Ordovician Brachiopods, Trilobites, and Stratigraphy in Eastern and Central Nevada

GEOLOGICAL SURVEY PROFESSIONAL PAPER 639

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By REUBEN JAMES ROSS, JR.

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A description of 79 species of 58 genera of brachiopods and trilobites in the context of seven strategically located stratigraphic sections. Interpretations of Middle Ordovician stratigraphy in central Nevada are modified

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON : 1970

UNITED STATES DEPARTMENT OF THE INTERIOR

WALTER J. HICKEL, *Secretary*

GEOLOGICAL SURVEY

William T. Pecora, *Director*

Library of Congress catalog-card No. 72-605081

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C. 20402

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ORDOVICIAN BRACHIOPODS, TRILOBITES, AND STRATIGRAPHY IN EASTERN AND CENTRAL NEVADA

By REUBEN JAMES ROSS, JR.

ABSTRACT

Trilobites, brachiopods, bryozoans, corals, ostracodes, and conodonts collected from seven Ordovician stratigraphic sections in Nevada have been tabulated and range in age from early Canadian to Barneveld. The 79 species described here represent 24 genera of brachiopods and 34 genera of trilobites; two genera are new.

Collation of the fossil assemblages, their stratigraphic positions, and their geographic distribution leads to several conclusions, some of which are:

1. The trilobites of the great bioherm at Meiklejohn Peak, near Beatty, Nev., of the Table Head Formation, Newfoundland, Canada, and from Lower Head, Newfoundland, Canada, are correlated with the *Orthidiella* zone (Whiterock Stage) of east and central Nevada and with the *Orthambonites minusculus* beds and older beds at Ikes Canyon, Toquima Range, Nev. These beds are earliest Whiterock or latest Canadian.
2. The *Palliseria* zone (Whiterock Stage) is correlative for the most part with the lower *Anomalorthis* zone (Whiterock Stage), the *Rhysostrophia* zone is correlative with the upper *Anomalorthis* zone, and the upper *Anomalorthis* zone is probably of Ashby?–Porterfield age.
3. The highest limestone of the Pogonip Group in east and central Nevada is probably of Porterfield age, correlative with the lower part of the Copenhagen Formation of the Monitor Range.
4. Differences in fossil assemblages previously interpreted as temporal are considered to have resulted from differences in facies.
5. At Ikes Canyon, Toquima Range, Nev., an unnamed limestone above the Pogonip Group and below the Silurian Roberts Mountains Formation is the lateral equivalent of the Ordovician Hanson Creek and Copenhagen (highest part) Formations; this unit has been mapped previously as the Silurian Diana Limestone of Kay and Crawford (1964).
6. An unconformity at Lone Mountain, west of Eureka, Nev., represents much of the upper part of the Antelope Valley Limestone and all the lower part of the Copenhagen Formation, approximately 700 feet of strata is believed to be missing.

INTRODUCTION

The study of Ordovician stratigraphy across southern Nevada into adjoining California (Ross, 1964a) indicated that fossil zones and lateral facies might be so interrelated as to require modifications in Middle Ordovician stages as they were then understood. In order to obtain more information in a more northerly and westerly direction, in areas where sections were least likely to include unconformities, collections were made from measured sections in the Pahranagat Range, in the southern Groom Range, in Antelope Valley, and in the northern Egan Range (fig. 1). Two other sections have always been problems. The Toquima Range (Ikes Canyon) is structurally complex, represents a somewhat different lithologic facies than more easterly sections, and includes a brachiopod fauna that is provincial. The section at Lone Mountain includes an unconformity in the Antelope Valley Limestone, the size of which was not previously known.

The relationship between stratigraphy and enclosed fossils is of prime importance. Therefore, stratigraphic sections are presented first and descriptive paleontology second. The discussion of each stratigraphic section includes remarks on previous investigation, lithologic description with positions of fossil collections, fossils from each collection, and stratigraphic significance of the fossils. Ages and correlations indicated by the fossils are discussed so that the reader may refer to them close to their context.

On plates 20 and 21 (in pocket) the positions of stratigraphic sections are indicated on an index map, the measured generalized lithologies are shown graphically, and the position of fossil collections are plotted. All sections are compared with a section at Ibex in west Utah, which was compiled from Hintze (1951). A few fossil collections were made in 1965 from the Ibex section. Jensen (1967) presented a more complete distribution of brachiopods found in that section.

In the overall stratigraphic summary, previously published information (Ross, 1964a; 1967a) is related to the sections presented in this report. Revisions are suggested for existing zonal fossil assemblages and for correlations. It has become evident that some of the author's previous conclusions (such as those on the migration of the *Palliseria* zone, Ross, 1964a, p. C79–C80, fig. 10) should be corrected.

An effort was made to collect all available kinds of fossils. Jean M. Berdan contributed identifications of ostracodes, John W. Huddle identified the conodonts, and William A. Oliver, Jr., the corals. A few poorly

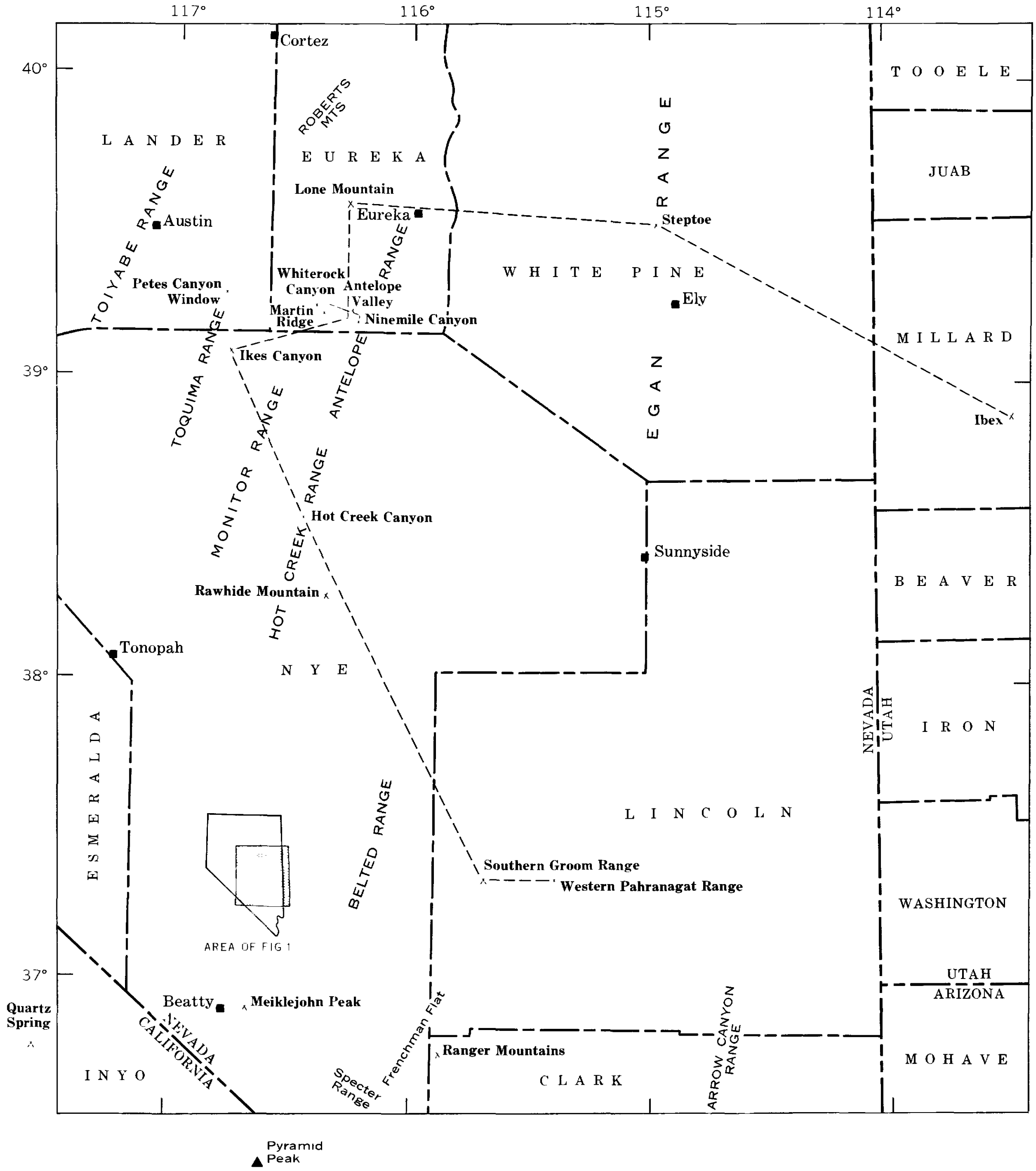

FIGURE 1.—Index map showing relative positions of stratigraphic sections. Dashed lines and X's indicate lines of section and locations of measured sections shown on plates 20 and 21.

preserved bryozoans were examined by Olgarts L. Karklins. Gastropods were identified by Ellis Yochelson, sponges by R. M. Finks, and pelecypods by John Pojeta.

Brachiopods and trilobites are described and illustrated in the second half of the report and represent 58 genera and 79 species. The 24 genera of brachiopods, of which one is new, include 34 species, of which seven are new. Trilobite genera number 34, of which one is new. These genera include 45 species, of which 11 are new.

PURPOSE OF THE REPORT

It is the purpose of this report (1) to present the distribution of Ordovician, particularly Middle Ordovician, fossils stratigraphically and geographically across the depositional strike in Nevada, (2) to examine critically the fossil distribution at Ikes Canyon, Toquima Range, in a section that has been much quoted and that has been used as the type section for two of the substages or zones of the Whiterock Stage (Cooper, 1956, p. 127; Kay, 1962; Ross, 1964a, p. C74–C78), (3) to link the thick, presumably more complete sections of eastern and central Nevada with those near the edge of the miogeosycline, (4) to make available biostratigraphic data on the Early Ordovician from sections in Antelope Valley. Although this information is far from complete, it demonstrates that Early Ordovician trilobites of central Nevada are a considerably different association of genera than to the east in eastern Nevada and Utah, and (5) to reexamine correlations of the zones and stages of the Middle Ordovician in light of new data.

EXTENT OF INVESTIGATION

Stratigraphic sections (pls. 20 and 21) were measured in the western Pahranagat Range, southern Groom Range, Hot Creek Canyon, and Ikes Canyon, Toquima Range. These cross the depositional area in a much different direction than a line of sections previously presented (Ross, 1964a; 1967a, pl. 11) across southern Nevada.

The composite Pogonip section from the environs of Antelope Valley is presented because it is the type or reference section for most of the Ordovician of Nevada and because it is a very thick section. It is partly compiled from the works of others and partly from the author's.

The Steptoe section north of Ely in eastern Nevada is also very thick and shows interesting comparisons with the sections in Antelope Valley to the west and the Ibex area of Utah (Hintze, 1952) to the east. Between the Antelope Valley and Steptoe section the Lone Mountain section is inserted to show how markedly it differs from them in its sub-Eureka part.

Fossil collections have been compiled on following pages and the results tabulated on plates 20 and 21 to show stratigraphic ranges. The collections made do not provide final answers to stratigraphic problems, but they do provide a more complete coverage than has been available heretofore.

BASIC CONSIDERATIONS

Several considerations are basic to this investigation: (1) The presence of Tooele Arch indicates an east-west area of instability in Ordovician time, which is known to have resulted in disconformities within the Middle Ordovician strata at Lone Mountain, Roberts Creek Mountains, and Cortez (Gilluly and Masursky, 1965, p. 16). This trend may have continued southwestward into the vicinity of Austin and may have resulted in similar disconformities in the Toquima and Toiyabe Ranges, (2) In discussing the Tertiary history of the Great Basin of California, Gilluly (1949, p. 568–569) stated "* * * obviously the places to seek evidence of discordance in strata are at the border of the basins, not in the middle of them. In the middle of the basins only the movements that finally stopped deposition could be recorded, and of course such movements would be most widely recorded," (3) The center of the Middle Ordovician basin in the Basin Ranges lies in eastern Nevada virtually along a line from the Nevada Test Site on the south through Ely to the north (Ross, 1964b, figs. 7, 9; [correct reversal of 800-ft and 1,200-ft designations switched erroneously in fig. 7 south of Tooele arch]), (4) Correlations are based on the presence of the same or closely related animals or assemblages of animals at different localities. Correlation is not correctly based on the absence of fossils (there are no dinosaurs in the Precambrian), nor does the absence of fossils necessarily obviate correlation. None of the shellfish or trilobites of the Middle Ordovician limestones in Nevada are known in the graptolite-bearing Middle Ordovician argillites and shales from the Vinini and Valmy Formations. There is no question but that the two contrasting sequences were deposited contemporaneously. Similarly, though the contrast is less, the absence of some of the fossils considered characteristic of the Chazy Group of New York from the Antelope Valley Limestone of Nevada should not preclude correlation of these two units.

ACKNOWLEDGMENTS

In September 1965, several stratigraphic paleontologists inspected key sections covered in this report, in U.S. Geological Survey Bulletin 1180–C, and in Professional Paper 523–D; the criticisms of this group were valuable, though they did not all concur. The group included B. S. Norford, Geological Survey of Canada; J. T. Dutro, Jr., U.S. Geological Survey; H. B. Whittington, Harvard University; Frederick Shaw, Mount Holyoke College; and R. S. Boardman and G. A. Cooper, U.S. National Museum or the Smithsonian Institution.

Marjorie MacLachlan assisted with field collecting in the Antelope Valley area in 1955, and A. R. Palmer helped measure and collect from the Goodwin Limestone in Ninemile Canyon in 1957. In making collections from the Copenhagen Formation, I was aided by Shaw and by L. A. Wilson, who proved an invaluable field assistant, companion, and photographer through most of these studies. A. L. Brokaw located the excellent section west of Steptoe and recommended that it be measured in 1966. Assistance and advice from many other peers have been welcome and too numerous to acknowledge.

Throughout work on the Ordovician of Nevada, G. A. Cooper assisted and advised the author. In September 1966, he conducted a tour of Middle Ordovician sections in Oklahoma, Tennessee, Alabama, and Virginia, so that the author might better understand the basis for his scheme of zonation.

He was one of several critical readers of this manuscript and assisted in Denver (April 22, 1968) in identification of troublesome brachiopods critical to the author's stratigraphic interpretation. Although it became evident that Cooper and the author were not in agreement as to interpretation of biostratigraphic data, he discussed all phases of this work freely.

After returning to Washington on April 24, 1968, unbeknown to this author, Cooper reexamined several of the collections he had previously made at Ikes Canyon, Nev., and mailed four of them with an explanatory letter to the author a few days later. One of these collections (USNM 110170) provided the first concrete proof that *Anomalorthis* ranges upward into the *Rhysostrophia* zone, a conclusion at variance with Cooper's original interpretation but agreeing with that of the author. The other collections support fossil distributions shown in figure 2 of this report.

In June and July 1968, the author visited Ordovician stratigraphic sections in Scandinavia and Great Britain under National Science Foundation Research Grant GA–4020. During this program a partly undescribed trilobite assemblage was discovered in the Albany Mudstones of the Stinchar Valley, Ayrshire, Scotland, by J. Keith Ingham and the author. This assemblage (p. 52) may be significant in the Middle Ordovician correlation discussed in this report.

STRATIGRAPHIC SECTIONS AND DISTRIBUTION OF FOSSILS

Sections recorded below that have U.S. Geological Survey fossil collections were measured in the Pahranagat Range, southern Groom Range, Hot Creek Canyon, Ikes Canyon in the Toquima Range, both sides of Antelope Valley (Nolan and others, 1956; Merriam, 1963), Lone Mountain, and Steptoe, Nev.

PAHRANAGAT RANGE

The Ordovician sections in the Pahranagat Range were originally studied by Reso (1963), and the area was included in the geologic map of Lincoln County by Tschanz and Pampeyan (1961). In 1963 the author was very fortunate in having Reso as a guide to the best Ordovician sections. One of these is in the center of the Pahranagat Range in sec. 27, T. 6 S., R. 59 E.; the other is on the west side of the range. Because it is more readily accessible, the western section was measured in 1966 in conjunction with somewhat more detailed fossil collecting than had previously been possible. This section is in the center of the E¼ sec. 18, and the center of the W½ sec. 17, T. S., R. 59 E. The lower part of the Goodwin Limestone has been cut out by faulting, as Reso (1963, p. 905) indicated might be true, but all the rest of the Pogonip Group is well exposed.

It should be noted that the top of the Ninemile Formation is gradational into the lower part of the Antelope Valley Limestone and that some investigators might place the boundary between the two formations 120 feet lower than the author has here.

PAHRANAGAT RANGE SECTION

[Section of the Pogonip Group on west side of Pahranagat Range, Caliente 2° quad., Nevada, center E¼ sec. 18, and center W½ sec. 17, T. 7 S., R. 59 E.]

Eureka Quartzite, not measured. Thickness according to Reso (1963, pl. 2) is 385–550 ft. Basal 6 in. is mottled red and orange sandstone.

Pogonip Group:

Antelope Valley Limestone:

Upper member:	*Feet*
Limestone, dolomitic, fine-grained, dark-gray; weathers brownish medium gray to light gray. Colln. D1662 CO from this unit	17
Limestone, finely sandy, and limy sandstone intermixed	2
Quartzite, fine-grained; grading to sandstone; both weather yellowish orange	4
Limestone, very sandy; weathers yellowish gray to yellowish orange	2

Pogonip Group—Continued

Antelope Valley Limestone—Continued

Upper member—Continued	*Feet*
Limestone, silty, irregularly laminated; has silty partings. Limestone weathers light medium gray; silt weathers yellowish orange. Interval weathers into rubbly slopes alternating with low ledges. Collns. D1663 CO and D1381 CO from top 3 ft	28
Limestone, fine-grained, dark-gray, resistant	6
Limestone, silty, nodular, irregularly laminated; weathers rubbly. Fossiliferous: bryozoans and brachiopods	6
Limestone, very silty, thinly laminated; weathers yellowish gray	2
Dolomite, thin- to thick-bedded; some beds weather medium brownish gray and others light olive gray. Fossiliferous: corals and brachiopods in top 3 ft. Colln. D1665 CO	10
Limestone, silty, light-gray; weathers yellowish gray in silty part	3
Limestone, evenly laminated, very silty; weathers yellowish gray	6
Limestone, aphanitic, resistant; in thick beds, finely and irregularly laminated; weathers medium light gray	4
Limestone, aphanitic; like unit above, but weathers dark gray	5
Limestone; like unit above, but weathers medium light gray	9
Limestone, very silty, finely and regularly laminated; weathers yellowish gray. A good marker bed	3
Limestone, aphanitic, resistant; 2- to 6-ft beds, finely and irregularly laminated; weathers medium light gray, which contrasts with cliff below	27
Limestone, thinly and regularly laminated, light-gray; weathers into light-gray, platy slope	3
Limestone, very cherty, thin-bedded, silty, dark-gray	3
Limestone, resistant, cliff-forming. Fine grained, irregularly laminated; has silty partings which weather recessive and yellowish gray. Limestone itself weathers dark to medium gray. Very abundant chert in top 9 ft	80
Limestone, nodular, silty, nonresistant	12
Limestone, coarsely calcarenitic, medium-gray, resistant	2
Limestone, nodular; weathers rubbly and light medium gray. Forms weak slope. Fossils from float (colln. D1666 CO) from lower 10 ft of this unit and 9 ft of unit below	34
Limestone, fine to aphanitic, irregularly laminated; has silty partings. Weathers medium gray. Silty partings weather recessive, pale yellowish orange. This limestone forms resistant thick ledges, with tops 7, 14, and 25 ft above bottom of interval. Interbeds are thin nodular limestone which weathers to rubbly slope	25

Pogonip Group—Continued

Antelope Valley Limestone—Continued

Upper member—Continued	*Feet*
Limestone, medium-gray; in beds 2–3 ft thick protruding from rubble-covered slope. Rubble derived from silty nodular limestone interbeds. Fossils from float could all have been derived from bed at top of this interval with possible exception of *Bathyurus*. Colln. D1667 CO	38
Limestone, very silty, aphanitic, thinly laminated; weathers light yellowish orange. Forms a distinctive marker bed	2
(The section above this level was measured in fault block north of main ridge by using a key bed that weathers yellowish orange. The part of the section below this level was measured along north flank of main ridge closer to the ridge line.)	
Limestone, light-gray, aphanitic; surface mottled with orange-weathering silt	2
Limestone, resistant, fine-grained; has irregular silty partings. Large specimens (¾–1½ in diam) of "*Girvanella*"	22
Limestone, nodular, silty, medium-gray; has four equally spaced interbeds of aphanitic, resistant, silty limestone	27
Slope; largely float covered, but seems to be underlain mainly by nodular silty limestone. Ledges of fine-grained, irregularly laminated, silty, medium-gray limestone protrude through float. Beds very fossiliferous; ostracodes the most abundant fossils. Collns.: D1671 CO at 42 ft above base, D1670 CO at 50 ft above base, D1669 CO at 60 ft above base, and D1668 CO at 73 ft above base	89
Limestone, dolomitic, very silty; weathers yellowish orange	1
Limestone, aphanitic, irregularly laminated; has abundant silty partings. Limestone is dark to medium gray, but silt weathers yellowish orange	4
Limestone, dolomitic, very silty; weathers yellowish orange	4
Limestone, aphanitic, irregularly liminated; has abundant silty partings. Limestone is dark to medium gray, but silt weathers yellowish orange	10
Limestone, very thin bedded, fine-grained; weathers light gray to light medium gray. A few interbeds of calcarenite and silty limestone. Colln. D1673 CO is from 17 ft above base; D1672 CO is from float in top 12 ft	40
Total thickness of upper member	532

Middle member:	*Feet*
Limestone and dolomite interbedded. Abundant silicified gastropods throughout. About 50 percent covered by float	39
Limestone, dolomitic, thin-bedded; silty layers weather yellowish orange. Covered largely by float. *Palliseria* and *Girvanella* throughout	23

	Feet
Pogonip Group—Continued	
Antelope Valley Limestone—Continued	
Middle member—Continued	
Limestone, dolomitic, silty; weathers dark yellowish orange	1
Limestone, fine-grained, medium-gray	4
Limestone, dolomitic, silty; weathers dark yellowish orange	2
Limestone, medium-gray, thin-bedded	5
Dolomite, thick-bedded; weathers dusky yellow to light olive gray. Chert stringers and nodules abundant 20–31 ft above base. Cephalopod siphuncles 7 ft above base. "*Girvanella*" abundant upward from 31 ft above base; *Palliseria* also in this part. (Along strike this unit changes to dark-gray dolomitic limestone.)	90
Limestone, nodular, fine-grained, thin-bedded; mottled with silt. Colln. D1674 CO and probably D1382 CO	29
Limestone, coarsely calcarenitic, well-exposed; in beds 1–3 ft thick. Weathers medium gray and has grayish-orange silty streaks	14
Limestone, coarsely calcarenitic; in low ledges protruding through float. Very fossiliferous. Colln. D1675 CO	28
Limestone, medium-gray; in a few 2-ft beds protruding through float	20
Limestone, dark- to medium-gray; in beds 1–3 ft thick, which form cliffs and ledges 3–15 ft thick. "*Girvanella*" abundant throughout. *Palliseria* and receptaculitids upward from 130 ft above base, but *Palliseria* rare in upper 33 ft	207
Limestone, massive, medium-gray; has prominent dark-brown chert stringers parallel to bedding	16
Limestone, thin-bedded, weak, poorly exposed	8
Limestone, massive, medium-gray; has faint widely spaced bedding. Many solution cavities and small caves, similar to unit 25 ft above	62
Limestone, fine-grained; in thin irregular laminae and layers welded together to form massive beds up to 15 ft thick	93
Total thickness of middle member	641
Lower member:	
Limestone, thin-bedded; in beds 6 in.–2ft thick	12
Limestone, finely calcarenitic, somewhat silty; has abundant dark-brown chert stringers	74
Limestone; in beds 6 in.–3 ft thick; has scattered chert stringers and considerable silicified silt in wavy laminae that coalesce to form "crepe" structure on joint faces. Very thin siltstone layers interbedded but less than 20 percent of this interval. Colln. D1676 CO is from 50 ft above base	62

	Feet
Pogonip Group—Continued	
Antelope Valley Limestone—Continued	
Lower member—Continued	
Limestone and limestone intraformational conglomerate in thin 1–2-ft beds. Limestone is coarsely calcarenitic mainly. Considerable shale and siltstone in float that covers 50 percent of interval between ledges of limestone which are 5–10 ft apart. Fossils from 63 ft above base in colln. D1677 CO	71
Limestone and intraformational conglomerate, thin-bedded. Fossils from float colln. D1678 CO	9
Limestone, fine- to medium-grained, calcarenitic, medium-gray; in beds 3–8 ft thick. Partly silty with irregular silty layers forming "crepe" pattern on some weathered surfaces. Silt weathers grayish orange. Receptaculitids or sponges common, particularly 4–7 ft above base. "*Girvanella*" in bed 54–61 ft above base	62
Limestone and bioclastic calcarenite, medium-gray, thin- to thick-bedded; has lesser amounts of interbedded nodular silty limestone and siltstone. Much chert in stringers and fine aggregates throughout interval. Prominent 6-in. bed of dark-brown chert 8 ft below top. Colln. D1679 CO is from 5 ft below top, and D1680 CO is from 35 ft above base	48
Total thickness of lower member	338
Total thickness of Antelope Valley Limestone	1,511
Ninemile Formation:	
Siltstone, light-olive-gray; has thin, irregular interbeds of limestone, both partly silicified. A few beds of limestone intraformational conglomerate. Colln. D1681 CO at 26 ft above base, and D1682 CO at 10 ft above base	48
Limestone, very silty, nodular; in thin irregular beds. Some 1- to 3-ft interbeds of medium-gray calcarenite contain much siliceous silt and chert. Unit forms fairly steep slope. Colln. D1683 CO at 49 ft above base, and D1684 CO at 31 ft above base	62
Limestone, medium-gray, cherty; in 2- to 3-ft beds with interbeds of nodular limestone and siltstone	9
Siltstone, highly siliceous; has interbeds of light-gray limestone which are very irregular and 1–3 in. thick. Forms resistant ledge	17
Siltstone and shale; contains lesser amounts of limestone as lenses and nodules. Light olive gray, weathers to grayish orange. Slight silicification in top 15 ft. Colln. D1685 CO at 30 ft above base	57
Limestone, resistant; has resistant wavy silty partings forming "crepe" pattern on joint faces; this rock in 1- to 4-ft beds interbedded with nodular silty limestone, the two types intergrading. Colln. D1686 CO at top	34

Pogonip Group—Continued	
Ninemile Formation—Continued	*Feet*
Limestone, nodular, silty; weathers light brown, 5*YR* 5/6, and pale yellowish orange, 10 *YR* 8/6. Colln. D1687 CO at top; colln. D1688 CO at 15 ft above base	26
Slope, float-covered; seemingly underlain by shale	47
Total thickness of Ninemile Formation	300
Goodwin Limestone:	
Limestone, thin-bedded, somewhat cherty; in resistant ledges of intraformational conglomerate and calcarenite interbedded with silty slabby limestone and olive-gray siltstone. Chert abundant in top 26 ft. Interval forms resistant ridge	84
Limestone; like unit below but limestone beds thicker, more resistant, have less weak material between	17
Limestone, intraformational conglomerate; in thin ledges having a few thin laminated limestone layers protruding through float	58
Limestone, intraformational conglomerate, and calcarenite; form low ledges protruding through cover. Unit forms weak slope because of olive-gray shale between limestone beds	73
Slope, mostly covered. A few thin ledges of thin-bedded limestone protrude	27
Limestone, resistant, very cherty; in beds 6–10 in. thick welded to form 3- to 6-ft ledges. Many beds have coarse intraformational conglomerate in bottom grading upward through coarse calcarenite to fine thin laminae or cross-bedded calcarenite. This limestone weathers medium to dark gray. With the dark chert the interval forms a dark unit when compared with those below. Colln. D1689 CO at 58 ft above base	74
Slope; covered with float. Almost no ledges of limestone showing. Seems to form a weak slope along whole mountain front. Probably underlain by shaly or silty unit	68
Limestone, very cherty. Limestone is fine grained and contains minor amount of intraformational conglomerate. Mostly thin bedded. Much of chert is located along vertical joints abutting against underlying and overlying beds. Ledges about 30 percent covered by float in this interval	39
Limestone, very cherty; in ledges protruding through float in about 50 percent of slope	30
Dolomite and dolomitic limestone, has exceptionally abundant chert stringers and discontinuous beds of chert	17
Limestone and intraformational conglomerate, has interbeds of fine-grained calcarenite. Abundant chert stringers	38
Dolomite and dolomitic limestone, very cherty; weathers light gray with brownish tinge	45
Limestone, somewhat dolomitic and cherty	11
Limestone, thin-bedded; calcarenite and intraformational conglomerate; weathers medium gray	22

Pogonip Group—Continued	
Goodwin Limestone—Continued	*Feet*
Limestone; has abundant dark-brown chert stringers. About one-third of this interval is intraformational conglomerate. Colln. D1690 CO at 16 ft above base	70
Limestone, dolomitic; weathers medium olive gray, 5*Y* 5/1, in beds 1–3 ft thick	8
Total thickness of Goodwin Limestone	681

Faulted?

No measurement below this point.

FOSSILS FROM THE PAHRANAGAT RANGE

The following is a list of fossils in USGS collections from the section measured in 1966 on the west side of the Pahranagat Range Caliente 2° quad., Nevada, (center E¼ sec. 18, and center W½ sec. 17, T. 7 S., R. 59 E.). The list is supplemented by a few collections made during a reconnaissance with Anthony Reso in 1963.

D1662 CO. Antelope Valley Limestone, within top 15 ft beneath Eureka Quartzite.

Corals; examined by W. A. Oliver (written commun., Aug. 24, 1966):

"Indeterminate favositoid. *If* this is from your coral zone it is probably *Lichenaria* B, but it is too dolomitized for differentiation between this and several later favositoids."

Brachiopod:

Glyptorthis sp.

D1663 CO. Antelope Valley Limestone, 25–28 ft below base of Eureka Quartzite.

Coral; examined by W. A. Oliver (written commun., Aug. 24, 1969):

"This is too small a fragment for me to identify, but it may be an *Eofletcheria*."

Brachiopod:

Dactylogonia cf. *D. vespertina* Ross, n. sp

Trilobites:

Bathyurus sp.

Cybelid (free cheek)

Isotelid?

Ostracodes:

Hyperchilarina? sp.

Budnaniella sp. aff. *B. shenandoense* Kraft

D1381 CO. Antelope Valley Limestone, 25 ft below base of Eureka Quartzite.

Brachiopod:

Dactylogonia cf. *D. vespertina* Ross, n. sp.

Trilobite:

Cybelid, probably the same species as found in colln. D990 CO (Ross, 1964a, p. C49–C50).

Ostracodes:

Hypochilarina? sp.

Leperditella? sp.

Schmidtella sp.

Krausella? sp.

Eurychilina? sp.

Conodonts:	*Number of specimens*
Drepanodus subarcuatus Furnish	1
Cyrtoniodus flexuosus (Branson and Mehl)	2
Paltodus aff. *Distacodus falcatus* Stauffer	1
Polyplacognathus aff. *P. foliaceous* Fahraeus	2

D1665 CO. Antelope Valley Limestone, 67–70 ft below base of Eureka Quartzite.

Corals; identified by W. A. Oliver (written commun., Aug. 24, 1966):

Lichenaria B

Semiphaceloid *Lichenaria* A

Brachiopods:

Sphenotreta cf. *S. sulcata* Cooper

Plectorthis? cf. *P. perplexus* (Ross)

Conodonts:	*Number of specimens*
Coelocerodontus sp.	1
Cyrtoniodus flexuosus (Branson and Mehl)	4
Drepanodus suberectus (Branson and Mehl) (type element)	6
homocurvatus	38
subarcuatus Furnish	9
Dichognathus typica Branson and Mehl	2
Hibbardella? n. sp.	3
Erismodus gracilis (Branson and Mehl)	5
asymmetricus Branson and Mehl	25
symmetricus (Branson and Mehl)	22
Ligonodina? sp.	1
Plectodina sp.	20
Polycaudalodus bidentatus Branson and Mehl	1
Prioniodina joachimensis Andrews	5
sp.	4

This collection probably correlates with D1565 CO in the Groom Range.

D1373 CO. Antelope Valley Limestone, approximately 120 ft below base of Eureka Quartzite. (This collection was taken from central part of Pahranagat Range in sec. 27, T. 6 S., R. 69 E.)

Pelecypods; identified by John Pojeta (written commun., Feb. 15, 1967): "*Ctenodonta* sp. This species belongs to *Ctenodonta* sensu stricto; it is comparable in size to that from colln. D1560 CO" from the southern Groom Range."

Conodonts:	*Number of specimens*
Erismodus sp.	
Chirognathus sp.	
Cardiodella sp. (= *C.* cf. *C. delicatula* in colln. D1658)	2
Cyrtoniodus flexuosus? (Branson and Mehl)	1
Dichognathus sp.	2
Distacodus sp.	1
Drepanodus suberectus (Branson and Mehl), 3 types	20
Erismodus asymmetricus (Branson and Mehl)	12
gracilis (Branson and Mehl)	3
symmetricus Branson and Mehl	5
Multioistodus subdentatus Cullison	3
Oistodus sp.	6
Paltodus sp.	2
Plectodina furcata (Hinde)	7
Polycaulodus aff. *P. bidentatus* Branson and Mehl	3
Prioniodina sp.	2
Scandodus sp.	1

Erismodus and *M. subdentatus* occur together in the Dutchtown Formation of McQueen (1937), according to J. W. Huddle (written commun., March 6, 1968).

D1374 CO. Antelope Valley Limestone, approximately 150 ft below base of Eureka Quartzite. (This collection from central part of Pahranagat Range in sec. 27, T. 6 S., R. 69 E.)

Pelecypods; identified by John Pojeta (written commun., Feb. 15, 1967):

"*Ctenodonta* sp. This species belongs to *Ctenodonta* sensu stricto; it is comparable in size to that in colln. D1560 CO" from the southern Groom Range.

"*Tancrediopsis* aff. *T. cuneata* (Hall). Eastern species of this genus are all larger than the material from this collection. Walcott (1884) reported a similar species from the Pogonip of the Eureka District of Nevada."

D1666 CO. Antelope Valley Limestone, 258–277 ft below base of Eureka Quartzite.

Brachiopod:

Anomalorthis cf. *A. oklahomensis* Ulrich and Cooper

Trilobites:

Cybelopsis? sp.

Bathyurus acutus subsp. *angustus* Ross, n. subsp.

Ostracodes:

Eoleperditia sp. cf. *E. bivia* (White), ends not flattened

Leperditella sp.

D1667 CO. Antelope Valley Limestone, 293–331 ft below base of Eureka Quartzite.

Brachiopods:

Anomalorthis nevadensis Ulrich and Cooper

sp.

Small orthid with external form of *Skenidioides*

Trilobites:

Bathyurus cf. *B. extans* (Hall)

Illaenus utahensis Hintze

Pliomerid indet., possibly *Cybelopsis*

Ostracodes:

Eoleperditia sp. cf. *E. bivia* (White), ends not flattened

Eurychilina sp.

Leperditella sp.

D1668 CO. Antelope Valley Limestone, 400 ft below base of Eureka Quartzite.

Brachiopod:

Orthambonites sp.

Ostracodes:

Eoleperditia bivia (White)

Eurychilina sp.

Eurychilina? sp., flat velum

Leperditella? sp.

Hyperchilarina? sp.

Krausella sp.

D1669 CO. Antelope Valley Limestone, 413 ft below base of Eureka Quartzite.

Ostracodes:

Eoleperditia bivia (White)

Leperditella sp.

Monotiopleura? sp.

N. gen. A, sp. a

D1670 CO. Antelope Valley Limestone, 423 ft below base of Eureka Quartzite.

Ostracodes:

Eoleperditia bivia (White)?, one specimen

Eurychilina sp.

Physalidopisthia? sp.

Leperditella? sp.

Krausella sp.

D1671 CO. Antelope Valley Limestone, 431 ft below base of Eureka Quartzite.

Brachiopod:

Anomalorthis sp.

D1672 CO. Antelope Valley Limestone, 492–504 ft below base of Eureka Quartzite.

Brachiopods:

Anomalorthis cf. *A. lonensis* (Walcott)

cf. *A. nevadensis* Ulrich and Cooper

Trilobite:

Cybelopsis (large species of zone M)

Ostracodes:

Eoleperditia bivia (White)

Eurychilina sp.

Schmidtella? sp., small, long

Macrocyproides? sp.

Krausella sp.

D1673 CO. Antelope Valley Limestone, 515 ft below base of Eureka Quartzite.

Brachiopod:

Anomalorthis lonensis (Walcott)

Ostracodes:

Eoleperditia bivia (White)

Schmidtella? sp., small, long

Krausella sp.

D1376 CO. Antelope Valley Limestone, approximately 670 ft below base of Eureka Quartzite. (This collection made in 1963 from central part of range in sec. 27, T. 6 S., R. 69 E.)

Brachiopod:

Anomalorthis cf. *A. lonensis* (Walcott)

Pelecypods; identified by John Pojeta (written commun., Feb. 15, 1967):

"This collection contains a large species of *Ctenodonta* sensu stricto comparable in size to that from colln. D1571 CO" from the southern Groom Range.

Conodonts:	*Number of specimens*
Drepanodus suberectus (Branson and Mehl)	10
Multioistodus cryptodens (Mound), trident (equal *M.* n. sp. Lindström)	23
monodent	24
bident	14
Paltodus sp. (D1660 CO) (also in D1677 CO)	9
Oistodus multicorrugatus Harris	2
sp.	4
Scandodus sp.	4

D1383 CO. Antelope Valley Limestone, approximately 670 ft below base of Eureka Quartzite. (This collection made in 1963 from west side of range.)

Brachiopod:

Anomalorthis fascicostellatus Ross, n. sp.

D1674 CO; D1382 CO. Antelope Valley Limestone, 696–725 ft below base of Eureka Quartzite. (When these fossils were collected in 1963, the author erroneously estimated that colln. D1382 CO was about 800 ft below the Eureka.)

Brachiopods:

Hesperorthis cf. *H. matutina* Cooper

Anomalorthis lonensis (Walcott)

resoi Ross, n. sp.

Desmorthis crassus Ross, n. sp. (see p. 14 for colln. D1573 CO and p. 24 for colln. D1513 CO.)

Conodonts, D1674 CO:	*Number of specimens*
Drepanodus subarcuatus Furnish	2
suberectus (Branson and Mehl), type element	6
homocurvatus	20
planus	10
oistodus	2
Gothodus sp.	1
Oistodus multicorrugatus Harris	14
pseudomulticorrugatus Mound, elements of	23
Multioistodus bidens form	38
Oistodus scaleonocarinatus Mound, one species?	18
Multioistodus cryptodens (Mound), *tridens* element	3
bidens form	2
subdentatus Cullison, type element	1
tridens element	3
Paltodus sp. (like D1367 CO)	7

Conodonts, D1382 CO:	
Drepanodus suberectus (Branson and Mehl), type element 0, *homocurvatus* 26, *planus* 6, *Oistodus* 1	33
Oistodus pseudomulticorrugatus Mound	11
multicorrugatus Harris	29
scaleonocarinatus Mound	11
Multioistodus (*bidens* element)	21
lateralis Cullison, *tridens* type	4
Oistodus aff. *Scanodus pippa* Lindström	9
Paltodus sp.	5

Oistodus pseudomulticorrugatus, O. multicorrugatus, and the *bidens* element of *Multioistodus* probably all belong to a single biologic species. This species also occurs in D1516 CO and other collections. These forms have been described from the Joins Formation.

D1675 CO. Antelope Valley Limestone, 739–767 ft below base of Eureka Quartzite.

Brachiopods:

Anomalorthis lonensis (Walcott)

utahensis Ulrich and Cooper

Orthambonites sp.

Ostracode:

Leperditella valida Harris

D1379 CO. Antelope Valley Limestone, probably 1,200–1,250 ft below base of Eureka Quartzite. Originally roughly estimated to be 1,500 ft below base of Eureka (central Pahranagat Range, sec. 27, T. 6 S., R. 69 E.).

Brachiopod:

Hesperonomiella minor Ulrich and Cooper

Conodonts:	*Number of specimens*
Acontiodus curvatus? Mound	1
Drepanodus suberectus (Branson and Mehl), type element	4
homocurvatus element	42
oistodus element	4
D. n. sp. D, see D1639 CO	12
Oistodus pseudomulticorrugatus Mound	7
scalenocarinatus Mound	6
Paltodus sp. 4	4

D1676 CO. Antelope Valley Limestone, lower part, 1,271 ft below base of Eureka Quartzite.
Brachiopod:
Hesperonomia? sp.
Trilobites:
Trigonocerca sp.
Goniotelina? sp.

D1677 CO. Antelope Valley Limestone, 1,329 ft below base of Eureka Quartzite.
Brachiopod:
Archaeorthis? sp.
Trilobites:
Presbynileus? sp.
Lachnostoma sp.

D1678 CO. Antelope Valley Limestime, 1,399–1,401 ft below base of Eureka Quartzite.
Brachiopods, at least three genera. No interiors. Possibly:
Archaeorthis? sp.
Hesperonomia sp.
Leptella? sp.
Plectotrophia? sp.
Tritoechia sp.
Trilobites:
Presbynileus sp.
Ptyocephalus sp.

D1679 CO. Antelope Valley Limestone, 1,468 ft below base of Eureka Quartzite.
Brachiopods:
Hesperonomia sp.
Syntrophopsis? sp.
Trilobites:
Ptyocephalus sp.
Presbynileus sp.

D1680 CO. Antelope Valley Limestone, 1,476 ft below base of Eureka Quartzite.
Trilobite:
Ptyocephalus sp.

D1681 CO. Ninemile Formation, 278 ft above base; 1,533 ft below base of Eureka Quartzite.
Possible algae or sponge

D1682 CO. Ninemile Formation, 262 ft above base; 1,549 ft below base of Eureka Quartzite.
Brachiopod:
Hesperonomia? sp.
Trilobites:
Ischyrotoma caudanodosa Ross
Trigonocerca sp.
Pliomerid

D1683 CO. Ninemile Formation, 239 ft above base; 1,572 ft below base of Eureka Quartzite.
Trilobites:
Ischyrotoma sp.
Ptyocephalus sp.
Trigonocerca sp.
Peltabellia? sp.
(The combination of these trilobites seems to indicate a correlation within the range zone G(2) to zone J.)

D1684 CO. Ninemile Formation, 221 ft above base; 1,590 ft below base of Eureka Quartzite.
Brachiopod:
Diparelasma? sp.
Trilobites:
Trigonocerca typica Ross
Isoteloides? sp.
Diacanthaspis? (Hintze, 1952, pl. 19, fig. 16)
Psalikilus pikum Hintze
Bolbocephalus? sp.
Dasycladacean algae
This assemblage belongs to zone H of Ross (1951).

D1685 CO. Ninemile Formation, 137 ft above base; 1,674 ft below base of Eureka Quartzite.
Trilobites:
Ptyocephalus sp.
Protopliomerops sensu latu (pre-Harrington, 1957)
Pseudomera sp.
Shumardia sp.

D1686 CO. Ninemile Formation, 107 ft above base; 1,704 ft below base of Eureka Quartzite.
Trilobites:
Ptyocephalus accliva Hintze
Megalaspides sp.
Ischyrotoma ovata (Hintze)
Carolinites sp.
Proparian, possibly *Leiostrototropis*
Assemblage belongs to zone H.

D1384 CO. Antelope Valley Limestone, estimated roughly as 1,600 ft below base of Eureka Quartzite when collected in 1963 and thought to be from lowest beds of the formation. Now considered as having probably come from the Ninemile Formation only slightly above colln. D1686 CO.
Brachiopod:
Hesperonomia iones (Walcott)
Idiostrophia cf. *I. nuda* Cooper
Trilobites:
Ischyrotoma ovata (Hintze)
Carolinites sp.
Pseudocybele altinasuta Hintze
lemurei Hintze
Presbynileus ibexensis (Hintze)
Trigonocerca sp.
Pygidium undet. (Hintze, 1952, pl. 9, fig. 16)
Jeffersonia sp.
This assemblage belongs in zone I and probably correlates with the middle or lower part of the Ninemile Formation in its type area. It is also found in the top of the Fillmore Limestone of Hintze (1951, p. 17) in Utah's Ibex area.

D1687 CO. Ninemile Formation, 73 ft above base; 1,738 ft below base of Eureka Quartzite.
Trilobites:
Ptyocephalus sp.
Ischyrotoma sp.
Pliomerid undet.
Brachiopods:
Archaeorthis? sp.

D1688 CO. Ninemile Formation, 62 ft above base; 1,749 ft below base of Eureka Quartzite.
Brachiopod:
Archaeorthis elongatus Ulrich and Cooper
Trilobite:
Ptyocephalus? sp.

D1689 CO. Goodwin Limestone, 276 ft below top; 2,087 ft below base of Eureka Quartzite.
Trilobite (see Ross, 1957, p. 497):
Megistaspis (*Ekeraspis*) *nevadensis* Ross, n. sp.

D1380 CO. Goodwin Limestone, estimated to be 2,400 ft below base of Eureka Quartzite when collected in 1963. Now believed to have come from strata about 2,200 ft below the Eureka.

Trilobite:

Asaphellus cf. *A.* sp. 1 (probably same as in colln. D1833 CO at Steptoe)

D1690 CO. Goodwin Limestone, 584 ft below top; 2,395 ft below base of Eureka Quartzite.

Trilobites:

Geragnostus sp.

Kainella sp. (cranidium only)

Hystricurus cf. *H. genalatus* Ross

Leiostegium sp.

AGE AND CORRELATION OF PAHRANAGAT RANGE FOSSILS

From a study of the fossils, it is obvious that the upper beds of the Antelope Valley Limestone are of Marmor (Chazy) or younger age. *Dactylogonia* in collections D1381 CO and D1663 CO is a Marmor-to-Porterfield genus. *Sphenotreta* cf. *S. sulcata* which occurs in D1665 CO was previously reported only from the McLish Formation of Oklahoma, considered by Cooper (1956, chart 1) to be Marmor. This collection correlates with D710 CO in the Ranger Mountains (Ross, 1964a, p. C19).

John Pojeta commented (written commun., Feb. 15, 1967) that *Ctenodonta* sensu stricto, as represented in collections D1373 CO and D1374 CO, is not known in the Eastern United States in beds older than the Murfreesboro Limestone (Porterfield). The trilobite *Bathyurus acutus* Raymond, of which a subspecies was found in collection D1666 CO, is known only from the Black River Group (Porterfield-Wilderness) in the East; here it is associated with *Anomalorthis* cf. *A. oklahomensis* supposedly occurring only in Whiterock strata. This situation is nearly paralleled by collection D1563 CO in the southern Groom Range.

The species of *Desmorthis* in collection D1674 CO is similar to or synonymous with that in D1573 CO in the southern Groom Range and in D1513 CO at Ikes Canyon. Collection D1674 CO contains the same fauna as older collection D1382 CO, including *Hesperorthis matutina* Cooper. This assemblage correlates with D1764 CO at Lone Mountain.

Hesperonomiella minor Ulrich and Cooper occurs in collection D1379 CO, roughly estimated in the field to be about 1,500 feet below the top of the formation; unfortunately, this collection was not duplicated in 1966. It is more likely that the collection was actually made about 1,200–1,250 feet below the top of the Antelope Valley Limestone, and the collection is interjected in that position in the lists. However, a species identified in collection D1678 CO as the pedicle valve of *Plectotrophia?* may be the brachial valve of *Hesperonomiella*. If so, the range of *Hesperonomiella* used by Hinze (1952, p. 19) to mark zone K may overlap zone J in this area.

Another 1963 collection, D1384 CO, includes species assigned by Hintze to zone I. It seems to correspond to collection D1686 CO made in 1966. It is particularly interesting to note *Idiostrophia* cf. *I. nuda* Cooper in collection D1384 CO, a species one finds in the *Orthidiella* zone in the Ranger Mountains to the southwest and in the lower beds of the great bioherm at Meiklejohn Peak.

J. W. Huddle (written commun., Nov. 8, 1967) noted that the conodont genera of collections D1665 CO and D1373 CO are characteristic of the Glenwood Shale, Harding Sandstone, and lower beds of the Bighorn Dolomite and this suggests an early Wilderness or late Porterfield age.

In this section, Ninemile lithology is limited to zone H or somewhat older zone I. The author has considered its age to be equal to zone J to the west but has been partly mistaken. At the type section of the formation, it is largely correlative with zone H.

Commenting on the ostracodes, Jean Berdan (written commun., April 3, 1967) stated:

Most interesting ostracode collections are those from the Pahranagat Range. The lowest of these (USGS D1675–CO) contain *Leperditella valida* Harris, which was originally described from the Joins Formation, and occurs associated with large *Schmidtella* in the middle part of the Kanosh Shale in the Ibex section, Utah. It occurs in Nevada in collection USGS D560–CO, from the Kanosh Shale on Bastian Peak, Ely No. 4 quad. To date, it appears to indicate the middle faunal zone of the Kanosh. Another interesting collection is USGS D1669–CO, from 413 feet below the top of the Antelope Valley. This collection contains *Monotiopleura?* sp. and a new genus. *Monotiopleura?* also occurs in USGS D1567–CO from the southern Groom Range, associated with what may be another species of the new genus, and in USGS D1100–CO from the lower quartzite unit at Crystal Peak, Utah, although the Utah form may be another species of *Monotiopleura?*. The new genus (N. gen. A. sp. a) also occurs in USGS D1770–CO from Lone Mountain, 134 feet below the Eureka, but to date *Monotiopleura?* has not turned up in this collection. Most of the other genera present in these collections are long ranging and not particularly significant.

USGS D1669–CO, USGS D1770–CO and USGS D1567–CO (Groom) may represent about the same horizon, especially since *Eurychilina?* (with flat velum) occurs above the first two in the same relative position in the Pahranagat section (USGS D1668–CO) and at Lone Mountain (USGS D1771–CO). However, we still know far too little about the ranges of the ostracodes in the upper part of the Antelope Valley to justify firm correlations.

It is curious that *Anisocyamus* sp., which was identified from a previous collection from the Pahranagat Range (USGS D1065–CO), has not been found in any of the collections reported on here. Neither have the two species of *Ballardina* which have been noted previously from the Lehman Formation and the upper part of the Antelope Valley. * * * the variations of *Eoleperditia bivia* do not seem to be correlated with any particular horizon.

SOUTHEAST END, GROOM RANGE

The section at the southeast end of the Groom Range (on old maps shown as Timpahute Range) is not readily accessible and is only partly exposed. The Ninemile Formation is completely masked in a wash. It is possible that the bottom part of the Antelope Valley Limestone is also covered. The Eureka Quartzite, although well exposed at the base, is not particularly prominent and is not exposed at the top.

The Antelope Valley Limestone was measured and yielded many fossils. Both lithologically and faunally the section correlates closely with the section in the Pahranagat Range. The upper beds of the Antelope Valley are probably temporal equivalents of the lower quartzite beds of the Eureka at the Ranger Mountains (Nevada Test Site) (Ross, 1967a, pl. 11).

SECTION AT SOUTHEAST END, GROOM RANGE

[Section east of Groom mine, at southeast end of Groom Range. Nevada coord., central zone: E. 780,550 ft, N. 941,000 ft, Caliente 2° quad., 1:250,000 scale, Nevada. This is an incomplete section of the Pogonip Group. It includes only the Antelope Valley Limestone and may not include all the basal part of that]

Eureka Quartzite—not measured.

Pogonip Group:

Antelope Valley Limestone:	*Feet*
Slope; obscured by float	20
Limestone, resistant, mottled, silty. Colln. D1559 CO in top 1 ft	11
Limestone and silty limestone; weather pale yellowish orange	7
Limestone, silty, irregularly laminated and blotched. Colln. D1560 CO 39 ft above base of unit	50
Limestone, silty, thin-bedded, partly slabby; weathers pale yellowish orange	58
Limestone, resistant, crudely laminated, silty, blotched; weathers brownish gray. Silicified cystid plates and bryozoans not collected. Colln. D1561 CO taken 53 ft above base of unit	99
Limestone, silty, irregular laminated, weak; forms a slope. Colln. D1562 CO at 25 ft above base	97
Limestone, resistant, silty, irregularly laminated. Colln. D1563 CO at 29 ft above base of unit	55
Limestone, thin-bedded, weak, nodular; rubbly in upper part; dark gray and coarsely crystalline in lower part. Colln. D1564 CO from soft interval in top 8 ft	60
Limestone, very silty, crudely laminated; almost forms "crepe" effect. Very fossiliferous, has abundant leperditiid osteracodes. Colln. D1565 CO at 53 ft above base	78
Limestone, nodular, silty, weak. Collns. D1566 CO in top 17 ft (*Anomalorthis* and *Prasopora*) D1567 CO at 8 ft above base of unit	30

Pogonip Group—Continued

Antelope Valley Limestone—Continued	*Feet*
Limestone, very sandy, platy. Trilobite, colln. D1568 CO at 4 ft above base	16
Limestone, crudely laminated, silty, resistant	7
Limestone, dolomitic; weathers yellowish gray	6
Limestone, thin-bedded, silty. *Girvanella*, colln. D1569 CO at 43 ft above base; D1570 DO at 22 ft above base	65
Limestone, silty, rubbly and nodular; weathers gray and greenish yellow	26
Limestone, aphanitic, irregularly laminated, partly silty, resistant	5
Limestone, silty, thinly laminated; weathers brown	25
Limestone, platy, thinly laminated	15
Limestone, irregularly laminated, silty, resistant	6
Limestone, medium-grained, thin- and evenly bedded, partly laminated. Colln. D1571 CO at 12 ft above base, and D1572 CO at 6 ft above base. Sponges at 32 ft not collected. *Palliseria* and *Receptaculites* continue upward	45
Limestone, fine- and even-grained, evenly bedded. Partly covered by float. Colln. D1573 CO at top. Colln. D1574 CO from middle	8
Limestone, coarsely granular, weak; has resistant interbeds of silty, crudely laminated limestone	48
Limestone, bioclastic; in beds 6 in. to 2 ft thick. Very fossiliferous, *Girvanella*, *Palliseria*, and *Maclurites*. *Anomalorthis* cf. *oklahomensis* 27 ft above base of interval. Colln. D1575 CO is 45 ft above base. D1576 CO at 39 ft above base	62
Limestone, coarsely crystalline, sparry. In 1–3 ft beds. Clearly bioclastic. Weathers with brownish hue	24
Limestone, coarsely crystalline, "crinoidal." Exposed as scattered ledges protruding through float in upper 14 ft. Colln. D1577 CO at 11 ft above base	27
Limestone; abundant *Girvanella*, *Palliseria*, and *Maclurites*. *Receptaculites* abundant in middle. Colln. D1578 CO from top 1 ft	58
Limestone, granular to fine-grained; thinner bedded than underlying unit. *Girvanella* common. *Palliseria* above 42 ft from base of unit. Colln. D1579 CO is 43 ft above base	70
Limestone, granular to fine-grained, thick-bedded. *Girvanella* forms as much as one-fourth of rock. *Receptaculites* above 122 ft above base. Colln. D1580 CO at 149 ft above base of unit, D1581 CO at 130 ft above base, and D1582 CO at 68 ft above base	152
Limestone; granular and fine grained in alternating irregular layers. Beds 3 in. to 2 ft thick. Very minor silty mottling. *Girvanella* common. D1583 CO at 30 ft above base	72
Limestone, granular; in beds 1–2 ft thick	13
Siltstone; in a solid, thick bed, overlain by a few thinner laminae. Weathers a conspicuous dark brown or dark brownish orange	10
Limestone, crudely laminated; has abuntant silt and chert partings in the lower part, but is almost lacking chert in upper part	15

Pogonip Group—Continued

Antelope Valley Limestone—Continued

	Feet
Siltstone, siliceous, calcareous, weak, somewhat "fucoidal"; weathers orange brown	13
Limestone, coarse and fine-grained; in beds 1–4 ft thick. Appears irregularly laminated but lacks silty partings. Colln. D1584 CO 10 ft below top	85
Limestone, coarse and fine-grained; in beds 2–8 ft thick, forms resistant ledge or cliff	97
Limestone, coarsely crystalline, bioclastic; in beds 2 in. to 3 ft thick, crudely laminated with silty partings producing "crepe" structure. Intraformational conglomerate in some beds more than 75 ft above base of section. *Girvanella* in beds 35, 56, and 87 ft above base. D1585 CO is 14 ft above base	95
Thickness of Antelope Valley Limestone measured	1,630

No measurement below this level. Lower part of Pogonip covered in wash. Top of Ninemile Formation probably not much below this point.

