 10 mm. Their apertures are concave and have a well-developed denticle.

The Idaho specimen agrees closely with Ruedemann's description. It is 15 mm long, 8.5 mm wide, and has a 3 mm deep distal notch. The sicula is approximately 2 mm long. The thecae number 12 in 10 mm distally and 14 in 10 mm proximally. The first few thecae grew subparallel to the sicula, and the distal thecae make a 40° angle with the axis initially, then curve outwards. Their apertures have a distinct mucro.

Figured specimen: USNM 138512.

Occurrence: Phi Kappa formation, 1367 (SD).

Range: Zone of *Isograptus.*

Discussion.—This form is quite close to *C. morsus* Harris and Keble but differs from it by the more closely spaced thecae (12–14 in 10 mm and 9–11 in 10 mm in *C. morsus*) and by widening more rapidly. *C. morsus* widens gradually and thus tapers somewhat proximally, whereas *C. folium* is a more square form. In all other respects, however, the two species are identical.

Genus ISOGRAPTUS Moberg, 1892

Isograptus Moberg. Bulman, 1955, Geol. Soc. America, Treatise on invertebrate paleontology, pt. V, p. V80–V81.

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Rhabdosome composed of two stipes, reclined. Thecae inclined at high angles to axis of each stipe; overlap large. First few thecae growing downward.

Isograptus caduceus cf. I. c. var. divergens Harris

Plate 5, figure 22

Isograptus caduceus var. *divergens* Harris, 1933, Royal Soc. Victoria Proc., v. 46, new ser., pt. 1, figs. 14–18.

Isograptus caduceus var. *divergens* Harris. Berry, 1960, Texas Univ. Pub. 6005, p. 66, pl. 11, fig. 6.

Although named and figured by Harris this variety has never been described. From his remarks it is clear that Harris (1933, p. 85, 88, 91) considered it an end product in a series in which the stipes become narrower and their angle of divergence (greater than 180°) increases. Harris' figures 14–18 show that the angle of divergence is about 330° in this variety, as against 315° in variety *maxima*, below. Width of stipes is 3 mm. Thecae number 9 in 10 mm.

The specimens at hand have stipes diverging 340°. Stipes are a little more than 2.5 mm wide and thecae number 10 in 10 mm. The sicula is at least 2.5 mm long. There can be no positive assurance that this form belongs to var. *divergens* until that variety is properly described.

Figured specimen: USNM 138513.

Occurrence: Valmy and Vinini equivalent, D442d (CO), D442f (CO), D359 (CO), D359b (CO).

Range: Zone of *Isograptus*.

Isograptus caduceus cf. I. c. var. maxima Harris

Plate 5, figures 10, 12, 15

Isograptus caduceus var. *maxima* Harris, 1933, Royal Soc. Victoria Proc., v. 46, new ser., pt. 1, figs. 11–12.

Isograptus caduceus var. *maxima* Harris. Berry, 1960, Texas Univ. Pub. 6005, p. 66–67, pl. 11, fig. 8.

Like *I. caduceus* var. *divergens* this variety was illustrated but not described by Harris. His figures (1933, figs. 11–12) show it to be more robust than variety *divergens* with a smaller angle of divergence, 315°, between the stipes. Thecae seem to number 9–10 in 10 mm, and the width of stipes is 4 mm. These measurements are taken from line drawings without indication of magnification and may be unreliable.

The specimens at hand have wide (4 mm) stipes diverging at 330° distally. The sicula is more than 2 mm long. Thecae number 10–11 in 10 mm. Smaller immature specimens have stipes diverging at 310° and these are more nearly comparable to those figured by Harris.

Figured specimens: USNM 138514a,b,c.
Occurrence: Palmetto formation, D533 (CO). Valmy and Vinini equivalent, D359 (CO), D359c (CO), D442d (CO), D442f (CO), D442h (CO).
Range: Zone of *Isograptus*.

Isograptus caduceus cf. I. c. var maximo-divergens Harris

Plate 5, figure 14

Isograptus caduceus var. *maximo-divergens* Harris, 1933, Royal Soc. Victoria Proc., v. 46, new ser., pt. 1, p. 91, 110, 112, fig. 13.
Isograptus caduceus var. *maximo-divergens* Harris. Berry, 1960, Texas Univ. Pub. 6005, p. 67, pl. 11, fig. 11.

This variety was illustrated by Harris (1933, fig. 13) but not described in full. The angle of divergence of the stipes is about 320°. The stipes are a little less than 4 mm wide, although Harris (1933, p. 91) states that they attain 5 mm in width. The thecal count seems to be about 8 in 10 mm although Harris's failure to provide more than line drawings of this leaves us in doubt.

Figured specimen: USNM 138515.
Occurrence: Phi Kappa formation, 1367 (SD).
Range: Zone of *Isograptus*.

Isograptus caduceus var. nanus Ruedemann

Didymograptus caduceus mut. *nanus* Ruedemann, 1904, New York State Mus. Mem. 7, p. 698, pl. 15, figs. 8, 9; fig. 90.
Isograptus caduceus mut. *nanus* (Ruedemann). Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 351–352, pl. 57, figs. 17–19.

This is a very small subspecies of *I. caduceus*, only 5 mm long and 2.3–2.5 mm wide. The stipes are very short. If it were not for the presence of a relatively large sicula the rhabdosome would resemble a *Cardiograptus* in crude outline. However the stipes in *Cardiograptus* are scandent and in *Isograptus* are reclined.

Thecae number 14–18 in 10 mm, and are ornamented with strong mucros.

Reference specimen: USNM 138516.
Occurrence: Vinini formation, 2353 (SD).
Range: Zone of *Isograptus*.

Isograptus caduceus cf. I. c. var. victoriae Harris

Plate 5, figures, 20, 21

Isograptus caduceus var. *victoriae* Harris, 1933, Royal Soc. Victoria Proc., v. 46, new ser., pt. 1, figs. 7–10.
Isograptus caduceus var. *victoriae* Harris. Berry, 1960, Texas Univ. Pub. 6005, p. 67, pl. 11, fig. 7.

This is another variety illustrated by Harris without being described. From his illustrations it can be estimated that stipes diverge at an angle close to 315°, that the resulting acute angle between stipes

is more rounded than in variety *maxima*, that the stipes are about 3 mm wide at the 9th–11th thecae, narrowing distally, and that there are about 7–8 thecae in 10 mm.

Figured specimen: USNM 138483, 138484.

Occurrences: Palmetto formation, D533 (CO). Vinini and Valmy equivalent, D359b (CO).

Range: Zone of *Isograptus*.

Discussion.—The specimens at hand have more closely spaced thecae than is indicated in Harris's sketch and they are also slightly wider than his figures. In other respects they agree closely with Harris's figures.

Isograptus dumosus Harris

Isograptus dumosus Harris, 1933, Royal Soc. Victoria, Proc., v. 46, new ser., pt. 1, p. 105, pl. 6, figs. 2a–c.

According to the original description this is a very small species with a rhabdosome less than 5 mm in length or width. The sicula is prominent and wide. A "tuft" of thecae grow downward from the sicula. From these thecae two stipes arise, turning upward alongside the sicula. Distally along each short stipe, overlap of thecae decreases. The length of each stipe seems to be about 4–5 thecae, excluding downward-directed thecae of the original "tuft."

Reference specimens: USNM 138517, 138518.

Occurrence: Vinini formation, 222 (OS).

Range: Zone of *Hallograptus etheridgei*. In Australia it is reported also from beds equivalent to the zone of *Isograptus*.

Discussion.—Immature stage of *I. manubriatus* may be confused with this species, but stipes of *I. manubriatus* are considerably longer. A form possibly assigned to this species is illustrated on plate 5, figure 8 (USNM 138519).

Isograptus forcipiformis (Ruedemann)

Didymograptus forcipiformis Ruedemann, 1904, New York State Mus. Mem. 7, p. 699–700, pl. 15, figs. 10–13.

Isograptus forcipiformis Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 352–353, pl. 57, fig. 37–40.

This species is characterized by strong reflexion of the stipes (350° or more) so that they become subparallel. The sicula is about 3.5 mm long. The stipes may be 24 mm long with bases 3 mm wide, tapering to widths of about 0.6 mm. Thecae are inclined 45° in distal parts of stipes, number 9–10 in 10 mm, about 3 times as long as wide. Lower edges of apertures are mucronate.

Reference specimen: USNM 138520.

Occurrence: Vinini formation, 222 (OS). Vinini and Valmy equivalent, D359b (CO).

Range: Zones of *Isograptus* and *Hallograptus etheridgei.*

Discussion.—A form possibly assignable to this species is illustrated on plate 5, figure 8 (USNM 138519).

Isograptus cf. I. manubriatus (T. S. Hall)

Isograptus manubriatus (T.S. Hall). Harris, 1933, Royal Soc. Victoria Proc., v. 46, new ser., pt. 1, p. 102–104, pl. 6, fig. 1a–i.

Isograptus cf. *I. manubriatus* (T. S. Hall). Berry, 1960, Texas Univ. Pub. 6005, p. 67, pl. 11, fig. 5, pl. 12, fig. 4.

According to the original description, this species is small, with stipes about 10 mm long. The sicula is about 3 mm long and appears very robust. As in *I. dumosus* the first few thecae are produced in a "tuft" with apertures downward. Thereafter the reflexed stipes take form diverging at about 300°. They are about 2.5 mm wide distally. Thecae number 10 in 10 mm.

Identified specimen: USNM 138521.

Occurrence: Vinini formation, 222 (OS).

Range: Zone of *Hallograptus etheridgei.*

Discussion.—The immature stages of this species probably cannot be distinguished from those of *I. dumosus*, but mature forms have wider and longer stipes with a lesser angle of divergence. A specimen possibly belonging to this species is shown in plate 5, figure 8 (USNM 138519).

Family CORYNOIDIDAE

Genus CORYNOIDES Nicholson, 1867

Corynoides Nicholson. Strachan, 1949, Geol. Mag., v. 86, p. 153–155.

Rhabdosome consisting of a very long sicula (as much as 10 mm) to which 1–3 almost equally long thecae are joined.

Corynoides calicularis Nicholson

Plate 5, figures 32–34

Corynoides calicularis Nicholson, 1867, Geol. Mag., v. 4, p. 108, pl. 7, figs. 9–11.

Corynoides calicularis Nicholson. Strachan, 1949, Geol. Mag., v. 86, p. 156–157.

Corynoides calicularis Nicholson. Berry, 1960, Texas Univ. Pub. 6005, p. 68, pl. 15, fig. 5.

According to Nicholson's original description, the rhabdosome is ⅓–½ inch (9–13 mm) long and 1/20 (1.3 mm) wide. The "polypary" expands from a tapered point to form a sort of calyx.

Strachan (1949, p. 156–157) agrees with the dimensions given in the original description noting that the average width is 0.6 mm and that the rhabdosome is generally slightly curved. He further notes

that it is composed of a sicula and two thecae; a third theca may be partially developed arising near the apical end.

Figured specimens: USNM 138523a, b; 138524.
Occurrence: Valmy and Vinini equivalent, D505 (CO).
Range: Probably zone of *Climacograptus bicornis*. In Great Britain it is known in the zone of *Dicranograptus clingani*.

Discussion.—Strachan (1949, p. 156–157) indicates that the species described by Ruedemann (1947, p. 361, pl. 58, figs. 34–37a) as *C. gracilis* and (1947, p. 361, pl. 58, figs. 38–46) as *C. gracilis* mut. *perungulatus* are both synonyms of *C. calicularis*.

Corynoides incurvus Hadding

Plate 5, figure 31

Corynoides incurvus Hadding, 1915, Lunds Univ. Arsskr., NF, afd 2, v. 11, no. 4, p. 25, pl. 3, fig. 24–27.
Corynoides incurvus Hadding. Strachan, 1949, Geol, Mag., v. 86, p. 158–159, text fig. 3.
Corynoides incurvus Hadding. Berry, 1960, Texas Univ. Pub. 6005, p. 69, pl. 1.

The rhabdosome is 5–7 mm long, 0.8 mm wide on an average, but 1.5 mm wide at apertural end. Processes developed at the apertures are seemingly wider than in other species. Relative to its length this is a wider species than most others.

Figured specimen: USNM 138525.
Occurrence: Valmy and Vinini equivalent, D505 (CO).
Range: Probably zone of *Climacograptus bicornis*.

Family CRYPTOGRAPTIDAE

Genus CRYPTOGRAPTUS Lapworth, 1880

Cryptograptus Lapworth. Bulman, 1955, Geol. Soc. America, Treatise on invertebrate paleontology, pt. V, p. V81, fig. 59, 1a, b.

Rhabdosome parallel sided, biserial, scandent. Stipes side by side rather than back to back as in *Climacograptus*. Basal spines usually present. Thecae may appear *Orthograptus*-like to nearly *Climacograptus*-like.

Cryptograptus schäferi Lapworth

Plate 5, figures 28, 29.

Cryptograptus tricornis var. *schäferi* Lapworth, 1880, Annals and Mag. Nat. History, v. 5, 5th ser., pl. 5, figs. 28a, b.
Cryptograptus tricornis var. *schäferi* Lapworth. Elles and Wood, 1908, Palaeontographical Soc., v. 62, Mon. British Graptolites, pt. 7, p. 299, pl. 32, figs. 13a–c.
Cryptograptus schäferi Lapworth. Bulman, 1933, Geol. Soc. London Quart. Jour., v. 89, p. 352.

Cryptograptus schäferi Lapworth. Harris and Thomas, 1935, Royal Soc. Victoria Proc., v. 47, new ser., pt. 2, p. 304, fig. 3, nos. 11, 12.

Cryptograptus schäferi Lapworth. Berry, 1960, Texas Univ Pub 6005, p. 69–70, pl. 12, figs. 7, 8.

The rhabdosome of the Nevada specimens is a maximum of 1.75 mm wide, 9 mm long, and parallel sided. The thecae number 13–14 in 10 mm and each has a short mucronate extension. The proximal end bears a stout sicular spine, and the proximal thecae bear small spines.

The long spines on the proximal thecae which characterize the form *C. tricornis* are not present. Also *C. schäferi* is slightly wider, and its thecal count slightly greater than in *C. tricornis*. The present authors follow Bulman (1933) in considering these differences significant enough to recognize *C. schäferi* as a distinct species.

Figured specimens: USNM 138526, 138527.

Occurrence: Vinini formation, 222 (OS) Valmy and Vinini equivalent, D445 (CO), D541 (CO).

Range: Zones of *Hallograptus etheridgei* and *Glyptograptus teretiusculus*. The form ranges from Elles and Wood's zone 7 through 10 in the British Isles.

Cryptograptus tricornis (Carruthers)

Plate 5, figure 27

Diplograpsus tricornis Carruthers, 1859, Annals and Mag. Nat. History, v. 3, 3d ser., p. 25, fig. on p. 25, not numbered.

Cryptograptus tricornis (Carruthers). Elles and Wood, 1908, Palaeontographical Soc., v. 62, Mon. British Graptolites, pt. 7, p. 296–298, pl. 32, fig. 12a–d, fig. 200a–j.

Cryptograptus tricornis (Carruthers). Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 446, pl. 76, figs. 23–33.

Cryptograptus tricornis (Carruthers). Berry, 1960, Texas Univ. Pub. 6005, p. 70, pl. 15, fig. 9.

Carruther's original description emphasized the three spines at the proximal end of the rhabdosome. The spines are fully shown when the rhabdosome is so oriented that the thecae are not well shown. Conversely, when the thecae do show, all three spines do not. Elles and Wood (1908, p. 296–297) corroborated Carruther's findings in this respect.

Elles and Wood (1908, p. 296–297) noted that the rhabdosome is very slender and widest at the proximal end. The maximum width is about 1.5 mm, but rarely exceeds 1 mm. The length is 20–40 mm. The sicula is as much as 3 mm long with a conspicuous virgella and straight lateral spines. The thecal count is 11 in 10 mm; apertural edges are everted.

Figured specimen: USNM 138528.

Occurrences: Vinini formation, 222 (OS), 2351 (SD), 2353 (SD). Valmy formation, D116 (CO), D118 (CO), D120 (CO), D129 (CO), D489 (CO);

Valmy and Vinini equivalent, D446 (CO), D478a (CO). Toquima formation, 311 (SD), 328 (SD), 444z (OS). Phi Kappa formation, 1370 (SD).

Range: Zone of *Glyptograptus teretiusculus* to zone of *Climacograptus bicornis.* In Great Britain its first appearance is reported in zone 4, the zone of *Didymograptus extensus* and the form ranges into zone 12, that of *Dicranograptus clingani.*

Discussion.—The specimen figured here (pl. 5, fig. 27) illustrates very well the fact that thecae are not discernible when the basal spines are visible.

Cryptograptus sp.

Plate 5, figure 30

The rhabdosome is about 9.0 mm long and 2.5 mm wide, with 2 very large basal spines as much as 6.5 mm long and possibly 2 others, much shorter. Thecae number 15 in 10 mm. Virgula extends at least 13 mm above the rhabdosome.

Figured specimen: USNM 138529.
Occurrence: Vinini formation, 2353 (SD).
Range Zone of *Hallograptus etheridgei.*

Discussion.—This single specimen probably represents a new species but is considered an inadequate sample on which to base a description. No other species of this width possesses such closely spaced thecae. *C. antennarius* (J. Hall) is closest to this form but has 8–11 thecae in 10 mm.

Genus GLOSSOGRAPTUS Emmons, 1855

Glossograptus Emmons. Bulman, 1955, Geol. Soc. America, Treatise on invertebrate paleontology, pt. V, p. V82, fig. 59, 3a, b, c.

Scandent biserial stipes side by side as in *Cryptograptus*, rather than back to back. Characterized by long apertural spines and much longer lateral and dorsal spines; these larger spines may be located in whorls, spaced 2, 3, or 4 thecae apart. Thecae long, straight, with much overlap.

In some species the form of rhabdosome looks much like *Phyllograptus*, but in *Glossograptus* there is no stipe at right angles along the axis. Some of the more spinose species of *Orthograptus* may be confused with *Glossograptus*, but in the former the stipes are arranged back to back. Thecae are very difficult to distinguish in *Glossograptus.*

A vesicle or pouch of unknown purpose is present in many of the specimens of this genus from the Vinini formation at Garden Pass (USGS colln. 222 [OS]) as shown on plate 5, figures 16, 25, 26. This pouch is at the proximal end of the rhabdosome. It is present in so many specimens that it cannot be an accident of nature, and yet it does not seem to have been reported or illustrated previously.

Glossograptus acanthus Elles and Wood

Plate 5, figures 18, 19

Glossograptus acanthus Elles and Wood, 1908, Palaeontographical Soc., v. 62, Mon. British Graptolites, pt. 7, p. 314, pl. 33, figs. 4a–c.

According to the original description, the rhabdosome is narrowly elliptical in outline and 25 mm or more in length with a width of 4 mm. Thecae number 10 in 10 mm; apertural margins are everted as indicated by the manner in which apertural spines turn downward. The spines appear thickened and stiff as compared with those of other species.

Figured specimens: USNM 138530, 138531.
Occurrence: Vinini formation, 222 (OS).
Range: Zone of *Glyptograptus teretiusculus.*

Discussion.—Most of our specimens have about 10 thecae in 10 mm, but some have 12 in 10. The great development of spines "nearly equal in length to the breadth of the polypary" (Elles and Wood, 1908, p. 314) we do not find preserved.

Glossograptus hincksii (Hopkinson)

Plate 5, figures 25, 26

Diplograptus hincksii Hopkinson, 1872, Geol. Mag., v. 9, p. 507–508, pl. 12, fig. 9.
Glossograptus hincksii (Hopkinson). Elles and Wood, 1908, Palaeontographical Soc., v. 62, Mon. British Graptolites, pt. 7, p. 309–312, pl. 33, figs. 2a–j.
Glossograptus hincksii (Hopkinson). Berry, 1960, Texas Univ. Pub. 6005, p. 71, pl. 12, fig. 9a.

The present specimens are about 3–4 mm wide, excluding their many spines and are a little less than 15 mm long. In these respects they differ from typical *G. hincksii*, in which the rhabdosome is described as 3.0–3.2 mm wide and 20–40 mm long according to Elles and Wood (1908, p. 309) or 50–75 mm long according to Hopkinson (1872, p. 507). Thecae cannot be clearly distinguished in our specimens. They should number 10–16 in 10 mm. Spines are developed in profusion, being as much as 5 mm long and very slender.

Figured specimens: USNM 138532, 138533.
Occurrences: Vinini formation, 222 (OS), 2351 (SD), 2353 (SD). Valmy formation, D113 (CO), D129 (CO), D392 (CO), D446 (CO), D482 (CO), D500 (CO). Valmy and Vinini equivalent, D150 (CO), D500 (CO), D442 (CO), D442a (CO). Palmetto formation, D530 (CO). Unnamed formation, Mount Morrison quad., California, D514 (CO). Phi Kappa formation, 1370 (SD).
Range: Zone of *Hallograptus etheridgei* to zone of *Climacograptus bicornis.*

Glossograptus hincksii var. fimbriatus (Hopkinson)

Plate 5, figures 23, 24

Diplograptus fimbriatus Hopkinson, 1872, Geol. Mag., v. 9, p. 506–507, pl. 12, fig. 8.

Glossograptus hincksii var. *fimbriatus* (Hopkinson). Elles and Wood, 1908, Palaeontographical Soc., v. 62, Mon. British Graptolites, pt. 7, p. 312, pl. 33, figs. 3a–d.

The rhabdosome is about 12 mm long and 1.5 mm wide. Thecae number 15–16 in 10 mm. The proximal end is seemingly fringed with spines that are more sparsely arranged distally. Spines are about 1.3 mm long.

Figured specimen: USNM 138534 a,b.
Occurrences: Valmy formation, D104 (CO), D111 (CO), D116 (CO).
Range: Zones of *Nemagraptus gracilis* and *Climacograptus bicornis*.

Glossograptus horridus Ruedemann

Plate 5, figures 13, 16

Glossograptus ciliatus mut. *horridus* Ruedemann, 1908, New York State Mus. Mem. 11, p. 383.
Glossograptus horridus Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 451–452, pl. 77, fig. 17–22.

According to Ruedemann's original description, this species is characterized by the profusion of apertural and lateral spines, their great length, and their slenderness. No other distinguishing features are mentioned in the description, and we have been forced to rely entirely on paratype material from the Vinini formation (USGS colln. 222 [OS]) for identifications. The specimen illustrated on plate 5, figure 16, may be the holotype illustrated by Ruedemann (1908, pl. 26, fig. 8; 1947, pl. 77, fig. 17); his illustration is so generalized that it is impossible to be sure.

This and several other topotype specimens possess a pair of long downwardly directed flexuous spines. This seems to be the only significant difference between *G. horridus* and the more spinose forms here assigned to *G. hincksii*. Whether these flexuous spines should be the basis of distinction at the species level seems doubtful. They are found on specimens from the Phi Kappa formation (colln. 1370 [SD]) that would otherwise be *G. hincksii*. Perhaps they are a manifestation of dimorphism. The senior author believes that this is more likely and that Ruedemann's concept of *G. horridus* included many of the specimens here included in *G. hincksii* (particularly pl. 5, fig. 26).

Figured specimens: USNM 138535, 138536.
Occurrences: Vinini formation, 222 (OS), 2351 (SD). Phi Kappa formation, 1370 (SD).
Range: Zone of *Hallograptus etheridgei* to zone of *Climacograptus bicornis*.

Discussion.—The peculiar pouches found at the proximal end of the rhabdosome are particularly well shown in all our specimens of this species from the Vinini formation.

Family LEPTOGRAPTIDAE

Genus LEPTOGRAPTUS Lapworth, 1873

Leptograptus Lapworth. Bulman, 1955, Geol. Soc. America, Treatise on invertebrate paleontology, pt. V, p. V83, fig. 60.

Rhabdosome composed of two uniserial stipes, bilaterally symmetrical, diverging at 180° initially. Stipes are flexuous and slender, slightly reclined. Thecae distinctly sigmoid, at low angle to axis of stipe, elongate (Bulman, 1955, fig. 31, 1). Sicula prominent.

This genus is distinguished from *Didymograptus* by its sigmoid thecae and flexuous stipes. It also possesses 2 instead of 1 crossing canals.

Leptograptus flaccidus (J. Hall)

Plate 6, figure 6

Graptolithus flaccidus J. Hall, 1865, Canada Geol. Survey, Canadian Organic Remains, Decade 2, p. 143–144, pl. 2, figs. 17–19.

Leptograptus flaccidus (J. Hall). Elles and Wood, 1903, Palaeontographical Soc., v. 57, Mon. British Graptolites, pt. 3, p. 106–108, pl. 14, figs. 1a–g.

Leptograptus flaccidus (J. Hall). Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 364–365, pl. 59, figs. 10–13.

Stipes of this species are long (as much as 25 cm), slender, and flexed, widening from 0.5 mm proximally to 1.0 mm distally. The sicula is 1.5 mm in length. Thecae number 10–8 in 10 mm according to Elles and Wood; they found this count correct on Hall's material even though his published count was 11–12 in 10 mm (28–32 in 1 inch) (Hall, 1865, p. 143). Thecae are inclined at about 15° to the axis of stipe; overlapping ⅓–½. Apertures are very slightly introverted.

Figured specimen: USNM 138537.

Occurrence: Hanson Creek formation, D342 (CO).

Range: Probably zone of *Orthograptus quadrimucronatus.* In Great Britain from the zones of *Dicranograptus clingani* and *Pleurograptus linearis.*

Leptograptus cf. L. flaccidus var. macer Elles and Wood

Plate 6, figure 1

Leptograptus flaccidus var. *macer* Elles and Wood, 1903, Palaentographical Soc., v. 57, Mon. British Graptolites, pt. 3, p. 110–111, pl. 15, figs. 2a–i.

This variety is distinguished by its long (5–7 cm) and very slender stipes. Their proximal width is 0.3 mm and distally they reach a maximum of about 0.6 mm. The stipes diverge at about 250°. Typically the sicula measures 2 mm in length.

Figured specimen: USNM 138538.

Occurrence: Hanson Creek formation, D342 (CO); Phi Kappa formation (probably), 1368 (SD).

Range: Probably the zone of *Orthograptus quadrimucronatus.*

Discussion.—The specimen figured on pl. 6, fig. 1, lacks the long sicula of the original types; it may have been broken or may not have been present originally. That specimen is tentatively referred to this species because thecae cannot be clearly differentiated.

Genus NEMAGRAPTUS Emmons, 1855

Nemagraptus Emmons. Bulman, 1955, Geol. Soc. America, Treatise on invertebrate palaeontology, pt. V, p. V83.

Stipes slender, in some species reclined, but in most curved, so that both stipes together have an S-shaped outline. Lateral branches stem regularly from the convex side of each curve.

Nemagraptus aff. N. exilis (Lapworth)

Plate 6, figure 3

Nemagraptus exilis (Lapworth). Ruedemann, 1908, New York State Mus. Mem. 11, p. 287–290, figs. 202, 203; pl. 17, figs. 3, 5, 8, 9.

Nemagraptus exilis (Lapworth). Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 371 pl. 61, figs. 1–9.

One specimen, and that immature, is referred questionably to this species. The fact that secondary branches originate less than 4 mm from the sicula indicates that the specimen probably does not belong to this species. Its immaturity makes an attempt at proper identification futile.

Figured specimen: USNM 38539.
Occurrence: Valmy formation, D116 (CO).
Range: Probably zone of *Nemagraptus gracilis*.

Nemagraptus cf. N. gracilis (J. Hall)

Plate 6, figure 4

Graptolithus gracilis J. Hall, 1847, Palaeontology of New York, Nat. History New York: v. 1, p. 274, pl. 74, figs. 6a–d.

Nemagraptus gracilis (J. Hall). Elles and Wood, 1903, Palaeontographical Soc., v. 57, Mon. British Graptolites, pt. 3, p. 127–129, pl. 19, fig. 1a–f.

Nemagraptus gracilis (J. Hall). Ruedemann, 1908, New York State Mus. Mem. 11, p. 277–282, pl. 16, figs. 1–5.

Nemagraptus gracilis (J. Hall). Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 367–368; pl. 60, figs. 1–12.

Nemagraptus gracilis (J. Hall). Berry, 1960, Texas Univ. Pub. 6005, p. 73, pl.15, fig. 13.

This species is represented only by fragments of rhabdosomes in our collections, and these are too poorly preserved to show individual thecae. Therefore its identification is questionable.

Typically, two main branches stem from the sicula, curving in opposite directions, so that the whole forms a broad S shape.

From the convex sides of the curves and within 1 mm of the sicula secondary branches are given off, about 1.5–2.0 mm apart.

On these branches thecae are arranged 7–9 in 10 mm. Thecae on primary branches are spaced similarly but may be poorly defined.

Figured specimen: USNM 138540.
Occurrence: Toquima formation, 328 (SD), 444z (OS).
Range: Zones of *Nemagraptus gracilis* and *Climacograptus bicornis*.

Nemagraptus cf. N. gracilis var. surcularis (J. Hall)

Plate 6, figure 2

Nemagraptus gracilis var. *surcularis* (J. Hall). Elles and Wood, 1903, Palaeontographical Soc. v. 57, Mon. British Graptolites, pt. 3, p. 129, fig. 77a–c; pl. 19, figs. 2a–d.
Nemagraptus gracilis var. *surcularis* (J. Hall). Ruedemann, 1908, New York State Mus. Mem. 11, p. 282–285, fig. 196, 197; pl. 17, fig. 1, 2.
Nemagraptus gracilis var. *surcularis* (J. Hall). Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 370, pl. 60, figs. 17–24.

The primary branches diverge at about 310° at their origin from the sicula, curving gently, so that they eventually cross each other. Although the secondary branches stem from the convex side of the curves, because of the different orientation of its main stipes, the aspect is one of bilateral symmetry, far different from that of *N. gracilis* s. s.

Figured specimen: USNM 138541.
Occurrence: Toquima formation, 444z (OS).
Range: Zone of *Nemagraptus gracilis*, probably.

Discussion.—Only one fragmentary specimen has been recognized in our collections. The dimensions of thecae are not ascertainable and positive identification is therefore impossible.

Family DICRANOGRAPTIDAE

Genus DICELLOGRAPTUS Hopkinson, 1871

Dicellograptus Hopkinson. Bulman, 1955, Geol. Soc. America, Treatise on invertebrate paleontology, pt. V, p. V83, fig. 62, 1a, b.

Rhabdosome composed of two reclined uniserial stipes; these are unbranched. Thecae sigmoid; may be introverted and ornamented with spines.

Dicellograptus complanatus var. ornatus Elles and Wood

Plate 6, figures 8, 12, 13, 17, 19.

Dicellograptus complanatus var. *ornatus* Elles and Wood, 1904, Palaeontographical Soc., v. 58, Mon. British Graptolites, pt. 4, p. 140–141, fig. 85a, b; pl. 20, fig. 2a–c.

Dicellograptus complanatus var. *ornatus* Elles and Wood. Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 377–378, pl. 62, figs. 16–20.

Dicellograptus affinis T. S. Hall, 1902b, Rec. Geol. Survey New South Wales, v. 7, pt. 2, p. 51, pl. 12, fig. 2.

Dicellograptus complanatus var. *oratus*, Elles and Wood. Berry, 1960, Texas Univ. Pub. 6005, p. 74, pl. 20, fig. 3.

This variety is characterized by the strong development of the lateral spines at the proximal end.

Stipes exceed 2 cm in length, diverging 270°–315° according to Elles' and Wood's illustrations. Specimens from Idaho indicate that divergence may be as much as 330°. Proximally, stipes are 0.3–0.4 mm wide and distally, about 0.7–1.0 mm. The axil between stipes is characteristically square.

Elles and Wood give no thecal count other than that of *D. complanatus* s. s., 10–8 in 10 mm. The material before us agrees in this respect. Thecae are of a simple type, not strongly introverted.

Figured specimens: USNM 138543, 138544, 138545, 138546, 138550a, b.

Occurrences: Valmy and Vinini formations, D480a (CO). Phi Kappa formation, 1368 (SD).

Range: Zone of *Dicellograptus complanatus*.

Dicellograptus divaricatus var. bicurvatus Ruedemann

Plate 6, figure 5, 9

Dicellograptus divaricatus var. *bicurvatus* Ruedemann, 1908, New York State Mus. Mem. 11, p. 300, fig. 216; pl. 18, fig. 8.

Dicellograptus divaricatus var. *bicurvatus* Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 379, pl. 62, figs. 31–35; pl. 63, fig. 4.

In this variety the stipes diverge at an angle greater than 270° (the axil is acutely rounded) and 2–5 mm from the sicula bend abruptly, so that their subsequent divergence is lessened.

The width of stipes varies from 0.75 mm proximally to 1 mm distally. Thecae are spaced 12–10 in in 10 mm and are slightly introverted.

Figured specimens: USNM 102812, 138552.

Occurrence: Phi Kappa formation, 1370 (SD).

Range: Zone of *Climacograptus bicornis*.

Discussion.—This variety differs from *D. divaricatus* in the strict sense, in the acuteness of the axil. The stipes bend in the latter but not as abruptly as in var. *bicurvatus*.

Dicellograptus divaricatus var. salopiensis Elles and Wood

Plate 6, figures 21, 24

Dicellograptus divaricatus var. *salopiensis* Elles and Wood, 1904, Palaeontographical Soc., v. 58, Mon. British Graptolites, pt. 4, p. 145–146.

Dicellograptus divaricatus var. *salopiensis* Elles and Wood. Ruedemann, 1908, New York State Mus. Mem. 11, p. 300, figs. 217–219, pl. 18, fig. 5.
Dicellograptus divaricatus var. *salopiensis* Elles and Wood. Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 380, pl. 63, figs. 2–3.
Dicellograptus divaricatus var. *salopiensis* Elles and Wood. Berry, 1960, Texas Univ. Pub. 6005, p. 74, pl. 16, fig. 1.

The variety *salopiensis* is characterized by its very narrow stipes, 0.5–0.6 mm wide throughout their length; stipes diverge at about 270° according to all previously published descriptions and illustrations. Our specimens show divergences as high as 310°.

Thecae are of the simple type found in *D. divaricatus* s. s. and number 12–10 in 10 mm.

Figured specimens: USNM 138553a, 138554.

Occurrences: Palmetto formation, D137 (CO); Valmy formation, D116 (CO), D118 (CO); Phi Kappa formation, 1370 (SD).

Range: Zones of *Nemagraptus gracilis* and *Climacograptus bicornis*.

Dicellograptus gurleyi Lapworth

Plate 6, figures 14, 16, 18

Dicellograpsus gurleyi Lapworth Ms. Gurley, 1896, Jour. Geology, v. 4, p. 70–71.
Dicellograptus gurleyi Lapworth. Ruedemann, 1908, New York State Mus. Mem. 11, p. 303–306, figs. 223–228; pl. 19, figs. 7–9.
Dicellograptus gurleyi Lapworth. Berry, 1960, Texas Univ. Pub. 6005, p. 75, pl. 16, fig. 9.

According to Gurley's (Lapworth Ms) original description the stipes in this species diverge initially at an angle of 270°, gradually decreasing to 240°. The stipes may reach lengths of at least 100 mm; they are 0.5 mm wide proximally and as much as 1.25 mm distally. Thecae average 10 in 10 mm. Apertural excavations are deep, occupying one-third of the width of the stipe. Apertures are introverted markedly in the proximal part.

Ruedemann (1908, p. 303–305) made additions to this description, broadening the concept of the species, and reproduced Lapworth's manuscript figures of type material (1908, figs. 223, 226). Our plate 6, figure 18, closely resembles Lapworth's type.

Ruedemann's investigations indicated that the species included forms characterized by twisted or spiralling stipes which tended to cross each other. The stipes reached lengths of 200 mm but their width did not exceed 0.8 mm. Thecae numbered 9–12 in 10 mm. The initial angle of divergence of stipes varied from 270°–330° according to his illustrations.

None of the specimens in the present collections exhibits twisted stipes. Several do possess initial angles of divergence in excess of 270°.

Figured specimens: USNM 138555, 138556, 138557.

Occurrence: Palmetto formation, D137 (CO). Valmy and Vinini equivalent, D478a (CO).

Range: Zones of *Nemagraptus gracilis* and *Climacograptus bicornis.*

Discussion.—This species can be distinguished from *D. divaricatus* by its more complex and more strongly introverted thecae. In its twisted form it may resemble *D. caduceus;* the latter possesses 14–12 thecae in 10 mm.

Dicellograptus intortus Lapworth

Plate 6, figures 23, 25

Dicellograptus intortus Lapworth, 1880, Annals and Mag. Nat. History, v. 5, 5th ser., p. 161–162, pl. 5, figs. 19a–19c.

Dicellograptus intortus Lapworth. Elles and Wood, 1904, Palaeontographical Soc., v. 58, Mon. British Graptolites, pt. 4, p. 146–147, figs. 90a–d, pl. 20, figs. 4a–f.

Dicellograptus intortus Lapworth. Berry, 1960, Texas Univ. Pub. 6005, p. 75, pl. 15, fig. 1.

Stipes diverge at an angle of 320° or more, gently curving, in some specimens crossing 20–30 mm from the sicula, in others remaining subparallel. They widen from 0.5 mm proximally to 1.0 mm distally. Thecae number 9–11 in 10 mm according to Lapworth (1880, p. 161), but 14–11 in 10 mm according to Elles and Wood (1904, p. 161). In the present specimens the count is 12 in 10 mm.

Well-preserved specimens show the thecae to have straight ventral walls and only slightly introverted apertures.

Figured specimens: USNM 138558, 138559.

Occurrences: Valmy formation, D495 (CO), D135 (CO), D103 (CO). Toquima formation (probably), 328 (SD), 444z (OS), Palmetto formation, D137 (CO).

Range: Zone of *Nemagraptus gracilis.* Probably zone of *Climacograptus bicornis.*

Dicellograptus sextans J. Hall

Plate 6, figures 10, 11, 22

Dicellograptus sextans J. Hall. Elles and Wood, 1904, Palaeontographical Soc. v. 58, Mon. British Graptolites, pt. 4, p. 153–155, fig. 96a, b; pl. 21, fig. 1a–e.

Dicellograptus sextans J. Hall. Ruedemann, 1908, New York State Mus. Mem. 11, p. 306–308, g. 229, pl. 19, g. 1.

Dicellograptus sextans J. Hall. Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 386–387, pl. 64, fig. 28–31.

According to Ruedemann (1947, p. 386), the stipes diverge at 300°; the axillary angle is acutely pointed. The stipes are commonly 10 mm long; some are 20 mm long; their width is uniformly 0.8 mm. In smaller specimens stipes are straight, but curved gently in longer ones. The convex side of the curve is usually on the ventral side.

The proximal end may appear broad, with a pair of small lateral spines. The sicula is inconspicuous.

Thecae number 11–13 in 10 mm. The convex ventral side of each bears a mesial spine. Each aperture is introverted within an excavation occupying one-third the width of the stipe.

Figured specimens: USNM 138560, 138561a, 138562.

Occurrences: Palmetto formation, 2352 (SD) probably. Toquima formation, 311 (SD), 328 (SD), 444z (OS). Valmy formation, D112 (CO), D102 (CO), D131 (CO), D495 (CO), 1953 (CO).

Range: Zones of *Nemagraptus gracilis* and *Climacograptus bicornis*.

Dicellograptus sextans var. exilis Elles and Wood

Plate 6, figures 7, 15

Dicellograptus sextans var. *exilis* Elles and Wood, 1904, Palaeontographical Soc., v. 58, Mon. British Graptolites, pt. 4, 155, fig. 79; pl. 21, figs. 2a–d.

Dicellograptus sextans var. *exilis* Elles and Wood. Ruedemann, 1908, New York State Mus. Mem. 11, p. 309–310, fig. 231.

Dicellograptus sextans var. *exilis* Elles and Wood. Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 387, pl. 64, figs. 32, 33.

Dicellograptus sextans var. *exilis* Elles and Wood. Berry, 1960, Texas Univ. Pub. 6005, p. 77, pl. 15, fig. 11.

This variety agrees with *D. sextans* in all respects except that the width of its stipes are about half that of the parent species (0.3–0.4 mm).

Figured specimens: USNM 138563a, 138564.

Occurrences: Palmetto formation, 2352 (SD). Toquima formation, 308 (SD), 444z (OS). Valmy formation, D112 (CO), D116 (CO), D135 (CO), 1952 (CO). Phi Kappa formation, 1370 (SD).

Range: Zone of *Nemagraptus gracilis* and *Climacograptus bicornis*.

Dicellograptus cf. D. smithi Ruedemann

Plate 6, figure 20

Dicellograptus smithi Ruedemann, 1908, New York State Mus. Mem. 11, p. 313–315, figs. 237, 238; pl. 19, figs. 3, 4.

Dicellograptus smithi Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 388, pl. 65, figs. 1, 2, 7, 8.

Dicellograptus smithi Ruedemann. Berry, 1960, Texas Univ. Pub. 6005, p. 77, pl. 15, fig. 3b.

The species is small with stipes about 15 mm long and 0.6 mm wide. The initial angle of divergence is so great that the stipes are almost parallel for the first 2 mm. They then bend abruptly, so that the divergence is about 300°, but thereafter the stipes curve gently with the convex side ventral. Thecae number 12–14 in 10 mm, strongly introverted and introtorted.

628607 O—63——8

The Nevada material illustrated here lacks the pronounced proximal subparallelism shown in Ruedemann's type specimens. In other respects it agrees favorably with his description.

Figured specimen: USNM 138565a.
Occurrence: Valmy formation, 1952 (CO).
Range: Zone of *Nemagraptus gracilis*.

TABLE 5.—*Characteristics of some species of the genus* Dicranograptus

Species	Character of stipes		Number of thecae in 10 mm	Thecal characteristics	Other features
	Biserial part	Uniserial part			
D. contortus	3 mm long, 0.8 mm wide, composed of 5 pairs of thecae.	0.7 mm wide, distal parts converge and twist.	20–18	Strongly introverted and introtorted apertures and mesial spines.	Virgella and lateral spines at proximal end.
D. kirki	3.5 mm long, 0.8–1.0 mm wide, composed of 3–5 thecae on each side.	Diverge initially at 270°–320° angle, converge at 6 mm from divergence.	9–8	Outer wall slightly curved.	Minute virgella and lateral spines at proximal end.
D. nicholsoni	12–13 mm long, 2.5 mm wide, composed of 8 thecae on each side.	1.3 mm wide diverge at 280°–290°.	10–8	Strongly introverted and introtorted apertures.	Minute virgella and lateral spines at proximal end.
D. nicholsoni var. *geniculatus*.	10 mm long, 2.5 mm wide, composed of 11 pairs of thecae.	1.3–1.5 mm wide diverge at 250°–280° then inwardly flexed.	8	do	
D. nicholsoni var. *whitianus*.	6 mm long, 1.0–1.5 mm wide, composed of 8–9 thecae on each side.	1 mm wide, diverge at 320°–325° initially.	10–9	do	
D. ramosus	10–15 mm long, composed of 13–18 thecae on each side.	1.2 mm wide, diverge initially at 320°, but in 10 mm stipes flex to 330°.	10–8	Strongly curved outer wall, apertures strongly introverted and introtorted nonspinose.	
D. ramosus var. *longicaulis*.	20–30 mm long, composed of 20 thecae on each side.	do	10–8	do	
D. spinifer	15 mm fusiform composed of 17–18 thecae on each side.	1.2 mm wide diverge initially at 320°, but in 10 mm stipes flex to 330°.	10–8	Same as in *D. ramosus* except the thecae are spinose.	
D. tcali	Composed of 3–4 thecae on each side.	Diverge initially at 300°, but twist and cross.	14–12		

Genus DICRANOGRAPTUS Hall, 1865

Dicranograptus Hall. Bulman, 1955, Geol. Soc. America, Treatise on invertebrate paleontology, pt. V, p. V83, fig. 62, 2a, b.

Rhabdosome composed proximally of a biserial scandent part, dividing distally into two uniserial reclined stipes. Thecae sigmoid in shape, may be ornamented with spines and strongly introverted in some species.

Dicranograptus contortus Ruedemann

Plate 7, figures 9, 14

Dicranograptus contortus Ruedemann, 1908, New York State Mus. Mem. 11, p. 337, figs. 275–278; pl. 23, fig. 9.

Dicranograptus contortus Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 389, pl. 65, figs. 15–36.

According to the original description, this is a small species with highly contorted stipes. The biserial part is about 3 mm long and 0.8 mm wide, composed of 5 pairs of thecae. The uniserial part is about 0.7 mm wide. On well-preserved specimens virgella and lateral spines may be conspicuous at the proximal end. Thecae number 18–20 in 10 mm, with mesial spines and strongly introverted and introtorted apertures.

Ruedemann notes that specimens from the Phi Kappa formation (1370 [SD]) have 16–20 thecae in 10 mm and slightly narrower stipes.

Figured specimens: USNM 138567, 138568.
Occurrence: Phi Kappa formation, 1370 (SD).
Range: Zone of *Climacograptus bicornis*.

Dicranograptus kirki Ruedemann

Plate 7, figures 1–4, 6, 21

Dicranograptus kirki Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 391, pl. 66, figs. 1–4.

All the type specimens figured by Ruedemann are illustrated photographically here, along with additional topotypes.

The biserial part of the rhabdosome is about 3.5 mm long and 0.8.–1.0 mm wide and is composed of 3–5 thecae on each side. These measurements are based on Ruedemann's holotype and paratypes, but they do not agree entirely with his published observations.

In some specimens the uniserial stipes diverge at angles of 320° for a little more than 1 mm and then at 240°–260°. In others, an initial divergence of 270°–300° is maintained. In all specimens distally the stipes bend with the convex side ventral, so that they become subparallel or approach each other slightly.

Thecae number 8–9 in 10 mm. Spines are barely discernible on some specimens in the thecae of the biserial part, but minute virgellar and lateral spines are more easily distinguished.

Holotype: 138569a.
Paratypes: 138569b, 138571a, b, 138574.
Topotypes: 138570, 138573a, b.
Occurrences: Saturday Mountain formation (or Phi Kappa formation), 2519 (SD), D456 (CO).

Discussion.—Ruedemann noted a close similarity between this species and *D. hians* T. S. Hall (1905, p. 24, pl. 6, fig. 6); its resemblance to a form referred to *D. zic-zac* var. *minimus* Lapworth by T. S. Hall, 1902, p. 52–53, pl. 12, fig. 5) may also be noted. Its branches diverge as widely as those of *D. arkansasensis* Gurley from which it differs in length of the biserial part.

Dicranograptus nicholsoni Hopkinson

Plate 7, figure 5

Dicranograptus nicholsoni Hopkinson, 1870, Geol. Mag., v. 7, p. 357, pl. 16, fig. 3.
Dicranograptus nicholsoni Hopkinson. Elles and Wood, 1904, Palaeontographical Soc., v. 58, Mon. British Graptolites, pt. 4, p. 171–173, figs. 108a–e, 109 fig., pl. 25, figs. 1a–h.
Dicranograptus nicholsoni Hopkinson, Ruedemann, 1908, New York State Mus. Mem. 11, p. 317–320, figs. 239–242; pl. 20, figs. 3–5; pl. 21, fig. 1.
Dicranograptus nicholsoni Hopkinson. Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 391–392, pl. 66 figs. 5–11.
Dicranograptus nicholsoni Hopkinson. Berry, 1960, Texas Univ. Pub. 6005, p. 78, pl. 17, fig. 6.

According to Hopkinson's description, the biserial part of the rhabdosome is 12–13 mm long and widens distally up to the point of bifurcation. The branches diverge at 280°–290°. They are 0.8–1.3 mm wide. The thecae number 8–10 in 10 mm. At the proximal end minute virgella and equally minute lateral spines are present. About 2.5 mm beyond the point of bifurcation, the branches are joined together by membrane.

Elles and Wood (1904, p. 172) found that the biserial part is 5–8 mm, rarely 9–11 mm, long and that it widens from 1 mm proximally to 2.5 mm near the bifurcation. About 8 thecae on each side of it. The uniserial branches are 70–80 mm long, and 1.3 mm wide with angle of divergence equal to 300°–320°. Thecae number 12–9 in 10 mm and are strongly introverted and introtorted, with strong mesial spines in the biserial part.

Ruedemann (1908, p. 317–318; 1947, p. 391) contributed a third version. According to him the biserial part is 5 mm long, varying from 4–6 mm, and widens from 0.7–1.7 mm; there are 5–6 thecae on each side (8 only in specimens from Ohio). Branches diverge 300°–320°, with ranges from 280°–335°. Thecae number 10 in 10 mm in most specimens, varying 9–13 in 10 mm.

Two specimens, one of which is illustrated, (pl. 7, fig. 5) from USGS colln. 1370 (SD) are definitely referred to this species. In length of the biserial part and width of uniserial branches, they agree with Hopkinson's description. In thecal count, width of biserial part, and characteristics of thecae, they agree most with the Elles and Wood version.

Four specimens from USGS colln. 315 (SD) are doubtfully re-

ferred to this species. They agree reasonably well in outline and general proportions with Ruedemann's (1908, p. 317–318; 1947, p. 391) description of the species but not with the original of Hopkinson (1870, p. 357) nor with that of Elles and Wood (1904, p. 171–173). Thecae are not well enough preserved to determine whether they are simple or introverted and introtorted. As a result, specific indentification is not certain.

Figured specimen: USNM 138575.

Occurrences: Phi Kappa formation, 1370 (SD). Possibly Toquima formation, 315 (SD).

Range: Zone of *Climacograptus bicornis*. Possibly zone of *Orthograptus truncatus* var. *intermedius*.

Dicranograptus nicholsoni var. geniculatus Ruedemann and Decker

Plate 7, figures 7, 12, 22

Dicranograptus nicholsoni var. *geniculatus* Ruedemann and Decker, 1934, Jour. Paleontology, v. 8, p. 312–313, pl. 41, figs. 8, 8a

Dicranograptus nicholsoni var. *geniculatus* Ruedemann and Decker. Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 393, pl. 66, figs. 21–24.

Dicranograptus nicholsoni var. *geniculatus* Ruedemann and Decker. Berry, 1960, Texas Univ. Pub. 6005, p. 78, pl. 17, fig. 8.

This variety differs from *D. nicholsoni* s. s. by having a wider angle of divergence 250°–280° and in that the uniserial branches bend rather sharply dorsally.

A good specimen of this species (pl. 7, fig. 22) comes from Idaho. The biserial part of the rhabdosome is about 10 mm long, 1 mm wide proximally, and 2.5 mm wide below the bifurcation; 11 thecae comprise each side of it and are spiniferous. The uniserial stipes diverge at 280° for 5 mm and then are flexed slightly toward each other. They are 1.5–1.3 mm wide with thecae spaced 8 in 10 mm.

Because of the outline alone, the poorly preserved specimens, illustrated on plate 7, figures 7, 12 are referred to the variety. They do not show thecal characteristics and therefore cannot be assigned with certainty.

Figured specimens: USNM 138576a, 138576b, 138577.

Occurrences: Saturday Mountain formation, D456 (CO). Toquima formation, 315 (SD).

Range: Zone of *Orthograptus truncatus* var. *intermedius*.

Dicranograptus nicholsoni var. whitianus (Miller)

Plate 8, figures 1–3.

Graptolithus (*Climacograptus*?) *ramulus* White, 1874, U.S. Geog. Survey W. 100th Mer. Prelim. Rept., Invertebrate fossils, p. 13–14.

Graptolithus (*Climacograptus*) *ramulus* White, 1877, U.S. Geog. Survey W. 100th Mer. Rept., v. 4, pt. 1, p. 62–63, pl. 4, figs. 3a–c. (Pt. 4 also issued separately 1875.)

[Not] *Graptolithus ramulus* Hall, 1865, Canada Geol. Survey, Canadian Organic Remains, Decade 2, p. 108, pl. 12, figs. 9, 10.

Graptolithus whitianus Miller, 1883, Am. Paleozoic Fossils, 2d ed., p. 269.

Dicranograptus nicholsoni var. *parvangulus* Gurley, 1892, Geol. Survey Arkansas Ann. Rept., v. 3, p. 417.

Dicranograptus nicholsoni var. *whitianus* (Miller). Gurley, 1896, Jour. Geol., v. 4, p. 72, 300.

Dicranograptus nicholsoni var. *parvangulus* Gurley, 1896, Jour. Geology, v. 4, p. 73.

Dicranograptus nicholsoni var. *parvangulus* Gurley. Ruedemann, 1908, New York State Mus. Men. 11, p. 320–322, figs. 243–248; pl. 21, fig. 2.

Dicranograptus nicholsoni var. *parvangulus* Gurley. Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 394, pl. 67, figs. 6–11.

According to Gurley's description, the biserial part is about 6 mm long, widening from 1.0–1.5 mm below the bifurcation. There are 8–9 thecae on each side, each with a horizontal spine. Uniserial branches diverge at 320°–325°; they are 1 mm wide and often bend very slightly without becoming parallel. Thecae are spaced about 9–10 in 10 mm, shaped as in *D. nicholsoni*. The proximal five or more thecae on each uniserial branch bear spines.

The present specimens have branches diverging 295° initially and possessing 8–10 thecae in 10 mm.

We have at hand the original specimen on which White based the species *Graptolithus* (*Climacograptus*) *ramulus* (pl. 8, fig. 3). Despite the inadequacies of White's illustrations (1877, pl. 4, figs. 3b, c), the thecae are of the highly introverted and introtorted type, and each bears a mesial spine.

The biserial part is about 6 mm long, 1.0–1.5 mm wide, nearly parallel sided or very slightly expanding, and composed of 6–7 thecae on each side. (The proximal end of White's holotype is not preserved, and the exact number cannot be ascertained). The uniserial branches diverge at an angle of 295°–330° initially and may then curve very gently toward each other without becoming parallel. The stipes are 1.0–1.3 mm wide and more than 12 mm long. Thecae number 9–12 in 10 mm.

Holotype: USNM 8555.

Figured specimens: USNM 138578, 138579.

Occurrences: Unnamed formation, Mt. Morrison quad., California, D514 (CO). Toquima formation, 5 miles north of Belmont, Nev.; also 444z (OS).

Range: Zone of *Climacograptus bicornis*.

Discussion.—This species became a homonym because White, an ultraconservative, assigned it to *Climacograptus* as a subgenus of the outmoded genus *Graptolithus* instead of retaining *Climacograptus* as a genus. Miller gave a new name to it—using the original describer's name as that of the species. When the old generic term

Graptolithus was broken down, Gurley placed the form in the genus *Dicranograptus* and recognized that it was closely allied to the species *nicholsoni*. The type specimen is badly preserved, and Gurley interpreted it to be slightly different from the form he described as *D. nicholsoni* var. *parvangulus*. However, we are of the opinion that the forms described as *D. nicholsoni* var. *parvangulus* are identical with forms described as *D. nicholsoni* var. *whitianus* and therefore the former name becomes a synonym of the latter.

Dicranograptus ramosus (J. Hall)

Graptolithus ramosus J. Hall, 1847, Palaeontology of New York, Nat. History New York: v. 1, p. 270. (Not pl. 73, fig. 3.)

Dicranograptus ramosus J. Hall. Elles and Wood, 1904, Palaeontographical Soc., v. 58, Mon. British Graptolites, pt. 4, p. 175–176, figs. 111a–b; pl. 24, fig. 6a, b.

Dicranograptus ramosus J. Hall. Ruedemann, 1908, New York State Mus. Mem. 11, p. 325–328, pl. 21, figs. 6, 7; pl. 23, fig. 1.

Dicranograptus ramosus J. Hall. Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 395–396, pl. 67, figs. 15–19.

No specimens of this species in the strict sense have been identified in the collections under study, but several varieties of the species are present. In order to present a proper base for the variety *longicaulis* and to give a comparison with *D. nicholsoni* the species is briefly reviewed here.

D. ramosus is distinguished from *D. nicholsoni* in the number of thecae composing the biserial part of the rhabdosome—13–18 on either side as against 5–8. The spacing of thecae is 8–10 in 10 mm as against 9–13 in 10 mm. The length of the biserial part is 10–15 mm while that of *D. nicholsoni* is 5–11 (according to Hopkinson 11–13 mm).

The angle of divergence of the uniserial branches in *D. nicholsoni* is generally 300°–320°, but may be as much as 335°. In *D. ramosus* the initial angle is usually about 320°, but in 10 mm the arms are flexed to the angle of 330°–335°, the arms then remain fairly straight.

Although not spiniferous in true *D. ramosus*, the thecae of the two species are of the same introverted type.

Dicranograptus ramosus var. longicaulis Elles and Wood

Plate 7, figures 11, 17, 18

Dicranograptus ramosus var. *longicaulis* Elles and Wood, 1904, Palaeontographical Soc., v. 58, Mon. British Graptolites, pt. 4, p. 177, pl. 24, figs, 8a–c.

This variety differs from *D. ramosus* s. s. by its longer biserial part, which is composed typically of approximately 20 thecae on each side and has a length of 20–30 mm. The biserial parts of some specimens are reported by Elles and Wood to reach 40 mm in length with 33 thecae on each side. The thecae are not spinose.

Figured specimens: USNM 138580, 138581a, 138581b.

Occurrence: Phi Kappa formation, 1370 (SD).

Range: Zone of *Climacograptus bicornis.* In Great Britain, reported much higher from the zones of *Dicranograptus clingani* and *Pleurograptus linearis,* but not from zone of *C. bicornis.*

Dicranograptus spinifer Elles and Wood

Plate 7, figures 8, 13, 15

Dicranograptus ramosus var. *spinifer* Elles and Wood, 1904, Palaeontographical Soc., v. 58, Mon. British Graptolites, pt. 4, p. 176.

Dicranograptus spinifer Elles and Wood. Ruedemann, 1908, New York State Mus. Mem. 11, p. 330, pl. 23, fig. 3.

Dicranograptus spinifer Elles and Wood. Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 396, pl. 67, figs. 20–23.

This species is characterized by the long fusiform biserial part of the rhabdosome, and the spiniferous nature of the thecae that compose it.

Proximally the rhabdosome is 0.5 mm wide, broadening to 2.5–3.0 mm and then narrowing to about 2.0 mm below the bifurcation of stipes. Length of the biserial part is about 15 mm, and it is composed of 17–18 spiniferous thecae on each side. Other features are mainly those of *D. ramosus.*

The typical British specimens have a somewhat longer (20–30 mm) and narrower (2 mm) biserial part, while those described from New York by Ruedemann have a wide range, probably too wide to be limited to the species. Specimens from the Palmetto formation are as narrow as the British forms but lack the great length of biserial part.

Figured specimens: USNM 102796, 138582, 138583.

Occurrence: Phi Kappa formation, 1370 (SD). Palmetto formation, D530 (CO). Questionable in Saturday Mountain formation, 2519 (SD).

Range: Zone of *Climacograptus bicornis.* Questionable in zone of *Orthograptus truncatus* var. *intermedius* or younger. In Britain the range is reported as from zone of *Nemagraptus gracilis* through the zone of *Dicranograptus clingani.*

Discussion.—In addition to specimens from the Phi Kappa formation, Ruedemann (1947, p. 396) assigned to this species a specimen (1947, pl. 67, fig. 24; here illustrated as pl. 7, fig. 13) with nonfusiform biserial part from the Saturday Mountain(?) formation (2519 [SD]). This specimen is probably assignable to *D. nicholsoni.*

Dicranograptus tealei Harris and Thomas

Plate 7, figure 19

Dicranograptus tealei Harris and Thomas, 1955, Victoria Dept. Mines, Mining and Geol. Jour., v. 5, no. 6, p. 43–44, figs. 27–29.

According to the original description, the biserial part of the rhabdosome is composed of 3–4 thecae on each side, some of which may be spinose. The uniserial branches may be 50 mm or more in length, diverging at an angle of 300°; because of torsion the thecae may appear on the "wrong" side of the stipes, and the direction of the branches in most (but not all) specimens may change within 4–5 mm, so that they cross each other. There are 12–14 thecae in 10 mm.

The present specimens agree closely with this description except in spacing of thecae which is 9–12 in 10 mm.

Figured specimen: USNM 138585a.
Occurrence: Saturday Mountain (?) formation. D456 (CO).
Range: Zone of *Orthograptus truncatus* var. *intermedius*.

Discussion.—This species is associated with *D. kirki* which it resembles in many respects, including length of biserial part, angle of divergence of uniserial arms, and slenderness of these stipes. It differs from *D. kirki* in number of thecae in 10 mm and in the fact that the branches actually effect a crossing. The possibility of such a crossing is incipient in all specimens of *D. kirki* (Ruedemann, 1947, p. 391). Therefore, this species, as represented in USGS colln. D456 (CO), may be a deformed *D. kirki* or a variant thereof.

TABLE 6.—*Characteristics of some species of the genus* Climacograptus

Species	Character of rhabdosome	Maximum width (mm)	Length (mm)	Character of proximal end	Number of thecae in 10 mm	Character of thecae
C. bicornis	Very long and tapering.	2.6	100+	Two conspicuous basal spines.	12–7	Apertural excavations occupy one-third to one-fourth width of rhabdosome and one-third ventral margin.
C. bicornis var. *longispina.*	Long and tapering.	2.5	25–50	Long (10+ mm) basal spines may be thickened with membrane.	10–8	Do.
C. bicornis var. *peltifer.*	do	2.5		Basal spines enclosed in a large disk-shaped membrane.		Apertural excavations occupy one-fifth width of rhabdosome.
C. caudatus	Very long and tapering.	2.0–2.5	20–60	Stout rodlike virgella 10–30 mm long, surrounded by a membrane 3–13 mm long.	12–9	Apertural excavations occupy one-fourth width of stipe and one-third ventral margin.
C. eximius	Short and narrow.	1	8–10	Short virgella	18–16	Apertural margins horizontal. Apertural excavations occupy one-fourth to one-third width of rhabdosome.
C. hastatus	Long and tapering.	2.5	40–50	Virgella 20 mm long and it is thickened by a membrane 2, 3, or 4 spines at right angles to axis.	10–8	Apertural margins horizontal.

TABLE 6.—*Characteristics of some species of the genus* Climacograptus—Con.

Species	Character of rhabdosome	Maximum width (mm)	Length (mm)	Character of proximal end	Number of thecae in 10 mm	Character of thecae
C. hastatus var. *americanus.*	Short and tapering.	3.0	20–25	Same as *C. hastatus* except virgella is shorter.	12–9	----------
C. hastatus var. *angustus.*	Narrow, parallel sided.	2.2	40–50	Virgella 3 mm long, lateral spines slender.	10–8	----------
C. hastatus var. *martini.*	Tapers proximally, nearly parallel sided distally.	2.6–3.0	35+	Virgella 11+ mm long, upper part surrounded by fleshy membrane 2–7 mm long, lateral spines long.	12–8	----------
C. hvalross	Short, parallel sided.	2	23	Stout basal spines as much as 1.1 cm long thickened by a membrane.	14–12½	Apertural margins introverted and situated in excavations occupying one-half width of rhabdosome.
C. innotatus var. *pacificus.*	Short, relatively stout.	1.5	8+	----------	20	Apertural margins horizontal, mesial spine projects from free edge of each theca.
C. minimus	Slender, parallel sided.	2	10–30	Rounded virgella short, as much as 1 mm long.	14–11	Apertural excavations occupy one-third and one-fourth margin of rhabdosome.
C. phyllophorus	Slender	1.5–2.0	10–30	Two short basal spines and virgella 2–6 mm long.	15–12	Apertural excavations occupy one-third width of rhabdosome and are slightly introverted.
C. raricaudatus	Tapers proximally, parallel sided distally.	2	20–35	Virgella as much as 10 mm long, surrounded by membrane for 2–3 mm.	10–9	Apertural excavations occupy one-fourth width of rhabdosome.
C. riddellensis	Long, widens gradually, may narrow distally.	1.4–1.7	30+	Virgella 1.0–1.5 mm long.	11–10 and rarely 13.	Apertural excavations occupy one-third width of rhabdosome and are semicircular.
C. putillus	Very small	1–1.3	9	Small virgella	14–12	----------
C. scharenbergi	Parallel sided	1.5–2	10–40	Rounded, with short conspicuous virgella.	14–11	Apertural excavations occupy one-third width and one-fourth ventral margin.
C. spiniferus	Long and slender.	1.8	40	Two conspicuous small slender basal spines.	14	Apertures horizontal to slightly everted, apertural excavation about one-fourth width.
C. supernus	Short	1.2	10–20	Two small slender basal spines.	14	Apertural excavations occupy one-fourth width.
C. tubuliferus	Long, tapering with virgula 30 mm long surrounded by fleshy tube.	2.5	30–60	Virgella as much as 4 mm long.	12–8	Apertural excavations occupy one-fourth ventral margin and one-fourth to one-sixth width.
C. typicalis var. *crassimarginalis.*	Long, tapering	2.0–2.4	40+	Very narrow	15–11	Apertures horizontal to slightly everted. Apertural excavations occupy one-fourth width and one-fourth ventral margin. Characteristic feature is presence of mesial spines.

Family DIPLOGRAPTIDAE

Genus CLIMACOGRAPTUS Hall, 1865

Climacograptus Hall. Bulman, 1955, Geol. Soc. America, Treatise on invertebrate paleontology, pt. V, p. V83, fig. 62, 1a, b.

Rhabdosome biserial, scandent. Thecae strongly sigmoid, so that ventral wall is virtually parallel to axis and apertures mainly at right angles to it. Apertures are in excavations. Because cross section of rhabdosome is almost circular, specimens are often flattened with excavations "upward," appearing as a series of ellipses.

Amplexograptus differs by having introverted thecal apertures. *Lasiograptus* if poorly preserved may be confused with spinose species of *Climacograptus*.

Climacograptus bicornis (J. Hall)

Plate 8, figures 4–6

Graptolithus bicornis J. Hall, 1847, Palaeontology of New York, Nat. History, New York : v. 1, p. 268–269, pl. 73, figs. 2a–s.

Climacograptus bicornis (J. Hall). T. S. Hall, 1906, Geol. Survey Victoria Rec., v. 1, pt. 4, p. 275, pl. 34, fig. 8.

Climacograptus bicornis (J. Hall). Ruedemann, 1908, New York State Mus. Mem. 11, p. 433–437, pl. 28, figs. 24–26, fig. 404, 405.