FOSSILS FROM THE SOUTHERN GROOM RANGE

Fossils collected from the southern Groom Range are as follows:

D1559 CO. Antelope Valley Limestone, 21 ft below top of formation.

Corals; identified by W. A. Oliver (written commun., June 25, 1965):

Lichenaria, semiphaceloid sp. A.

Brachiopods;

Orthambonites paucicostatus Cooper

cf. *O. occidentalis* Cooper

Dactylogonia vespertina Ross, n. sp.

Conodonts; identified by J. W. Huddle (written commun., Jan. 13, 1966):

	Number of specimens
Belodina compressa Branson and Mehl	1
ornata? Branson and Mehl	1
Belodina? or *Euprioniodina*?	1
Chirognathus cf. *C. delicatula* Stauffer	1
Chirognathus? *dubia* Branson and Mehl	1
Coelocerodontus tetragonius Ethington	1
Cordylodus delicatus Branson and Mehl	7
flexuosus (Branson and Mehl)	6
sp	1
Dichognathus n. sp	5
Drepanodus sp	1
Microcoelodus multidentatus Branson and Mehl	1
robustus? (Stauffer)	3
Oistodus abundans Branson and Mehl	1
Paltodus sp	1
Panderodus unicostatus (Branson and Mehl)	2
Phragmodus undatus Branson and Mehl	25
Trucherognathus cf. *T. bidentatus* (Branson and Mehl)	1
Steroconus? sp	1
Zygognathus sp	1

D1560 CO. Antelope Valley Limestone, 49 ft below top of formation.

Pelecypods; identified by John Pojeta (written commun., Feb. 15, 1967):

"*Ctenodonta* sp. This species belongs to *Ctenodonta* sensu stricto. It is a small species as much as 15 mm long. Comparable in size to the specimens in colln. D1769 CO from Lone Mountain."

Conodonts; identified by J. W. Huddle (written commun., Jan. 13, 1966):

	Number of specimens
Cordylodus sp	1
Cordylodus? sp	1
Ozarkodina cf. *O. macrodentata* Graves and Ellison	11
Paracordylodus? sp	1
Trichonodella sp	1

D1561 CO. Antelope Valley Limestone, 192 ft below top of formation.

Corals; identified by W. A. Oliver (written commun., June 21, 1965):

Lichenaria, semiphaceloid sp. A

D1562 CO. Antelope Valley Limestone, 317 ft below top of formation.

Ostracodes:

Leperditella? sp., no ventral overlap

Eurychilina? sp.

Small ostracodes, smooth, indet.

D1563 CO. Antelope Valley Limestone, 368 ft below top of formation:

Trilobite:

Bathyurus cf. *B. extans* (Hall)

Ostracodes:

Leperditiid, indet., too poorly preserved to identify

Leperditella sp.

D1564 CO. Antelope Valley Limestone, 397–405 ft below top of formation.

Brachiopods:

Anomalorthis nevadensis Ulrich and Cooper

oklahomensis Ulrich and Cooper

Trilobite:

Goniotelina? sp. (pygidium only)

Conodonts; identified by J. W. Huddle (written commun., Jan. 13, 1966):

	Number of specimens
Acodus sp	3
sp.	1
Belodus? (shallow cavity)	1
Cordylodus sp	1
Cordylodus? sp	2
Drepanodus homocurvatus Lindström	7
Oistodus sp	1
Paltodus sp	3
sp.	1
Scandodus vulgaris (Branson and Mehl)	1
Tetraprioniodus? sp	1

D1565 CO. Antelope Valley Limestone, 482 ft below top of formation.

Trilobite:

Bathyurid free cheeks, indet.

Conodonts; identified by J. W. Huddle (written commun., Jan. 13, 1966):

	Number of specimens
Acodus sp	3
Cordylodus cf. *C. rotundatus* Pander	2
Cyrtionodus sp	2
Drepanodus homocurvatus Lindström	1
subarcuatus Furnish	4
sp., fragments	---

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Conodonts—Continued

	Number of specimens
Erismodus radicans (Hinde)	1
Oneotodus sp	1
Ozarkodina? sp	1
Paracordylodus sp	7
Prioniodina sp	2
Prioniodus n. sp. 1 Lindström	5
n. sp	6
Scolopodus striolatus Harris and Harris	1
sp.	1
Tetraprioniodus? sp	1

D1566 CO. Antelope Valley Limestone, 535–552 ft below top of formation.

Bryozoan; identified by O. L. Karklins (written commun., June 22, 1965):

Trepostome, probably a batostomid

Brachiopod:

Anomalorthis nevadensis Ulrich and Cooper

D1567 CO. Antelope Valley Limestone, 557 ft below top of formation.

Ostracodes:

Eoleperditia? sp., too poorly preserved to identify

Schmidtella sp., two specimens—one punctate, one smooth

Leperditella? sp., rare

Eurychilina? sp., flat velum, same as that in colln. D1668 CO and D1771 CO.

Monotiopleura? sp., same as that in colln. D1669 CO.

N. gen. A, sp. b

N. gen. B, sp. a

D1568 CO. Antelope Valley Limestone, 557 ft below top of formation.

Bryozoan; identified by O. L. Karklins (written commun., June 4, 1965):

Probably a trepostome, fragmentary

D1569 CO. Antelope Valley Limestone, 616 ft below top of formation.

Brachiopod:

Anomalorthis oklahomensis Ulrich and Cooper

Conodonts; identified by J. W. Huddle (written commun., Jan. 13, 1966):

	Number of specimens
Chosonodina? *lunata* Harris and Harris	2
Drepanodus homocurvatus Lindström	5
sp.	2
sp.	1
Multioistodus n. sp. A	2
sp.	2
N. gen. n. sp., irregular	7
Oistodus contractus Lindström	1
sp.	2
Scandodus cf. *S. vulgaris* Branson and Mehl	8
n. sp	8
Scolopodus striolatus Harris and Harris	3

D1570 CO. Antelope Valley Limestone, 637 ft below top of formation.

Ostracodes:

Eoleperditia sp. cf. *E. bivia* (White), ends only slightly flattened

Small ostracodes, too poorly preserved to identify

Conodonts; identified by J. W. Huddle (written commun., Jan. 13, 1966):

Conodonts—Continued

	Number of specimens
Drepanodus homocurvatus Lindström	2
subarcuatus Furnish	1
sp.	1
sp.	1
Oistodus aff. *O. multicorrugatus* Harris	1
sp.	1
Scandodus cf. *S. vulgaris* Branson and Mehl	1

D1571 CO. Antelope Valley Limestone, 769 ft below top of formation.

Brachiopod:

Anomalorthis? sp.

Gastropod: identified by E. L. Yochelson (written commun., May 25, 1965):

cf. *Proplina* sp., probably a new genus of monoplacophoran

Pelecypods; identified by John Pojeta (written commun., May 25, 1965):

"*Ctenodonta* sp. This species belongs to *Ctenodonta* sensu stricto. It is much larger (up to 30 mm long) than the species from colln. D1560 CO."

D1572 CO. Antelope Valley Limestone, 775 ft below top of formation.

Brachiopods:

Desmorthis? sp. (fragmentary)

Anomalorthis cf. *A. fascicostellatus* Ross, n. sp.

Asymphylotoechia nolani Ross, n. gen., n. sp.

Syntrophopsis sp. (a gigantic species)

Conodonts; identified by J. W. Huddle (written commun., Jan. 13, 1966):

	Number of specimens
Acodus n. sp. A	5
Acodus? sp	3
Cordylodus sp	1
Drepanodus homocurvatus Lindström	1
sp.	1
Leptochirognathus cf. *L. prima* Branson and Mehl	1
Multioistodus cf. *M. lateralis* Cullison	1
subdentatus Cullison (*tridens* type)	7
n. sp. Lindström (1964, p. 80)	6
Oistodus cf. *O. abundans* Branson and Mehl	1
bilongatus Harris	2
contractus Lindström	1
lanceolatus Pander (triangular form with extra denticle)	1
sp.	2
Scandodus sp	1
Scolopodus striolatus Harris and Harris	1

D1573 CO. Antelope Valley Limestone, 782 ft below top of formation.

Brachiopod:

Desmorthis cf. *D. crassus* Ross, n. sp.

Conodonts; identified by J. W. Huddle (written commun., Jan. 13, 1966):

	Number of specimens
Acodus auritus Harris and Harris	5
n. sp. A (perhaps a form of *A. auritus*)	5
Drepanodus inclinatus Branson and Mehl	3
subarcuatus Furnish	1
sp.	3
sp.	1

Conodonts—Continued	*Number of specimens*
Leptochirognathus? sp.	1
Multioistodus n. sp. Lindström (1964, p. 80)	46
sp.	1
Oistodus cf. *O. abundans* Branson and Mehl	7
sp.	8
Paltodus sp.	1
sp.	1

D1574 CO. Antelope Valley Limestone, 785 ft below top of formation.

Brachiopods:

Anomalorthis spp., fragmentary, probably represent *A. lonensis* and *A. nevadensis*

Cystids:

Numerous silicified fragmentary plates

Conodonts; identified by J. W. Huddle (written commun., Jan. 13, 1966):

	Number of specimens
Acodus auritus Harris and Harris	3
Prioniodus evae Lindström	1

D1575 CO. Antelope Valley Limestone, 854 ft below top of formation.

Sponge; identified by R. M. Finks (written commun., Sept. 2, 1966):

Nevadacoelia pulchra Bassler

D1576 CO. Antelope Valley Limestone, 860 ft below top of formation.

Brachiopod:

Anomalorthis sp. fragmentary, probably *A. resoi* Ross, n. sp.

Gastropods; identified by E. L. Yochelson (written commun., May 25, 1965):

Amphineuran plate, undet.

Gastropods indet., two or more genera, badly worn fragments

Gastropod opercula, two or more types

Pelmatozoan:

Numerous plates

Conodonts; identified by J. W. Huddle (written commun., Jan. 13, 1966):

	Number of specimens
Acodus sp.	1
Drepanodus homocurvatus Lindström	2
Paltodus sp.	1

D1577 CO. Antelope Valley Limestone, 939 ft below top of formation.

Bryozoan; identified by O. L. Karklins (written commun., Jan. 13, 1966):

Trepostome, probably a batostomid

Brachiopods:

Desmorthis nevadensis Ulrich and Cooper

Anomalorthis lonensis (Walcott)

nevadensis Ulrich and Cooper

Conodonts; identified by J. W. Huddle (written commun., Jan. 13, 1966):

	Number of specimens
Acodus n. sp. B	10
sp.	2
sp.	1
Drepanodus sp.	1
Multioistodus aff. n. sp. Lindström (1964, p. 80)	31
Oistodus cf. *O. abundans* Branson and Mehl	10
Scandodus rectus? Lindström	1
Scolopodus sp.	1

D1578 CO. Antelope Valley Limestone 951 ft below top of formation.

Brachiopods:

Hesperorthis cf. H. matutina Cooper

Desmorthis? sp.

Anomalorthis nevadensis Ulrich and Cooper

lonensis (Walcott)

Trilobite:

Illaenus sp. 1 (close to *I. fraternus* Billings)

Conodonts; identified by J. W. Huddle (written commun., Jan. 13, 1966):

	Number of specimens
Acodus n. sp. B	4
Drepanodus sp.	5
sp.	1
Histiodella sp.	1
Ligonodina sp. (*oulodus* element)	1
Multioistodus aff. *M.* n. sp. Lindström, (1964, p. 80)	23
Oistodus cf. *O. abundans* Branson and Mehl	9
cf. *O. contractus* Lindström	1

D1579 CO. Antelope Valley Limestone, 1,035 ft. below top of formation.

Brachiopod:

Orthidiella cf. *O. carinata* Ulrich and Cooper

Cephalopod:

R. H. Flower (written commun., May 12, 1965) stated that the partial specimen examined by him was an unidentifiable michelinoceratid with advanced cameral deposits but unknown siphonal deposits. He stated further that forms similar to this were known from the "Sponge beds" at Ikes Canyon (p. 21) and from the Juab Limestone of Hintze (1951) in western Utah; there were also undescribed forms from the middle and upper parts of the Chazy Formation that seemed comparable.

On February 7, 1967, R. H. Flower wrote concerning the the same specimen:

"It is a member of the Michelinoceratida with a subcentral tubular siphuncle; there are traces of cameral deposits; there is a structure in the siphuncle which is probably adventitious (one cannot tell from one specimen alone when it is thus preserved) which would be remarkable if it should be organic; such structures are known only in the Battoceratidae and Protocycloceratidae. Though this is a generalized type of cephalopod, it does not recall strongly any species in the Ordovician by its proportions. I believe that it recalled Chazy things to me first, but this is more in the manner of preservation, than in the organic features of the specimen. It is scant comfort that I cannot identify with this anything from the 'Whiterock' cephalopod faunas as I know them."

Conodonts; identified by J. W. Huddle (written commun., Jan. 13, 1966):

	Number of specimens
Drepanodus deltifer Lindström	2
homocurvatus Lindström	2
planus Lindström	6
n. sp. D	3
sp.	1
Histiodella sp.	1
Ligonodina sp.	1
Multioistodus aff. n. sp. Lindström, (1964, p. 80)	6

Conodonts—Continued	*Number of specimens*
Oistodus complanatus Lindström	1
lanceolatus Pander	1
sp	1
Paltodus sp	1
sp	1
sp	1
Periodon? sp	1
Scolopodus sp	1
Trichonodella? sp	1

D1580 CO. Antelope Valley Limestone, 1,081 ft below top of formation.

Brachiopods:

Orthidiella sp.

Orthambonites? (small, rotund species)

Plectambonitid, indeterminate (specimens poorly silicified, lack diagnostic features)

Trilobite:

Ectenonotus sp.

Conodonts; identified by J. W. Huddle (written commun., Jan. 13, 1966):

	Number of specimens
Drepandous aff. *D. expansus* Graves and Ellison	2
homocurvatus Lindström	10
cf. *D. planus* Lindström	3
n. sp. D	9
n. sp	1
sp	1
Multioistodus sp	3
N. gen. n. sp	25
Oistodus cf. *O. contractus* Lindström	1
lanceolatus Pander (*triangulata* type)	2
aff. *O. multicorrugatus* Harris	6
parallelus Pander	1
Oistodus? sp	1
Paltodus sp. 80	12
Scandodus sp	1
sp	1
quadraplicatus? Branson and Mehl	1
rex? Lindström	2

D1581 CO. Antelope Valley Limestone, 1,100 ft below top of formation.

Brachiopods:

Orthidiella costellata Cooper

longwelli Ulrich and Cooper

Orthambonites sp.

Ingria cf. *I. cloudi* Ulrich and Cooper

Conodonts; identified by J. W. Huddle (written commun., Jan. 13, 1966):

	Number of specimens
Drepanodus aff. *D. expansus* Graves and Ellison	8
planus Lindström	8
sp	1
sp	2
Histiodella sp	1
N. gen. n. sp	20
Oistodus cf. *O. abundans* Branson and Mehl	1
lanceolatus Pander	4
aff. *O. multicorrugatus* Harris	9
parallelus Pander	5
Oulodus? sp	1
Scolopodus quadraplicatus Branson and Mehl	1

D1582 CO. Antelope Valley Limestone, 1,162 ft below top of formation.

Brachiopods:

Orthidiella extensa Ulrich and Copper

longwelli Ulrich and Cooper

sp. indet.

Conodonts; identified by J. W. Huddle (written commun., Jan. 13, 1966):

	Number of specimens
Acodus sp	1
Drepanodus planus Lindström	4
cf. *D. planus* Linström	2
n. sp. D	18
sp	1
aff. *D. expansus* Graves and Ellison	8
Falodus? sp	1
Multioistodus sp	1
n. sp	21
Oepikodus cf. *O. equidentatus* Ethington and Clark	4
Oistodus complanatus Lindström	2
longiramus? Lindström	2
aff. *O. parallelus* Pander	2
sp	3
Paltodus sp	1
n. sp	3
sp.	2
Scandodus cf. *S. vulgaris* (Branson and Mehl)	2
sp	2
Scandodus? sp	2
Scolopodus cf. *S. triangularis* Ethington and Clark	8

D1583 CO. Antelope Valley Limestone, 1,272 ft below top of formation.

Brachiopods:

Orthidiella sp.

Orthambonites marshalli (Wilson) (described p. 54)

Anomalorthis n. sp. a (described p. 62)

Conodonts; identified by J. W. Huddle (written commun., Jan. 13, 1966):

	Number of specimens
Acontiodus sp	2
Cyrtoniodus sp	1
Drepanodus aff. *D. expansus* Graves and Ellison	1
n. sp. D	19
sp	1
sp	1
sp	1
sp	1
Histiodella? n. sp. B	1
N. gen. n. sp	12
Oepikodus cf. *O. equidentatus* Ethington and Clark	6
Oistodus complanatus Lindström	8
lanceolatus Pander (*triangularis* type)	6
aff. *O. multicorrugatus* Harris	6
sp	5
Paltodus sp	2
Paracordylodus sp	1
Scandodus sp	1
Scandodus? sp	5
Scandodus sp	1
Scolopodus striatolatus Harris and Harris	2

D1584 CO. Antelope Valley Limestone, 1,363 ft below top of formation.

Brachiopod:

Orthambonites marshalli (Wilson)

Trilobites:

Bathyurellus sp.

Raymondaspis sp.

Ectenonotus sp.

Conodonts; identified by J. W. Huddle (written commun., Jan. 13, 1966):

	Number of specimens
Acodus sp.	1
Acodus? sp.	1
Acontiodus sp.	1
Coelocerodontus? sp.	2
Drepanodus n. sp. D	10
sp	3
sp	2
sp. (also found in colln. D1583 CO)	3
sp	1
Histiodella? n. sp. B	10
N. gen. n. sp. (regular and irregular forms)	10
Oepikodus cf. *O. equidentatus* Ethington and Clark	5
Oistodus bilongatus Harris	3
complanatus Lindström	16
lanceolatus Pander (*triangularis* type)	14
aff. *O. multicorrugatus* Harris	17
sp	1
Oistodus?, freak	1
Paltodus sp. (same as seen in collns. D1582 CO, D1583 CO)	15
Scolopodus striatolatus Harris and Harris	9
n. sp. 8 Lindström	2

D1585 CO. Antelope Valley Limestone, 1,616 ft below top of formation; very close to base of formation, which is buried in alluvium.

Brachiopods:

Hesperonomia cf. *H. planidorsalis* Ulrich and Cooper

cf. *H. nemea* (Hall and Whitfield)

Trilobites:

Ptyocephalus sp.

Goniotelina sp.

Ischyrotoma sp.

Pseudomera sp.

Pseudocybele sp.

Conodonts; identified by J. W. Huddle (written commun., Jan. 13, 1966):

	Number of specimens
Drepanodus n. sp. D	2
Oistodus lanceolatus Pander (*triangularis* type)	4
sp	2
sp	1

AGE AND CORRELATION OF FOSSILS FROM THE SOUTHERN GROOM RANGE

Fossils collected from the section in the southern Groom Range seem to indicate several correlations with other sections. For instance, *Asymphylotoechia nolani* Ross, n. gen., n. sp., occurs here in collection D1572 CO and at Lone Mountain (p. 34, 36) in collections D375a CO and D1764 CO.

The assemblage in collection D1559 CO has a counterpart in the Pahranagat Range in collections D1662 CO, D1663 CO, and D1381 CO. This same assemblage probably correlates with collection D1812 CO to D1810 CO in the Steptoe section. The assemblage is of Marmor or younger age and is equivalent in age to the lower part of the Copenhagen Formation of the Monitor Range.

It may further be noted that *Bathyurus*, such as *B.* cf. *B. extans* in collection D1563 CO, is recognized as a Black River (Porterfield or younger) fossil.

Pelecypods in collections D1560 CO and D1571 CO were identified by John Pojeta, who commented, "In the eastern United States the oldest known specimens of *Ctenodonta* s. s. are from the Murfreesboro Limestone." The Murfreesboro is considered to be of Porterfield age.

J. W. Huddle (written commun., Jan. 13, 1966) identified conodonts and commented as follows concerning them:

All the collections here reported seem to be Middle Ordovician in age. Collection D1559 CO is probably Middle Ordovician in age but it could be early Upper Ordovician. The genus *Erismodus* in collection D1565 CO is indicative of Middle Ordovician age.

Collections D1569 CO to D1580 CO include abundant *Oistodus* and *Multioistodus*. *Chosodina*, *Acodus* sp. A, and a new genus all stop at the top of this zone. D1569 CO at the top of this zone of *Multioistodous* may be about equivalent to D1516 CO in Ikes Canyon. *Multioistodus* has previously been reported from the Dutchtown, Joins, Oil Creek, Burgen and Tyner Formations. The *Multioistodus* zone is probably early Middle Ordovician, but might be as young as Ashby.

Histiodella first appears in D1584 CO and continues up to D1578 CO. This genus was described from the Joins Formation and has not been reported from other localities yet. Presumably this part of the Antelope Valley Limestone is Whiterock in age. *Scolopodus rex* and *S. quadriplicatus*, however, have never before been reported from Middle Ordovician age rocks. They have been previously reported from the El Paso Limestone, Jefferson City, and Shakopee Dolomites. Perhaps additional collections will clear up some of these problems.

The *Orthidiella* zone encompasses collections D1584 CO up to D1579 CO in this section. The *Anomalorthis* zone is represented by collections from D1578 CO upward through D1564 CO.

HOT CREEK CANYON

The stratigraphic and structural setting of Hot Creek Canyon has been presented by Lowell (1965) in a concise and useful paper. In connection with the present study, a partial section was measured on the north side of Hot Creek Canyon in sec. 24, T. 8 N., R. 49 E. (Tonopah 1°×2° quad.). The measured part of the section includes only the Copenhagen Formation and the upper part of the Antelope Valley Limestone. The Eureka Quartzite, for which Lowell (1965, table 1) gave a thickness in this area of 280–365 feet, is enormously thicker than on the west side of Antelope Valley to the north.

Lowell (1965, p. 263) is of the opinion that all three members of the Copenhagen Formation are present at Hot Creek Canyon if a unit of dolomitic sandstone and quartzite is the same as the basal quartzite in the Monitor Range to the north. The basal units the author believes to be equivalent, but the upper member of the Copenhagen probably is not present at Hot Creek Canyon. The fossils obtained in collection D1860 CO only 20 feet below the top are the same as one finds over 120 feet above the base of the lower member in the type area. The thickening of the Eureka Quartzite seems to have taken place at the expense of the upper member of the Copenhagen.

Fossils collected to date from the section are not abundant, but a few like those in collection D1860 CO are highly significant. In the Antelope Valley Limestone no collections were obtained in the upper 99 feet; that interval requires further intensive search.

HOT CREEK CANYON SECTION

[On north side of canyon, sec. 24, T. 8 N., R. 49 E., Tonopah 1°×2° quad., Nevada]

	Feet
Eureka Quartzite—not measured. (Lowell, 1965, table 1)	280–365
Copenhagen Formation:	
Mostly covered; thin-bedded, silty limestone masked by quartzite talus. Colln. D1861 CO from top 6 in	21
Limestone; calcarenite in beds 1–2 in. thick Colln. D1860 CO 1 ft below top	2
Limestone, shaly and silty, irregularly bedded. Colln. D1486 CO from 3 ft above bottom of interval	13
Shale, fissile	8
Limestone, dolomitic, silty; weathers light olive gray mottled with orange	23
Sandstone and quartzite, dolomitic; weathers brownish orange	24
Total thickness of Copenhagen Formation	91
Copenhagen Formation? (transition beds):	
Siltstone, dolomitic, and sandstone, fine. Both light gray; weather pale yellowish gray. Thin bedded and finely laminated within beds	10
Fault of slight displacement.	
Pogonip Group:	
Antelope Valley Limestone:	
Limestone, dolomitic, and dolomite; both silty, resistant, thick bedded	50
Limestone, medium- to dark-gray, crudely laminated, silty; forms one massive unbedded cliff. Silicified pelecypods (*Ctenodonta* sp.) about 3 ft above base of interval	36
Limestone, light-gray; finely laminated within beds 2 ft thick, somewhat silty, interlayered with medium-gray limestone that is irregularly laminated with silty partings	4
Pogonip Group—Continued	
Antelope Valley Limestone—Continued	
Limestone, irregularly laminated, silty; weathers light to medium gray, splotched and streaked yellowish orange. Resistant. *Girvanella* in upper half. Colln. D1857 CO at 12 ft above base in float. D1858 CO at 36 ft above base. Colln. D1485 CO (*Orthambonites*, *Anomalorthis*) from 32–42 ft above base of interval. Colln. D1859 CO at 48 ft above base	58
Limestone, medium-gray; has silty irregular partings. Similar to underlying unit but more compact. Forms small cliff. Sponges fairly abundant. Colln. D1483 CO from 3 ft above bottom and D1484 CO from 3 ft below top of this interval. Colln. D1482 CO, from float lower in section, was derived from top of this interval	14
Limestone, thinly and crudely laminated; has abundant silty partings weathering yellowish orange. On gentle slopes breaks into nodular rubble. In 3- to 4-ft beds which are interlayered with 6-in to 1-ft beds of calcarenite. *Girvanella* in lower 100 ft. Colln. D1854 CO at 1 ft above base. Colln. D1479 CO at 23 ft above base. Large pliomerid and *Anomalorthis* 24 ft above base not collected. D1480 CO (*Anomalorthis*) 48–50 ft above base. Colln. D1855 CO at 79 ft above base. Colln. D1856 CO from float 113 ft above base. D1481 CO 131–135 ft above base. D1482 CO from float includes *Bathyurus* probably from 132 ft and *Anomalorthis* derived from next higher lithologic unit	168
Limestone, medium-gray, fine-grained, silty; has silt partings forming irregular yellowish-orange-weathering lines and splotches. *Girvanella* abundant. Colln. D1478 CO (*Anomalorthis*) at 17 ft above base	22
Limestone, very sandy; weathers brownish orange	1
Limestone, medium-gray, fine-grained, silty; has silt partings forming irregular yellowish lines and splotches. *Girvanella* overabundant. *Palliseria* 15 ft above base	37
Sandstone, fine-grained; and quartzose dolomitic crossbedded siltstone. Weathers brownish. (This unit is distinctive and can probably be used to tie this section into others in this canyon.)	18
Measured thickness of Antelope Valley Limestone	408

FOSSILS FROM THE HOT CREEK CANYON SECTION

Bryozoans from this section were studied by O. L. Karklins (June 22, 1965), sponge by R. M. Finks (Sept. 2, 1966), ostracodes by Jean Berdan (Apr. 7, 1967), and conodonts by J. W. Huddle (Jan. 14, 1966).

D1860 CO. Copenhagen Formation, 69 ft above base and 22 ft below Eureka Quartzite.

Brachiopods:

Valcourea cf. *V. transversa* Cooper

Dorytreta? sp.

Trilobites:
Isotelus cf. *I. spurius* Phleger
Remopleurides sp.
Lonchodomas sp.
Ceraurus? sp.
Illaenus sp.
Indet. sp. cf. *Goniophrys*
Ostracodes, abundant.

This assemblage has affinities with the McLish Formation and Mountain Lake Member (Cooper, 1956), of the Bromide Formation in Oklahoma.

D1486 CO. Copenhagen Formation, 58 ft above base (34 ft above top of basal sandstone).
Bryozoans:
Nicholsonella-like genus

"These specimens resemble *Nicholsonella*-like forms found in the McLish Formation and Bromide strata from Oklahoma. From the material available to me it seems that the resemblance is greater with the forms in the Bromide strata than with those in the McLish Formation. However, more specimens are needed to verify the similarity in morphology."

Conodonts:	*Number of specimens*
Dichognathus cf. *D. typica* Branson and Mehl	3
Drepanodus sp	1
Trichonodella? sp	1

D1859 CO. Antelope Valley Limestone, 100 ft below top of formation.
Anomalorthis oklahomensis Ulrich and Cooper
Plectorthis perplexus (Ross) (same as specimens from Rawhide Mountain, Ross, 1967a, p. D3–D4)

D1858 CO. Antelope Valley Limestone, 112 ft below top of formation.
Anomalorthis cf. *A. nevadensis* Ulrich and Cooper
Cybelopsis? sp. or *Pseudomera*? sp. (preservation very poor)
Perissopliomera maclachlani Ross, n. gen., n. sp.
Leperditiid ostracodes

D1485 CO. Antelope Valley Limestone, 126 ft below top.

Bryozoans:	*Number of specimens*
Trepostomes, probably batostomids	3

"These forms resemble batostomids from colln. D1510 CO, Ikes Canyon, and from collns. D1566 CO, D1577 CO, Pahranagat Range," according to Olgarts Karklins (written commun., June 22, 1965)

Brachiopods:
Orthambonites cf. *O. paucicostatus* Cooper
cf. *O. swanensis* Ulrich and Cooper
Anomalorthis nevadensis Ulrich and Cooper
Trilobites:
Illaenus sp.
Uromystrum? sp.
Basilicus sp.
Ostracodes:
Eoleperditia bivia (White)
Leperditella sp., has muscle spot and entrenched hinge

Conodonts:	*Number of specimens*
Acodus sp. (occurs in colln. D1525 CO in Ikes Canyon)	1
Acontiodus sp	2
Drepanodus homocurvatus Lindström	2
suberectus Branson and Mehl	2
Oistodus lanceolatus Pander	1
Paltodus sp. (occurs in colln. D1525 CO in Ikes Canyon)	2
n. sp	1
Panderodus n. sp. (occurs in colln. D1524 CO in Ikes Canyon)	1
sp.	1
Prioniodina sp	1
Scandodus sp	1

D1857 CO. Antelope Valley Limestone, in float 136 ft below top of formation.
Anomalorthis nevadensis Ulrich and Cooper
Basilicus mckeei Ross n. sp. (same species in colln. D1508 CO and D1511 CO at Ikes Canyon)
Illaenus sp.
Nileid? trilobite
Leperditiid ostracodes

D1484 CO. Antelope Valley Limestone, 151 ft below top.
Brachiopod:
Anomalorthis sp.
Trilobite:
Bathyurus acutus subsp. *angustus* Ross, n. subsp.
Ostracodes:
Eoleperditia bivia (White)
Small ostracodes, poorly preserved, indet.

D1483 CO. Antelope Valley Limestone, 159 ft below top.
Sponge:
Calycocoelia typicalis Bassler, 1927

"The specimens are fragmental and weathered, but the size and arrangement of spicules and pores are characteristic of this genus and species among the Pogonip sponges.

"The type locality and horizon of this species in the Antelope Valley Limestone (*Rhysostrophia*-zone of Cooper) at Ikes Canyon, Toquima Range, Nevada."

Brachiopods:
Anomalorthis? sp.
Aporthophyla? sp. or *Toquimia*? sp. (pedicle valves only but of large size like *T. kirki*)
Trilobites:
Bathyurus acutus subsp. *angustus* Ross, n. subsp.
Pseudomera? sp. (hypostome only)
Ostracodes:
Eoleperditia sp. cf. *E. bivia* (White), posterior not flattened
Leperditella sp. aff. *L. incisa* Harris
"*Paraschimdtella*"? sp.
Hyperchilarina? sp.
Cryptophyllus sp.

Conodonts:	*Number of specimens*
Acontiodus? sp	1
Drepanodus sp	1
sp	1
sp	1
Falodus prodentatus? (Graves and Ellison)	1

D1482 CO. Antelope Valley Limestone, from float collected 203–209 ft below top but believed to have been derived from beds 148 ft below top.
Brachiopod:
Anomalorthis nevadensis Ulrich and Cooper
Trilobite:
Bathyurus nevadensis Ross

Ostracodes:
Eoleperditia sp. cf. *E. bivia* (White), one small specimen
Schmidtella sp., ventral bend on smaller valve

D1481 CO. Antelope Valley Limestone, partly in place, partly float, both from beds 195–199 ft below top.
Trilobite:
Bathyurus nevadensis Ross
Ostracodes:
Eoleperditia bivia (White)
Small ostracodes, indet.

A part of colln. D1481 CO labeled "float" contains the following:
Eoleperditia bivia (White)
sp. cf. *E. bivia* (White), posterior not flattened
Leperitella sp. aff. *L. incisa* Harris
Schmidtella sp., small
Cryptophyllus? sp., one poor specimen
Ectoprimitia sp.
Monotiopleura? sp., see also colln. D1669 CO

D1856 CO. Antelope Valley Limestone, from float 217 ft. below top of formation.
Anomalorthis sp.
Orthambonites? sp.
Bathyurus cf. *B. extans* (Hall)
Uromystrum? sp.
Illaenus sp.
Leperditiid ostracodes

D1855 CO. Antelope Valley Limestone, 251 ft. below top of formation.
Cephalopod; identified by R. H. Flower (written commun., Aug. 6, 1967):
Wutinoceras cf. *W. huygenae* Flower

D1480 CO. Antelope Valley Limestone, 280–282 ft. below top.
Brachiopods:
Anomalorthis sp. (not *nevadensis* or *utahensis*)
Syntrophopsis? sp., possibly *Rhysostrophia?* sp., one very fragmentary specimen
Ostracode:
?*Eoleperditia bivia* (White), two crudely silicified specimens

Conodonts:	*Number of specimens*
Acodus sp.	1
Drepanodus cf. *Oistodus gracilis* Branson and Mehl	3
homocurvatus Lindström	1
suberectus Branson and Mehl	1
sp.	1
Bar fragment *Loxodus?*	1
Panderodus cf. *P. striolatus* Harris	2
Prioniodina sp.	1
sp.	3

D1479 CO. Antelope Valley Limestone, 307 ft. below base.

Bryozoans:	*Number of specimens*
Trepostomelike genus	5

"These forms may or may not be batostomid-like. Additional material is needed for more meaningful comparisons."

D1478 CO. Antelope Valley Limestone, 335 ft. below top.
Brachiopod:
Anomalorthis sp.
Trilobite:
Bathyurus sp. (same species in colln. D1816 CO at Steptoe)
Ostracodes:
Eoleperditia bivia (White)
Small ostracodes, poorly preserved, indet.

Conodonts:	
Drepanodus homocurvatus Lindström	1
Oistodus n. sp.	1
N. gen., n. sp.	1

AGE AND CORRELATION OF FOSSILS FROM HOT CREEK CANYON

Unfortunately no fossils were obtained from the upper 100 feet of the Antelope Valley Limestone; all collections made from the formation are within the *Anomalorthis* zone. The collections indicate probable correlation betweeen the *Rhysostrophia* zone at Ikes Canyon and the *Anomalorthis zone* at Hot Creek canyon; evidence of trilobites suggests a Marmor, Porterfield, or younger age for this part of the *Anomalorthis* zone.

Collection D1858 CO includes the same unusual *Pliomera*-like species, *Perissopliomera maclachlani*, n. gen., n. sp., that is in collection D299e CO on the west side of Antelope Valley. *Basilicus mckeei*, n. sp. is in collection D1857 CO indicating a correlation with collections D1508 CO–D1511 CO at Ikes Canyon. The two trilobites *Perissopliomera* and *Basilicus* suggest a Marmor, Porterfield or younger age.

Somewhat lower in collection D1483 CO a large brachiopod, represented by two pedicle valves, is either *Aporthophyla* or *Toquimia;* neither genus has previously been reported away from the Ikes Canyon area. Also included in collection D1483 CO with *Anomalorthis* is *Bathyurus acutus* subsp. *angustus* n. subsp., a trilobite also in collection D1814 CO at Steptoe; in D1814 CO it is associated with *Öpikina*, a Porterfield or younger genus (Cooper, 1956, p. 167–168).

Still lower in the section in collection D1481 CO *Bathyurus nevadensis* Ross is present, and in collection D1478 CO *Bathyurus* sp. is the same as that in collection D1816 CO at Steptoe, described on page 87 (pl. 16, figs. 15, 18). *Bathyurus* is a Black River (Porterfield) genus.

Conodonts identified by J. W. Huddle (written commun., Jan. 14, 1966) indicate a correlation between collection D1485 CO and collections D1524 CO and D1525 CO at Ikes Canyon, that is, with the type section of the *Rhysostrophia* zone. Bryozoans from collection D1485 CO are stated by O. L. Karklins (written commun., June 22, 1965) to resemble those from collection D1510 CO at Ikes Canyon.

R. H. Flower (written commun., 1967) stated that the genus *Wutinoceras* from collection D1855 CO is abundant in the *Palliseria* beds at Ikes Canyon, in the same zone at Meiklejohn Peak, and at Ibex, Utah, where it ranges upward into the Lehman Formation.

IKES CANYON, TOQUIMA RANGE

Since the 1930's the Ordovician rocks of Ikes Canyon have furnished abundant fossils of wide variety. Bassler (1941) described a large sponge fauna collected near the canyon. Ulrich and Cooper (1938) and Cooper (1956) obtained many of the brachiopods described from lower Middle Ordovician strata from this area. Kay (1962, p. 1422–1425) listed a varied assemblage of fossils collected from a section measured in a bluff south of the mouth of Ikes Canyon. Two years later Kay and Crawford (1964, p. 430–433, pl. 1) described several Ordovician formations and published a geologic map including the area of the canyon. It was on their geologic map (pl. 1) and on their plate 2, figure 2, that they designated hill 8474, half a mile northwest of the canyon's mouth, as Copper Mountain.

The section presented below was measured on the southeast side of hill 8474. The section is cut by several minor faults for which allowance must be made. The foot of the section is covered so that the contact of Antelope Valley Limestone with Stoneberger Shale of Kay and Crawford (1964) is masked.

The beds above the Antelope Valley Limestone proper include about 130 feet of strata below the Masket Shale of Kay and Crawford (1964) (= Roberts Mountains Formation). The lower 53 feet of this interval is classed here as questionable Antelope Valley Limestone. The upper 77 feet is dark gray and partly calcarenitic and seems to have been placed in the Diana Limestone by Kay and Crawford (1964, p. 439, pl. 1); on Copper Mountain they mapped Silurian Diana Limestone above Antelope Valley and below Masket Shale (= Roberts Mountains Formation).

The trilobites and conodonts collected from this unit (USGS collns. D1526 CO, D1611 CO, D1506 CO, and D1525 CO) are of late Middle or Late Ordovician age. To date I have found no exactly comparable fossil assemblage to the east. The age suggests that this unit is equivalent to the uppermost Copenhagen Formation or the lower part of the Hanson Creek. If such a correlation is correct, the contact below this unnamed Ordovician unit and above the Antelope Valley Limestone is disconformable and may represent (1) the same unconformity that exists between lower and upper parts of the Copenhagen in the Antelope Valley area, or (2) an unconformity beneath the Hanson Creek beds beneath which the Eureka and most of the Copenhagen beds are missing.

Although the three members of the Antelope Valley Limestone can be recognized, the entire formation is more silty and muddy than in the Monitor Range to the east. The Eureka Quartzite is absent.

IKES CANYON, TOQUIMA RANGE, SECTION

["Copper Mountain" of Kay and Crawford (1964), north of Ikes Canyon, one-half mile northwest of canyon's mouth. Section on southeast side of hill 8474. Nevada coords., east zone: E. 173,700 ft, N. 1,569,200 ft]

	Feet
Silurian:	
Roberts Mountains Formation (equals Masket Shale of Kay and Crawford, 1964, p. 439).	
Ordovician:	
Unnamed formation (equals Silurian Diana Limestone of Kay and Crawford, 1964, mapped at this locality).	
Limestone, dark-gray, finely calcarenitic; in 10-in. beds, has 3-in. interbeds of argillaceous limestone. Colln. D1526 CO from top and middle of unit	30
(The above unit may represent a faulted block equal to the top of the unit listed below. Exposed on west side of section near ridge crest.)	
Limestone, fine-grained to finely calcarenitic. Calcarenite highly fossiliferous. Colln. D1506 CO from this unit	45
Total thickness of unnamed formation	75
Pogonip Group:	
Antelope Valley(?) Limestone:	
Limestone, thin-bedded, evenly bedded; beds 1–6 in. thick, has fine laminae within beds. Color dark gray; brownish-orange sandy lenses and laminae. A fault-and-gouge zone crosses this interval 19–32 ft above base. Colln. D1525 CO 16 ft above base	53
Antelope Valley Limestone:	
Limestone, very silty, thin-bedded, slabby; forms weak slope, weathers yellowish orange to grayish yellow. Colln. D1507 CO has *Leptellina* in top 2 ft	66
Limestone, silty, compact, massive, medium-gray, cliff-forming. Colln. D1610 CO from top	29
Limestone, silty, slabby; in beds 2–4 in. thick. Colln. D1508 CO from top 4 ft of this interval	9
Limestone; more evenly laminated and less silty than above or below. Colln. D1609 CO, 7 ft above base	16
Limestone; alternating layers of rubbly, nodular silty and compact silty limestone, forms cliff. Colln. D1509 CO at base and colln. D1524 2 ft below top. *Rhysostrophia, Valcourea?*	42
Limestone, thin-bedded to nodular, silty; weathers to grayish-orange and yellowish-gray slopes having protruding ledges. Colln. D1523 CO, 5 ft above base	10

Ordovician—Continued
Pogonip Group—Continued
Antelope Valley Limestone—Continued

	Feet
Limestone, finely crystalline; thick bedded in 4- to 8-ft beds, beds composed of irregular laminae; interbedded with limestone, silty, nodular, weak, partly slabby, in beds 3–10 ft thick. Colln. D1511 CO from 35 ft above base; colln. D1510 CO from 73 ft above base. Colln. D1522 CO from float at bottom of this interval to show what must come from higher in section	77
Limestone, silty, thin-bedded, not nodular. Colln. D1521 CO from 1 to 10 ft above base of interval	23
Limestone, finely crystalline; medium gray, has irregular silty partings weathering yellowish gray. Bedding inconspicuous, massive. *Girvanella*. Large gastropods (*Palliseria*?)	17
Limestone, nodular, silty	8
Limestone, crystalline, medium-gray; in beds 1–3 ft thick; abundant cephalopods, *Girvanella*	5
Limestone, nodular and irregularly laminated, very silty, weathers yellowish gray and yellowish orange	18
Limestone, finely crystalline; has large *Maclurites*. Colln. D1608 CO (cephalopods)	3
Limestone, very silty, nodular; in beds 1–3 in. thick. Colln. D1513 CO from 10 ft above base	17
Limestone, finely crystalline; in beds 1–8 ft thick, composed of 3- to 12-in. layers. Abundant relict fossils. *Girvanella*	21
Limestone interbeds of thinly laminated dark-gray limestone and silty irregularly laminated, nodular, "crepe"—structure limestone with chert nodules	23
Limestone, resistant; in 2- to 4-ft beds, composed of irregular laminae 1–3 in. thick, separated by silty partings that produce "crepe" effect. Silty partings weather yellowish orange. Abundant large gastropods (*Palliseria*) as well as numerous small high-spired gastropods. Colln. D1607 CO at 48 ft above base (cephalopods, brachiopods)	53
Limestone, fine-grained, thin-bedded to slabby or nodular, silty; has interbeds of more resistant and more compact silty calcarenite. Sponges in upper 60 ft. Colln. D1514 CO at 234 ft above base. Colln. D1605 CO 199 ft above base. Colln. D1606 CO 214 ft above base. Colln. D1516 CO at 139 ft above base. Colln. D1517 CO at 100 ft above base. Colln. D1518 CO at 69 ft above base. Colln. D1519 CO at 43 ft above base. Colln. D1520 CO at base of measurement	313
Limestone, very thin bedded, partly silty; in layers 1–3 in. thick, interbedded with thin layers of fissile shale. Limestone weathers medium gray; silty parts and shale weather grayish orange. Very slabby and platy float results from this unit. A minor fault cuts section 145 ft above base. Colln. D1603 CO from 44 ft above base. Colln. D1602 CO from 35–36 ft above base. Colln. D1604 CO 71–73 ft above base. Also cephalopods collected by Flower 8 ft below colln. D1520 CO which is 177 ft above base. Thickness of this unit	185
Limestone, coarse calcarenite, forms resistant ledge approximately 15 ft thick. This unit overlies Stoneberger Shale of Kay and Crawford (1964)	approx 15
Total thickness of Antelope Valley Limestone	950

FOSSILS FROM THE IKES CANYON SECTION

As indicated previously this section is overlain by the Silurian Roberts Mountains Formation (Masket Shale of Kay and Crawford, 1964).

D1526 CO. Unnamed formation (Diana Limestone of Kay and Crawford, 1964), 115–128 ft above top of Antelope Valley Limestone, and approximately 30 ft below base of Roberts Mountains Formation.
- Brachiopods:
  - *Paucicrura* sp.
  - *Oxoplecia*? sp.
- Trilobites:
  - *Astroproetus* sp.
  - *Brongniartella* sp.
  - *Whittingtonia*? sp.
  - *Encrinuroides* sp.
- Ostracodes; identified by Jean Berdan (written commun., Apr. 28, 1967):
  - *Parenthatia*? sp.
  - *Ectoprimitia*? sp., one specimen, broken
  - *Platybolbina* sp. B
  - Ostracodes, smooth, undet.
- Conodonts; identified by J. W. Huddle (written commun., Jan. 20, 1966, and Apr. 25, 1967) indicate a Middle Ordovician age and include:
  - *Amorphognathus ordovicica* Branson and Mehl
  - *Scolopodus insculptus* (Branson and Mehl)
  - *Periodon grandis* Ethington

D1506 CO. Unnamed limestone formation (Diana Limestone of Kay and Crawford, 1964), 60–90 ft above top of Antelope Valley Limestone.
- Brachiopods:
  - *Leptaena* cf. *L. ordovicica* Cooper
  - *Zygospira*? sp.
  - Genus and species indet. (see p. 70, pl. 9, fig. 26)
  - *Paucicrura*? sp. or other dalmanellid

Trilobites:
Brongniartella sp.
Encrinuroides sp.
Astroproctus sp.
Ostracodes; listed by Jean Berdan (written commun., Apr. 28, 1967):
Parenthatia? sp.
Schmidtella sp., small, long
Schmidtella? sp., marked overreach
Bythocypris? sp.
Ostracodes, small, smooth, indet.
Conodonts; listed by J. W. Huddle (written commun., Jan. 20, 1966, and Apr. 25, 1967):

	Number of specimens
Acodus sp	1
Mutatus? (Branson and Mehl)	5
Amorphognathus ordovicica Branson and Mehl	5
Distacodus sp	1
Drepanodus suberectus (Branson and Mehl)	1
Periodon aculeatus Hadding	6
Panderodus intermedius? (Branson, Mehl, and Branson)	1
cf. *P. similis* Rhodes	2
Polyplacognathus sp	3
Scandodus? *disimilaris* (Branson and Mehl)	2
Scolopodus insculptus (Branson and Mehl)	43

The presence of *Polyplacognathus* and the kind of *Periodon aculeatus* suggest a Middle Ordovician age for this collection. Several of the species in this fauna occur as high as the Thebes Sandstone in Illinois and Missouri and the Maravillas Chert of Texas. Although collection D1506 CO is probably Middle Ordovician, it might be as young as Richmond, but is unlikely that it could be as young as Early Silurian.

D1525 CO. Antelope Valley? Limestone.
16 ft above top of Antelope Valley Limestone.
Pelecypods:
Ctenodonta sp.
Ostracodes, listed by Jean Berdan (written commun., Apr. 28, 1967):
?*Eoleperditia bivia* (White), one incomplete specimen
Leperditella? sp., small, hinge not entrenched, no ventral overlap
Pinnatulites? sp.
Milleratia? sp., one specimen
Eridoconcha sp., one specimen
Ostracodes, small sulcate, indet.
Conodonts; listed by J. W. Huddle (written commun., Jan. 13, 1966, and Apr. 25, 1967):

	Number of specimens
Acontiodus cf. A. rectus Lindström	1
sp.	1
Drepanodus suberectus (Branson and Mehl)	13
Oistodus parallelus Pander	2
Paltodus n. sp	1
Rhipodognathus? n. sp	3
Scandodus sp	2

Rhipodognathus has been found only in Middle and Upper Ordovician rocks. *Paltodus* n. sp. and *Scandodus* sp. occur in upper part of Antelope Valley Limestone.

D1507 CO. Antelope Valley Limestone, from top 2 ft of formation (933–935 ft above top of basal calcarenite).
Brachiopods:
Toquimia cf. *T. kirki* Ulrich and Cooper
Orthambonites bifurcatus Cooper
Leptellina occidentalis Ulrich and Cooper
Taphrodonta parallela Cooper
Trilobites:
Nileus sp.
Pygidium, indet. (p. 73, pl. 11, fig. 3)
Rhomboporidlike bryozoan
Ostracodes; listed by Jean Berdan (writen commun., Apr. 28, 1967):
?*Eoleperditia* sp. cf. *E. bivia* (White), posterior not flattened. This is a very small collection and the specimens are fragmentary.

D1610 CO. Antelope Valley Limestone, 66 ft below top.
Brachiopod:
Toquimia? sp.

D1508 CO. Antelope Valley Limestone, 95–99 ft below top.
Brachiopods:
Toquimia kirki Ulrich and Cooper
Orthambonites cf. *O. bifurcatus* Cooper
Valcourea sp.
Hesperomena leptellinoidea Cooper
Trilobites:
Illaenus sp.
Basilicus mckeei Ross, n. sp. (same as in D1857 CO).
Ostracodes, listed by Jean Berdan (written commun., Apr. 28, 1967):
Eoleperditia sp. cf. *E. bivia* (White), posterior not flattened.
Ostracodes, smooth, poorly preserved, indet.
Conodonts; listed by J. W. Huddle (written commun., Jan. 13, 1966):

	Number of specimens
Acontiodus n. sp. A	2
Amorphognathus ordovicica (Branson and Mehl)	1
Distacodus sp	1
Drepanodus suberectus (Branson and Mehl)	1
Oistodus sp	2
Scandodus sp	2

D1609 CO. Antelope Valley Limestone, 113 ft below top.
Ostracodes, listed by Jean Berdan (written commun., Apr. 28, 1967):
Eoleperditia sp. cf. *E. bivia* (White), posterior not flattened
Leperditella sp., medium to large sized, entrenched hinge, inflated venter
Macrocyproides sp.
Krausella sp.
Ostracodes, small, indet.

D1524 CO. Antelope Valley Limestone, 122 ft below top.
Brachiopods:
Valcourea intracarinata Ulrich and Cooper
Ostracodes; listed by Jean Berdan (Apr. 28, 1967):
Eoleperditia sp. cf. *E. bivia* (White), posterior not flattened
Ostracodes, small, indet.

Conodonts; listed by J. W. Huddle (written commun., Jan. 13, 1966):

	Number of specimens
Acodus sp.	1
cf. *A. gladiatus* Lindström	3
Acontiodus n. sp. A (same as above in colln. D1508 CO)	12
Drepanodus suberectus	3
Loxodus sp.	1
Oneotodus sp.	1
Paltodus? sp.	1
Scandodus n. sp.	1

D1509 CO. Antelope Valley Limestone, 162 ft below top.
Brachiopods:
Rhysostrophia nevadensis Ulrich and Cooper
Orthambonites occidentalis Cooper
Indet. plectambonitid
Toquimia? sp.
Trilobites:
Illaenus cf. *I. alveatus* Raymond
Ostracodes; listed by Jean Berdan (written commun., Apr. 28, 1967):
Eoleperditia sp. cf. *E. bivia* (White), posterior not flattened
Ostracodes, small, indet.

D1523 CO. Antelope Valley Limestone, 167 ft below top.
Brachiopods:
Rhysostrophia occidentalis Ulrich and Cooper
Toquimia kirki Ulrich and Cooper
Valcourea intracarinata Ulrich and Cooper
Trilobites:
Illaenus sp.
Pseudomera sp.
Ostracodes; listed by Jean Berdan (written commun., Apr. 28, 1967):
Eoleperditia sp. cf. *E. bivia* (White), posterior not flattened
Isochilina sp.
Platybolbina sp. A
Cryptophyllus sp.
Sp. indet., smooth, has ventral lobe.

D1510 CO. Antelope Valley Limestone, 176 ft below top of formation.
Brachiopods:
Orthambonites paucicostatus Cooper
bifurcatus Cooper
Plectambonitid, indet.
Trilobites:
Pseudomera cf. *P. barrandei* (Billings)
Batostomid bryozoans similar to those from collns. D1566 CO, D1577 CO (in Groom section), D1485 CO at Hot Creek
Ostracodes; listed by Jean Berdan (written commun., Apr. 28, 1967):
Eoleperditia sp. cf. *E. bivia* (White), posterior not flattened
Leperditella sp., large, marked ventral overlap
sp. aff. *L. incisa* Harris
Leperditella? sp., small, hinge not entrenched, no ventral overlap
Aparchites sp.
Hyperchilarina? sp.
Platybolbina sp. A
Ectoprimitia? sp. B
Macrocyproides sp.
Krausella sp.

D1511 CO. Antelope Valley Limestone, 214 ft below top of formation.
Brachiopods:
Valcourea intracarinata Ulrich and Cooper
Rhysostrophia n. sp.
Orthambonites paucicostatus Cooper
minusculus (Phleger)
Toquimia kirki Ulrich and Cooper (some specimens may be rafinesquinid; see p. 64)
Toquimia? sp.
Plectambonitid, indet.
Trilobites:
Pseudomera cf. *P. barrandei* (Billings)
Basilicus mckeei Ross, n. sp.
Ostracodes; listed by Jean Berdan (written commun., Apr. 28, 1967):
Eoleperditia sp. cf. *E. bivia* (White), posterior not flattened
Leperditella sp., large, marked ventral overlap
sp., small, little ventral overlap
sp. aff. *L. incisa* Harris
Aparchites sp.
Hyperchilarina? sp.
Platybolbina sp. A
Ectoprimitia sp. B
Macrocyproides sp.

D1521 CO. Antelope Valley Limestone, 262–271 ft below top and 664–673 above top of basal calcarenite.
Brachiopod:
Taphrodonta? sp.