Climacograptus bicornis (J. Hall). Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 425, pl. 72, figs. 44, 45, 52.

Climacograptus bicornis (J. Hall) Berry, 1960, Texas Univ. Pub. 6005, p. 79, pl. 16, figs. 10, 11 ; pl. 19, fig. 4.

J. Hall's original description of this species is very generalized. Except for the reference to a bifurcate base it could apply to almost any species of *Climacograptus*. Ruedemann's (1908, p. 435–436; 1947, p. 425) description based on typical New York material is far superior.

The rhabdosome reaches 10 cm or more in length and gradually widens at a distance of 30 mm from sicular end to 2.6 mm. The proximal end is always equipped with two diverging lateral spines. The virgella varies greatly in length. The sicula is 1 mm long. Thecae number 12–7 in 10 mm and, apertural excavations consume 1/3 the ventral margin and 1/3–1/4 the width of the rhabdosome.

Range: Zone of *Climacograptus bicornis*. Harris and Thomas (1938, p. 67, pl. 3) place this species in the Gisbornian and Eastonian of Victoria. In Great Britain it is recorded from most of the Caradoc (zones 9–12 of Elles and Wood).

Figured specimens: USNM 138586, 138587, 138588.

Occurrence: Unnamed formation, Mt. Morrison quad., California, D514 (CO), D515 (CO). Toquima formation, 444z (old colln.), 336 (SD). Vinini and Valmy equivalent, D360 (CO), D443 (CO), 478a (CO), D394 (CO), 1072 (CO), Phi Kappa formation, 1370 (SD).

Discussion.—In the past, two graptolites that resemble this form may have passed for it. *C. bicornis* var. *longispina* possesses much

larger proximal spines, as described and illustrated below. C. *hvalross* n. sp. is a narrower species with well-developed proximal spines of greater length than those of *C. bicornis* but smaller than those of var. *longispina.*

Climacograptus bicornis var. longispina T. S. Hall

Plate 8, figure 13

Climacograptus bicornis var. *longispina* T. S. Hall, 1902, Rec. Geol. Survey New South Wales, v. 7, pt. 2, p. 54, pl. 12, figs. 8, 9.

According to the original description, the rhabdosome widens gradually from a narrow base. The length is usually about 25 mm, some as much as 50 mm and the width is 2.5 mm. Thecae number 8–10 in 10 mm. Two very strong spines arise from the base, curving in a proximal direction.

The Nevada specimens are initially about 0.8 mm wide, increasing to 2.5 mm in 25 mm of length. The number of thecae agrees with *C. bicornis*, 8–10 in 10 mm. The basal spines appear to have been thickened, being composed of membranous material. They are gracefully curved and exceed 10 mm in length.

T. S. Hall (1902, p. 54) remarked that the basal spines of this variety were of unusual size but fundamentally seemed inseparable from those of *C. bicornis* (J. Hall). His illustrations show that these are developed to an extent never found in that species. However, Elles and Wood (1906, p. 193) placed variety *longispina* in synonomy with *bicornis;* two of their illustrations (pl. 26, figs. 8e, 8f) show specimens the basal spines of which approach proportions of the Australian variety although they lack the characteristic curvature.

Figured specimen: USNM 138589.

Occurrence: Vinini and Valmy equivalent, D480a (CO), D163 (CO); Hanson Creek formation, D342 (CO), D474c (CO).

Range: Zone of *Dicellograptus complanatus.*

Climacograptus bicornis var. peltifer Lapworth

Plate 8, figure 9

Climacograptus bicornis var. *peltifer* Lapworth, 1876, Catalogue of the Western Scottish Fossils, *in* Armstrong and others, the Silurian system in the south of Scotland: British Acad. Sci., pl. 2, fig. 73.

Climacograptus bicornis var. *peltifer* Lapworth, 1877, Belfast Naturalists' Field Club Proc., App. 1876–77, p. 139, pl. 6, fig. 38b.

Climacograptus bicornis var. *peltifer* Lapworth. Elles and Wood, 1906, Palaeontographical Soc., v. 60, Mon. British Graptolites, pt. 5, p. 196, pl. 26, figs. 10a–c.

Climacograptus bicornis var. *peltifer* Lapworth. Ruedemann, 1908, New York State Mus. Mem. 11, pl. A, figs. 15–17, 20–26; 1947, p. 425–426, pl. 72, figs. 53, 54.

This variety is characterized by a membrane surrounding the two basal spines so as to produce a triangular shield enveloping the proxi-

mal end of the rhabdosome. The present specimens are poorly preserved but show a narrower and longer proximal "shield" than that illustrated by Lapworth (1877, pl. 6, fig. 38b). Elles and Wood (1906, p. 196) indicate that apertural excavations tend to be smaller than in *C. bicornis* (J. Hall), occupying one-fifth (rather than one-fourth) of the breadth of the rhabdosome.

Figured specimen: USNM 102815.

Occurrences: Toquima formation, 325 (SD). Phi Kappa formation, 1370 (SD).

Range: Zone of *Climacograptus bicornis*. In Great Britain, reported from Caradoc, zone 10 of Elles and Wood; in Australia reported by Harris and Thomas (1938) from the Gisbornian.

Climacograptus cf. C. brevis Elles and Wood

Text figure 1

Climacograptus brevis Elles and Wood, 1906, Palaeontographical Soc., v. 60, Mon. British Graptolites, pt. 5, p. 192–193, pl. 27, figs. 2a–f, figs. 125a, b.
Climacograptus strictus Ruedemann, 1925, New York State Mus. Bull. 262, p. 62; 1947, Geol. Soc. America Mem. 19, p. 436, pl. 72, figs. 16–19.

According to the original description, this is a small species, about 1.5 cm long with an average uniform width of 1 mm. The virgella is conspicuous although only 0.5–1.0 mm long. Thecae number 10–14 in 10 mm and are nearly opposed. Apertures are in semicircular excavations, occupying ⅓–¼ the width of the rhabdosome and ⅓ the ventral margin.

The specimens at hand are poorly preserved and referred only very tentatively to this species.

Figured specimen: USNM 138590.

Occurrence: Vinini equivalent, D480e (CO). Valmy formation, D110 (CO).

Range: Possibly zone of *Nemagraptus gracilis*. Probably zone of *C. bicornis* to zone of *Orthograptus quadrimucronatus*.

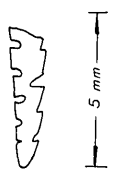

FIGURE 1.—*Climacograptus* cf. *C. brevis* Elles and Wood. Vinini equivalent, USGS colln. D480e (CO). A camera lucida drawing.

Climacograptus caudatus Lapworth

Plate 8, figures 11, 12

Climacograptus caudatus Lapworth, 1876, Catalogue of the Western Scottish Fossils; *in* Armstrong and others, the Silurian system in the south of Scotland, British Acad. Sci., p. 6, pl. 2, fig. 48.

Climacograptus scalaris var. *caudatus* Lapworth, 1877, Belfast Naturalists' Field Club Proc., App. 1876–77, p. 138, pl. 6, fig. 34.

Climacograptus caudatus Lapworth. Elles and Wood, 1906, Palaeontographical Soc., v. 60, Mon. British Graptolites, pt. 5, p. 202, pl. 27, fig. 7a–c; fig. 133a, b.

Climacograptus caudatus Lapworth. Ruedemann, 1908, New York State Mus. Mem. 11, p. 438–439, pl. 28, fig. 17; fig. 406.

Climacograptus caudatus Lapworth. Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 424, pl. 72, figs. 58, 59, 61 [not other figures on pls. 71 and 72].

Climacograptus caudatus Lapworth. Berry, 1960, Texas Univ. Pub. 6005, p. 79, pl. 18, fig. 7.

According to Lapworth (1877, p. 138), the rhabdosome tapers and is several inches in length, with a stout virgella and virgula, each prolonged to a length equal to the rhabdosome itself.

Elles and Wood (1906, p. 202–203) enlarged on Lapworth's description, noting that the rhabdosome is 20–60 mm in length, exclusive of virgella or virgula. From the proximal end it gradually widens to a maximum width of 2.0–2.5 mm. The virgella is 10–30 (or more) mm long and is commonly surrounded by a "membranous body" 3–13 mm long. The thecae are spaced 12–9 in 10 mm; apertural excavations occupy one-fourth of the width of stipe and one-third the ventral margin. Ventral margins of distal thecae are slightly curved.

Figured specimen: USNM 138591, 138592.

Occurrence: Vinini and Valmy equivalents, D149 (CO), D157 (CO), and D164 (CO).

Range: Zone of *Orthograptus quadrimucronatus.* It is reported from the Caradoc (or zone 12 of Elles and Wood) in Great Britain, and from the Eastonian of Australia by Harris and Thomas (1938).

Climacograptus eximius Ruedemann

Plate 8, figure 25

Climacograptus putillus mut. *eximius* Ruedemann, 1908, New York State Mus. Mem. 11, p. 420, figs. 378–384; pl. 28, fig. 16.

Climacograptus eximius Ruedemann. Ruedemann and Decker, 1934, Jour. Paleontology, v. 8, p. 319–320, pl. 43, figs. 2, 2a.

Climacograptus eximius Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 435, pl. 72, figs. 1–9.

According to Ruedemann (1908, p. 420), this species is characterized by its narrowness (0.7–1.0 mm wide), by its shortness (8–10 mm long), and by the close set of thecae (16–18 in 10 mm). Most specimens possess only a short virgella, but Ruedemann (1908, fig. 378) figures one with a pair of lateral spines in addition.

C. putillus differs by being slightly wider (1.0–1.3 mm) and by having 12–14 thecae in 10 mm.

Figured specimen: USNM 138593.

Occurrences: Palmetto formation, 2352 (SD), Toquima formation, 444z (old colln.). Valmy formation, D117 (CO), D486 (CO).

Range: Zones of *Nemagraptus gracilis* and *Climacograptus bicornis.*

Climacograptus hastatus T. S. Hall

Plate 8, figures 8, 10

Climacograptus hastata T. S. Hall, 1902, Rec. Geol. Survey New South Wales, v. 7, pt. 2, p. 54–55, pl. 14, figs. 1–3.

Climacograptus hastatus T. S. Hall. Berry, 1960, Texas Univ. Pub. 6005, p. 80, pl. 20, fig. 11.

On examination of photographs of Hall's cotypes, it is obvious that at least 2 if not 3 different forms are present. Thus, *C. hastatus* is founded on a hypodigm with some latitude in measurements. We propose to recognize under the species *C. hastatus*, 4 different varieties: *C. hastatus*, *C. hastatus* var. *americanus*, *C. hastatus* var. *angustus*, and *C. hastatus* var. *martini*. All intergrade with one another. (Also *C. tridentatus* var. *maximus* may be included here as a fifth end member.)

The original description of this species states that specimens are 4–5 cm long and 2.5 mm wide. The virgula may be free for 30 mm while the virgella extends 20 mm in some specimens. Two, three, or four spines rise at the proximal end at right angles to the axis, extending 5–6 mm. Thecae number 8–10 in 10 mm.

The species itself is here restricted to those forms that fall within limits set by T. S. Hall's original description. However, the following additional limitations are noted. The width of the rhabdosome initially is 0.7 mm; at a length of 5 mm it is 1.5–1.7 mm; at 10 mm it is 2.0–2.3; at 15 mm it is 2 3–2.5; and thereafter it remains 2.5 mm. In the proximal 5–8 mm the thecae are spaced at a rate of 12 in 10 mm, while distally there are 8 in 10 mm. The virgella (sicula?) appears to be thickened and 3–5 mm long; with spine exceeding 7 mm in length past the tip of the thickened virgella (sicula?). The horizontal spines at the proximal end are 3 to more than 5.5 mm in length. No specimens have been obtained with these or the virgellar spine unbroken.

Figured specimens: USNM 138594, 138595.

Occurrences: Hanson Creek formation, D342 (CO), D247 (CO), D474b (CO), Vinini and Valmy equivalent, D480–b (CO).

Range: Zone of *Orthograptus quadrimucronatus* and of *Dicellograptus complanatus*.

Discussion.—Two additional varieties of this species are recognized in Nevada and one in central Idaho. *C. hastatus* var. *angustus* n. var. is a narrow form similar to, if not the same as, specimens figured by Harris and Thomas (1954, p. 39–40) as *C. hastatus*. The new variety *martini* is a wide form very similar to (if not identical with) *C. tridentatus maximus* Decker. *C. hastatus* var. *americanus* was described by Ruedemann (1947, p. 427–428) from the Phi Kappa formation

of Idaho; it is a short wide form with four proximal horizontal spines and a short very stout virgella (or monstrous sicula).

Climacograptus hastatus var. americanus Ruedemann

Plate 8, figures 22–24

Climacograptus hastatus var. *americanus* Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 427, pl. 73, figs. 5, 6?, 7, 8, 9, 13, 17.

According to Ruedemann this variety differs from the true *C. hastatus* by being "smaller, reaching but half the length of the Australian specimens, and having the thecae arranged a little closer (12–10 in 10 mm). The greatest width * * * is 2.8 mm."

In the type lot and topotypic material from the Phi Kappa formation, some specimens exceed 25 mm in length. Our measurements of the specimen figured by Ruedemann (1947, pl. 73, figs. 8, 9) show that the width at the proximal end is 1 mm; at a length of 5 mm it is 2.25; at 10 mm it is 2.5 mm; at 15 mm it is 2.7 mm; and at 20 mm it is 3.0 mm. Some specimens of this variety taper more rapidly than true *C. hastatus* and are slightly wider. The thecae number 12 in 10 mm proximally and 9 in 10 mm distally. In this respect it is the same as or very close to typical *C. hastatus* and to variety *martini*.

In several specimens, the four laterally directed proximal spines are beautifully developed. In others, only three are seen, but this does not mean that a fourth is not present in a different plane than that of the rock surface. A similar circumstance affects specimens of *C. hastatus* and *C. hastatus martini*.

The virgella is shorter than in *C. hastatus* or its other varieties. The thickened part seems to have been narrowly subconical and may actually represent the monstrous development of the sicula in this variety. It is about 4 mm long and is not prolonged by more than a spur of a virgellar spine.

Holotype: USNM 138598.
Paratypes: USNM 138596, 138597.
Occurrence: Phi Kappa formation, USGS colln. 1368 (SD).
Range: Zone of *Dicellograptus complanatus*.

Climacograptus hastatus var. angustus n. var.

Plate 9, figure 22

Climacograptus hastatus T. S. Hall. Harris and Thomas, 1955, Victoria Dept. Mines, Mining and Geol. Jour., v. 5, no. 6, p. 39, figs. 8, 9.

This variety is characterized by its narrowness and by the shortness of the proximal lateral spines, which are barely more than 1.0 mm in length. Rhabdosomes of most specimens do not exceed 25 mm in length.

The initial width of the rhabdosome is 0.7–0.8 mm, at a length of 5.0 mm it is 1.75–2.0 wide, and at 10 mm it is 2.2 mm. That seems to be the maximum width and is maintained thereafter.

The virgella is at least 3 mm long and slender in some specimens, but in others, preserved a little differently, it is broad and extends for more than 5 mm. It is always more prominent than the laterally directed spines. The lateral spines number 4 although only 2 are usually seen.

The thecae are spaced 12 in 10 mm proximally and 8–10 in 10 mm distally.

Holotype: USNM 138599.
Paratype: USNM 139600.
Occurrence: Vinini and Valmy equivalent, USGS colln. D480a–b (CO).
Range: Zone of *Dicellograptus complanatus.*

Discussion.—This variety bears a strong resemblance to specimens described by Harris and Thomas (1955, p. 39, figs. 8, 9) and assigned by them to *C. hastatus.* Tentatively they are considered synonymous.

Climacograptus hastatus var. martini n. var.

Plate 9, figures 4, 6, 7, 10, 11, 16

This variety is at least 35 mm long. Its width at the proximal end is 0.7–0.9 mm, at a length of 5 mm it is 1.75–2.0 mm, at 10 mm 2.2–2.5, at 15 mm it is 2.4–2.7 mm, at 20 mm it is 2.6–3.0. This is usually the maximum width although the width of the narrowest specimens seems to increase to 2.8 mm at a length of 25 mm which is maintained. Thecae proximally are spaced 11–12 in 10 mm, but distally are 8 in 10 mm.

The proximal end is equipped with at least 3 and probably 4 long spines originating in a plane normal to the axis, while the virgella extends more than 11 mm; the upper end of the virgella is surrounded by a membranous thickening from 2–7 mm long.

Holotype: USNM 138603.
Paratypes: USNM 138601, 138602, 138604–138607 inclusive.
Occurrence: Hanson Creek formation D247 (CO), D342 (CO).
Range: Zone of *Dicellograptus complanatus* and probably of *Orthograptus quadrimucronatus.*

Discussion.—This variety differs from *C. hastatus* only in the greater width of the rhabdosome. Most of our specimens are 3.0 mm wide. One (pl. 9, fig. 16) falls precisely halfway between, being 2.75 mm in width and otherwise indistinguishable.

From associated specimens that have been tentatively identified as *C. tridentatus* var. *maximus* Decker, this variety differs in proximal spacing of thecae which does not exceed 10 in 10 mm in variety *maxi-*

628607 O—63——9

mus but is usually 12 in 10 mm in this variety. The development of sideward projecting spines is somewhat greater in variety *maximus* as is the length of the membranous part of the virgella. In the opinion of the senior author, the possession of such a virgella may be grounds for separating all the Hanson Creek specimens from *C. tridentatus* var. *maximus*, no such structure was mentioned by Decker or illustrated. Its greater length is probably not sufficient grounds for differentiating a few specimens from *C. hastatus* var. *martini*, however.

Measurements of some typical specimens follows:

Measurement	*Climacograptus hastatus* var. *martini* n. var. shown on plate 9, figure—							
	6	-------	11	10	7	4	16	Not illustrated
Specimen designated	I	II	III	IV	V	VI	VII	VIII
Length (mm)	31	24	22	18	32	10.5	65	23
Width (mm), at proximal end	.75	.8	.8	.75	.9	.75	-------	.75
at length of 5 mm	1.75	2	1.8	2.0	2.0	1.7	1.7	1.75
10 mm	2.3	2.5	2.25	2.5	?	2.2	2.2	2.4
15 mm	2.5	2.9	2.4	2.7	2.7	-------	2.5	-------
20 mm	3.0	3.0	2.9	[1]3.0	3.0	-------	2.6	3.0
25 mm	-------	-------	-------	-------	-------	-------	2.7	-------
30 mm	3.0	-------	-------	-------	3.0	-------	2.75	-------
35 mm	-------	-------	-------	-------	-------	-------	2.75	-------
40 mm	-------	-------	-------	-------	-------	-------	2.75	-------
Length (mm) of virgella	5	2½+	3.2	1.5+	7	4	4.5+	2+
Length (mm) of virgellar spine	6.0	?	3+	?	3+	7+	-------	-------
Number of thecae in 10 mm:								
proximally	12	10	12	11	11-12	12	12	10
distally	8	8	8	8	8	?	8	8
Horizontal spines:								
thickness	Slender	Slender	-------	Thin	Thin	Thin	Membranous	Thin
length (mm)	2.5	5	-------	2+	6+	4.5	5.5	2.5
minimum number visible	2	2	3	3	3	3	3	?

[1] At 18 mm.

Climacograptus hvalross, n. sp.

Plate 8, figures 19, 26, 27

Description.—The rhabdosome is at least 2.3 cm long and widens from 0.7 mm proximally to 2mm in a distance of approximately 0.9 cm and remains parallel sided thereafter. Thecae number 14 in the first 10 mm and 12½ in 10 mm distally. The apertural margins are slightly introverted and are situated in conspicuous elliptical excavations that occupy fully one-half of the width of the rhabdosome. The proximal end has conspicuous stout spines that are as much as 1.1 cm in length and are thickened by a membrane for at least one-half their length.

This species is quite distinctive and closely resembles but one other form, *Climacograptus bicornis* var. *longispina* T. S. Hall. *C. hvalross* differs from *C. bicornis* by being thinner, having more numerous thecae with deeper thecal excavations, and slightly introverted aper-

tural margins. The proximal spines of mature forms of *C. hvalross* are not as long or as robust as those of mature specimens of *C. bicornis* var. *longispina* T. S. Hall.

Holotype: USNM 138608. The spines on this specimen have been crushed, however it does show all other characteristics well. Plate 8, figure 26, shows the typical development of the proximal end with the spines.

Paratypes: USNM 138609–138614 incl.

Occurrence: Phi Kappa formation, 1368 (SD); Valmy and Vinini equivalent, D507 (CO).

Range: Zone of *Dicellograptus complanatus.*

Climacograptus innotatus var. pacificus Ruedemann

Plate 8, figure 21

Climacograptus innotatus var. *pacificus* Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 429, pl. 73, fig. 29.

Original description:

Rhabdosome small, 8+ mm long, with a uniform average width of 1.5 mm, exclusive of spines. Sicula not observed. Thecae 20 in 10 mm, about ¾ mm long, in contact only. Apertural margins horizontal, opening within wide semicircular excavations, which are of same extent as free edge of each theca, from mesial angle of which a long conspicuous spine projects.

Type specimen: USNM 102838.

Occurrence: Phi Kappa formation, 1368 (SD).

Range: Zone of *Dicellograptus complanatus.* Probably limited to highest part of the zone.

Climacograptus minimus (Carruthers)

Plate 8, figure 7

Diplograpsus minimus Carruthers, 1868, Geol. Mag., v. 5, p. 74, pl. 5, figs. 12a, b.

Diplograpsus minutus Carruthers, 1868, Geol. Mag., v. 5, p. 130. [Not *minutus*, p. 132.]

Climacograptus minimus (Carruthers). Elles and Wood, 1906, Palaeontographical Soc., v. 60, Mon. British Graptolites, pt. 5, p. 191–192, pl. 27, figs. 1a–g.

Climacograptus minimus (Carruthers). Berry, 1960, Texas Univ. Pub. 6005, p. 80, pl. 19, fig. 2.

Carruthers (1868, p. 130) characterized this species as a small-sized "*Diplograpsus*" *pristis* Hisinger, with about 15 thecae in 10 mm. A more complete description by Elles and Wood (1906, p. 191–192) indicates that the length is 10–30 mm, with the width increasing gradually to a maximum of 2 mm in a length of 4 mm. The sicula may be visible for 1 mm. The virgella is fairly short (their fig. 124a suggests it is also about 1 mm long). Thecae number 11–14 in 10 mm. Margins of the apertures are horizontal; apertural excavations consume one-third of the width and one-fourth of the ventral margin of the rhabdosome.

Figured specimen: USNM 138617.

Occurrence: Valmy and Vinini equivalent, D149 (CO).
Range: Zone of *Orthograptus quadrimucronatus.*

Climacograptus cf. C. mississippiensis Ruedemann

Plate 8, figure 20; text figure 2

Climacograptus mississippiensis Ruedemann, 1908, New York State Mus. Mem. 11, p. 413–414, figs. 366, 367; pl. 28, figs. 12, 13.
Climacograptus mississippiensis Ruedemann. Berry, 1960, Texas Univ. Pub. 6005, p. 81, pl. 20, fig. 7.

Ruedemann's original description states that the rhabdosome does not exceed 15 mm in length, most are 7–10 mm; the width varies from 0.6 mm proximally to 2 mm distally. The virgella is rodlike and 1.8 mm long. The sicula is long (1.8 mm) and slender. Proximally thecae number 12 in 10 mm, distally only 10 in 10 mm. Thecae are sigmoid and apertures horizontal to slightly everted; excavations consume one-fourth of the width and one-fourth of the ventral margin of the rhabdosome.

Decker (1935, p. 706) showed that the virgula (nemacaulus) was longer than the rest of the main part of the rhabdosome.

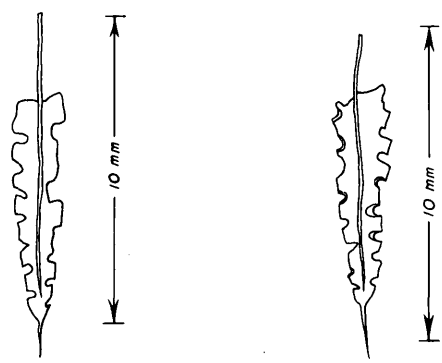

Figure 2.—*Climacograptus* cf. *C. mississippiensis* Ruedemann. Vinini equivalent, USGS colln. D480b (CO). Camera lucida drawings. USNM a. 138619a, b. 138620a.

Although not mentioned by either Ruedemann or Decker, the thecae are arranged alternately as shown by the former's figures (1908, fig. 366, 367). The Nevada specimens have 14–10 thecae in 10 mm, and apertural excavations consume approximately ¼–½ the ventral margin. The virgula is swollen, similar to that of *C. tubuliferus.*

Figured specimens: USNM 138618, 138619a,b, 138620a,b.
Occurrence: Valmy and Vinini equivalent, D480b, e (CO).
Range: Zone of *Dicellograptus complanatus.*

Climacograptus phyllophorus Gurley

Plate 8, figure 17; plate 9, figures 13, 18

Climacograptus phyllophorus Gurley, 1896, Jour. Geology, v. 4, p. 77–78, pl. 4, figs. 4–6.

Climacograptus phyllophorus Gurley. Weller, 1903, Geol. Survey New Jersey, Rept. on Paleontology, v. 3, p. 212–213, pl. 16, figs. 14–15.

Climacograptus parvus J. Hall. Ruedemann, 1908, New York State Mus. Mem. 11, p. 426–428, pl. 28, figs. 19–23, figs. 388–391.

Climacograptus parvus J. Hall. Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 433–434, pl. 74, figs. 10–21.

Climacograptus parvus J. Hall. Berry, 1960, Texas Univ. Pub. 6005, p. 81, pl. 16, fig. 12.

According to the original description of this small species by Gurley (1896, p. 77), the rhabdosome widens to a maximum of 1.5–2.0 mm in the length of 6–8 thecae (approximately 5 mm). Its length, exclusive of the virgula, is usually about 20 mm, varying from 10–30 mm. The proximal end is equipped with two short lateral spines and a virgella 2–6 mm long. Thecae number 12–15 in 10 mm with apertural excavations consuming one-third of the width of the rhabdosome. Apertures are slightly introverted.

The virgula is prolonged and, when preserved, is attached to a "disk" or float that is 6–10 mm long and 1–3 mm wide.

The present specimens are poorly preserved. None shows the float and few show all the details of the proximal end.

Figured specimens: USNM 138621, 138622.

Occurrence: Palmetto formation, D530 (CO), 2352 (SD); unnamed Ordovician units, Mt. Morrison quad., California, D534 (CO); Vinini formation, D486 (CO).

Range: Zones of *Nemagraptus gracilis* and *Climacograptus bicornis.*

Discussions.—The first description of this species was by Gurley in 1896. It was listed by Hall as *C. parvus* as early as 1865 but never described or figured by him. Therefore, Ruedemann's retention of the name *parvus* in 1908 and in subsequent publications was ill advised.

An immature specimen tentatively referred to this species is illustrated on plate 8, figure 17.

Climacograptus putillus (J. Hall)

Plate 8, figure 16

Graptolithus putillus Hall, Canada Geol. Survey, Canadian Organic Remains, Decade 2, 1865, p. 27, 44, pl. A, figs. 10–12a.

Climacograptus putillus (Hall). Ruedemann, 1908, New York State Mus. Mem. 11, p. 415–419, figs. 368–369.

Climacograptus putillus (Hall). Ruedemann, 1947, Geol. Soc. America, Mem. 19, p. 434–435, pl. 72, figs. 29–42.

According to Ruedemann (1908, p. 415) this species is very small, usually less than 9 mm long and 1–1.3 mm wide. The sicula is small (1.3 mm) with a short virgellar spine. Thecae are tubular, inclined very slightly at the proximal end but subparallel to axis distally; they number 14–12 in 10 mm, and the apertures are at right angles to the long axes of the thecae.

The spacing of thecae in this species (14–12 in 10 mm) is less dense than in *C. eximius* (18–16 in 10 mm) from which it also differs by its slightly wider rhabdosome. The specimens at hand are about 1 mm wide with about 12 thecae in 10 mm.

Figured specimen: USNM 138624.
Occurrence: Phi Kappa formation, 1368 (SD).
Range: Zone of *Dicellograptus complanatus.*

Climacograptus raricaudatus n. sp.

Plate 9, figures 1, 2, 5, 15

The rhabdosome is 20–35 mm or more in length, exclusive of the virgellar projection, and widens gradually from an initial breadth of 0.5 mm to a maximum of 1.5–2 mm and is parallel sided thereafter. The sicula is obscure, but the virgella is as much as 10 mm long and, for the initial 2–3 mm, is surrounded by a membranous body. A long thin virgula is present. The thecae number 10 in 10 mm in the proximal region and 9–10 in 10 mm in the distal. The ventral thecal margins are straight and are inclined to the axis of the rhabdosome. The apertural margins of the distal thecae are slightly introverted, but in the proximal thecae they are slightly inclined or are horizontal. The apertural excavations occupy approximately one-fourth the width of the rhabdosome.

Climacograptus raricaudatus is distinctly related to *C. caudatus* and is closely similar to that form in general rhabdosome shape and in the characteristic virgellar projection. *Climacograptus raricaudatus* is thinner than *C. caudatus*, and it does not have a median septum. Also, the ventral thecal margins in *C. raricaudatus* are straight, whereas they are curved in *C. caudatus;* and the proximal thecae number but 10 in 10 mm in *C. raricaudatus* as compared with 12 in 10 mm in *C. caudatus.*

Holotype: USNM 138626.
Paratypes: USNM 138625, 138627–138629, 138630a, b, c, 138631a, b.
Occurrence: Saturday Mountain formation (Phi Kappa?) D456 (CO) 2519 (SD); Valmy formation, D98 (CO).
Range: Zones of *Orthograptus truncatus* var. *intermedius* and *O. quadrimucronatus.*

Climacograptus riddellensis Harris

Plate 9, figures 8, 20

Climacograptus riddellensis Harris, 1924, Royal Soc. Victoria Proc., v. 36, new ser., pt. 2, p. 100–101, pl. 8, figs. 11, 12.

Climacograptus riddellensis Harris. Berry, 1960, Texas Univ. Pub. 6005, p. 82, pl. 14, figs. 9, 10.

According to the original description, the rhabdosome averages 3 cm in length. Its width varies from 0.7 mm proximally to 1.4 or 1.7 mm at a length of 1 cm, widening very gradually. Distally the rhabdosome may narrow slightly. The virgella is only 1.0–1.5 mm long, but it is conspicuous. The basal thecae carry small spines. Thecae number 10–11, rarely 13, in 10 mm, overlapping about one-third of their length, with straight vertical ventral margins and horizontal apertures. Excavations are semicircular, taking up more than one-third of the width of the rhabdosome. The virgula is often visible within the rhabdosome and prolonged distally.

The specimens found in the Vinini formation show considerable variation. Some match the original description almost exactly; others are wider (2.0 mm) and possess a very long virgella (6+ mm) and amplexograptidlike thecae. Berry (1960, pl. 14, fig. 10) has illustrated similar forms from Texas.

Figured specimens: USNM 138632, 138633.

Occurrences: Vinini formation, 222 (OS), 2353 (SD); Valmy formation, D113 (CO), D106 (CO).

Range: Zones of *Glyptograptus teretiusculus* to *Climacograptus bicornis*.

Climacograptus scharenbergi Lapworth

Plate 9, figures 14, 17

Climacograptus scharenbergi Lapworth, 1876, Catalogue of the Western Scottish Fossils, *in* Armstrong and others, the Silurian system in the south of Scotland, British Acad. Sci., p. 6, pl. 5, fig. 35.

Climacograptus scharenbergi Lapworth, 1877, Belfast Naturalists' Field Club Proc., App. 1876–77, p. 138, pl. 6, fig. 36.

Climacograptus scharenbergi Lapworth. Elles and Wood, 1906, Palaeontographical Soc., v. 60, Mon. British Graptolites, pt. 5, p. 206–208, text fig. 139; pl. 27, figs. 14a–e.

Climacograptus scharenbergi Lapworth. Ruedemann, 1908, New York State Mus. Mem. 11, p. 428–431, text fig. 394–399; pl. 28, fig. 31.

Climacograptus scharenbergi Lapworth. Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 438–439, pl. 74, fig. 41–54.

According to Lapworth's (1877, p. 138–139) description, this species is about 1 inch (25 mm) long and one-twelfth of an inch (2 mm) wide. The proximal end is furnished with a "radicle" (virgella) only. The median suture is deep and zigzagged. Thecae number 28–36 in 1 inch (11–14 in 10 mm).

Elles and Wood (1906, p. 207) revised this description slightly, noting that the length is 10–40 mm and the width 1.5 mm. The zigzag groove is the trace of a septum between the two series of thecae, which alternate in position on opposite sides of the septum. The distal end of each theca is slightly introverted. Apertural excavations occupy one-fourth of the ventral margin and one-third of the width of the rhabdosome.

Because compression may destroy the zigzag septal groove (as it has with all our Nevada specimens), the introversion of apertures and alternate arrangement of thecae are important distinguishing features.

Figured specimens: USNM 138634, 138635.

Occurrences: Vinini and Valmy equivalents, D111 (CO), D389 (CO).

Range: Zone of *Climacograptus bicornis*. However, in Great Britain it ranges from the zone of *Didymograptus bifidus* to the zone of *O. truncatus intermedius*.