D1608 CO. Antelope Valley Limestone, 320–323 ft below top and 612–615 ft above top of basal calcarenite.
Gastropods:
"*Maclurites*" sp. indet.
Murchisonia (?*Hormotoma*) sp. indet.

D1513 CO. Antelope Valley Limestone, 330 ft below top of formation. (Colln. D1655 CO from "Caesar Canyon" correlates with this collection.)
Receptaculitids
Brachiopods:
Desmorthis cf. *D. crassus* Ross, n. sp. (Compare with colln. D1573 CO in Groom section)
Orthambonites minusculus (Phleger)
Aporthophyla typa Ulrich and Cooper
Plectambonitid, indet.
Gastropods, fragmentary:
Maclurites? sp.
Conodonts; listed by J. W. Huddle (written commun., Jan. 13, 1966):

	Number of specimens
Acodus n. sp.	1
Acontiodus cf. *A. rectus* Lindström	1
Cordylodus? n. sp.	1
Drepanodus pandus? Branson and Mehl	1
proetus Lindström	1
subarcuatus Furnish	1
suberectus (Branson and Mehl)	5
Oistodus forceps Lindström	1
lanceolatus Pander (*O. triangularis* type)	5
aff. *O. multicorrugatus* Harris	2
parallelus Pander	3
sp.	1
Panderodus sp.	1

Conodonts—Continued

	Number of specimens
Scandodus cf. *S. vulgaris* (Branson and Mehl)	3
sp.	1
Scandodus? sp.	1
Scolopodus giganteus Sweet and Bergström	1

D1607 CO. Antelope Valley Limestone, 389 ft below top of formation.

Brachiopod:

Aporthophyla typa Ulrich and Cooper.

D1514 CO. Antelope Valley Limestone, 516 ft below top of formation.

Sponges:

Nevadacoelia wistae Bassler

Calycocoelia typicalis Bassler

Gastropod:

Clisospira sp.

Brachiopods:

Orthidium cf. *O. bellulum* Ulrich and Cooper

Orthidiella? sp.

Orthambonites minusculus (Phleger)

Syndielasma biseptatum Cooper

Taphrodonta sp., immature

Trilobites:

Remopleurides sp.

Ischyrotoma sp.

Goniophrys? sp.

Xystocrania cf. *X. perforator* (Billings)

Cydonocephalus sp.

Pseudomera cf. *P. barrandei* (Billings)

Protocalymene sp.

Ectenonotus cf. *E. westoni* (Billings)

Ostracodes; listed by Jean Berdan (written commun., Apr. 28, 1967):

Eoleperditia bivia (White)

Leperditella sp. aff. *L. tumida* (Ulrich), large, entrenched hinge

sp. aff. *L. incisa* Harris

Aparchites sp.

Hyperchilarina? sp.

Schmidtella? sp., medium-sized, ventral bend

Ectoprimitia? sp. A

D1606 CO. Antelope Valley Limestone, 536 ft below top of formation.

Sponge

Brachiopod:

Taphrodonta sp.

Trilobites:

Illaenus sp.

Nileus sp.

Pseudomera cf. *P. barrandei* (Billings)

Xystocrania cf. *X. perforator* (Billings)

Cybelid, indeterminate, possibly *Miracybele*, cranidium.

Kawina? sp. (gigantic form)

Encrinurid

Ostracodes; listed by Jean Berdan (written commun., Apr. 28, 1967):

Eoleperditia bivia (White)

Leperditella sp. aff. *L. tumida* (Ulrich), large

sp. aff. *L. incisa* Harris

Schmidtella sp.

Macrocyproides? sp.

Ostracode, small, sulcate, indet.

Conodonts; listed by J. W. Huddle (written commun., Apr. 21, 1967):

	Number of specimens
Acodus sp.	1
sp.	1
sp.	1
Drepanodus subercctus (Branson and Mehl)	5
Oistodus forceps Lindström	3
Periodon aculeatus? Hadding *ligonodina* element	1
falodus element	1

Probably Middle Ordovician.

D1605 CO. Antelope Valley Limestone, 551 ft below top of formation.

Brachiopods:

Orthambonites minusculus (Phleger)

Syndielasma sp. (cf. *S. biseptatum* Cooper)

Trilobite:

Protocalymene sp.

D1516 CO. Antelope Valley Limestone, 611 ft below top of formation.

Sponge:

cf. *Calycocoelia typicalis* Bassler (identified by R. M. Finks)

Brachiopods:

Orthambonites minusculus (Phleger)

Syndielasma sp. (cf. *S. biseptatum* Cooper)

Trilobites:

Pseudomera sp.

Nileus sp.

Kawina? sp. (gigantic form) = *Niezkowskia*?

Pelecypod:

Ctenodonta? sp.

Gastropods:

Loxoplocus (*Lophospira*) sp.

Clathrospira sp.

Trochonema (*Trochonema*) sp.

Ostracodes; listed by Jean Berdan (written commun., Apr. 28, 1967)

Eoleperditia bivia (White), sharp anterior end

Leperditella sp.

Schmidtella sp., quite large

Ostracode, small, sulcate, indet.

Conodonts; listed by J. W. Huddle (written commun., Jan. 13, 1966):

	Number of specimens
Acodus n. sp	5
Drepanodus subercctus (Branson and Mehl)	8
cf. *D. cyranoicus* Lindström	1
cf. *D. proetus* Lindström	2
Multioistodus sp	1
Oistodus lanceolatus Pander	3
venustus Stauffer	8
Oneotodus sp	1
Periodon aculeatus Hadding	5
"*Roundya*" *pyramidalis* Sweet and Bergström	1
Scolopodus giganteus Sweet and Bergström	2
varicostatus Sweet and Bergström	3
Trichonodella sp	1

The three species described by Sweet and Bergström came from the Pratt Ferry Limestone (Cooper, 1956) of Porterfield age.

D1517 CO. Antelope Valley Limestone, 650 ft below top of formation.

Brachiopods:

Orthambonites minusculus (Phleger)

Aporthophyla typa Ulrich and Cooper

Trilobites:

Pseudomera sp.

Kawina? sp. (gigantic form) = *Niezkowskia?*

Nileus sp.

D1518 CO. Antelope Valley Limestone, 681 ft below top of formation.

Sponge:

Calycocoelia typicalis Bassler

Brachiopods:

Orthambonites minusculus (Phleger)

Orthidium sp.

Taphrodonta parallela Cooper

Anomalorthis sp., brachial valve only

Gastropods:

Maclurites sp.

Trilobites:

Carolinites sp.

Nileus hesperaffinis Ross

Cydonocephalus sp.

Protocalymene sp.

Ectenonotus sp.

Pseudomera sp.

Ostracodes, listed by Jean Berdan (written commun., Apr. 28, 1967)

Eoleperditia sp. aff. *E. bivia* (White), small, has small prongs

Schmidtella? sp., medium-size, nearly circular

Schmidtella? sp., large

Hyperchilarina? sp.

Ostracodes, small, sulcate, poorly preserved, indet.

Conodonts; listed by J. W. Huddle (written commun., Jan. 13, 1966):

	Number of specimens
Acodus sp	2
Acontiodus sp	1
Drepanodus suberectus (Branson and Mehl)	3
Oistodus parallelus Pander	2
venustus Stauffer	3
Periodon aculeatus Hadding	7

D1519 CO. Antelope Valley Limestone, 707 ft below top of formation.

Brachiopod:

Orthambonites minusculus (Phleger)

Primitive crinoid-like specimen

Pelecypod:

Deceptrix sp. (cf. *Ctenodonta levata* group)

Trilobite:

Ectenonotus sp.

Conodonts; listed by J. W. Huddle (written commun., Jan. 13, 1966):

	Number of specimens
Amorphognathus ordovicica Branson and Mehl	1
Chosonodina? lunata Harris	1
Coleocerodontus? sp	1
Drepanodus suberectus (Branson and Mehl)	13
Oistodus venustus Stauffer	7
sp	1
Polyplacognathus n. sp	1

Conodonts—Continued

	Number of specimens
Scolopodus giganteus? Sweet and Bergström	1
Trichonodella sp	1

"*C.? lunata* was described from the West Spring Creek Formation in Oklahoma. *Amorphognathus* has never been found in rocks older than Llanvirnian in Europe and the Edinburg Formation (of Cooper, 1956) in the Appalachians."

D1520 CO. Antelope Valley Limestone, 750 ft below top of formation.

Brachiopods:

Orthambonites minusculus (Phleger), silicified

Aporthophyla typa Ulrich and Cooper

Pelecypod:

Deceptrix sp. (cf. *Ctenodonta levata* group)

Gastropod:

Maclurites sp.

Trilobites:

Nileus hesperaffinis Ross

Peraspis erugata Ross, n. sp.

Pseudomera sp.

Niobe cf. *N. quadraticaudata* (Billings)

Remopleurides sp.

Illaenus sp., has pits in anterior border furrow

Ectenonotus whittingtoni Ross

Protocalymene sp.

Conularids

Ostracodes; listed by Jean Berdan (written commun., Apr. 28, 1967):

Eoleperditia bivia (White)

Isochilina sp.

Leperditella? sp., large

Leperditella sp. aff. *L. incisa* Harris

Schmidtella sp.

Macrocyproides sp.

Ostracode, small with dorso-median pit, indet.

Conodonts; listed by J. W. Huddle (written commun., Jan. 13, 1966):

	Number of specimens
Acontiodus cooperi Sweet and Bergström	1
n. sp	1
Drepanodus suberectus (Branson and Mehl)	15
Multioistodus multicorrugatus Harris	1
Oistodus forceps Lindström	3
lanceolatus Pander	2
parallelus Pander	1
Periodon aculeatus Hadding	13
Polyplacognatus n. sp.	1
Scolopodus varicostatus Sweet and Bergström	9
Scolopodus? sp	1

"The presence of *Scolopodus varicostatus*, *S. giganteus*, *Peridon aculeatus* in D1518 CO to D1520 CO suggest a younger age (Porterfield) than is indicated by the trilobites and brachiopods (Whiterock). Possibly the range of these conodonts is greater than was previously known. D1516 CO is at the top of the *Multioistodus* zone and may be about the same horizon as D1569 CO (at Groom section)."

D1604 CO. Antelope Valley Limestone, 862–864 ft below top of formation.

Cephalopods; identified by R. H. Flower (1968b):

Leonardoceras parvum Flower

Bactroceras wilsoni Flower

Michelinoceras wilsoni Flower

Gastropods:

E. L. Yochelson (written commun., Nov. 7, 1967) stated: "Collection D1604 CO contains one steinkern with a shape much like *Trochonema*?. I have used this name in connection with specimens collected in the Franklin Mountains, Texas, in a 5–6 foot interval below the Montoya, but differing in lithology from the underlying El Paso Limestone. A second steinkern is that of a small slowly expanding macluritacean. This form is congeneric, and possibly conspecific, with specimens collected by R. H. Flower from an informal unit at the very top of the El Paso or in an overlying thin bed. The third specimen is a low-spired steinkern which could be that of a *Helicotoma*. It is impossible with this sample to draw any meaningful conclusion as to precise age, though I would incline a bit more toward an earliest Middle Ordovician age than toward a latest Early Ordovician age."

Bryozoans indet.

Graptolite:

Holmograptus? sp. (identified by W. B. N. Berry)

Poor trilobites

D1603 CO. Antelope Valley Limestone, lower member, 891 ft below top of formation, 44 ft above top of basal calcarenite.

Trilobite:

Peraspis erugata Ross, n. sp.

Nileus? sp.

Perischoclonus sp.

aff. *Miracybele* sp. 1 (Ross, 1964a, p. C20–C21; 1967a, p. D25, pl. 8, figs. 23–25, D727 CO)

Conodonts: listed by J. W. Huddle (written commun., Apr. 21, 1967):

	Number of specimens
Drepanodus suberectus (Branson and Mehl), type element	4
homocurvatus element	2
Oistodus lanceolatus Pander *accuminatus* type	1
triangularis element	2
Oistodus venustus Stauffer	13
Periodon aculeatus Hadding, type element	9
cordylodus element	7
ligonodina element	7
falodus prodentatus element	7
ozarkodina macrodentata element	3
Polyplacognathus sp	2
"*Roundya*" *pyramidalis* Sweet and Bergström	1
Scandodus sp	1
Scolopodus varicostatus Sweet and Bergström	3

"There is nothing very distinctive in this collection. Probably early Middle Ordovician."

D1602 CO. Antelope Valley Limestone, 899–900 ft below top of formation.

Brachiopod:

Aporthophyla? sp., very questionable

Trilobites:

Carolinites sp.

Peraspis sp. (cf. *P. erugata* Ross, n. sp.)

Nileus sp.

Pliomerid

Cydonocephalus sp.

Conodonts; listed by J. W. Huddle (written commun., Apr. 21, 1967):

	Number of specimens
Acontiodus cooperi Sweet and Bergström	1
Drepanodus suberectus (Branson and Mehl) (two elements)	3
Oistodus cf. *O. lanceolatus* Pander	1
Oulodus? sp	1
Scandodus cf. *S. unicostatus* Sweet and Bergström	1
Scolopodus giganteus Sweet and Bergström	3
varicostatus Sweet and Bergström	3

"Several of these species were described from the early Porterfield Pratt Ferry Formation in Alabama. Some of these species have been found in the Antelope Valley Limestone in beds you regard as Whiterock in age.

"Evidently the ranges of these conodont species are not established."

AGE AND CORRELATION OF FOSSILS FROM IKES CANYON, TOQUIMA RANGE

The preceding lists of fossils include mainly trilobites, brachiopods, ostracodes, and conodonts and are up to date as of April 28, 1967.

Bryozoans in D1510 CO, conodonts in D1524 CO and D1525 CO, trilobites in D1508 CO and D1511 CO, and ostracodes in D1510 CO and D1523 CO indicate a close correlation of the uper 220 feet of the Antelope Valley Limestone at Ikes Canyon with the interval 100–170 ft. below the top at Hot Creek Canyon.

Jean Berdan examined ostracodes collected from the Ikes Canyon section and commented (written commun., Apr. 28, 1967),

The ostracodes from these collections do not agree too well with those from other measured sections of the upper part of the Antelope Valley. The more distinctive forms such as *Ballardina* and *Monotiopleura*? have not been found in any of these collections, but two other genera, *Aparchites* and *Platybolbina*, which have not been found in any other collections of Antelope Valley, appear 516 feet below the top and 214 feet below the top, respectively. *Aparchites* is common in the type Chazy around Chazy, New York, and *Platybolbina*, which may be a junior synonym of *Apatochilina* Ulrich, has been reported from beds considered to be of Black River age in Michigan. As a very tentative and hesitant guess, and bearing in mind that the ranges of ostracodes in this part of the section are very poorly known, I would think that possibly the lower collections from Ikes Canyon, up to USGS D1514–CO, may be about equivalent to the upper collections from other sections, and collections including USGS D1514–CO and above may be younger than any I have seen to date.

There does not appear to be any abrupt change in the ostracode associations up through the Antelope Valley Limestone, except for the appearance of *Aparchites* and *Platybolbina* already noted. Above USGS D1523–CO, 167 feet below the top, the ostracode fauna is very poor, and good specimens are hard to come by. However, the ostracodes from the "Diana Limestone" of Kay and Crawford (1964) appear to be distinctly different from those in the Antelope Valley.

As yet, *Eoleperditia bivia* and its varieties cannot be used for detailed correlation. The variety in which the posterior end lacks the characteristic flattened brim appears to come in higher in the sections studied, but typical *E. bivia* may occur above it, and I don't trust any of them.

The trilobites of collection D1514 CO link it to the "white boulder" at Lower Head, Newfoundland (Whittington, 1963), and the brachiopods and trilobites tie it to beds well within the *Orthidiella* zone of the Nevada Test Site and Meiklejohn Peak.

The ostracodes of collection D1511 CO, according to Jean Berdan, seem to be of Black River age. Collections D1510 CO and D1523 CO include ostracodes nearly identical to those of collection D1483 CO at Hot Creek Canyon. Brachiopods of these collections include *Valcourea* and *Rhysostrophia* as well as *Toquimia;* this is the *Rhysostrophia* zone of Cooper (1956).

J. W. Huddle's analysis of conodonts indicates that collections as low as D1519 CO, D1520 CO, and D1602 CO, have Porterfield (Pratt Ferry) affinities.

Commenting on the pelecypods from collections D 1519 CO and D1520 CO, John Pojeta stated: "The oldest known undoubted species of the group reported from the eastern United States are from the Decorah Shale."

Kay (1962, p. 1424) reported *Orthidiella* at Ikes Canyon from beds stratigraphically below collection D1602 CO. It may be present in collection D1514 CO. Otherwise, the genus is not known at this locality. Trilobites identified by H. B. Whittington and stated to be associated with *Orthidiella* by Marshall Kay include "*Cybele* cf. *C. myra*" (equals aff. *Myracybele* of colln. D1603 CO), *Ectenonotus*, *Illaenus*, *Nileus*, aff. *Perischoclonus*, *Pseudomera*, and *Remopleurides*. These trilobites are a mixture of forms found in collections D1602 CO and D1603 CO with others found in collections as high as collection D1514 CO at the top of the range of *Ectenonotus*. This includes at least some of the strata assigned by Kay (1962, p. 1422, 1424, table 2, d) to the "sponge beds." In other sections (Ross, 1967a, pl. 11) at the Nevada Test Site and Meiklejohn Peak, the trilobites in that range characterize the *Orthidiella* zone. At Ikes Canyon in most of the expected range of *Orthidiella*, *Orthambonites minusculus* (Phleger) seems to substitute; externally the shells of the two have much in common and could be confused.

Valcourea, a Marmor (Chazy) to Porterfield (Black River) genus, first occurs at collection D1511 CO and ranges upward through the range of *Rhysostrophia*. *Orthidium*, a genus previously reported from the *Rhysostrophia* zone (Cooper, 1956, p. 169) at Ikes Canyon and in the Table Head of Newfoundland, actually occurs in collection D1514 CO at the top of the *Orthidiella* zone and in D1518 CO. It also occurs in collection D1441 CO of the Specter Range (Ross, 1967a, pl. 11), where it is associated with *Orthidiella*.

Syndielasma biseptatum is characteristic of the *Orthidiella* zone and may range as high as *Rhysostrophia*, with which it was originally reported (Cooper, 1956, p. 127). The range of *Taphrodonta parallela* Cooper also extends much lower than the *Rhysostrophia* zone to collection D1518 CO.

It becomes evident that the assemblage of brachiopods assigned by Cooper (1956, p. 127) to his *Rhysostrophia* zone covers a much greater stratigraphic range than he intended, for it overlaps downward into the *Orthidiella* zone.

COMPOSITE ANTELOPE VALLEY SECTION

The Pogonip Group and overlying Copenhager Formation are exposed on both sides of Antelope Valley in the Horse Heaven Mountain quadrangle and eastern edge of Cockalorum Wash quadrangle. The Antelope Valley Limestone and Copenhagen Formation are readily visited on the west side of the valley along the east side of Martin Ridge. The section in Antelope Valley is a thick one, comparable to sections at Steptoe, Meiklejohn Peak (Ross, 1964a, p. C 24; 1967a, pl. 11), the Ranger Mountains, and the Pahranagat Range. These sections clearly lie in the deepest part of a basin (Ross, 1964b, fig. 7; 800 and 1,200 ft isopach designations switched erroneously south of Tooele arch).

The type section of the Ninemile Formation is exposed more than 2 miles east of the mouth of Ninemile Canyon in a tributary canyon in the E½NE¼NE¼ sec. 5, T. 15 N., R. 51 E., Cockalorum Wash quadrangle. The Goodwin Limestone is exposed along the same tributary and in hill 8567 in the N½ sec. 5, T. 15 N., R. 51 E., in both the Horse Heaven Mountain and the Cockalorum Wash quadrangles. This part of the Ordovician section is shown diagrammatically by Merriam (1963, fig. 5), but was also measured in 1957 by the author assited by A. R. Palmer, and is presented below.

The diagrammatic section (pl. 21) is compiled partly from measurements by Nolan and others (1956, p. 23–24), by Merriam (1963, p. 17–33), and the author. Positions of fossil collections made by the author are indicated as far as possible; not all collections were made coincident with measuring of the sections and were not all made at the same place as the measurement. The author's measurements indicate that the Goodwin Limestone is only 1,400 feet thick in Ninemile Canyon. The Goodwin section is included here.

On hill 8308 south of Water Canyon (SW¼ sec. 24, T. 15 N., R. 51 E.), the Copenhagen is 490 feet thick excluding the lower quartzite; Merriam (1963, p. 26) estimated a lesser thickness. Fossils indicate that the upper part, member C of Merriam (1963, p. 26), is of early Trenton age, probably about the same age as the lower part of the Hanson Creek Formation where the latter is exposed in the Roberts Creek Mountains and near Cortez. The lower part is considerably older, probably not much younger than the top of the Antelope Valley Limestone.

It is evident that the *Pseudocybele* zone is present through more than 100 feet of strata at the base of the Antelope Valley Limestone as well as in the upper part of the Ninemile Formation. The *Orthidiella* zone occurs somewhat higher but may be overlapped with the *Pseudocybele* zone. The beds bearing *Orthidiella* in Whiterock Canyon (Cooper, 1956, p. 126) form the sole of a thrust plate (Lehner and others, 1961) overriding a shale that can be mistaken for shales of the Ninemile Formation.

The lower part of the Ninemile and uppermost Goodwin are equivalent to zone G2—*Protopliomerops contracta* zone—of Ross (1951) and Hintze (1952).

Goodwin beds contain a trilobite fauna rich in olenids (*Hypermecaspis*, *Parabolinella*, *Bienvillia*), a very different assemblage from correlative trilobites of the lower part of the Garden City Formation and units described by Hintze in Utah (Ross, 1951; Hintze, 1952). These olenids as well as *Asaphellus* cf. *A. riojanus* Harrington suggest a link with South America as well as with the Baltic. Such a link is also supported by the presence of *Varvia?* sp., and *Niobella* sp. in the Goodwin Limestone and of *Hunnebergia?* sp. and *Megistaspis* (*Ekeraspis*) *floweri* Ross, n. sp., in the Ninemile Formation.

The occurrence of the trilobite *Megistaspis* (*Ekeraspis*) in the lower part of the Ninemile Formation in the Antelope Valley area and in the upper part of the Goodwin Limestone in the Pahranagat Range seems to indicate that the boundary between the two formations is probably of early Arenig age. *Parabolinella* which is present in the lower part of the Goodwin Limestone is not known above the Tremadoc.

SECTION OF GOODWIN LIMESTONE

[N½ sec. 5, T. 15 N., R. 51 E., Horse Heaven Mountain and Cockalorum Wash quads. Measured by A. R. Palmer and R. J. Ross, Jr., July 15–16, 1957]

Goodwin Limestone:	Feet
Limestone, finely crystalline, slabby, and thin-bedded. Abundant high-spired gastropods 11 ft below top. Colln. D297 CO and D368l CO are 10 ft below top. Colln. D368k CO is 40 ft below top. Colln. D368j CO is 55 ft below top	57
Limestone, light-gray, laminated to thin-bedded; has minor amounts of chert throughout. Colln. D368i CO is 57 ft above base of interval	161
Limestone; in large part intraformational conglomerate, and partly masked by float. Colln. D368h CO is 3 ft above base	188
Limestone, dolomitic, laminated	25
Dolomite, medium-bedded, possibly secondary (a fault may cut section here)	61
Limestone, light-gray, fine-grained to aphanitic. Minor amounts of chert. Thin bedded in bottom half of interval but forms resistant 4–6 ft beds in upper 80 ft	154
Limestone, thin-bedded to laminated, very cherty. Chert equaling at least 50 percent of rock in lower 40 ft	219
Limestone, thin-bedded, silty; silty partings equal about 50 percent of rock. Colln. D368f CO at 97 ft above base of interval. Colln. D368g CO is 117 ft above base	164
Limestone, thick- to medium-bedded, fine-grained; has silty partings. Colln. D368d CO at 16 ft above base; colln. D368e at 82 ft above base. Colln. D291 CO at 45 ft above base. Colln. D295 CO at 55 ft above base	177
Limestone, slabby, silty; interbedded with 4–ft beds of calcarenite. Minor chert stringers. Colln. D368c CO at 43 ft above base and D289 CO at 47 ft above base of interval. Colln. D290 CO from float 3[illegible] ft above base	73
Limestone, slabby, thin-bedded; has shaly interbeds. Pale olive to greenish gray, weathers pale grayish orange. Colln. D368b CO at 3 ft above base of interval. Colln. D288 CO about 5 ft above base	107
Shale, pale-olive; has interbeds of slabby limestone. Colln. D368a CO, phosphatic brachiopods at bottom	15
Thickness of Goodwin Limestone	1,401

Possible fault. Not measured below this.

FOSSILS FROM COMPOSITE ANTELOPE VALLEY SECTION

HANSON CREEK FORMATION

Fossils collected from the Hanson Creek Formation in the Antelope Valley area have been limited to graptolites and have been published by Ross and Berry (1963, p. 65–67). Fossils from the strata considered Hanson Creek on Lone Mountain are all corals; no graptolite-bearing limestones are present above the Eureka Quartzite. Fossils from the lower beds of the Hanson creek at the type section include a few graptolites, *Cryptolithoides*, and *Anataphrus*, a fact suggesting that there is not much difference between its age and the age of the upper part of the Copenhagen Formation.

COPENHAGEN FORMATION

Fossils collected from the Copenhagen Formation came from a section on the southeast side of hill 8308, south of Water Canyon (SW¼ sec. 24, T. 15 N., R. 51 E., Horse Heaven Mountain quad., Nevada). Compared to the list published by Cooper (1956, p. 127–128), the following list is regrettably limited but does indicate the stratigraphic position of fossils fairly accurately.

The discovery of *Hypodicranotus* and a large lichad, *Amphilichas*, establishes trilobites for the first time in the West and corroborates the early Trenton (late

Wilderness) age given by Cooper (1956, chart 1) to these upper beds on the basis of brachiopods.

Fossils from the Copenhagen have been examined cursorily for purposes of this report; a more detailed study of the trilobites and regional stratigraphy of the unit is in progress.

D1880 CO. Copenhagen Formation, upper 100 ft of formation.
- Trilobites:
  - *Cryptolithoides* 2 spp.
  - *Anataphrus* n. sp.
  - *Robergia deckeri* B. N. Cooper
  - *Raymondella* n. sp.
  - *Ceraurus*? sp.

D1879 CO. Copenhagen Formation, 341 ft above base.
- Brachiopods:
  - *Sowerbyella merriami* Cooper
  - Resupinate plectambonitid?
- Trilobite:
  - *Isotelus* sp.

D1878 CO. Copenhagen Formation, 337 ft above base.
- Brachiopod:
  - *Sowerbyella* sp.
- Trilobite:
  - *Isotelus* cf. *I. gigas* Hall

D1877 CO. Copenhagen Formation, 330 ft above base.
- Brachiopods:
  - *Plectorthis*? *obesa* Cooper
  - *Sowerbyella merriami* Cooper
  - *Cristiferina* sp.

D1876 CO. Copenhagen Formation, 303 ft above base.
- Brachiopods:
  - *Oxoplecia nevadensis* Cooper
  - *Sowerbyella* sp. (large)
  - *Cristiferina* sp.
  - *Strophomena* sp.
- Trilobites:
  - *Calyptaulax* sp.
  - Lichad, very large, fragmentary

D1875 CO. Copenhagen Formation, 301 ft above base.
- Brachiopods:
  - *Sowerbyella* sp.
  - *Strophomena*? sp.
  - *Cristiferina* sp.
- Trilobite:
  - *Anataphrus* n. sp.
- *Receptaculites* sp.
- Ostracodes, abundant

D1874 CO. Copenhagen Formation, 277 ft above base.
- Brachiopods:
  - *Strophomena* sp.
  - *Sowerbyella* sp.
- Trilobites:
  - *Amphilichas* sp.
  - *Anataphrus* n. sp.
  - *Calyptaulax* sp.
  - *Hypodicranotus* sp.
  - *Isotelus* sp. (large)
- Ostracodes, abundant
- Graptolite:
  - *Climacograptus* cf. *C. phyllophorus* Gurley

D1873 CO. Copenhagen Formation, 272 ft above base. Rocks in place.
- Brachiopods:
  - *Hesperorthis*? sp.
  - *Sowerbyella* sp.
  - *Leptellina*? sp. (small species)
- Trilobites:
  - *Hypodicranotus* sp.
  - *Isotelus* sp. (large)
  - *Anataphrus* n. sp.
  - *Calyptaulax* sp.

D1872 CO. Copenhagen Formation, float at 259–268 ft. Almost all this material probably comes from considerably higher in the section and is mixed stratigraphically.
- Brachiopods:
  - *Oxoplecia nevadensis* Cooper
  - *Plectorthis*? *obesa* Cooper
  - *Cristiferina* sp.
  - *Bilobia* sp.
  - *Strophomena* sp.
- Trilobites:
  - *Calyptaulax* sp.
  - *Anataphrus* n. sp.
  - *Isotelus* sp.
  - *Cryptolithoides* sp.

D1871 CO. Copenhagen Formation, float, 225 ft above base.
- Brachiopods:
  - Orthid, undet.
  - *Cristiferina cristifera* Cooper
  - *Eoplectodonta alternata* Butts
  - *Skenidioides*? sp.
  - *Sowerbyella*? sp.
  - *Bimuria*? sp.

D1870 CO. Copenhagen Formation, 193 ft above base.
- Brachiopods:
  - *Valcourea plana* Cooper
  - Plectambonitid, probably *Sowerbyella*
- Trilobites:
  - *Isotelus* sp.
  - *Calyptaulax* sp.

D1869 CO. Copenhagen Formation, 151–156 ft above base.
- Brachiopods:
  - *Valcourea* cf. *V. plana* Cooper
    - *transversa* Cooper, large variety
  - *Multicostella*? sp., possibly *Plectorthis*
  - Strongly geniculate strophomenoid
- Cephalopod:
  - Indet. siphuncle

Fossils from this collection are reminiscent of the Mountain Lake Member of the Bromide.

D1868 CO. Copenhagen Formation, 119 ft above base.
- Trilobite, unidentified

D1867 CO. Copenhagen Formation, float at 44 ft above base.
- Trilobite:
  - *Anataphrus* sp.

D1866 CO. Copenhagen Formation, 35–39 ft above base.
- Brachiopods:
  - *Valcourea* sp.
  - Plectambonitid
- Trilobite:
  - *Isotelus*? sp.

D1865 CO. Copenhagen Formation, 29 ft above base.
- Brachiopod:
  - *Sowerbyella*? sp.

D1614 CO. Copenhagen Formation, 24–30 ft above base.
Brachiopod:
Strophomenoid indet.
Trilobite:
Illaenid? indet.

D1864 CO. Copenhagen Formation, 6–17 ft above base of formation.
Brachiopod:
Valcourea sp.
Trilobite:
Illaenus sp.

D1863 CO. Copenhagen Formation, 1 ft above base.

D1862 CO. Antelope Valley Limestone, approximately 35 ft below basal sand of Copenhagen Formation, on southeast side of hill 8308, NE¼SW¼ sec. 24, T. 15 N., R. 51 E., Antelope Range, Horse Heaven Mountain quad.
Leptellina cf. *L. occidentalis* Ulrich and Cooper
Large plectambonitid?
Small asaphid pygidium

ANTELOPE VALLEY LIMESTONE

D369 CO. Antelope Valley Limestone, 5 ft below base of overlying sandstone, east side of Martin Ridge, altitude 6,880 ft. Coords., east zone; E. 273,100 ft. N. 1,628,700 ft, Horse Heaven Mountain quad.
Brachiopods:
Leptellina sp.
Valcourea sp.
Trilobites:
Bathyurus cf. *B. extans* Hall
Calyptaulax sp.

D370 CO. Antelope Valley Limestone, 25 ft below top. East side of Martin Ridge, altitude 6,710 ft. Coords., east zone: E. 274,300 ft, N. 1,627,560 ft.
Brachiopod:
Anomalorthis sp.
Trilobites:
Illaenus cf. *I. utahensis* Hintze
Bathyurus acutus subsp. *angustus* Ross, n. sp.
Leperditiid ostracodes

D371 CO. Antelope Valley Limestone, from float 60 ft below top, east side of Martin Ridge. Coords., east zone: E. 274,250 ft, N. 1,626,300 ft.
Brachiopods:
Anomalorthis cf. *A. oklahomensis* Ulrich and Cooper
Illaenus sp.

Collections D299a CO–D299e CO from the hill 1.2 miles south of mouth of Copenhagen Canyon. Nevada coords., central zone: E. 583,000 ft, N. 1,628,400 ft, Horse Heaven Mountain quad.

D299e Co. Antelope Valley Limestone, 82 ft below top.
Anomalorthis sp.
Gacella? sp.
Perissopliomera maclachlani Ross, n. gen., n. sp.
Illaenus sp.
Bathyurus cf. *B. acutus* subsp. *angustus* Ross

D299d CO. Antelope Valley Limestone, 87–104 ft below top.
Anomalorthis lonensis (Walcott)

D299c CO. Antelope Valley Limestone, 179–249 ft below top.
Orthambonites sp.
Anomalorthis sp. (large)

D299b CO. Antelope Valley Limestone, 730 ft below top.
Palliseria sp. (genus ranges upward to within 439 ft of top)

D299a CO. Antelope Valley Limestone, 952 ft below top.
Palliseria sp.
Asymphylotoechia nolani Ross n. gen., n. sp.
Hesperorthis cf. *H. matutina* Cooper
Nileus? sp.

D298 CO. Antelope Valley Limestone, basal beds at bottom of cliff on south side of Ninemile Canyon, 1½ miles above canyon mouth. SW¼ sec. 5, T. 15 N., R. 51 E., Horse Heaven Mountain quad.
Brachiopod:
Hesperonomia sp.
Trilobites:
Ptyocephalus vigilans Whittington
Pseudocybele nasuta Ross
Pygidium (like that of Hintze, 1952, pl. 15 fig. 18a)

NINEMILE FORMATION

Fossils listed below in collections D340a–m CO were collected in 1957 from the type section of the Ninemile Formation. This section is in the NW¼ sec. 5, T. 15 N., R. 51 E., Cockalorum Wash quadrangle.

D340m CO. Ninemile Formation, 518 ft above base, or lowest Antelope Valley Limestone.
Brachiopods:
Hesperonomia antelopensis Ulrich and Cooper
Idiostrophia? sp.
Trilobites:
Ptyocephalus sp.
Ischyrotoma caudanodosa (Ross)
Isoteloides? sp.
Pseudocybele sp.
Genus and species undet. (p. 80)
Graptolites:
Didymograptus cf. *D. artus* Elles and Wood (fragmentary)

This assemblage correlates with zone J of Ross (1951) and Hintze (1952). The occurrence of graptolite fragments highly suggestive of *D. artus* Elles indicates that the zone may be equivalent to early Llanvirn.

D340l CO. Ninemile Formation, 161 ft above base.
Presbynileus? sp.
Hunnebergia? sp.

D340k CO. Ninemile Formation, 153 ft above base.
Presbynileus? sp.
Trigonocerca? sp. (may be fragmentary *Megistapis* (*Ekeraspis*))

D340i CO. Ninemile Formation, 141 ft above base.
Geragnostus sp.
Megistaspis (*Ekeraspis*) *floweri*, n. sp.
Presbynileus sp.
Aulacoparia (*Aulacoparia*) cf. *A. venta* (Hintze)

D340h CO. Ninemile Formation, 137 ft above base.
Curtoceras sp. (identified by R. H. Flower, written commun., Aug. 6, 1967)
Presbynileus? sp.
Remopleurid, possibly *Eorobergia*
Pliomerid, possibly *Pseudocybele*

D340g CO. Ninemile Formation, 109 ft above base.
Presbynileus? sp.

D340f CO. Ninemile Formation, 98 ft above base.
Megistaspis (*Ekeraspis*) sp.
Pliomerid, indet.

D340e CO. Ninemile Formation, 80 ft above base.
Megistaspis (*Ekeraspis*) sp.
Presbynileus? sp.

D340d CO. Ninemile Formation, 78 ft above base.
Megistaspis (*Ekeraspis*) sp.
Protopresbynileus sp.

D340c CO. Ninemile Formation, 62 ft above base.
Archaeorthis costellatus Ulrich and Cooper
elongatus Ulrich and Cooper
Megistaspis (*Ekeraspis*) sp. (easily taken for *Trigonocerca*)

D340b CO. Ninemile Formation, 50 ft above base.
Archaeorthis sp.

D340a CO. Ninemile Formation, 25 ft above base.
Archaeorthis n. sp. (brachial sulcus too deep and costellae too coarse for *A. costellatus;* sulcus too deep for *A. elongatus*)
Trigonocerca? sp.

D296 CO. Ninemile Formation, lower 100 ft, type section, Cockalorum Wash quad.
Brachiopod:
Archaeorthis? sp.
Trilobites:
Goniophrys? sp.
Shumardia sp.
Presbynileus ibexensis Hintze
Isoteloides? sp.
Megistaspis (*Ekeraspis*) ? sp.

GOODWIN LIMESTONE

Collections D288 CO–D291 CO and D295 CO–D297 CO were collected in N½ sec. 5, T. 15 N., R. 51 E., Horse Heaven Mountain and Cockalorum Wash quadrangles.

D297 CO. Goodwin Limestone, top 10 ft.
Trilobites:
Protopresbynileus wildeni Hintze
Apatokephalus sp.
Megalaspid
Leiostegium goodwinensis Ross, n. sp.
Niobella? sp. (pygidium only)
Undetermined hystricurid(?) species (p. 73, pl. 10, figs. 32–34)

D368l CO. Goodwin Limestone, approximately 10 ft below top.
Brachiopods, orthid, indet.
Asaphellus cf. *A. riojanus* Harrington and Leanza

D368k CO. Goodwin Limestone, 40 ft below top.
Brachiopods, orthid, indet.
Asaphellus cf. *A. riojanus* Harrington and Leanza
Varvia? sp. (see pl. 11, fig. 26)
Rossaspis sp.

D368j CO. Goodwin Limestone, 55 ft below top.
Asaphellus cf. *A. riojanus* Harrington and Leanza
Megalaspid, undet.
Apatokephalus sp. (possibly *finalis* Walcott)
Hillyardina? sp.

D368i CO. Goodwin Limestone, 1,240 ft above base and 161 ft below top.
Asaphellus cf. *A. riojanus* Harrington and Leanza
Niobella sp., cranidium

D368h CO. Goodwin Limestone, 998 ft above base.
Rhombella? sp.
Hystricurus aff. *H. genalatus* Ross
Pseudohystricurus sp. or *Ischyrotoma* sp.

D368g CO. Goodwin Limestone, 489 ft above base.
Nanorthis hamburgensis (Walcott)
Agnostid, undet.
Paenebeltella sp.
Hystricurus? aff. *H. politus* Ross
Pseudohystricurus? sp.
Apatokephalus sp.

D368f CO. Goodwin Limestone, 469 ft above base.
Nanorthis hamburgensis (Walcott)

D368e CO. Goodwin Limestone, 277 ft above base.
Agnostid, undet.
Parabolinella hecuba (Walcott)
Kainella flagricauda (White)

D295 CO. Goodwin Limestone, 250 ft above exposed base.
Geragnostus sp.
Shumardia sp.
Hystricurus sp.
Apatokephalus sp. (sparsely pustulose)
Eorobergia sp. (abundantly pustulose)
Kainella flagricauda (White)
Hystricurid aff. *Euloma* sp. (lacks glabellar furrows)
Rossaspis sp.

D 291 CO. Goodwin Limestone, 240 ft above exposed base.
Parabolinella sp.
Kainella flagricauda White
Geragnostus sp.
Apatokephalus sp.

D368d CO. Goodwin Limestone, 211 ft above base.
Nanorthis sp.
Parabolinella sp.
Hypermecaspis sp.
Kainella flagricauda (White)
Apatokephalus sp.

D290 CO. Goodwin Limestone, 155 ft above exposed base (foat).
Parabolinella sp.

D289 CO. Goodwin Limestone, 169 ft above exposed base.
Parabolinella hecuba (Walcott)
Hypermecaspis kolouros Ross, n. sp.

D368c CO. Goodwin Limestone, 165 ft above base.
Parabolinella sp.
Parabolinella? sp.

D288 CO. Goodwin Limestone, 20 ft above exposed base.
Geragnostus sp.
Parabolinella sp.
Eorobergia sp.
Kainella sp.

D368b CO. Goodwin Limestone, 18 ft above base.
Bienvillia sp.
Parabolinella sp.

AGE AND CORRELATION OF FOSSILS IN COMPOSITE ANTELOPE VALLEY SECTION

Fossils from the east side of Martin Ridge demonstrate that the *Anomalorthis* zone (colln. D370 CO) extends upward at least to within 25 feet of the gradational sandstone at the base of the Copenhagen Formation and to within 15 feet of *Leptellina* and *Valcourea* (colln. D369 CO). The brachiopod *Gacella*? and trilobite *Bathyurus*, both Porterfield (or Black River) genera, range downward 82 feet below the sandstone (colln. D299e CO); they are associated with *Perissopliomera*, a new genus closely related to *Pliomera*, another genus of Porterfield age. *Pliomera* was found originally in the Kukruse-Stufe of Estonia. The same species of *Perissopliomera* is found in collection D1858 CO at Hot Creek Canyon.

The occurrence of *Valcourea* and *Leptellina* in the upper part of the Antelope Valley Limestone and the gradational nature of the contact with the overlying sandstone indicate little or no stratigraphic break between the Pogonip and lower beds of the Copenhagen. It is probable that collection D369 CO is approximately equivalent to the uppermost part of the Antelope Valley Limestone at Ikes Canyon.

It has generally been assumed that the lowest Whiterock beds (*Orthidiella* zone) virtually coincided with the base of the Antelope Valley Limestone and that the *Pseudocybele* zone marked the Ninemile Formation. Ross (1964a; 1967a, pl. 11) showed that this was too simple an interpretation in southern Nevada, and work reported here has similar results.

LONE MOUNTAIN SECTION

This section was designated by Kirk (1933) as the type section of the Eureka Quartzite, beneath which the Antelope Valley Limestone is partly exposed.

According to Merriam (1963, p. 31) the Eureka Quartzite at Lone Mountain is overlain by the Hanson Creek Formation, which some investigators might prefer to call Ely Springs Dolomite at this place. The only fossils from the base of the Eureka Quartzite are conodonts from USGS collection D1658 CO; these are of early Wilderness age. The unit including this collection was excluded by Webb (1956, p. 13, 60) from the Eureka as an unnamed formation within the Pogonip Group. That unit is approximately equivalent to some part of the upper part of the Copenhagen Formation.

The highest fossil collections in the Antelope Valley Limestone correlate with those 500–750 feet below the upper part of the Copenhagen Formation. Therefore the lower part of the Copenhagen and much of the upper part of the Antelope Valley are missing at Lone Mountain.

This impressive unconformity is probably due to proximity to the Tooele Arch which was tectonically active in Middle Ordovician time.

LONE MOUNTAIN SECTION

[Nevada coord., east zone: E. 304,800 ft, N. 1,761,920 ft for Hanson Creek; E. 304,200 ft, N. 1,761,180 ft for Antelope Valley, Bartine Ranch quadrangle]

	Feet
Roberts Mountains Formation [not measured]:	
Chert beds.	
Hanson Creek Formation:	
Dolomite, light-gray	24
Dolomite, dark-gray to brownish-black, vuggy	10
Dolomite, light-gray	30
Dolomite, light-medium-gray; contains abundant floating sand grains, well-rounded	13
Dolomite, silty; weathers orange; could be interpreted as result of corrosion at top of underlying bed	½
Dolomite, medium-gray; weathers pale yellowish brown grading upward to light gray	35
Slope covered by float composed of blocky material	39
Slope covered mainly by float and forms saddle in ridge. Float composed mainly of very thin bedded, silty dolomite	25
Dolomite, light-gray; basal 1 ft is gradational from underlying unit	63
Dolomite, coarse-grained, locally vuggy, dark-gray; weathers brownish gray. Corals abundant. Colln. D1773 CO	67
Total thickness of Hanson Creek measured	307

Eureka Quartzite:
[The upper 10 ft of the Eureka is dolomitic and becomes increasingly so upward. About 1 ft below the contact with the Hanson Creek, the rock is a dolomitic sandstone. Nonetheless, the contact is not as gradational as some accounts suggest. Obviously some sand has been reworked into the basal foot or two of the Hanson Creek, but a fairly clear line of demarcation between the two units is present. Thickness figures for the Eureka taken mainly from Webb's paper (1956) except for lower 55 feet]

	Feet
Eureka Quartzite:	
Main quartzite body	±200
Quartzite, red	5
Quartzite, white, vitreous	25
Sandstone, dolomitic, very fine grained	15
Dolomite, sandy, and sandstone dolomitic; includes jasperoid chert (colln. D1658 CO)	10
Total thickness of Eureka Quartzite	255
Antelope Valley Limestone:	
Dolomite, almost aphanitic, evenly bedded, medium-gray; weathers medium gray	5
Slope covered by quartzite talus and float	39
Dolomite, almost aphanitic; evenly bedded in 6-in. to 2-ft beds; light medium gray, weathers yellowish gray, 5Y 7/2	20
Slope covered by mixed limestone, dolomite, and quartzite float	20
Limestone, thin-bedded, silty; some beds nodular. Colln. D1772 CO at top	16

Antelope Valley Limestone—Continued	Feet
Limestone ledges protruding through float; ledges composed mostly of aphanitic to fine-grained silty limestone. Colln. D1771 CO at top. Colln. D1770 CO at 41 ft above base of interval; colln. D1769 CO at 22 ft above base	75
Limestone ledges protruding through float; ledges in this interval composed of calcarenite, fine-grained limestone, and silty nodular limestone. In top 12 ft much silty limestone weathers yellowish orange	36
Slope covered by float; no ledges protrude	38
Limestone ledges, very few protrude through float. Much thin, slabby, silty limestone float in upper 25 ft. Colln. D1768 CO at 5 ft below top of interval; large pliomerid cranidium in float at top but origin not found. (Should be same ledge from which colln. D1659 CO came.)	40
Limestone like that below but is less nodular and chert content decreases upward. Almost no chert at top. Colln. D1767 CO at 8 ft below top. Colln. D1766 CO at 20 ft below top	29
Limestone, fine-grained, resistant; in thin, irregular laminae separated by silty partings. Interbeds of weaker nodular limestone compose about one-third of this interval, so that overall effect is one of large steps with 7- to 12-ft risers. Higher than 21 ft above base, resistant beds include abundant chert stringers at 21–30 and 35–39 ft, extremely abundant at 45–51 ft, common at 51–65 ft, and extremely abundant at 65–70 ft above base. Colln. D1765 CO at 32 ft, colln. D1764 CO at 11 ft, and colln. D1763 CO at 3 ft above base of interval	70
Slope mostly float covered; a few thin ledges of limestone protrude in upper 11 ft	15
Limestone, bioclastic, thin-bedded; 3-in. to 2-ft beds form resistant ledges 3–8 ft thick. A few thin beds weather rubbly. Interval weathers pale grayish orange. Colln. D1762 CO at top	27
Limestone similar to that below but less resistant, more silty, weathers to rounded slope with a few ledges. *Girvanella* persists	21
Limestone, fine-grained to calcarenitic, thick bedded; moderately resistant, composed of thin, irregular laminae separated by silty partings. Partings weather recessive and light yellowish gray. Limestone weathers medium gray. "*Girvanella*" abundant. Black chert abundant in upper 5 ft	26
Limestone, silty, less resistant than above or below	8
Limestone, calcarenitic; has interbeds of silty and nodular limestone. Moderately resistant. "*Girvanella*" common. Receptaculitids present	26
Limestone, thin-bedded, silty, nodular; has calcarenite interbeds. *Receptaculites* very abundant, particularly in silty beds. Forms a weaker slope than unit below	26
Limestone, resistant; in bed 2–6 ft thick, composed of thin irregular laminae separated by thin irregular silty partings. Silt weathers recessive and yellow gray. Mostly fine grained, some thin layers calcarenitic	7
Limestone, thin-bedded, silty, somewhat nodular; has thin interbeds of "*Girvanella*"-bearing limestone. Abundant bryozoans and sponges(?) in float. Large gastropods in place	11
Limestone; fine calcarenite, has abundant fine quartz sand in lenses in some layers; evenly and thinly bedded. Colln. D1761 CO from float 5 ft above bottom	16
Limestone, fine-grained, very resistant; in 3- to 6-ft beds. Somewhat silty. Vertical faces weather into "pit-and-pinacle" texture and yellowish-gray color. *Girvanella* abundant throughout. *Palliseria* and receptaculitids near base. Colln. D1760 CO is 15 ft above base	30
Limestone, fine-grained, moderately resistant; abundant "*Girvanella.*" *Maclurites* at 9 ft above base. Minor calcarenite interbeds	17
Limestone, fine-grained, silty, irregularly laminated	14
Limestone; forms low ledges, mostly calcarenite. Interval mostly covered	5
Limestone, very silty, thinly and regularly laminated, somewhat cherty	4
Limestone, irregularly laminated; cherty with chert in thin siliceous discontinuous layers	5
Limestone, calcarenitic; in thin 1- to 2-ft ledges interbedded with silty, nodular limestone which forms rubbly slopes. Colln. D1759 CO is 5–6 ft above base	10
Limestone, medium-grained, calcarenitic, irregularly laminated, somewhat silty; beds 2–4 ft thick. Forms rounded outcrop without protruding thin ledges, but still not weak and receding. Medium gray	22
Slope mainly covered by float and has a few thin ledges of coarse calcarenite protruding. Colln. D1758 CO at 2 ft below top	11
Total thickness of Antelope Valley Limestone measured	689

Remainder of Antelope Valley Limestone not measured below this level.

FOSSILS FROM THE LONE MOUNTAIN SECTION

D1773 CO. Hanson Creek Formation (=Ely Springs Dolomite), lower 65 ft.

Corals: identified by W. A. Oliver (written commun., Aug. 24, 1966):

Catenipora? sp.
Indeterminate horn corals
Indeterminate phaceloid corals

"Preservation is very poor but some horn corals may be of the *Streptelasma prolongatum* type. These plus the type of *Catenipora*? present suggest the Late Ordovician (Bighorn-Red River fauna). The phaceloid coral(?) doesn't fit too well but may be a *Palaeophyllum* (no structure is preserved, only the gross size and growth habit). The collections may be Late Ordovician but I can't prove it on these corals."

D1658 CO. Eureka Quartzite, sandy dolomite, dolomitic sandstone and jasperoid chert at base.

Conodonts; listed by J. W. Huddle (written commun., Apr. 25, 1967):

	Number of specimens
Chirognathus cf. *C. delicatula* Stauffer	1
Coelocerodontus trigonius? Ethington	1
Phragmodus sp	1
dichognathus element	1
oistodus element	----
Ptiloconus gracilis (Branson and Mehl)	1

This fauna suggests a Glenwood age.

D1772 CO. Antelope Valley Limestone, 85 ft below Eureka Quartzite.

Ostracodes:

Leperditiid, indet.
Leperditella sp.
Small smooth ostracodes, indet.

D1771 CO. Antelope Valley Limestone, 101 ft below Eureka Quartzite.

Ostracodes:

Eoleperditia sp. cf. *E. bivia* (White), posterior not flattened.
Isochilina? sp.
Eurychilina? sp., flat velum
Leperditella sp.

D1770 CO. Antelope Valley Limestone, 134 ft below Eureka Quartzite.

Ostracodes:

Eoleperditia sp. cf. *E. bivia* (White), ends not flattened
Leperditella? sp.
N. gen. A, sp. a, like colln. D1669 CO at Pahranagat Range
"*Paraschmidtella*"? sp.

D1769 CO. Antelope Valley Limestone, 153 ft below Eureka Quartzite.

Pelecypods; identified by John Pojeta (written commun., Feb. 15, 1967):

Ctenodonta sp. "This species belongs to *Ctenodonta sensu stricto;* it is a small species comparable in size to colln. D1560 CO from the southern Groom Range section."

Conodonts:	Number of specimens
Chosonodina? lunata Harris and Harris	8
Cyrtoniodus flexuosus (Branson and Mehl)	8
Dichognathus sp	1
Distacodus cf. *D. stola* Lindström	1
Drepanodus subarcuatus Furnish	3
suberectus (Branson and Mehl) (*homocurvatus* element)	2
planus element	5
cf. *Scandodus pippa* Lindström	4
Oistodus sp	1
Paltodus sp. (*falcatus* type)	18
sp. (quadrate type)	8
Prioniodus evae Lindström	7
Scolopodus striatolatus Harris and Harris	2

This fauna occurs in the Groom Range in D1569 CO.

D1768 CO. Antelope Valley Limestone, 254 ft below Eureka Quartzite.

This is the same locality as colln. D1659 CO.

Brachiopods:

Desmorthis nevadensis Ulrich and Cooper

Conodonts:	Number of specimens
Drepanodus subarcuatus Furnish	1
suberectus (Branson and Mehl) (*homocurvatus* element)	3
planus element	1
sp	8
Multioistodus cryptodens (Mound)	41
bidens element	50
tridens element	43
subdentatus Cullison	26

Conodonts—Continued	Number of specimens
tridens element	25
Oistodus sp	8
sp	15
sp	15
Prioniodus evae? Lindström	1

D1659 CO. About 250 ft below top of Antelope Valley Limestone (*Desmorthis* zone), Lone Mountain west side, Bartine Ranch quad.

Conodonts; listed by J. W. Huddle (written commun., Apr. 25, 1967):

	Number of specimens
Distacodus symmetricus Mound	1
Drepanodus sp	1
Gothodus communis? Ethington and Clark	1
Multioistodus compressus Harris and Harris	3
subdentatus Cullison, type element	6
lateralis element	2
tridens element	6
n. sp. (Lindström, 1964, p. 80) single element	11
bidens element	13
tridens element	2
Oistodus sp	1
sp	5
sp	4
Scandodus sp	2

This collection seems to be about the same age as colln. D1650 CO (85 ft below top of Kanosh Shale at Ibex, Utah).

D1767 CO. Antelope Valley Limestone, 297 ft below Eureka Quartzite.

Brachiopod (fragment):

Anomalorthis sp.

Pelecypods; identified by John Pojeta (written commun., Feb. 15, 1967):

"*Ctenodonta* sp. This species belongs to *Ctenodonta* sensu stricto. It is probably as large as the species in colln. D1766 CO below."

Conodonts:	Number of specimens
Acontiodus sp. hooded	5
Drepanodus subarcuatus Furnish	4
suberectus (Branson and Mehl), *oistodus* element	5
homocurvatus element	6
Multioistodus cryptodens (Mound), type element	1
bidens element	9
tridens element	6
Paltodus sp. (as in colln. D1768 CO)	10
Prioniodus evae Lindström	3

D1766 CO. Antelope Valley Limestone, 309 ft below Eureka Quartzite.

Brachiopods, fragments:

Anomalorthis sp.
Desmorthis? sp.

Pelecypods; identified by John Pojeta (written commun., Feb. 15, 1967):

"*Ctenodonta* sp. This species belongs to *Ctenodonta* sensu stricto. While all specimens are fragmentary they came from a species at least as large as that from colln. D1571 CO from the southern Groom Range section."