Climacograptus spiniferus Ruedemann

Plate 9, figure 12

Climacograptus typicalis mut. *spinifer* Ruedemann, 1908, New York State Mus. Mem. 11, p. 411–412, text fig. 236, pl. 28, figs. 8, 9.

Climacograptus spiniferus Ruedemann, 1912, New York State Mus. Bull. 162, p. 84.

This species is like *C. typicalis* in the shape of the thecae and particularly in its slender proximal end. It never becomes as wide as that species, 1.8 mm being the maximum known width. The thecae are spaced 14 in 10 mm including distal parts of the rhabdosome. At the proximal end there are two spines, differing from those of *C. bicornis* by being more like sharp straight bristles.

Figured specimen: USNM 138636.

Occurrence: Valmy and Vinini equivalent, D454 (CO).

Range: Zone of *O. truncatus intermedius*.

Climacograptus supernus Elles and Wood

Plate 8, figures 14, 15, 18

Climacograptus supernus Elles and Wood, 1906, Palaeontographical Soc., v. 60, Mon. British Graptolites, pt. 5, p. 196–197, pl. 26, fig. 11a–d, figs. 127a–d.

This is a small species with a length of 10–20 mm and a width of about 1.2 mm. The initial breadth is about 0.5 mm, and the full width is attained in a length of 5.0 mm. A pair of very small spines is given off from the initial theca; thecal count numbers 14 in 10 mm.

Figured specimens: USNM 138615, 138637a,b, 138638.

Occurrences: Valmy and Vinini equivalent, D507 (CO); Phi Kappa formation, 1368 (SD).

Range: Zone of *Dicellograptus complanatus*.

Climacograptus cf. C. tridentatus var. maximus Decker

Plate 9, figures 9, 21

Climacograptus tridentatus var. *maximus* Decker, 1935, Jour. Paleontology, v. 9, p. 707, figs. 1p–t, figs. 2a–d.

Three specimens from the Hanson Creek formation resemble this variety. However, the Hanson Creek forms are parallel sided after attaining a width of 3 mm, whereas Decker's (1935, p. 707, figs. 1p–t, 2a–d) syntypes indicate that the width of the Oklahoma specimens increases at least to 4 mm at a length of 30 mm. Spacing of thecae is virtually the same. The development of the proximal spines is in some ways similar but far more robust in the Nevada specimens. Furthermore, Decker's figures (1935, fig. 2a, d) show that the lateral spines at the proximal end are declined although they are principally normal to the axis of the rhabdosome in our forms.

All the Hanson Creek specimens show the stump of a lateral spine directed toward the viewer (pl. 9, fig. 21), as with *C. hastatus* and its varieties. It seems probable that they actually possessed four lateral spines plus the virgellar spine, a condition not found in *C. tridentatus*. It is probable that the Hanson Creek specimens should be considered a variety of *C. hastatus* or a separate species.

Measurements of some of the pertinent characters of the Hanson Creek specimens and the three Oklahoma syntypes that Ross has examined are tabulated here:

Measurement	*C.* cf. *C. tridentatus* var. *maximus* Hanson Creek formation, Nevada			*C. tridentatus* var. *maximus* Polk Creek shale (Decker, 1935)		
	Not figured	Pl. 9, fig. 21	Pl. 9, fig. 9	Fig. 1t B2361	Fig. 2a B2362	Fig. 2d B2364
Length (mm) of rhabdosome	40	40	26	29.8	32	19
Width (mm) of rhabdosome:						
at proximal end	1.0	1.0	1.0	1.0	----------	1
at length of 5 mm	1.75	1.6	1.7	1.75	----------	----------
10 mm	?	2.5	2.3	2.25	2.25	----------
15 mm	2.7?	3.0	2.5	2.5	----------	----------
20 mm	3.0	3.0	2.6	3.0	----------	3.5
25 mm	3.0	3.0	2.7	3.5	3.0	----------
30 mm	3.0	3.0	----------	4.0	3.0	----------
40 mm	3.0	3.0	----------	----------	----------	----------
Number of thecae in 10 mm:						
proximally	10–11	10	10	11	10–11	11
distally	8	8	7–8	8	----------	----------
Length of virgella:						
fleshy part	9	9	5	----------	1.6?	----------
total including spine	9+ ?	13+	8.5+	1.5	5.0	1.0
Length of lateral proximal spines	13	7.5	8	Not preserved	4.5	1.5

From this tabulation one notes that the Hanson Creek specimens show a resemblance to *C. hastatus* var. *martini* in all respects but two: the thecal count at the proximal end is lower than in variety *martini*

and the development of the virgella and lateral spines is much greater.

This material probably does not belong to *C. tridentatus* var. *maximus* Decker because of the continuously tapering form and different arrangement of basal spines. It may belong to a robust variety of *C. hastatus*.

Figured specimens: USNM 138639–138641 incl.

Occurrences: Hanson Creek formation, D342 (CO), D247 (CO).

Range: Zone of *Dicellograptus complanatus* and possibly of *Orthograptus quadrimucronatus*.

Climacograptus tubuliferus Lapworth

Plate 10, figures 1, 2

Climacograptus tubuliferus Lapworth, 1876, Catalogue of the Western Scottish Fossils, *in* Armstrong and others, the Silurian system in the south of Scotland. British Acad. Sci., pl. 2, fig. 49.

Climacograptus tubuliferus Lapworth, 1877, Belfast Naturalists' Field Club, Proc., App. 1876–77, p. 138, pl. 6, fig. 3.

Climacograptus tubuliferus Lapworth. Elles and Wood, 1906, Palaeontographical Soc., v. 60, Mon. British Graptolites, pt. 5, p. 203–204, pl. 27, fig. 8a–d.

Climacograptus tubuliferus Lapworth. Berry, 1960, Texas Univ. Pub. 6005, p. 83, pl. 19, fig. 5.

According to Elles and Wood (1906, p. 203), the rhabdosome is 30–60 mm long, increasing very gradually from an initial width of 0.7 mm to a width of 2.5 mm over a length of 30 mm. The sicula, if visible, is 1 mm long. The virgella is well developed and as much as 4 mm long. Thecae number 12–8 in 10 mm with apertures slightly introverted. Apertural excavations occupy ¼–⅙ the width of the rhabdosome.

The virgula is very prominent, 30+ mm long, and surrounded by a membranous tube or sack from which the species takes its name.

Figured specimens: USNM 138642, 138643, 138644(?).

Occurrences: Hanson Creek formation, D474b (CO). Vinini and Valmy equivalent, D163 (CO).

Range: Zone of *Orthograptus quadrimucronatus*.

Discussion.—In Britain this species is limited to the zone here called that of *Orthograptus quadrimucronatus*. It is one of the forms that gives the fauna of the Hanson Creek formation a high Caradoc aspect although other elements suggest an Ashgill age.

Climacograptus cf. C. typicalis J. Hall

Plate 9, figure 3

Climacograptus typicalis J. Hall, 1865, Canada Geol. Survey, Canadian Organic Remains, Decade 2, p. 57, pl. A, figs. 1–9.

Climacograptus typicalis J. Hall. Ruedemann, 1908, New York State Mus. Mem. 11, p. 407–411, figs. 354–362; pl. 28, figs. 6, 7.

Climacograptus typicalis J. Hall. Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 440–441, pl. 75, figs. 27–35.

Although named by Hall in 1865, this species was first described by Ruedemann in 1908.

According to Ruedemann (1947, p. 440) the rhabdosome is 65+ mm long and at the proximal end very narrow (0.3–0.4 mm), gradually expanding through a length of about 15 mm to a width of 2–2.4 mm which is then maintained. The sicula is 1.2 mm long and is equipped with 2 short mucros. The thecal count is 11–15 in 10 mm; thecae are twice bent, in the proximal half being parallel to the axis, then bent outward, and then again parallel to axis. Apertures are horizontal to slightly everted, the excavations consuming one-fourth of the ventral margin and one-fourth of the width of the rhabdosome.

Figured specimen: USNM 138645.

Occurrences: Hanson Creek formation, D247 (CO); Vinini formation, D149 (CO).

Range: Zone of *Orthograptus quadrimucronatus* and (or) *Dicellograptus complanatus.*

Discussion.—The most distinctive feature of this species is its slender proximal end. Unfortunately none of our material shows that part of the rhabdosome, and none can therefore be identified with certainty.

Climacograptus typicalis var. crassimarginalis Ruedemann and Decker

Climacograptus typicalis var. *crassimarginalis* Ruedemann and Decker, 1934, Jour. Paleontology, v. 8, p. 322–323, pl. 43, fig. 8, 9, 12, 12a.

Climacograptus typicalis var. *crassimarginalis* Ruedemann and Decker. Berry, 1960, Texas Univ. Pub. 6005, p. 84, pl. 17, figs. 1, 2.

A single small specimen of this variety is available to us. Despite its small size it shows the relatively large mucro or spine developed on the ventral wall of each theca above the apertural excavation of the preceding theca. This is the distinguishing feature of the variety which in other respects is the same as *C. typicalis.*

Reference specimen: USNM 138646.

Occurrence: Valmy and Vinini equivalent, D359c (CO).

Range: Zone of *Orthograptus truncatus* var. *intermedius.*

Genus DIPLOGRAPTUS McCoy, 1850

Diplograptus McCoy. Bulman, 1955, Geol. Soc. America, Treatise on invertebrate paleontology, pt. V, p. V85, figs. 63, 2a, b.

The thecae of this genus resemble those of three others. At the proximal end they are sigmoid as in *Amplexograptus* (or *Climacograptus*). They then change to gently curved thecae like those of

Glyptograptus, and finally to straight thecae like those of *Orthograptus*.

The rhabdosome is biserial scandent. The cross section is either elliptical or subrectangular.

Diplograptus decoratus (Harris and Thomas)

Plate 10, figures 4, 5, 30

Climacograptus caelatus Lapworth. Ruedemann, 1908, New York State Mus. Mem. 11, p. 89, figs. 21, 22; p. 440, fig. 409.

(?)*Mesograptus decoratus* Harris and Thomas, 1935, Royal Soc. Victoria Proc., v. 47, new ser., pt. 2, p. 298–300, fig. 3, nos. 32–38.

Climacograptus antiquus var. *bursifer* Elles and Wood. Ruedemann, 1947, Geol. Soc. America Mem. 19, pl. 71, fig. 53.

Harris and Thomas (1935, p. 298) give the following description for *?Mesograptus decoratus:*

Rhabdosome large, 3–6 mm long, widening from a blunt proximal end (about 1.0 to 1.5 mm wide) and reaching a maximum width of up to 4 mm, after which this width may be maintained or the rhabdosome may narrow slightly and gradually. The distal narrowing is very common. Virgella conspicuous and partly enclosed in a membrane. The virgula is usually well shown, and is often produced beyond the distal end of the rhabdosome to carry a heart-shaped vesicle. Thecae 12–7 in 10 mm, overlapping about one-half.

Specimens from Nevada display a wide range of variation in spacing of thecae and in rhabdosome width; yet they agree with the description by Harris and Thomas in all other details. Three distinct forms may be recognized in the Nevada material, and the name *Diplograptus decoratus* has been given to those specimens with a maximum rhabdosome width of 2.5–3.0 mm and a thecal count of 11–12 in 10 mm in the mature region. Distal narrowing is present in nearly all specimens and a heart-shaped vesicle at the terminal end of the virgula is present in most.

The thecal characteristics show clearly that these forms belong in the genus *Diplograptus*. Amplexograptid thecae are present in the first 10–15 mm of the rhabdosome, then the thecae gradually become glyptograptid in aspect. Commonly, the most distal thecae are compressed, so that they appear to be near climacograptid.

Figured specimens: USNM 138648, 138649, 138652.
Occurrence: Vinini formation, 222(OS).
Range: Zone of *Glyptograptus teretiusculus* in Nevada.

Discussion.—The *Climacograptus*-like appearance of the distal parts of many rhabdosomes has led to a confusion of this species with *Climacograptus antiquus* Lapworth and its varieties. Ruedemann (1908, p. 89, figs. 21, 22, and p. 440, fig. 409) figured as *Climacograptus caelatus* Lapworth (this form = C. *antiquus* Lapworth) forms which,

upon careful examination of the entire rhabdosome, are clearly *D. decoratus* or one of its subspecies. Gurley originally worked on and identified the specimens Ruedemann figured. The authors have reexamined all Gurley's material, as well as his notes and figures, which are with each specimen. Ruedemann (1947, pl. 71, fig. 53) (pl. 10, fig. 4) illustrated as an example of *Climacograptus antiquus* var. *bursifer* Elles and Wood a form which is also *D. decoratus*.

Diplograptus decoratus variety amplexograptoideus n. var.

Plate 10, figures 6, 7, 8, 29

As mentioned above under the discussion of the Nevada material, three distinct forms of *D. decoratus* exist. To one of these, the present authors have given the variety name *amplexograptoideus* because the thecae in it are amplexograptid in aspect up to 30 mm from the proximal end. The variety *amplexograptoideus* is characterized by a long (6+ cm), slender rhabdosome in which the proximal end is from 0.5 to 0.8 mm in thickness and the rhabdosome widens gradually to a maximum width of 1.8–2.2 mm. This width is attained in approximately 2 cm, and the rhabdosome is parallel sided thereafter, in most specimens. A few rhabdosomes narrow distally. The thecae number 11–12 in 10 mm proximally and 10–11 in 10 mm in the distal region. A short virgella is present, and a virgula that terminates in a heart-shaped sac is common. This variety may be readily differentiated by its long, thin shape and the large number of amplexograptid thecae. A number of transients between this variety and the typical form of the species are present.

Holotype: USNM 138656.

Paratypes: USNM 138650, 138653, 138654, 138655, 138657, a, b, c, 138659.

Occurrence: Vinini formation, 2351 (SD), 222 (OS).

Range: Common in the zone of ***Hallograptus etheridgei*** and ranges into the succeeding zone of ***Glyptograptus teretiusculus***.

Diplograptus decoratus variety multus n. var.

Plate 10, figures 9, 10, 15

The variety *multus* is the third distinct form with the general characteristics of *D. decoratus*. This variety is characterized by being relatively wider than the other forms. It is 2.5–3.2 mm in maximum width—widening from an initial width of approximately 1 mm. Distal narrowing is common in this variety. The thecae number 14–15 in 10 mm in the proximal region and 12–14 in the distal part. A short, stout virgella is present as is a stout virgula. A heart-shaped sac is commonly present at the terminal end of the virgula. Amplexograptid thecae are present in the proximal 10–12 mm of the rhabdosome.

Holotype: USNM 138661.
Paratypes: USNM 54343, 138651, 138658, 138660, 138662, 138663.
Occurrence: Vinini formation, 222 (OS).
Range: Zones of *Hallograptus etheridgei* and *Glyptograptus teretiusculus*.

Diplograptus vespertinus Ruedemann

Plate 10, figure 20

Diplograptus foliaceus mut. *vespertinus* Ruedemann, 1908, New York State Mus. Mem. 11, p. 352–354, figs. 296–298; pl. 25, figs. 4, 5, 18.
Diplograptus vespertinus Ruedemann. Ruedemann and Decker, 1934, Jour. Paleontology, v. 8, p. 317, pl. 42, fig. 7.
Diplograptus (*Glyptograptus*) *vespertinus* Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 410, pl. 69, figs. 62–68.

According to the original description this species is usually about 15 mm long, but may approach 45 mm. Its proximal width is about 1.0 mm increasing in a distance of 15 mm to 2.5 mm which is maintained. The virgella is short and blunt. Two very short lateral spines are present on the proximal end. Thecae number 11–13 in 10 mm.

The species as represented here does not have the lateral spines preserved at the proximal end. *Climacograptus*-like thecae are present for about 5 mm, followed by *Glyptograptus*-like thecae.

Figured specimen: USNM 138664.
Occurrence: Saturday Mountain formation, D456 (CO).
Range: Zone of *Orthograptus truncatus* var. *intermedius*.

Genus AMPLEXOGRAPTUS Elles and Wood, 1907

Amplexograptus Elles and Wood. Bulman, 1955, Geol. Soc. America, Treatise on invertebrate paleontology, pt. V, p. V86, fig. 63, 3.

Biserial scandent rhabdosome. Thecae angularly sigmoid as in *Climacograptus*, but apertures are introverted. Edges of apertural excavations are thickened to form lists (or strengthening rods). Cross section approximately rectangular.

Amplexograptus arctus (Elles and Wood)

Plate 10, figures 11, 12, 18

Diplograptus (*Amplexograptus*) *arctus* Elles and Wood, 1907, Palaeontographical Soc., v. 61, Mon. British Graptolites, pt. 6, p. 271–272, fig. 187; pl. 31, figs. 16a–d.

According to the original diagnosis and description, this species is small, about 2–3 cm long, and 1–1.5 mm wide; the sicula is 1.5 mm long, and the virgella 8 mm long. Spines are present on the basal thecae 1 mm long. Thecae number 14–10 in 10 mm, and excavations occupy ⅓ of the width and ½–⅓ of the ventral margin of the rhabdosome.

Most specimens from Nevada agree in all respects with this description, except that the virgella may be somewhat shorter. One specimen,

figured on plate 10, figure 11, shows a greater width (2.0 mm) than is found in other examples.

Figured specimens: USNM 138666–138668 incl.
Occurrence: Vinini formation, 222 (OS).
Range: Zones of *Hallograptus etheridgei* and *Glyptograptus teretiusculus*.

Amplexograptus confertus (Lapworth)

Plate 10, figures 13, 14, 16

Climacograptus confertus Lapworth. Hopkinson and Lapworth, 1875, Geol. Soc. London Quart. Jour., v. 31, p. 655, pl. 34, figs. 4a–f.
Climacograptus confertus Lapworth, 1880, Annals and Mag. Nat. History, v. 5, 5th ser., p. 169, pl. 4, figs. 15 a–c.
Diplograptus (*Amplexograptus*) *confertus* (Lapworth). Elles and Wood, 1907, Palaeontographical Soc., v. 61, Mon. British Graptolites, pt. 6, p. 269–270, pl. 31, figs. 18a–e; fig. 185a–c.
Amplexograptus confertus (Lapworth). Harris and Thomas, 1935, Royal Soc. Victoria Proc., v. 47, new ser., pt. 2, p. 300–301, fig. 1, no. 14a, b, and fig. 3, nos. 21–26.
Amplexograptus confertus (Lapworth). Berry, 1960, Texas Univ. Pub. 6005, p. 85, pl. 14, fig. 1, 2.
Diplograptus (*Amplexograptus*) cf. *confertus* Lapworth. Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 412–413, pl. 70, figs. 23–26.

Lapworth's (Hopkinson and Lapworth, 1875, p. 655) original description states that this species is about 1 inch (25 mm) long with a maximum width of one-twelfth of an inch (2 mm), and has parallel margins. The proximal end is pointed and furnished with a short radicle (virgella). Thecae number about 40 per inch (15–16 in 10 mm); the interspaces (apertural excavations) are slightly oblique and occupy about one-third of the ventral margin.

Elles and Wood (1907, p. 269) indicated that shorter specimens, 10 mm in length, may have a width of only 1 mm. The thecal count according to them ranges from 16 to 12 in 10 mm. Excavations occupy about one-third of the width of the rhabdosome.

Harris and Thomas (1935, p. 300–301) include in this species specimens with 14–10 thecae in 10 mm. Like the British forms, those from Australia have markedly oblique apertural excavations. The species is reported from the Upper Darriwilian (zone of *Didymograptus nodosus*), Middle Ordovician of current Australian usage.

Several specimens, of which an example is shown in plate 10, figure 25, possess long virgellae, longer than has heretofore been recorded for the species, and 14–12 thecae in 10 mm. Berry has found this variety during his work on the Ordovician of the Marathon region, Texas, and considers it probably conspecific with the more typical forms, which have 16–14 thecae in 10 mm.

Figured specimens: USNM 138511, 138669, 138670.
Reference specimen: USNM 138671.

Occurrence: Vinini formation, 222 (OS), 2349 (SD), 2351 (SD), 2353 (SD).
Range: Zone of *Hallograptus etheridgei.*

Amplexograptus cf. A. differtus Harris and Thomas

Plate 10, figure 26

Amplexograptus differtus Harris and Thomas, 1935, Royal Soc. Victoria Proc., v. 4, new ser., pt. 2, p. 301, fig. 1, no. 15; fig. 3, nos. 27–31.

According to the original description of *A. differtus*, the length of the rhabdosome is as much as 2.5 cm. The proximal end is blunt and 1.0–1.5 mm wide. The maximum width of 2.0–2.5 mm is attained in 1 cm. Thecae number 13–10 in 10 mm. Apertural excavations with thickened margins are slightly inclined, occupying ⅓ the width and ¼–⅓ the ventral margin.

Harris and Thomas state that the thecal spacing is "more lax" than in *A. confertus*, but it is virtually identical with that given in their own description of that species. It is more lax than in Lapworth's or Elles' and Wood's descriptions of *A. confertus*, however.

The specimens at hand are incomplete, none possessing the proximal end. The thecal count is 15 in 10 mm, high for *A. differtus*, and similar to *A. confertus*. The width of rhabdosome is 2.5 mm, which is too wide for *A. confertus*.

Figured specimen: USNM 138673.
Occurrence: Vinini formation, 222 (OS).
Range: Zone of *Glyptograptus teretiusculus* and (or) *Hallograptus etheridgei.* Middle Ordovician in the Australian sense.

Amplexograptus cf. A. modicellus Harris and Thomas

Text figure 3

Amplexograptus modicellus Harris and Thomas, 1935, Royal Soc. Victoria Proc., v. 47, new ser., pt. 2, p. 300, fig. 1, nos. 10a–f; fig. 3, nos. 17–20.

According to the original description the rhabdosome is small and parallel sided—5 mm long, 1 mm wide. The proximal end is blunt; the virgella is 1 mm long, and the sicula 1 mm long. Thecae number 14–18 in 10 mm and alternate in position. Apertural excavations consume ¼–⅓ the ventral margin and ⅓ the width of the rhabdosome.

The present specimens are about 1.2–1.7 mm wide, a little too wide to be positively identified as this minute species. The number of thecae averages about 15 in 10 mm.

Figured specimen: USNM 138674.
Occurrence: Vinini formation, 222 (OS), 2351 (SD).
Range: Zone of *Hallograptus etheridgei* and (or) *Glyptograptus teretiusculus.*

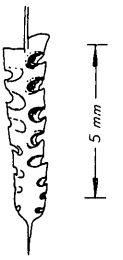

FIGURE 3.—*Amplexograptus* cf. *A. modicellus* Harris and Thomas. Vinini formation, USGS colln. 2351 (SD). A camera lucida drawing. USNM 138674.

TABLE 7.—*Characteristics of some species of the genus* Glyptograptus

Species	Character of rhabdosome	Maximum width (mm)	Length (cm)	Number of thecae in 10 mm	Thecal characteristics
G. altus	Long, tapers proximally parallel sided distally.	2.3–2.8	4+	14–12 proximal 11–10 distal	Apertural margin undulate. Thecae overlap one-half their length.
G. euglyphus	Long, thin, tapers.	2.1	2.5–10	10–7	Outer margin of thecae convex. Apertural margin concave. Pronounced thecal excavation.
G. euglyphus var *pygmaeus.*	Small, tapers	0.9–1.4	1.0–2.1	15–14	Do.
G. tamariscus	Long and narrow	1.0	7–4.5	14–10	Ventral walls curved. Apertural margins slightly undulate.
G. tenuissimus	do	1.6	2.6	12–11 proximal 11–10 distal	Ventral walls curved. Apertural margins lobate.[1]
G. teretiusculus	Long and widens gradually. Prominent virgella.	2	5	14	Apertural margins undulate.
G. teretiusculus var. *occidentalis.*	Slender, narrow	2	3.2	11–10	Apertural margins nearly straight.

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 curved sigmoidally, but curve is gentle. The lip of each aperture tends to be undulatory rather than flat. The cross section of rhabdosome is elliptical or subcircular.

Glyptograptus altus n. sp.

Plate 11, figures 1, 2

The rhabdosome is greater than 4 cm in length and widens gradually from 1.0 mm proximally to a maximum of 2.3–2.8 mm in a space of 11–15 mm and remains parallel sided thereafter. The thecae number 12–14 in 10 mm in the proximal part of the rhabdosome and 10–11 in 10 mm in the distal part. They are of the general

Glyptograptus type, are 1.8–2.0 mm long, and overlap nearly one-half their extent. The apertural margins are slightly undulate. The proximal end is relatively broad but the initial thecae are small. The sicula has a short but stout virgella. Theca 1^1 grew down before bending abruptly upward. It has a distinct mesial spine approximately 0.5 mm long that comes off just below the aperture. Theca 1^2 also grew downward before turning to grow outward. It, too, has a mesial spine which is 0.5 mm long and was given off at approximately the middle part of the theca. The tiny spines on these two initial thecae are shown on plate 11, figure 1. This form is readily distinguished from other glyptograptids by its greater size and gradually tapering proximal region.

Holotype: USNM 138675a, b.

Paratypes: USNM 138676a, 138676b, 138676c, 138677, 138678.

Occurrence: Phi Kappa formation, 1368, Vinini and Valmy equivalent, D480a (float) D480d, and D480e.

Range: Zone of *Dicellograptus complanatus*.

Glyptograptus euglyphus (Lapworth)

Plate 10, figures 27, 28; plate 11, figures 3, 4

Diplograptus (*Glyptograptus*) *euglyphus* Lapworth, 1880, Annals and Mag. Nat. History, v. 5, 5th ser., p. 166–167, pl. 4, figs. 14a–e.

Diplograptus (*Glyptograptus*) *teretiusculus* var. *euglyphus* Lapworth. Elles and Wood, 1907, Palaeontographical Soc., v. 61, Mon. British Graptolites, pt. 6, p. 252; fig. 172, pl. 31, figs. 2a–d.

Diplograptus (*Glyptograptus*) *euglyphus* Lapworth. Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 405–406, pl. 69, figs. 46–50.

According to the original description of this species, the rhabdosome is 25–100 mm in length, averaging 2.1 mm in width except at the proximal end which tapers rather rapidly to a very short virgella. Lateral spines are absent at the proximal end. Thecae number 7–10 in 10 mm and are inclined at an angle of 40° to the axis. The outer edge of each theca is convex; the margin of each aperture is concave.

The marked excavation between thecae produces a fairly strong saw-toothed appearance along the margins.

Figured specimens: USNM 138679a, 138679b, 138680, 138681.

Occurrence: Vinini formation, 222 (OC), 2353 (SD). Unnamed formation, Mt. Morrison quad., California, D515 (CO).

Range: Zone of *Hallograptus etheridgei* to zone of *Orthograptus truncatus* var. *intermedius*.

Discussion.—Elles and Wood (1907, p. 252) note that this species differs from G. *teretiusculus* in that the rhabdosome is long and more tapering, in the absence of lateral spines proximally, and in having thecae more widely spaced at the proximal end.

Glyptograptus euglyphus var. pygmaeus (Ruedemann)

Plate 10, figure 23

Diplograptus euglyphus var. *pygmaeus* Ruedemann, 1908, New York State Mus. Mem. 11, p. 371, fig. 317, 318; pl. 25, fig. 24.

Diplograptus (*Glyptograptus*) *euglyphus* var. *pygmaeus* Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 406, pl. 69, figs. 51–53.

This variety is characterized by its small size and close arrangement of thecae. Its average length of rhabdosome is reported as 10 mm, some specimens reaching 21 mm. Its width is 0.9–1.4 mm. When preserved, the sicular end bears a tiny virgella and a pair of small lateral spines. The thecae number 14–15 in 10 mm, inclined 30°–40° to the axis, with pronounced interthecal excavation.

Figured specimen: USNM 138682.

Occurrence: Palmetto formation, 5 miles north of Belmont, Nev. (Collected by G. K. Gilbert). Valmy formation, D102 (CO).

Range: Zone of *Climacograptus bicornis.*

Glyptograptus tamariscus (Nicholson)

Plate 10, figure 22

Diplograptus tamariscus Nicholson, 1868, Geol. Soc. London Quart. Jour., v. 24, p. 526, pl. 9, figs. 10–13.

Diplograptus (*Glyptograptus*) *tamariscus* Nicholson. Elles and Wood, 1907, Palaeontographical Soc., v. 61, Mon. British Graptolites, pt. 6, p. 247, figs. 167a–d; pl. 30, figs. 8a–d.

According to Nicholson's description the rhabdosome is about 1.0 mm wide. The proximal end is tapered to a point and may bear a long virgella. The thecae number 10–12 in 10 mm and are distinctly alternate in position on opposite sides. They are inclined at 10° to the axis with curved ventral walls. The interthecal excavations take up nearly one-half of the width of the rhabdosome. Apertures are at right angles to the axis.

Elles and Wood (1907, p. 247) added the information that the length may vary from 7–45 mm, and they indicate a different thecal count of 14–12 in 10 mm. The present specimens agree with their revision in this respect.

Figured specimens: USNM 138683.

Occurrence: Phi Kappa formation, 1368 (SD).

Range: Zone of *Dicellograptus complanatus.* In Great Britain this species is reported only from Silurian rocks.

Glyptograptus tenuissimus n. sp.

Plate 11, figure 6

The rhabdosome is at least 26 mm long and relatively narrow. It widens gradually from a width of 0.6 mm to a maximum of 1.6 mm and remains parallel sided thereafter. The thecae number 11–12 in

10 mm in the proximal part of the rhabdosome and 10–11 in 10 mm in the distal. They have a length of 1.0–1.3 mm and a slight overlap. The ventral margins have the characteristic glyptograptid curvature, and the apertural margins are lobate. The thecal excavations are pouch shaped and occupy one-half the width of the rhabdosome. The thecae are inclined at an angle of 20° to 25° to the axis of the rhabdosome. The diagnostic features of this species are its small size, its small thecal overlap, and fewer thecae than most other species in the genus.

Holotype: USNM 138685 a, b.
Occurrence: Hanson Creek formation, D474c.
Range: Zone of *Orthograptus quadrimucronatus*.

Glyptograptus cf. G. teretiusculus (Hisinger)

Plate 10, figure 19; plate 11, figure 5

Diplograptus (*Glyptograptus*) *teretiusculus* (Hisinger). Elles and Wood, 1907, Palaeontographical Soc., v. 61, Mon. British Graptolites, pt. 6, p. 250–252, 171a–d, pl. 31, figs. 1a–e.
Glyptograptus teretiusculus (Hisinger). Berry, 1960, Texas Univ. Pub. 6005, p. 87, pl. 14, figs. 3–5, 8; pl. 16, fig. 5.

According to Elles and Wood (1907, p. 25) this species is about 50 mm long and reaches a maximum width of 2 mm. It has a long virgella and a pair of lateral spines on the proximal thecae. Thecae number 14 in 10 mm. Apertural margins are slightly wavy.

Figured specimen: USNM 138687.
Occurrence: Vinini formation, 222(OC). Vinini and Valmy equivalent, D478a (CO).
Range: Zone of *G. teretiusculus* to zone of *Climacograptus bicornis*.

Discussion.—Many specimens are assigned to this species with confidence but are not photogenic. Others, such as those illustrated on plate 10, figures 19, 24 and plate 11, figure 9, lack critical structures because of poor preservation or differ from the typical forms in width of rhabdosome or spacing of thecae. The specimen shown on plate 11, figure 5, has a few seemingly amplexograptid thecae in the proximal part as do some British examples of the species (Elles and Wood, 1907, fig. 171b).

Glyptograptus teretiusculus var. occidentalis (Ruedemann)

Plate 11, figures 7, 8

Diplograptus (*Glyptograptus*) *teretiusclus* mut. *occidentalis* Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 409, pl. 69, fig. 61.

This variety differs from true *G. teretiusculus* by possessing 11–10 thecae in 10 mm. Although no virgella or spines are known at the proximal end, that lack may be caused by poor preservation.

Holotype: USNM 138547a, b.
Topotype: USNM 138548.
Occurrence: Phi Kappa formation, 1368 (SD).
Range: Zone of *Dicellograptus complanatus.*

TABLE 8.—*Characteristics of some species of the genus* Orthograptus

Species	Character of rhabdosome	Maximum width (mm)	Length (cm)	Character of proximal end	Number of thecae in 10 mm	Thecal characteristics
O. calcaratus	Long and broad. Well-developed virgula.	2.5–3.5	8–10	Long conspicuous virgella, three conspicuous basal spines.	10–8	Apertural margins lobate.
O. calcaratus var. *acutus.*	Wider, and widens more rapidly in proximal region than *O. calcaratus.*	3.0–4.0	.....	Slender virgella, two small basal spines may be present.	12–9	Thecae have greater angle of inclination, apertural margins more curved and everted than in *O. calcaratus.* Apertural margins have a distinct flange.
O. calcaratus var. *grandis.*	Robust, wide	5	7.5+	Broad, two short stout basal spines.	15 proximal 12–11 distal.	Like var. *acutus* except apertural margins slightly more curved and not as everted.
O. quadrimucronatus.	Long and broad widens gradually.	3.0–3.2	6–7	Narrow	12–8	Apertural margins lobate. Corners of the apertures have short stout spines.
O. truncatus var. *rariithecatus.*	Widens rapidly, then parallel sided for most of length.	2.5–3.0	3.5+	Rounded	12 proximal 10–8 distal.	Similar to those of *O. truncatus* var. *intermedius.*
O. truncatus var. *richmondensis.*	Short, relatively stout.	2.8	2+	Rounded	14 proximal 13–12 distal	Thecae tubular, apertural margins nearly straight, slightly everted.
O. truncatus var. *socialis.*	Small	1.5	[1] 1.5	Minute spines on two basal thecae.	14–11	Thecae tubular, expand slightly. Apertural margins slightly everted.
O. truncatus var. *strigosus.*	Long, slender, parallel sided for much of length but narrow distally.	2.4–2.9	6+	Small mesial spines on basal thecae.	12–11 proximal 9–8 distal	Thecae are slender tubes widening throughout their length. Apertural margins everted.
O. whitfieldi	Short and relatively wide.	2–3	3.5	Conspicuous virgella.	11–9	Apertural margins sublobate. Corners of the apertures have slender stout spines oriented horizontally or upward.
O. quadrimucronatus var. *angustus.*	Long, more slender than *O. quadrimucronatus.*	2.6	5+	Narrow	9–8	Same as in *O. quadrimucronatus.*
O. truncatus	Long robust fusiform.	4	6	Rounded small virgella and basal spines.	13–10	Thecae tubular. Apertural margins undulate and slightly everted.