Conodonts:	*Number of specimens*
Drepanodus subarcuatus Furnish	3
suberectus (Branson and Mehl) type element	3
homocurvatus element	16
planus element	1
oistodus element	12
cf. *Scandodus pippa* Lindström	2
Multioistodus cryptodens (Mound)	10
bidens element	18
tridens element	9
Oistodus multicorrugatus Harris	1
pseudomulticorrugatus element	2
sp.	2
Scolopodus striatolatus Harris and Harris	3

D1765 CO. Antelope Valley Limestone, 356 ft below Eureka Quartzite.

Brachiopods:
- *Hesperorthis* cf. *H. matutina* Cooper
- *Anomalorthis lonensis* (Walcott)
  - *nevadensis* (Ulrich and Cooper)

Cystids:
- Possibly holdfasts; small balls with single perforation within vestibule

Conodonts:	*Number of specimens*
Acontiodus sp. (see also D1518 CO), hooded	7
Distacodus cf. *D. stola* Lindström	2
Drepanodus subarcuatus Furnish	9
suberectus (Branson and Mehl), type element	4
n. sp. D	3
cf. *Scandodus pippa* Lindström	1
Multioistodus cryptodens (Mound), *tridens* element	1
Oistodus multicorrugatus Harris	2
pseudomulticorrugatus	2
Paltodus sp.	2
Scolopodus striatolatus Harris and Harris	4

D1764 CO. Antelope Valley Limestone, 377 ft below Eureka Quartzite. Same as collns. D375 CO and D375a CO.

Brachiopods:
- *Hesperorthis* cf. *H. matutina* Cooper
- *Anomalorthis lonensis* (Walcott)
  - *nevadensis* Ulrich and Cooper
  - *fascicostellatus* Ross, n. sp.
- *Xenelasma?* sp.
- *Asymphylotoechia nolani* Ross, n. gen., n. sp.

Conodonts:	*Number of specimens*
Acontiodus sp., hooded	5
Distacodus cf. *D. stola* Lindström	1
Drepanodus subarcuatus Furnish	5
suberectus (Branson and Mehl), type element	2
homocurvatus	10
oistodus	2
planus	1
cf. *Scandodus pippa* Lindström	4
Histiodella sinuosa (Graves and Ellison)	1
Multioistodus cryptodens (Mound)	1

Conodonts—Continued	*Number of specimens*
Oistodus multicorrugatus Harris	3
scaleonocarinatus Mound	1
multioistodus	0
pseudomulticorrugatus	0
Scandodus sp.	1

D1763 CO. Antelope Valley Limestone, 385 ft below Eureka Quartzite.

Bryozoans:
- Probably indet.

Brachiopods:
- *Anomalorthis lonensis* (Walcott)
  - n. sp. (= Ulrich and Cooper, 1938, p. 130, pl. 21F, figs. 19–21)
- *Orthambonites* sp.

Cystid:
- Has coarse pustules

Ostracode:
- Leperditiid

Conodonts:	*Number of specimens*
Acontiodus sp., hooded	6
sp. (as in D1762 CO)	1
Distacodus cf. *D. stola* Lindström	3
Drepanodus subarcuatus Furnish	19
suberectus (Branson and Mehl), type element	11
homocurvatus	30
planus	0
oistodus	3
aff. *Scandodus pippa* Lindström	10
Oistodus multicorrugatus Harris	5
pseudomulticorrugatus Mound	8
scalenocarinatus Mound	3
multioistodus	0
Multioistodus cryptodens (Mound), *tridens* element	3
Paltodus sp. as in D1764, D1373, D1660	17

D1762 CO. Antelope Valley Limestone, 405 ft below base of Eureka Quartzite.

Brachiopods:
- *Anomalorthis* cf. *A. nevadensis* Ulrich and Cooper
  - cf. *A. utahensis* Ulrich and Cooper
- *Desmorthis?* sp.

Conodonts:	*Number of specimens*
Acontiodus sp	1
Distacodus cf. *D. stola* Lindström = N. G., n. sp. of D1582 CO	10
Drepanodus subarcuatus Furnish	1
suberectus (Branson and Mehl), type element	17
homocurvatus	12
planus	10
oistodus	4
cf. *Scandodus pippa* Lindström	3
Histiodella sinuosa (Graves and Ellison)	12
Oistoidus multicorrugatus Harris	4
pseudomulticorrugatus Mound	8
scaleonocarinatus Mound	3
multioistodus form	0

Conodonts—Continued	*Number of specimens*
Paltodus sp., quadrate form	10
Paltodus? sp., fibrous and gray	7

About equivalent to D1582 at the Groom mine.

D1761 CO. Antelope Valley Limestone, from float, 566 ft below Eureka Quartzite.

Receptaculites sp.

D1760 CO. Antelope Valley Limestone, 586 ft below Eureka Quartzite.

Receptaculites sp.

D1759 CO. Antelope Valley Limestone, 650 ft below Eureka Quartzite.

Brachiopod:

Anomalorthis sp. (very fragmentary; apsacline, costellae spaces 2 per mm. Closer to *A. lonensis* than to any other species.)

Gastropod, identified by E. L. Yochelson (written commun., Dec. 23, 1966):

"New genus. This has rugose growth lines on the base and is hyperstrophically coiled (but not near *Maclurites*) with a prominent flattened upper surface. I cannot recall seeing any form quite like it except *Maclurea speciosa* Billings from Newfoundland."

Conodonts:	*Number of specimens*
Acodus sp., hooded	2
Drepanodus suberectus (Branson and Mehl), type element	6
homocurvatus	5
oistodus	2
planus	0
cf. *Scandodus pippa* Lindström	2
Multioistodus cryptodens? (Mound)	1
tridens form	4
Oistodus pseudomulticorrugatus Mound	4
multicorrugatus	0
scaleonocarinatus	1
multioistodus	1
Paltodus sp	1

Cystid(?):

Holdfasts? (small hollow balls with single perforation within a vestibule)

D1758 CO. Antelope Valley Limestone, 680 ft below Eureka Quartzite.

Brachiopod:

Anomalorthis sp.

Conodonts:	*Number of specimens*
Gothodus? sp	2
Paltodus sp	1
Oistodus pseudomulticorrugatus? Mound	1

Poor collection. All broken specimens.

AGE AND CORRELATION OF FOSSILS FROM THE LONE MOUNTAIN SECTION

Collection D1764 CO is important in including *Hesperorthis* cf. *H. matutina* Cooper, a species that is probably fairly common in Nevada and one that the author finds almost identical to *Hesperorthis matutina* Cooper from the Tulip Creek Formation of Oklahoma. The species is abundant in collection D1674 CO from the Pahranagat Range.

Also from collection D1764 CO comes a second species, representing a new genus, *Asymphylotoechia nolani* Ross. This species is also found a few miles to the southwest (colln. D299a CO) on the east side of Martin Ridge 952 feet below the top of the Antelope Valley Limestone and in the southern Groom Range (colln. D1572 CO) 781 feet below the top of the formation. *Asymphylotoechia nolani* seems to have a restricted stratigraphic range.

When the Groom, Pahranagat, Antelope Valley, and Lone Mountain sections are alined stratigraphically on the basis of occurrences of *Hesperorthis* cf. *H. matutina* and *Asymphylotoechia nolani* (pls. 20 and 21), it seems evident that about 500 feet from the top of the Antelope Valley Limestone and about 200 feet of the lower part of the Copenhagen are missing at Lone Mountain.

STEPTOE SECTION

Hintze (1952, p. 56–59) and Webb (1956, p. 55–56) published sections near the old Steptoe Ranch in sec. 30, T. 19 N., R. 63 E., on the east side of the Egan Range. Woodward (1964) published a geologic map of the northern Egan Range; with the help of his map and the reconnaissance by A. L. Brokaw, a more complete section was located along a ridge that approximately follows a section line between secs. 12 and 13, T. 19 N., R. 62 E.

In dividing the upper part of this section, I have used Hintze's (1952, p. 19–20) definition of the Lehman Formation in which the base is designated as the base of the lowest sandstone or quartzite. In the present section the base of that sandstone is 229 feet below the Eureka Quartzite. The break between shale and upper limestone of the Kanosh is much more easily traced for mapping in the field and was used essentially as the Kanosh-Lehman boundary by Woodward (1964).

The Lehman Formation of this area correlates with the Crystal Peak Dolomite of Webb (1956) to the southeast and with Ashby?-Porterfield age rocks of the Pahranagat and Groom Ranges to the south. Shaly lithology of the Kanosh is present above the *Orthidiella* zone. The Ninemile Formation is not present as a shale in its customary position below fossils of the *Orthidiella* zone. However, the interval corresponding to the lower three-fourths of formation D of Woodward (1964) is poorly exposed, probably is partly shaly, and probably is the lithologic approximation of the Ninemile.

SECTION SOUTHWEST OF STEPTOE RANCH

[Along section line between secs. 12 and 13, T. 19 N., R. 62 E., northern Egan Range, Nev., Ely 1° × 2° quadrangle]

Ely Springs Dolomite:

Not measured. Lower part of formation overlies Eureka Quartzite without marked sign of unconformity. Abundant silicified brachiopods in lower 25 ft, colln. D1808 CO.

Eureka Quartzite:	Feet
Quartzite, vitreous; thick bedded at top to thin bedded in lower half	223
Slope, talus-covered	31
Siltstone, dolomitic; weathers yellowish orange. Fossiliferous, but fossils not recoverable	3
Sandstone, dolomitic; has interbeds of vitreous quartzite and dolomitic quartzite. Weathers yellowish orange, pale reddish orange, and yellowish gray	10
Covered slope	10
Total thickness of Eureka Quartzite	277

Pogonip Group:

Lehman Formation:	Feet
Dolomite, very silty; weathers yellowish orange with splotches of pale reddish orange	8
Limestone; dolomitized variably along strike, grades from limestone on bottom to dolomite at top	2
Limestone, aphanitic, dark-gray; appears irregularly fractured with silt filling fractures. Fractures apparently syngenetic. Beds 2–3 ft thick, no or only slight evidence of lamination within beds. Colln. D1809 CO at top	15
Limestone; very silty and in part finely sandy, thin-bedded, nodular to slabby, weak. Colln. D1810 CO	7
Limestone, fine-grained, resistant, cliff-forming. Composed of irregular laminae welded into thick beds that form 3- to 10-ft ledges. Corals, *Eofletcheria* and *Lichenaria*, colln. D1811 CO at 79 ft above base; *Plectorthis* and strophomenids, colln. D1812 CO at 18 ft above base. Strophomenids, colln. D1813 CO at 5 ft above base	93
Limestone, thin-bedded, silty, fine-grained, partly nodular. A few thin beds of very fine calcarenite. Slope-forming unit. Strophomenids and *Bathyurus*, colln. D1814 CO at 36 ft above base	73
Limestone, fine-grained, resistant, irregularly laminated; interbedded with weaker nodular limestone, both in 1- to 2-ft beds	7
Limestone, silty, thin-bedded; in large part nodular. Slope forming	17
Limestone, fine-grained, resistant, irregularly laminated, silty	5
Slope mostly covered. Appears to be underlain mainly by nodular limestone and thinly bedded silty limestone identical to the strata beneath the underlying quartzite. Fossils from ledge in bottom 6 in. Colln. D1815 CO (leperditiids)	30
Quartzite, white, crossbedded. Beds 6–12 in. thick	9
Total thickness of Lehman Formation measured	266

Pogonip Group—Continued

Kanosh Shale:	Feet
[Note that Woodward (1964) included about 170 ft of strata in the Lehman that the author has assigned to the Kanosh; in this assignment the author has followed Hintze's original definition of the Lehman. Actually the limestones above and below the basal quartzite of the Lehman are identical]	
Limestone, fine-grained, thin-bedded, thinly and irregularly laminated; laminae grouped together to form 1- to 2-ft beds. Some beds grade downward into silty nodular limestone. Others are fine calcarenite. Nodular limestone composes a little less than 50 percent of this interval. Colln. D1816 CO (*Bathyurus*) at 116 ft above base; colln. D1817 CO (bathyurid) at 30 ft above base	147
Limestone, fine-grained and calcarenitic; in beds up to 2 ft thick, spaced about 6 ft apart vertically with nodular limestone interbeds apparently composing about 65 percent of interval. (Interval almost entirely float covered; presence of nodular limestone only ascertained by sampling pits.) Colln. D1818 CO at base	26
This is probably the base of Lehman Formation as interpreted by Woodward (1964).	
Slope almost completely covered by float, underlain by nodular limestone and a few protruding beds of calcarenitic limestone. Colln. D1819 CO (*Pseudoolenoides*) at 34 ft above base	84
Shale, olive-gray, fissile	3
Limestone, silty, nodular; has interbeds of fine-grained and calcarenitic limestone protruding above float that masks entire slope. Colln. D1820 CO (*Pseudoolenoides*) at top	47
Shale, fissile, gray; weathers light olive gray. Interbedded with thin beds of silty nodular limestone, fine calcarenite, and silty laminated limestone; limestone beds more numerous upward, particularly in top 28 ft. Colln. D1821 CO (*Anomalorthis*) at 198 ft above base; colln. D1822 CO (*Desmorthis*?) at 96 ft above base	268
Total thickness of Kanosh Shale	575

Formation D of Woodward (1964):	Feet
Limestone, calcarenitic, very silty, fossiliferous; weathers yellowish orange and pale reddish orange	8
Limestone, fine-grained and finely calcarenitic; in thin beds 3 in. to 2 ft thick protruding through float-covered slope. At least 50 percent masked	91
Limestone, resistant, irregularly laminated, slightly silty. Fossils abundant but almost impossible to extract. Colln. D1823 CO (pliomerids) 23 ft above base. Also abundant sponges (not receptaculitids)	95
Covered slope	11
Limestone, very fine grained, massive, stromatolitic, almost unbedded. Some sponges	13
Limestone, resistant, irregularly laminated, silty	8

Pogonip Group—Continued

Formation D of Woodward (1964)—Continued	Feet
Limestone, silty, nodular, thin-bedded	3
Covered slope	22
Limestone, resistant, irregularly laminated, silty. Fossils at top; colln. D1824 CO	10
Limestone, silty, nodular, thin-bedded	6
Covered slope	23
Limestone; mostly replaced by black chert	2
Covered slope	8
Limestone, resistant, irregularly laminated, silty	9
Covered slope	9
Limestone, resistant, irregularly laminated, silty. Fossils in top 2 ft; colln. D1825 CO (*Ptyocephalus*, also sponges)	32
Covered slope	26
Limestone, resistant, irregularly laminated, silty	8
Covered slope	14
Limestone, silty, nodular; and irregularly laminated silty limestone	6
Limestone, resistant, silty; thinly laminated with laminae welded into 6-in. to 1-ft layers forming 1- to 6-ft ledges	23
Slope, mostly covered; underlain by silty, thin-bedded nodular limestone	21
Limestone, resistant, silty, irregularly laminated	4
Covered slope	18
Limestone, silty, fine-grained, thin-bedded; has interbeds of nodular silty limestone	14
Covered slope	33
Limestone, thin. Colln. D1826 CO (*Hesperonomia*)	1
Covered slope	16
Limestone, resistant, fine-grained, thick-bedded, slightly silty	10
Covered slope except for two calcarenite beds in lower half	44
Limestone, silty, thin-bedded; protrudes through float; about 50 percent covered. Fossils at top; colln. D1827 CO	19
Limestone, resistant, thinly and irregularly laminated; silty partings partly silicified	8
Limestone, calcarenite, and intraformational conglomerate, have silicified silt; form ledges protruding through float which covers 30 percent of interval	34
Limestone, resistant, irregularly laminated, cherty	8
Limestone, nodular, silty; calcareous siltstone interbeds. Weathers yellowish orange and pale reddish orange on silty surfaces	27
Limestone; coarse calcarenite interbedded with intraformational conglomerate and much light chert. Some yellowish orange siltstone. Colln. D1828 CO at 23 ft above base; colln. D1829 CO at 15 ft above base	31
Slope almost entirely covered by float	35
Total thickness of formation D of Woodward (1964) measured	750

Formation C of Woodward (1964):	
Limestone, fine-grained, thin-bedded, cherty. Minor intraformational conglomerate and calcarenite. Colln. D1830 CO at 11 ft below top	138

Pogonip Group—Continued

Formation C of Woodward (1964)—Continued	Feet
Limestone, fine-grained, calcarenitic; silty and finely sandy, has minor intraformational conglomerate. Beds 6 in. to 4 ft thick. Cliff forming. Very cherty. Chert beds and stringers throughout. Colln. D1831 CO at 72 ft above base	248
Slope, mostly talus covered. Appears to be underlain by same unit as above	28
Limestone, very silty and cherty as thin ledges protrude through float of the same	8
Total formation C of Woodward (1964) measured	422

Formation B of Woodward (1964):	
Limestone, intraformational conglomerate, and fine-grained calcarenite. Throughout this formation about 50 percent of it is covered by float so that the composition of half of it is not apparent. Particularly resistant beds are present 470 ft above the base. There seems to be no clear-cut preponderance of lithologies in any particular part of the formation. Colln. D1832 CO at 783 ft above base. Colln. D1833 CO at 725 ft above base. Colln. D1834 CO at 573 ft above base. Colln. D1835 CO at 432 ft above base. Colln. D1836 CO at 45 ft above base. Colln. D1837 CO at 2 ft above base	1,054

Formation A of Woodward (1964):

Limestone, slightly dolomitic, very cherty; in beds 2–4 ft thick. This unit resistant as a whole. It is medium grained (sugary), medium gray; weathers medium gray with a brownish tinge. The extremely abundant chert is milky colored and weathers brown.

No fossils could be found in the upper 300 ft of this unit. Whether it is partly Ordovician as Woodward indicates, I cannot tell. The fossils near the base of formation B are very early Ordovician; as a result I find it hard to believe that much if any of formation A is Ordovician.

FOSSILS FROM THE STEPTOE SECTION

D1808 CO. Ely Springs Dolomite, lower 25 ft.

Brachiopods:
- Rhynchonellids
- Dalmanellids

D1809 CO. Lehman Formation, 255 ft above base (11 ft below base of Eureka Quartzite).

Conodonts:	Number of specimens
Cyrtoniodus flexuosus (Branson and Mehl)	3
Drepanodus suberectus (Branson and Mehl)	2
Loxodus bransoni? Furnish	1
Oistodus sp	2
Periodon n. sp., two elements	14
Polycaulodus bidens Branson and Mehl	1
inclinatus Branson and Mehl	4
Roundya bispicata Sweet and Bergström	4
Trichonodella sp	2

Roundya bispicata has been reported previously from the Pratt Ferry Formation and *Loxodus bransoni* from the Oneota Dolomite. (This specimen is better preserved than the only figured specimen.) *Polycaulodus* is from Dutchtown to Decorah age.

D1810 CO. Lehman Formation, 234–241 ft above base (25–32 ft below base of Eureka Quartzite).
Brachiopods:
Orthambonites? 2 spp.
Plectambonitid
Trilobites:

D1811 CO. Lehman Formation, 220 ft above base (46 ft below base of Eureka Quartzite).
Corals; identified by W. A. Oliver (written commun., Feb. 8, 1967):
"Semiphaceloid *Lichenaria* B (=*Eofletcharia* B). There may be 2 semiphaceloid species here—one with larger corallites than previously seen. Presumably this is the Pogonip *Eofletcharia* zone."

D1812 CO. Lehman Formation, 159 ft above base (107 ft below base of Eureka Quartzite).
Brachiopods:
Plectorthis? sp.
Orthambonites? sp.
Dactylogonia? sp. (appears to be same as in upper Pogonip beds in Pahranagat and southern Groom Ranges)
Öpikina? sp.
Trilobites:
Bathyurus sp. (cf. *B. extans* Hall)
Raymondaspis? sp. (see *Illaenopsis*? sp., colln. D680 CO, Ross, 1967a, pl. 4, fig. 33, and pl. 11, limestone in lower part of the Eureka Quartzite, Ranger Mountains, Nevada Test Site).

D1813 CO. Lehman Formation, 146 ft above base (120 ft below base of Eureka Quartzite).
Brachiopods:
Glyptomena? sp. (may be the same as some of specimens called *Kirkina* at Ibex by Jensen, 1967, p. 99)
Macrocoelia? sp.

Conodonts:	*Number of specimens*
Drepanodus suberectus (Branson and Mehl)	2
Oistodus sp.	18
Phragmodus inflexus Stauffer, type element	10
cordylodus element	10
dichognathus element	0

This species occurs in the McLish, Dutchtown, and Glenwood Formations.

D1814 CO. Lehman Formation, 104 ft above base (162 ft below base of Eureka Quartzite).
Brachiopods:
Öpikina cf. *Ö. expatiata* Cooper
Coarse ribbed orthid, probably *Hesperorthis*
Gastropods
Trilobites:
Bathyurus acutus subsp. *angustus* Ross, n. subsp.
Ostracodes:
Leperditella sp.

Jean Berdan (written commun., Nov. 16, 1967) stated: "This *Leperditella* is rather nondescript. To date, I have not found it in the Ibex area."

D1815 CO. Lehman Formation (256 ft below base of Eureka Quartzite) 10 ft above base of formation and half a foot above top of basal quartzite of Lehman Formation.
Ostracodes:
Eoleperditia bivia (White)
Eurychilina sp.
Schmidtella? sp., very small
Krausella sp.

D1816 CO. Kanosh Shale, 31 ft below basal quartzite of Lehman Formation (297 ft below base of Eureka Quartzite).
Brachiopod:
Anomalorthis sp.
Trilobites:
Bathyurus sp.
Goniotelina? sp. (small transverse, short bathyurid pygidium)
Ostracodes:
Eoleperditia sp. aff. *E. bivia* (White), very conspicuous brim
Isochilina sp.
Eurychilina sp.
Lomatopisthia? sp.
Leperditella sp.
Schmidtella sp.
Hyperchilarina? sp.
Krausella 2 spp.

D1817 CO. Kanosh Shale, 117 ft below basal quartzite of the Lehman (383 ft below base of Eureka Quartzite).
Brachiopod:
Desmorthis sp.
Trilobites:
Bathyurus acutus subsp. *angustus* Ross, n. subsp. (probably same species as colln. D1483 Co at Hot Creek Canyon)

D1818 CO. Kanosh Shale, 172 ft below basal quartzite of Lehman Formation (438 ft below base of Eureka Quartzite).
Ostracodes:
Eoleperditia sp. cf. *E. bivia* (White), posterior not flattened
Leperditella sp., small, 2 specimens

D1819 CO. Kanosh Shale, 223 ft below basal quartzite of Lehman Formation (489 ft below base of Eureka Quartzite).
Brachiopod:
Desmorthis costata Cooper
Trilobite:
Pseudoolenoides acicaudus Hintze
Ostracodes:
Eoleperditia sp. cf. *E. bivia* (White), posterior not flattened
Schmidtella sp., small, one valve only

D1820 CO. Kanosh Shale, 261 ft below basal quartzite of Lehman Formation (527 ft below top of Eureka Quartzite).
Brachiopod:
Desmorthis sp.
Trilobite:
Pseudoolenoides acicaudus Hintze
Ostracodes:
Eoleperditia bivia (White)
Eoleperditia sp.
"*Paraschmidtella*"? sp., punctate

D1821 CO. Kanosh Shale, 198 ft above base, 377 ft below basal quartzite of Lehman Formation (643 ft below base of Eureka Quartzite).
Brachiopods:
Anomalorthis utahensis Ulrich and Cooper
Orthambonites sp.

D1822 CO. Kanosh Shale, 96 ft above base, 479 ft below basal quartzite of Lehman Formation (745 ft below base of Eureka Quartzite).
Brachiopods:
Anomalorthis cf. *A. nevadensis* Ulrich and Cooper
cf. *A. lonensis* (Walcott)
Orthambonites sp.
Trilobite:
Pseudoolenoides cf. *P. dilectus* Hintze
Ostracodes:
Ballardina sp.
Leperditella sp.
Leperditella? sp.

Jean Berdan (written commun., Nov. 16, 1967) commented: "The *Ballardina* appears to be a new species and unlike other previously listed forms identified as *Ballardina*. A similar form occurs about 82 feet above the base of the Kanosh Shale in the 'K-North' section at Ibex, Utah."

D1823 CO. Pogonip Group, limestone, 1,012 ft below base of Eureka Quartzite, 171 ft below base of Kanosh Shale (171 ft below top of formation D of Woodward, 1964).
Brachiopod:
Anomalorthis sp. (possibly same as *A*. n. sp. a from Groom colln. D1583 CO).
Trilobites:
Ischyrotoma sp.
Goniotelina? sp.
Ectenonotus sp.
Pliomerid indet., possibly *Pseudomera*

D1824 CO. Pogonip Group, limestone 1,093 ft below base of Eureka Quartzite, 252 ft below base of Kanosh Shale (252 ft below top of formation D of Woodward, 1964).
Trilobite:
Goniotelina? cf. *G. pseudobathyurus* (Ross) (Ross, 1967a, p. D20))

D1825 CO. Pogonip Group, limestone, 1,160 ft below base of Eureka Quartzite, 319 ft below base of Kanosh Shale (319 ft below top of formation D of Woodward, 1964).
Sponges.
Brachiopods:
Genus and species indet.
Trilobites, fragmentary, mostly indet.:
Ptyocephalus sp., identified in field
Pliomerids (several partial pygidia)
Bathyurid (partial pygidium)

D1826 CO. Pogonip Group, limestone, 1,358 ft below base of Eureka Quartzite, 518 ft below base of Kanosh Shale (518 ft below top of formation D of Woodward, 1964).
Brachiopod:
Hesperonomia sp. (a small species)
Trilobites:
Indet. pygidia, possibly like *Licnocephala cavigladius* Hintze

D1827 CO. Pogonip Group, limestone, 1,429 ft below base of Eureka Quartzite, 588 ft below base of Kanosh Shale (588 ft below top of formation D of Woodward, 1964).
Brachiopods:
Two genera, indet.
Trilobites:
Asaphid, indet.
Goniotelina sp. (cranidium only)

D1828 CO. Pogonip Group, limestone, 1,533 ft below base of Eureka Quartzite, 692 ft below base of Kanosh Shale (58 ft above base of formation D of Woodward, 1964).
Brachiopod:
Diparelasma sp.
Trilobites:
Ptyocephalus vigilans Whittington
Presbynileus sp.

D1829 CO. Pogonip Group, limestone, 1,541 ft below base of Eureka Quartzite, 700 ft below base of Kanosh Shale (50 ft above base of formation D of Woodward, 1964).
Triolobites:
Trigonocerca typica Ross
Presbynileus sp.
Small pygidium, possibly *Peltabellia*

D1830 CO. Pogonip Group, limestone, 1,602 ft below base of Eureka Quartzite, 761 ft below base of Kanosh Shale (11 ft below top of formation C of Woodward, 1964).
Brachiopods:
Small, indet.
Trilobites:
Fragments, indet. *Psalikilus* cf. *P. pikum* Hintze=zone H
Licnocephala? sp.

D1831 CO. Pogonip Group, limestone, 1,905 ft below base of Eureka Quartzite, 1,064 ft below base of Kanosh Shale (108 ft above base of formation C of Woodward, 1964).
Trilobites:
Protopresbynileus sp.
Probably correlates with zone G(2) of Ross (1951).

D1832 CO. Pogonip Group, limestone, 2,284 ft below base of Eureka Quartzite, 1,443 ft below base of Kanosh Shale (783 ft above base of formation B of Woodward, 1964).
Trilobite:
Asaphellus? cf. *A*? *eudocia* (Walcott) (Ross, 1951, pl. 27, figs. 17, 22, 23)
Probably zone G(1) of Ross (1951).

D1833 CO. Pogonip Group, limestone, 2,342 ft below base of Eureka Quartzite, 1,501 ft below base of Kanosh Shale (725 ft above base of formation B of Woodward, 1964).
Trilobites:
Pseudohystricurus? sp.
Asaphellus sp. 1
Probably zone C of Ross (1951).

D1834 CO. Pogonip Group, limestone, 2,494 ft below base of Eureka Quartzite, 1,653 ft below base of Kanosh Shale (573 ft above base of formation B of Woodward, 1964).
Trilobite:
Hystricurus cf. *H. oculilunatus* Ross

D1835 CO. Pogonip Group, limestone, 2,635 ft below base of Eureka Quartzite, 1,794 ft below base of Kanosh shale (432 ft above base of formation B of Woodward, 1964).
Trilobite:
Hystricurus? sp. (a single small pygidium)

D1836 CO. Pogonip Group, limestone, 3,022 ft below base of Eureka Quartzite, 2,181 ft below base of Kanosh Shale (45 ft above base of formation B of Woodward, 1964).
Trilobites:
Hystricurus sp. cf. *H. genalatus* Ross
Bellefontia sp.

D1837 CO. Pogonip Group, limestone, 3,065 ft below base of Eureka Quartzite, 2,224 ft below Kanosh Shale (2 ft above base of formation B of Woodward, 1964).

Xenostegium cf. *X. franklinense* Ross

No fossils were found in the underlying 300 ft of cherty dolomitic limestone.

AGE AND CORRELATION OF FOSSILS FROM THE STEPTOE SECTION

Fossils from this section include sponges, corals, bryozoans, brachiopods, gastropods, trilobites, ostracodes, and conodonts. Several fossil zones indicate close correlation with sections in Nevada to the south and west, although lithologic distribution differs from those sections. Such differences are particularly noticeable in making comparison with sections in west Utah.

The occurrence of *Dactylogonia?*, *Glyptomena?*, *Macrocoelia*, and *Öpikina* in the upper 165 feet of the Lehman Formation indicates that the upper part of the Pogonip Group is at least as young as the Ashby of Cooper (1956) and may be younger in this area. Although the first three of these genera can occur as low as Marmor, *Öpikina* is represented by a single species in beds as old as Ashby (Cooper, 1956, p. 168, 925). All other species of *Öpikina* are Porterfield or younger in age.

Kirkina is probably in collection D1812 CO and may be in D1813 CO although not listed there. Recently, Jensen (1967, p. 99, pl. 6, fig. 8; text fig. 2) has demonstrated the correct position of *K. millardensis* in the Crystal Peak Dolomite at Ibex, Utah. It becomes evident (L. F. Hintze, written commun., Apr. 3, 1968) that the original collections on which Salmon based the species were mixed with material from much lower in the section. This new information permits correct correlation of the Crystal Peak Dolomite at Ibex with the Lehman Formation at Steptoe. The base of the Eureka Quartzite and the lithic units close beneath it are younger at Steptoe than at Ibex to the southeast.

The occurrence of *Bathyurus*, not to be confused with *Goniotelina*, supports a Black River (Porterfield or younger) dating for collections as low as D1817 CO, and overlaps the upper range of *Anomalorthis*. This overlap is duplicated at Hot Creek Canyon.

The ostracode faunas of collections D1815 CO and D1816 CO, upper *Anomalorthis* zone, are comparable to those in the upper part of the Antelope Valley Limestone at Ikes Canyon. Positions of *Anomalorthis* and *Orthidiella* zones are indicated on plate 21.

There is a great abundance of sponges in the upper range of zone J (*Pseudocybele* zone) in this section.

FOSSIL ASSEMBLAGES AND CORRELATIONS

Tabulation and study of fossils in the foregoing stratigraphic sections coupled with corrections and additions to sections already published (Ross, 1964a, 1967a) indicate that previous views on Middle Ordovician correlations (Cooper, 1956; Kay, 1962; Ross, 1964 a, b), must be modified, that constitutions of faunal zones can be revised slightly, and that details of stratigraphy in several areas must be corrected.

Trilobites in the Lower Ordovician parts of the Pahranagat Range and Antelope Valley sections include genera of Baltic and South American types, many contrasting with assemblages found farther east.

ADDITIONS AND CORRECTIONS

Before discussing the correlation of Middle Ordovician strata in sections covered by this report, it is important to note additions and corrections to stratigraphic and paleontologic data presented previously (Ross, 1964a, 1967a).

Subsequent to publication of U.S. Geological Survey Professional Paper 523–D, J. W. Huddle identified conodonts and Jean Berdan ostracodes, from several collections that should be indicated on plate 11 of that publication (Ross, 1967a, pl. 11). It is suggested that the reader refer to plate 11 of Ross (1967a) and make notations to indicate positions and probable ages of collections listed below.

The additions and corrections noted below support the belief, previously gained from brachiopods, that varying thicknesses of the upper part of the Antelope Valley Limestone are of Marmor–Porterfield age. The possible lateral equivalence of strata of the Whiterock *Anomalorthis* zone to presumably younger Marmor–Porterfield strata has been previously noted (Ross, 1967a, p. D2, pl. 11).

NORTHERN INYO MOUNTAINS, CALIFORNIA

[Ross, 1964a, p. C35 ; 1967a, pl. 11]

The brachiopod *Multicostella* is in the Barrel Spring Formation although erroneously listed as *Plaesiomys* by Ross (1967a, p. D4, pl. 1, fig. 30). With the exception of a single species, *Multicostella* is considered to be of Ashby, Porterfield, and possibly Wilderness age. It is in the lower part of the Copenhagen Formation of central Nevada and in the Bromide strata of Oklahoma.

PYRAMID PEAK SECTION, RYAN QUADRANGLE, CALIFORNIA

[Ross, 1967a, p. D32, pl. 11]

The following collection should be added to Pyramid Peak column (Ross, 1967a, pl. 11):

D1691 CO. Antelope Valley(?) Limestone or lower part, Copenhagen Formation, 30–35 ft below base of Eureka Quartzite, approximately 11 miles southeast of Schwaub Peak. California coord., zone 4: E. 2,694,-100 ft, N. 419,400 ft, Ryan quad.

Brachiopods:

Orthambonites cf. *O. dinorthoides* Cooper

Concerning ostracodes, Jean Berdan (written commun., May 1, 1967) reported:

This collection contains a large species of *Schmidtella* with flattened umbones. Although the preservation is too poor to be certain, this species appears to be similar to *Schmidtella* from the following collections: USGS D680 CO, from 59–77 feet above base of Eureka, NW slope of Ranger Mts. (Ross, 1964a, p. C18), Nev.; USGS D710a CO, about 30 feet below base of quartzite, Ranger Mts. (Ross, 1964a, p. C19), Nev.; USGS 5458 CO, 69 feet above base of Eureka, Ranger Mts. section A, Nev.; USGS D836 CO, black shale beneath Eureka Quartzite, Rawhide Mt. (Ross, 1964a, p. C65, C68, fig. 5), Nev.; and probably also USGS D1616 CO, from 20 feet below the Eureka, 3.1 miles N. 65° E. of Schwaub Peak, Funeral Range, Calif. It has not as yet been found in any of the numerous collections from the upper part of the Antelope Valley Limestone in central and northern Nevada. This large species with flattened umbones is probably not conspecific with any of the three large species of *Schmidtella* from the middle part of the Kanosh Shale of Utah and eastern Nevada.

MEIKLEJOHN PEAK, BARE MOUNTAIN QUADRANGLE, NEVADA

[Ross, 1964a, p. C29; 1967a, pl. 11]

D1600 CO. Antelope Valley Limestone, uppermost 3 ft, beneath sandy base of lower part of the Copenhagen Formation.

Desmorthis n. sp. (pl. 19, figs. 12–15)
Valcourea plana Cooper
Leptellina occidentalis Ulrich and Cooper

Desmorthis is considered a contemporary of *Anomalorthis*. *Valcourea plana* is an early Copenhagen species, here occurring below that formation. *Leptellina occidentalis* is a *Rhysostrophia*-zone species. Here is another example of a mixed Whiterock and Ashby?–Porterfield assemblage.

D1598 CO. Antelope Valley Limestone, 280 ft below base of Copenhagen Formation (same locality as colln. D832 CO) (Ross, 1964a, p. C29, C30).

Brachiopod:

Atelelasma primotica Ross

Conodonts; listed by J. W. Huddle (written commun., Apr. 21, 1967):

	Number of specimens
"*Amorphognathus ordovicica* Branson and Mehl (type element)	4
ambalodus triangularis element	11
Periodon aculeatus Hadding, type element	1
ozarkodina macrodonta element	1
falodus prodentatus element	1
Phragmodus undatus Branson and Mehl, type element	2
dichognathus element	1
oistodus abundans element	2
Plectodina aculeata? (Stauffer)	2

"According to the Mississippi Valley ranges of these conodonts this fauna is late Wilderness or Barneveld in age."

On the basis of brachiopods this collection should be no younger than Porterfield. In Oklahoma, where Ordovician sections bear a close resemblance to those of Nevada, the brachiopods would probably be correlated with the Tulip Creek Formation or Mountain Lake Member of the Bromide (Cooper, 1956, p. 120–121, chart 1), or Ashby to Porterfield.

RANGER MOUNTAINS, NEVADA TEST SITE, FRENCHMAN LAKE QUADRANGLE

[Byers and others, 1961, table 189.1; Ross, 1964a, p. C17–C19; Ross, 1967a, pl. 11]

D1661 CO. Ely Springs Dolomite, approximately 160 ft above base, about 30 ft above base of upper member.

Brachiopods:

Furcitella sp.
Austinella sp.
Zygospira sp.
Skenidioides sp.
Paucicrura? sp.
Sowerbyella sp.

Conodonts; listed by J. W. Huddle (written commun., Apr. 21, 1967):

	Number of specimens
Amorphognathus ordovicia Branson and Mehl:	
nonblade type	6
blade type	3
ambalodus element	3
trichonodella element?	1
Belodina compressa (Branson and Mehl)	3
Cyrtoniodus flexuosus (Branson and Mehl)	3
Plectodina furcata (Hinde), *cordylodus* element	2
ligonodina element	1
zygognathus element	2
oulodus element	2
hibbardella element	1
ozarkodina element	1
Prioniodina sp	1
Ozarkodina tenuis (Branson and Mehl)	14
Scandodus cf. *S. unistriatus* Sweet and Bergström	1
Bryantodina? or *Rhipodognathus* n. sp	3

This fauna is probably Wilderness to Barneveld in age. The brachiopods give no cause to question the age indicated by the conodonts.

D1634 CO. Antelope Valley Limestone, 86–91 ft below top of formation (Ross, 1967a, pl. 11, position indicated but brachiopod identifications incorrect; corrected in this report, below).

Brachiopods:

Camerella aff. *C. nuda* Cooper

Dorytreta subcircularis Ross n. sp.

Conodonts; listed by J. W. Huddle (written commun., Apr. 21, 1967):

	Number of specimens
Acodus? sp	1
Drepanodus subcrectus (Branson and Mehl)	
type element	2
homocurvatus element	4
Drepanodus n. sp. D (occurs in D1579 CO)	1
Oepikodus? sp	2
Phragmodus inflexus Stauffer type element	10
dichognathus element	1
cordylodus element	1

"*Phragmodus inflexus* occurs in the Dutchtown, McLish and lower part of the Glenwood Formations. It is older than the other species of *Phragmodus* and ranges from Marmor to early Wilderness in the Mississippi Valley."

Evidence of the brachiopods and conodonts is in accord. Species of *Camerella* similar to *C.* aff. *C. nuda* are known primarily from strata of Porterfield or younger age. *Dorytreta* is of Marmor and Ashby age (Cooper, 1956, p. 155, 172).

D1660 CO. Antelope Valley Limestone, 175 ft below top, Ranger Mountains section of Byers and others (1961) (Ross, 1964a, p. C17; 1967a, pl. 11)

Conodonts; listed by J. W. Huddle (written commun., Apr. 21, 1967):

	Number of specimens
Drepanodus suberectus (Branson and Mehl)	
type element	1
homocurvatus element	5
Cordylodus sp	3
sp.	3
Oistodus multicorrugatus Harris	1
sp.	1
sp.	2
Paltodus n. sp	18
Phragmodus n. sp. *cordylodus* element	7
ligonodina element	12
dichognathus element	10
hibbardella element	4
Prioniodina sp	2
Dichognathus? sp., has three denticulate bars	7

This is a new fauna, presumably Middle Ordovician. *Prioriodina* sp. and *Dichognathus*? sp. may belong in *Phragmodus* n. sp.

UNIT 3 OF McALLISTER (1952)

Unit 3 of McAllister (1952) is indicated on plate 11 of Ross (1967a) as a remarkably persistent shaly interval, but its position at the Nevada Test Site has been incorrectly plotted. It actually lies 250–320 feet below the Ninemile Formation in the Test Site section.

REVERSED ISOPACHS

The designations of the 800-ft and 1,200-foot isopachs were erroneously switched in figure 7 of Ross (1964b).

REVISION OF MIDDLE ORDOVICIAN FOSSIL ZONES

The compilation of fossil occurrences in many more stratigraphic sections than were known previously permits reevaluation of the fossil zones of the Whiterock Stage. As already noted (Ross, 1964a, p. C74–C78; 1964b, p. 1534–1539), this stage has been a source of disagreement; the modifications and correlations that follow may reduce previous discords.

THE WHITEROCK STAGE

Although the Whiterock Stage has been discussed at considerable length (Kay, 1962; Ross, 1964a, p. C74–C84; 1964b, p. 1534–1541), some conclusions previously reached by the author are untenable in light of work reported here; others are strengthened. Recent versions of the meaning of the Whiterock Stage have been presented by Whittington (1968, p. 51–52) and Flower (1968, p. 6–8). None of the facts presented by these authors is incompatible with the revision proposed.

Kay (1960), in reviewing the Ordovician stages of North America, indicated that all seem to be useable and readily understood except the Whiterock of Cooper (1956). One must conclude, as a result of this author's work across southern Nevada (Ross, 1964a, p. C74–C85; 1964b, p. 1534–1540; 1967a, p. D2, pl. 11), that the fossil zones of the Whiterock Stage are generally valid but not as Cooper (1956, p. 7–8, 126–127, chart 1) conceived them. It is certain that several modifications of fossil ranges within zones of the stage must be made. How much, if any, overlap there may be between the Whiterock Stage and the older Canadian or younger Marmor–Porterfield needs further examination.

The Whiterock Stage, as defined by Cooper (1956, p. 7–8, 126–127, chart 1), was composed of five fossil zones; Cooper (1956, p. 126) implied that the type area of the stage was the environs of Antelope Valley and the Toquima Range, and stated, "* * * the complete section has never been ascertained, and some uncertainty exists as to sequence." However, the compilation of a composite section introduced some unfortunate anomalies.

The inclusion of the provincial faunas and differing facies of the Toquima Range (Ikes Canyon) has caused unnecessary confusion within the concept of the Whiterock Stage. So much more evidence is available than was available to Cooper and so much more will continue to be available than has been gathered to date that adjustments will continue to be made.

The discovery (Ross, 1964a, p. C69–C70 of *Leptellina-Valcourea*-bearing beds in the uppermost Antelope Valley Limestone on the west side of Antelope Valley indicated that there was no great difference, if any, in age between the lower beds of the Copenhagen and the upper beds of the Antelope Valley. Since Cooper (1956, chart 1, Nevada column) considered the lower beds of the Copenhagen to be Ashby-Porterfield, the *Anomalorthis* zone of the Whiterock Stage seemed to be succeeded by Ashby strata without space for Marmor age rocks and without apparent disconformity. Nor was there obvious room for the fifth zone of the Whiterock Stage—the *Rhysostrophia* zone. The possibility existed that the Whiterock might itself be synonymous with the Marmor in an age sense. A review of Cooper's (1956) correlation chart 1 did not discourage that possibility. The discovery (Ross, 1964a, p. C24–C31; 1967a, pl. 11) at Meiklejohn Peak of a mixed Marmor–Porterfield brachiopod fauna as the lateral equivalent of the upper *Anomalorthis* zone at the Nevada Test Site (Ross, 1967a, pl. 11), both beneath an early Copenhagen fauna, strengthened the possibility that a large part of the Whiterock Stage might correlate with the Marmor Stage.

Any alternate hypothesis calls for unconformities of geographic extent and stratigraphic positions so unusual as to be unlikely. To eliminate the effect of such potential unconformities, the most complete Pogonip sections were measured and collected and are the subject of this part of the report. Measurement and comparison of sections in the Pahranagat, Groom, Egan, Hot Creek, and Monitor Ranges indicate that the northern Monitor Range section is more complete than Cooper (1956, chart 1) realized and that the existence of a major unconformity is very unlikely between the top of the Antelope Valley Limestone and the lower beds of the Copenhagen Formation.

The fossil evidence for all zones of the Whiterock Stage has been reassessed in an effort to reconcile the greatest possible number of seeming anomalies within the stratigraphic framework. As noted above, these anomalies are all caused by the inclusion of the Toquima Range (Ikes Canyon) section, the Meiklejohn Peak section, and the northern Inyo Mountains (Mazourka Canyon) section (R. J., Ross, 1964a, p. C35–C41; 1967a, pl. 11; D. C. Ross, 1966, p. 12–18, pl. 2).

THE ORTHIDIELLA ZONE REVISED

The *Orthidiella* zone was based largely on collections from south of Frenchman Flat (Cooper, 1956, p. 126) on the Nevada Test Site; this locality was re-collected by this author (Ross, 1964a, p. C20–C21, USGS collns. D718 CO–D720 CO, D726 CO–D728 CO; 1967a, pl. 11). The zone is gradational with the older *Pseudocybele* zone (zone J); a considerable number of species of the two zones overlap (Ross, 1967a, pl. 11, Nevada Test Site col.).

The *Orthidiella* zone is also in Whiterock Canyon, west of Martin Ridge, in the northern Monitor Range; in that locality, however, the base of the Antelope Valley Limestone has ben removed tectonically, and the *Orthidiella* zone is in the sole of a thrust plate (Lehner and others, 1961). The underlying shale is not the Canadian Ninemile Formation as Cooper (1956, p. 126) thought.

The correlative of the *Orthidiella* zone is the fossil assemblage of the Juab Limestone and the lower 6 feet of the Kanosh Shale at Ibex, Utah (Jensen, 1967, p. 74; text fig. 2). Jensen proposed to extend the *Anomalorthis* zone downward to include *Anomalorthis juabensis* Jensen, but this is a species having a low cardinal area similar to *A. lambda* Ross (1968, p. H9, pl. 4, figs. 1–12) and to *Anomalorthis* n. sp. A (this report p. 62, pl. 5, figs. 26–31; pl. 6, figs. 2, 3, 5). Such species of *Anomalorthis* seem to be characteristic of the *Orthidiella* zone (zone L), and are also in the same zone in the Canadian Rockies (B. F. Norford, written commun., Sept. 1965). Ross (1968, p. H2–H4) discussed correlation of the Garden City Formation in eastern Utah with zone L.

Westward, the brachiopod composition of the *Orthidiella* zone changes to some extent. *Orthidium* is in the Specter Range (Ross, 1967a, p. D37, colln. D1441 CO; this paper, p. 53). *Porambonites* occurs in the great bioherm at Meiklejohn Peak, as does *Syndielasma*. All three of these genera were considered characteristic of his *Rhysostrophia* zone by Cooper (1956, p. 127).

In addition, experience in the Nevada Test Site section (Ross, 1964a, p. C20–C21), in the Specter Range section (Ross, 1967a, p. D37), in the Pyramid Peak section (Ross, 1967a, p. D33–D34), and in the Ibex section, Utah (this report pl. 21; Jensen, 1967, p. 73, text fig. 2), shows that the *Orthidiella* zone fauna includes the brachiopods and trilobites listed below.

As noted before, the *Orthidiella* zone of Jensen (1967, p. 73, text fig. 2) must be modified to include *Anomalorthis juabensis* Jensen, all the brachiopods of the Juab Limestone, and brachiopods of the lower 6-foot limestone of the Kanosh Shale.

Brachiopods:
- *Orthidium barnesi* Ross, n. sp.
  - *extensa* Ulrich and Cooper
  - *longwelli* Ulrich and Cooper
  - *costellata* Ulrich and Cooper
- *Trematorthis* sp.
- *Orthambonites marshalli* (Wilson) (listed previously as *O. subalata*)
- *Anomalorthis* (always species with low cardinal areas)
  - *juabensis* Jensen
  - *lambda* Ross
  - n. sp. A (p. 62)

Brachiopods—Continued
- *Ingria cloudi* Ulrich and Cooper
- *Syndielasma* sp.
- *Liricamera nevadensis*
- *Idiostrophia nuda* Cooper (collected at Meiklejohn Peak within bioherm and below *Orthidiella* itself; also at Ibex, Utah)
- *Porambonites*? sp.

Trilobites (17 genera):
- *Carolinites indentus* Ross
  - *angustagena* Ross
- *Nileus hesperaffinis* Ross
  - sp.
- *Goniotelina hesperia* Ross
- *Ampyx compactus* Ross
- *Trinodus clusus* (Whittington)
- *Illaenus auriculatus* Ross
- *Ischyrotoma* sp.
- *Protocalymene mcallesteri* Ross
- *Ectenonotus whittingtoni* Ross
  - cf. *E. westoni*
- *Raymondaspis vespertinus* Ross
- *Cydonocephalus scrobiculus* Whittington
- *Apatolichas* sp.
- *Heliomeroides* sp.
- *Diacanthaspis* sp.
- aff. *Myracybele* sp. 1 (a new genus) (Ross, 1967a, p. C25–C26)
- *Bathyurellus* sp.
- *Remopleurides* sp.

This is a fairly impressive list of genera and species, yet others can be added. Besides the brachiopods noted at Meiklejohn Peak (Ross, 1967a, pl. 11) within the great bioherm, more trilobites, brachiopods, gastropods, and cephalopods are present. The study of that assemblage is only starting. Although the study will eventually be reported elsewhere, it is important to take stock of some of the trilobite genera already known to be present. These include the following 11 genera:

- *Bathyurellus*
- *Ectenonotus*
- *Endymionia*
- *Nileus*
- *Illaenus*
- *Selenoharpes*
- *Kawina*
- *Cydonocephalus*
- *Xystocrania*
- *Pseudomera*
- *Carolinites*

The resemblance to the assemblages from the reef rock at Lower Table Head and from the Middle Table Head Formation, Newfoundland (Whittington, 1963, 1965a) is undeniable. But this close relationship is already obvious from the lists of trilobites from the *Orthidiella* zone already given. Even at the generic level there exists an equally striking resemblance to the trilobites from the Ikes Canyon section in the interval from collection D1602 CO upward through collection D1514 CO.

Whittington (1965a, p. 289–290) used Simpson's (1960) index of faunal resemblance, second method, to compare Lower and Middle Table Head trilobite assemblages with possible correlatives. So that comparable results may be reached here, the same index is used below based on genera; as a standard Whittington gave the index for two localities of the Middle Table Head located within a mile of each other and the index for comparing Lower and Middle Table Head.

Trilobite assemblages compared	*Faunal resemblance index*[1]
Middle Table Head, type section/Middle Table Head, Table Cove (Whittington, 1965, p. 290)	80
Lower Table Head/Middle Table Head (Whittington, 1965a, p. 290)	45
1. *Orthidiella* zone composite/Ikes Canyon, D1602 CO–D1514 CO	76
2. Meiklejohn bioherm/Ikes Canyon, D1602 CO–D1514 CO	73
3. Meiklejohn bioherm/Lower Head boulder (Whittington, 1963)	73
4. Ikes Canyon. D1602 CO–D1514 CO/Middle Table Head	70
5. *Orthidiella* zone composite/Middle Table Head	65
6. Meiklejohn bioherm/Middle Table Head	64
7. *Orthidiella* zone composite/Ibex area zone L (U.S. Geol. Survey collns.)	60
8. *Orthidiella* zone excluding bioherm/Ikes Canyon, D1602 CO–D1514 CO	58
9. *Orthidiella* zone composite/Lower Table Head	57
10. Meiklejohn bioherm/Lower Table Head	55
11. *Orthidiella* zone composite/Ibex area, zone N (Hintze, 1952, p. 22)	50
12. Ikes Canyon, D1602 CO–1514 CO/Lower Table Head	45
13. *Orthidiella* zone composite/Ibex area, zone M (Hintze, 1952, p. 21)	44
14. Ikes Canyon, D1602 CO–D1514 CO/Ibex area, zone L (U.S. Geol. Survey collns.)	40
15. Ikes Canyon, D1602 CO–D1514 CO/Ibex area, zones M and N (Hintze, 1952, p. 21, 22)	40
16. *Orthidiella* zone composite/Ibex area, zones M and N (Hintze, 1952, p. 21, 22)	33

[1] Simpson's (1960) index of faunal resemblance, method 2. C=taxa common to both assemblages. N_1=total taxa in the smaller assemblage. Index=$C/N_1 \times 100$.

From this tabulation we may conclude that the *Orthidiella* zone trilobites of southern Nevada are almost as much like those of the lower part of Ikes Canyon section (colln. D1601 CO upward through colln. D1514 CO) (index=76) as are trilobites of two neighboring sections of the Middle Table Head Formation (index=80). Ikes Canyon is 150 miles north of Meikle-you section (colln. D1601 CO upward through colln. than a mile apart (Whittington, 1965a, p. 290). The *Orthidiella* zone trilobites of southern Nevada show less resemblance to their known contemporaries in zone L at Ibex area, Utah (index=60).

From this tabulation it also becomes apparent that the close resemblance between the Table Head Formation and the Antelope Valley Limestone (index=63) indicated by Whittington (1965a, p. 290) is in truth a close correspondence between the trilobite fauna of the *Orthidiella* zone and that of the Middle Table Head (index=65).

That these correlations are strongly affected by environmental conditions is shown strikingly by the high resemblance between the Meiklejohn bioherm and the biohermal boulder at Lower Head (Whittington, 1963; index=73), from which one might conclude that the Lower Head fauna should be correlated with the Middle Table Head were it not for the assurances of Whittington (1965a, p. 290) that the fauna probably correlates with the Lower Table Head.

We find that environment must also affect relative resemblance when comparing equations 1, 2, and 8 of the tabulation. Although fossils in the pure limestone of the reef have much in common with those in the surrounding silty limestones, there are marked differences.

Despite such differences it seems obvious from the trilobite evidence that the lower part of the Antelope Valley Limestone at Ikes Canyon (collns. D1602 CO upward to include D1514 CO) is best correlated with the *Orthidiella* zone. This interval includes the basal calcarenite, the lower slabby bedded unit (calcilutite beds of Kay, 1962), the nileid beds (asaphid beds of Kay, 1962), and at least the lower part of the so-called "sponge beds."

Previously the "sponge beds" were correlated with the *Anomalorthis* zone to the east primarily on the basis of *Xystocrania* and a large *Kawina*- or *Neizkowskia*-like species in both the "sponge beds" and zone N at Ibex, Utah (Hintze, 1952, p. 22). Brachiopods are of little help in making the correlation because most of those at Ikes Canyon are very provincial, have little distribution eastward, and are almost unknown in sections of central, eastern, and southern Nevada. They are known, however, in the Table Head of Newfoundland. *Orthambonites minusculus* (Phleger) is the most common species in the Toquima Range. It is known in the northern Inyo Mountains (Ross, 1967a, pl. 11) well below *Palliseria* and is associated with *Rhysostrophia.*

Flower (1968, p. 6–7, 20–22) presented cephalopod evidence that the "sponge beds" of Ikes Canyon correlate with the reef limestones of Meiklejohn Peak, that is, with the *Orthidiella* zone. He further showed that an assemblage from the underlying nileid beds has no counterpart eastward in Nevada and Utah, a fact that this author suggests may be related to facies. Flower also confirmed that cephalopods common to zones M and N (*Anomalorthis* zone) are derived from beds immediately above the "sponge beds"—from the *Palliseria*-bearing strata. He also noted that virtually no cephalopods have been collected in beds above *Palliseria* that are still within the range of the *Anomalorthis* zone in central Nevada.