[1] Maximum.

TABLE 8.—*Characteristics of some species of the genus* Orthograptus—Con.

Species	Character of rhabdosome	Maximum width (mm)	Length (cm)	Character of proximal end	Number of thecae in 10 mm	Thecal characteristics
O. truncatus var. *abbreviatus.*	Short subfusiform, may widen throughout.	3	2	Rounded small virgella and basal spines.	13–10	Thecae tubular, widen conspicuously towards apertural margin. Apertural margins undulate and slightly everted.
O. truncatus var. *intermedius.*	Very long and relatively narrow.	2.5	13+	-----do-----	14–10	Apertural margins less everted than in *O. truncatus.* Thecae approach those of *Glyptograptus* in character.
O. truncatus var. *pertenuis.*	Narrower than other varieties of *O. truncatus.*	1.2–1.4	4	Small virgella, no basal spines.	14–13	Thecae tubular with slight curvature of ventral wall in some.

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 virtually straight, though in some species they may curve slightly. Large spines fairly common at the proximal end. In some species paired apertural spines are well developed and have led to erroneous assignments to *Glossograptus.* Cross section elliptical or rectangular.

Orthograptus calcaratus (Lapworth)

Plate 11, figure 14

Diplograptus foliaceus var. *calcaratus* Lapworth, 1876, Catalogue of the Western Scottish Fossils *in* Armstrong and others, the Silurian system in the south of Scotland, British Acad. Sci., p. 6, pl. 1, fig. 30.

Diplograptus (*Orthograptus*) *calcaratus* Lapworth. Elles and Wood, 1907, Palaeontographical Soc., v. 61, Mon. British Graptolites, pt. 6, p. 239–241, figs. 159a–c; pl. 30, figs. 1a–c.

This species has a stout rhabdosome 80–100 mm long and 2.5–3.5 mm wide, according to Elles and Wood. Although widening gradually, it is never slender at the proximal end. The virgella is obvious with large spines projecting from the basal thecae. Thecae number 10–8 in 10 mm. The virgula is well developed and extends distally.

Figured specimen: USNM 138694.

Occurrence: Vinini and Valmy equivalent, D161 (CO).

Range: Zone of *Climacograptus bicornis.* In Great Britain the range is reported from the zone of *Orthograptus truncatus* var. *intermedius* to that of *Pleurograptus linearis.*

Discussion.—Specimens from several localities (Toquima formation, 315 [SD]; Hanson Creek formation, D247 [CO]) closely resemble this species but differ in spacing of thecae or other features. Some specimens from colln. D161 (CO) have 12 thecae in 10 mm but otherwise seem to belong to the species (pl. 11, fig. 15, 16). Others, like those in colln. D530 (SD) from the Palmetto formation, are like *O. calcaratus* in all aspects except they measure 4.5 mm wide (pl. 11, fig. 13). Ruedemann (1947, p. 398–399) reported a wide form of this species from the Phi Kappa formation of the Hailey quadrangle in USGS colln. 1370 (SD), but we have found no representatives of it in that collection. It is likely that he intended the form we have called *O. calcaratus* var. *grandis* n. var. from colln. 1368 (SD).

Orthograptus calcaratus var. acutus Elles and Wood

Plate 11, figure 18; plate 12, figure 1, 17

Diplograptus (*Orthograptus*) *calcaratus* var. *acutus* [Lapworth Ms] Elles and Wood, 1907, Palaeontographical Soc., v. 61, Mon. British Graptolites, pt. 6, p. 242, fig. 161; pl. 30, figs. 3a–c.

Diplograptus foliaceus var. *acutus* Lapworth *in* Ruedemann, 1908, New York State Mus. Mem. 11, p. 349–351, figs. 288–293, pl. 25, figs. 1, 2.

Orthograptus calcaratus var. *acutus* (Lapworth). Berry, 1960, Texas Univ. Pub. 6005, p. 89, pl. 16, figs. 3, 4.

This variety lacks the large basal spines of true *O. calcaratus* and possesses 12–9 thecae in 10 mm. Its initial width of 1 mm increases to 4 mm in a distance of 15 mm in British specimens, but Lapworth's description of New York material gives 3.0 mm as the width. The specimens before us have widths of 3.5 mm. Lapworth's original description also notes the presence of a virgella and two basal spines 1–2 mm long, although Elles and Wood state that spines are absent.

Figured specimens: USNM 138697, 138698, 138699.

Occurrence: Unnamed formation, Mt. Morrison quad., California, D513 (CO), D514 (CO). Palmetto formation, D530 (CO). Toquima formation, 308 (SD), 328 (SD), 336 (SD), 444z (OC). Saturday Mountain(?) formation, 2519 (SD), D456 (CO).

Range: Zones of *Climacograptus bicornis* and *Orthograptus truncatus* var. *intermedius*.

Orthograptus aff. O. calcaratus var. basilicus Elles and Wood

Plate 11, figure 20

Orthograptus calcaratus var. *basilicus* Elles and Wood, 1907, Palaeontographical Soc. v. 61, Mon. British Graptolites, pt. 6, p. 243, figs. 162a, b; pl. 30, figs. 2a–d.

Typically this variety lacks the huge basal spines of true *O. calcaratus*, but has a tiny virgella and even smaller spines on the basal

thecae. It is a narrow form, reaching a width of 2.5 mm in a 10 mm distance from the proximal end. The initial width is 1 mm. The thecae number 9–10 in 10 mm.

The specimen at hand is similar in general form and in features of the proximal end. However, its width is 3.0 mm and the thecae number 6–7 in 10 mm, lower than any known species.

Figured specimen: USNM 138700a, b.
Occurrence: Toquima formation, 320 (SD).
Range: Zone of *Orthograptus truncatus* var. *intermedius*.

Orthograptus calcaratus var. grandis (Ruedemann)

Plate 12, figures 2, 3, 18

Retiograptus grandis Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 459, pl. 80, figs. 27–32.

Examination of the types of *Retiograptus grandis* revealed that they are not retiograptids but orthograptids of the *calcaratus* type. These forms are wider than any previously described variety of that species, and hence Ruedemann's name *grandis* applies well to them.

The rhabdosome is large, attaining a length of more than 7.5 cm. It widens from an initial breadth of 1.2–4 mm in a distance of 9 mm, then increases gradually to 5 mm and remains parallel sided thereafter. The thecae number 15 in 10 mm in the proximal region and 11–12 in 10 mm distally. They have the general characteristics of those of the variety *acutus* except that the apertural margins are slightly more curved and not as everted. The proximal end is broad, and Th 1^1 and 1^2 have short stout apertural spines. This variety is readily recognized by its width and numerous thecae.

Holotype: USNM 102764.
Paratypes: USNM 138701–138705 incl.
Occurrence: Phi Kappa formation, 1368.
Range: Zone of *Dicellograptus complanatus*.

Orthograptus quadrimucronatus (J. Hall)

Plate 12, figures 4–6

Graptolithus quadrimucronatus J. Hall, 1865, Canada Geol. Survey, Canadian Organic Remains, Decade 2, p. 144–146, pl. 13, figs. 1–10.

Diplograptus (Orthograptus) quadrimucronatus (J. Hall). Elles and Wood, 1907, Palaeontographical Soc., v. 61, Mon. British Graptolites, pt. 6, p. 223–224, figs. 145a–f; pl. 28, figs. 1a–d.

Glossograptus (Orthograptus) quadrimucronatus (J. Hall). Ruedemann, 1908, New York State Mus. Mem. 11, p. 385–392.

Glossograptus quadrimucronatus (J. Hall). Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 452–454, pl. 78, figs. 1–5.

?Diplograptus (Orthograptus) quadrimucronatus (J. Hall). Harris and Thomas, 1955, Victoria Dept. Mines, Mining and Geol. Jour., v. 5, no. 6, p. 37, fig. 37.

Orthograptus quadrimucronatus (J. Hall). Berry, 1960, Texas Univ. Pub. 6005, p. 91, pl. 18, fig. 1.

In cross section the rhabdosome of this species is rectangular. The corners of the thecal apertures are furnished with strong spines. The apertures of a pair of thecae back to back therefore produce four spines.

The rhabdosome reaches 60–70 mm in length. Initially 1.5 mm wide, within 20 mm it broadens to a width of about 3 mm. (Hall's original description states one-eighth of an inch or 3.2 mm.) In his description, Hall (1865, p. 145) stated that the thecae number 22 per inch (8–9 in 10 mm); Elles and Wood (1907, p. 223) considered the count as 12–8 in 10 mm and Ruedemann (1908, p. 386) as 11–10 in 10 mm.

Because of variations in direction of compression, the apertural spines may appear full length (as much as 2 mm) or not at all. The "corners" of the faces of the thecae are thickened lists that may cause a meshlike appearance (pl. 12, fig. 6), not unlike some of the retiograptids.

Figured specimens: USNM 138703–138705 incl.

Occurrence: Valmy and Vinini equivalent, D442h (CO), D480e (CO), D507 (CO), D540 (CO) and questionably D453 (CO). Saturday Mountain (?) formation, 2519 (SD).

Range: Zone of *O. quadrimucronatus.*

Discussion.—This species has been reported by Harris and Thomas (1955, p. 37) from Victoria, but their forms are narrower than the types or our specimens. The Australian forms may belong in *O. quadrimucronatus* var. *angustus* (Ruedemann, 1947, p. 454).

Orthograptus quadrimucronatus var. angustus (Ruedemann)

Plate 11, figure 24

Glossograptus quadrimucronatus var. *angustus* Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 454, pl. 79, figs. 20–24.

Orthograptus quadrimucronatus var. *angustus* (Ruedemann). Berry, 1960, Texas Univ. Pub. 6005, p. 91, pl. 17, figs. 10a, 11.

This variety is represented by a single poor specimen in the present collections.

It is like the parent species in all respects except width, which does not exceed 2.6 mm. The thecal count agrees with Hall's original description of *O. quadrimucronatus*, 8–9 in 10 mm.

Figured specimen: USNM 138707.

Occurrence: Valmy formation, 1950 (CO).

Range: Zone of *O. truncatus* var. *intermedius.*

Orthograptus quadrimucronatus var. whitfieldi (J. Hall)

Plate 12, figures 21, 22(?)

Graptolithus whitfieldi J. Hall, 1859, Palaeontology of New York, Nat. History New York: v. 3, p. 516, fig. 1.

Diplograptus (Orthograptus) whitfieldi (J. Hall). Elles and Wood, 1907, Palaeontographical Soc., v. 61, Mon. British Graptolites, pt. 6, p. 227–228, pl. 27, figs. 6a–d.

Glossograptus whitfieldi (J. Hall). Ruedemann, 1908, New York State Mus. Mem. 11, p. 394–397, figs. 344, 345.

Glossograptus whitfieldi (J. Hall). Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 457–458, pl. 77, figs. 23, 24.

Orthograptus whitfieldi (J. Hall). Berry, 1960, Texas Univ. Pub. 6005, p. 93–94, pl. 16, fig. 7.

This variety bears large slender spines on the thecal apertures; and in this respect as well as in rectangular cross section, it is allied to *O. quadrimucronatus.*

The rhabdosome reaches a length of 35 mm, or more, and a breadth of 2–3 mm. Initially about 0.8 mm wide, it reaches full width within 10 mm, then remains parallel sided or diminishes in width distally. Thecae number 9–11 in 10 mm and according to previous descriptions are inclined at about 30° to the axis. Ruedemann's figures (1908, fig. 345) indicate a much more acute angle. Overlap is ⅓–½.

The thecal spines are stiff and 0.8–1 mm long. They are horizontal or ascending in orientation.

Figured specimen: USNM 138725, 138726(?).

Discussion.—According to Ruedemann (1947, p. 458; 1908, p. 397) this variety is distinguished from *O. quadrimucronatus* by its "more slender rhabdosomes and the slightly ascending direction of the spines." Elles and Wood (1907, p. 227–228) state that the slender nature of the spines, their upward direction, and their greater length serve to differentiate it from *quadrimucronatus.*

Because almost all dimensions of the species and its variety overlap, it seems impossible to differentiate them in all specimens. Because *O. quadrimucronatus* attains greater lengths, its mature stages should be distinguished easily. Similarly narrow forms of subspecies *whitfieldi* would be more slender than any specimens of *O. quadrimucronatus* s. s. more than 20 mm long.

Orthograptus truncatus (Lapworth)

Plate 11, figure 25

Diplograptus pristis var. *truncatus* Lapworth, 1876, Catalogue of the Western Scottish Fossils *in* Armstrong and others, the Silurian System in the south of Scotland; British Acad. Sci., p. 6, pl. 1, fig. 28.

Diplograptus truncatus Lapworth, 1877, Belfast Naturalists' Field Club Proc., App. 1876–77, p. 133, pl. 6, fig. 17.

Diplograptus (*Orthograptus*) *truncatus* Lapworth. Elles and Wood, 1907, Palaeontographical Soc. v. 61, Mon. British Graptolites, pt. 6, p. 233–235, figs. 154a, b; pl. 29, figs. 3a–e.

This species typifies a group in which the cross section of the rhabdosome is subcircular or elliptical, rather than rectangular. There are no apertural spines and no conspicuous excavations above thecal apertures.

According to Elles and Wood (1907, p. 233–234) the rhabdosome is usually fusiform in outline; its initial width is 1 mm; at a length of 15 mm the width is 4 mm and thereafter decreases. The length is about 60 mm.

The proximal end is rounded. The virgella and lateral spines are small. Thecae are simple tubes, numbering 13–10 in 10 mm; they are inclined 35°–45° to the axis depending on direction of compression and overlap ½–⅔ of their length. Apertures may appear slightly everted.

Figured specimen: USNM 138708.

Occurrence: Palmetto formation, 2347 (SD). Saturday Mountain(?) formation, D456 (CO). Valmy and Vinini equivalent, D507 (CO).

Range: Zones of *Orthograptus truncatus* var. *intermedius* and *O. quadrimucronatus*.

Orthograptus truncatus var. abbreviatus Elles and Wood

Plate 11, figure 26; plate 12, figure 8

Diplograptus (*Orthograptus*) *truncatus* var. *abbreviatus* Elles and Wood, 1907, Palaeontographical Soc., v. 61, Mon. British Graptolites, pt. 6, figs. 155a–d; pl. 29, figs. 6a–e.

Diplograptus (*Orthograptus*) *truncatus* var. *abbreviatus* Lapworth. Ruedemann, 1947, Geol. Soc. America Mem. 19, pl. 69, figs. 12, 13a.

Typically this variety differs from *O. truncatus* s. s. by being smaller, only 20 mm long and 3 mm wide.

Figured specimen: USNM 102930, 138709.

Occurrence: Phi Kappa formation, 1368 (SD).

Range: Zone of *Dicellograptus complanatus*.

Discussion.—Associated with this variety in the Phi Kappa is a form which appears to be a very large more mature example of it (pl. 12, fig. 8). Unfortunately, we lack the intermediate specimens. If the large and small forms belong to the same variety, the Idaho specimens probably should not be assigned the name *abbreviatus;* they may represent a much larger variety.

Orthograptus truncatus var. intermedius Elles and Wood

Plate 11, figure 22

Diplograptus (*Orthograptus*) *truncatus* var. *intermedius* Elles and Wood, 1907, Palaeontographical Soc., v. 61, Mon. British Graptolites, pt. 6, p. 236–237, figs. 156a, b; pl. 29, figs. 4a–e.

Diplograptus (*Orthograptus*) *truncatus* var. *intermedius* Elles and Wood. Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 403–404, pl. 69, figs. 16–17.
Orthograptus truncatus var. *intermedius* (Elles and Wood). Berry, 1960, Texas Univ. Pub. 6005, p. 92–93, pl. 17, figs. 4, 5.

This variety is only 2.5 mm wide but attains lengths of 130 mm or more. The maximum width is reached in a length of 20 mm.

The thecae are not as simple as in *O. truncatus* s. s. being shaped something like those of a *Glyptograptus*. They number 14–10 in 10 mm.

Figured specimen: USNM 138710.
Occurrence: Saturday Mountain(?) formation, D456 (CO). A form questionably referred to this form has been identified in collection 2347 (SD) from the Palmetto formation.
Range: Zone of *O. truncatus* var. *intermedius*.

Orthograptus truncatus var. pertenuis (Ruedemann)

Plate 11, figure 23

Diplograptus (*Amplexograptus*) *amplexicaulis* var. *pertenuis* Ruedemann, 1908, New York State Mus. Mem. 11, p. 365–366, figs. 308–310, pl. 25, figs. 14–16.

This variety is very slender, its maximum width is 1.2–1.4 mm and its length about 40 mm. The virgella is small. There are no lateral spines on the present example. Thecae number 13–14 in 10 mm and are inclined at about 20° to the axis. Ruedemann (1908, p. 366) states that the inclination is 30°–40°, but his figures (fig. 309) show it to be 20° also.

Figured specimen: USNM 138711.
Occurrence: Valmy formation, D157 (CO).
Range: Zone of *O. truncatus intermedius*.

Discussion.—Our material for this variety is limited to one poor specimen. Despite its inadequacies we identify it with fair confidence.

Orthograptus truncatus var. rarithecatus n. var.

Plate 12, figures 11–15

The rhabdosome is at least 3.5 cm in length and widens rapidly from a rounded sicular region that is 0.8 mm in breadth to 2.5–3.0 mm in breadth then remains parallel sided. The thecae number 12 in 10 mm in the proximal region and 8–10 in 10 mm distally. They are 2–2.5 mm long, overlap one-half their extent, are inclined at a 15°–20° angle, and are of the *O. truncatus* type—closely similar to those of the variety *intermedius*. The variety *rarithecatus* can be separated from other varieties of *O. truncatus* by its long slender shape and lesser number of thecae.

Holotype: USNM 138549 a, b.
Paratypes: USNM 138616, 138713a, 138713b, 138714, 138715.

Occurrence: Phi Kappa formation, 1368 (SD).
Range: Zone of *Dicellograptus complanatus*.

Orthograptus truncatus var. richmondensis (Ruedemann)

Plate 12, figures 23–25

Diplograptus (*Amplexograptus*) *recurrens* mut. *richmondensis* Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 414, pl. 70, figs. 51–54.

An examination of the type specimens and Ruedemann's figures reveals that the species *Amplexograptus recurrens* and the supposed mutation of it, *richmondensis* are both orthograptids of the *truncatus* type. As there is no specific or varietal name *richmondensis* within the genus *Orthograptus*, the writers propose to use that name for this variety of *O. truncatus*.

The Idaho specimens of the variety *richmondensis* exceed 20 mm in length. They widen rapidly from a broadly rounded proximal end that is 0.8–1 mm in breadth to a maximum of 2.5–2.8 mm in breadth. The thecae are of the characteristic *truncatus* type and number 14 in 10 mm proximally and 12–13 in 10 mm distally. They have a length of 2 mm, an overlap of one-half their extent, and an inclination to the stipe of 35°–40°. The short relatively stout shape and high number of thecae in the proximal region are distinctive characters of this variety.

Figured specimens: USNM 138551, 138716, 138717.
Occurrence: Phi Kappa formation, 1368 (SD).
Range: Zone of *Dicranograptus complanatus* in Idaho. Ruedemann's types came from the Arnheim shale of the Richmond group near Oxford, Ohio.

Discussion.—According to Ruedemann's description, there are as many as 16 thecae in 10 mm, presumably in the proximal region. None of the Idaho specimens shows more than 14 in 10 mm, however. The specimen shown on plate 12, figure 25, has thecae more widely spaced and seems intermediate between this variety and *O. trucatus* var. *rarithecatus*.

Orthograptus truncatus var. socialis (Lapworth)

Plate 11, figure 21

Diplograptus socialis Lapworth, 1880, Annals and Mag. Nat. History, v. 5, 5th ser., p. 166, pl. 4, figs. 13a–e.

Diplograptus (*Orthograptus*) *truncatus* var. *socialis* Lapworth. Elles and Wood, 1907, Palaeontographical Soc., v. 61, Mon. British Graptolites, pt. 6, p. 237–238, figs. 157a–d; pl. 29, figs. 7a–e.

According to Elles and Wood (1907, p. 237–238) the rhabdosome is always less than 15 mm, usually less than 10 mm, in length. The width is less than 2.1 mm, usually less than 1.5 mm. Two basal thecae

possess minute lateral spines. Thecae number 11–14 in 10 mm and are inclined at about a 45° angle to the axis with ⅓–½ overlap. Thecae are tubular, expanding slightly, and alternating in position on opposite sides of the rhabdosome.

Figured specimens: USNM 138718.
Occurrence: Valmy and Vinini equivalent, D480a (CO), D480c (CO).
Range: Zone of *Dicellograptus complanatus.*

Orthograptus truncatus var. strigosus n. var.

Plate 13, figures 1–4

The rhabdosome is long and slender. It is 6 cm or more in length and widens gradually from 0.5 mm at the proximal end to a maximum of 2.4 mm commonly, but a few forms are as wide as 2.9 mm. After the maximum width is attained, the rhabdosome is parallel sided for most of its length but narrows slightly distally. The sicula is approximately 2 mm long and has a small virgella that is 0.5 mm long. Theca 1^1 appears to originate near the middle of the sicula and to have grown down below the level of its aperture then bent abruptly to grow upward. A thecal spine was given off near the point of change in growth. Theca 1^2 appears to have grown around in front of the sicula, and it, too, has a mesial spine. The thecae are approximately 1.5 mm long and 0.5–0.7 mm wide. They overlap about one-third of their length, number 11–12 in the proximal region and 8–9 in 10 mm in the distal, and are inclined to the stipe at a 30°–40° angle. They are slender tubes that widen throughout their length. The apertural margins are commonly everted, and, in some modes of preservation, the eversion is pronounced. The long slender shape of rhabdosome and lower number of thecae are distinctive characteristics of this variety.

Holotype: USNM 138719.
Paratypes: USNM 138720–138722, 138723a, 138723b, 138724.
Occurrence: Saturday Mountain formation (Phi Kappa? formation), 2519 (SD) and D456 (CO).
Range: Zones of *Orthograptus truncatus intermedius* and of *Orthograptus quadrimucronatus.*

Discussion.—This variety is not as narrow as *O. truncatus pertenuis* Ruedemann and has more widely spaced thecae. As shown on plate 13, figures 2, 3, 4, the thecae are everted. The holotype (pl. 13, fig. 1) appears to have introverted thecae but this effect is caused by our inability to reproduce all features photographically because of imperfect preservation.

Family ?DIPLOGRAPTIDAE, position uncertain

Genus TRIGONOGRAPTUS Nicholson, 1869

Trigonograptus Nicholson. Bulman, 1955, Geol. Soc. America, Treatise on invertebrate paleontology, pt. V, p. V87, fig. 64, 1.

According to Bulman (1955, p. V87): "Rhabdosome fusiform, concavo-convex or trigonal in cross section, thecae markedly alternating, almost straight, overlapping for their entire length, apertural margins forming an even line."

This genus is sometimes mistaken for *Phyllograptus*.

Trigonograptus martellii n. sp.

Plate 12, figures 9, 10, 16

The rhabdosome expands gracefully for 4–5 mm from the proximal end to a maximum width of 2–3 mm, thereafter decreasing more gradually. The length is about 15 mm. Thecae number 12–14 in 10 mm and are inclined at about 40°–50° to the axis; they seem to alternate on opposite sides of virgula(?), but this characteristic may not be true of all specimens.

Holotype: USNM 138728.

Paratypes: USNM 138729, 138730.

Occurrence: Valmy formation, D102 (CO). Vinini and Valmy equivalent, D442d (CO).

Range: Zone of *Climacograptus bicornis*. The occurrence of a representative of *Trigonograptus* this high stratigraphically is previously unknown. The range of the genus in Britain is limited to beds older than the zone of *Isograptus*. The possibility of a mixed collection must be considered.

Discussion.—This species differs from *T. ensiformis* (Hall) by closer spacing of thecae and in its lesser width. The specimens at hand show considerable variation in width, some being relatively long and narrow compared with others that are short and wide.

Family LASIOGRAPTIDAE

Genus HALLOGRAPTUS Lapworth, 1877

Diplograptus (*Hallograptus*) Lapworth, 1877, Belfast Naturalists' Field Club Proc., App., 1876–77, p. 134.

Lasiograptus (*Hallograptus*) Carruthers. Elles and Wood, 1908, Palaeontographical Soc., v. 62, Mon. British Graptolites, pt. 7, p. 320.

The biserial scandent rhabdosome is characterized by thecae like those of *Orthograptus*. Spiny processes given off from thecae, probably in pairs, splitting and joining with others to form a network (or lacinia) at a short distance from the ventral margin. From the sides of the rhabdosome peculiar membranous protuberances (or scopulae) may be supported on other spines or rods; scopulae are best seen when the rhabdosome has been flattened to give a scalariform

view. In the case of the usual lateral flattening, scopulae may not show, just as the lacinia may not show well in the scalariform view.

There has been considerable confusion in the past concerning the correct type species of *Hallograptus* and the means of distinguishing this genus from *Lasiograptus*. A chronologic summary of pertinent literature may serve as a review to show how the confusion arose and the evidence for its solution.

1847. J. Hall (p. 268, pl. 73, figs. 1a–d) described and illustrated "*Graptolithus mucronatus*"; according to the figures its thecae are orthograptid and each bears a flexuous spine.

1865. J. Hall (p. 32–33, pl. B, figs. 6–11) described remarkable reproductive sacs or processes in some specimens of *Graptolithus whitfieldi* (these specimens now considered as belonging to *Hallograptus bimucronatus*). These are the scopulae of later descriptions.

1869. Nicholson (p. 236, pl. 11, fig. 12, 12′) described and figured "*Diplograpsus bimucronatus*." Despite stylized illustrations this species clearly possesses orthograptid thecae, although Nicholson states that they are different from those of *O. quadrimucronatus* Hall. Two spines are described and figured at the aperture of each theca, but they are not shown to anastomose although attaining great lengths.

1873. Lapworth (p. 550) named the genus *Lasiograptus*, with *L. costatus* described as the type species. The thecae were stated to be somewhat climacograptid (they are actually amplexograptid in the modern sense). From each theca a spinous process is prolonged, giving rise to "slender filaments which anastomose with those derived in a similar manner from the processes immediately above and below, and form a row of meshes almost surrounding the rhabdosome."

1876. Lapworth (p. 7, pl. 2, fig. 58) referred *bimucronatus* to the genus *Hallograptus*. This was in an illustrated listing, so that no text explained the erection of the genus *Hallograptus* or the reasons for the assignment of *bimucronatus* Nicholson to it. However, the listing did establish that species as the first in the genus and therefore the type species by monotypy in 1876.

1877. Lapworth (p. 134, pl. 6, fig. 22) described and figured "*Diplograptus* (*Lasiograptus*?) *mucronatus* Hall," noting that "the apertural fibres occasionally anastomose; and examples with lateral reproductive appendages are not infrequent in the Moffat Series." The presence of lacinia and scopulae in Scottish specimens is here established. Note that Lapworth did not follow Carruthers' suggestion to place this species in *Hallograptus*.

1877. Lapworth (p. 134, pl. 6, fig. 23) figured "*Diplograptus* (*Hallograptus*) *bimucronatus* Nich." noting that scopulae are most common in this species as well as the fibers that support them. He further credits Carruthers with the suggestion that this species and "*Diplograptus mucronatus* should be erected into a new genus under the title of *Hallograptus* * * *." On this basis and on that cited above we believe the type species of *Hallograptus* is unavoidably *H. bimucronatus* Nicholson.

1877. Lapworth (p. 135) declared *Lasiograptus costatus* a synonym of *L. harknessi* Nicholson. His illustration (pl. 6, fig. 26) clearly shows amplexograptid thecae.

1908. Ruedemann (p. 479–483) referred *Hallograptus bimucronatus* as well as *mucronatus* to *Lasiograptus*. His descriptions and illustrations indicated that the filamentous processes anastomosed in both species, although scopulae are better developed in *H. bimucronatus*. Illustrations show clearly that thecae of both species are orthograptid. (1908, pl. 29, figs. 9–13, 15–17; pl. 30, figs. 1, 2, 4–6; pl. 31, figs. 1, 2.)

1908. Elles and Wood (p. 318–328) reduced *Hallograptus* to a subgenus of *Lasiograptus*, naming *H. mucronatus* Hall the type species, and ignoring the already existing type. They then reduced the type species of the genus to a subspecies of their erroneously designated type species.

1947. Ruedemann (p. 461–465) accepted Elles' and Wood's designation of *Hallograptus* as a subgenus of *Lasiograptus*, but correctly noted that the type species of the former is *H. bimucronatus* Nicholson.

1955. Bulman (p. V87–88) separated *Lasiograptus* with amplexograptid thecae from *Hallograptus* with orthograptid thecae. His statement that the latter lacks lacinia is not substantiated by previous works, noted above. *H. mucronatus* is not the type species and this may be a misprint.

On the basis of previously published literature, although lacking first hand knowledge of the type material of *H. mucronatus* and *H. bimucronatus*, we conclude that both species possess a lacinia and orthograptid thecae. As shown by Elles and Wood (1908, fig. 215a), *Lasiograptus costatus* also possesses a lacinia but has distinctly amplexograptid thecae. Therefore, the distinguishing of thecal type is essential to identification of *Hallograptus* and *Lasiograptus*.

Hallograptus? eucharis (J. Hall)

Plate 13, figure 7

Lasiograptus (*Thysanograptus*) *eucharis* (J. Hall). Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 461–462, pl. 81, fig. 33; pl. 82, figs. 1–4, 9–13, 14–20, 22 [not figs. 5–8, 21, 23–26].

The rhabdosome in the Nevada specimen is small, 1.6 mm wide, 5 mm long and of uniform width. The thecae number 16 in 10 mm, are short and broad, and are inclined at approximately 40°. They appear to be orthograptid in character and for that reason this species is provisionally referred to the genus *Hallograptus*. The thecal apertures are straight and normal to the axis of the rhabdosome. The apertures have two short spines which bifurcate and curve distally to join with similar processes from other thecae to form lacinia.

The Nevada specimen agrees closely with the description given by Ruedemann. However, Ruedemann's figures clearly include at least 3 different species -2 of which do not belong in the same genus with this form. Also, the form herein described, and the specimens figured by Ruedemann that it has been compared with, appear to have orthograptid thecae and should therefore be included in the genus *Hallograptus* and not in *Lasiograptus* as suggested by Ruedemann.

628607 O—63——11

Figured specimen: USNM 138731.
Occurrence: Palmetto formation, USGS colln. 2347 (SD).
Range: Zone of *Orthograptus quadrimucronatus.*

Hallograptus? mucronatus (J. Hall)

Plate 13, figures 8, 9

Lasiograptus mucronatus (J. Hall). Ruedemann, 1908, New York State Mus. Mem. 11, p. 479–483, pl. 30, figs. 1, 2, 4, 5; pl. 31, fig. 2.
[Part] *Lasiograptus* (*Hallograptus*) *bimucronatus* Nicholson. Ruedemann, 1947, Geol. Soc. America Mem. 19, pl. 81, figs. 25–28.
[Not] *Lasiograptus* (*Hallograptus*) *mucronatus* (J. Hall). Elles and Wood, 1908, Palaeontographical Soc., v. 62, Mon. British Graptolites, pt. 7, p. 321–322, pl. 33, figs. 6a–e.

The rhabdosome is less than 15 mm long and is 2.5 mm wide, exclusive of spinal processes. Thecae number 9 in 10 mm. The lacinia is formed by spines running outward for about 1 mm before turning downward to join spines from the next lower thecae.

Figured specimens: USNM 102818.
Occurrence: Phi Kappa formation, 1370 (SD).
Range: Zone of *Climacograptus bicornis.*

Discussion.—Unfortunately the shape of thecae cannot be determined, and we are uncertain, therefore, whether these specimens belong to *Hallograptus* or *Lasiograptus.* They were originally assigned to *Hallograptus bimucronatus* by Ruedemann (1947, pl. 81, figs. 25–28), but do not conform to measurements given by him. They closely resemble forms of *H. mucronatus* described by Ruedemann from Mount Moreno, N.Y.