As a result the inclusion in the *Anomalorthis* zone (Cooper, 1956, p. 127) of five brachiopods occurring in the *Orthidiella* zone can be altered: *Aporthophyla typa* Ulrich and Cooper, *Idiostrophia paucicostata* Cooper, *Orthambonites minusculus* (Phleger), *Porambonites?* sp. 1, and *Lingulella* sp. 1. Of these, *Aporthophyla typa* ranges above the "sponge beds" as high as collection D1513 CO at Ikes Canyon and for that reason probably belongs also in the *Anomalorthis* zone. *Porambonites?* unquestionably belongs in the *Orthidiella* zone although it too may range higher. *Porambonites?* sp. 1 of Cooper (1956, p. 127, 609–610, pl. 108H, figs. 40–42) was actually collected by McAllister (1952, unit 8, p. 11), 300 feet below the Eureka Quartzite west of Racetrack Valley, Calif. If plotted on the appropriate stratigraphic section of Ross (1967a, pl. 11), it is low in the *Palliseria* zone and very close to the *Orthidiella* zone. A second very important result of these correlations and rectifications in the Ikes Canyon section is the discovery that *Palliseria* seems to succeed the *Orthidiella* zone, as it does in other sections south and east.

PALLISERIA ZONE REDUCED TO SUBZONE

As originally defined (Cooper, 1956, p. 127; Nolan and others, 1956, p. 28–29, = *Mitrospira* zone), the *Palliseria* zone overlay the *Orthidiella* zone west of Antelope Valley and underlay the *Anomalorthis* zone at Lone Mountain (pl. 21). Relative to the *Orthidiella* zone the *Palliseria* beds hold a remarkably consistent position. As far away as Mons Glacier and Mount Whiterose in Alberta (Aitken and Norford, 1967, p. 179, 203, figs. 5, 7), they are in the same position. The position relative to the *Anomalorthis* zone is corroborated in the Arrow Canyon Range and at the Nevada Test Site (Ross, 1967a, pl. 11).

At Meiklejohn Peak (Ross, 1964a, p. C24–C25) *Palliseria* is 180 feet above the *Orthidiella* zone.

Collections made from sections in the Pahranagat Range (p. 7) and Groom Range (p. 13), summarized on plate 20 and in fig. 2 demonstrate that the *Palliseria* zone overlaps much of the range of the *Anomalorthis* zone. In the most easterly section, the Pahranagat Range (pl. 20), the *Palliseria* zone may have masked the *Orthidiella* zone much as it may have masked the lower *Anomalorthis* zone at Meiklejohn Peak.

The author previously proposed a westward shift in the age of the *Palliseria* zone to explain its occurrence with *Rhysostrophia* in the northern Inyo Mountains (Ross, 1964a, p. C79–C80, fig. 10; 1964b, p. 1540, fig. 6).

At that time the ranges of components of the *Rhysostrophia*-zone assemblage (Cooper, 1956, p. 127) were not so well known as they now are; there was little evidence to show that the *Rhysostrophia* zone was coeval with the *Anomalorthis* zone.

Since the *Palliseria* zone overlaps at least the lower *Anomalorthis* zone, its position below *Rhysostrophia* at Ikes Canyon and associated with *Rhysostrophia* in the northern Inyo Mountains is not anomalous. The hypothesis that *Palliseria* migrated westward (Ross, 1964a, fig. 10; 1964b, fig. 6) must be curtailed.

Flower (1968, p. 7) in his work with cephalopods noted the probable equivalence of the *Palliseria* zone at Ikes Canyon and at Meiklejohn Peak; this also supports the necessity of abandoning the migration hypothesis. The assemblage of the zone is composed of *Palliseria*, large *Maclurites*, and usually an abundance of *Girvanella* or *Girvanella*-like structures. This assemblage is obviously controlled to some extent by facies, being more common in thick-bedded limestones and dolomites than in thinner muddy limestones. However, it does occur in the more muddy strata in the northern Inyo Mountains. The *Palliseria* zone is useful stratigraphically because it is easily recognized in the field. It should be considered a subsidiary zone of the *Anomalorthis* zone.

ANOMALORTHIS ZONE REDEFINED

Considerable confusion results from any effort to reconcile what is now known of fossil ranges with original descriptions of the *Anomalorthis* zone (Cooper, 1956, p. 127); the limits of the zone were not specified. The "sponge beds" at Ikes Canyon (Bassler, 1941), which Cooper (1956, p. 127) thought should be assigned to this zone, can now be correlated with the *Orthidiella* zone; these beds must not be taken as a "type section" for the *Anomalorthis* zone as some workers would insist. (The stratigraphic code, American Commission on Stratigraphic Nomenclature (1961) excludes type sections for biostratigraphic units such as zones.)

A compilation of relative ranges of a few distinctive brachiopods and trilobites of the middle and upper members of the Antelope Valley Limestone is shown in figure 2A. This compilation is taken from the Pahranagat, southern Groom, Hot Creek, and Egan Ranges, supplemented by the Ranger Mountains section on the Nevada Test Site (p. 43; Ross, 1967a, pl. 11), and the Monitor Range west of Antelope Valley. The Monitor Range section was not used as a prime source for this compilation because it itself is a composite from several sources (p. 28) and surely includes inaccuracies inherent in its own compilation.

Ranges of fossils were first compiled on a purely stratigraphic basis by using the base of the Eureka Quartzite or the Copenhagen Formation as a datum. Because that lithic boundary is probably time-transgressive, the datum for the compilation of figure 2A was changed to the highest occurrence of *Anomalorthis* in each section.

The result is probably not precisely correct and surely needs further adjustment; however, positions of fossils and combinations of fossils are remarkably consistent from one stratigraphic section to another. No account was taken of the section at Ibex, Utah, either from the author's collections or the zonation published by Jensen (1967, text fig. 2); the close comparison is therefore worth noting. *Anomalorthis oklahomensis* is not known at Ibex, although it is common in the upper part of the *Anomalorthis* zone southward and westward in Nevada. *A. utahensis* has a much longer range at Ibex, according to Jensen, than in Nevada. His data show that a similar contrast must exist in ranges of *Desmorthis nevadensis*. Although these differences are relatively minor, they do indicate geographic influence on species distribution.

As indicated in figure 2A, the stratigraphic distribution of the species of *Anomalorthis* forms a natural basis for the *Anomalorthis* zone through about 700 feet of strata. The two longest ranging species seem to be *A. lonensis* (Walcott) and *A. nevadensis* Ulrich and Cooper. When present, *A. oklahomensis* Ulrich and Cooper occurs in the upper two-thirds of the zone. *A. fascicostellatus* and *A. resoi* are so far known only from the lower part of the *Anomalorthis* zone; *A. resoi* can be distinguished from *A. oklahomensis* only if suites of well-preserved specimens are available.

It is important to note that the upper range of the *Anomalorthis* zone includes *Plectorthis*, several species of *Bathyurus*, and at least one species of *Basilicus*. These are Llandeilo and Black River (Porterfield–Wilderness) genera.

Various species of *Desmorthis* occur throughout the zone, so that the "*Desmorthis* zone" is virtually a synonym of the *Anomalorthis* zone. At Ibex, Utah, Jensen (1967, text fig. 2) indicated that *Desmorthis* ranges higher than any species of *Anomalorthis;* this may be true at Meiklejohn Peak (USGS colln. D1600 CO, p. 43).

Palliseria overlaps the lower one-third to two-thirds of the *Anomalorthis* zone, depending on local conditions of sedimentation.

A natural division of the species of *Anomalorthis* seems to correspond closely with the separation of Hintze's (1952, p. 20–22) zones M and N, based on *Pseudoolenoides dilectus* Hintze and *P. acicaudus* Hintze. These two species have been recognized at Steptoe but no farther west in Nevada; *Pseudoolenoides dilectus* is one of the most abundant trilobites in the lower part of the Swan Peak Formation of Utah.

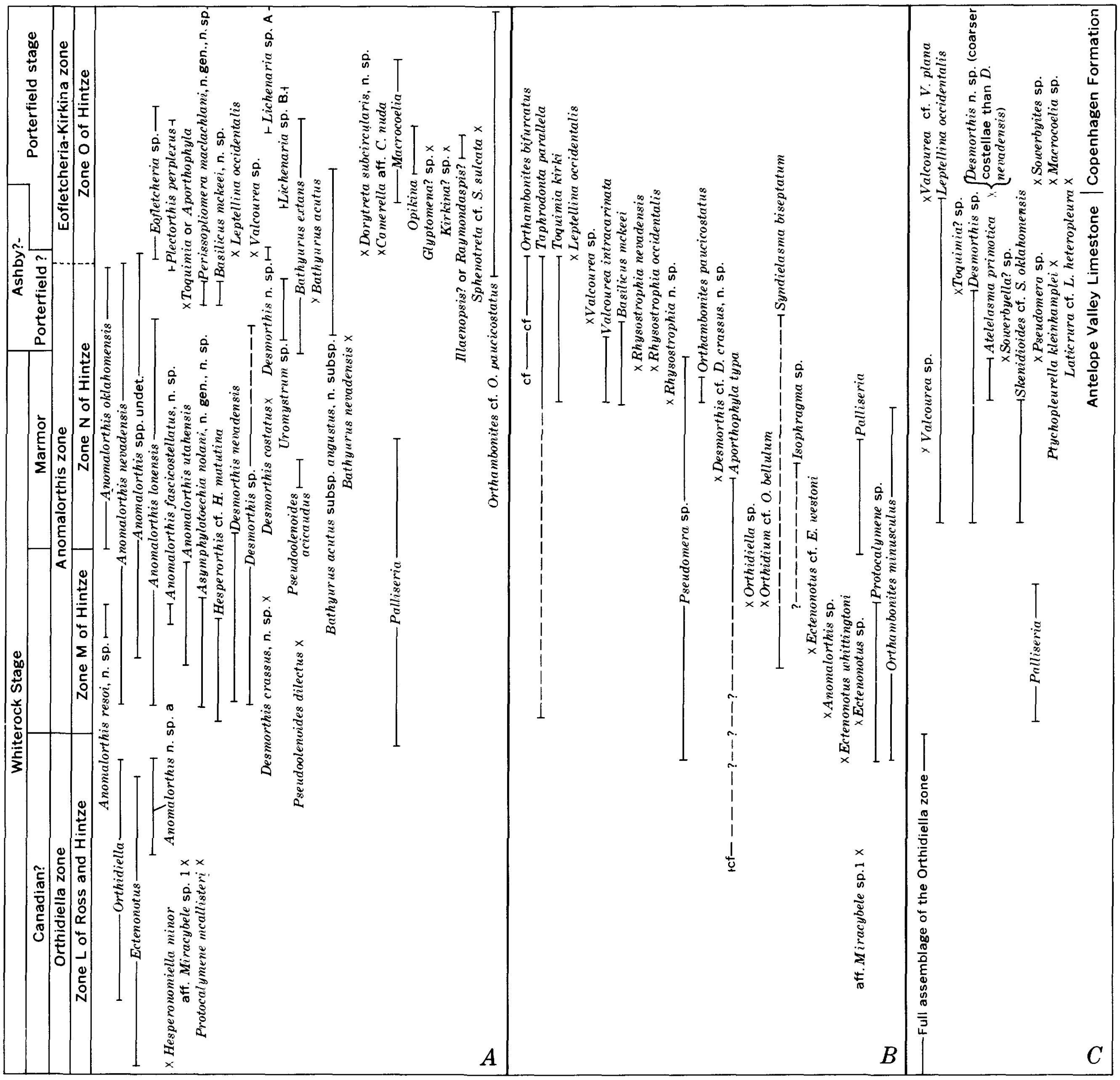

FIGURE 2.—Relative ranges of selected Middle Ordovician fossils, all compiled to the same vertical scale for comparison. *A*, Based on Pahranagat, Groom, Hot Creek, and northern Egan Ranges, supplemented by Nevada Test Site, and northern Monitor Range, *B*, Based on Ikes Canyon, Toquima Range. *C*, Based on Meiklejohn Peak, Bare Mountain quadrangle, Nevada.

It should be noted that *Pseudomera* is so common a trilobite throughout the *Anomalorthis* zone that it was not plotted in figure 2*A*. It is equally common in zone L of the Garden City Formation (equals *Orthidiella* zone).

In the Ibex, Utah, area, from which *Anomalorthis oklahomensis* is absent and where *A. nevadensis* does not range as high as in Nevada, the separation of Hintze's (1952) zone O (*Eofletcheria* zone) is relatively simple. Westward this separation becomes almost impossible, and it is probable that the simplicity of the separation at Ibex is misleading, being facilitated by the presence of the unfossiliferous Watson Ranch Tongue of the Swan Peak Quartzite (Jensen, 1967, text fig. 2).

In the following list the position of each species within the zone is indicated by: L, low; M, middle; and U, upper. These positions are tentative. Several species are common to the upper *Anomalorthis* and *Eofletcheria* zones. As indicated in figure 2*A*, the *Anomalorthis* zone includes:

Brachiopods:

L–U	*Anomalorthis lonensis* Walcott
L–U	*nevadensis* Ulrich and Cooper
M–U	*oklahomensis* Ulrich and Cooper
L	*fascicostellatus* Ross, n. sp.
L	*resoi* Ross, n. sp.
L	*utahensis* Ulrich and Cooper
L–M	*Desmorthis nevadensis* Ulrich and Cooper
M	*costatus* Cooper
L	*crassus* Ross, n. sp.
L	*Hesperorthis* cf. *H. matutina* Cooper
L	*Asymphylotoechia nolani* Ross, n. gen., n. sp.
U	*Plectorthis perplexus* (Ross)
M–U	*Toquimia* or *Aporthophyla* sp.
U	*Dorytreta subcircularis* Ross, n. sp.
U	*Camerella* aff. *C. nuda* Cooper
U	*Orthambonites* cf. *O. paucicostatus* Cooper
U	*Leptellina occidentalis* Ulrich and Cooper
U	*Valcourea* sp.

Trilobites:

L	*Pseudoolenoides dilectus* Hintze
M	*acicaudus* Hintze
	Pseudomera barrandei Billings
U	*Perissopliomera machlachlani* Ross, n. gen., n. sp.
U	*Basilicus mckeei* Ross, n. sp.
M–U	*Bathyurus extans* Billings
U	*acutus* Billings
M–U	*acutus* var. *angustus* Ross, n. var.
U	*nevadensis* Ross
M–U	*Uromystrum* sp.

In establishing the fossil assemblage of the *Anomalorthis* zone, no heed has been paid the Toquima Range (Ikes Canyon) sections or the Meiklejohn Peak section. At both places the upper part of the Antelope Valley Limestone is more muddy than to the east. At both, above the *Orthidiella* zone, the position of the *Anomalorthis* zone is taken by a very different assemblage of brachiopods. Stratigraphic position strongly suggests that these different assemblages correlate with the *Anomalorthis* zone. The aspect of the more westerly assemblages is seemingly younger.

In both of these sections the position of the *Orthidiella* zone is well established. At Meiklejohn Peak (fig. 2*C*; Ross, 1967a, pl. 11) the position of the *Macrocoelia-Sowerbyites - Laticrura - Valcourea - Leptellina*-bearing beds, equivalent to the lower part of the Copenhagen Formation, is evident. These beds are correlative with the fossils of zone O of the composite section (fig. 2*A*, pl. 22.

The distribution of brachiopods between the *Orthidiella* zone and zone O at Meiklejohn Peak is shown in figure 2*C*. Spacing of the two bracketing zones is almost identical to their spacing in the composite section.

The lower *Anomalorthis* zone is seemingly masked by the *Palliseria* subzone facies. The overlying fossil assemblage—*Skenidioides*, *Atelelasma*, *Valcourea*, *Leptellina*, *Ptychopleurella*—suggests a Porterfield age.

A Porterfield-Wilderness (Black River) age assignment for the upper *Anomalorthis* zone is in accord with the evidence of such fossils at *Bathyurus* (several species), *Basilicus* (Llandeilo), *Plectorthis*, *Dorytreta*, and *Camerella* aff. *C. nuda* of the composite section (fig. 2*A*). These are succeeded by other fossils of undeniable Porterfield age.

The distribution of fossils in the Ikes Canyon section (pls. 20 and 21 and fig. 2*B*) is more difficult to reconcile with the composite distribution (text fig. 2*A*), mainly because it has been interpreted by Cooper (1956, p. 126–127) in a very different way, on the basis of less complete knowledge of faunal occurrences.

The "sponge beds" of Ikes Canyon were unfortunately assigned to the *Anomalorthis* zone; their correct assignment to the *Orthidiella* zone has been previously discussed. The *Palliseria* beds overlie the "sponge beds" (and the *Orthidiella* zone) as they do elsewhere.

Four of the brachiopods listed by Cooper (1956, p. 127) for the *Anomalorthis* zone—*Aporthophyla typa*, *Orthambonites minusculus* (Phleger), *Idiostrophia paucicostata*, and *Porambonites* sp. 1—probably all occur in the *Orthidiella* zone. However, *A. typa* ranges higher; it and *O. minusculus* are present above *Palliseria*.

It is likely that the upper *Anomalorthis* zone of the composite section (fig. 2*A*) is correlative with the *Rhysostrophia* zone of Cooper (1956, p. 127) at Ikes Canyon. Therefore, a discussion of some of the problems of the *Rhysostrophia* zone is in order.

RHYSOSTROPHIA ZONE REDUCED TO SUBZONE

In the Western United States the *Rhysostrophia* zone is known only at Ikes Canyon (Cooper, 1956, p. 127; Kay, 1962, p. 1422, table 2; this paper, pls. 20, 21) and in the northern Inyo Mountains (R. J. Ross, Jr., 1964a, p. C40, C80; 1964b, p. 1539; 1967a, pl. 11; D. C. Ross, 1966, p. 14). Its stratigraphic position relative to other Middle Ordovician zones has not been clear, and its age has been uncertain. At Ikes Canyon the zone seems to be of Marmor or Porterfield age; in the northern Inyo Mountains it occurs with *Palliseria*.

Kay (1962, p. 1422, table 2) first showed that the *Rhysostrophia*-zone assemblage could be refined by separating "*Leptellina-Sowerbyella* beds" from the upper part in the vicinity of Ikes Canyon. The work tabulated here (fig. 2, pls. 20 and 21) agrees in most essentials of lithologic description and fossil distribution with Kay's. The author (Ross, 1964a, p. C80–C83; 1964b,

p. 1536–1538) analyzed the composition of the *Rhysostrophia* zone as presented by Cooper (1956, p. 127) and concluded that it was probably of Marmor (Chazy) age and might be partly coeval with the *Anomalorthis* zone. As a result of the present study, stratigraphic distributions of some of the genera are revised.

Ross (1967a, p. D2, D37) reported that *Orthidium* occurs in the Specter Range in the *Orthidiella* zone. The species is described on page 53 as *Orthidium barnesi* Ross, n. sp. At Ikes Canyon, *Orthidium* cf. *O. bellulum* Cooper was found in collection D1514 CO (pl. 1, fig. 1) in the *Orthidiella* zone far below the range of *Rhysostrophia;* no example of the genus was discovered higher in the section. *Syndielasma biseptatum* Cooper is in the range of collections D1516 CO to D1514 CO (*Orthidiella* zone) at Ikes Canyon and is probably as high as D1508 CO. At Ikes Canyon the author failed to find *Porambonites*, but the lithology of the upper part of the stratigraphic interval correlative with the *Orthidiella* zone is a silty yellowish-gray-weathering nodular limestone very much like the higher part of the *Rhysostrophia* zone. All collections of *Porambonites* made by this author to date from other sections have been from the *Orthidiella* zone.

Taphrodonta and *Toquimia* range upward from the *Rhysostrophia* zone proper; *Taphrodonta* is present as low as collection D1518 CO within the *Orthidiella* zone (see p. 26). Neither genus is known outside central Nevada.

Toquimia is questionably at Hot Creek Canyon (D1483 CO) well below the top of the *Anomalorthis* zone, and it may be at Meiklejohn Peak (D1599 CO). In neither collection were brachial valves found that would have clinched identification. However, these occurrences hint that the *Rhysostrophia* zone is the same age as the upper *Anomalorthis* zone.

The presence of the same species of *Basilicus* in collections D1508 CO and D1511 CO at Ikes Canyon and in collection D1857 CO at Hot Creek Canyon supports this possible correlation. Conodonts in collections D1524 CO and D1525 CO (p. 23–24) indicate equivalence with D1485 CO at Hot Creek Canyon. Ostracodes (p. 24, 28) suggest correlation of D1510 CO and D1523 CO at Ikes Canyon with D1483 CO at Hot Creek Canyon.

It seems fairly evident that correlation of the *Rhysostrophia* zone at Ikes Canyon with the upper *Anomalorthis* zone of more easterly sections is more than a possibility.

The probable Porterfield age of the upper *Anomalorthis* zone has been already noted. What of the age of the *Rhysostrophia* zone? *Leptellina*, *Valcourea*, and *Basilicus* are all Black River–Porterfield genera, although the range of the first two includes the Marmor (Chazy). *Toquimia*, *Taphrodonta*, *Goniotrema*, and *Hesperomena* are too provincial to be used for correlation to the eastern sections. However, the surprising discovery of *Isophragma* in strata as low as collection D1513 CO (actually in colln. D1655 CO) at Ikes Canyon furnished another Porterfield correlation.

Proof of the correspondence of the *Rhysostrophia* and upper *Anomalorthis* zones will probably never be incontrovertible. Many more stratigraphic problems are removed than are created if one accepts this possibility and if one considers the possible Porterfield age of the upper *Anomalorthis* zone and Marmor age of the lower *Anomalorthis* zone.

REVISED CORRELATION OF ANOMALORTHIS AND RHYSOSTROPHIA ZONES
(pl. 22)

If one postulates (a) that the restricted *Rhysostrophia* zone correlates with part of the *Anomalorthis* zone, (b) that the *Rhysostrophia*-bearing beds are of Ashby?–Porterfield age, (c) that the lower part of the *Anomalorthis* zone is of Marmor age, and (d) that fossils of Marmor aspect may be provincial in their allegiance to a more muddy environment peripheral to the carbonate-rich shelf and to the craton, then one is at once permitted the rational reinterpretation of a large number of stratigraphic relationships that previously seemed anomalous.

1. With the realization that the *Palliseria* zone holds a fairly constant position overlapping the lower *Anomalorthis* zone the somewhat artificial westward migration of the *Palliseria* zone previously postulated (Ross, 1964a, p. C80, figs. 9, 10; 1964b, p. 1536–1540, figs. 5, 6) becomes unnecessary.

2. The occurrence of Marmor or younger fossils both at Meiklejohn Peak (Ross, 1964a, p. C24–C32, C83; 1964b, p. 1539; 1967a, pl. 11; this paper, p. 43) and at Ikes Canyon above the *Orthidiella* zone and *Palliseria* or lower *Anomalorthis* zone is no longer anomalous.

3. Because it can be shown that no significant stratigraphic break is present beneath the basal Copenhagen sandstone both in Antelope Valley and at Hot Creek Canyon and since the lower part of the Copenhagen Formation was dated as Ashby–Porterfield by Cooper (1956, p. 128, table 1), it is reasonable to consider the probability that the underlying strata are of Marmor age.

4. The presence of genera having Marmor, Ashby, and Porterfield age ranges immediately above or within the *Anomalorthis* zone is readily explained without recourse to unconformities if the age of the *Anomalorthis* zone is considered to be Marmor–Porterfield. Sec-

tions in which these genera are found are the most complete in the Basin and Range area and least likely to include unconformities.

5. The placement of the *Rhysostrophia* zone equivalent to the *Anomalorthis* zone in the northern Inyo Mountains and in the Marmor–Porterfield "*Valcourea*-zone" at Ikes Canyon need no longer be considered anomalous.

6. Large *Maclurites* which are common in the type Chazy of New York no longer need be considered out of place in the *Anomalorthis* zone.

7. Evidence of conodonts, ostracodes, and corals in many collections supports these reinterpretations and nowhere seems to deny them. J. W. Huddle (written commun., Jan. 13, 1966) called attention to the Pratt Ferry (presumably Porterfield) aspect of the conodonts in the beds correlated with the *Orthidiella* zone at Ikes Canyon. In the Belted Range to the southeast, the same Pratt Ferry conodonts occur with *Ectenonotus* in the *Orthidiella* zone (USGS colln. D1500 CO). Jean Berdan noted on previous pages that ostracodes of the Ikes Canyon sequence have a Chazy and Black River aspect in beds correlated here with the *Anomalorthis* zone on other grounds.

This interpretation obviously is not and will not be acceptable to all investigators. Ostracodes of the *Anomalorthis* zone at Ibex, Utah, are not the same as those at Ikes Canyon to the west; Jean Berdan (see p. 27) is unable to reconcile this seeming discrepancy. And yet the discrepancy posed by ostracodes over a distance of 175 miles is no worse than the difference described by Williams (1963, p. 333–344) over a distance of 60 miles between acceptedly correlative Caradoc brachiopod assemblages of Shropshire and northern Wales. Furthermore, these objections are in no way resolved by strict adherence to Cooper's original interpretation of the Ikes Canyon sequence.

Subsequent to the completion of the first draft of this manuscript, written communication and fossil collections were received from G. A. Cooper (Apr. 30, 1968; see p. 4). These collections, all from Ikes Canyon, support the evidence shown on plates 20 and 21 and in figure 2. But most important, they provide specimens of *Anomalorthis* cf. *A. nevadensis* from the *Rhysostrophia* zone and provide concrete evidence to support the inferred correlation of the *Rhysostrophia* zone with the upper *Anomalorthis* zone.

Furthermore, the collections support the belief that separation of the Ikes Canyon section into zones is not easy. One collection from the "sponge beds," probably from some place in the interval between collections D1514 CO and D1607 CO (pls. 20 and 21), includes *Aporthophyla typa*, a gigantic *Syntrophopsis*-like pedicle valve, and a small specimen in external aspect much like *Rhysostrophia*. This association below *Palliseria* would parallel the occurrence of *Rhysostrophia* in the northern Inyo Mountains in the lowest *Anomalorthis* zone if generic identity of this small specimen could be confirmed.

On July 2–3, 1968, this author and Dr. J. Keith Ingham of Glasgow University collected a trilobite assemblage from the Albany Mudstones of Williams (1962, p. 46–47) and Tripp (1965, p. 578) south of the Stinchar Valley, Ayrshire, Scotland. To our surprise this assemblage included *Miracybele*, *Peraspis*, and several other genera of "Whiterock" Table Head aspect. The locality was revisited by Dr. Ingham and Dr. Ian Rolfe on July 27th, and according to Dr. Ingham (written commun., July 30, 1968), they collected specimens that included the following trilobite genera: *Trinodus*, *Remopleurides*, *Peraspis*, *Nileus*, *Bronteopsis*, *Myracybele*, *Ceraurinella*, *Lonchodomas*, *Bumastoides*, *Cybeloides*, *Atractopyge*, *Platicalymene?*, *Sphaerexochus*, *Sphaerocoryphe*, *Toernquistia*, and *Ceratocephala?*. The brachiopods *Ptychoglyptus* and *Isophragma* were also present. The first seven of these genera are characteristic of Table Head faunas described by Whittington (1963, 1965).

It may further be noted that the fauna of the Albany Mudstone of the Girvan District (Tripp, 1965, p. 577; Williams, 1962, p. 47, table 2) is readily correlated with the Stinchar Limestone, which is in turn readily correlated with the early Porterfield of North America (Tripp, 1967, p. 85). But correlation with the standard British sequence is very difficult because of facies problems. Graptolites in the overlying *Didymograptus superstes* mudstones (Walton, 1965, p. 174) seem to indicate the zone of *Nemagraptus gracilis*, generally accepted on somewhat indirect grounds as the base of the Caradoc Stage. It is implicit that the Albany Mudstone assemblage is either earliest Caradoc or Llandeilo in age.

A detailed study of the new Albany collections is required at the subgeneric level, but discovery of this assemblage suggests that Whiterock trilobites may range at least as high as Llandeilo in Scotland. This would agree with findings based on combined brachiopods and trilobites in Nevada.

It seems likely to this author that the Whiterock Stage, consisting of the *Orthidiella* and *Anomalorthis* zones, is contemporaneous with part of the youngest Canadian, the Marmor, at least the Ashby, and probably oldest Porterfield. A more conservative view would consider the *Orthidiella* zone partly correlative with youngest Canadian, partly within the distinct Whiterock, whereas the lower *Anomalorthis* zone was Whiterock and the upper *Anomalorthis* zone Ashby or Porterfield. Arguments can be advanced for each interpretation.

There is no denying that elements of the Canadian *Pseudocybele* zone and of the *Orthidiella* zone are intermixed at one extreme and that elements of the *Anomalorthis* zone and of the Porterfield–Wilderness (Black River) at the other.

Although the Whiterock Stage may be temporally synonymous with a late Canadian to early Porterfield (late Arenig to earliest Caradoc) span, it need not be discarded. As a provincial term descriptive of a particular faunal facies, it can be very useful. Whittington (1968, p. 55–56) called attention to the close similarity between so-called Whiterock assemblages and those found in the North Atlantic region—Greenland, western Ireland, Spitsbergen, northern Norway. To these we can now add southwestern Scotland as noted above. Furthermore many of the fossil collections that this author examined from these areas in the summer of 1968 are in matrix that would defy lithologic distinction from correlative rocks of the Basin Ranges.

The geographic distribution of Whiterock facies may prove to be strong evidence for former juxtaposition of the northeast coast of North America against Ireland, Scotland, Scandinavia, and Spitsbergen.

DESCRIPTIVE PALEONTOLOGY

Although the fossils described in this section have been studied in general for their stratigraphic value, almost all have also contributed information about morphology, evolutionary trends, and geographic distribution. A few examples follow.

The discovery of a pseudodeltidium in *Anomalorthis resoi*, n. sp., was unexpected, although a similar structure had been illustrated, but not described, in *A. nevadensis* by Ulrich and Cooper (1938, pl. 21D, fig. 16). Silicified specimens of *Toquimia* and *Aporthophyla* permitted a better understanding of the interiors of brachial valves than had been possible previously. *Orthambonites* cf. *O. perplexus* Ross is a possible ancestor of *Plectorthis* and is reassigned to *Plectorthis* itself. *Hesperorthis* cf. *H. matutina* may be the oldest known species of the genus but is almost indistinguishable from *H. matutina* of Ashby age.

Asymphylotoechia is a new genus seemingly related to *Pomatotrema;* it occurs with *Hesperorthis* cf. *H. matutina* low in the *Anomalorthis* zone. As is true for the Garden City Formation (Ross, 1968), the genus *Anomalorthis* is represented in the *Orthidiella* zone of the Groom Range (colln. D1583 CO) by a primitive species possessing a very low cardinal area. *Toquimia* possesses a cardinal process which appears like a bilobed process of a strophomenid or rafinesquinid when sectioned.

The most unusual trilobite described is probably *Perissopliomera* n. gen. A new species of *Basilicus* links the upper *Anomalorthis* beds with the Black River Group of New York. *Hypermecaspis*, *Parabolinella*, *Megistaspis* (*Ekeraspis*), and *Asaphellus* are among species lending a Baltic or South American air to Lower Ordovician assemblages. A rather drastic restriction of the genus *Lloydia* is recommended.

PHYLUM BRACHIOPODA DUMERIL, 1806

CLASS ARTICULATA HUXLEY, 1869

Formal classification of brachiopods is not repeated. The classification of the "Treatise on Invertebrate Paleontology, Part H" (Muir-Wood and Williams, 1965) is followed, and the reader is referred to it for suprageneric details.

Genus ORTHIDIUM Hall and Clarke, 1892

The known occurrences of this genus are in Quebec, Newfoundland (Table Head Formation), and Nevada. Cooper (1956, p. 142) suggested that all the known occurrences of *Orthidium* were of Whiterock age and indicated (p. 169) that *O. bellulum* Ulrich and Cooper, the one previously reported Nevada species, came from the *Rhysostrophia* zone or very young Whiterock.

In USGS collection D1514 CO *Orthidium* cf. *O. bellulum* occurs at Ikes Canyon in the *Orthidiella* zone, a fact suggesting that the original specimens (Ulrich and Cooper, 1938, p. 111, pl. 16F) may have been obtained lower than supposed. The genus is also in collection D1518 CO at Ikes Canyon. Another species, *O. barnesi* Ross, n. sp., was obtained in collection D1441 CO from the *Orthidiella* zone of the Specter range (Ross, 1967a, p. D35, D37). These occurrences suggest that the genus is characteristic of the *Orthidiella* zone and therefore earliest Whiterock, rather than latest Whiterock, age. It is also possible that this genus may have been lower in the section and mistaken for *Archaeorthis*, which it resembles in outline and convexity.

Orthidium barnesi Ross, n. sp.

Plate 1, figures 2–11

In the type collection, fractured and fragmentary preservation of silicified shells hampers measurements. Only three specimens are illustrated here.

Shells small, strongly and subequally biconvex in lateral view. Brachial valve sulcate; pedicle valve correspondingly carinate in anterior view. Hinge width approximating greatest width. Hinge width equaling or slightly exceeding length. Costellae spaced four to five in 1 mm at front of valve. Lamellae irregular and spaced four to five in radial space of 1 mm.

Pedicle valve deep, strongly convex. Cardinal area apsacline. Dental lamellae obscured by callus deposits. Crural fossettes deep. Diductors scars elongate, narrow, extend in front of wide triangular adductor scar.

Brachial valve much more convex in lateral than anterior view. Cardinal process (pl. 1, figs. 10, 11) similar to that of *Orthidiella*, fills space between brachiophores, triangular as seen is posterior view. Brachiophores slender, reinforced by much callus to line dental sockets (pl. 1, fig. 11).

Measurements in millimeters—

Type	USNM No.	Valve	Length	Width	Hinge width	Depth	Costellae in 1 mm	Lamellae in 1 mm
Holotype	160791	Brachial	3.7	--------	4.9	1.8	4.5	4
Do		Pedicle	4.1	--------	4.9	2.6	4.5	4
Paratype	160792a	do	4.6	4.5	4.3	2.5	4	4
	160792b	Brachial and pedicle.[1]						

[1] Fragmentary; no measurements.

Occurrence.—USGS collection D1441 CO, Antelope Valley Limestone, 45 feet above base of Barnes' unit 12 (Ross, 1967a, p. D35, D37, pl. 11, app. B), Specter Range, Nev.

Discussion.—This species differs from *Orthidium bellulum* Ulrich and Cooper in closer spacing of its concentric lamellae, narrower outline, and greater convexity of the pedicle valve. It differs from *O. gemmiculum* (Billings) in its narrower outline but is similar in spacing of costellae and lamellae. *O. barnesi* lacks the pedicle sulcus of *O. fimbriatum* Cooper. *O. barnesi* has the outline and convexity of *Archaeorthis elongatus* but differs externally in profile and ornamentation. *O. barnesi* was originally listed as *Orthidium* cf. *O. bellulum* Ulrich and Cooper (Ross, 1967a, p. D37).

Orthidium cf. O. bellulum Ulrich and Cooper

Plate 1, figure 1

In size and outline very similar to *O. bellulum* but has somewhat more closely spaced costellae (five to six in 1 mm at front of valve). Concentric frills spaced two per millimeter.

Measurements in millimeters (figured specimen).—

USNM No.	Length (L)	Width (W)	Hinge width	L÷W	Costellae in 1 mm
160793	4.0	5.9	5.6	0.68	5–6

Occurrence.—USGS collection D1514 CO, Antelope Valley Limestone, 516 feet below top, on southeast side of hill 8474, Ikes Canyon, Toquima Range, Nev. Ulrich and Cooper (1938, p. 111) described *Orthidium bellulum* from the same general locality.

Genus Orthambonites Pander, 1830

Orthambonites bifurcatus Cooper

Plate 3, figure 20

Orthambonites bifurcatus Cooper, 1956, Smithsonian Misc. Colln., v. 127, p. 297–298, pl. 34A, figs. 1–6.

A topotype specimen (pl. 3, fig. 20) has 42 costellae along the shell margin. The holotype (Cooper, 1956, pl. 34A, figs. 3–4) possesses about 50 costellae; however, if incipient bifurcations at the shell margin are included, the count can be raised to about 60. A paratype (Cooper, 1956, pl. 34A, fig. 1) has about 46 costellae.

Figured specimen.—USNM 160796.

Occurrence.—USGS collection D1507 CO, Antelope Valley Limestone, top 2 feet. USGS collection D1510 CO, Antelope Valley Limestone, 176 feet below top. Ikes Canyon, Toquima Range, Nev.

Discussion.—Examination of the paratypes of *Orthambonites bifurcatus* Cooper shows that most shells bear 35–45 costellae. Most of the paratypes are smaller than the holotype, but increase in size is not precisely related to increase in number of costellae.

O. bifurcatus occurs at Ikes Canyon through the top 180 feet of the Antelope Valley Limestone and overlaps *Rhysostrophia* at the lower end of its range and *Leptellina occidentalis* at the upper end.

Orthambonites marshalli Wilson

Plate 3, figures 4–19; plate 4, figures 1–3

Orthis marshalli A. E. Wilson, 1926, Canada Geol. Survey, Geol. Ser. 46, Contr. to Canadian Palaeontology, Bull. 44, p. 24–25, pl. 5, figs. 1–6.

Orthis subalata Ulrich and Cooper, 1938, Geol. Soc. America Spec. Paper 13, p. 103–104, pl. 15B, figs. 10–15.

Little can be added here to Wilson's (1926) original description. Secondary sockets and crural fossettes well developed, particularly on large individuals. Muscle scars of pedicle field obscure in all California and Nevada specimens because of coarse silicification. In brachial valve posterior pair of adductor scars appears to be about half as large as anterior pair.

Total number of costae varies considerably from 20 to 32; this variation has greatest range in the Canadian collections. Specimens from California and Nevada have 20–26 costae, whereas those described for *O. subalata* by Ulrich and Cooper (1938, p. 103) from Utah were stated to have had 29.

In most specimens outline subalate with hinge forming widest part of shells; in some, however, cardinal angles are right angled. Very shallow sulcus containing four to five costae on brachial valve, regardless of geographic distribution.

Figured specimens.—USNM 160797 a–h.

Occurrence.—Lower part of the Antelope Valley Limestone, *Orthidiella* zone, in much of the Basin and Range province. USGS collection D1009 CO, Quartz Spring area, Calif. (Ross, 1964a, p. C33, pl. 1, col. 3); USGS collections D1583 CO and D1584 CO, southern Groom Range, Nev.; USGS collection D1399 CO, Pyramid Peak, Calif. (Ross, 1967a, p. D33, pl. 11).

Discussion.—This species is extremely useful stratigraphically, for it seems to mark the *Orthidiella* zone in many areas where *Orthidiella* itself is not abundant. The two species occur together in enough collections to insure determination that their ranges, if not exactly contemporaneous, overlap. *Orthambonites eucharis* resembles *Orthambonites marshalli* except for fineness of the former's ribbing. It also is an associate of *Orthidiella;* I have never found *Orthambonites eucharis* associated with *Orthambonites marshalli*, however.

The species which is widespread in the Basin Ranges in the *Orthidiella* zone and which I have previously referred to *Orthambonites* cf. *O. subalata* belongs properly to *O. marshalli* (Wilson). In 1965 Dr. Brian S. Norford of the Geological Survey of Canada demonstrated to me in the field that this species occurs in the Skoki Formation and not in the Beaverfoot as recorded by Wilson (1926, p. 25).

Orthambonites minusculus (Phleger)

Plate 4, figures 4–11; plate 19, figures 9–15

Orthis minusculus Phleger, 1933, Southern California Acad. Sci. Bull., v. 32, pt. 1, p. 7, pl. 2, figs. 6, 7.
Ulrich and Cooper, 1938, Geol. Soc. America Spec. Paper 13, pl. 15D, figs. 22–25.

Small, almost equally biconvex, costate species. Convexity of both valves low; pedicle valve the deeper and tends to be somewhat carinate. Corresponding sulcus on brachial valve includes about five costae. Outline of both valves tends to be subalate. Costae total 20–24, spaced five to six in 5 mm at front of valve 8–10 mm long. On brachial valve at 5-mm radius from umbo, costae spaced seven to eight in 5 mm on most specimens.

Exsagittal length of cardinal area of pedicle valve not much greater than that of brachial valve. Pedicle muscle field limited to floor of delthyrial chamber, but coarseness of silicification prevents detailed observations. In some specimens scar appears trilobed with combined adductor scar extended very slightly ahead of diductor; diductor scars each about as wide as combined adductors. Not certain that these few specimens are representative of species. In brachial valve cardinal process is slender blade, development of which seems to depend largely on silicification. In most specimens the brachiophores seem to be slender, three-sided rods or blades supported by greatly thickened shell material so that brachiophores resemble those of dalmanellids. Shell material surrounding sockets forms false fulcral plates in some specimens. Notothyrial platform and median ridge much thickened with shell material.

Figured specimens.—USNM 160798 a–f, 162056 a–h.

Occurrence.—USGS collections D1520 CO, D1519 CO, D1517 CO, D1516 CO, D1513 CO, D1511 CO, and D1605 CO, Antelope Valley Limestone, 214–750 feet below top, Ikes Canyon, Toquima Range. USGS collection D1637 CO and D1656 CO east side of Caesar Canyon on north side of Mill Canyon (Nevada coord., central zone: E. 470,350 ft; N. 1,546,800 ft, just south of Wildcat Peak 15-minute quad.), Toquima Range, Nev.

Discussion.—This species has more in common with Nevada specimens of *Orthambonites marshalli* (p. 54) than may be immediately obvious. In both species the outline is subalate; the main difference in form is in the greater convexity of the pedicle valve and the greater overall size and costal spacing of *O. marshalli.* Brachiophores in both species are supported and partly obscured by the same kind of secondary shell deposit.

Specimens from the collections D1511 CO and D1656 CO are clearly identical. However, those from as low as collection D1520 CO seem to be less convex, to have costae spaced somewhat closer, and to be more alate in outline. The differences are very slight and do not seem to be significant.

It is evident that *Orthambonites minusculus* as interpreted here ranges from the *Orthidiella* zone into the *Rhysostrophia* zone.

Measurements, in millimeters, of seven specimens from collection D1656 CO follows. These specimens are associated with *Aporthophyla typa* Cooper and are probably correlative with collection D1513 CO at Ikes Canyon.

USNM No.	Valve	Length	Width	Hinge width	Costae in 5 mm at 5-mm radius from brachial umbo
162056d	Brachial	7.7	----------	9.0	8.5
162056e	Pedicle	8.3	9.7	9.3	6
162056c	Brachial	8.7	11.3	11.3	6.5
162056f	do	8.0	10.7	11.0	7
162056g	Pedicle	7.7	10.3	9.8	6
162056h	do	8.2	9.2	9.4	6
162056a	Brachial	7.8	10.9	11.3	7+
	Pedicle	9.1	10.9	11.3	----------
162056b	Brachial [1]				7

[1] Specimen too fragmentary for measurement.

Genus HESPERORTHIS Schuchert and Cooper, 1931

Hesperorthis cf. H. matutina Cooper

Plate 1, figures 12–22; plate 2, figures 1–10, 13–16; plate 3, figures 1–3

Orthis sp. Ulrich and Cooper, 1938, Geol. Soc. America Spec. Paper 13, p. 104, pl. 14B, figs. 5–10.

Hesperorthis matutina Cooper, 1956, Smithsonian Misc. Colln., v. 127, p. 353–354, pl. 54A, figs. 1–4.

Shell planoconvex, about as wide as long. Cardinal angles slightly obtuse or right angled. Front margin broadly rounded. Surface marked by 20–26, most commonly 22–23, rounded costae. Interspaces about half as wide as costae. Costae and interspaces overlain by very fine radial costellae, best preserved in interspaces. In some specimens a very shallow brachial sulcus present, including three to seven costae, most commonly five. At 5 mm radius from brachial umbo, costae spaced seven in 5 mm, ranging from six to eight.

In lateral view greatest convexity of pedicle valve in posterior half. In anterior view, valve narrowly convex along midline and has evenly sloping flanks. Cardinal area apsacline, of varying length and curvature; its width four to six times its length. No apical plate found. Dental plates receding. Muscle area oblong, but slightly bilobed at front and divided by narrow median adductor ridge; very faint because of coarse silicification.

Brachial valve almost flat, only slightly convex near umbo in lateral and posterior profile, flattens anteriorly. Wide shallow sulcus includes three to nine costae; in some specimens sulcus seems more like flattened median sector with cardinal extremities deflected. In others no sulcus at all or sulcus is weakly developed near umbo but fades anteriorly. Very short interarea, anacline. Brachiophores short, stout, triangular in section. Notothyrial platform and median ridge slightly thickened. Adductor scars poorly developed; quadripartite on rare specimens. Cardinal process a distinct blade; a rounded shaft or a shaft having myophore developed in a few specimens depending on age at death.

Measurements in millimeters—

(Measurements in parentheses are estimated from broken specimens)

USNM No.	Valve	Length	Width	Hinge width	Total costae	Costae per 5 mm, front margin	Costae in sulcus
160795a	Pedicle	9.3	10.5	9.7	22	4–5	-------
160795b	Brachial	([1])	(10.0)	([1])	23	5	5
160795c	Pedicle	10.4	12.3	8.7	22	4–5	-------
160795d	Brachial	6.3	9.8	8.3	20	6	6
160795e	do	10.8	14.8	12.05	25	3–4	([2])
160795f	do	9.1	12.1	10.3	23	4	[3] 5
160795g	Brachial (broken)	10.8	(15.8)	(14.0)	22	3	([2])
160795h	do	9?	(13.2)	(12?)	22	(3–4)	5
160795i	Brachial	7.2	10.3	9.1	23	4–5	[4] 5
160795j	do	7.4	10.5	10.0	22	4	6
160795k	do	8.7	12.2	10.1	22	4	[5] 5
160795l	Brachial (broken)			(14)	23	-------	([2])
160795m	Brachial	7.2	10.8	10.7	26	5–6	7
160795n	Pedicle	11.1	13.5	11.4	23	4	-------
160795o	do	9.7	12.2	11.0	25	4	-------
160794	Complete (broken)	10.2	(12.1)	(11.8)	23	4	7
160795p	Pedicle	11.3	13.2	12.1	20	3	-------

[1] Specimen broken; measurement impossible.
[2] No sulcus.
[3] Weak.
[4] Early.
[5] Fold, injured.

Holotype—USNM 160794.

Paratypes—USNM 160795a–p.

Occurrence.—USGS collections D1674 CO and D1382 CO, Antelope Valley Limestone, 696–724 feet below top, Pahranagat Range, Nev. USGS collection D1578 CO, Antelope Valley Limestone, 951 feet below top, southern Groom Range, Nev. USGS collections D375 CO and D1764 CO, Antelope Valley Limestone, 377 feet below base of Eureka Quartzite, Lone Mountain, Bartine Ranch quadrangle, Nevada.

Discussion.—This species is distinguished from *Orthambonites* by its flattened brachial valve and from a typical *Hesperorthis* by three-sided rather than bladelike brachiophores and by lack of apical plate. It is probably conspecific with *Hesperorthis matutina* (Cooper 1956, p. 353, pl. 54A, figs. 1–4). It may differ from that species in its lesser number of costae. However, at 5 mm from the brachial umbo, costal spacing is identical, and any seeming difference can be attributed to size of valve.

The cardinal process on all specimens is fundamentally a blade in specimens of small size (pl. 2, fig. 11) and of large size (pl. 2, fig. 4). But in many others the process has been thickened and appears as a shaft (USNM 160795j); in two of the largest specimens, very different myophores seem to have been formed (pl. 3, figs. 1, 2). A somewhat smaller brachial valve (USNM 160795h) possesses a split shaft.

The convexity of the brachial valve is also variable. Where some are sulcate, others are almost flat or gently convex. One pathologic or injured specimen (pl. 3, fig. 3) possesses a low fold in place of the sulcus.

In general, specimens from Lone Mountain (USGS collns. D375 CO and D1764 CO) are smaller than and not so well preserved as those from the Pahranagat Range.

A very brief statistical study of 18 specimens showed a correlation between width of valve and total costae. One can expect that a valve 5 mm wide will bear 10 costae, one 10 mm wide will bear 19 costae, and one 15 mm wide will bear 28 costae. The standard error of estimate indicates that a spread of five costae on either side of these values should be within those for the species population.

One immature brachial valve 5.8 mm wide carries 20 costae (pl. 2, figs. 11, 12); considering its small size, this is almost twice as many costae as one would expect it to have. It is questionable that this small specimen belongs in the species.

Hesperorthis matutina was originally described from the Tulip Creek Formation of Oklahoma. Its probable presence low in the *Anomalorthis* zone adds to evidence that that zone is as young as Marmor.

Genus **PLECTORTHIS** Hall and Clarke, 1892

Plectorthis Hall and Clarke. Schuchert and Cooper, 1932, Yale Univ. Peabody Mus. Nat. History Mem., v. 4, pt. 1, p. 57–59, pl. 11.
Williams and Wright, 1965, Treatise on Invertebrate Paleontology, Pt. H, v. 1, p. H324.

Plectorthis cf. P. perplexus (Ross)

Plate 4, figures 12–20

Orthambonites perplexus Ross, 1967a, U.S. Geol. Survey Prof. Paper 523–D, p. D3–D4, pl. 1, figs. 20–29.
Jensen, 1967, Brigham Young Univ. Geology Studies, v. 14, p. 91–92, pl. 4, figs. 6–10.

Shell, small, gently biconvex, wider than long, ornamented with 18–22 costae. A very fine costella may be present between costae. Costae and interspaces of about equal width.

Greatest convexity of pedicle valve close to umbo; posterolateral flanks slightly concave. Dental plates recede. Muscle field trilobed; diductors scars extend somewhat in front of median adductor scars. Width of combined adductor equal to each of diductors.

Brachial valve possesses a very shallow sulcus in which about four costae are involved. Cardinal process a short blade, in some specimens bears a thickened crenulated myophore. Brachiophores triangular in cross section. Posterolateral side of each brachiophore bears a flange that extends beneath cardinal area to form rudimentary fulcral plate. Sockets well developed on all valves. Notothyrial platform only slightly thickened. Almost no median septum.

Measurements in millimeters—

USNM No.	Valve	Length	Width	Hinge width	Total costae	Costae in 5 mm	Thickness
160799a	Pedicle	8.3	9.9	8.2	21	4	--------
160799d	Brachial	7.7	10.0	7.1	18	4	--------
160799b	do	6.0	7.7	6.3	21	5	--------
160799e	Brachial (broken)	8.5	8.5	6.7	18	4	--------
160799f	Pedicle (broken)	(6.0)	--------	6.8	22	5	2.2
160799g	Pedicle	5.9	7.0	5.7	22	5	2.2
160799c	do	5.5	6.5	5.1	20	6	1.9

Occurrence.—USGS collection D1665 CO, Antelope Valley Limestone, 67–70 feet below base of Eureka Quartzite, west side of Pahranagat Range, Nev.

Discussion.—This species very closely resembles *Plectorthis perplexus* (Ross) (1967a, p. D3–D4, pl. 1, figs. 20–29). It tends to have fewer costae, 18–22 compared with 20–25; this is not an impressive difference, and there is considerable overlap in number of costae. Most of the specimens are smaller and more delicately silicified than are those of the type lot of *P. perplexus*. Both these conditions may account for differences that are not taxonomically significant. There is a suggestion that *P.* cf. *P. perplexus* has a wider hinge relative to total width; this is illustrated by a pedicle valve (pl. 4, figs. 19, 20), but specimens of *P. perplexus* (Ross) show considerable variation and overlap in this regard also.

From the type lot of *Plectorthis perplexus* (Ross) (Rawhide Mountain, USGS colln. D835 CO), all specimens differ in that they have a hinge width approximately equal to the length of pedicle valve, whereas the hinge width is always markedly less than the length in typical *P. perplexus*. In this respect specimens from the Ranger Mountains agree with the types. The Ranger Mountains specimens, however, have about 20 costae as compared with an average of 23–25 for those from the Rawhide Mountain; this difference may be attributable to the somewhat smaller size of the Ranger Mountains specimens. With regard to size the Pahranagat Range specimens are more similar to those from the Ranger Mountains.

The Pahranagat Range specimens in young stages tend to have rather well developed rudimentary fulcral plates, although these seem to be diminished in more mature shells. The possession of fulcral plates and of trilobed pedicle muscle scars, the latter varyingly developed, is suggestive of *Plectorthis*. Occurrence of a crenulated myophore on the cardinal process also suggests that this species should be assigned to *Plectorthis*. However, the myophore is not developed on all specimens. *Orthambonites subconvexus* (Cooper, 1956, pl. 34, figs. 21, 22) also possesses well-formed fulcral plates and probably should be assigned to *Plectorthis*.

Specimens of *P. perplexus* Ross from the uppermost Pogonip in the Ranger Mountains (USGS collns. D710 CO, D712 CO; Ross, 1964a, p. C18–C19) have very variable pedicle muscle scars; some scars are bilobed, the diductors being separated by a linear adductor track. In others a wide adductor scar produces a trilobed pattern. Between these extremes there is a complete gradation. These specimens have a subcircular outline that differs from specimens here called *P.* cf. *P. perplexus*, but all the Ranger Mountains specimens have been somewhat abraded; abrasion may account for rounding of the cardinal extremities. The specimens described here are probably conspecific and correlative with those in the Ranger Mountains.

Plectorthis? obesa Cooper

Plate 6, figures 19–21

Plectorthis obesa Cooper, 1956, Smithsonian Misc. Colln., v. 127, p. 450, pls. 92F, 269A.

The original description of *Plectorthis obesa* included nothing on the interiors of valves. Therefore, three topotype specimens were prepared so that latex casts could be made of the interiors of two brachial and one pedicle valves.

Pedicle muscle field trilobed. Adductor track as wide as, or almost as wide as, each diductor scar. Adductor track reaches front of scar and not enclosed by diductors. Front of combined scar distinctly elevated above floor of valve. Scar extends forward about one-third length of valve.

In brachial interior, brachiophores are rods triangular in cross section, their inner faces are nearly vertical until they meet floor of elevated notothyrial platform. Posterolateral sides of brachiophores slope beneath cardinal area to bound dental sockets. Discrete fulcral plates not clearly developed. Median septum well developed, begins near midpoint of shell. Cardinal process well developed, precise shape not certain. Adductor muscle scars extend as far forward as middle of valve.

Figured topotype specimens.—USNM 160810a–c.

Occurrence.—USGS collection D1877 CO, upper part of the Copenhagen Formation, 330 feet above base of formation, southeast side of hill 8308, south of Water Canyon, Antelope Valley, SW¼ sec. 24, T. 15 N., R. 51 E., Horse Heaven Mountain quadrangle, Nev.

Discussion.—The pedicle muscle scars are very similar to those of *Austinella*, as are those of *Plectorthis ponderosa* Cooper. The difference between a typically subquadrate combined scar in *Austinella* and a more triangular one in these specimens is a matter of degree. The cardinal process is an enormously thickened shaft narrowing to a thin septum where it joins the floor of the notothyrial platform. The specimen shown on plate 6, figure 20, has been excavated to show only this septum. The discrete fulcral plates which one expects in *Plectorthis* are not developed, although dental sockets are well formed.

It seems wise to consider the possibility that this species should be reassigned to *Austinella*.

Plectorthis? sp.

Plate 6, figures 22, 23

A brachial and a pedicle valve, both damaged, constitute this sample. Both convex and have 22 costae, spaced three to four in 5 mm.

Brachiophores not preserved; presence or absence of fulcral plates not determined. Cardinal process slender and there is suggestion of myophore. Notothyrial chamber deep; notothyrial platform occupies one-sixth length of valve.

In pedicle valve, muscle scars limited to posterior one-third of valve. Scars heart shaped; diductors protrude beyond adductors. Adductors wider than common in the genus.

Figured specimens.—USNM 160809a, b.

Occurrence.—USGS collection D1812 CO, Lehman Formation, 159 feet above base, 107 feet below base of Eureka Quartzite, Steptoe section, Nevada.

Discussion.—The stratigraphic position of this species is not very much above that for specimens described here as *Plectorthis* cf. *P. perplexus* (Ross), to which it bears a marked resemblance. Both the pedicle muscle scars and the pedicle cardinal area are considerably shorter in *Plectorthis*? sp. Until additional specimens are collected, description and positive identification of this species are impossible.

Genus DESMORTHIS Ulrich and Cooper, 1936

Desmorthis nevadensis Ulrich and Cooper

Plate 19, figures 1–4

Desmorthis nevadensis Ulrich and Cooper, 1938, Geol. Soc. America Spec. Paper 13, p. 159, pl. 30A, figs. 1–16.

Topotype specimens of this species are illustrated here for comparison with other species of *Desmorthis*. *D. nevadensis* is type species of the genus. The following information should be added to the original description:

Costellar spacing at 5-mm radius from brachial umbo equals 14.5 in 5 mm. Corresponds to wavelength per costella of 0.345 at 5-mm radius. Fine parvicostella between pairs of costellae; some parvicostellae grow to become costellae.

Brachial sulcus exceedingly shallow, includes seven to eight costellae; sulcus not discernible on all specimens.

Figured specimens.—USNM 162054a, b.

Occurrence.—USGS collection D374 CO, D1659 CO, D1768 CO, Antelope Valley Limestone, 254 feet below Eureka Quartzite, Lone Mountain section, Nevada. USGS collection D1577 CO, Antelope Valley Limestone, 939 feet below top, southern Groom Range, Nev.

Discussion.—*Desmorthis nevadensis* is the most finely costellate species so far described. At a standard distance of 5 mm from the brachial umbo, *D. costata* Cooper possesses eight costellae in 5 mm as compared with 14–15 in *D. nevadensis*. *D. crassus* Ross, n. sp., has nine to 10 in the same space. A new species of *Desmorthis* associated with *Valcourea plana* in collection D1600 CO (Meiklejohn Peak) also has 10 costellae in 5 mm but differs in possessing a distinct brachial sulcus.

Desmorthis crassus Ross, n. sp.

Plate 6, figures 1, 4, 6–18

Shell of usual size for genus, somewhat wider than long; greatest width near midlength. Anterior commissure rectimarginate in larger specimens, hardly affected by gentle sulcus in brachial valve in small specimens. Shells unequally biconvex, pedicle valve the deeper. Surface costellae simple, increase by implantation only adjacent to cardinal area; total number 26; on brachial valves at 5-mm radius from umbo, spaced 9–10 in 5 mm. Fine parvicostellae between costellae in most specimens.

Pedicle valve evenly convex in lateral profile, narrowly convex along midline in anterior profile. Umbo not much swollen, pointed. Cardinal area curved, apsacline. In interior, diductor scars bilobed, extend forward almost to middle of valve, separated by narrow adductor track. Dental lamellae recede.

Brachial valve evenly and gently convex in both anterior and lateral profiles. Sulcus only in immature specimens or earliest stages of mature valves; in either mature or immature specimens very shallow and indistinct.

Measurements in millimeters.—

USNM No.	Type	Valve	Length	Width	Hinge width	Total costae	Costae in 5 mm
160807	Holotype	Brachial	7.2	8.1	7.4	26	7
160808b	Paratype	Pedicle	6.6	7.1	6.2	26	8
160808a	do	Brachial	6.0	7.4	5.4	26	8
160808c	do	Pedicle	6.0	6.3	5.8	26	7–8
160808d	do	Brachial	4.1	5.5	4.9	26	12–13
	do	Pedicle	4.9	5.5	4.9	26	12–13

Occurrence.—USGS collection D1674 CO, Antelope Valley Limestone, 696–724 feet below Eureka Quartzite, Pahranagat Range. Possibly USGS collection D1513 CO, Antelope Valley Limestone, 330 feet below top of formation, Ikes Canyon, Toquima Range. Probably USGS collection D1573 CO, Antelope Valley Limestone, 782 feet below top of formation, southern Groom Range.

Discussion.—*Desmorthis crassus* is probably in the southern Groom Range as listed above, but specimens in collection D1573 CO are badly fragmented; only one brachial and one pedicle valve are nearly complete. Of these, the brachial valve is very similar to that of the types; the pedicle valve, however, bears 30 rather than 26 costae. In the brachial valve, spacing of costellae at a 5-mm radius is nine in 5 mm.

In collection D1513 CO from Ikes Canyon, several specimens are very similar to those of *D. crassus*. In the pedicle valve, the diductor field seems to be shorter; the brachial valve is flatter and somewhat sulcate in anterior profile. But, this comparison is based on only a very few specimens.

Desmorthis crassus is larger than *D. nevadensis* Ulrich and Cooper and bears a remarkably constant number of 26 costae, as compared with about 40 in *D. nevadensis*. Costae are added by intercalation in *D. nevadensis* and are spaced almost twice as closely. *D. costata* Cooper is about the same size but has 36 costae spaced very slightly closer than in *D. crassus*. The costae are similar in being simple. *D. planus* Ross is considerably smaller (it may be based on immature specimens), has a flattened sulcate brachial valve, and has approximately 30 closer spaced costae that increase by intercalation and some bifurcation.

Desmorthis crassus may also occur in the upper part of the Kanosh Shale in the Ibex area of Utah.

Desmorthis n. sp.

Plate 19, figures 5–8

About a dozen fragmentary specimens of a new species were found in the highest Antelope Valley Limestone at Meiklejohn Peak.

Outline subsemicircular; hinge width only very slightly less than width. Width about 1¼ times length of pedicle valve. Cardinal angles obtuse, almost right angled. Anterior commissure straight to slightly sulcate. Costae probably total 30–32. At radius of 5 mm from brachial umbo, costae number 10–11 in 5 mm and produce 0.454-mm wavelength at 5-mm radius. Costae seemingly of two generations, the second intercalated less than 2.5 from brachial umbo.

Pedicle valve gently convex in lateral view; greatest convexity along midline in anterior view; posterior flanks concave. Cardinal area apsacline, curved, its altitude less than one-third its width at hinge line.

Brachial valve gently convex in lateral profile, less convex in anterior profile. A shallow sulcus near umbo fades anteriorly; seven to eight costellae involved in sulcus.

Measurements of figured specimens in millimeters.—

USNM No.	Valve	Length	Width	Hinge width	Altitude cardinal area	Total costae
162055b	Pedicle	6+	7.7	7.3	2.0	30
162055a	Brachial	5.6	8+	7.5+	.5	32

Occurrence.—USGS collection D1600 CO, Antelope Valley Limestone, uppermost 3 feet, Meiklejohn Peak, north side (Ross, 1967a, pl. 11).

Discussion.—Although too few specimens are present for them to be a basis for formal description, the transverse outline of this species distinguishes it from the subcircular outlines of previously described species, including *Desmorthis crassus* Ross, n. sp. Inside the brachial valve the brachiophores are more strongly divergent than in *D. crassus* or *D. nevadensis*. Spacing of costae on the brachial valve at a standard 5-mm radius from the umbo is very similar to that of *D. crassus*, but parvicostellae are lacking in this unnamed new species.

This species is important in establishing the overlap in ranges of *Desmorthis*, *Valcourea*, and *Leptellina*.

Genus **ASYMPHYLOTOECHIA** Ross, n. gen.

To date, the new genus *Asymphylotoechia* seems to be represented by a single species found over a wide area of Nevada. Shells bear a resemblance to *Pomatotrema*. The species is not resupinate and has a much more constricted brachial muscle field than *Ingria*. Cardinalia resemble those of *Pomatotrema murale* Ulrich and Cooper. The arched pseudodeltidium and cardinalia indicate that this species probably should be classed with the Polytoechiidae.

For the time being the features of the genus are those of its type and only species, *A. nolani* Ross, n. sp., described below.

Asymphylotoechia nolani Ross, n. gen., n. sp.

Plate 6, figures 24, 25; plate 7, figures 1–13

Shells small, wider than long, unequally biconvex. Pedicle valve initially flat in lateral profile, becoming convex anteriorly. Brachial valve gently convex in lateral profile. Surface costellate, costellae of unequal size.

In brachial valve, cardinal process simple ridge; in some specimens thickened into knob. Chilidium not well preserved on any specimen but a single convex hood in one immature valve; in others seemingly two chilidial plates are present, possibly because of erosion along crest of chilidium.

Socket ridges contain well-developed cupped sockets. In some specimens the ridges resemble brachiophores and fulcral plates of orthoids. Median septum very variable; in some specimens no more than a vertical strut supporting cardinal process, in others a poorly defined very short ridge which fails to reach the center of the muscle area. Area of combined muscle scars subcircular in outline, confined to posterior half of valve, surrounded by faint rim. Two pairs of radial ridges subdivide the area of muscle scars and continue outward to define pallial trunks. The outer pair of ridges lies close to the socket ridges. The inner pair approximately bisects each half of the scar area. Beyond the area of muscle scars other faint pallial trunks. The outer pair of ridges lies close to the socket ridges. The inner pair approximately bisects each half of the scar area. Beyond the area of muscle scars, other faint pallial ridges are radially arranged.

On the pedicle valve the catacline cardinal area is about one-fourth as long as wide. The delthyrium is covered by an arched deltidium. On all specimens the apical end of the deltidium is perforated, but because of coarse preservation it is not certain whether there are true foramina or accidentally caused holes. Dental plates receding; teeth flattened, strong. Floor of valve in delthyrial cavity divided by strong median septum which extends in front of cavity and becomes a wide raised triangular median area between impressed pallial trunks. Elongate muscle scars extend only slightly in front of dental plates. A pair of low ridges extends forward into pallial area from ends of dental plates, and one or two other pairs extend anterolaterally from beneath cardinal area.

Holotype.—USNM 160811.

Paratypes.—USNM 160812a–n.

Occurrence.—USGS collections D375a CO and D1764 CO, Antelope Valley Limestone, 377 feet below base of Eureka Quartzite, Lone Mountain section, Nevada. USGS collection D299a CO, 952 feet below top of Antelope Valley Limestone, east side of Martin Ridge, Horse Heaven Mountain quadrangle, Nevada. USGS collection D1572 CO, Antelope Valley Limestone, 775 feet below top, southern Groom Range, Nev.

Discussion.—In outline and ornamentation this species bears a strong resemblance to species of *Ingria* but differs in being unequally biconvex rather than resupinate. The correct relationship of the genus seems to be with polytoechiids like *Pomatotrema*.

Two specimens (pl. 10, figs. 2, 3) have been found in USGS collection D299c which may belong to this species. No interiors are available, and identification is therefore impossible. The specimens are believed to belong to *Gacella*. If they belong to *Asymphylotoechia*, they occur somewhat higher than any other examples.

Asymphylotoechia nolani is associated with *Hesperorthis matutina*, *Anomalorthis*, *Palliseria*, and *Nileus*? in collection D299a CC.

Genus ANOMALORTHIS Ulrich and Cooper, 1936

Anomalorthis resoi Ross, n. sp.

Plate 4, figures 21–30; plate 5, figures 1–10

This species is represented by silicified specimens collected in the Pahranagat Range with the assistance of Anthony Reso, for whom the species is named.

Superficially, *Anomalorthis resoi* resembles *A. oklahomensis* Ulrich and Cooper but lacks a sulcus in pedicle valves over 6 mm long. In other respects the two are probably indistinguishable. Some illustrations of *A. oklahomensis* seem to show that a sulcus may not be distinct in that species (Cooper, 1956, pl. 78C, figs. 14, 15).

Two pedicle valves (pl. 4, figs. 21–25, 27, 28) possess an apical plate in the delthyrium in the same manner as a specimen of *A. nevadensis* illustrated by Ulrich and Cooper (1938, pl. 21D, fig. 16). Other specimens appear frayed along the edge of the apex of the delthyrium, suggesting that a similar plate may have been broken out of each. It therefore seems probable that an apical deltidial plate is characteristic of, or at least more common in, *Anomalorthis* than preservation would lead us to believe.

Two interesting complete but immature specimens are illustrated to show the enormous change in relative size and inclination of the cardinal area throughout growth. In the smaller of the two specimens (4.9 mm long; pl. 5, figs. 2, 3, 6, 7, 10), the angle between plane of commissure and cardinal area is not much over 30°; the altitude of the cardinal area exceeds the median length of the exterior of the shell from the umbo to the commissure. In the second shell (pl. 5, figs. 1, 4, 5, 8, 9), the cardinal area is inclined at about 65°; its altitude is less than the external median distance from umbo to commissure. Spacing of costellae is four in 1 mm regardless of size of shell; new costellae are intercalated to maintain this spacing.

Measurements in millimeters—

Type	USNM No.	Valve	Length	Width	Hinge width	Depth	Length of ventral exterior	Length of cardinal area	Costellae in 1 mm	Procline angle
Paratype	160801b	Brachial	12.9	12.1	9.7	2.8			4	
Holotype	160800	Pedicle (deformed)	10.0	15.1	14.2	5.9	7.8	7.0	4	55°
Paratype	160801a	Pedicle							4	
	160801c	Brachial	7.5	9.0	7.6	1.7			4–5	
	160801c	Pedicle	6.6	9.0	7.6	2.9	5.7	2.9	4–5	65°
	160801d	Brachial	4.9	6.2	6.5	.85			4	
	160801d	Pedicle	4.2	6.2	6.5	1.6	2.3	3.1	4	33°

Occurrence.—USGS collections D1382 CO and D1674 CO, Antelope Valley Limestone, 696–725 feet below base of Eureka Quartzite, Pahranagat Range, Nev.

Discussion.—In collection D1569 CO from the Groom Range, *Anomalorthis oklahomensis* is represented by specimens having a well-developed sulcus in the pedicle valve and a procline cardinal area; angle between plane of commissure and cardinal angle is about 65° in many specimens but almost 90° in some. The specimens of *A. resoi* from collection D1382 CO have a shallow or no pedicle sulcus except in immature specimens and about 65° proclivity of the cardinal area in mature specimens. The differences between the two are slight. Given a large statistical sample they could probably be differentiated, although there would surely be overlaps between them.

Stratigraphically, *A. oklahomensis* with deep sulcus seems to occur near the top of the range of the genus *Anomalorthis*; it may therefore be important not to confuse it with *A. resoi* from collection D1382 CO, which occurs lower and is associated with *A. lonensis* (Walcott).

Anomalorthis lonensis (Walcott)

Plate 5, figures 11–17

Anomalorthis lonensis (Walcott). Ulrich and Cooper, 1938, Geol. Soc. American Spec. Paper 13, p. 127–128, pl. 21E.

Topotype specimens of this species were collected from a measured section on the southwest side of Lone Mountain. Several are illustrated here to give a better idea of convexity of valves and inclination of cardinal area than can be obtained from previously published figures.

Costellae increase by implantation and bifurcation. Costellae three per millimeter. Cardinal area catacline to very steeply apsacline. Hemipyramidal pedicle valve may be flattened anteriorly, but this not evident in some specimens. Paired adductor tracks on pseudospondylium flanked by narrow impressed diductors. Very narrow adjustor scars may be present above diductors on dental lamellae. Pallial markings very much like those of *Tritoechia.*

Brachial valve wider than long, markedly convex in lateral profile; greatest convexity toward front of valve. Posterior adductor scars much smaller than anterior pair.

Measurements in millimeters.—

USNM No.	Valve	Length	Midlength width	Hinge width	Costellae in 5 mm
160802a	Pedicle	7.9	11.7	12.9	15
160802b	Brachial	6.9	10.1	16.4	15
160802c	Brachial (broken)	7.6	12.6	13.3	13

Figured and measured specimens.—USNM 160802a–d.

Occurrence.—USGS collections D375 CO and D1764 CO, Antelope Valley Limestone, 377 feet below base of Eureka Quartzite, Lone Mountain, Bartine Ranch quadrangle, Nevada (USNM 160802a–c). USGS collections D1382 CO (USNM 160802d, e), D1673 CO, D1674 CO, D1675 CO, Antelope Valley Limestone, 515–767 feet below base of Eureka Quartzite, Pahranagat Range. USGS collections D1577 CO, D1578 CO, Antelope Valley Limestone, 939–951 feet below top, southern Groom Range.

Discussion.—It is important to note that the cardinal areas are catacline or steeply apsacline, not procline. Another species with similar ribbing but a procline cardinal area occurs in the *Orthidiella* zone at some localities.

The specimens of *Anomalorthis lonensis* from the Pahranagat Range, USGS collection D1382 CO, USNM 160802e, have a somewhat better development of the pedicle sulcus than those in collections from Lone Mountain.

Anomalorthis fascicostellatus Ross, n. sp.

Plate 5, figure 18–25

This species is based on 14 valves from a single collection. Most of the shells are damaged or fragmentary. They are associated with about 1½ times as many valves of *Anomalorthis lonensis* (Walcott) and about one-fifth as many of *A. nevadensis* Ulrich and Cooper.

Shells of small to medium size for the genus. Hinge forms widest part; cardinal extremities acute to right-angled. Costellae distinctly bundled; main ribs branch so that they are flanked by one or a pair of narrower costellae. At front of valve three costellae in space of 1 mm.

Pedicle valve having apsacline to catacline cardinal area of moderate altitude. Surface of valve flat to slightly convex in lateral profile. No sulcus. Brachial valve most convex in the middle third. Posterolateral flanks concave. A shallow median sulcus present, particularly near umbo.

Measurements in millimeters.—

USNM	Type	Valve	Length	Midwidth	Hinge width	Costellae in 5 mm
160803	Holotype	Brachial	7.3	10.0	11.8	15
160804	Paratype	Pedicle	6.9	10.0	10.7	15

Occurrence.—USGS collection D1764 CO, Antelope Valley Limestone, 377 feet below base of Eureka Quartzite, Lone Mountain, Bartine Ranch quadrangle, Nevada. Also probably in collection D1572 CO in southern Groom Range section and in collection D1383 CO in Pahranagat Range.

Discussion.—The species *Anomalorthis fascicostellatus* is very similar to *A. lonensis* with which it is associated and from which it is distinguished by its fascicostellate ornamentation. The species is seemingly very uncommon. It is also associated with *Hesperorthis* cf. *H. matutina* Cooper and *Asymphylotoechia nolani* Ross, n. gen., n. sp. This association seems to have a very limited vertical range and has been found also in collection D1572 CO in the southern Groom Range; there *A. fascicostellatus* is questionably represented by a single fragment of a valve.

Anomalorthis n. sp. A

Plate 5, figures 26–31; plate 6, figures 2, 3, 5

Three specimens from the *Orthidiella* zone of the southern Groom Range (colln. D1583 CO) belong to a species of *Anomalorthis* not previously described; although too small a sample for the formal erection of a new species, the specimens are illustrated and discussed below as a matter of record.

Shell of moderate size for the genus, of low convexity. Costellae spaced four per millimeter at front. Brachial valve evenly convex in lateral profile; median sulcus deepest at midlength, widens and becomes shallower anteriorly.

Cardinal area of pedicle valve slightly procline, almost catacline, its length about one-third its width. In lateral profile, costellate portion flat to slightly concave; a suggestion of a sulcus present anteriorly. Muscle field bilobed, almost heart shaped, anterior edge only slightly elevated.

Measurements in millimeters; those in parentheses are estimated.—

USNM No.	Valve	Length (L)	Width (W)	Hinge width	Length of cardinal area	L÷W	Costellae in 5 mm
160805	Brachial	7.5	9.5	7.1	------------	0.79	21
160806b	Pedicle	6.5	(9.3)	(7.8)	2.3	.70	21

Figured specimens.—USNM 160805, 160806a, b.

Occurrence.—USGS collection D1583 CO, Antelope Valley Limestone, 1,272 feet below top, southern Groom Range.

Discussion.—This species possesses a short cardinal area which is a little longer and a little less procline than that of *Anomalorthis lambda* Ross. Both these species are from the *Orthidiella* zone; it is probable that shortness of cardinal area is a primitive characteristic in the genus *Anomalorthis.*

Anomalorthis n. sp. A differs from *A. lonensis* in having finer costellae and a more procline cardinal area. It differs from *A. oklahomensis* in outline and shortness of cardinal area. From *A. nevadensis* it can be distinguished by its coarser costellae and shorter and less procline cardinal area.

Anomalorthis juabensis Jensen (1967, p. 94–95, pl. 5, figs. 1–6) is a correlative species having somewhat finer costellae and a markedly alate outline.

Genus APORTHOPHYLA Ulrich and Cooper, 1936

Aporthophyla Ulrich and Cooper, 1938, Geol. Soc. America Spec. Paper 13, p. 183.
Muir-Wood and Williams, 1965, Treatise on Invertebrate Paleontology, Pt. H. v. 1, p. H372.

In the original description of this genus, Ulrich and Cooper stated that *Aporthophyla* differed from *Taffia* in the lack of a thickened rim inside the margin of the valves. Silicified specimens have been collected from two localities, one of them the type section; these specimens are better than any of the material originally available to Cooper and show that a thickened rim is indeed present. Therefore, the only major difference between *Aporthophyla* and *Taffia* is in the cardinalia.

Aporthophyla typa Ulrich and Cooper

Plate 9, figures 1–4

Aporthophyla typa Ulrich and Cooper, 1938, Geol. Soc. America Spec. Paper 13, p. 183, pl. 37A, figs. 1–3, 5, 7, 8, 10, 11.
Cooper, 1956, Smithsonian Misc. Colln., v. 127, pl. 163C.

Silicified specimens are illustrated here in order to show the thickened subperipheral rim on the inside of the brachial valve and the apparent lack of a similar rim inside the pedicle valve. Pedicle muscle field confined within delthyrial chamber. Diductor scars narrow, close against bases of dental plates. Adductor scars reach front of muscle area, faintly bilobed; width of adductor scars equals combined width of diductors. Vascular canals not shown on any of available specimens, except that proximal ends of vascula media(?) form strong ridges in pedicle valve (pl. 9, fig. 3).

Figured specimens.—USNM 160821a, b.

Occurrence.—USGS collection D1513 CO, Antelope Valley Limestone, 330 feet below top; USGS collection D1607 CO, 389 feet below top; D1517 CO, 650 feet below top; D1520 CO, 750 feet below top; southeast side of hill 8474, Ikes Canyon, Toquima Range, Nev. USGS collection D1656 CO, Antelope Valley Limestone, associated with *Orthambonites minusculus*, Caesar Canyon, north of Mill Canyon, Toquima Range, Nev.

Discussion.—Although the cardinal process seems to be a single prominent blade in this species, in some specimens an accessory ridge or thickening is present beneath the chilidium (pl. 9, fig. 2) on either side of the cardinal process.

Although externally this species bears a strong resemblance to *Toquimia kirki*, as stated by Ulrich and Cooper (1938, p. 182), interiors are even more different than they originally were able to know. It is evident that *Aporthophyla typa* is associated with *Orthambonites minusculus* and occurs lower stratigraphically than *T. kirki.* No collection was found in which *A. typa* and *T. kirki* are both present. *Aporthophyla* does not range high enough to be with *Rhysostrophia.* Whittington and Kindle (1963, p. 754) indicated that *Aporthophyla* occurs only in the lower Table Head in Newfoundland.

Genus TOQUIMIA Ulrich and Cooper, 1936

Toquimia Ulrich and Cooper, 1938, Geol. Soc. America Spec. Paper 13, p. 183–184.

Toquimia kirki Ulrich and Cooper

Plate 8, figures 16–18

Toquimia kirki Ulrich and Cooper, 1938, Geol. Soc. America Spec. Paper 13, p. 184.
Cooper, 1956, Smithsonian Misc. Colln., v. 127, p 698, pl. 164, figs. 4–14.

Several specimens of this species are illustrated here to supplement the descriptions given by Ulrich and Cooper (1938, p. 184) and by Cooper (1956, p. 698). The interior of a silicified brachial valve (pl. 8, fig. 18), although poorly preserved, shows a far better developed lophophore platform than is in any of the specimens previously available (Ulrich and Cooper, 1938, pl. 38C; Cooper, 1956, pl. 164, figs. 13–14). In size of shell and in development of the lophophore platform, the specimen rivals *Anoptambonites grayae* (Davidson), a resemblance suggesting that the species may be more closely related to the Leptellinidae than previous classifications indicate (Muir-Wood and Williams, 1965, p. H372–H376).

However, several other unsilicified specimens (pl. 8, fig. 16) demonstrate the rafinesquinoid shape described by Cooper (1956, p. 698). Ornamentation is also rafinesquinoid; between every two coarse costellae are one or more finer costellae, and about eight costellae, both coarse and fine, in a space of 5 mm at the front of a valve.

A polished section parallel to the hinge line and perpendicular to the plane of commissure (pl. 8, fig. 17) was cut into the cardinal process and revealed that the end of the process is bilobed. This fact suggests that *Toquimia* is more closely related to the Strophomenidae than to the Leptellinidae.

Figured specimens.—USNM 160820 a, b.

Occurrence.—USGS collection D1507 CO, Antelope Valley Limestone, top 2 feet; D1508 CO, approximately 100 feet below top; D1523 CO, 162 feet below top. *Rafinesquina*-like specimens from D1511 CO, 214 feet below top of formation. Ikes Canyon, Toquima Range, Nev.

Discussion.—The author has no ready explanation for the unexpected structure of the cardinal process as revealed in polished section (pl. 8, fig. 17). It seems possible that the specimens collected from collection D1511 CO are not *Toquimia*, but a true rafinesquinid. However, Cooper examined these specimens and concluded that all of them belong to *Toquimia*. He showed the author another specimen in his collections (October 5, 1966) that he polished in the same manner and that also has the same double structure. Unfortunately, the interiors of specimens sectioned in this manner are not visible; neither of us has been able to prove beyond all doubt that the large knobbed cardinal process of true *Toquimia* will appear bilobed when sectioned.

Toquimia kirki is associated with *Leptellina occidentalis* at the top of the Antelope Valley Limestone (colln. D1507 CO) at Ikes Canyon. About 100 feet lower (colln. D1508 CO) its associates are *Valcourea*, *Orthambonites* cf. *O. bifurcatus*, *Hesperomena leptellinoidea*, and *Illaenus*. Only in the lower part of its range (collns. D1509 CO, D1523 CO, and D1511 CO), 162–214 feet below the top of the formation, is *Toquimia* associated with *Rhysostrophia*.

Genus HESPEROMENA Cooper, 1956

Hesperomena Cooper, 1956, Smithsonian Misc. Colln., v. 127, p. 744–745.

Hesperomena leptellinoidea Cooper

Plate 10, figure 1

Hesperomena leptellinoidea Cooper, 1956, Smithsonian Misc. Colln., v. 127, p. 745, pl. 185A, figs. 1–10.

Several silicified fragments of shells are assigned with confidence to this species. One (pl. 10, fig. 1) shows the strong overhang of the cardinal process described by Cooper (1956, p. 745). Other fragments show the thickened boundary between visceral disc and geniculate margin.

Figured specimen.—USNM 160823.

Occurrence.—USGS collection D1508 CO, Antelope Valley Limestone, 95–99 feet below top of formation, Ikes Canyon, Toquima Range, Nev.

Discussion.—The discovery of this extremely rare species confirms the position of the species within the range of *Valcourea* but above *Rhysostrophia* at Ikes Canyon.

Genus ISOPHRAGMA Cooper, 1956

Isophragma sp.

Plate 9, figure 8

A single imperfect, very immature brachial valve belongs to *Isophragma*.

Cardinal process a thickened mass between brachiophores; posterior face crudely trilobed. No distinct chilidial plates. Brachiophores (or socket ridges) discrete from cardinal process, not being joined to it as in *Sowerbyella*.

A pair of narrow highly elevated septa extend forward from base of cardinal process. These septa widely separated against floor of valve; they converge above valve so that they are only narrowly separated. Pair of short accessory lateral septa also present.

Figured specimen.—USNM 160822.

Occurrence.—USGS collection D1655 CO, Antelope Valley Limestone, in small fault block, associated with *Aporthophyla typa* and *Orthambonites minusculus*, on ridge on east side of "Caesar Canyon" above its junction with Mill Canyon, Toquima Range, Nev., coordinates, central zone: E. 407,400 feet, N. 1,548,800 feet, Wildcat Peak quadrangle, Nevada.

Discussion.—The shape of brachiophores (socket ridges), lack of chilidial plates, presence of a thick cardinal process, and position of median septa resemble those of *Isophragma;* this small specimen represents an early concavo-convex stage in the development of a maturely resupinate shell. *Isophragma* is a Porterfield genus.

Genus TAPHRODONTA Cooper, 1956

Taphrodonta parallela Cooper

Plate 19, figures 16, 17

Taphrodonta parallela Cooper, 1956, Smithsonian Misc. Colln., v. 127, p. 741–742, pl. 165A, figs. 1–22.

Figured specimen.—USNM 162057.

Occurrence.—USGS collection D1518 CO, Antelope Valley Limestone, 681 feet below top; USGS collection D1507 CO, in top 2 feet, Ikes Canyon, Toquima Range, Nev.

Discussion.—A single immature brachial valve is illustrated. This specimen is the oldest recorded example of *Taphrondonta parallela* which previously has been considered a younger species (Cooper, 1956, p. 127).

The dual nature of the median ridge is evident in this specimen. The median sulcus of the concave valve distinguishes the specimen from *Isophragma* with which it might easily be confused.

Genus LEPTELLINA Ulrich and Cooper, 1936

Leptellina Ulrich and Cooper, 1938, Geol. Soc. America Spec. Paper 13, p. 190–191.

Leptellina occidentalis Ulrich and Cooper

Plate 9, figures 5, 7

Leptellina occidentalis Ulrich and Cooper, 1938, Geol. Soc. America Spec. Paper 13, p. 191–192, pl. 39B, figs. 3, 7.
Cooper, 1956, Smithsonian Misc. Colln., v. 127, p. 751, pl. 189C, figs. 30–37.
Ross, 1967a, U.S. Geol. Survey Prof. Paper 523–D, p. D6–D7, pl. 3, figs. 1–10.

Two specimens are illustrated here from Ikes Canyon to show the considerable variation in outline that one finds in this species. Although not given in the original description, a similar variation is illustrated by Cooper (1956, pl. 189C, compare figs. 34–37).

Figured specimens.—USNM 160824 a, b.

Occurrence.—USGS collection, D1507 CO, Antelope Valley Limestone, from top 2 feet, Ikes Canyon, Toquima Range, Nev. See also Ross (1964a, p. C27, C30, C31, C70, C82, C84; 1967a, p. D6–D7, pl. 3, figs. 1–10).

Discussion.—During the course of work published here *Leptellina occidentalis* was found at Ikes Canyon, Toquima Range, only in the very highest beds of the Antelope Valley Limestone. (USGS colln. D1507 CO). Although included by Cooper (1956, p. 127) in his *Rhysostrophia* zone, the species seems to be present above the range of *Rhysostrophia* itself. Although it is also above *Valcourea* in the Ikes Canyon section, *L. occidentalis* is now known to be associated with *Valcourea* in southern Nevada (USGS colln. D1600 CO) at Meiklejohn Peak (Ross, 1964a, p. C24–C31), 53 feet below the Eureka Quartzite (that is, 1 ft below beds equivalent to the Copenhagen Formation), and in central Nevada at Martin Ridge (Ross, 1964a, p. C70), in the top 5 feet of the Antelope Valley Limestone (beneath the type section of the Copenhagen Formation).

Genus GLYPTOMENA Cooper, 1956

Fairly small strophomenid shells of slight concavity and low convexity in the upper part of the Antelope Valley Limestone of eastern Nevada pose problems of identity because of poor preservation and lack of adequate brachial interiors. The report of *Glyptomena* by Ross (1964b, fig. 5, Snake Range) was based on fossils from USGS collection D378 CO. Like specimens from collection D1813 CO, described below from Steptoe, those are poorly preserved and were assigned to *Glyptomena* because of subdued development of the median and lateral septa of the brachial valve, minute size of double cardinal process, delicate yet well-formed socket ridges, and low convexity. Some of the shells from both collections are outwardly like *Platymena*, but none displays valve interiors adequately preserved to determine if that genus is truly present. Nor can one be certain that *Glyptomena* is represented. One must also consider the possibility that these specimens belong to *Kirkina*, a genus in which the median septum of the brachial valve seems to be better developed and the costellation coarser and more uniform than in these specimens.

Glyptomena? sp.

Plate 9, figures 11, 14

All shells poorly preserved, none silicified, but form a near coquina in very fine grained limestone.

Shells concavo-convex, almost flat. Width of most specimens 15–18 mm; a few specimens about 30 mm in width may belong to different species. Costellae spaced two to three per millimeter at front of valves; in some specimens, costellae of nearly equal size; in others three to five fine costellae between coarser ones (pl. 9, fig. 11).

Figured specimens.—USNM 160826a, b.

Occurrence.—USGS collection D1813 CO, Lehman Formation, 120 feet below base of Eureka Quartzite, Steptoe section, Nevada.

Discussion.—Full significance of this species cannot be appreciated because of inability to identify it completely. It is, in fact, possible that more than one species is included in this lot, one with differentiated costellae and the other with fairly uniform costellae. There is a further possibility of confusion with immature specimens of associated *Macrocoelia*.

In any event, *Platymena* older than Porterfield Stage is not known, and *Glyptomena* ranges from Marmor to Porterfield. Based on the occurrence of *Öpikina* lower in the section, a Porterfield or younger age is called for.

Genus ÖPIKINA Salmon, 1942

Öpikina cf. Ö. expatiata Cooper

Plate 9, figures 9, 10, 12, 13, 15, 16

At the Steptoe section in USGS collection D1814 CO (162 ft below the base of the Eureka Quartzite), *Öpikina* is abundantly represented. None of the specimens is silicified, and all must be broken from the fine-grained limestone matrix. Resulting preservation is not good, and critical features such as cardinalia have not been completely observed.

Shells wider than long. Hinge wider than midwidth in almost all specimens but about equal in a few. Costellae destroyed in visceral area on almost all shells; near the margin subequal to alternating costellae coarse and fine, spaced 5 per millimeter at front of shell.

Geniculation obscure at 15–18 mm from beaks. Lateral profile of pedicle valve strongly convex, and there is no well-marked geniculation. Brachial valve concave and has suggestion of shallow median sulcus.

Poorly preserved brachial interiors suggest cardinal processes small; myophores directed posteriorly. Septa subdued. No pedicle valve interiors observed.

Figured specimens.—USNM 160827a–d.

Occurrence.—USGS collection D1814 CO, Lehman Formation, 162 feet below base of Eureka Quartzite, Steptoe section, Nevada.

Discussion.—This species is probably a little more convex than *Öpikina expatiata* Cooper (1956, p. 907–908, pl. 241A), although it compares favorably in size and outline. Although preservation of cardinalia is too poor for reliable comparison, the cardinalia seem smaller than is common in *Öpikina* though they are not much different than those of *Ö. expatiata.*

The species is stratigraphically important in indicating that the enclosing beds should be at least as young as Porterfield. One poorly preserved species is reported from beds of Ashby age by Cooper (1956, p. 925–926, pl. 268E, *Ö.* sp. 5); all other known species are Porterfield or younger in age.

Genus LEPTAENA Dalman, 1828

Leptaena cf. L. ordovicica Cooper

Plate 9, figure 6

A pedicle value and very poor impression of exterior of a brachial valve constitute this sample.

Pedicle valve almost rectangular in outline. Hinge width slightly greater than width. Length a little less than seven-tenths width at middle. Surface costellate; costellae of nearly uniform size, spaced about 15 in 5 mm. Concentric undulations not entirely continuous. Umbonal region very slightly swollen. Geniculation forms a raised rim having trail at right angles. Geniculation at 15 mm from beak.

Figured specimen.—USNM 160825.

Occurrence.—USGS collection D1506 CO, unnamed formation, 60–90 feet above top of Antelope Valley Limestone, Ikes Canyon section.

Discussion.—The species represented here seems to be a little more coarsely ornamented than *Leptaena ordovicia* in the East. However, the Nevada specimens exhibit the variation in ornamentation, outline, and profile shown by specimens illustrated by Cooper (1956, pls. 208B, 212C, 228B). The specimen most closely resembled is that from the Martinsburg near Carlisle, Pa. (Cooper, 1956, pl. 208B).

Cooper (1956, p. 821) reported *L. ordovicica* from the "dark shale under Eureka Quartzite" that makes up the upper part of the Copenhagen Formation of Trenton age. Such a dating seems to be in accord with evidence of other fossils in beds above the Antelope Valley Limestone at Ikes Canyon.

Genus DACTYLOGONIA Ulrich and Cooper, 1942

Dactylogonia Ulrich and Cooper, 1942, Jour. Palentology, v. 16 no. 5, p. 623–624.
Cooper, 1956, Smithsonian Misc. Colln., v. 127, p. 824–825.
Williams, 1962, Geol. Soc. London Mem. 3, p. 200–202.

This genus has been reported from strata of Marmor to Trenton age in the Appalachian region (Cooper, 1956, p. 825), in the Porterfield Bromide Formation of Oklahoma, and in beds of ages equivalent to Porterfield to Trenton in the Girvan District of Scotland (Williams, 1962, p. 200–202). It had not previously been found in the Basin Ranges of the Western United States.

Dactylogonia is now known from two sections in southern Nevada. A single partial brachial valve was found in collection D710a in the Ranger Mountains on the Nevada Test Site (Ross, 1964a, p. C14; 1967a, p. 11) in the Antelope Valley Limesone 30 feet below the base of the Eureka Quartzite, where it is associated with *Plectorthis* cf. *P. perplexus* (Ross), *Lonchodomas* sp., and a new species of *Schmidtella.*

The genus is also represented by the new species *D. vespertina* (see p. 67) in the upper part of the Antelope Valley Limestone, 20 feet below the base of the Eureka Quartzite, in the Groom Range north of the Nevada Test Site. There it is associated with *Lichenaria*, *Orthambonites paucicostatus*, *O.* cf. *O. occidentalis*, and *Ctenodonta.*

Both occurrences lend weight to correlation of the upper part of the Antelope Valley Limestone in eastern and southern Nevada with part of the Copenhagen Formation of central Nevada.

Dactylogonia vespertina Ross, n. sp.

Plate 9, figures 17–22

Shell small for the genus. Hinge width less than greatest width which is just ahead of hinge. Surface marked by fine costellae, about 25 in 5 mm at the edge of a shell 10 mm long. Costellae of two sizes. Near middle of anterior margin, large and small costellae seem to alternate fairly regularly; laterally, however, there tends to be an irregularly increased number of fine costellae between coarser ones.

Pedicle valve a little wider than long. In lateral profile, geniculate at a distance of 5–7 mm from the beak. Angle of geniculation 105°–140°, less pronounced in less convex specimens. In anterior profile, convexity fairly even and some flattening toward cardinal angles. Interarea orthocline to very slightly apsacline. Well-developed deltidium. Pedicle opening small, apical.

Brachial valve gently concave, not distinctly geniculate; greatest concavity about 6 mm in front of umbo. Interarea very short, anacline. Interior has well-developed cardinal process; socket ridges parallel hinge line. Median septum very weak; two pairs of weak, yet distinct septa in muscle field. Subperipheral rim strong.

Measurements in millimeters.—

Type	USNM No.	Length	Brachial length	Midwidth	Hinge width	Thickness
Holotype	160828	------	8.5	13.0	10.9	------
Paratype	160829a	10.0	8.7	12.7	10.8	4.6
	160829b	9.5	8.2	11.2	9.8	2.9
	160829c	10.1	7.8	12±	10.7	4.5

Occurrence.—USGS collection D1559 CO, Antelope Valley Limestone, 21 feet below top, southeast end of Groom Range, Nev. Probably USGS collections D1663 CO, D1381 CO, Antelope Valley Limestone, 25–28 feet below top, Pahranagat Range.

Discussion.—In shape and size *Dactylogonia vespertina* closely resembles *D. subaequicostellata* from the Bromide Formation, and differs primarily in the fineness of costellation of two sizes and in the proper development of the transmuscle septa of the brachial valve. One valve is gently convex and compares closely in this regard with the holotype of *D. subaequicostellata.* Geniculation of another is much like that of the holotype of *D. geniculata* (Cooper, 1956, pl. 216D), a far more alate species. *D. vespertina* is readily differentiated from all Marmor species described to date in that its shells are widest at the hinge.

Genus GACELLA Williams, 1962

Gacella Williams, 1962, Geol. Soc. London Mem. 3, p. 222–223, pl. 22, figs. 18, 21–26; pl. 23, fig. 1.

Gacella? sp.

Plate 10, figures 2, 3

Two specimens, one the external mold of a brachial valve, the other the exterior of a deformed pedicle valve, are tentatively referred to *Gacella.* The external form, ornamentation, and impunctate shell favor the assignment. Costellae spaced three to four in one mm of which every second or third is coarser than the others. Lack of any interiors is regrettable.

Measurements in millimeters.—

USNM No.	Valve	Length	Width	Width of fold
160830b	Brachial	5.3	8.3	3.5 (approx.)
160830a	Pedicle	7.1	10.5	------

Occurrence.—USGS collection D229e CO, Antelope Valley Limestone, 82 feet below top of formation. Antelope Valley composite section, Nevada coordinates, central zone: E. 583,000 feet, N. 1,628,400 feet, Horse Heaven Mountain quadrangle.

Discussion.—Preservation of the two available specimens precludes comprehensive comparison with *Gacella insolita* Williams and *G. ponderosa* Williams. They are smaller than *G. ponderosa* and comparable in size with *G. insolita.* Costellation is similar to that of *G. ponderosa* but coarser than that of *G. insolita.*

On the basis of form, the author had originally considered assignment to *Furcitella* or *Holtedahlina,* before Cooper (oral commun., Oct. 5, 1966) called his attention to the fact that the resemblance to *Gacella* is greater. Stratigraphically, the possible presence of *Gacella* is important. In Scotland (Williams, 1962, p. 223, 256) the genus occurs in the *confinis* Flags and in the Stinchar limestone and Stinchar mudstone of the Lower Barr Series. These units are correlated (Williams, 1962, p. 59, table 2) with the Porterfield Stage.

Genus SYNTROPHOPSIS Ulrich and Cooper, 1936

Syntrophopsis sp.

Plate 9, figures 23–25

Four specimens probably belonging to *Syntrophopsis* were collected from the lower *Anomalorthis* zone in the southern Groom Range. Two specimens are brachial valves, one slightly deformed, the other fragmentary. *Syntrophopsis* is represented by a gigantic species. The genus has not been previously reported in strata as young as the *Anomalorthis* zone.

Brachial valve evenly and moderately convex in lateral profile and has inconspicuous umbo. In anterior profile, middle of shell is broadly convex and has flattened sloping flanks; anterior fold low. Fold differentiated only in anterior four-tenths of shell. In interior, brachiophores short and blunt; fulcral plates very well developed. Adductor scars limited to the posterior half of shell.

Pedicle valves fragmentary. One specimen shows spondylium of type characteristic of the genus.

Measurements in millimeters.—

USNM No.	Valve	Length	Width	Hinge width	Height
160832	Brachial	21.4	27.4	16.5	11.5

Occurrence.—USGS collection D1572 CO, Antelope Valley Limestone, 794 feet below top; section at southeast end of Groom Range.

Discussion.—In its great size this brachial valve exceeds similar valves of any other known species of *Syntrophopsis.* The fold is far less prominent than in *S. polita* or *S. obscura* and resembles more closely that of *S. laevicula* Ulrich and Cooper. In size it is approached only by *S. magna* Ulrich and Cooper.

Syntrophopsis has been considered a late Early Ordovician genus. One species, *S. transversa* Ulrich and Cooper, is found in zone "L" of the Garden City Formation (Ross, 1951, p. 27), which is equivalent to the *Orthidiella* zone. The specimens from the Groom Range are the youngest occurrence of the genus.

Genus **RHYSOSTROPHIA** Ulrich and Cooper, 1936

Rhysostrophia is represented by two or more species in beds of the Antelope Valley Limestone in central Nevada. The type species, *R. nevadensis* Ulrich and Cooper, came from Ikes Canyon (Ulrich and Cooper, 1938, p. 240–241); specimens assigned to that species but varying from it in character of ribbing were collected from the same section and are described herein from USGS collection D1509 CO. *R. occidentalis* Ulrich and Cooper is present at the same place in collection D1523 CO, at virtually the same stratigraphic position, as well as in the northern Inyo Mountains (pl. 7, figs. 14–16, 19; Ross, 1964a, p. C40).

Somewhat lower in collection D1520 CO, two poorly preserved specimens are present that have the fine ribbing of *R. occidentalis* but the wide sulcus of *R. nevadensis.*

In general, topotype specimens show considerably more variation than indicated by original descriptions of *R. nevadensis* and *R. occidentalis.* This may also be true of specimens from the Mazourka Group (USGS collns. D1003 CO, D1004 CO; Ross, 1964a, p. C40) in the Inyo Mountains.

With one exception *Rhysostrophia* is known in the West only from the Toquima and northern Inyo Ranges. One specimen has been reported in the Eureka District from the "*Desmorthis* zone" by Cooper (1956, *Rhysostrophia* sp. 1, p. 560, pl. 32D, figs. 7, 8). This is the only place outside the Toquima Range where the genus is known in one of the standard Whiterock zones, as for example the *Anomalorthis* zone.

The association of the genus with *Palliseria* and abundant sponges in the Inyo Mountains suggests that the genus occurs below or in the *Anomalorthis* zone, not above it. The occurrences at Ikes Canyon indicate that it occurs there above *Palliseria* and with *Valcourea.* Both these occurrences are west of the normal geographic occurrence of *Anomalorthis.*

Rhysostrophia nevadensis Ulrich and Cooper

Plate 7, figures 18, 21, 23

Rhystostrophia nevadensis Ulrich and Cooper, 1938, Geol. Soc. America Spec. Paper 13, p. 241, pl. 54D.

Figured specimen.—USNM 160813.

Occurrence.—USGS collection D1509 CO Antelope Valley Limestone, 162 feet below top, north side of Ikes Canyon, Toquima Range, Nev.

Discussion.—In collections from the Antelope Valley Limestone at Ikes Canyon are specimens that probably should be assigned to *Rhysostrophia nevadensis.* However, no two specimens are the same in regard to total number of costae or in regard to number of costae on flanks or folds of shells. In most specimens the numbers of costae are not even bilaterally symmetrical.

According to the original description, the number of costae on fold (or in sulcus) ranges from four to seven, but on specimens from collection D1509 CO, they range from eight to 11. The original description calls for nine to 11 costae on flanks; most of the present specimens have 12 but the one shown on plate 7, figures 18 and 23, has 11 on one flank and 13 on the other.

Possibly these specimens should be assigned to another species, but coarseness of ribbing, size, and proportions seem closer to *R. nevadensis* than to any other species.

A species having a greater number of ribs occurs lower in the section (USGS colln. D1511 CO); it possesses 20 costellae in the sulcus and about 13 on each flank. This species is represented by only two specimens, each too poorly preserved to warrant description.

Genus **CAMERELLA** Billings, 1859

Camerella aff. C. nuda Cooper

Plate 7, figures 17, 20, 22, 24; plate 8, figures 1, 2

Shell large for the genus, transversely elliptical. Apical angle about 105°. Brachial valve deeper than pedicle. Posterior halves of valves smooth. Uniplicate, inception of narrow, relatively high fold about at midlength of brachial valve; but two irregular costae that compose the fold not separable except in anterior third. Costae poorly defined and partly divided into secondary costae; two main costae in fold and one in sulcus. One or two very faint costae suggested on flanks. Surface finely parvicostellate, parvicostellae spaced two per millimeter.

Pedicle valve narrowly convex in umbonal region, flattened anterolaterally; sulcus deepens gradually to form anterior tongue, which appears geniculated at right angles in lateral profile only. Spondylium fairly wide, rests on slender septum, confined to posterior half of valve.

Brachial valve has greatest depth near midpoint, evenly convex in anterior profile. Fold high, quadrate in anterior view. Cruralium short; septum diminishes in height rapidly, reaches midpoint of valve as very low ridge between muscle scars.

Measurements in millimeters.—

USNM No.	Length	Brachial length	Width	Thickness
160815	14.0	13.0	15.0	9.5

Figured specimens.—USNM 160815, 160816a, b.

Occurrence.—USGS collection D1634 CO, Antelope Valley Limestone, 86–91 feet below top of formation, Ranger Mountains section, Nevada Test Site (Ross, 1967a, pl. 11).

Discussion.—The small sample available hinders adequate comparison with known species and prevents erection of a new species. Only *Camerella nuda* Cooper and *C. volborthi* Billings approach the Nevada forms in distinctness of costae. Descriptions of both those species (Cooper, 1956, p. 573; Hall and Clarke, 1894, pt. 2, p. 220) call for two indistinct costae in the sulcus. Only the much smaller species, *C. unicostata* Cooper (Cooper, 1956, p. 583, pl. 113B), possesses a single costa in the sulcus; the Tennessee species is less than one-half as big as that from Nevada and has better developed costae.

The same kind of parvicostellae is illustrated on the surface of *C. volborthi* by Schuchert and Cooper (1932, pl. 25, fig. 28); this very fine radial ornamentation is possibly related to the fibrous structure of the shells.

Genus DORYTRETA Cooper, 1956

Dorytreta Cooper, 1956, Smithsonian Misc. Colln., v. 127, p. 666.

Dorytreta subcircularis Ross, n. sp.

Plate 8, figures 11, 12, 14, 15

Shell small, broadly tear shaped, widest opposite midlength of shell. Apical angle approximately 85°; posterolateral margins almost straight; anterior margin evenly rounded, almost semicircular. Surface costate, 15–16 costae in largest specimens. Valves of about equal convexity in lateral profile. Greatest convexity opposite midlength.

Convexity of pedicle valve narrowest in umbonal region. Median costa on several valves bears a very narrow barely discernible groove; this costa only slightly higher, from its inception to the front margin of the shell, than those on either side of it. Pedicle foramen small, elongate, flanked by well-defined deltidial plates.

Brachial valve subcircular in outline. A narrow median sulcus marks entire length of valve. At its umbonal inception it is little more than the groove between two costae; behind the midlength of the shell, two costae are involved in the sulcus. At or near the midpoirt a second pair of costae is implanted medially so that there are four costae in the sulcus at the anterior margin, the middle pair being the lower. That the depth of the sulcus increases constantly toward the front is not apparent because of the proportionately greater increase in the width of the sulcus.

Measurements in millimeters.—

Type	USNM No.	Length	Brachial length	Width	Thickness	Total costae	Costae in 1 mm	Apical angle
Holotype	160818	3.4	3.0	3.1	1.7	15	3	85°
Paratype	160819a	3.5	3.1	3.1	1.8	15–16	3	85°
	160819b	2.7	2.4	2.2	1.3	12–13	3	86°

Occurrence.—USGS collection D1634 CO, antelope Valley Limestone, 86–91 feet below top of formation, Ranger Mountains section, Nevada Test Site (Ross, 1967a, pl. 11).

Discussion.—Immature specimens tend to be narrower in outline than the adults, and although they have fewer total costae, they hold the same spacing as in the larger specimens.

If the available specimens are representative, this species tends to be smaller than *Dorytreta bella* from the McLish Formation and larger than *D. ovata*. *D. subcircularis* differs from both of them in total number of costae and in having a less acute apical angle.

The stratigraphic significance of the species is in supporting the Marmor or younger age of the upper part of the Antelope Valley Limestone in the Ranger Mountains section of the Nevada Test Site.

Genus SPHENOTRETA Cooper, 1956

Sphenotreta Cooper, 1956, Smithsonian Misc. Colln., v. 127, p. 663–664.

Sphenotreta cf. S. sulcata Cooper

Plate 8, figures 3–9

This species is represented in a collection from the Pahranagat Range by one damaged complete shell, two pedicle valves, and four brachial valves. None of the specimens is perfectly preserved; all are silicified. Except for minor differences they compare closely with *Sphenotreta sulcata* Cooper (1956, p. 666) from the McLish Formation of Oklahoma.

Shells small, none exceed 4.1 mm in length. Outline triangular, and greatest width about two-thirds of length from posterior end. Apical angle varies between 60° and 75°. Surface costae number 16–18. Sulcus strongest in middle third of shell. Valves of about equal depth.

Pedicle valve moderately convex in lateral profile, deepest at its midlength. Foramen elongate triangular, fairly wide. Hinge teeth small, but prominent, directed dorsally and anteriorly, and somewhat convergent. Slender dental lamella vertical, not receding. Problematical deltidial plates shown on one specimen, only 0.16 mm in width. Seemingly absent from other specimens.

Brachial valve having median sulcus that forms prominent median ridge in interior. Cardinal process lacking, notothyrial cavity fairly wide. Each crural base supported proximally by short receding lamella, which may be adventitious shell material. No horizontal hinge plates. Crura slightly divergent, short, confined to posterior tenth of valve, at distal end hooked laterally and ventrally to form dental sockets.

Measurements in millimeters.—

USNM No.	Valve	Length	Brachial length	Greatest width	Midwidth	Thickness
160817a	Complete	3.9	3.4	3.0	2.8	1.7
160817b	Pedicle	3.9	3.3	2.9	2.7	
160817c	do	4.1	3.6	3.7	3.4	
160817e	Brachial		3+	3.5		
160817d	do		3.2	2.8		
160817g	do		3.5	3.0		
160817f	do		[1] 2.8+	3.3		

[1] Broken.

Occurrence.—USGS collection D1665 CO, Antelope Valley Limestone, 67–70 feet below top (below base of Eureka Quartzite), west side of Pahranagat Range, Nev.

Discussion.—The seven specimens on which this description is based are the first representatives of the genus found to be silicified and furnish the first view of the interiors of the valves.

Although the author has found the apical angle to be somewhat more acute than that of *Sphenotreta sulcata* as originally described, his observation is based on only three specimens, and the range exhibited by these three includes part of the range of the Oklahoma species (Cooper, 1956, p. 666). The ornamentation is very nearly identical. These Nevada forms may differ in convexity of the valves, however.

The species is important stratigraphically because it adds to the evidence for a Marmor or younger age for the upper beds of the Antelope Valley Limestone in the Pahranagat Range.

Genus and species Indeterminate

Plate 9, figure 26

This brachiopod species has the outline and external form of syntrophiids, triplesiids, and some camerellids. However, no silicified specimens have been found, and the several specimens to which techniques of serial sectioning have been applied have yielded no internal structures. As a result, it is impossible to place the species taxonomically at the present time.

Figured specimen.—USNM 160831.

Occurrence.—USGS collection D1506 CO, unnamed limestone formation, 60–90 feet above top of Antelope Valley Limestone, Ikes Canyon, Toquima Range, Nev.