Hallograptus sp.

Plate 13, figure 6

The rhabdosome is about 15 mm long and 2 mm wide. Thecae of the orthograptid type are spaced 14 in 10 mm. Apertural spines are very slender and curved, two per theca. Thecae are inclined about 50°–60° to axis.

Figured specimen: USNM 138732.
Occurrence: Phi Kappa formation, 1370 (SD).
Range: Zone of *Climacograptus bicornis.*

Discussion.—Representatives of this species resemble *H. mucronatus* but differ in higher thecal count and higher inclination of thecae.

Family RETIOLITIDAE Lapworth, 1873

Bulman (1955, p. V88) gave the following description for this family: "Scandent biserial, with straight stipes, adnate dorsally; periderm reduced to meshwork composed of reticula or clathria or both, lacinia present in some forms. Thecae markedly alternate." He

also stated that this "undoubtedly is a polyphyletic assemblage" and provisionally divided it into three subfamilies.

The first subfamily, Archiretiolitinae, has a diplograptid type of development, and the sicula is chitinized to some extent. In some members, a clathria only is present, whereas in others a well-developed reticula is prominent. The second subfamily, Retiolitinae, is characterized by a well-developed reticula supported on a distinct clathria. The sicula is not chitinized or only partially chitinized. A lacinia is present is some members of this group. The third subfamily, Plectograptinae, has well-developed clathriae, but commonly without reticulae or laciniae.

The new genus included by the authors in the Family Retiolitidae has a well-developed reticula, a poorly defined clathria, no lacinia, and an unchitinized sicula. It is provisionally included in the first subfamily although the sicula is not chitinized.

Subfamily ARCHIRETIOLITINAE Bulman, 1955

Bulman (1955, p. V88) erected this subfamily to encompass biserial scandent forms in which the periderm was reduced to a meshwork composed of a reticula or a clathria but the sicula was chitinized to some extent. Development of the rhabdosome is orthograptid in character.

Genus ORTHORETIOLITES Whittington, 1954

Orthoretiolites Whittington, 1954, Jour. Paleontology, v. 28, p. 613–614.
Orthoretiolites Whittington. Bulman, 1955, Geol. Soc. America, Treatise on invertebrate paleontology, pt. V, p. V88, fig. 66, 1.

Rhabdosome biserial, scandent. Periderm reduced, meshwork of clathriae only remaining, with one apertural spine from each theca. Sicula composed of chitin.

Orthoretiolites hami Whittington

Orthoretiolites hami Whittington, 1954, Jour. Paleontology, v. 28, p. 614–621, figs. 1–13; pl. 63, figs. 1–4.

The entire rhabdosome of this species is about 3 mm long and a little less than 1 mm wide. At the proximal end the conical chitinized sicula is about 0.9 mm long and seems to be enclosed in a tiny net. This net represents only the framework of the rhabdosome, all periderm having been lost. The thecae are arranged alternately on opposite sides of the axis, spaced 4 in 2 mm.

Reference specimen: USNM 138733.
Occurrence: Valmy formation, 1950 (CO). Valmy and Vinini equivalent, D612 (CO).
Range: Zone of *O. truncatus intermedius*.

628607 O–63—12

Genus RETIOGRAPTUS Hall, 1859

Retiograptus Hall. Bulman, 1955, Geol. Soc. America, Treatise on invertebrate paleontology, pt. V. p. V88, fig. 66, 3.

Rhabdosome biserial scandent. Framework of clathria only. No periderm except a very thin membrane at proximal end. No lacinia and no reticula (fine mesh supported by clathria). Thecae alternate.

On plate 13, figure 21, a rhabdosome is shown that has been ruptured. Two vertical rows of "frames" are in the center. On both sides are spinelike projections; these are actually broken parts of the clathria. In the right-hand vertical row the "frames" are rectangular; they form the apertural face of the rhabdosome. The left-hand side of the left-hand row is slightly zigzagged. This zigzagged line represents the suture between the two rows of scandent thecae. (See Bulman, 1955, fig. 66,3.)

Retiograptus geinitzianus J. Hall

Plate 13, figures 20–23

Retiograptus geinitzianus J. Hall, 1859, Palaeontology of New York, Nat. History New York: v. 3, p. 518.

Retiograptus geinitzianus J. Hall. Ruedemann, 1908, New York State Mus. Mem. 11, p. 463–467, figs. 444–448; pl. 29, figs. 5, 6; pl. 31, figs. 9–16.

Retiograptus geinitzianus J. Hall. Elles and Wood, 1908, Palaeontographical Soc. v. 62, Mon. British Graptolites, pt. 7, p. 316–317, figs. 209a–c; pl. 34, figs. 7a–d.

Retiograptus geinitzianus J. Hall. Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 459–460, pl. 80, figs. 11–25.

[Not] *Retiolities geinitzianus* (Barrande). Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 466–467.

Retiograptus geinitzianus J. Hall. Berry, 1960, Texas Univ. Pub. 6005, p. 96, pl. 15, fig. 3a.

The rhabdosome is small, parallel sided, and about 2 mm wide and 15 mm long. Thecae number 9–12 in 10 mm. A suggestion of membrane may remain between clathria as in the proximal part of one of the figured specimens (pl. 13, fig. 21).

Figured specimens: USNM 138542a, 138542b, 138734, 138735.

Occurrence: Toquima formation, 444z (OC). Valmy formation, D116 (CO), D118 (CO), D489 (CO).

Range: Zones of *Nemagraptus gracilis* and *Climacograptus bicornis.*

Retiograptus pulcherrimus Keble and Harris

Plate 13, figures 13, 13a, 14

Retiograptus pulcherrimus Keble and Harris, 1934, Mem. Natl. Mus. Victoria, Melbourne, no. 8, p. 178–179, fig. 6; pl. 22, fig. 1.

Retiograptus pulcherrimus Keble and Harris. Berry, 1960, Texas Univ. Pub. 6005, p. 96, pl. 17, figs. 9, 10b.

The rhabdosome is more than 170 mm long and 2–2.5 mm wide and mainly parallel sided. Our specimens appear like an *Orthograptus* of the *quadrimucronatus* type. There seem to be 9 thecae in 10 mm. Because the cross section is rectangular, apertures are nearly square; a short sharp spine appears to project from each corner of the aperture. As a result of flattening it may appear that there is only a single spine per aperture. It also seems probable that the width of rhabdosome would be 2 mm or less if no flattening had taken place.

Figured specimens: USNM 138736, 138737.

Occurrence: Valmy and Vinini equivalent, D480e (CO).

Range: Zone of *Orthograptus quadrimucronatus*. In Australia from the Bolindian series.

Genus ARACHNIOGRAPTUS n. gen.

The rhabdosome is bilaterally symmetrical and a biserial scandent form. It is composed of a well-developed reticula supported on poorly defined chathriae. No lacinia is present and the sicula is not chitinized. Thus, this genus resembles *Pseudoplegmatograptus* except that a lacinia is absent.

Arachniograptus laqueus n. sp.

Plate 13, figure 19

Plegmatograptus cf. *caudatus* T. S. Hall. Ruedemann, 1947, Geol. Soc. America Mem. 19, p. 469, pl. 83, figs. 16–20.

Retiograptus deckeri Ruedemann, 1947 [Part], Geol. Soc. America Mem. 19, p. 458–459, pl. 80, figs. 36–39.

The rhabdosome is short and stout, attaining a length of 25 mm and a maximum width of 6 mm. The rhabdosome widens rapidly from an initial width of 3 mm to its maximum dimension and remains parallel sided thereafter. A reticula composed of subhexagonal meshes forms the body of the rhabdosome. The clathria is poorly defined and seldom seen. A conspicuous virgula is present and extends as a central rodlike structure throughout the rhabdosome. In one specimen (figured and designated herein as the holotype), it has a membranous structure on its distal part. Thecae are not delimited and the sicula was apparently not chitinized.

Holotype: USNM 138743.

Paratype: USNM 138744.

Occurrence: Phi Kappa formation, 1368 (SD) and Valmy and Vinini equivalent, D163 (CO).

Range: Zone of *Dicellograptus complanatus*.

Discussion.—The forms figured by Ruedemann (1947, pl. 80, figs. 33–41) as *Retiograptus deckeri* include four distinct species. The specimen in his figure 33 is one, in his figures 34 and 35 a second, in

his figures 36, 37, 38, and 39 a third, and in his figures 40 and 41 a fourth. Specimens in his figures 34–39 are forms which do not have the characteristics of *Retiograptus*. The forms have a reticula supported on indistinct clathriae and no sicula is seen. They probably should be included in the new genus *Arachniograptus*, and the forms illustrated in his figures 36–39 are probably identical with the Idaho specimens described here as *A. laqueus*. Specimens (pl. 13, figs. 16, 18, 19) identified by Ruedemann (1947, p. 469, pl. 83, figs. 16–20) as *Plegmatograptus* cf. *caudatus* T. S. Hall have been reexamined, and they should not be related to the genus *Plegmatograptus* because they lack a lacinia. Because it is relatively well preserved, one of these forms (pl. 13, fig. 19) has been chosen as the holotype of *Arachniograptus laqueus*.

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INDEX

[Italic numbers indicate descriptions]

PLATES 1–13

None of the photographs of graptolites has been retouched except by opaquing the margins. The variety of backgrounds and modes of preservation prevent uniformity of reproduction.

Rather than illustrating these forms with drawings or retouched photographs and otherwise reconstructing them, we present them as they are more likely to appear to the field man.

PLATE 1

FIGURE 1. *Dendrograptus* sp. (p. 72). USNM 102817, × 2, Phi Kappa formation, USGS colln. 1370 (SD).

2. *Desmograptus* sp. (p. 72). USNM 138454, × 2, Garden City formation, USGS colln. D206a (CO).

3, 6. *Dictyonema* sp. (p. 72).

3. USNM 138455, × 2, Garden City formation USGS colln. D206a (CO).

6. USNM 138456, × 2, Garden City formation USGS colln. D229 (CO).

4. *Dichograptus octobrachiatus* (J. Hall) (p. 73). USNM 138465, × 4, Vinini equivalent, USGS colln. 359b (CO).

5, 7. *Clonograptus flexilis* (J. Hall) (p. 72; see also pl. 2.)

5. The sicula is broken from this immature specimen, showing only three orders of dichotomy, USNM 138461, × 2, Garden City formation, USGS colln. D230 (CO).

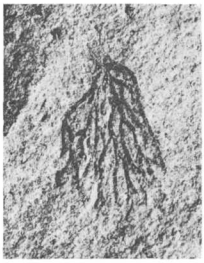
7. A larger specimen showing four orders of dichotomy. USNM 138460, × 2, Garden City formation USGS colln. D230 (CO).

8. *Trichograptus immotus* Harris and Thomas (p. 73). USNM 138463, × 4, Vinini equivalent, USGS colln. D442 g (CO).

9. *Adelograptus* sp. (p. 72). An immature specimen, USNM 138458, × 2, USGS colln. D229 (CO).

10. *Adelograptus* cf. *A. hunnebergensis* Moberg (p. 72). A fairly complete rhabdosome with fragments of another, × 2, USNM 138457, USGS colln. D229 (CO).

11. *Callograptus* sp. (p. 72). USNM 138453, × 2, Toquima formation, USGS colln. 328 (SD).



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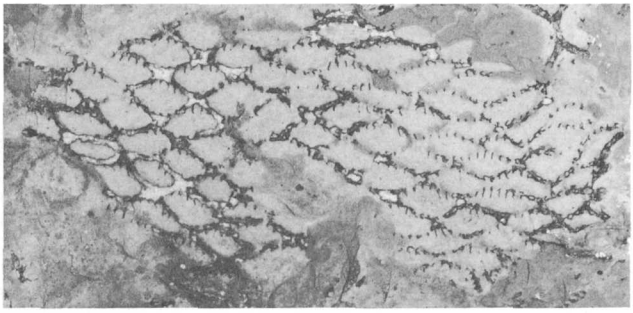

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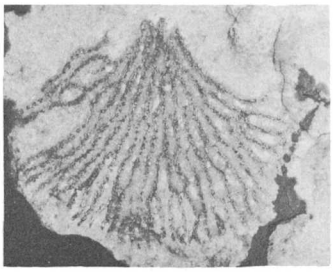

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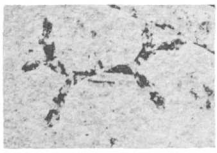

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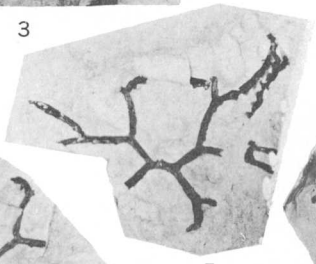

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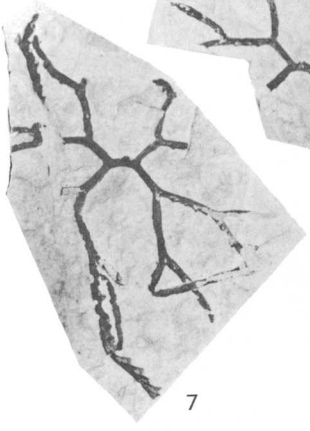

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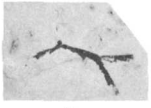

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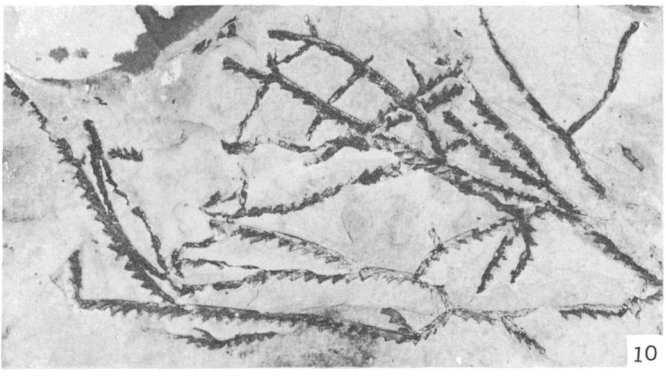

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ORDOVICIAN GRAPTOLITES OF THE GREAT BASIN

PLATE 2

FIGURE 1. *Clonograptus flexilis* J. Hall (p. 72; See also pl. 1.) Mature specimen, but lacking half the funicle, USNM 138459, × 2, Garden City formation, USGS colln. D230 (CO).

2. *Clonograptus* n. sp., not described. Compare greater length of funicle with pl. 1, fig. 5, 7, USNM 138462, × 2, Garden City formation, USGS colln. D206 (CO).

3. Dichograptid, n. gen. Not described. To left of sicula there are 2 orders of branching but to right there are 4, Utah State Univ. colln. L8–B, Garden City formation, Twin Bridges dugway, abandoned road at north end, Logan Canyon, Logan quad., Utah.

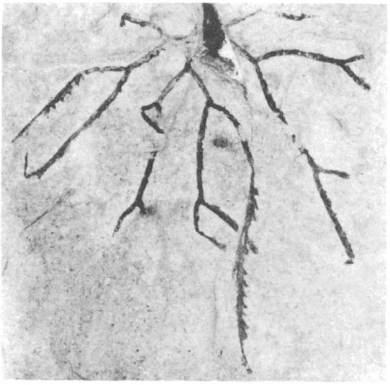
4. *Dichograptus octobrachiatus* (J. Hall). (p. 73). Sicula destroyed by break in matrix, USNM 138466, × 4, Vinini equivalent, USGS colln. D359 (CO).

5, 9. *Tetragraptus fruticosus* (J. Hall), (p. 77). 3-branched variety.
5. USNM 138471, × 2, Valmy formation, USGS colln. 1292 (CO).
9. USNM 138472, × 2, Valmy formation, USGS colln. D499 (CO). Latex cast.

6. *Dichograptus* n. sp. (not described) USNM 138467, × 2, Vinini equivalent, USGS colln. D442d (CO).

7. *Tetragraptus fruticosus* (J. Hall) (p. 77). 4-branched variety. USNM 138474, × 2, unnamed formation, Mt. Morrison quad., California, USGS colln. D516 (CO).

8. *Clonograptus* n. sp., not described. Utah State Univ. colln. L80, Garden City formation, mouth of Logan Canyon, Logan quad., Utah.



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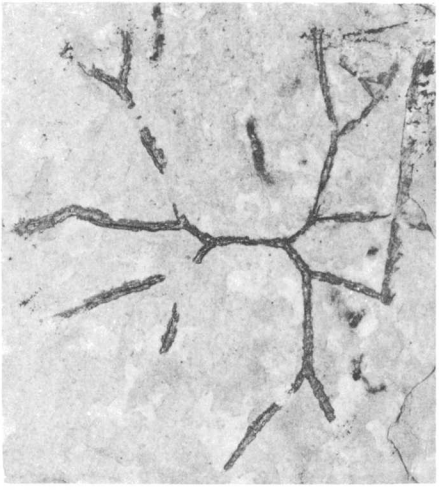

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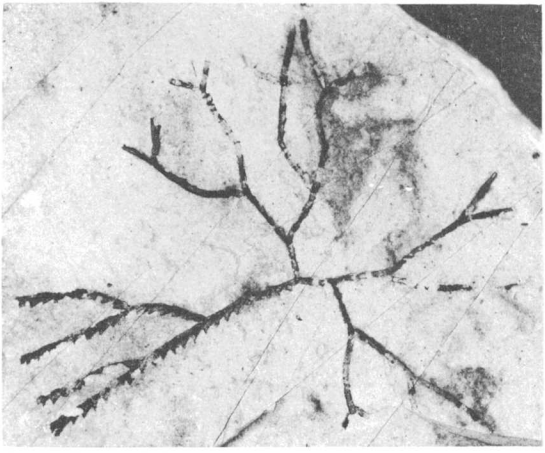

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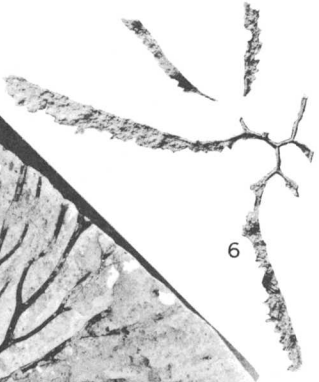

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CLONOGRAPTUS, DICHOGRAPTUS, AND *TETRAGRAPTUS*

PLATE 3

FIGURE 1. *Tetragraptus amii* Lapworth. (p. 74). USNM 138468, × 1; Phi Kappa formation, USGS colln. 1367 (SD).

2. *Tetragraptus quadribrachiatus* (J. Hall) (p. 78). USNM 138476a, × 2, Phi Kappa formation. USGS colln. 1367 (SD).

3. *Tetragraptus reclinatus* Elles and Wood (p. 79). USNM 138477, × 2, Phi Kappa formation, USGS colln. 1367 (SD).

4, 10. *Phyllograptus ilicifolius* (Hall) (p. 82).

4. Latex cast of the same specimen as shown in pl. 4, fig. 9. USNM 138487, × 2 Garden City formation, USGS colln. D206a (CO).

10. USNM 138488, × 2, Phi Kappa formation, USGS colln. 1367 (SD).

5. *Tetragraptus fruticosus* (J. Hall) (p. 77). Latex cast. USNM 138473, × 2,Valmy formation. USGS colln. D123 (CO).

6. *Tetragraptus serra* (Brongniart) (p. 79). Latex cast. USNM 138478, × 2, Vinini equivalent. USGS colln. D359 b (CO).

7. *Tetragraptus approximatus* (Nicholson) (p. 75). Latex cast. USNM 138469, × 2, Vinini equivalent. USGS colln. D442c (CO).

8, 9. *Tetragraptus* n. sp. (not described) note short funicle

8. USNM 138480, × 2 USGS colln. D206 (CO).

9. USNM 138479, × 1, USGS colln. D206 (CO).

11, 12, 15, 16. *Phyllograptus anna* (J. Hall) (p. 81).

11. Latex cast USNM 138481, × 4, USGS colln. D96 (CO).

12. Latex cast USNM 138482, × 4, USGS colln. D359b (CO).

15. Three dimensional specimen, oriented to show how crushing might result in specimen seeming to be in one plane. Stereophotograph. USNM 138485, × 2, USGS colln. D317h (CO).

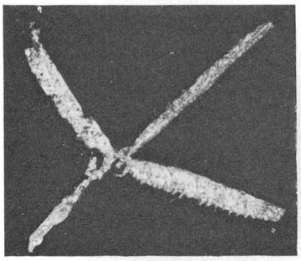
16. Three dimensional specimen, oriented so that crushing would result in preservation shown in fig. 11. Stereophotograph USNM 138486, × 2, USGS colln. D317h (CO).

13, 14. *Phyllograptus nobilis* Harris and Keble. (p. 84). The same specimen, two views, one the obverse of the other.

13. USNM 138491a, × 2, USGS colln. 222 (OS).

14. USNM 138491b, × 2, USGS colln. 222 (OS).

17. *Phyllograptus ilicifolius* var. *major* Ruedemann (p. 83). [Holotype], illustrated by Ruedemann, 1947, pl. 53, fig. 21; USNM 102,468, × 2, USGS colln. 1367 (SD).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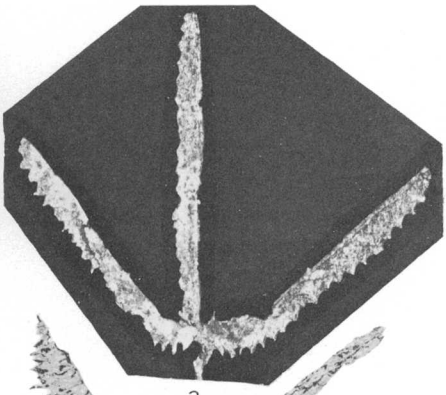
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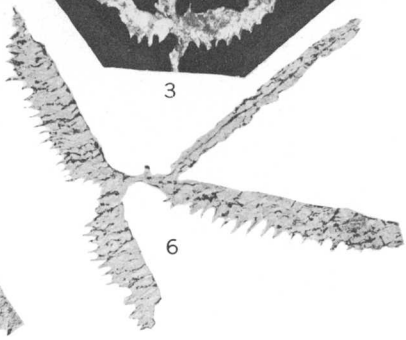
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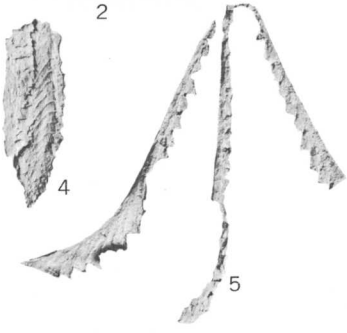
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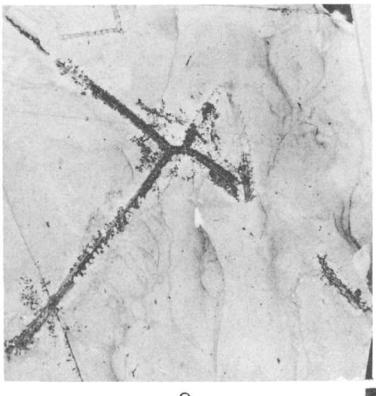
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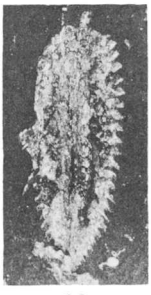
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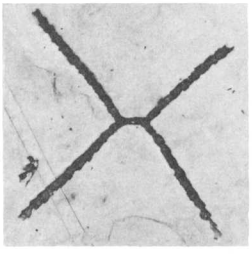
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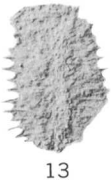
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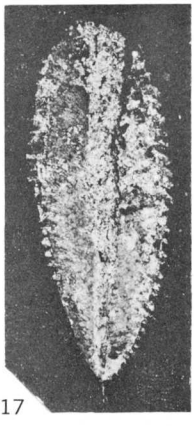
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TETRAGRAPTUS AND *PHYLLOGRAPTUS*

PLATE 4

FIGURE 1, 2. *Phyllograptus griggsi,* n. sp. (p. 81). Phi Kappa formation, USGS colln. 1367 (SD).

1. Paratype. Specimen figured by Ruedemann, 1947 pl. 53, fig. 7, as *P. angustifolius* var. *magnificus* from which it differs markedly. USNM 138489, × 2.
2. Holotype. USNM 138490, × 2.

3. *Phyllograptus loringi* White. (p. 83). Holotype USNM 8561, × 2. Pogonip group, Fish Springs Range, Utah.

4. *Didymograptus* n. sp. (not described) USNM 138508, × 2, Phi Kappa formation. USGS colln. 1367 (SD).

5. *Didymograptus* sp. (not described) USNM 138509, × 2. Phi Kappa formation. USGS coll. 1367 (SD).

6, 12. *Didymograptus protobifidus* Elles (p. 90). Phi Kappa formation, USGS colln. 1367 (SD).

6. USNM 138505, × 2.
12. USNM 138506, × 2.

7. *Didymograptus* n. sp. (not described). USNM 138507, × 2, Vinini equivalent. USGS colln. D442f (CO).

8. *Didymograptus* aff. *D. novus* Berry (p. 89). USNM 138503, × 4. Garden City formation, USGS colln. D229 (CO).

9. *Phyllograptus ilicifolius* J. Hall. (p. 82). Specimen of which the latex cast is shown in pl. 3, fig. 4, USNM 138487, × 4, Garden City formation, USGS colln. D206a (CO).

10, 11. *Didymograptus artus* Elles and Wood (p. 85). Shale member, Swan Peak formation, USGS colln. D204 (CO).

10. USNM 138495, × 4.
11. USNM 138496, × 4.

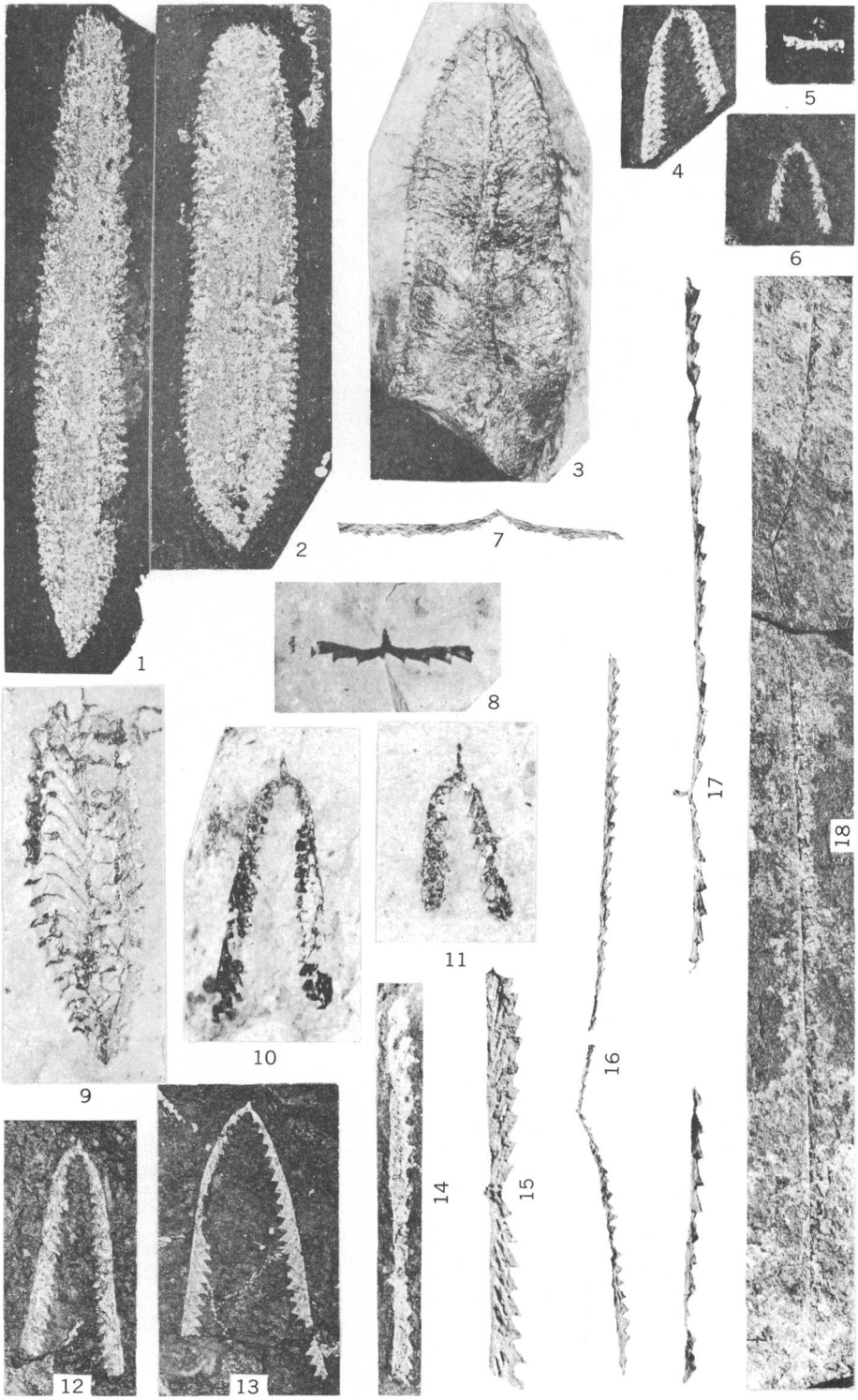
13. *Didymograptus* sp. USNM 102994. Phi Kappa formation, USGS colln. 1367 (SD).

14. *Didymograptus ensjøensis* Monsen (p. 86). USNM 138499, × 2, unnamed formation, Mt. Morrison quad., California, USGS colln. D516 (CO).

15. *Didymograptus* n. sp. (not described). USNM 138464, × 4, Vinini equivalent, USGS colln. D442g (CO).

16–18. *Didymograptus compressus* Harris and Thomas (p. 85). Vinini formation, USGS colln. 222 (OS).

16. Latex cast (× 2) of specimen shown in fig. 18. USNM 138497.
17. Latex cast, USNM 138498, × 4.
18. Specimen in matrix, neither coated nor retouched; see fig. 16. USNM 138497, × 4.



PHYLLOGRAPTUS AND *DIDYMOGRAPTUS*

PLATE 5

FIGURE 1. *Didymograptus extensus* (J. Hall) (p. 87). USNM 138500, × 2, Phi Kappa formation. USGS colln. 1367 (SD).

2, 4. *Didymograptus nitidus* (J. Hall) (p. 88). Garden City formation, USGS colln. D227 (CO). One specimen, two views, each the obverse of the other. 2. USNM 138502a, × 2. 4. USNM 138502b, × 2.

3, 5. *Didymograptus* cf. *D. patulus* J. Hall. Not described. Garden City formation, USGS colln. D227 (CO). One specimen, two views, each the obverse of the other. 3. USNM 138504a, × 2. 5. USNM 138504b, × 2.

6. *Ramulograptus surcularis* n. gen. n. sp. (p. 84). Holotype USNM 138492, × 4, Vinini equivalent, USGS colln. D442f (CO).

7. *Cardiograptus folium* Ruedemann (p. 91). Topotype USNM 138512, × 2. Phi Kappa formation, USGS colln. 1367 (SD).

8. *Isograptus* sp. (p. 95). Preservation not good. May be *I. dumosus* Harris, *I. manubriatus* (T. S. Hall), or immature of *I. forcipiformis* Ruedemann. USNM 138519 × 4, Vinini formation, USGS colln. 222 (OS).

9. *Cardiograptus crawfordi* Harris (p. 90). USNM 138510, × 4, Vinini formation, USGS colln. 2353 (SD).

10, 12, 15. *Isograptus caduceus* cf. *I. c.* var. *maxima* Harris (p. 92). Vinini equivalent, USGS colln. D442h (CO). 10. USNM 138514a, × 2, immature. 12. USNM 138514b, × 2, immature. 15. USNM 138514c × 2.

11. *Didymograptus gracilis* Törnquist (p. 88). USNM 138501, × 4, Phi Kappa formation, USGS colln. 1367 (SD).

13, 16. *Glossograptus horridus* Ruedemann (p. 100). Note well-developed pouch at base of each rhabdosome. Vinini formation, USGS colln. 222 (OS). 13. USNM 138535, × 2. 16. USNM 138536, × 2.

14. *Isograptus caduceus* cf. *I. c.* var. *maximo-divergens* Harris (p. 93). USNM 138515, × 2, Phi Kappa formation, USGS colln. 1367 (SD).

17. *Isograptus* n. sp. Possibly related to *I. norvegicus* Monsen. USNM 138522, × 2. Vinini equivalent. USGS colln. D 539 (CO).

18, 19. *Glossograptus acanthus* Elles and Wood (p. 99). Vinini formation, USGS colln. 222 (OS). 18. USNM 138530, × 2. 19. USNM 138531, × 2.

20, 21. *Isograptus caduceus* cf. *I. c.* var. *victoriae* Harris (p. 93). Vinini equivalent. USGS colln. D 359b (CO). 20. USNM 138483, × 2. 21. USNM 138484, × 2.

22. *Isograptus caduceus* cf. *I. c.* var. *divergens* Harris (p. 92). USNM 138513, × 2, Vinini equivalent, USGS colln. D442d (CO).

23, 24. *Glossograptus hincksii* var. *fimbriatus* (Hopkinson) (p. 99). Valmy formation, USGS colln. D116 (CO). One specimen, two views, one the obverse of the other. 23. USNM 138534a, × 2. 24. USNM 138534b, × 2.