Phylum ARTHROPODA
Subphylum TRILOBITOMORPHA
Class TRILOBITA

In describing trilobites the terminology of the "Treatise" (Moore, 1959) has been followed, except that the occipital ring is included in the glabella in all trilobites. Trilobites discussed here include Early Ordovician as well as Middle Ordovician species. Several of these have been obtained elsewhere beside the localities indicated in the fully measured sections on pages 4–42.

Genus GERAGNOSTUS Howell, 1935

Geragnostus sp.

Plate 10, figures 4–9

Geragnostus is represented in collections from the Ninemile Formation by a cranidium and a pygidium. Neither is well preserved. Were it not for a distinct furrow across the glabella, the specimens would be assigned to *Trinodus*. The pygidium is much like two described from the Valmy Formation (Ross, 1958, p. 564, pl. 83, figs. 5, 8) but differs in having a narrower third segment of the pygidial axis.

Figured specimens.—USNM 160833a, b.

Occurrence.—USGS collection D340i CO, Ninemile Formation, 141 feet above base, NW¼ sec. 5, T. 15 N., R. 51 E., Cockalorum Wash quadrangle, Nevada.

Genus PARABOLINELLA Brøgger, 1882

Parabolinella Brøgger. Henningsmoen, 1957, Skrifter Norske Vidensk.-Akad. Oslo, Mat.-Naturv. Kl. Skr. 1, p. 132–134.

Parabolinella hecuba (Walcott)

Plate 10, figures 10–13

Parabolinella hecuba (Walcott). Harrington and Leanza, 1957, p. 105–107, fig. 39, 2a–c.

Glabella subquadrate, anterolateral corner rounded. Length (sag.) of occipital ring almost two-tenths total length (sag.) of glabella. Occipital furrow shallow, yet distinct. Lateral glabellar furrows *1p* sigmoid but have bifid anterolateral ends; these ends opposite glabellar midpoint. Lateral furrows *2p* faint in decorticated specimens, outer ends closes to axial furrow and only slightly behind rounded anterolateral "corner" of glabella; furrows run inward and a little backward. Furrows *3p* almost obsolete, run inward and forward from "corner" of glabella.

Axial furrows distinct, confluent around front of glabella. Preglabellar field slopes downward and has slight convexity in lateral profile. Its length (sag.) about one-fifth that of glabella. Border furrow shallow and contains minute pits spaced about three per millimeter. Border subtubular, narrow.

Fixed cheek narrowest between eyes; width (trans.) of each cheek equals one-fourth glabellar width at palpebral lobes. Eyes located opposite lateral glabellar lobes *2p*. Faint eye ridges present. Facial sutures run posterolaterally in a gentle curve and cross narrow posterior border at distance from axial furrow equal to seven-tenths glabellar width. Anteriorly, facial sutures diverge slightly, reach border furrow, and turn sharply inward to cross border diagonally.

Free cheeks smoothly convex, bordered by narrow furrow and narrowly subtubular border. Genal spines long, slender, almost straight.

Figured specimens.—160834a, b.

Occurrence.—USGS collection D289 CO, Goodwin Limestone, 169 feet above lowest exposure, on north side of canyon tributary to Ninemile Canyon, N½SW¼ NE¼ sec. 5, T. 15 N., R. 51 E., Horse Heaven Mountain quadrangle, Nevada.

Discussion.—As noted by Harrington and Leanza (1957, p. 107), this species differs little from *Parabolinella triarthroides*. Decorticated condition of the cranidia prevents certainty that there is any truly significant difference.

Occurrence of *Parabolinella* along with *Hypermecaspis* indicates a faunal relationship with Argentina and the Baltic. Both genera are present in different lithology in Clear Creek Canyon, southern Monitor Range, secs. 31–32, T. 12 N., R. 49 E., Nye County, Nev.

Genus HYPERMECASPIS Harrington and Leanza, 1957

Hypermecaspis kolouros Ross, n. sp.

Plate 10, figures 14–19

Glabella subrectangular, its width (trans.) equals nine-tenths its length (sag.). Occipital ring bears median node on crescentic middle part; furrows divide two lateral parts of ring from central part not as strong as occipital furrow proper. Length (sag.) of ring almost two-tenths total glabellar length. Lateral furrows *1p* close to occipital furrow, run from axial furrow inward. Furrows *2p* and *3p* sigmoid, the former bifid at outer end. Furrows *4p* indistinct or obsolete. Furrows *5p* faint, run inward and a little forward close to anterior "corners" of glabella. Axial furrows confluent around rounded front of glabella. Preglabellar field very steep and very short (sag.). Border furrow deeper than preglabellar furrow. Border subtubular.

Palpebral lobes centered opposite glabellar lobe *3p*, short (exsag.). Fixed cheek between eyes very narrow. Facial suture behind eyes runs posterolaterally to border furrow, then turns to rear and cuts border at a distance from axial furrow equal to six-tenths of glabellar width.

Pygidium transversely elliptical in outline. Axis composed of articulating half ring, three distinct axial rings decreasing in length (sag.) to the rear, and postaxial ridge. Three pairs of pleural furrows distinct; two pairs of interpleural furrows less distinct. Both sets of furrows fade out before reaching margin to leave a somewhat concave border bearing Bertillon markings along outer edge.

Holotype.—USNM 160835.

Paratypes.—USNM 160836a, b.

Occurrence.—USGS collection D289 CO, Goodwin Limestone, 169 feet above lowest exposure, on north side of canyon tributary to Ninemile Canyon, N½SW¼NE¼ sec. 5, T. 15 N., R. 51 E., Horse Heaven Mountain quadrangle, Nevada.

Discussion.—*Hypermecaspis kolouros* closely resembles *H. inermis* Harrington and Leanza in regard to cranidial features but differs in having shorter (exsag.) palpebral lobes, located farther forward, and more slender posterior parts of the fixed cheeks. Although *H. inermis* lacks a node on the occipital ring, *H. armata* has such a node, as does *H.* cf. *H. bulmani* from the Table Head Formation (Whittington, 1965a, pl. 18, fig. 19).

H. kolouros differs from all other known species in shortness of the pygidial axis, which is composed of only three rings, as compared with the five to six rings of *H. inermis* and the five in *H. armata*. Except for the number of rings and pleural furrows, the pygidium can hardly be distinguished from that of *H. inermis*.

The occurrence of *H. kolouros* with *Parabolinella hecuba* (Walcott) gives the Tremadocian strata of central Nevada, the Baltic, and South America faunal links.

Genus HYSTRICURUS Raymond, 1913

Hystricurus cf. H. oculilunatus Ross

Plate 10, figure 35

A damaged cranidium closely resembles that of *Hystricurus oculilunatus* Ross (1951, p. 47–48, pl. 10, figs. 2, 3, 5, 8, 9, 12). It differs in having a nonpustulose surface.

Figured specimen.—USNM 160837.

Occurrence.—USGS collection D1834 CO, Pogonip Group, limestone, 2,494 feet below base of Eureka Quartzite; 1,653 feet below base of Kanosh Shale (573 feet above base of formation B of Woodward, 1964), Steptoe section, Nevada.

Discussion.—The presence of *Hystricurus* similar to *H. oculilunatus* suggests that the enclosing beds are equivalent to zone F of the Garden City Formation. This is equivalent to beds approximately 1,185 feet below the top of the Fillmore Limestone of Hintze (1951) in the Ibex area.

Hystricurus aff. H. genalatus Ross

Plate 10, figures 22–28

This species closely resembles *Hystricurus genalatus* but differs in having a smooth rather than pustulose anterior border and in having narrower (trans.) fixed cheeks between eye lobes. In other respects the two are almost indistinguishable.

Figured specimens.—USNM 160838a–c.

Occurrence.—USGS collection D368h CO, Goodwin Limestone, 998 feet above base, N½ sec. 5, T. 15 N., R. 51 E., Horse Heaven Mountain quadrangle, Nevada.

Discussion.—The occurrence of a species so much like *Hystricurus genalatus* almost 1,000 feet above the base of the Goodwin Limestone is unexpected. The genus has a considerable range within the Lower Ordovician strata of the Basin and Range province, but *H. genalatus* occurs near the bottom of that range.

Unidentified pygidium

Plate 10, figures 20, 21

A single pygidium lacks associated cephalic parts and is therefore considered temporarily indeterminate. Whether this pygidium belongs to a nonpustulose species of *Hystricurus* or to an olenid is not immediately determinable; I am inclined to favor the second possibility.

Surface covered with Bertillon pattern. Outline transversely semielliptical, width (trans.) 2.5 times length (sag.); moderately convex. Posterior medially very obtusely pointed. Axis shorter than width; its width (trans.) equals less than four-tenths width of pygidium; axial length (sag.) almost eight-tenths that of pygidium. Axis composed of half ring, two prominent rings, two diminishing rings, and a subdued terminal piece. Pleural field somewhat swollen, bounded distally by narrow marginal furrow and narrow convex border. Pleural field crossed by two distinct and a third obscure pleural furrow; one indistinct interpleural furrow and a second less distinct are also present.

Figured specimen.—USNM 160839.

Occurrence.—USGS collection D1835 CO, Pogonip Group, limestone, 1,794 feet below base of Kanosh Shale (432 feet above base of formation B of Woodward, 1964), Steptoe section, Nevada.

Discussion.—Regardless of whether this pygidium belongs to an olenid or solenopleurid trilobite, its age lies between zones B and F of Ross (1951) and Hintze (1952).

Genus PSEUDOHYSTRICURUS Ross, 1951

Pseudohystricurus sp.

Plate 10, figures 29–31

Cranidium strongly convex in lateral profile. Surface pustulose except on anterior border. Glabella almost globular, stands well above fixed cheeks. Width (trans.) of glabella about eight-tenths its length (sag.). Greatest convexity immediately in front of occipital furrow. Occipital ring strongly developed. Axial furrows deep, confluent around front of glabella, and tangent to anterior border furrow at sagittal line. Fixed cheeks narrow between eye lobes. Palpebral rims narrow, elevated, located opposite glabellar midpoint; length (exsag.) of rims about one-third length (sag.) of glabella. Preglabellar field sharply deflexed.

Figured specimen.—USNM 160840.

Occurrence.—USGS collection D368h CO, Goodwin Limestone, 998 feet above base, N½ sec. 5, T. 15 N., R. 51 E., Horse Heaven Mountain quadrangle, Nevada.

Discussion.—The species represented by a single cranidium is probably very similar to one described by Ross (1951, p. 75, pl. 16, figs. 26, 27, 31) but has a more rotund glabella. The two seem to hold about the same stratigraphic position. This type of cranidium is very nearly the same as that of *Ischyrotoma* (*Dimeropygiella* of Ross, 1951) and differs only in the anterior course of the facial sutures. Convergence of the sutures across the preglabellar field and anterior border gives the cranidium a beaked outline in *Ischyrotoma*. In *Pseudohystricurus* the outline is quadrate.

Pseudohystricurus? sp.

Plate 11, figures 1, 2

A single decorticated cranidium seems to be referable to *Pseudohystricurus.* Other parts are lacking.

Surface nonpustulose. Cranidium possesses short (sag.) steep preglabellar field, sagittally creased by a faint furrow. Glabella of low to moderate convexity, its width about eight-tenths its length; outline almost parallel sided with bluntly rounded front. Occipital furrow deep; length (sag.) of occipital ring about one-fifth that of entire glabella. Axial furrows distinctly impressed and confluent as preglabellar furrow. Palpebral lobes crescentic, long (exsag.); their length (exsag.) almost half that of glabella. Eye center located forward of glabellar midpoint. Facial sutures run forward from palpebral lobes and diverge slightly to steepest part of preglabellar field, then converge equally slightly to distinct shallow border furrow; sutures cross furrow into border but course thereafter cannot be ascertained. Posteriorly facial sutures delimit stout posterior areas of fixed cheeks and cross posterior margin at distance from axial furrow equal to eight-tenths the glabellar width at occipital ring.

Figured specimen.—USNM 160841.

Occurrence.—USGS collection D1833 CO, lower limestone of Pogonip Group, 1,501 feet below base of Kanosh Shale (725 feet above base of formation B of Woodward, 1964), and 2,342 feet below base of Eureka Quartzite, Steptoe section, Nevada.

Discussion.—This cranidium is similar to that of *Pseudohystricurus orbus* Ross (1953, p. 640–642, pl. 63, figs. 10, 11, 15, 16) but differs in its smooth surface and lack of nasute anterior outline. The specimen differs from all species previously described in the lack of pustulose surface. The palpebral lobes are larger transversely, and the lateral profile of the cranidium less convex than in *P. obesus* or *P. rotundus.*

Undetermined hystricurid(?) species

Plate 10, figures 32–34

Several very small cranidia of uncertain affinities may belong to the same genus as forms assigned questionably to *Paraplethopeltis* by Hintze (1952, p. 202–204, pl. 7, figs. 1, 3, 8).

Surface smooth except for Bertillon pattern. Glabella semiovoid; axial furrows deep, confluent around sharply rounded front of glabella. Length (sag.) of occipital ring almost one-fourth total length (sag.) of glabella. Width (trans.) of glabella at occipital ring about eight-tenths its length. Preglabellar field steeply sloping, gently convex, bounded distally by shallow border furrow. Palpebral lobes large; length (exsag.) a little less than half the length (sag.) of glabella. Width (trans.) of each fixed cheek at widest part of palpebral lobe about six-tenths width of glabella. Facial sutures anteriorly somewhat divergent, run almost straight to cross narrow border. Posteriorly, sutures diverge at angle close to 35° from sagittal line, cross posterior border furrow, and turn across border at a distance from axial furrow slightly less than width of glabella.

Figured specimen.—USNM 160842.

Occurrence.—USGS collection D297 CO, Goodwin Limestone, uppermost 10 feet, northern tributary of Ninemile Canyon, center of the N½NE¼ sec. 5, T. 15 N., R. 51 E., Cockalorum Wash quadrangle, Nevada.

Discussion.—This species is probably closely related to "*Paraplethopeltis*"? *generectus* Hintze (1952, p. 204, pl. 7, fig. 8), although it is believed to be considerably younger. It differs in having a more convex glabella and somewhat shorter (sag.) preglabellar field. Lacking other cephalic parts and pygidium, other comparisons would be speculative.

Pygidium, indeterminate

Plate 11, figure 3

A tiny pygidium, which has not been identified and is probably immature, occurs in topmost beds of the Antelope Valley Limestone. Transversely elliptical in outline. Axis composed of three rings and protruding terminal boss. Four pairs of pleura, all abruptly defined.

Figured specimen.—USNM 160843.

Occurrence.—USGS collection D1507 CO, Antelope Valley Limestone, top 2 feet of formation, Ikes Canyon section, Nevada.

Discussion.—This little pygidium may belong to a dimeropygid species but is too poorly preserved to be certain without associated parts.

Genus LEIOSTEGIUM Raymond, 1913

Differentiating *Lloydia* and *Leiostegium* is a confusing problem. The type specimen of *Lloydia* (Vogdes, 1890, p. 97) was designated as a cranidium of *Bathyurus bituberculatus* Billings (Billings, 1865, p. 410, fig. 391) characterized by discrete oblong preoccipital lobes on the glabella. No other species assigned to the genus by subsequent authors possesses such glabellar lobes. Furthermore, several species have cranida that belong in *Leiostegium.* No pygidium has ever been described for *Lloydia bituberculatus;* the pygidium shown in the "Treatise" (Harrington and others, 1959, p. O313, fig. 232, 1c) seems to be the same specimen illustrated by Billings (1865, p. 259, fig. 241) and by Raymond (1913, p. 67, pl. 7, fig. 17) as one of the types of *Lloydia saffordi.*

In *Lloydia* Shaw (1966, p. 1315, 1318–1320) included species in which the glabellar outline tapers forward with concave sides and in which the pygidial border is wide. The importance of the preoccipital lobes was disregarded as was the lack of a described pygidium for the type species. In effect, Shaw used *L. saffordi* as the type species of *Lloydia.*

It is recommended here that *Lloydia* be restricted to species having preoccipital glabellar lobes as in *L. bituberculatus.* As thus restricted, *Lloydia* is virtually monotypic.

A complete revision of the genus *Leiostegium* is not intended here but rather a search for a certain amount of consistency in the interpretation of the genus. Berg and Ross (1959, p. 114–115) made *Perischodory* Raymond and *Manitouella* subgenera of *Leiostegium;* these two differ so markedly from other forms that they are readily recognized. The list that follows includes western species of *Leiostegium* and species with which they must be compared. The features that separate species are glabellar outline (rectangular-quadrate as opposed to tapering), exsagittal length and position of palpebral lobes, outline of pygidium (subtriangular, semicircular, or parabolic), and width of pygidial border (usually indicated by relative length of axis). In all listed species the width of the fixed cheeks including palpebral lobes is half or a little more than half the width of the glabella on a line through the eye centers.

Leiostegium—	Cranidium			Pygidium		
		Palpebral lobes				
	Glabellar outline	Exsag. length ÷ glabellar	Position relative to glabellar midpoint	Outline	Border	L axis ÷ L pyg. (sag.)
quadratus Billings (1865, p. 412, fig. 396)	Quadrate	Short: 0.2	Front opposite midpoint	?		
quadratus (Raymond, 1913, pl. 7, fig. 17)				?	Narrow	?
manitouensis (Berg and Ross, 1959, pl. 21, figs. 19, 17).	Rectangular	Long: .4	Front opposite midpoint	Subtriangular to semicircular.	do	0.9
manitouensis (Berg and Ross, 1959, pl. 21, figs. 11, 13).	do	Short: .3	Center opposite midpoint	do	do:	.9
manitouensis (Berg and Ross, 1959, pl. 21, figs. 10, 12).	Tapering	Short: .2	Front opposite midpoint	Subtriangular to parabolic	do	.9
saffordi Billings (1865, p. 259, 411, figs. 241, 393) (Raymond, 1913, pl. 7, fig. 16).	do	Not preserved	?	Parabolic; L÷W=0.7	Wide	.8
saffordi (Whittington, 1963, pl. 11, fig. 16)				Parabolic; L÷W=0.6	do	.8
saffordi (Shaw, 1966, pl. 161, fig. 132)				Parabolic; L÷W=0.6	do	.85
mudgei Ross (1958, pl. 83, figs. 25, 26)	Tapering	Short: .3	Center opposite midpoint	Parabolic; L÷W=0.7	do	.8
douglasi Harrington (Harrington and Leanza 1957, figs. 24, 3).	do	Short: .3	do	Parabolic; L÷W=0.6	Narrow	.9
goodwinensis Ross, n. sp.	Rectangular	Long: .4	Center opposite or just behind midpoint.	Subsemicircular; L÷W=0.6.	Wide	.8
tyboensis Ross, n. sp.	do	Long: .4	Center opposite midpoint	Parabolic; L÷W=0.7	do	.8

From this very generalized analysis it becomes evident that *Leiostegium saffordi* cannot be distinguished consistently from *L. mudgei* Ross unless a well-preserved cranidium is found that proves some difference in position and size of the palpebral lobes. The axis of the pygidium of *L. saffordi* bears six to seven rings, according to Billings (1865, fig. 241) and Raymond (1913, pl. 7, fig. 16), but these are exceedingly faint, according to Whittington (1963, p. 66, pl. 11, figs. 16, 17) and Shaw (1966, pl. 161, fig. 13a). Decorticated specimens of the Nevada species *L. mudgei* show three to four fairly distinct axial rings followed by an equal number of indistinct rings. Both species have tapering glabellae.

There is no assurance that all pygidia attributed to *L. saffordi* belong to the same species. Another species described here, *Leiostegium tyboensis* Ross, n. sp., possesses a very similar pygidium but a rectangular glabella and long palpebral lobes. It occurs near the top of the Goodwin Limestone in central Nevada.

The tabulated characteristics are not intended to be all inclusive. Other features, such as surface ornamentation, are useful in separating species. But the belief that all pygidia with wide borders belong to one genus while all those with narrow borders belong to another is actually an assumption based on lack of information about cranidia.

Leiostegium goodwinensis Ross, n. sp.

Plate 11, figures 4–11

Surface sparsely pustulose. Cranidium strongly convex in lateral profile. Glabella rectangular, bluntly rounded in front; its width a little over six-tenths its length (sag.). Length (sag.) of occipital ring about one-fourth glabellar length (sag.). Axial furrows deep, intersect anterior border furrow at fossula. Anterior border very narrow sagittally, twice as high as wide. Anterior border furrow exceedingly shallow sagittally but deep laterally. Length of palpebral lobes over four-tenths the length (sag.) of glabella. Width of each fixed cheek, including palpebral rim, equals 0.55 glabellar width (trans.) on line through eye centers. Eye centers located opposite glabellar midpoint. Posterior area of fixed cheek deflexed strongly. Facial suture cuts posterior margin at a distance from axial furrow almost equal to six-tenths glabellar width (trans.) at occipital ring.

Hypostome not known.

Pygidium subsemicircular, its length (sag.) a little over one-half its width. Axis composed of articulating half ring, five distinct rings, and terminal piece; its length (sag.) approximately eight-tenths that of pygidium and its width about one-fourth that of pygidium. Axial furrows deep. Border wide, convex, set off by deep border furrow.

Holotype.—USNM 160844.

Paratypes.—USNM 160845a–c.

Occurrence.—USGS collection D297 CO, uppermost 10 feet, Goodwin Limestone, northern tributary of Ninemile Canyon, center of the N½NE¼ sec. 5, T. 15 N., R. 51 E., Cockalorum Wash quadrangle, Nevada (immediately below type section of Ninemile Formation).

Discussion.—Although the pygidium of this species possesses a wide border like that of *Leiostegium saffordi*, *L. mudgei*, and *L. tyboensis*, its outline is nearly semicircular rather than parabolic. The convexity of the cranidium is much more pronounced than in any of those species and the surface of the carapace is pustulose rather than smooth. Unlike several species of *Leiostegium*, *L. goodwinensis* possesses a fossula at the junction of the axial furrow and preglabellar border furrow, not in the axial furrow behind the junction.

Stratigraphically, this species is considerably younger than the age that the genus *Leiostegium* has generally been considered to be. Its position in the G zone of Ross (1951) was noted previously (Berg and Ross, 1959, p. 114), but the species was not described at that time. The occurrence of wide-bordered species in the upper part of the Goodwin Limestone at Ninemile Canyon and at Rawhide Mountain indicates that other occurrences in the Valmy Formation (Ross, 1958, p. 565–566) may not be as old as previously believed.

Leiostegium tyboensis Ross, n. sp.

Plate 11, figures 12–15

Surface of carapace smooth. Cranidium of low convexity. Glabella subrectangular in outline, bluntly rounded in front; its width two-thirds its length (sag.). Length (sag.) of occipital ring a little over one-fifth the total glabellar length. Occipital furrow deep on flanks of glabella but very shallow on either side of sagittal line. Axial furrows subparallel, moderately deep, joining anterior border furrow in front of deep fossula. Fixed cheeks not as high as crest of glabella; palpebral rim an open crescent. Length (exsag.) of palpebral lobes equals four-tenths glabellar length (sag.). On line through eye centers, width of each fixed cheek, including palpebral rim, equals half width of glabella. Eye centers approximately opposite glabellar midpoint. Anterior border narrowly convex; its height (sag.) double its width (sag.). Border furrow very shallow sagittally, deepening laterally.

Pygidium broadly parabolic in outline; its length (sag.) equals seven-tenths its anterior width (trans.). Axis prominent; its length excluding articulating half ring equals eight-tenths pygidial length (sag.); its anterior width almost three-tenths anterior width of pygidium. Axis tapers to rounded terminus. Axial furrows shallow, confluent around terminus, and tangent to border furrow. In decorticated specimens, articulating half ring and seven faint rings are distinguishable, but only a few of these are probably visible on outer surface of carapace. Border furrow wide, moderately deep, bounding convex pleural field. Radius of pleural field at anterolateral corner equals three-fourths the length of axis. Radius to anterolateral "corner" of outer margin slightly less than length of axis. Border wide, flattened, sloping quaquaversally somewhat wider and less steep sagittally than anterolaterally.

Holotype.—USNM 160846.

Paratype.—USNM 160847.

Occurrence.—USGS collection D812 CO, Goodwin Limestone, 95–175 feet below top, Rawhide Mountain, Nev. (Ross, 1964a, p. C69, fig. 5).

Discussion.—This species differs from *Leiostegium saffordi* and *L. mudgei* in the rectangular rather than anteriorly tapering outline of the glabella. It differs from *L. mudgei* in possessing large palpebral lobes placed farther forward. Possession of a fossula in the axial furrow behind the intersection of the axial and anterior border furrows is a feature also in *L. douglasi*. The pygidium is very similar in proportions but has a markedly wider border than either *L. saffordi* or *L. mudgei*. From *L. goodwinensis* it differs in the lesser convexity of the cranidium and glabella, wider (sag.) anterior border, smooth rather than pustulose surface, and somewhat longer pygidium.

The species is associated with *Asaphellus* cf. *A. riojanus* Harrington and Leanza and with *Megistaspis* (*Ekeraspis*) *nevadensis* Ross, n. sp.

Genus APATOKEPHALUS Brogger, 1897

Apatokephalus sp.

Plate 11, figures 16–20; plate 13, figure 1

Surface of carapace exceedingly finely granular, except for Bertillon markings on border and smooth surface on palpebral rims. Convexity of glabella and entire cephalon low. Greatest glabellar width (trans.) between palpebral rims, almost equal glabellar length (sag.).

Occipital furrow deep; occipital ring occupies about one-fourth glabellar length. Glabellar width (trans.) at occipital ring about three-fourths the greatest width. Glabellar width (trans). in front of palpebral lobes almost six-tenths the greatest width. Two pairs of glabellar furrows; posterior pair, usually open sigmoid in *Apatokephalus*, in this species nearly straight, shallow creases that have anterior ends reaching line through glabella midpoint. Anterior pair of furrows crease sides of glabellar posteroproximally from within anterior ends of palpebral rims. Anterior outline of glabella subquadrate to bluntly rounded. Palpebral rims large; their length (exsag.) equals almost six-tenths glabellar length (sag.). Preglabellar field very narrow (sag.) and separated from wide (sag.) convex border by very shallow, pitted border furrow.

Free cheeks have wide, gently convex ocular platform. Wide border continues into genal spine. Border furrow distinct but fades out before reaching posterior border furrow. Facial suture starts at rear of eye, immediately crosses border furrow, runs diagonally outward across border and turns to rear to cut margin halfway between axial furrow and base of genal spine.

Pygidium characterized by short axis of two rings and quarter spherical terminal piece from which a pointed terminus extends. Four pairs of pleural furrows obvious. Two anterior pairs of pleurae broad and have blunt points. Third pair somewhat narrow. Between tips of this pair lie three pairs of small tips for which proximal pleural portions are undifferentiated.

Figured specimens.—USNM 160848 a–c.

Occurrence.—USGS collection D812 CO, Goodwin Limestone, 95–175 feet below top, Rawhide Mountain, Nev. (Ross, 1964a, p. C69).

Discussion.—This species differs from *Apatokephalus gillulyi* in the broader anterior portion of glabella, in the lesser number of axial rings on the pygidium, and in having fewer small pleural spines on the pygidium. It differs from *A. serratus* in having few pygidial axial segments. *A. pecten* Wiman has the same kind of pygidial axis as this Nevada species but many more pairs of denticles on the posterior border of the pygidium. The lack of an anterior pair of lateral glabellar furrows except on immature cranidia and the different pygidial pattern distinguish this species from *A. exiguus* Harrington and Leanza, which it resembles in the width of ocular platform, length of palpebral lobes, and glabellar outline.

This species was previously misidentified as *Scinocephalus* (Ross, 1964a, p. C69), which it resembles in outline and profile of pygidium and in width of ocular platform.

Genus VARVIA Tjernvik, 1956

Varvia? sp.

Plate 11, figure 26

A small transversely semielliptical pygidium was found in the upper part of the Goodwin Limestone without obviously associated cephalic parts. Axis blunt, short, faintly segmented, except where decorticated. Pleural fields small triangles on either side of axis. Border wide, flattened.

Figured specimen.—USNM 160849.

Occurrence.—USGS collection D368k CO. Goodwin Limestone, 40 feet below top, NW¼ sec. 5, T. 15 N., R. 51 E., Cockalorum Wash quadrangle, Nevada.

Discussion.—Assignment to *Varvia* is tenuous because of cephalic parts, but resemblance to species described by Tjernvik (1956, p. 213–216, pl. 3, figs 1–11) is suggestive of possible relationship. Proportions seem to be closer to those of *V. breviceps* than to those of the other species.

Genus AULACOPARIA Hintze and Jaanusson, 1956

Aulacoparia cf. A. venta (Hintze)

Plate 11, figures 22–25

Two cranidia are assigned to *Aulacoparia* cf. *A. venta*, the tentative designation resulting from lack of accompanying pygidia. The pygidium (Hintze, 1952, pl. 16, figs. 10, 11) of *A. venta* is distinctive and is needed to be certain of the identification.

Figured specimens—USNM 160850 a–c.

Occurrence.—USGS collection D340i CO, Ninemile Formation, 141 feet above base of formation, NW¼ sec. 5, T. 15 N., R. 51 E., Cockalorum Wash quadrangle, Nevada. Possibly USGS collection D827 CO, Goodwin Limestone, upper 10 feet, Meiklejohn Peak (Ross, 1964a, p. C28).

Discussion.—The genus *Aulacoparia* is represented in the uppermost Goodwin Limestone at Meiklejohn Peak, but the specific assignment of the specimen (pl. 11, fig. 21, USNM 160897) is uncertain.

Genus BASILICUS Salter, 1849

The generic assignment of one species is uncertain. Like *Basilicus*, *Pseudobasilicus*, and *Basiliella*, it is characterized by a clavate glabella. Its facial sutures are so broadly isoteliform that they nearly duplicate the "niobiform" sutures of *Basilicus* and *Basiliella*. The outline of its pygidium is parabolic as in *Basilicus* and *Pseudobasilicus*. The width and form of the pygidial doublure is like that of *Basilicus* but not as wide as in *Pseudobasilicus*. The hypostome closely approximates that of *Basilicus*, not that of *Basiliella*. The tips of thoracic pleurae are fairly blunt, not falcate as in *Pseudobasilicus*. Similarity to the two known species of *Stegnopsis* Whittington (1965a, p. 340–344) is superficial, and it seems likely that those species will eventually be assigned to two different genera. Size and position of the palpebral lobes are comparable to those of *Pseudobasilicus* and *Basilicus*.

Despite the supramarginal course of the anterior facial suture, this species has more in common with species of *Basilicus* than with any others. The anterior border is flattened and does not bear a tubular margin as in *Basilicus tyrranus* Murchison, as illustrated by Salter (1866, pl. 22, fig. 5). Neither Whittard (1964, pl. 34, figs. 1–3) nor MacGregor (1963, pl. 116, fig. 2) shows such a tubular margin in *Basilicus*.

The significance of niobiform versus isoteliform facial sutures, indeed the validity of the former, has been questioned by Lake (1942, p. 327–328) and by Whittard (1964, p. 231–232). The position of the suture in the Nevada species is so nearly marginal that I suspect it is of subgeneric importance. Therefore the species is assigned tentatively to *Basilicus*.

Here is yet another trilobite of Porterfield (Black River) aspect that occurs in the upper reaches of the *Anomalorthis* zone at Hot Creek Canyon and in the *Rhysostrophia*- and *Valcourea*-bearing beds at Ikes Canyon.

Basilicus mckeei Ross, n. sp.

Plate 11, figure 27; plate 12, figures 1–18

Cephalon semicircular with stout genal spines extending backward almost as far as the front of the pygidium. Glabella club shaped, rounded in front, constricted between rear ends of eye lobes to a little less than one-half anterior width. Width (trans.) of glabella at posterior margin essentially equal to anterior width. Glabellar furrows produce a pair of elongate diagonal pits between fronts of palpebral lobes in immature specimens. Other furrows isolate a pair of preoccipital lateral lobes or nodes of subcircular outline. Median tubercle located between rear halves of palpebral lobes. Front of palpebral lobes opposite glabellar midpoint; length (exsag.) of each lobe equals three-tenths glabellar length (sag.). Back edges of palpebral lobes opposite occipital furrow. From palpebral lobe facial suture runs anterolaterally at 45° so that the width of the flattened area on each side of the widest anterior part of the glabella is equal to half the anterior glabellar width (trans.). The suture curves narrowly inward, then converges at angle close to 155°. The suture barely remains on dorsal side of carapace approaching convergence. Median suture separates free cheeks. Length (sag.) of preglabellar field equals one-seventh total cephalic midlength (sag.).

Free cheeks bear moderately convex ocular platforms separated from flattened border by break in slope. Flattened border fades out halfway along outside of genal spine. Eyes very large, high, protruding. Visual surface tangent to border furrow at back.

Hypostome characterized by subrectangular outline of middle body; this outline widens (trans.) toward rear and is widest (trans.) three-quarters of the length (sag.) of the middle body from the front. Greatest width almost equals length, but anterior width (trans.) of middle body is less than eight-tenths its length (sag.). Lateral furrows shallow, confluent with posterior furrow. Posterior furrow deep behind "corners" of middle body and shallow at sagittal line.

Posterior border bifurcate. Greatest width of hypostome opposite back end of middle body; greatest length (exsag.) equals 1.8 times sagittal length of middle body. Angle between interior sides of bifurcation equals 60°.

Outline of hypostome and particularly its middle body as in *Basilicus tyrranus* (Murchison) (Salter, 1866, pl. 22, fig. 6).

Thorax composed of eight segments having blunt tips. Width (trans.) of axis about four-tenths total width. Pleurae on each side horizontal about half their length, then flexed downward. Each pleura bears diagonal groove.

Pygidium moderately convex, subparabolic in outline. Axis narrowly rounded, tapers markedly. Axis composed of six or more rings seemingly visible only in decorticated specimens. Five pleural furrows in large specimens; furrows do not reach margin. In immature specimens up to seven pleural furrows observed. Length (sag.) of pygidium about seven-tenths its width (trans.). Length of axis equals three-fourths to eight-tenths pygidial length. Width (trans.) of axis a little less than three-tenths width of pygidium at front. Pleural fields separated from flattened border by concave break in slope. Border narrowest behind axis. Doublure of moderate width, notched at posterior midline. Width of doublure approximates one-third radius of pygidium near anterior margin.

Holotype.—USNM 160852.

Paratypes.—USNM 160853a–g; 160851a, b; 160854a, b; 160852; 160853a–f.

Occurrence.—USGS collection D1857 CO, Antelope Valley Limestone, from float 136 feet below top of formation, Hot Creek Canyon, north side, sec. 24, T. 8 N., R. 49 E., Tonopah 2° quadrangle, Nevada. USGS collection D1511 CO, Antelope Valley Limestone, 214 feet below top, Ikes Canyon. USGC collection D1508

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CO, Antelope Valley Limestone, 95–99 feet below top, Ikes Canyon. USGS collection D1884 CO, Antelope Valley Limestone, above saddle east of hill 7220, north edge of SW¼ sec. 10, T. 16 N., R. 46 E., Wildcat Peak quadrangle, Nevada (McKee and Ross, 1969, p. 423).

Discussion.—If it becomes necessary to separate the hypodigm of *Basilicus mckeei* into two species, it is fairly certain that the specimens from Hot Creek Canyon collection D1857 CO and Ikes Canyon collection D1511 CO are the same; those from D1884 CO on the west side of the Toquima Range and from D1508 CO at Ikes Canyon are the same. Differences are believed to be attributable to stage of ontogenetic development.

The cranidium from Hot Creek Canyon is considerably larger than any of those from the Toquima Range; it lacks the deep impression of a pair of diagonal glabellar furrows or pits between the front halves of the palpebral lobes as does one large broken specimen from collection D1511 CO. Because such features are commonly more deeply impressed on the immature than on the mature cranidia of asaphids, it is probable that these lots of specimens belong to a single species. Similarly, although the impression of furrows on the pygidia from the Toquima Range seems to be more distinct than on those from Hot Creek Canyon, all but one of the specimens from Hot Creek Canyon are larger than those from the Toquima Range; all are weathered and poorly preserved. Tentatively all are assigned to the single species *B. mckeei.*

B. mckeei is readily differentiated from *B. tyrranus* in having fewer pygidial segments. The two probably differ little in size of mature stages. *B. mckeei* differs from *B. peltastes* Salter in the same manner.

This species is especially important stratigraphically in providing one of the few bridges between fossil assemblages of the upper *Anomalorthis* zone and the assemblages in the muddier facies at Ikes Canyon to the west.

Genus ISOTELUS DeKay, 1824

Isotelus? spurius Phleger

Plate 13, figures 3, 5, 7, 10

Isotelus spurius Phleger. Ross, 1967a, U.S. Geol. Survey Prof. Paper 523–D, p. D12, pl. 4, figs. 6–9.

This species was recently redescribed by Ross (1967a, p. D12, pl. 4, figs. 6–9) from the northern Inyo Range and from limy beds within the lower part of the Eureka Quartzite at the Nevada Test Site. It also occurs in the uppermost 30 feet of the Antelope Valley Limestone at the Nevada Test Site. This fact is potentially important in correlating the upper beds of the Antelope Valley.

Figured specimens.—USNM 160855a–c.

Occurrence.—USGS collection D710a CO, Antelope Valley Limestone, 30 feet below base of Eureka Quartzite, Ranger Mountains, Nevada Test Site, Nev. (see Ross, 1964a, p. C19). This collection was made in 1965 from the same level as collection D710 CO.

Discussion.—This stratigraphically important occurrence supports the belief that limestone beds within the lower part of the Eureka Quartzite are essentially the same age as the top of the Antelope Valley in the Ranger Mountains. The fact that the species is almost indistinguishable from *Homotelus bromidensis* Esker (1964, p. 195–198, pl. 1, figs. 5, 6) from the Pooleville Member of the Bromide Formation of Oklahoma indicates that the Oklahoma species should be reassigned to *Isotelus;* it also indicates that *Isotelus* may not be particularly useful in dating Middle Ordovician strata or that the Nevada occurrences may be somewhat younger than has been believed previously.

Specimens of *Isotelus bromidensis* (Esker) in USGS collection D1720 CO from the type area show conclusively that the species has the same type of hypostome, ventral vincular structures, and doublure as *Isotelus gigas* DeKay (Ross, 1967b, pl. 1).

It is probable that both the Nevada and Oklahoma species should be assigned to *Anataphrus* Whittington but few of the ventral structures of that genus are now known.

Genus ASAPHELLUS Callaway, 1877

Asaphellus cf. A. eudocia (Walcott)

Plate 13, figure 4

Pygidium subsemicircular, moderately convex. Axis narrow, tapers, bluntly rounded at terminus, composed of six distinct rings. Pleural field almost smooth, at least three pairs of very faint pleurae present. No distinct border or marginal furrow. Doublure probably covers about half the ventral side.

Figured specimen.—USNM 160856.

Occurrence.—USGS collection D1832 CO, lower limestone of the Pogonip Group, 1,443 feet below base of Kanosh Shale (783 feet above base of formation B of Woodward, 1964), and 2,284 feet below base of Eureka Quartzite, Steptoe section, Nevada.

Discussion.—Several pygidia and a single partial cranidium comprise this sample. The cranidium has the usual poor definition of glabella anteriorly, prominent palpebral lobes, and posteriorly placed glabellar tubercle. The pygidia compare favorably with that of *Asaphellus* cf. *A. eudocia* (Walcott) as illustrated by Ross (1951, pl. 27, figs. 17, 22, 23). They are less triangular in outline than those of *A.* cf. *A. riojanus* from the Goodwin Limestone (USGS colln. D812 CO) at Rawhide Mountain (Ross, 1964a, p. C65, C69).

Asaphellus cf. A. riojanus Harrington and Leanza

Plate 13, figures 6, 8, 9, 11, 14, 15, 17–19

Cranidium of low convexity. Glabella ill defined; axial furrows weak behind palpebral lobes, barely indent posterior margin of cranidium. In front of palpebral lobes, axial furrows indistinguishable. Glabella bounded anteriorly by broad, shallow marginal furrow and constricted somewhat between palpebral lobes. Posterior width (trans.) of glabella about seven-tenths its length (sag.). Glabellar length (sag.) about eight-tenths that of cranidium. Glabellar tubercle about one-fifth of glabellar length from rear margin. Palpebral lobes opposite glabellar midlength; proximally sloping upward from axial furrow and distally flattened at about same elevation as crest of glabella.

Facial sutures run almost straight forward from palpebral lobes, cross marginal furrow and converge to ogival point. Behind palpebral lobes, sutures diverge abruptly, run almost straight transversely, then turn at 90° to cross posterior margin. As a result, posterior parts of fixed cheeks are subrectangular, about twice as wide (trans.) as long (exsag.). Distance between axial furrow and facial suture at posterior margin approximates width of glabella.

Free cheeks and thoracic segments not obtained.

Pygidium subtriangular in outline, its length (sag.) two-thirds its width. Axis narrow, low; length of axis a little over eight-tenths the pygidial length and its width about one-fourth the pygidial width. Axial rings faint. Pleural fields almost smooth, proximally divided into at least six very faint pairs of pleurae by raised lines rather than furrows; these lines limited to proximal halves of fields. Distal part of pleural fields steepen and then flatten to margin. No distinct border or border furrow.

Figured specimens.—USNM 160857 a–e; 160858 a–b.

Occurrence.—USGS collection D812 CO, Goodwin Limestone, 95–175 feet below top, Rawhide Mountain, Nev. (Ross, 1964a, p. C64–C69, fig. 5). USGS collections D368i CO and D368j CO, Goodwin Limestone, 161 feet and 55 feet below top, north side of tributary to Ninemile Canyon, N½, sec. 5, T. 15 N., R. 51 E., Cockalorum Wash quadrangle, Nevada.

Discussion.—This species closely resembles *Asaphellus? eudocia* (Walcott) (Ross, 1951, pl. 27, figs. 17, 22, 23, 27) from zone G(1) of the Garden City Formation. It differs from the Utah species in having a somewhat longer pygidium. It differs for the same reason from specimens in USGS collection D1832 CO from Steptoe.

Stratigraphically it is probably of about the same age as both of these occurrences of similar forms.

Decorticated cranidia show the glabellar tubercle more clearly than do more complete specimens and also exhibit probable muscle scars of which there seem to be five pairs (pl. 13, fig. 14).

Comparison with *Asaphellus riojanus* Harrington and Leanza (1957, p. 153, fig. 66) is hindered by difference in preservation. The two seem to be very similar in regard to pygidial outline and cranidial proportions if some allowance is made for obvious deformation of the Argentinian specimens. However, pygidial pleurae seem to be somewhat better defined in *A. riojanus*, and palpebral lobes may be somewhat larger. Although the original description (Harrington and Leanza, 1957, p. 153) stated that the mesial glabellar tubercle is lacking and that the glabella is defined by moderately deep axial furrows, accompanying illustrations (Harrington and Leanza, 1957, figs. 66, 6, 7, 9) indicate that neither statement is consistently so. As a result there is probably little significant difference between cranidia from the Argentine and Nevada.

Asaphellus sp. 1

Plate 12, figures 19–22; plate 13, figure 2

A fragmentary cranidium, partial hypostome, and decorticated pygidium comprise this sample. The cranidium is so poorly preserved that one can ascertain only that it can be assigned to *Asaphellus*. The hypostome is of the unforked type commonly ascribed to *Asaphellus*.

Pygidium, semielliptical in outline, its length (sag.) almost six-tenths its width (trans.). Moderately convex. Axis narrow, composed of six to eight rings plus bluntly rounded terminal piece. Length (sag.) of axis almost nine-tenths that of pygidium; its anterior width (trans.) almost three-tenths that of pygidium. Pleural fields bear four faint pairs of pleural furrows; furrows probably visible only in decorticated specimens. Border flattened, separated from pleural fields by concave break in slope.

Figured specimens.—USNM 160859a–c.

Occurrence.—USGS collection D1833 CO, lower of the limestone Pogonip Group, 1,501 feet below base of Kanosh Shale (725 feet above base of formation B of Woodward, 1964), and 2,342 feet below base of Eureka Quartzite, Steptoe section, Nevada.

Discussion.—This species differs from *A.* cf. *A. eudocia* (Walcott) in possessing a fairly wide flattened pygidial border. It closely resembles *Asaphellus catamarcensis* Kobayashi (Harrington and Leanza, 1957, p. 147–151, figs. 64, 65) in shape of pygidium and hypostome. *Asaphellus* sp. 1, or a very nearly identical species, is in USGS collection D1380 CO in the Pahranagat Range somewhat lower than D1689 CO.

Genus and species undetermined

Plate 13, figures 13, 16

A pygidium of asaphid aspect is not identified for lack of cephalic parts. Its length is two-thirds its greatest width. The axis is half as long as the pygidium and about one-fifth as wide. There are no axial rings, pleural ribs, and differentiated border. Strong Bertillon lines mark the dorsal surface. The doublure covers all the bottom except that under the axis.

Figured specimens.—USNM 160860 a, b.

Occurrence.—USGS collection D340m CO, Ninemile Formation, 518 feet above base, or lowest Antelope Valley Limestone, NW¼ sec. 5, T. 15 N., R. 51 E., Cockalorum Wash quadrangle, Nevada.

Discussion.—This species is probably closely related to that illustrated by Hintze (1952, pl. 9, fig. 16) and by Ross (1967a, pl. 4, fig. 31).

Genus MEGISTASPIS Jaanusson, 1956
Subgenus EKERASPIS Tjernvik 1956

Megistaspis (Ekeraspis) nevadensis Ross, n. sp.

Plate 13, figures 20, 21; plate 14, figures 1–10

Assignment of correct cranidium to this species is very difficult because there are only a few in the collection, and they must represent two genera, this and *Asaphellus*. A similar problem exists with hypostomes. Several cranidia are characterized by preglabellar fields of great length (sag.), and these are believed to belong to *Ekeraspis*.

Cranidium of low convexity. Glabella poorly defined, its length about three-fourths the cranidial length (sag.). Glabella widest (trans.) at posterior margin; its width about seven-tenths its length; its width between eye centers about half its length. Front of glabella defined by break in slope, not by preglabellar furrow. Preglabellar area flat. Palpebral lobes subhorizontal flaps somewhat elevated above glabella and somewhat more than semicircles. Located opposite glabellar midpoint. Glabellar tubercle in posterior third of glabella. Facial sutures in front of eyes diverge slightly, then converge rapidly to meet at 110° angle. Posteriorly, sutures diverge in sigmoid curves before turning sharply to rear to cross margin at distance from axial furrow exceeding six-tenths posterior glabellar width. Posterior border furrows shallow on either side of glabella. Occipital furrow and ring lacking.

Associated free cheek has long genal spine but is immature. It suggests that isoteliform facial sutures meet behind cephalic margin.

Hypostome as in *M.* (*Ekeraspis*) *armata* Tjernvik (1956, pl. 7, fig. 8) except that posterior margin is obtusely pointed as in *M. planilimbata* (Angelin) (Tjernvik, 1965, pl. 6, fig. 4).

Pygidium subtriangular in outline, bluntly pointed, almost smooth on exterior of carapace, convexity low. Axis narrow, low, faintly segmented; axial furrows barely impressed. Axis tapering but swollen at posterior end. Six faint axial rings visible on outside of carapace but in decorticated specimens nine are readily distinguished; one or two more may be present, plus blunt terminal piece. Seven pairs of segments on pleural field. Length (sag.) equals six-tenths to two-thirds width (trans.) of pygidium. Length of axis close to eight-tenths pygidial length (sag.) Anterior width of axis approximately one-fourth the pygidial width (trans.) Border flattened, bounded proximally by strongly concave break in slope from pleural field of moderate convexity. Border widens only slightly posteriorly and forms obtusely rounded point. In immature specimens (pl. 13, fig. 20) border forms strong acute spine which decreases with growth.

Holotype.—USNM 160861.

Paratypes.—USNM 160862 a–l.

Occurrence.—USGS collection D812 CO, Goodwin Limestone, 95–175 feet below top of formation, Rawhide Mountain, Nev. (Ross, 1964a, p. C69). USGS collection D1689 CO, Goodwin Limestone, 267 feet below top, Pahranagat Range, Nev.

Discussion.—This species is associated with *Asaphellus* cf. *A. riojanus* Harrington and Leanza, and the author is not completely certain that he has correctly assigned cranidia and hypostomes. Assignments seem reasonable compared to other species of the two genera, but it is obvious that the two are not very different.

The pygidium of *Megistaspis* (*Ekeraspis*) *nevadensis* compares closely with that of *M.* (*E.*) *heroides* (Brøgger) (Tjernvik, 1956, pl. 8, figs. 2–4) but may have one or two fewer axial rings. The glabella is not as well defined as in either *M.* (*E.*) *heroides* or *M.* (*E.*) *armata* Tjernvik. The posterior course of facial sutures more closely resembles that in *E. armata*. The hypostome is very similar to that of *M. planilimbata* (Angelin) (Tjernvik, 1956, pl. 6, fig. 4).

This species is stratigraphically important in linking the late Goodwin fauna of zone G with the Lower Arenig of the Baltic. It has been intimated by Whittington (1966a, p. 709) that asaphid genera were particularly provincial in the Early and early Middle Ordovician, but I suspect that much of this provincialism is human. Resemblances between asaphids of the Western United States and Argentina have been noted by Ross (1957, p. 490–497), and there is surely a close connection between North and South American Ordovician trilobites of other kinds. *Megistaspis* is found in the Baltic region, in France, and in Nevada.

Associated with larger specimens of *M.* (*E.*) *nevadensis* is a small pygidium that has a large terminal spine (pl. 13, fig. 20). This pygidium closely resembles those of *Trigonocercella* but is probably an immature specimen of *M.* (*E.*) *nevadensis;* the relative length of the terminal spine was shortened as animals of this species grew.

Megitaspis (Ekeraspis) floweri Ross, n. sp.

Plate 14, figs. 11–13, 15

Cranidium represented by a single specimen which, despite its elongate appearance, does not seem to have been deformed. Glabellar length (sag.) about seventenths that of cranidium. Glabellar outline rounded anteriorly, widest at posterior margin, pinched at midlength between eye centers. Posterior glabellar width (trans.) about half glabellar length (sag.), anterior width 0.45 glabellar length, middle width 0.28 glabellar length. Occipital furrow and glabellar tubercle lacking. Axial furrows shallow. Anterior of glabella defined more by break in slope than by preglabellar furrow. Preglabellar field nearly flat. Palpebral lobes subhorizontal flaps elevated somewhat above glabella. Width of cranidium at palpebral lobes equals 2.5 glabellar width between lobes. Facial sutures diverge until opposite most forward part of glabella, then curve forward a very short distance before converging at angle close to 110°. Behind eyes facial sutures run outward and only slightly backward; at distance from axial furrows equal to half posterior width of glabella, sutures turn sharply backward to cross posterior margin. Posterior border furrow shallow.

Hypostome and free cheeks not known.

Pygidium subtriangular to subsemicircular in outline, moderately convex, bears a slender median spine. This spine broken in almost all specimens. Axis narrow, tapering, composed of half ring, nine axial rings, and somewhat expanded terminal piece. Posterior two or three rings. May be separable only in decorticated specimens. Posterior end of terminal piece bluntly semiconical, tapers into slender spine base at or just inside border furrow. Base of spine strongly developed in decorticated specimens, may be somewhat obscured when dorsal carapace is entire. Five pairs of segments on pleural fields extend outward to about three-fourths the pygidial radius. Border furrow shallow; border gently convex and narrowest at either side of median spine. Doublure extends inward about one-fourth pygidial radius.

Holotype.—USNM 160863.

Paratypes.—USNM 160864 a–d.

Occurrence.—USGS collection D340i CO, Ninemile Formation, 141 feet above base of formation, NW¼ sec. 5, T. 15 N., R. 51 E., Cockalorum Wash quadrangle, Nevada.

Discussion.—The length of the slender terminal spine is shown in the holotype pygidium to be 6 mm longer than the broken stump; the tip end of the spine is still in position although the middle was lost during preparation (pl. 14, fig. 11). Because of the spine, the pygidium of *M.* (*Ekeraspis*) *floweri* is more like that of the Swedish species *M.* (*E.*) *heroides* (Brøgger) than any other described species; however, the length of the spine is almost twice that of the Swedish species. *M.* (*E.*) *heroides* seems to have six paired segments on the pleural fields (Tjernvik, 1956, p. 245, pl. 8, figs. 3, 4) although Tjernvik's description calls for eight or nine. Whichever number is correct, that number is greater than in *M.* (*E.*) *floweri*, as is the number of axial rings. The glabella and the posterior parts of the fixed cheeks are narrower (trans.) than in *M.* (*E.*) *heroides.*

M. (*E.*) *nevadensis* Ross, n. sp., possesses a blunt broad terminal spine more like that of *M.* (*E.*) *armata* Tjernvik than like that of either *M.* (*E.*) *heroides* or M. (*E.*) *floweri.* If cranadia have been assigned correctly to *M.* (*E.*) *floweri* and *M.* (*E.*) *nevadensis*, the glabella is much narrower between the eyes of the *M.* (*E.*) *floweri.*

In Sweden, *M.* (*E.*) *armata* having a broad terminal spine holds a stratigraphic position below that of *M.* (*E.*) *heroides* having a slender spine. The probable stratigraphic position of *M.* (*E.*) *nevadensis* having a broad spine is similarly below that of *M.* (*E.*) *floweri.*

Megalaspid hypostome

Plate 14, figure 20

Hypostomes from the top Goodwin Limestone at Ninemile Canyon (USGS colln. D297 CO) include several that resemble those of *Megistaspis planilimbata* (Angelin) as illustrated by Tjernvik (1956, pl. 6, fig. 4). Collection D297 CO includes several genera but no megalaspids. However, in the upper part of the Goodwin Limestone at Rawhide Mountain (USGS colln. D812 CO), *Megistaspis* (*Ekeraspis*) has been found. It therefore seems likely that megalaspids are at the Ninemile Canyon locality but unfortunately have not been collected.

Figured specimen.—USNM 160865.

Occurrence.—USGS collection D297 CO, Goodwin Limestone, topmost 10 feet; northern tributary of Ninemile Canyon, center of the N½NE¼ sec. 5, T. 15 N., R. 51 E., Cockalorum Wash quadrangle, Nevada.

Genus HUNNEBERGIA Tjernvik, 1956

Hunnebergia? sp.

Plate 14, figure 19

A single pygidium from the Ninemile Formation may belong to the genus *Hunnebergia;* lack of associated cephalic parts prevents positive identification.

Pygidium crudely transversely subelliptical in outline; shallow emargination at posterior midline. Length (sag.) of axis a little over three-fourths pygidial midlength. Segmentation of axis indistinct. Only anterior three pairs of ribs visible on pleural fields; all three fade out within distance equal to one-half pygidial radius. Border very wide, flat to gently convex. Border furrows on each side very shallow, nearly straight, not confluent around posterior end of axis. Greatest width (trans.) of pygidium 13.5 mm, located opposite midlength of axis. Length (sag.) of axis 6.8 mm; length of pygidium (sag.) 8.9 mm. Anterior width of axis 3.2 mm.

Figured specimen.—USNM 160866.

Occurrence.—USGS collection D3401 CO, Ninemile Formation, 161 feet above base, NW¼ sec. 5, T. 15 N., R. 51 E., Cockalorum Wash quadrangle, Nevada.