25, 26. *Glossograptus hincksii* (Hopkinson) (p. 99). Vinini formation, USGS colln. 222 (OS). 25. USNM 138532, × 2. 26. USNM 138533, × 2.

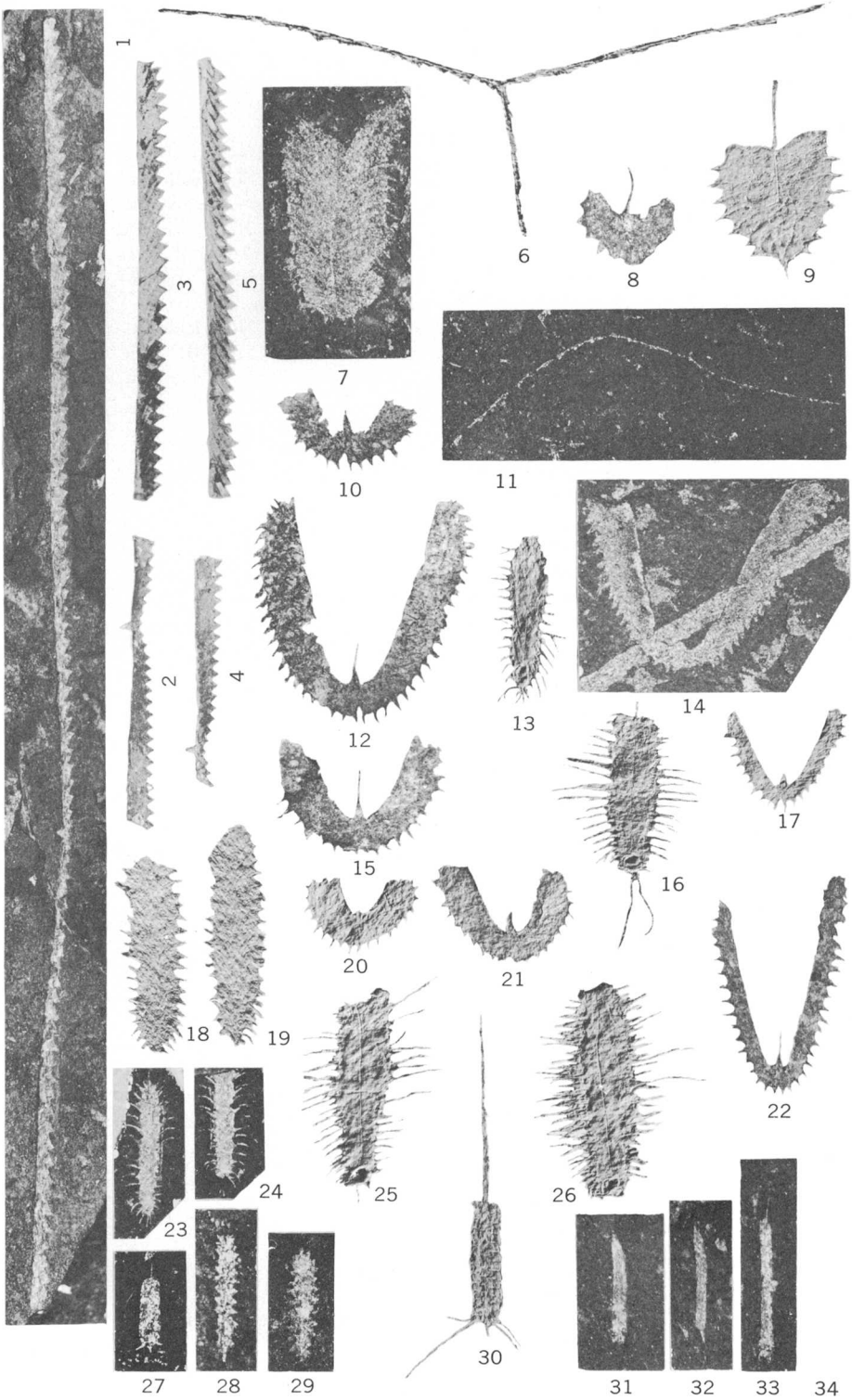
27. *Cryptograptus tricornis* (Carruthers) (p. 97). USNM 138528, × 2, Phi Kappa formation, USGS colln. 1370 (SD).

28, 29. *Cryptograptus schäferi* Lapworth (p. 96). 28. USNM 138526, × 2, Vinini formation, USGS colln. 222 (OS). 29. USNM 138527, × 2, Vinini equivalent, USGS colln. D541 (CO).

30. *Cryptograptus* sp. (p. 98). Related to *C. antennarius* J. Hall. USNM 138529, × 2. Vinini formation, USGS colln. 2353 (SD).

31. *Corynoides incurvus* Hadding (p. 96). USNM 138525, × 4, Valmy and Vinini equivalent. USGS colln. D505 (CO).

32–34. *Corynoides calicularis* Nicholson (p. 95). Valmy and Vinini equivalent, USGS colln. D505 (CO). 32. USNM 138523a, × 4. 33. USNM 138523b, × 4. 34. USNM 138524, × 4.



ORDOVICIAN GRAPTOLITES OF THE GREAT BASIN

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PLATE 6

FIGURE 1. *Leptograptus* cf. *L. flaccidus* var. *macer* Elles and Wood, (p. 101). USNM 138538, × 2, Phi Kappa formation. USGS colln. 1368 (SD).

2. *Nemagraptus gracilis* var. *surcularis* J. Hall (p. 103). USNM 138541, × 2. Toquima formation, USGS colln. 444z (OS). A very fragmentary specimen, poorly preserved in slaty rock.

3. *Nemagraptus* aff. *N. exilis* Lapworth (p. 102). USNM 138539. × 4, Valmy formation, USGS colln. D116 (CO).

4. *Nemagraptus* cf. *N. gracilis* J. Hall (p. 102). USNM 138540. × 2. Toquima formation, USGS colln. 328 (SD).

5, 9. *Dicellograptus divaricatus* var. *bicurvatus* Ruedemann (p. 104). Phi Kappa formation, USGS colln. 1370 (SD).

5. USNM 102812, × 2. Specimen illustrated by Ruedemann, 1947, pl. 62, fig. 32.

9. USNM 138552, × 2.

6. *Leptograptus flaccidus* (J. Hall) (p. 101). USNM 138537, × 2. Hanson Creek formation. USGS colln. D342 (CO).

7, 15. *Dicellograptus sextans* var. *exilis* Elles and Wood (p. 107).

7. USNM 138563a, × 4. Valmy formation, USGS colln. D116 (CO).

15. USNM 138564 × 2. Phi Kappa formation, USGS colln. 1370 (SD).

8, 12, 13, 17, 19. *Dicellograptus complanatus* var. *ornatus* Elles and Wood (p. 103).

8. Latex cast of USNM 138543, × 4, Hanson Creek formation, USGS colln. D480a (CO).

12. USNM 138544, × 2. Phi Kappa formation, USGS colln. 1368 (SD). Specimen illustrated by Ruedemann, 1947, pl. 62, fig. 19.

13. USNM 138545, × 2, Phi Kappa formation, USGS colln. 1368 (SD). Specimen illustrated by Ruedemann, 1947, pl. 62, fig. 17.

17. USNM 138546, × 2. Phi Kappa formation, USGS Coll. 1368 (SD). Specimen illustrated by Ruedemann, 1947, pl. 62, fig. 1, as *D.* cf *D. affinis* T. S. Hall.

19. USNM 138550a, × 2, Phi Kappa formation, USGS colln. 1368 (SD). Illustrated by Ruedemann, 1947, pl. 62, fig. 20.

10, 11, 22. *Dicellograptus sextans* J. Hall (p. 106).

10. Latex cast of USNM 138560, × 4. Valmy formation. USGS colln. D495 (CO).

11. USNM 138561a, × 2, Toquima formation, USGS colln. 311 (SD).

22. USNM 138562, × 4. Valmy formation, USGS colln. D112 (CO).

14, 16, 18. *Dicellograptus gurleyi* Lapworth (p. 105). These three specimens show a considerable range in divergence of the stipes.

14. Latex cast of USNM 138555, × 4, Palmetto formation, USGS colln. D137 (CO).

16. Latex cast of USNM 138556, × 4, Palmetto formation, USGS colln. D137 (CO).

18. USNM 138557, × 4, Vinini equivalent, USGS colln. D478a (CO).

20. *Dicellograptus* of *D. smithi* Ruedemann (p. 107). USNM 138565a, × 4, Valmy formation, USGS colln. 1952 (CO).

21, 24. *Dicellograptus divaricatus* var. *salopiensis* Elles and Wood (p. 104).

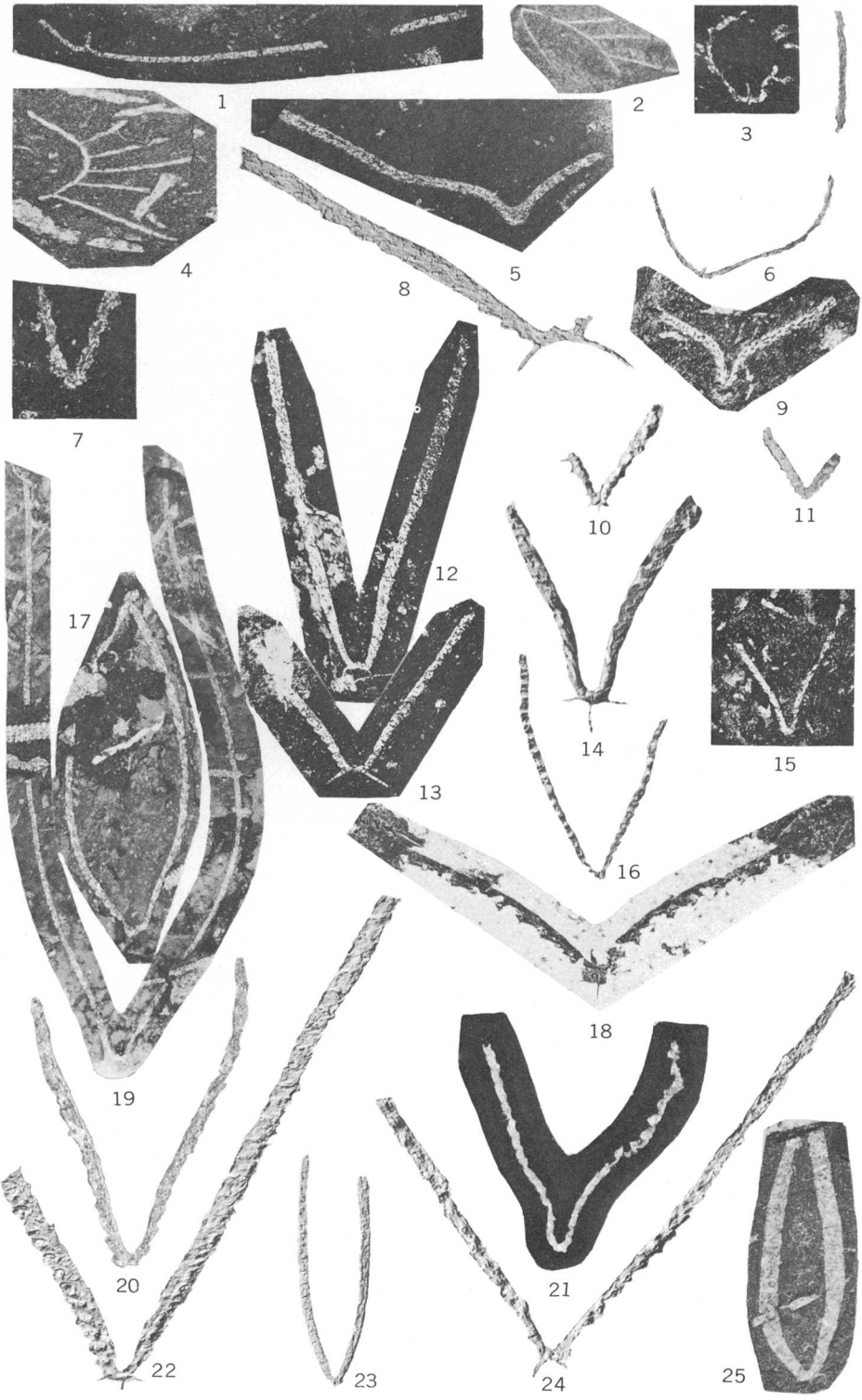
21. USNM 138553a, × 2, Valmy formation, USGS colln. D116 (CO).

24. Latex cast of USNM 138554, × 4. Palmetto formation, USGS colln. D137 (CO).

23, 25. *Dicellograptus intortus* Lapworth (p. 106).

23. Latex cast of USNM 138558, × 2, Valmy formation, USGS colln. D495 (CO).

25. A poor specimen showing form only, in slaty rock, USNM. 138559, × 2, Toquima formation, USGS colln. 444z (OS).



LEPTOGRAPTUS, NEMAGRAPTUS, AND *DICELLOGRAPTUS*

PLATE 7

FIGURES 1–4, 6, 21. *Dicranograptus kirki* Ruedemann (p. 109). Saturday Mountain(?) formation.

1. USNM 138569a, b, × 2. Holotype and paratype. Actually two specimens, neither showing thecal characters. Illustrated by Ruedemann, 1947, pl. 66, fig. 1, 2. USGS colln. 2519 (SD).
2. USNM 138570, × 2. Topotype USGS colln. 2519 (SD).
3. USNM 138571a, × 2. Paratype, obverse. USGS colln. 2519 (SD). Illustrated by Ruedemann, 1947, pl. 66, fig. 4.
4. USNM 138572, × 2. USGS colln. D456 (CO). This specimen shows the greatest known length to which stipes grew in this species.
6. USNM 138573a, × 2. USGS colln. D456 (CO).
21. USNM 138574, × 2. Paratype. Illustrated by Ruedemann, 1947, pl. 66, fig. 3, USGS colln. 2519 (SD).

5. *Dicranograptus nicholsoni* Hopkinson (p. 110). Latex cast of USNM 138575, × 2. Phi Kappa formation, USGS colln. 1370 (SD).

7, 12, 22. *Dicranograptus nicholsoni* var. *geniculatus* Ruedemann and Decker (p. 111).

7. Latex cast of USNM 138576a, × 2. Toquima formation, USGS colln. 315 (SD).
12. Latex cast of USNM 138576b, × 2. Toquima formation, USGS colln. 315 (SD).
22. USNM 138577, × 2. Saturday Mountain(?) formation, USGS colln. D456 (CO).

8, 13, 15. *Dicranograptus spinifer* Elles and Wood (p. 114).

8. Latex cast of USNM 138582, × 2, Phi Kappa formation, USGS colln. 1370 (SD).
13. Latex cast of USNM 102796, × 2. Saturday Mountain(?) formation, USGS colln. 2519 (SD). Specimen illustrated by Ruedemann, 1947, pl. 67, fig. 24. Probably belongs properly to *D. nicholsoni*.
15. Latex cast of USNM 138583, × 2. Phi Kappa formation, USGS colln. 1370 (SD).

9, 14. *Dicranograptus contortus* Ruedemann (p. 109). Phi Kappa formation, USGS colln. 1370 (SD).

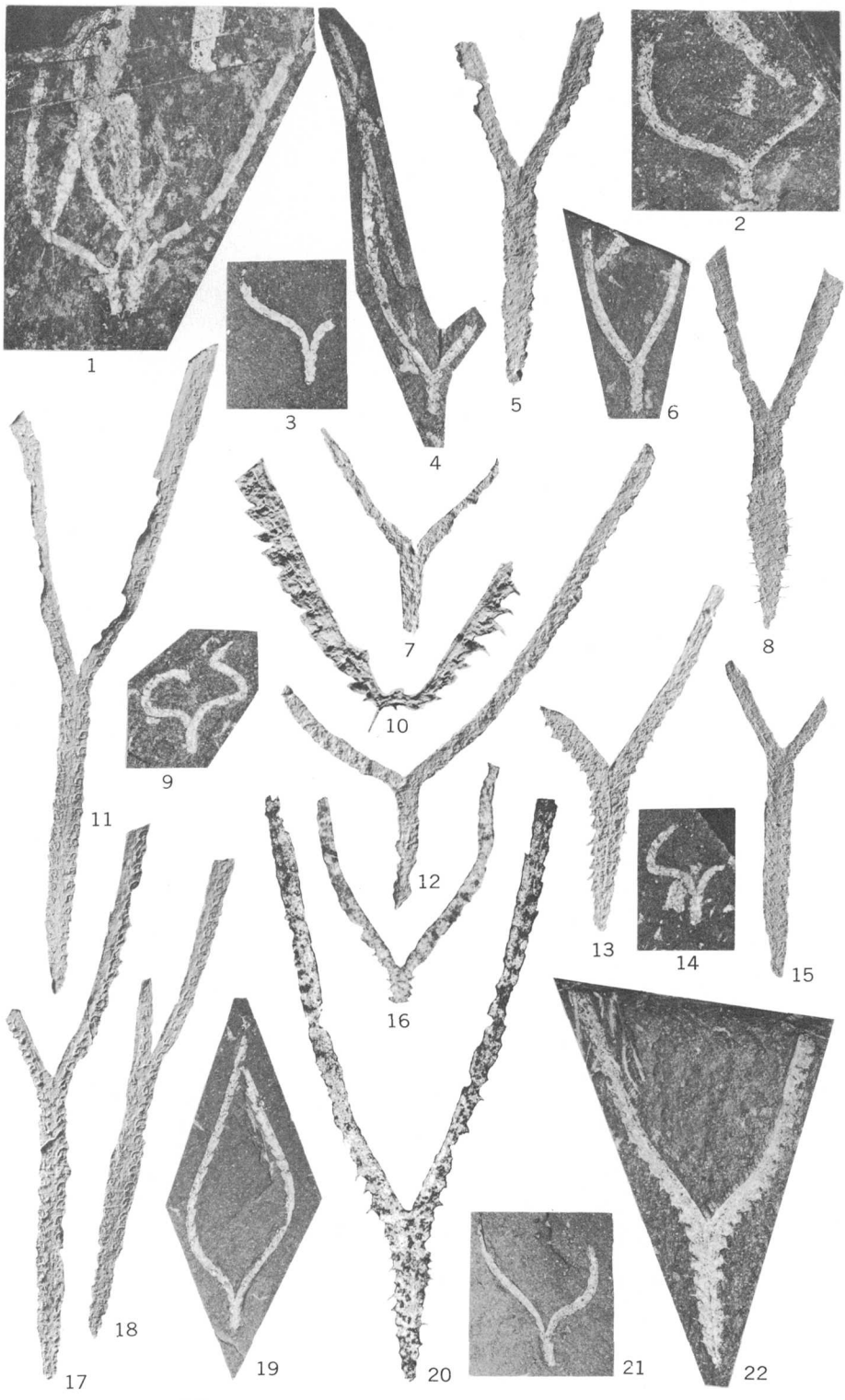
9. USNM 138567, × 2. Illustrated by Ruedemann, 1947, pl. 65, fig. 21, 24.
14. USNM 138568, × 2. Illustrated by Ruedemann, 1947, pl. 65, fig. 19.

10. *Dicellograptus* n. sp. (Not described). Latex cast of USNM 138566, × 4, Vinini formation, USGS colln. D477 (CO).

11, 17, 18. *Dicranograptus ramosus* var. *longicaulis* Lapworth (p. 113). Phi Kappa formation, USGS colln. 1370 (SD).

11. Latex cast of USNM 138580, × 2.
17. Latex cast of USNM 138581a, × 2.
18. Latex cast of USNM 138581b, × 2.

16. *Dicranograptus* cf. *D. furcatus* (Hall). Not described. USNM 138748, × 2. Toquima formation, USGS colln. 444z (CO).
19. *Dicranograptus tealei* Harris and Thomas (p. 114). USNM 138585a, × 2. Saturday Mountain(?) formation, USGS colln. D456 (CO).
20. *Dicranograptus ramosus* cf. *D. r.* var. *semispinifer* T. S. Hall. Not described. USNM 138584, × 2. Saturday Mountain (?) formation, USGS colln. D456 (CO).



DICRANOGRAPTUS AND *DICELLOGRAPTUS*

PLATE 8

FIGURES 1–3. *Dicranograptus nicholsoni* var. *whitianus* (Miller) (p. 111). 1. USNM 138578, × 2, unnamed formation, USGS colln. D514 (CO). 2. USNM 138579, × 2, Toquima formation, USGS colln. 444z (OS). 3. USNM 8555, × 2, latex cast of holotype. Toquima formation, near Belmont, Nev. Type specimen of *D. ramulus* (White), 1877 (homonym).

4–6. *Climacograptus bicornis* J. Hall (p. 117). 4. USNM 138586, × 2, latex cast. Phi Kappa formation, USGS colln. 1370 (SD). 5. USNM 138587, × 2, latex cast, Vinini formation, USGS colln. D478a (CO). 6. USNM 138588, × 2, latex cast, Vinini equivalent, USGS colln. D360 (CO).

7. *Climacograptus minimus* (Carruthers) (p. 125). USNM 138617, × 4, latex cast. Vinini formation, USGS colln. D149 (CO).

8, 10. *Climacograptus hastatus* T. S. Hall (p. 121). Latex casts, Hanson Creek formation, USGS colln. D247 (CO). 8. USNM 138594, × 2. 10. USNM 138595, × 4. On both of these specimens there is present the stump of a spine directed toward the viewer. It is seen better in fig. 10.

9. *Climacograptus bicornis* var. *peltifer* Lapworth (p. 118). USNM 102815, × 2, latex cast. Left side of the shield is broken. Ordinarily it would be bilaterally symmetrical, both sides resembling the right side of this specimen. Phi Kappa formation, USGS formation, USGS colln. 1370 (SD).

11, 12. *Climacograptus caudatus* Lapworth. (p. 119). Latex casts. 11. USNM 138591, × 2, Vinini formation, USGS colln. D164 (CO). 12. USNM 138592, × 4, Vinini formation, USGS colln. D149 (CO).

13. *Climacograptus bicornis* var. *longispina* T. S. Hall (p. 118). Latex cast. USNM 138589, × 2, Vinini formation USGS colln. D480a (CO).

14, 15, 18. *Climacograptus supernus* Elles and Wood. (p. 130). Phi Kappa formation, USGS colln. 1368 (SD). 14. USNM 138637a, b, × 2. Note pair of extremely delicate spines on basal thecae of upper specimen. 15. USNM 138615, × 2. Basal spines well shown. 18. USNM 138638, × 4.

16. *Climacograptus putillus* (J. Hall) (p. 127). USNM 138624, × 2. Phi Kappa formation, USGS colln. 1368 (SD).

17. *Climacograptus* cf. *C. phyllophorus* Gurley (p. 127). USNM 138623, × 4, latex cast. Vinini formation, USGS colln. D486 (CO).

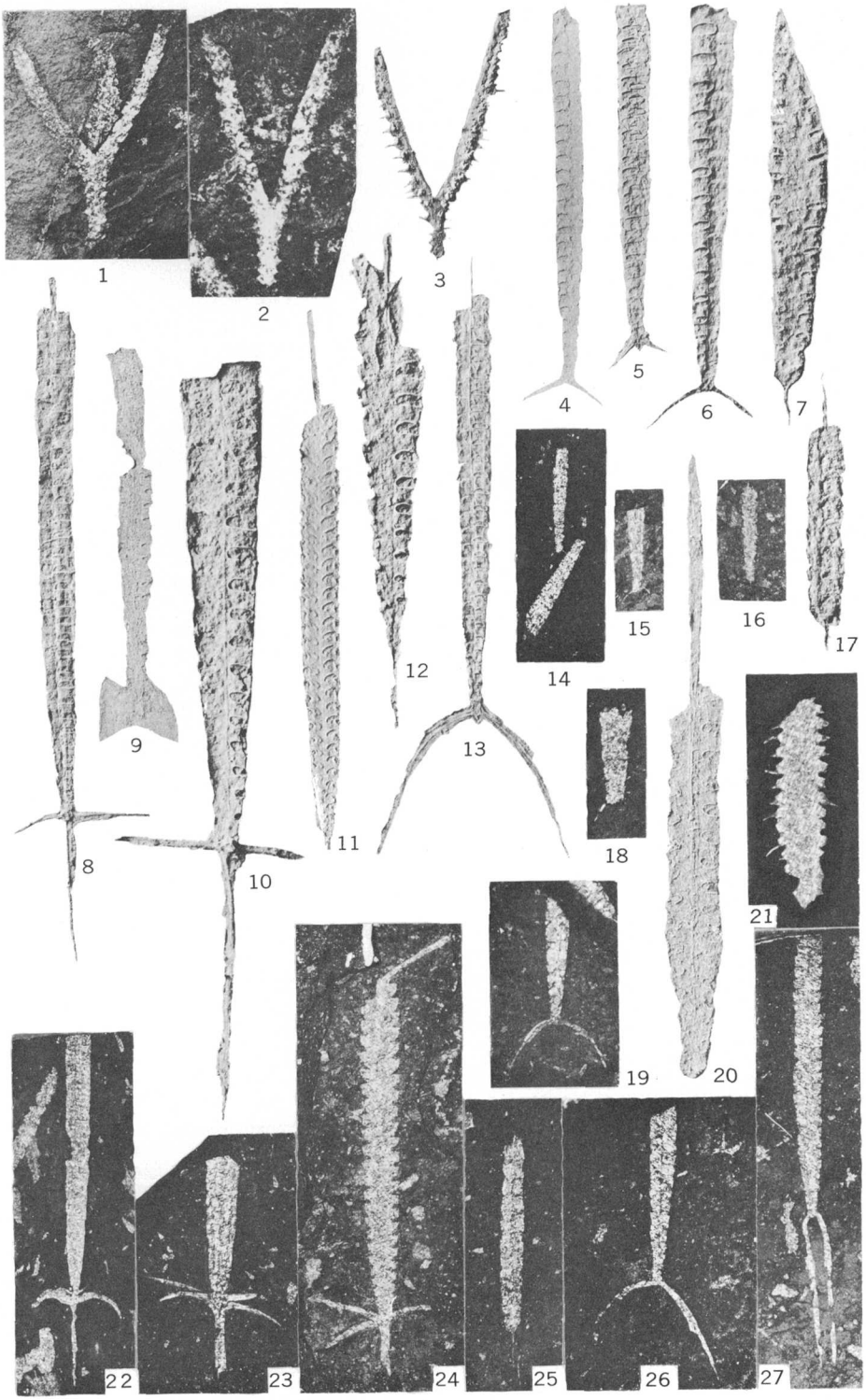
19, 26, 27. *Climacograptus hvalross* n. sp. (p. 124). Phi Kappa formation, USGS colln. 1368 (SD). 19. USNM 138609, × 2. Paratype 26. USNM 138610, × 2. Paratype. Basal spines typically formed. Illustrated by Ruedemann, 1947, pl. 73, fig. 16, 20. 27. USNM 138608, × 2. Holotype. Basal spines deformed. Illustrated by Ruedemann, 1947, pl. 73, fig. 15.

20. *Climacograptus* cf. *C. mississippiensis* Ruedemann (p. 124). USNM 138618, × 4. Latex cast, Vinini formation, USGS colln. D480b (CO), D480e float.

21. *Climacograptus innotatus* var. *pacificus* Ruedemann (p. 125). Type specimen. USNM 102838, × 4. Phi Kappa formation, USGS colln. 294i (OS) [equals 1368 (SD)]. Illustrated by Ruedemann, 1947, pl. 73, fig. 29.

22–24. *Climacograptus hastatus* var. *americanus* (p. 122). Ruedemann. Phi Kappa formation, USGS colln. 1370 (SD). 22. USNM 138596, × 2. Specimen flattened so that only 2 of 4 horizontal spines are shown. Illustrated by Ruedemann, 1947, pl. 73, fig. 19. 23. USNM 138597, × 2. Showing all four horizontal basal spines and large sicula or virgellar thickening. Illustrated by Ruedemann, 1947, pl. 73, fig. 17. 24. USNM 138598, × 2. The type specimen, showing spacing of thecae and only 3 of 4 horizontal basal spines. Illustrated by Ruedemann, 1947, pl. 73, figs. 8, 9.

25. *Climacograptus eximius* Ruedemann (p. 120). USNM 138593, × 4. Threadlike virgella barely discernible. Valmy formation. USGS colln. D117 (CO).



DICRANOGRAPTUS AND *CLIMACOGRAPTUS*

PLATE 9

FIGURES 1, 2, 5, 15. *Climacograptus raricaudatus* n. sp. (p. 128).

1. USNM 138625, × 2. Paratype. Saturday Mountain(?) formation, USGS colln. 2519 (SD).
2. USNM 138628, × 4. Latex cast. Valmy formation, USGS colln. D98 (CO).
5. USNM 138627, × 2. Paratype. Saturday Mountain(?) formation, USGS colln. D456 (CO).
15. USNM 138626, × 2. The holotype Saturday Mountain(?) formation, USGS colln. D456 (CO).

3. *Climacograptus* cf. *C. typicalis* J. Hall (p. 132). USNM 138645, × 4. Vinini formation, USGS colln. D149 (CO).

4, 6, 7, 10, 11, 16. *Climacograptus hastatus* var. *martini* n. var. (p. 123). Hanson Creek formation.

4. USNM 138606, × 4. Paratype. Latex cast. Note stump of third visible spine directed toward left. Specimen VI in table, p. 124. USGS colln. D342 (CO).
6. USNM 138601, × 2. Paratype. Latex cast. Specimen I in table, p. 124. USGS colln. D247 (CO).
7. USNM 138605, × 2. Paratype. Latex cast. Specimen V in table, p. 124. USGS colln. D247 (CO).
10. USNM 138604, × 2. Paratype. Latex cast. Specimen IV in table, p. 124, USGS colln. D342 (CO).
11. USNM 138603, × 2. Holotype is a latex cast showing 3 of 4 horizontal basal spines. Specimen III of table, p. 124. USGS colln. D342 (CO).
16. USNM 138607, × 2. Paratype is a latex cast. Specimen VII of table, p. 124. USGS colln. D342 (CO). Note stump of a third horizontal spine directed toward left.

8, 20. *Climacograptus riddellensis* Harris (p. 129). Vinini formation.

8. USNM 138632, × 4. Latex cast. USGS colln. 2353 (SD). Note that apertures are amplexograptid in nature on this specimen.
20. USNM 138633, × 4. Latex cast. USGS colln. 222 (OS). Amplexograptid thecae and long virgella suggest that this specimen might be assigned to *Amplexograptus confertus*.

9, 21. *Climacograptus tridentatus* var. *maximus* Decker (p. 131). Hanson Creek formation.

9. USNM 138639, × 2. Latex cast showing stump of a third horizontal spine directed to left. USGS colln. D342 (CO).
21. USNM 138640, × 2. Latex cast with stump of a third horizontal spine directed toward the viewer. USGS colln. D247 (CO).

12. *Climacograptus spiniferus* Ruedemann (p. 130). USNM 138636, × 4. Latex cast. Vinini formation, USGS colln. D454 (CO).

13, 18. *Climacograptus phyllophorus* Gurley (p. 127).

13. USNM 138621, × 2. Latex cast. Unnamed formation, USGS colln. D534 (CO). Most of left side of specimen not preserved.

18. USNM 138662, × 2. Latex cast. Palmetto formation, USGS colln. 2352 (SD).

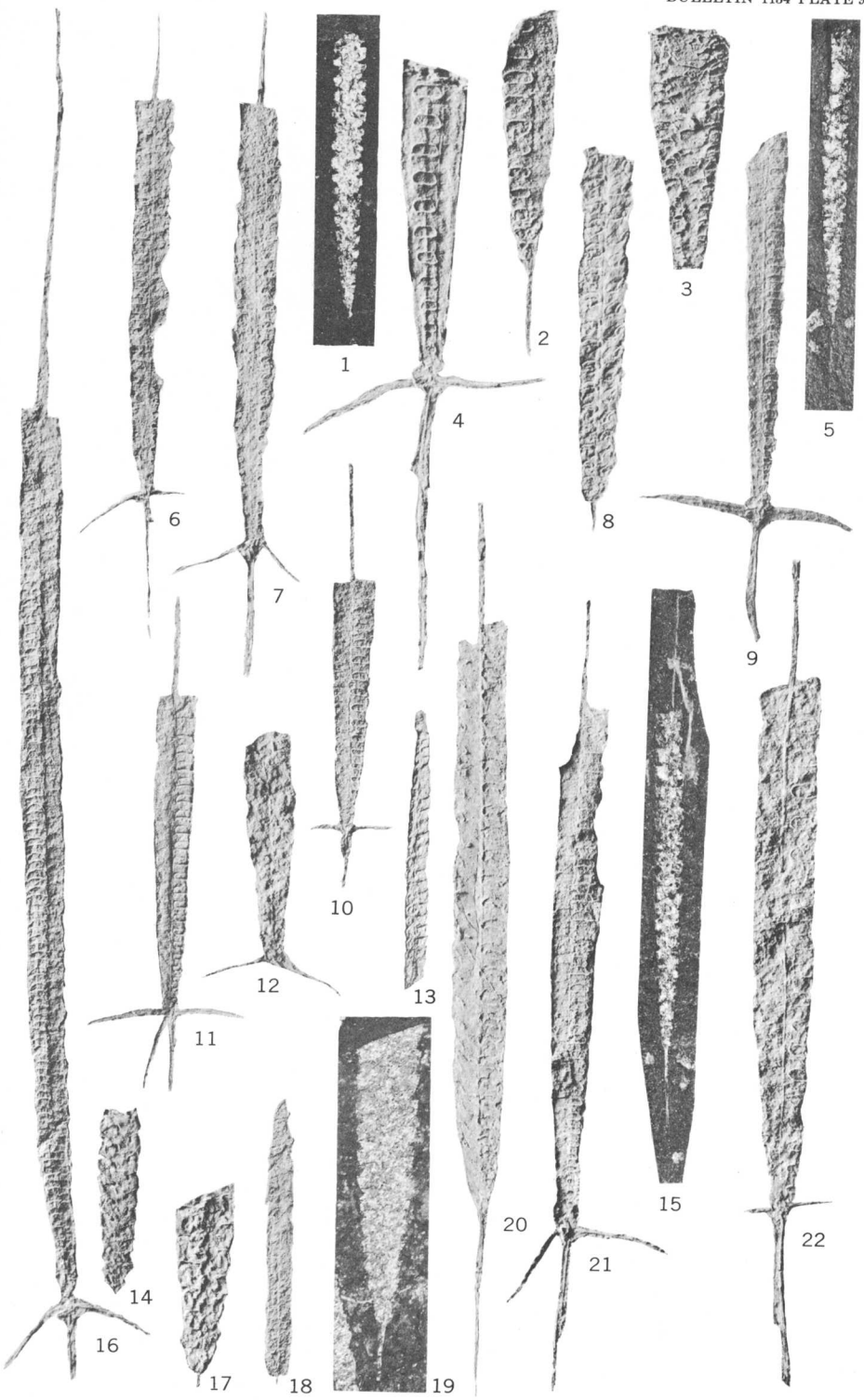
14, 17. *Climacograptus scharenbergi* Lapworth (p. 129).

14. USNM 138634, × 4. Latex cast showing introverted apertures and alternating arrangement of thecae. Valmy formation, USGS colln. D111 (CO).

17. USNM 138635, × 4. Latex cast showing proximal end. Vinini equivalent, USGS colln. D389 (CO).

19. *Climacograptus* n. sp. (not described) USNM 138647, × 4. Phi Kappa formation, USGS colln. 1368 (SD). Note rounded proximal end with pair of fine lateral spines.

22. *Climacograptus hastatus* var. *angustus* n. var. (p. 122). USNM 138599, × 4. Latex cast of the holotype. Vinini formation, USGS colln. D480a (CO).



CLIMACOGRAPTUS

628607 O–63—15

PLATE 10

FIGURES 1, 2. *Climacograptus tubuliferus* Lapworth (p. 132).

1. USNM 138642, × 2. Latex cast. Vinini formation, USGS colln. D163 (CO).
2. USNM 138643, × 2. Latex cast. Hanson Creek formation, D474b (CO).
3. *Climacograptus* cf. *C. tubuliferus* Lapworth. USNM 138644, × 2. Latex cast. Vinini equivalent, USGS colln. D453 (CO).

4, 5, 30. *Diplograptus decoratus* Harris and Thomas (p. 134). Vinini formation, USGS colln. 222 (OS).

4. USNM 138648, × 2. Latex cast. Distal end originally illustrated by Ruedemann, 1908, figs. 21, 22, 409. (Formerly USNM 54339.)
5. USNM 138649, × 2. Latex cast.
30. USNM 138652, × 4. Latex cast of a nearly complete specimen, showing proximal end as well as distal float.

6, 7, 8, 29. *Diplograptus decoratus* var. *amplexograptoideus* n. var. (p. 135). Vinini formation USGS colln. 222 (OS).

6. USNM 138653, × 2. Paratype Latex cast. Scalariform view; specimen flattened with apertures on side toward viewer. Distal end illustrated by Ruedemann, 1908, fig. 21.
7. USNM 138654, × 2. Latex cast. Paratype. Proximal end damaged.
8. USNM 138655, × 2. Latex cast. Paratype. Proximal end not present.
29. USNM 138656, × 4. Latex cast of the holotype. Note that earliest thecae are amplexograptid.

9, 10, 15. *Diplograptus decoratus* var. *multus* n. var. (p. 135). Vinini formation, USGS colln. 222 (OS).

9. USNM 54343, × 2. Latex cast. Paratype showing proximal end.
10. USNM 138660, × 2. Latex cast. Paratype. Specimen illustrated by Ruedemann, 1908, fig. 22.
15. USNM 138661, × 4. Latex cast of the holotype. Virgella and first few thecae broken off.

11, 12, 18. *Amplexograptus arctus* Elles and Wood (p. 136). Vinini formation, USGS colln. 222 (OS).

11. USNM 138666, × 4. Latex cast.
12. USNM 138667, × 4. Latex cast.
18. USNM 138668, × 4. Latex cast.

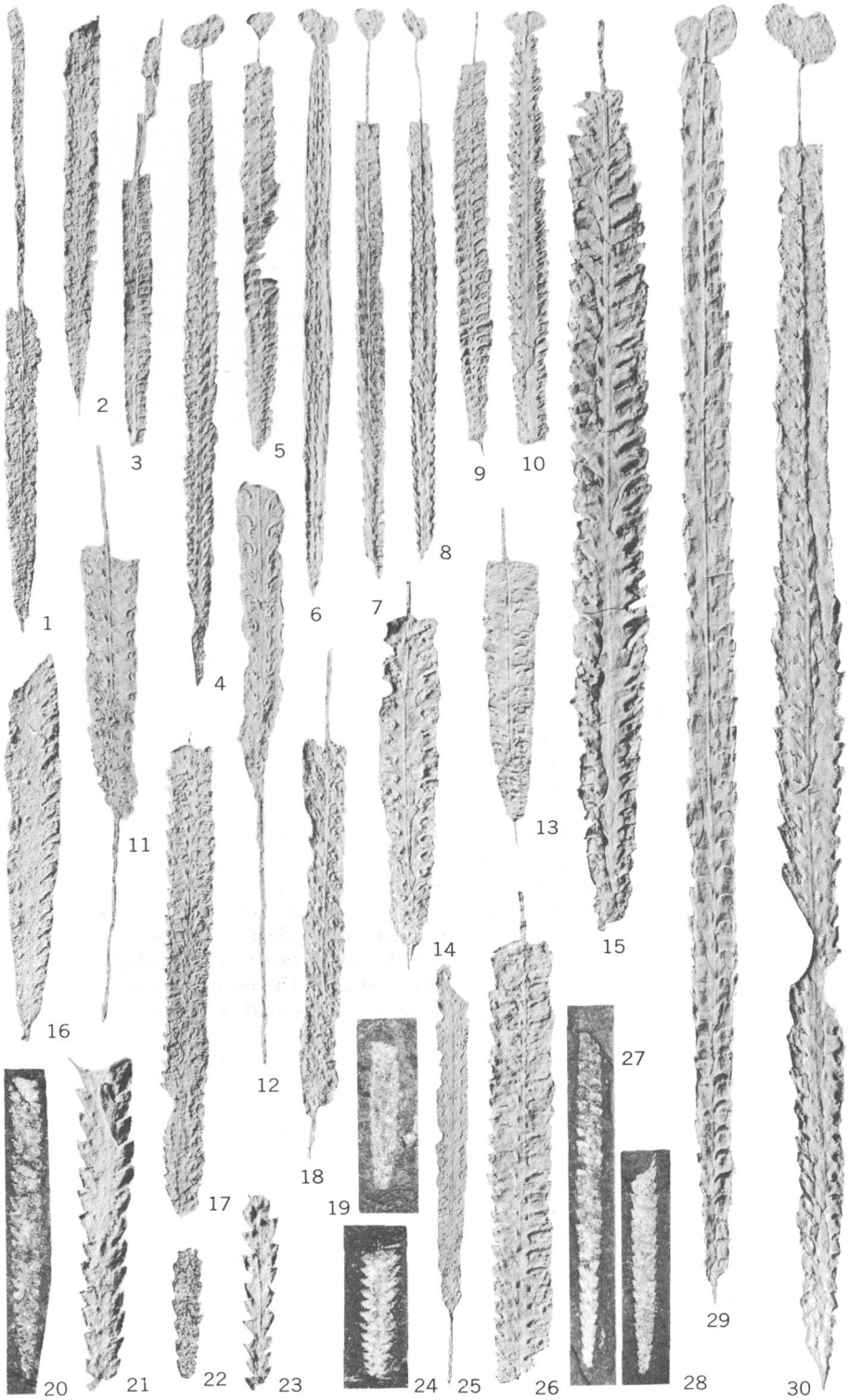
13, 14, 16. *Amplexograptus confertus* Lapworth (p. 137). Vinini formation.

13. USNM 138511, × 4. Latex cast. USGS colln. 2353 (SD).
14. USNM 138670, × 4. Latex cast. USGS colln. 222 (OS).
16. USNM 138669, × 4. Latex cast. USGS colln. 2349 (SD).

17. *Diplograptus*? sp. Not described. USNM 138625, × 2. Latex cast. Vinini formation, USGS colln. D480e (CO). (Float.)
19. *Glyptograptus* cf. *G. teretiusculus* (Hisinger) (p. 142). USNM 138688, × 2. A very poor fragmentary specimen. Phi Kappa formation, USGS colln. 1370 (SD).
20. *Diplograptus vespertinus* Ruedemann (p. 136). USNM 138664, × 2. Saturday Mountain(?) formation, USGS colln. D456 (CO).

21. *Glyptograptus euglyphus* Lapworth var.? Not described. USNM 138684, × 4. Valmy formation, USGS colln. D102 (CO).
22. *Glyptograptus tamariscus* Nicholson (p. 141). USNM 138683, × 4. Phi Kappa formation USGS colln. 1368 (SD).
23. *Glyptograptus euglyphus* var. *pygmaeus* Ruedemann (p. 141). USNM 138682, × 4. Latex cast. Valmy formation, USGS colln. D102 (CO).
24. *Glyptograptus* aff. *G. teretiusculus* (Hisinger). Not described. USNM 138686, × 2. Toquima formation, USGS colln. 444z (OS).
25. *Amplexograptus* cf. *A. confertus* Lapworth. Not described. USNM 138672, × 2. Latex cast. Vinini formation, USGS colln. 222 (OS).
26. *Amplexograptus* cf. *A. differtus* Harris and Thomas (p. 138). USNM 138673, × 4. Latex cast. Vinini formation, USGS colln. 222 (OS).

27, 28. *Glyptograptus euglyphus* Lapworth (p. 140). Unnamed formation. USGS colln. D515 (CO).
27. USNM 138679a, × 2.
28. USNM 138679b, × 2.



CLIMACOGRAPTUS, DIPLOGRAPTUS, AMPLEXOGRAPTUS,
AND *GLYPTOGRAPTUS*

PLATE 11

FIGURES 1, 2. *Glyptograptus altus* n. sp. (p. 139).
1. USNM 138675a, × 2. Holotype. Note spines on proximal end. Phi Kappa formation, USGS colln. 1368 (SD).
2. USNM 138676a, × 4. Latex cast of a paratype showing shape of thecae in a distal fragment. Vinini formation, USGS colln. D480a (CO).

3, 4. *Glyptograptus euglyphus* Lapworth (p. 140). Vinini formation, USGS colln. 222 (OS). See also pl. 10, fig. 27 and 28 for another mode of preservation.
3. USNM 138680, × 4. Latex cast.
4. USNM 138681, × 2. Latex cast of distal end only.

5. *Glyptograptus* cf. *G. teretiusculus* (Hisinger) (p. 142). USNM 138687, × 2. Latex cast. Vinini formation, USGS colln. 222 (OS).

6. *Glyptograptus tenuissimus* n. sp. (p. 141). USNM 138685a, × 2. Holotype. Hanson Creek formation, USGS colln. 474c (CO).

7, 8. *Glyptograptus teretiusculus* var. *occidentalis* Ruedemann (p. 142). Phi Kappa formation, USGS colln. 1368 (SD).
7. USNM 138547a, × 2. Holotype, obverse side. Illustrated by Ruedemann, 1947, pl. 69, fig. 61.
8. USNM 138548, × 2. Topotype.

9. *Glyptograptus* cf. *G. teretiusculus* (Hisinger) (p. 142). USNM 8556. Toquima formation. This specimen was called *Diplograptus hypniformis* by White (1874, p. 12; 1877, p. 63, pl. 4, fig. 4a, b).

10. *Glyptograptus* n. sp. (not described). USNM 138689, × 2. Latex cast. Hanson Creek formation, USGS colln. D342 (CO).

11, 12, 19. *Glyptograptus* sp. (not described). Latex casts of specimens from Vinini formation and equivalents.
11. USNM 138691, × 4. USGS colln. D442b (CO).
12. USNM 138693, × 4. USGS colln. D480e (CO).
19. USNM 138692, × 4. USGS colln. D453 (CO).

13, 15, 16. *Orthograptus* cf. *O. calcaratus* Lapworth (p. 145).
13. USNM 138695, × 2. Palmetto formation, USGS colln. D530 (CO). Rhabdosome wider than typical specimens.
15, 16. USNM 138696, × 2. Latex cast and original specimen, showing contrast in appearances. Thecae more closely spaced than in typical specimens. Vinini formation, USGS colln. D161 (CO).

14. *Orthograptus calcaratus* Lapworth (p. 144). USNM 138694, × 2. Latex cast. Vinini formation, USGS colln. D161 (CO).

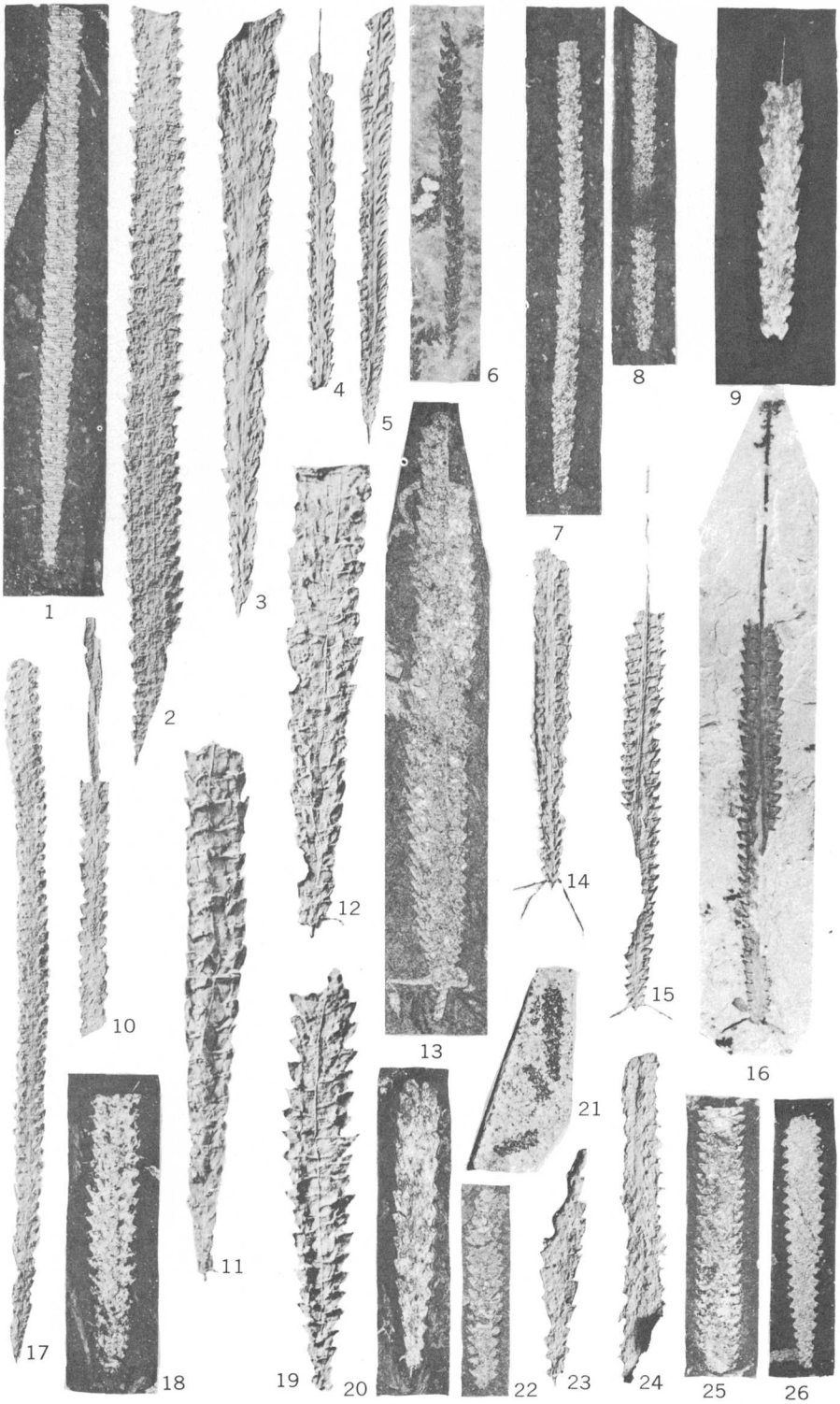
17. *Glyptograptus* n. sp. (not described). USNM 138690, × 2. Latex cast. Hanson Creek formation, USGS colln. D247 (CO).

18. *Orthograptus calcaratus* var. *acutus* Elles and Wood. (p. 145). USNM 138699, × 2. Saturday Mountain(?) formation, USGS colln. D456 (CO).

20. *Orthograptus* aff. *O. calcaratus* var. *basilicus* Lapworth (p. 145). USNM 138700a, × 2. Toquima formation. USGS colln. 320 (SD).

21. *Orthograptus truncatus* var. *socialis* Lapworth (p. 151). USNM 138718, × 2. Vinini formation, USGS colln. D480a (CO) (float).

22. *Orthograptus truncatus* var. *intermedius* Elles and Wood (p. 149). USNM 138710, × 2. Saturday Mountain(?) formation, USGS colln. D456 (CO).
23. *Orthograptus truncatus* var. *pertenuis* (Ruedemann) (p. 150). USNM 138711, × 4. Latex cast. Vinini and Valmy equivalent, USGS colln. D157 (CO).
24. *Orthograptus quadrimucronatus* var. *angustus* Ruedemann (p. 147). USNM 138707, × 2. Latex cast. Valmy formation, USGS colln. 1950 (CO).
25. *Orthograptus truncatus* Lapworth (p. 148). USNM 138708, × 2. Saturday Mountain(?) formation, USGS colln. D456 (CO).
26. *Orthograptus truncatus* var. *abbreviatus* Elles and Wood (p. 149). USNM 102930, × 2. Phi Kappa formation, USGS colln. 1368 (SD). Specimen illustrated by Ruedemann, 1947, pl. 69, fig. 13a.



GLYPTOGRAPTUS AND *ORTHOGRAPTUS*

PLATE 12

FIGURES 1, 17. *Orthograptus calcaratus* var. *acutus* Elles and Wood (p. 145). Saturday Mountain(?) formation.

1. USNM 138697, × 2. USGS colln. D456 (CO).

17. USNM 138698, × 2. USGS colln. 2519 (SD).

2, 3, 18. *Orthograptus calcaratus* var. *grandis* (Ruedemann) (p. 146). Phi Kappa formation, USGS colln. 1368 (SD).

2. USNM 138701, × 2. Paratype. Illustrated by Ruedemann, 1947, pl. 80, fig. 30.

3. USNM 102764, × 2. Holotype. Illustrated by Ruedemann, 1947, pl. 80, fig. 29.

18. USNM 138702, × 2. Paratype. Illustrated by Ruedemann, 1947, pl. 80, fig. 28.

4–6. *Orthograptus quadrimucronatus* (J. Hall) (p. 146).

4. USNM 138703, × 2. Saturday Mountain(?) formation, USGS colln. 2519 (SD).

5. USNM 138704, × 2. Latex cast. Vinini formation, USGS colln. D540 (CO).

6. USNM 138705, × 2. Latex cast. Vinini formation, USGS colln. D480e (CO) (float).

7. *Orthograptus* cf. *O. quadrimucronatus*. USNM 13806 × 2. Latex cast. Vinini formation, USGS colln. D453 (CO). Thecae spaced closer than in typical forms. Figs. 6 and 7 both show the edge and one side of a rhabdosome. The rectangular section is not difficult to visualize.

8. *Orthograptus truncatus* var. *abbreviatus* Elles and Wood (p. 149). USNM 138709, × 2. Phi Kappa formation, USGS colln. 1368 (SD). (See also pl. 11, fig. 26.) Illustrated by Ruedemann, 1947, pl. 69, fig. 12.

9, 10, 16. *Trigonograptus martellii* n. sp. (p. 153). Valmy formation, USGS colln. D102 (CO). 9, USNM 138728, × 2, holotype; 10, USNM 138729, × 2; 16, USNM 138730, × 2.

11–15. *Orthograptus truncatus* var. *rarithecatus* n. var. (p. 150). Phi Kappa formation, USGS colln. 1368 (SD). 11, USNM 138713a, × 2, paratype; 12, USNM 138714, × 2, paratype; 13, USNM 138715, × 2, paratype; 14, USNM 138549a, × 2, holotype; 15, USNM 138616, × 2, paratype.

19. *Orthograptus truncatus* cf. *O. t.* var. *pauperatus* Elles and Wood. Not described. USNM 138712, × 4. Latex cast showing "growth lines" on several thecae. Hanson Creek formation, USGS colln. 474d (CO).

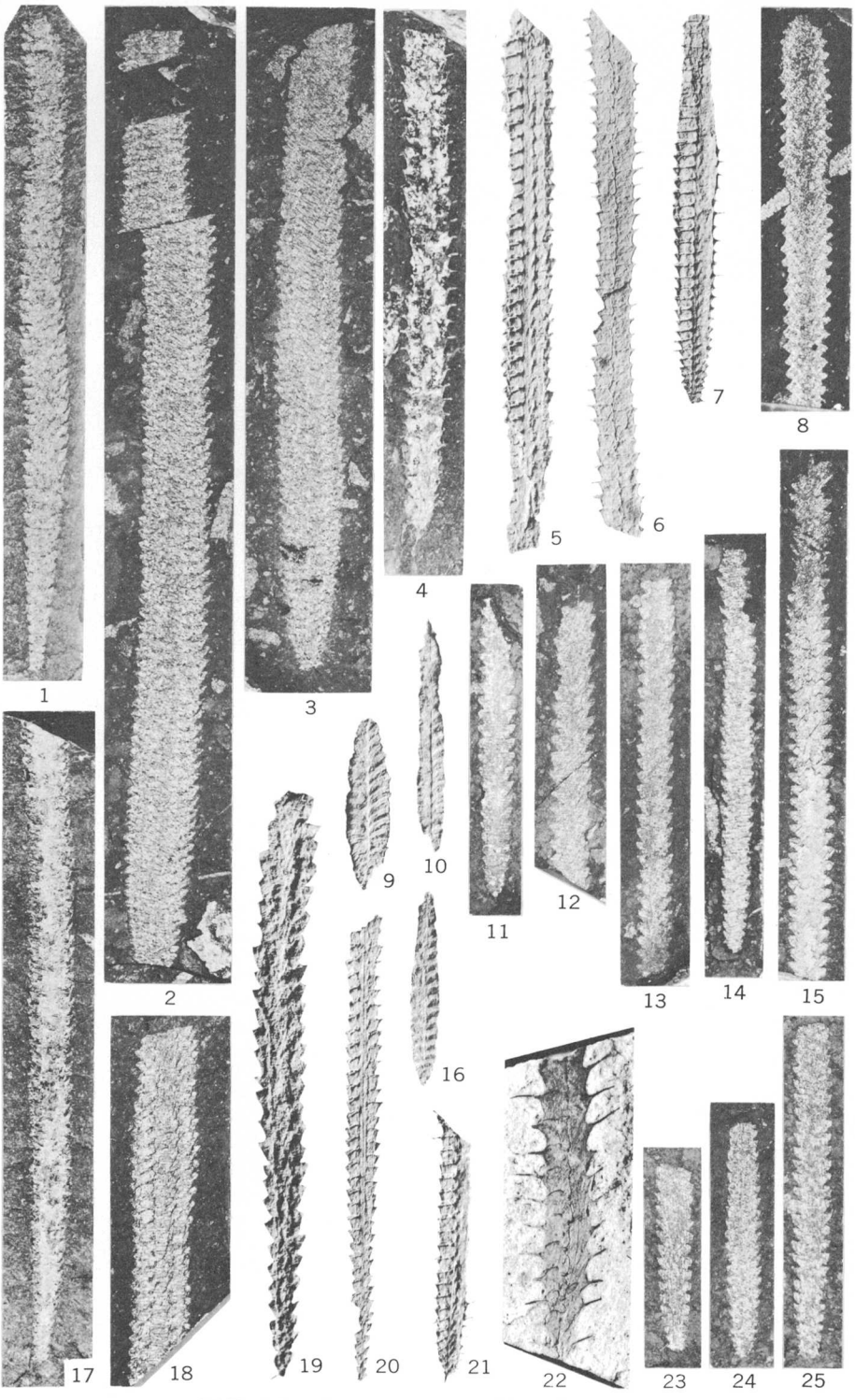
20. *Orthograptus* sp. (not described). USNM 138727, × 2. Latex cast. Vinini formation, USGS colln. D161 (CO).

21. *Orthograptus quadrimucronatus whitfieldi* (J. Hall) (p. 148). USNM 138725, × 2. Latex cast showing thecae of type of *O. quadrimucronatus*. Vinini equivalent, USGS colln. D359a (CO).

22. *Orthograptus* sp. (cf. *O. whitfieldi* of Elles and Wood, not *O. whitfieldi* of J. Hall). USNM 138726, × 4. Vinini equivalent, USGS colln. D453 (CO).

23–25. *Orthograptus truncatus* var. *richmondensis* (Ruedemann) (p. 151). Phi Kappa formation, USGS colln. 1368 (SD).

23. USNM 138851, × 2, showing rounded proximal end.
24. USNM 138716, × 2. Initial thecae spaced at rate of 15 in 10 mm.
25. USNM 138717, × 2. Thecae more widely spaced. This specimen intermediate with *O. truncatus* var. *rarithecatus* n. var.



ORTHOGRAPTUS AND *TRIGONOGRAPTUS*

PLATE 13

FIGURES 1–4. *Orthograptus truncatus* var. *strigosus* n. var. (p. 152). Saturday Mountain formation.

1. USNM 138719, × 2. Holotype. USGS colln. D456 (CO).
2. USNM 138720, × 2. Paratype. USGS colln. 2519 (SD).
3. USNM 138721, × 2. Paratype. USGS colln. 2519 (SD).
4. USNM 138722, × 2. Paratype. USGS colln. 2519 (SD).

5, 10, 12. *Retiograptus* sp. (like *R. pulcherrimus* Keble and Harris, but with long apertural spines). Not described.

5. USNM 138739, × 2. Two specimens. Vinini formation, USGS colln. D507 (CO).
10. USNM 138740, × 2. Vinini formation, USGS colln. D161 (CO).
12. USNM 138741, × 4. Latex cast of a partial specimen, Vinini formation, USGS colln. D507 (CO).

6. *Hallograptus* sp. (p. 156) USNM 138732, × 2. Phi Kappa formation, USGS colln. 1370 (SD).

7. *Hallograptus*? *eucharis* (J. Hall) (p. 155). USNM 138731, × 4. Palmetto formation, USGS colln. 2347 (SD).

8, 9. *Hallograptus*? *mucronatus* (J. Hall) (p. 156). Phi Kappa formation, USGS colln. 1370 (SD). USNM 102818, × 2.

8. Illustrated by Ruedemann, 1947, pl. 81, figs. 26, 28.
9. The obverse of fig. 8. Illustrated by Ruedemann, 1947, pl. 81, figs. 25, 27.

11. *Retiograptus* aff. *R. speciosus* Harris. (not described) USNM 138742, × 4. Latex cast of a fragmentary specimen. Vinini formation, USGS colln. 2353 (SD).

13, 13a, 14. *Retiograptus pulcherrimus* Keble and Harris (p. 158). Vinini formation, USGS colln. D480e (CO). Latex casts. 13, 13a. Two fragments of same specimen. USNM 138736, × 2.

14. USNM 138737, × 2.

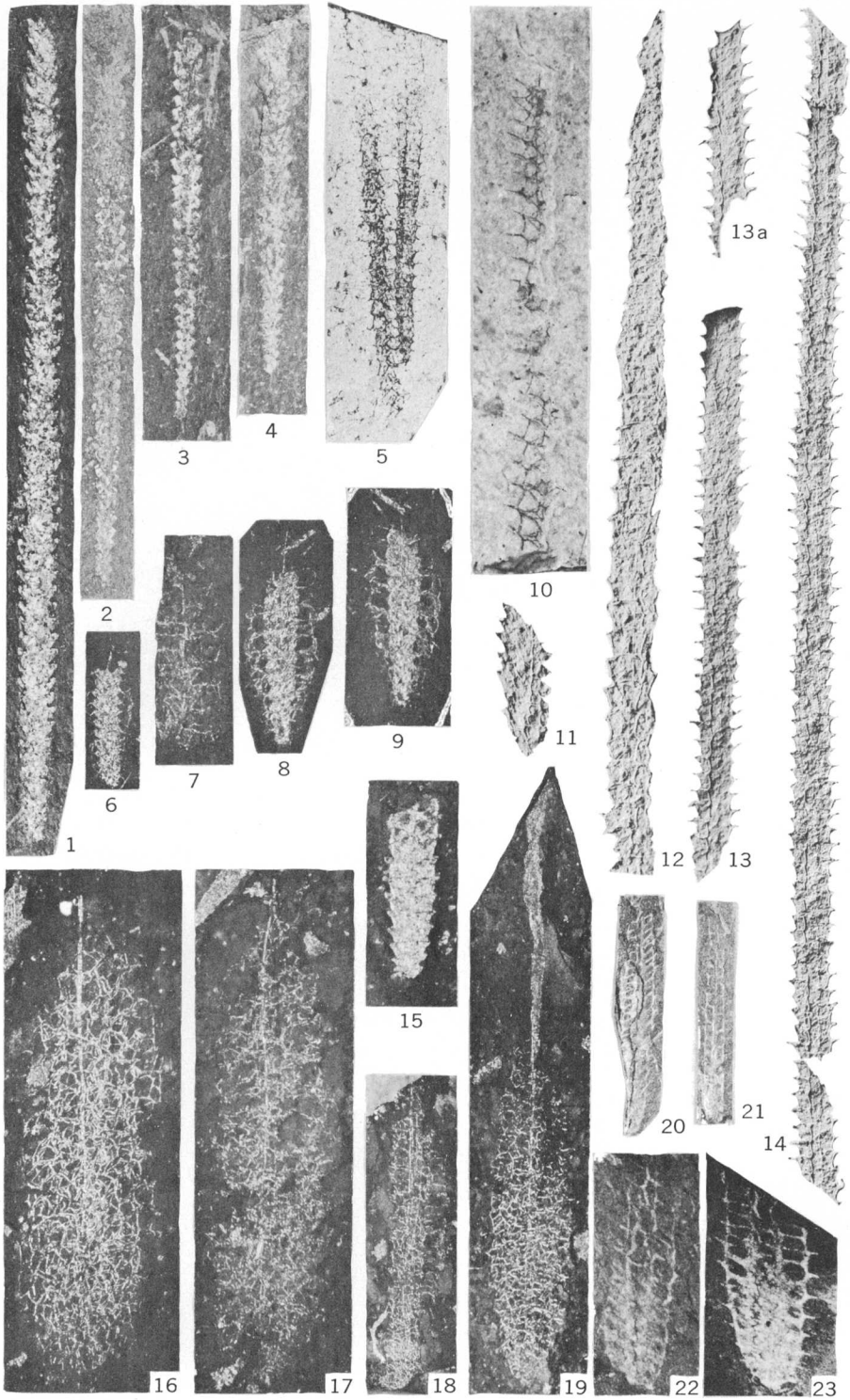
15. *Retiograptus* cf. *R. pulcherrimus* Keble and Harris (p. 158). USNM 138738, × 4. Phi Kappa formation, USGS colln. 1368 (SD).

16–18. *Arachniograptus*? sp. (p. 160). Phi Kappa formation, USGS colln. 1368 (SD).

16. USNM 138745, × 4. Illustrated by Ruedemann, 1947, pl. 83, figs. 17, 19.
17. USNM 138746, × 4.
18. USNM 138747, × 2. Illustrated by Ruedemann, 1947, pl. 83, figs. 18, 20.

19. *Arachniograptus laqueus* n. gen. n. sp. (p. 159). USNM 138743, × 4. Holotype. Phi Kappa formation, USGS colln. 1368 (SD). Illustrated by Ruedemann, 1947, pl. 83, fig. 16.

20–23. *Retiograptus geinitzianus* J. Hall (p. 158). Toquima formation, USGS colln. 444z (OS). 20, USNM 138542a, × 2; 21. USNM 138542 b × 2; 22. USNM 138734, × 4; 23. USNM 138735, × 4.



ORTHOGRAPTUS, RETIOGRAPTUS, AND *HALLOGRAPTUS*