Genus NIOBELLA Reed, 1931

Niobella Reed. Tjernvik, 1956, Uppsala Univ. Geol. Inst. Bull. v. 36, p. 228–229.

Niobella sp.

Plate 14, figure 14

A single cranidium in the upper part of the Goodwin Limestone is assignable to *Niobella.*

Glabella subrectangular and has bluntly rounded frontal outline; its width (trans.) about two-thirds its length. Length (sag.) of glabella almost eight-tenths the length of cranidium. Basal glabellar lobe may be present but too poorly defined for determination as to whether it is original feature or caused by deformation during deposition. Tubercle located one-fifth of glabellar length (sag.) from posterior margin. Axial and preglabellar furrows very faintly and poorly defined. Length (sag.) of preglabellar field about one-fifth that of crandidum—long for the genus. Eye lobes more than semicircular flaps, somewhat elevated. The rear halves of eye lobes positioned opposite midpoint of glabella. Facial sutures diverge at 35° from exsagittal line, turn opposite front end of glabella to converge at 130°. Posteriorly, facial sutures define stout posterior part of fixed cheeks of unknown width (trans.).

Figured specimen.—USNM 160867.

Occurrence.—USGS collection D368i CO, Goodwin Limestone, 161 feet below top, north side of tributary to Ninemile Canyon, N½ sec. 5, T. 15 N., R. 51 E., Cockalorum Wash quadrangle, Nevada.

Discussion.—This cranidium possesses a much longer (sag.) preglabellar field than *Niobella kanauguki* Ross but is almost comparable in this respect to *N.* sp. aff. *N. imparilimbata,* described by Tjernvik (1956, p. 233, pl. 5, fig. 11, text fig. 37C). It lacks the anterior expansion of the glabella found in the Scandinavian species, however.

Niobella? sp.

Plate 14, figures 16–18

No cephalic parts identified. Pygidium transversely semielliptical, moderately convex. Length (sag.) almost six-tenths greatest width (trans.). Axis low, bounded by distinct but shallow axial furrows. Length of axis 0.85 length (sag.) of pygidium. Width of axis about three-tenths width of pygidium. Axis composed of four distinct rings, one very indistinct ring, and a terminal piece. Pleural regions moderately convex. Three pairs of flattened pleura seemingly indicated by narrow ridges. Ridges terminate abruptly against line on dorsal surface that seems to correspond to edge of doublure below; this line also seems to form proximal edge of border. One-third radial distance from proximal edge of border to margin of border is marked by shallow yet distinct break in slope that emulates border furrow tangent to tip of axis. Otherwise border is flattened and inclined.

Figured specimen.—USNM 160868.

Occurrence.—USGS collection D297 CO, Goodwin Limestone, upper 10 feet, northern tributary of Ninemile Canyon, center of the N½NE¼ sec. 5, T. 15 N., R. 51 E., Cockalorum Wash quadrangle, Nevada (immediately below type section of Ninemile Formation).

Discussion.—Because of lack of cephalic parts the generic assignment of this species is in doubt. If correctly assigned to *Niobella,* the pygidium resembles fairly closely that of *N. bohlini* Tjernvik from Sweden. The axis is wider than in *N. kanauguki* Ross and seems to be composed of at least one more ring.

The association of this species that resembles *Niobella bohlini* with a species of *Megistaspis* (*Ekeraspis*) that resembles *M.* (*E.*) *heroides* suggests a correlation with the *M. planilimbata* zone of Sweden and indicates that the upper Goodwin Limestone is as young as early Arenig.

Genus PERASPIS Whittington, 1965

At least one species assignable to this genus is in the lowest platy beds of the Antelope Valley Limestone at Ikes Canyon. It differs from the type species, *Peraspis* *lineolata* Whittington, in its seeming lack of an anterior border sagittally on the cephalon. In this respect it is more like *Nileus* than *Peraspis.* Stout genal spines are present, and one associated free cheek shows a remarkably wide (sag.) nileid doublure like that of *P. lineolata* (Whittington, 1965a, pl. 35, fig. 4). The pygidium lacks the fairly prominent pleural grooves of the Newfoundland type species.

Peraspis erugata Ross, n. sp.

Plate 14, figures 21, 22; plate 15, figures 1–5

Cephalon seemingly subsemicircular, equipped with blunt genal spines. Border poorly developed, somewhat flattened laterally, probably lacking sagittally. Associated free cheek possesses nileid doublure of great width (sag.) yoking two sides (pl. 15, fig. 1). Glabella widest at front; greatest width about eight-tenths its length. Glabella narrows between fronts and backs of palpebral areas, expands between eye centers. Axial furrows shallow. Palpebral lobes large crescentic flaps. Facial sutures in front of eyes diverge along sides of glabella, then turn abruptly inward confluently to define front of glabella. Behind palpebral lobes facial sutures diverge and cross posterior margin of cephalon at angle close to 35°. Length (exsag.) of palpebral lobes equals about one-half glabellar length (sag.), so located that a line through eye centers crosses glabella about four-tenths of its length (sag.) from the rear.

A single specimen (pl. 15, fig. 2) indicates that there were seven thoracic segments. Pygidium almost semicircular in outline. Axis narrow, tapering, ending close to proximal edge of border. Broad, very shallow border furrow bounds flattened to very gently convex border; width of border (sag.) equals one-tenth pygidial length (sag.). Length (sag.) of axis three-fourths to eight-tenths pygidial length. Segmentation of axis faint, better shown along sides than on crest; five rings (possibly six) and terminal piece faintly indicated in decorticated specimens. A single large partly silicified specimen (pl. 15, fig. 2) shows three poorly developed pairs of ribs on pleural regions of pygidium; other specimens show one very faint pair of ribs or are smooth.

Holotype.—USNM 160869.

Paratypes.—USNM 160870a–h.

Occurrence.—USGS collection D1603 CO, Antelope Valley Limestone, 891 feet below top of formation; USGS collection D1520 CO, 750 feet below top of formation, Ikes Canyon section, Nevada.

Discussion.—This species differs from *Peraspis lineolata* Whittington in the lack of preglabellar furrow on the cranidium, in the expansion of glabella between eye centers, in the virtual lack or very faint development of pygidial segmentation, and in fewer axial segments on the pygidium.

The only associated hypostome may belong to *Niobe;* it has little in common with the hypostome of *Peraspis lineolata* (Whittington, 1965a, pl. 35, figs. 6, 8). The presence of *Peraspis* is another link between the *Orthidiella* zone of Ikes Canyon and the Middle Table Head Formation of Newfoundland.

Genus ILLAENUS Dalman, 1827

Illaenus cf. I. alveatus Raymond

Plate 15, figures 9, 12, 13, 15

Sample includes one cranidium and one pygidium. Both partly decorticated, the pygidium excavated to reveal shape of doublure. These specimens closely resemble *Illaenus alveatus* Raymond as redescribed by Whittington (1965a, p. 391–393, pl. 48, figs. 7, 9, 11–15; pl. 49, figs. 1–10, 12, 13).

Cranidium characterized by nearly parallel-sided glabella, palpebral lobes close to posterior margin, and narrow preglabellar furrow and narrowly convex projecting anterior border.

Glabella equipped with median tubercle positioned between posterior halves of palpebral lobes. Axial furrows virtually straight, subparallel, fading out anteriorly about one-half circumferential (exsag.) distance from posterior to anterior border. On decorticated and partly weathered specimen, presence of lunettes not certain. On line between eye centers, width of glabella (trans.) equals 1.5 times width of fixed cheeks (including palpebral lobes). Lateral profile strongly curved downward and under; greatest convexity approximately between front ends of palpebral lobes. Palpebral lobes close to rear margin. Posterior course of facial suture not certain, anterior course as in *Illaenus alveatus* Raymond (Whittington, 1965a, pl. 48, fig. 13; pl. 49, figs. 6, 7).

Width of pygidium more than twice its length. Width of axis about one-third that of pygidium. Width of doublure (exsag.) and width of tongue (trans.) as in *I. alveatus.*

Figured specimens.—USNM 160871a, b.

Occurrence.—USGS collection D1509 CO, Antelope Valley Limestone, 161 feet below top of formation, Ikes Canyon section, Nevada.

Discussion.—In cranidial convexity, in both lateral and anterior profiles of the cranidium, in shape, size, and position of palpebral lobes, in width of fixed cheeks, in position of glabellar tubercle, in shape and width of anterior border, and in proportions of all the pygidial features that can be observed these specimens are virtually indistinguishable from *Illaenus alveatus* Raymond (Whittington, 1965a, p. 391–393, pl. 48, figs. 7, 9, 11–15; pl. 49, figs. 1–10, 12, 13). However, the weathered and decorticated cranidium seems to differ in the lack of sigmoidal curvature of axial furrows; this sigmoidal outline is not pronounced in all specimens of *I. alveatus* (Whittington, 1965a, pl. 48, fig. 11; pl. 49, fig. 3). On decorticated cranidia *I. alveatus* possesses an elongate median depression forward from the glabellar tubercle (Whittington, 1965a, p. 392, pl. 49, fig. 9); on the decorticated glabella of the Nevada specimen (pl. 15, figs. 9, 12, 13) there appears to be a faint narrow ridge flanked by extremely narrow and shallow depressions.

Two specimens are hardly adequate for detailed comparisons, but they do indicate that a species closely related to *I. alveatus* of the Lower Table Head is in the *Rhysostrophia*-bearing beds of the Antelope Valley Limestone at Ikes Canyon.

Illaenus sp. 1

Plate 15, figures 6, 7, 10

This species is represented by a lone cranidium. Without pygidium and free cheeks assignment to a species is impossible. However, the cranidium bears a marked resemblance to that of *Illaenus fraternus* Billings (Whittington, 1965a, p. 387–389; pl. 45; pl. 46, figs. 1–5, 6, 8, 10).

In dorsal, lateral, and anterior aspects the cranidium is almost identical to that of *I. fraternus*. However, the axial furrows of *I. fraternus* are posteriorly straight and diverge just before dying out ahead of the palpebral lobes. In the Nevada specimen they are similarly straight until opposite the front of the palpebral lobes; there they converge sharply and briefly before again diverging and fading out. Within the point of convergence the glabella is impressed by a pair of triangular, transversely oriented muscle scars; on the outside of the axial furrows at the same point is an irregular, small smooth area—the lunette of Whittington (1965a, p. 388, 392), the "lateraleindruck" of Jaanusson (1954, pl. 2, fig. 7), and the lateral muscle scars of Snajdr (1956; text fig. 1). In anterior view the glabella is anteriorly club shaped and is defined by a faint swelling rather than by axial furrows. Barely discernible are three other pairs of muscle scars, an irregularly elongate basal pair and subcircular medial and anterior pairs.

Figured specimen.—USNM 160872.

Occurrence.—USGS collection D1578 CO, Antelope Valley Limestone, 951 feet below top of formation, southern Groom Range section, Nevada.

Discussion.—There is no evidence of a glabellar tubercle on this specimen, but that might be a matter of lack of preservation. The position of the lunette seems to be the same as in *Illaenus fraternus* (Whittington, 1965a, pl. 45, figs. 4, 5). The glabella is of the same shape and may even bear similar muscle scars.

Nothing is known at present about the pygidium or free cheeks of the Nevada species. The species was found in the *Anomalorthis* zone.

Genus RAYMONDASPIS Pribyl, 1948

Raymondaspis? sp.

Plate 15, figures 8, 11, 14

Illaenopsis? sp. Ross, 1967a, U.S. Geol. Survey Prof. Paper 523–D, p. D14–D15, pl. 4, fig. 33.

Although from a different locality, specimens of *Raymondaspis*? from Steptoe (USGS colln. D1812 CO) are certainly conspecific with a cranidium previously assigned to *Illaenopsis*? from the Nevada Test Site (Ross, 1967a, p. D14–D15, pl. 4, fig. 33, pl. 11, USGS colln. D680 CO). A pygidium and two free cheeks, all damaged, are associated with a cranidium at Steptoe and are believed to be assignable to this species.

Only border of free cheek, partial genal spine, and proximal part of ocular platform preserved. Surface finely granular. Border furrow wide, so that border seems concave.

Pygidium small, subtriangular to broadly parabolic in outline. Axis strongly convex, bluntly pointed. Composed of two distinct rings, one faint ring, and terminal piece. Length of axis two-thirds sagittal length of pygidium. Width (trans.) of axis about three-fourths its own length and about one-third width (trans.) of pygidium. Pleural region small, probably crossed by three pairs of pleural furrows. Border wide (radially), crossed anteriorly by one pair of interpleural furrows and dimpled at probable positions of at least two others. Border sloping, somewhat concave.

Figured specimens.—USNM 160873a–c.

Occurrence.—USGS collection D1812 CO, Lehman Formation, 159 feet above base, 107 feet below base of Eureka Quartzite, Steptoe section, Nevada.

Discussion.—Tripp (1962, p. 8; pl. 2, figs. 1–3) described *Raymondaspis hermaion* from the *confinis* Flags of the Girvan District; the present species seems surely congeneric and is therefore assigned to *Raymondaspis* rather than *Illaenopsis*.

The Nevada cranidia possess an occipital ring. *R. hermaion* Tripp has a similar occipital ring as does *R. limbata* (Angelin). Both *I. thomsoni* Salter (1866, pl. 20, fig. 1) and *I. stenorhachis* (Harrington) lack an occipital ring (Harrington and Leanza, 1957, p. 183, figs. 92, 93, 1, 2). The difference between having and not having an occipital ring may be not only the difference between *Raymondaspis* and *Illaenopsis* but may also distinguish between Middle Ordovician (Porterfield?) and older Tremadoc species.

However, it should be noted that the fixed cheeks of some species assigned to *Raymondaspis* (Whittington, 1965a, p. 401–407; Skjeseth, 1955; Ross, 1967a, p. D15) are quite different from the species described here. It may eventually prove necessary to assign this species and *R. hermaion* to a distinct genus.

Genus BATHYURUS Billings, 1859

Bathyurus cf. B. extans (Hall)

Plate 13, figure 12; plate 15, figures 16–19

Description based on two fragmentary cranidia and three pygidia. Surface crowded with fine pustules or granules. Cranidium probably can be distinguished with difficulty from that of *Bathyurus extans* (Hall) (Whittington, 1953, p. 652, pl. 65, figs. 4–9) which it resembles in all respects except finely granular surface. Thorax not known.

Pygidium also resembles that of *B. extans* except for granular surface and (compare with Whittington, 1953, p. 651, pl. 65, figs. 1–5, 7, 8, 12) the fact that posterior margin at midline forms obtuse angle of 110°–125°.

Figured specimens.—USNM 160874a–e.

Occurrence.—USGS collection D1667 CO, Antelope Valley Limestone, 293–331 feet below top of formation, Pahranagat Range, Nev.; USGS collection D1563 CO, Antelope Valley Limestone, 368 feet below top of formation, southern Groom Range; USGS collection D1856 CO, from float 217 feet below top of formation, Hot Creek Canyon, Nev.; USGS collection D1651 CO, Kanosh Shale, 10 feet below top, Ibex area, The Barn quadrangle, Utah.

Discussion.—These specimens resemble *Bathyurus extans* (Hall) more closely than any other species; that Black River species also has a subtriangular pygidium, but only in a specimen illustrated by Wilson (1947, pl. 2, fig. 6) is there an approach to an obtuse terminal point. The type and other specimens described and illustrated by Whittington (1953, p. 651–652, pl. 65, figs. 1–9, 12) lack such a blunt spine. The surface is very finely and closely granular in texture, whereas that of *B. extans* is sparsely pustulose.

The surface of the pygidial axis of *Bathyurus acutus* Raymond is finely granulated (Wilson, 1947, p. 16); the pygidium possesses a terminal pygidial spine more acutely pointed than in *B.* cf. *B. extans*, but the difference is a matter of degree. In that regard these Nevada specimens are intermediate between *B. extans* (Hall) and *B. acutus* Raymond.

Stratigraphically, the significance of the specimens of this trilobite lies in the obviously close relationship to both *B. extans* and *B. acutus*, both of Black River age (Porterfield or younger). Since this trilobite occurs 358 feet below the top of the Antelope Valley Limestone and almost immediately above the *Anomalorthis* zone, it supports the author's belief that the Whiterock may be in part equivalent to the Marmor (Chazy) Stage, or younger.

Bathyurus extans subsp. emaciatus Ross, n. subsp.

Plate 15, figures 20–24

No complete cranidia available. Surface finely granulated. Glabella nearly parallel sided but narrowing anteriorly to rounded point. Front of glabella steep in lateral profile and slightly overhanging preglabellar furrow. Glabellar width about seven-tenths the length; length (sag.) of occipital ring less than one-fifth total glabellar length (sag.). Occipital furrow distinct. Four lateral glabellar furrows may be represented by indistinct impressions between occipital furrow and front of palpebral lobes. Axial furrows shallow, confluent around front of glabella, and tangent at midline to border furrow.

Width (trans.) of each fixed cheek at palpebral lobe equals one-half glabellar width (trans.). Palpebral lobes large, semicircular, inclined upward away from axial furrows. Outer edge of each lobe higher than crest of glabella. Eye centers located behind glabellar midpoint; one-third of glabella extends forward of fronts of palpebral lobes. Backs of lobes slightly in front of occipital furrow. Fixed cheeks ahead of eyes steeply sloping, convex. Anterior border narrow.

Free cheeks, hypostome and thorax not known.

Pygidium subtriangular in outline, its length (sag.) about two-thirds its greatest width (trans.). Axis composed of three distinct and a fourth less distinct rings plus long terminal piece. Pleural region divided by four pairs of pleural furrows that do not cross concave border. Anterior interpleural furrow strong across border only; two other furrows faintly dimple border in decorticated specimen.

Holotype.—USNM 160875.

Paratype.—USNM 160876.

Occurrence.—USGS collection D1810 CO, Lehman Formation, 234–241 feet above base (25–32 feet below base of Eureka Quartzite), Steptoe section, Nevada.

Discussion.—This subspecies resembles *Bathyurus extans* more closely than *B.* cf. *B. extans* described above (pl. 15, figs. 16, 18) as regards the pygidium which lacks an obtuse angular terminal point. However, the front of the glabella narrows as in some species of *Goniotelina* rather than expanding as in *B. extans*. Were it not for this difference in glabellar outline, I would assign it to *B. extans*. The difference is probably of subspecies rank.

Since the subspecies occurs higher stratigraphically than *Öpikinia*, it is possibly of Ashby but probably of Porterfield or younger age.

Bathyurus acutus subsp. angustus Ross, n. subsp.

Plate 16, figures 6–12

This subspecies is based on about 20 specimens from the upper part of the Antelope Valley Limestone from four localities. All specimens occur in a very fine grained compact silty limestone.

Glabella widest at anterior lobe, almost parallel sided posterior thereto. Front evenly rounded. Width (trans.) at occipital ring about or a little less than six-tenths of glabellar length. Glabella moderately convex in anterior profile; in lateral profile, front of glabella slopes steeply to preglabellar furrow but without any overhang. Occipital ring occupies about 0.15 glabellar length (sag.). Lateral glabellar furrows too weak to be determined. Axial furrows and occipital furrow shallow; anteriorly, axial furrows join preglabellar border furrow at low angle near anterolateral "corners" of glabella and become confluent with it. Fixed cheeks slope upward from axial furrows, then flatten into subhorizontal palpebral area bordered by distinct palpebral furrow and rim.

Line through eye centers crosses sagittal line of glabella almost four-tenths of glabellar length from posterior edge of occipital ring.

Associated free cheeks possess long, slender genal spines that have marginal furrow extending along side of each genal spine almost to its tip. Thoracic segments not known.

Pygidium subtriangular in outline, wider than long, equipped with terminal spine. Axis prominent; anterior ring weak, others essentially undifferentiated. Terminus of axis joined to spine base by carinate ridge in immature specimens. Pleural region bears four pairs of pleural furrows that terminate before reaching border. Four pairs of interpleural furrows cross border but do not extend proximally onto pleural region; these furrows better developed on immature than on mature specimens and faint on both. In decorticated specimens, terminal spine appears as slender spine, but in complete carapace as wide somewhat flattened spike.

Holotype.—USNM 160877.

Paratypes.—USNM 160878a–d.

Occurrence.—USGS collection D1814 CO, Steptoe section, Lehman Formation, 104 feet above base (162 ft below base of Eureka Quartzite); USGS collection D1817 CO, Steptoe section, Kanosh Shale, 117 feet below basal quartzite of Lehman (383 ft below base of Eureka Quartzite); USGS collection D1483 CO, D1484 CO, Hot Creek Canyon section, 151–159 feet below top of Antelope Valley Limestone; USGS collection D1666 CO, Pahranagat Range section, Antelope Valley Limestone, 258–277 feet below base of Eureka Quartzite.

Discussion.—In making comparison with the type material of *Bathyurus acutus* Raymond (GSC 7821, 7821a–d), I found that the holotype pygidium (pl. 16, figs. 3–5) is probably a transitory pygidium about to lose the anterior segment to the thorax; in any case it is smaller and less mature than any of the specimens compared with it. Its axis bears only one well-defined ring. Its pleural and interpleural furrows are distinct; the anterior interpleural furrow runs proximally across the pleural region to the axial furrow as the trace of an incipient suture.

One of the pygidia that compares closely with the type of *B. acutus* is illustrated on plate 16, figures 6, 8, 12. This specimen has the same outline, very nearly the same convexity, same postaxis carinate ridge, and similar development of interpleural and pleural furrows. The segmentation of the axis is not as well developed in the Nevada specimen, but that difference may be attributed to the slightly larger size and presumably later developmental stage. More mature pygidia of *B. acutus* subsp. *angustus* seem to be slightly more convex than this specimen. At the posterior end of the axis of the holotype of *B. acutus* a pair of creases run posteriorly and horizontally. When the anterior segment is shed into the thorax, this pair of creases may become the axial furrows around the end of the axis, and the adjacent segment of the axial furrows may become the pleural furrows of the fourth segment.

The length of the terminal spine cannot be compared adequately with that of Raymond's holotype specimen from the Pamelia Formation; that pygidium lacks the posterior part of the spine (pl. 16, fig. 4). One specimen from collection D1814 CO possesses a spine extending 5.5 mm behind the axis; the width of this pygidium is about 10 mm.

The cranidium of *B. a. angustus* differs from that of *B. acutus* in having a very slightly narrower glabella, in having a more gentle inclination of the front of the glabella into the preglabellar furrow, and in lacking the faint indentations that mark glabella furrows. In *B. acutus* the frontal lobe of the glabella is separated by a pair of constrictions ahead of the front ends of the palpebral lobes; comparable constrictions seem to be lacking in *B. a. augustus*. In the Nevada subspecies there is no real preglabellar furrow, but in *B. acutus* that furrow undercuts the front of the glabella. Otherwise the cranidia of the two are virtually the same.

Bathyurus sp.

Plate 16, figures 15, 18

Identification and description of this species is hampered by lack of cranidia. One fragmentary free cheek and two decorticated pygidia comprise the sample.

Free cheek moderately convex, bounded laterally by narrow border and shallow border furrow, both of which extend along outer side of genal spine. Genal spine bears carinate ridge along dorsal side. Posterior border and narrow border furrow extend along inner side of genal spine. Deep furrow beneath eye surface. Exterior of carapace probably pustulose except on lateral border.

Pygidium subsemicircular, rear border obtusely pointed medially. Border ill defined. Four pairs of pleural furrows terminate distally before crossing border; anterior three pairs of interpleural furrows crease border lightly. Axis one-third to one-fourth as wide (trans.) at anterior end as pygidium (trans.). Its length (sag.) equals 0.85 length of pygidium. Four rings well developed, form a little more than one-half of axis; on posterior half are three additional pairs of muscle scars near axial furrows but rings not developed. Pleural field bears three strong ribs and a very weak fourth pair.

Figured specimens.—USNM 160879a, b.

Occurrence.—USGS collection D1816 CO, Antelope Valley Limestone, 297 feet below base of Eureka Quartzite, Steptoe section, Nevada.

Discussion.—Were it not for the faint development of a fourth pair of pleural ribs on the pygidium and the lack of clear-cut border, this species might be assigned to *Goniotelina* and compared favorably with *G. crassicornis* (Poulsen). However, its pygidium is clearly more like those of *Bathyurus*. In form, particularly in the obtusely pointed rear border, it closely resembles specimens assigned here (p. 85, pl. 15, figs. 16, 18) to *B.* cf. *B. extans* from the upper part of the Antelope Valley in the southern Groom Range (USGS colln. D1563 CO) and from the top 10 feet of the Kanosh Shale in the Ibex area of Utah (pl. 13, fig. 12; USGS colln. D1651 CO). It differs in the fainter development of the fourth pair of pleural ribs; in that respect it may be intermediate between *Goniotelina* and other species of *Bathyurus*.

Genus UROMYSTRUM Whittington, 1953

Uromystrum is reported from the "enormous white boulder" at Lower Head, Newfoundland (Whittington, 1963, p. 10, 57–62), in an association that occurs in the *Orthidiella* zone at Meiklejohn Peak. It is also included in specimens assigned to *Bathyurellus pogonipensis* by Hintze (1952, pl. 10, figs. 11a, b) in zone M of his Kanosh Shale. The genus is also reported from the Lower Table Head Formation (Whittington and Kindle, 1963, text fig. 2) in strata correlative with the *Orthidiella* zone. It is also found in the lower beds of the Swan Peak Formation (USGS colln. D209 CO) in Green Canyon, east of Logan Canyon, Utah. According to Frederick Shaw (oral commun., Sept. 1, 1965), it is virtually the only bathyurid trilobite in the type Chazy Group of New York.

Uromystrum? sp.

Plate 15, figure 25

No cephalic parts have been distinguished for this species; therefore its generic assignment is not completely certain.

Pygidium almost semicircular in outline. Dorsal surface concave except for axis. Axis of low convexity, bluntly semiconical, composed of three fairly distinct rings, a fourth indistinct ring, and a terminal piece; its length a little more than one-half pygidial length (sag.). Close to axis, concave pleural region marked by two very faint pairs of pleural furrows that fade out before attaining one-half the pygidial radius. Near middle of radius of pygidium, pleural regions bear three fairly strong and a fourth very faint pair of interpleural furrows; these fade before reaching distal margin.

Figured specimen.—USNM 160880.

Occurrence.—USGS collection D209 CO, Swan Peak Formation, limestone interbeds in lower member, north side of Green Canyon, NE¼ sec. 28, T. 12 N., R. 23 E., Logan quadrangle, Utah.

Discussion.—This species may be indistinguishable on the basis of pygidia from *Uromystrum? pogonipensis* (Hintze) (Hintze, 1952, pl. 10, figs. 11a, b) from zone M of the Ibex area, Utah. The zonal occurrence is the same.

Genus GONIOTELINA Whittington and Ross 1953

Goniotelina? sp.

Plate 16, figures 13, 14, 17

A single small pygidium probably assignable to *Goniotelina* sp. was found high in the Pogonip beds associated with *Bathyurus* (pl. 16, fig. 15, 18) and *Anomalorthis* at Steptoe.

Surface coarsely pustulose on axis, finely pustulose proximally on pleural field, changes to Bertillon pattern distally. Outline almost semielliptical; width (trans.) twice the length (sag.). Axis tapers and has bluntly rounded terminus; composed of four rings and quarterspherical terminal piece. Length of axis (sag.) equals 0.85 length of pygidium; its width equals a little less than four-tenths pygidial width (trans.). Pleural regions strongly convex, not limited by marginal furrow or border. Three pairs of pleural furrows fade out distally in smooth margin. Two indistinct pairs and a third less distinct pair of interpleural furrows dimple marginal area. Broken stump of very fine medial spine based in margin behind axis.

Figured specimen.—USNM 160881.

Occurrence.—USGS collection D1816 CO, Kanosh Shale, 31 feet below basal quartzite of Lehman Formation (297 ft below base of Eureka Quartzite), Steptoe section, Nevada.

Discussion.—This pygidium bears a resemblance to that of *Goniotelina brevis* Hintze but lacks the strong median spine and distinct border of the older species. The construction is fundamentally more like that of *Bathyurus* than of *Goniotelina* except *Goniotelina* has one fewer pair of pleural segments than *Bathyurus*.

Genus LICNOCEPHALA Ross, 1951

Licnocephala? sp.

Plate 16, figure 22

A single pygidium is tentatively assigned to *Licnocephala* because of its resemblance to the pygidium of *L. cavigladius* Hintze (1952, pl. 10, fig. 1).

Outline longitudinally semielliptical; length (sag.) two-thirds the width (trans.). Axis very small; its length half that of pygidium and its width a third that of pygidium. Axis composed of one ring and a subconical terminal piece. Axial furrows distinct, shallow, confluent around terminus of axis. Pleural field marked by a single pair of pleural furrows; otherwise smooth and has open Bertillon pattern.

Figured specimen.—USNM 160882.

Occurrence.—USGS collection D1830 CO, lower limestone of the Pogonip Group, 1,602 feet below base of Eureka Quartzite, 761 feet below base of Kanosh Shale (11 ft below top of formation C of Woodward, 1964) Steptoe section, Nevada.

Discussion.—This specimen differs from the pygidium of *Licnocephala cavigladius* Hintze in lacking more than a single pair of pleura on the pleural field and in being somewhat narrower (trans.). Otherwise the two are remarkably similar. Positive generic assignment is impossible without cephalic parts.

Genus ASTROPROETUS Begg, 1939

Astroproetus Begg. Whittington, 1966b, A monograph of the Ordovician trilobites of the Bala area, Merioneth, Palaeont. Soc. London [Mon.], v. 119, pt. 3, p. 81–82.

Astroproetus sp.

Plate 16, figures 16, 19–21

Astroproetus is represented in a collection by two cranidia of very different size and in another collection by three cranidia, all of different sizes, and a free cheek. How many if any of the differences are due to stratigraphic position is uncertain because of disparity of sizes and poor quality of preservation.

Larger cranidium lacks greater part of preglabellar field and right palpebral lobe. Preservation coarse, so that presence or absence of glabellar furrows is uncertain. Glabellar outline as wide as long. Length (sag.) of preglabellar field estimated about one-eighth glabellar length. Smaller cranidum (pl. 16, fig. 20) has a median preglabellar furrow on preglabellar field which is lacking on the larger specimen, probably because of difference in stage of development. Both specimens have faint pustule on occipital ring.

Free cheek has well-defined border furrow both anteriolaterally and posteriorly. Genal spine short, slender, rooted in flattened border.

Figured specimens.—USNM 160883a–d.

Occurrence.—USGS collection D1506 CO, unnamed formation, 60–90 feet above top of Antelope Valley Limestone; D1526 CO, unnamed formation, 115–128 feet above top of Antelope Valley Limestone. Both from Ikes Canyon, Toquima Range, Nev.

Discussion.—Two large pygidia are from the same collection and differ so much that they may represent two species. Neither is well preserved. The larger, not illustrated, lacks most of the front edge of the entire shield and the top of the axis; it has at least seven axial rings and six parts of pleural furrows which do not cross the border to the margin. The smaller (pl. 16, fig. 16) may have as many as seven axial rings but only five can be distinguished; only five pairs of pleural furrows are present, and they cross the border to the margin. Conceivably these two could belong to the same species but they probably do not. The smallest pygidium, not illustrated, has five pairs of pleural furrows crossing the border and nine axial rings. To which, if either, of the two large pygidia the small one corresponds is impossible to tell at present. The specific identity of these specimens must remain temporarily in question, but their stratigraphic significance indicates a probable Middle Ordovician age for the enclosing strata.

Genus LONCHODOMAS Angelin, 1854

Lonchodomas paenepennatus Ross, n. sp.

Plate 16, figures 23–27; plate 17, figures 1, 2

Glabellar outline diamond shaped, widest part being very close to midlength, excluding anterior spine. Width (trans.) of glabella about two-thirds its length (sag.). Occipital ring confluent with moderately inclined posterior border, not separated by axial furrows; length (sag.) of ring about one-tenth that of glabella. Anterior spine seemingly straight, grooved on four sides. Crest of glabella somewhat carinate, particularly in front of midpoint and in immature specimens. Fossula low on flanks of glabella just ahead of midlength. Axial furrows faint, confluent around and beneath anterior protrusion which accounts for one-fourth of glabella. Facial sutures cut posterior margin so that cranidial width (trans.) is about 1.7 times its length (excluding anterior spine). Transverse pit lies in posterior border furrow close to facial sutures.

Pygidium subtriangular in outline, its length (sag.) half its width (trans.). Margin vertical; border high and very narrow. A single pair of pleural furrows curved concave side forward. In some specimens faint raised lines correspond to interpleural furrows; up to four of these pairs on flat horizontal pleural fields. Low triangular axis virtually unsegmented; its anterior width (trans.) equals three-fourths that of pygidium.

Holotype.—USNM 160884.

Paratypes.—USNM 160885a–e.

Occurrence.—USGS collection D710a CO, Antelope Valley Limestone, approximately 30 feet below base of Eureka Quartzite, Nevada coordinates, central zone: E. 729,300 feet; N. 741,350 feet, Ranger Mountains, Nevada Test Site, Nev. (Ross, 1964a, p. C19; 1967a, pl. 11).

Discussion.—*Lonchodomus paenepennatus* most closely resembles *L. retrolatus* Ross (1967a, p. D22; pl. 7, figs. 22–28) from the overlying Eureka Quartzite, and it is probable that the two are nearly the same age. There is a slight difference in length of pygidium, *L. retrolatus* having the shorter. *L. paenepennatus* possesses a slight glabellar crest lacked by *L. retrolatus*. It differs from *L. normalis* (Billings) and *L. clavulus* Whittington in having the widest part of the glabella farther to the rear and in having a wider pygidial axis. The pygidial outline of *L. pennatus* (La Touche) (Dean, 1962, pl. 6, figs. 5, 12) is more convexly curved on the posterolateral margins than in this species; other proportions are almost identical.

Genus **PERISCHOCLONUS** Raymond, 1925

Perischolonus Raymond, 1925, Harvard Coll. Mus. Comp. Zool. Bull., v. 67, no. 1, p. 159.

Perischoclonus sp.

Plate 17, figure 20

A single poorly preserved cranidium attests to the presence of this rare genus at Ikes Canyon. Comparison with *Perischoclonus capitalis* Raymond as described by Whittington (1963, p. 80–84, pl. 22; pl. 35, figs. 10, 11; pl. 36, figs. 5, 7, 8) leaves no doubt about the generic assignment.

Glabella expands forward; anterior squarely rounded. Occipital ring bears median tubercle; occipital furrow deep and continuous across glabella. Lateral glabellar furrows hold relative positions very similar to those of *P. capitalis*. Furrows *1p* distinctively inverted, V-shaped, located four-tenths of glabellar length from posterior of occipital ring. Furrows *2p* at right angles to axial furrow, shallow, located six-tenths of glabellar length from back of occipital ring. Furrows *3p* deeper than *2p* but closer to axial furrow. Fixed cheek bears an eye ridge only on decorticated surface; ridge seemingly does not show on exterior of carapace. Inception of ridge at axial furrow opposite lateral furrow *2p*, runs posterolaterally. Terminus and eye not preserved. A deep fossula present in axial furrow.

Surface of glabella covered with Bertillon pattern, not pustulose.

No thorax or pygidium known.

Figured specimen.—USNM 160886.

Occurrence.—USGS collection D1603 CO, Antelope Valley Limestone, 891 feet below top of formation, Ikes Canyon section.

Discussion.—This species differs from *Perischoclonus capitalis* Raymond in seeming lack of pustules on the surface of the carapace. The possession of eye lines in the decorticated cranidium may also be distinctive, but no decorticated specimens of Raymond's species have been described. Comparison of pygidia is not possible.

Stratigraphically, this occurrence of *Perischoclonus* is another link between Table Head and Lower Head faunas and the *Orthidiella* zone of Nevada.

Genus **XYSTOCRANIA** Whittington, 1963

Xystocrania cf. X. perforator (Billings)

Plate 17, figures 3–7, 10

Whittington (1965a, p. 412–414, pl. 61, figs. 1–11 redescribed and illustrated Billings' species in modern terms, but he lacked any pygidia. The specimens from Ikes Canyon agree closely with all details of Whittington's description of the cranidium, except that none shows whether fixigenal spines were present. A single pygidium was found that can be assigned to this species with confidence.

Pygidium of low convexity. Axial part wider than long, composed of articulating half ring, two distinct segments and a terminal piece partially delineated at its rear only by a short, curved, transverse segment of a furrow. Length (sag.) of axis 7.5 mm; width (trans.) of axis at anterior segment 10.0 mm. Outline of axis subparabolic. Pleura dagger shaped, flattened, having slender points on two anterior pairs, but somewhat wider points on third (terminal) pair. Pleura of third pair not completely separated from terminal piece of axis or from each other. Tips of two anterior pairs extend as far or farther backward than third pair.

Figured specimens.—USNM 160887 a–c.

Occurrence.—USGS collection D1606 CO, D1514 CO, Antelope Valley Limestone, 536 feet and 516 feet below top of formation, Ikes Canyon, Toquima Range, Nev.

Discussion.—The pygidium from Ikes Canyon is different from that of *X. unicornica* Hintze in the shape of the pleural tips. The pleura of Hintze's (1952, pl. 28, fig. 4, 5) Ibex species are parallel sided rather than tapering distally, and their tips possess blunt points. The pleura appear to be cut at 45° on each side so that the angle of the point is 90°. The pygidium of *X.* cf. *X. perforator*, however, possesses tapering pleura that come to gradually acute points.

Unfortunately, one cannot yet tell what the pygidial characteristics are of the species that occurs in the Lower and Middle Table Head Formation of Newfoundland (Whittington, 1965a, p. 413–414). When they are determined it may become necessary to erect another species for the specimens from Ikes Canyon.

Although not previously reported, *Xystocrania* is abundantly represented in the large bioherm at Meiklejohn Peak well below the top of the *Orthidiella* zone. Work in progress may be expected to determine whether the specimens at Ikes Canyon should be correlated with those at Meiklejohn Peak, or whether they are more closely related to the presumably younger *X. unicornica* Hintze.

Genus CYDONOCEPHALUS Whittington, 1963

Cydonocephalus Whittington, 1963, Harvard Coll. Mus. Comp. Zoology Bull., v. 129, no. 1, p. 97–103.

Cydonocephalus sp.

Plate 17, figures 21–24

Cydonocephalus is represented in collections from Ikes Canyon by a single poorly preserved cranidium.

Glabella has low lateral profile characteristic of genus. Lateral glabellar furrows not well preserved and S-shape of furrows *1p* not obvious. Glabellar outline narrower anteriorly than in described species, resembles *C. torulus* Whittington more closely than other species. Position of eye uncertain. Sagittal length of glabella 6.6 mm; greatest width (trans.) at lateral lobes *2p* equals 6.6 mm also. Lateral lobes *1p* conform in convexity to the whole glabella. Occipital ring appreciably lower in lateral profile than medial lobe between lateral lobes *1p*.

Figured specimen.—USNM 160888.

Occurrence.—USGS collection D1514 CO, Antelope Valley Limestone, 516 feet below top of formation, Ikes Canyon section, Toquima Range, Nev.

Discussion.—The importance of this specimen is its contribution to correlation of the fossils from Lower Head, Newfoundland (Whittington, 1963, p. 10–15). It occurs at Ikes Canyon in an assemblage no younger than the *Orthidiella* zone.

Genus PERISSOPLIOMERA Ross, n. gen.

This genus is based entirely on the few known specimens that make up the described type species, *Perissopliomera maclachlani.* Comparison with related genera is given.

Cranidium possesses two pairs of glabellar furrows (*1p* and *2p*) behind the anterolateral angles and two other pairs *3p* and *4p*(?) on the front of the glabella. The preglabellar border is crossed by exsagittal creases precisely alined with the four furrows of pairs *3p* and *4p*(?).

Perissopliomera maclachlani Ross, n. gen., n. sp.

Plate 17, figures 8, 9, 11, 12, 14, 15, 18

This very unusual species is known from a cranidium from Martin Ridge west of Antelope Valley and two cranidia and three pygidia from Hot Creek Canyon. All specimens are poorly preserved. Considerable information can be pieced together to demonstrate that this is a unique species closely related to *Pliomera*, as exemplified by *P. fischeri* (Eichwald).

Glabella rectangular in outline, only slightly longer than wide. In lateral profile depressed, of low convexity. Occipital ring widest (sag.) at midline. Lateral glabellar furrows *1p* and *2p* curved posteroproximally from dorsal furrows, divide sides of glabella subequally between anterolateral corner and occipital furrow. Front of glabella incised by four equally spaced furrows, probably comprising pairs *3p* and *4p*. Fixed cheek incompletely preserved, L-shaped, maximum width (trans.) of each cheek at posterior marginal furrow somewhat less than width of glabella. Palpebral lobe approximately opposite glabellar lobe *2p*. Facial suture proparian.

Pygidium subsemicircular. Axis composed of five rings and elongate terminal piece. Five pairs of pointed pleurae flexed downward at right angles to plane of pleural field. Tips of posterior pair enclose tip of axial terminal piece.

Holotype.—USNM 160889.

Paratype.—USNM 160890a, b.

Occurrence.—USGS collection D229e CO, Antelope Valley Limestone, 82 feet below top; east side of Martin Ridge, 1 mile south of north end of ridge, Nevada coordinates, east zone: E. 275,400 feet; N. 1,629,700 feet. For comparison of stratigraphic position with other collections see Ross (1964a, p. C69–C70). USGS collection D1858 CO, 112 feet below top of Antelope Valley Limestone, Hot Creek Canyon, north side, sec. 24, T. 8 N., R. 49 E., Tonopah 2° quadrangle.

Discussion.—This species seems to be intermediate between *Cybelopsis* and *Pliomera* in regard to both cranidial and pygidial features.

There is remarkable correspondence between the spacing of tips of the posterior two pairs of pygidial pleurae and the spacing of creases on the preglabellar border. Schmidt (1881, pl. 13, fig. 4) illustrated a completely enrolled individual of *P. fischeri* in which the pleural tips overlap and fit into similar creases on the border as described by Whittington (1961, p. 917–918). This system would prevent breaking enrollment by lateral movement of pygidium past the cranidium. In *P. fischeri* the pleural tips are small, neat, and only lapped against the border.

In the Nevada species the tips of pleurae are coarse and farther apart. Although we have no enrolled individual to prove the point, it seems likely that the pleural tips extended past the border fitting into furrows on the front of the glabella. The question then arises as to whether these anterior glabellar furrows are furrows for appendifers 3*p* and 4*p*, whether they are mere modifications for locking the individual into an enrolled position more firmly, or whether they served both functions.

The shape of the glabella allies the species with *Pliomera* and *Pliomerops*. The proparian facial suture is like that of the latter. The fairly long terminal piece on the pygidial axis is considerably shorter than in *Cybelopsis* but larger than in either *Pliomera fischeri* or *Pliomerops canadensis*. In glabellar outline, *Perissopliomera meclachlani* is much like *Pliomera tmetophrys* Harrington and Leanza.

Genus PSEUDOMERA Holliday, 1942

Pseudomera cf. P. barrandei (Billings)

Plate 17, figures 13, 17

Pseudomera cf. *P. barrandei* (Billings) Whittington, 1961, Jour. Paleontology, v. 35, no. 5, p. 918–919, pl. 100, figs. 11, 12, 16, 17.

This species is stated by Whittington (1961, p. 918) to occur in the "sponge beds of upper Pogonip Group *Anomalorthis* zone, Toquima Range." Although the author's collections show that the species does occur in the "sponge beds," they indicate that it falls also within the *Orthidiella* zone.

Figured specimens.—USNM 160891.

Occurrence.—USGS collection D1606 CO, Antelope Valley Limestone, 536 feet below top of formation, USGS collection D1510 CO, 176 feet below top of formation; D1511 CO, 214 feet below top of formation; D1514 CO, 516 feet below top of formation. Ikes Canyon, Toquima Range.

Discussion.—The occurrence of this species accompanied by *Ectenonotus* at Ikes Canyon links the Table Head Formation not only to part of the Antelope Valley Limestone but also to the *Orthidiella* zone.

Genus ENCRINUROIDES Reed, 1931

Encrinuroides sp.

Plate 17, figures 16, 19; plate 18, figure 1

Because no cranidium was found associated, the assignment of a pygidium and a hypostome to *Encrinuroides* is tentative.

Hypostome having broadly rounded anterior outline and narrowly rounded posterior outline. Middle body semiovoid, separated posteriorly and posterolaterally from ventrally flexed border by deep furrow; border widest sagittally. Anteriorly middle body bounded from anterior wings by very shallow furrows; wings flexed dorsally, triangular.

Pygidium triangular in outline; length (sag.) about three-fourths the greatest width (trans.). Anterior width of axis one-third that of pygidium, its length nine-tenths that of pygidium. Axis composed of at least 14 rings. Pleural regions include seven pairs of blunt pleura. Surface of axial and pleural portions very finely granular and has large scattered pustules. Posterior portion of axis and pleural region damaged so that exact number of axial rings and construction of terminus are not discernible.

Figured specimens.—USNM 160892a, b.

Occurrence.—USGS collection D1506 CO, unnamed formation, calcarenite, 60–90 feet above top of Antelope Valley Limestone, Ikes Canyon, Toquima Range, Nev.

Discussion.—The pygidium described here is remarkably like that of *Encrinuroides sexcostatus* (Salter) illustrated by Whittington (1965c, pl. 12, figs. 13, 14). The hypostome is not unlike that of *E. autochthon* Tripp (1962, pl. 3, fig. 21), but the Scottish species has more axial and pleural segments.

The presence of *Encrinuroides* supports evidence given by other fossils in establishing the Ordovician age of about 130 feet of strata above the Antelope Valley Limestone and below Roberts Mountains Formation (=Masket Shale of Kay and Crawford, 1964), at Ikes Canyon.

Genus MIRACYBELE Whittington, 1963

Aff. Miracybele sp. 1

Plate 18, figure 6

Miracybele? sp. 1, Ross, 1967a, U.S. Geol. Survey Prof. Paper 523–D, p. D25–D26, pl. 8, figs. 23–25.

A single poorly preserved cranidium belongs to the same unnamed species as is in USGS collection D727 CO (Ross, 1964a, p. C20–C21), approximately 390 feet above the base of the Antelope Valley Limestone on the Nevada Test Site; that occurrence is in the *Orthidiella* zone and supports correlation between Ikes Canyon and the Nevada Test Site.

This species, described and illustrated by Ross (1967a, p. D25, pl. 8, figs. 23–25), cannot properly be included in *Miracybele* but is represented by too few specimens to warrant formal description. Paradoxically, it is distinctive enough to be readily recognized as a form useful for correlation and different from true *Miracybele*, for which it has probably been mistaken (H. B. Whittington, in Kay, 1962, p. 1424, table 2, pt. a).

Figured specimen.—USNM 160893.

Occurrence.—USGS collection D1603 CO, Antelope Valley Limestone, 891 feet below top of formation, Ikes Canyon, Toquima Range, Nev.

Genus PROTOCALYMENE Ross, 1967

aff. *Calymenidius* Rasetti. Whittington, 1965a, Harvard Coll. Mus. Comp. Zool. Bull., v. 132, no. 4, p. 419.

Protocalymene Ross, 1967a, U.S. Geol. Survey Prof. Paper 523–D, p. D27.

Protocalymene sp.

Plate 18, figures 2–5

Two poorly preserved cranidia, two free cheeks, and three pygidia of *Protocalymene* have been obtained from the lower part of the Antelope Valley Limestone at Ikes Canyon. These specimens are clearly congeneric with two cranidia described as "aff. *Calymenidius* sp. ind." by Whittington (1965a, p. 286, 419–420; pl. 59, figs. 10, 12–15) from the Middle Table Head Formation of Newfoundland, as well as being congeneric with *P. mcallesteri* from the *Orthidiella* zone of the Nevada Test Site.

Larger cranidium 2.4 mm long (sag.). Surface tuberculated; tubercles of varying sizes. Glabellar length three-fourths of cranidial length (sag.), about equal to width (trans.) at lateral lobes *1p*. Length (sag.) of occipital ring one-fourth to one-fifth total glabellar length. Lateral glabellar furrows *1p* very deep, curve posteromedially. Furrows *2p* essentially a pair of deep pits adjacent to axial furrows and impressing sides of glabella. No furrows *3p* evident. Preglabellar furrow shallow and narrow (sag.) but tangent to deep, wide border furrow at midline (sag.). Anterior border highly arched, tuberculate. Fixed cheeks broken away, not observed.

Pygidium probably transitory, about 1.8 mm long. Axis composed of six rings and a terminal piece. Pleural regions divided by at least six pairs of deep interpleural furrows. Each pleura bears a shallow furrow.

Figured specimens.—USNM 160894a–c.

Occurrence.—USGS collection D1520 CO, Antelope Valley Limestone, 750 feet below top of formation, USGS collection D1514 CO, 516 feet below top of formation; D1605 CO, 551 feet below top of formation, Ikes Canyon section, Toquima Range, Nev.

Discussion.—This species differs from *Protocalymene mcallesteri* in greater depth of anterior border furrow, lack of preglabellar field at sagittal line, and greater number of segments in the pygidial axis. Specimens of the two species are of comparable size so that stage of development probably does not account for differences. Comparison with the specimens called "aff. *Calymenidius* sp. ind." by Whittington (1965a, p. 419–420, pl. 59, figs. 10–15) is rendered almost impossible because of the poor condition of both the Newfoundland and the Nevada specimens. The glabellae seem very similar; there is no way to compare fixed cheeks because they have been broken in the Nevada specimens.

Stratigraphically, the occurrence of these species in the Middle Table Head Formation and in the lower *Orthidiella* zone at Ikes Canyon and the Nevada Test Site supports the author's belief that much or most of the Table Head is equivalent to the lowest Whiterock of Cooper (1956).

Genus BRONGNIARTELLA Reed, 1918

Brongniartella Reed, 1918, Geol. Mag., new ser., decade 6 v. 5, no. 6, p. 322.

Dean, 1961, British Mus. (Nat. History) Bull., Geology, v. 5, no. 8, p. 345–346.

Whittington, 1966b, A monograph of the Ordovician trilobites of the Bala area, Merioneth, Pt. 3, p. 64, Paleont. Soc. London [Mon.], v. 119.

Specimens from Ikes Canyon from beds above the Antelope Valley Limestone and below the Silurian Roberts Mountains Formation (Masket Shale of Kay and Crawford, 1964) seem to be assignable to this genus, although the author is not certain that they could not be placed in *Eohomolanotus*. The glabella lacks lateral furrows and therefore cannot be assigned to *Platycorypha*. The hypostome is very similar to that of *Platycorypha vulcani* (Murchison) (Whittard, 1961, p. 165, pl. 22, fig.

17) and *Brongniartella bisulcata* (M'Coy) (Dean, 1961, p. 347, pl. 54, fig. 9). The pygidium seems to differ from any previously described in that the axis extends the full length (sag.).

This occurrence along with that of *Encrinuroides* is stratigraphically important in indicating a Middle or Late Ordovician age of beds above the Antelope Valley Limestone at Ikes Canyon, Toquima Range.

Brongniartella, n. sp.

Plate 18, figures 7–10

The sample is composed of one incomplete cephalon from USGS collection D1526 CO, a partial cranidium, and well-preserved pygidium and hypostome from collection D1506 CO. These probably represent a new species, for the description of which four specimens are hardly adequate.

Cephalon crushed but left side preserved adequately to demonstrate glabella lacks lateral furrows, occipital furrow present but faint, length (sag.) of occipital ring about one-sixth total length of glabella. Axial furrows faint, converge slightly to opposite glabellar midlength then converge more strongly for another fourth glabellar length (exsag.), finally become less convergent in anterior fourth. Length (sag.) of preglabellar field equals almost one-fifth glabellar length (sag.). Eye lobe located ahead of glabellar midlength. Width (trans.) of fixed cheek relative to glabellar width not determined. Facial sutures behind eye run almost directly laterad close to border before turning abruptly posteriorly to cut margin at rounded genal angle. As a result posterior part of fixed cheek long (exsag.).

Hypostome almost rectangular in outline. Surface granular. Middle body moderately inflated, divided into anterior and posterior lobes by broad furrow. Sagittal length of posterior lobe equals one-fourth total length (sag.) of middle body. No maculae discernible. Posterior lobe crescentic in outline. Anterior wings form widest part of hypostome; anterior edge between tips appear almost straight, may be damaged. Posterior border set off by shallow but distinct border furrow. Border produced into a pair of very blunt points at posterior corners with shallow wide notch between.

Pygidium subtriangular, length (sag.) almost two-thirds its greatest width. Axis strongly convex, defined by distinct axial furrows. Anterior seven axial rings distinct, form tapering part of axis; two additional rings and terminal piece, swollen and have sharp point on terminal piece, produce peculiar knob. Six pairs of pleurae on convex pleural regions. Pleural furrows almost reach margin.

Figured specimens.—USNM 160895a–c.

Occurrence.—USGS collections D1526 CO and D1506 CO, unnamed formation (possibly Diana Limestone of Kay and Crawford, 1964), calcarenite, 60–90 feet above top of Antelope Valley Limestone, north side of Ikes Canyon, Toquima Range.

Discussion.—The bulbous yet pointed axial termination of the pygidium seems to be unique; on that basis the species is probably not previously described. The hypostome as noted in the generic discussion is much like that of species of *Brongniartella* and *Platycorypha.*

The exsagittal length of the posterior fixed cheek is greater than in *Brongniartella minor* (Salter) (Whittington, 1966b, pl. 19, figs. 9, 19) of Caradoc age. The pygidium differs markedly in number of axial rings as well as relative axial length. The comparison between the Nevada cephalon and *B. bisulcata* (M'Coy) also indicates a longer (exsag.) posterior fixed cheek in the former (Dean, 1961, pl. 54, figs. 2, 4; pl. 55, fig. 7), but very similar hypostome; the number of axial rings is greater and shape of axis different in the Upper Caradoc (Marshbrookian) *B. bisulcata. B. edgelli* (Salter) (Dean, 1961, pl. 55, fig. 9) possesses a much narrower pygidium than that from Ikes Canyon. Cephalic features seem to be very similar to those of *B. platynotus* (Dalman), although the pygidium is markedly different (Kielan-Jaworowska, 1959, pl. 19, figs. 1–3).

Stratigraphically, this occurrence is important in substantiating the presence of Middle or Upper Ordovician beds above the Antelope Valley Limestone and below the Silurian Roberts Mountains Formation (Masket Shale of Kay and Crawford, 1964) in a section where no such strata were previously reported.

Genus WHITTINGTONIA Prantl and Pribyl, 1949

Whittingtonia Prantl and Pribyl. Kielan-Jaworowska, 1959, Palaeont. Polonica 11, p. 109.

Whittingtonia sp.

Plate 18, figure 13

Although cephalic parts are lacking, the only odontopleurid genus fulfilling thoracic and pygidial characteristics exemplified is *Whittingtonia.*

Thorax of at least seven segments. Slender spines directed posteriorly and laterally are extensions of posterior pleural ridge.

Pygidial axis composed of single ring and minute terminal piece. Pleural region flat, bears two pairs of spines directed posteriorly. The outer pair almost twice the length of inner pair. Some suggestion that outer pair of spines belongs to anterior axial ring.

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Figured specimen.—USNM 160896.

Occurrence.—USGS collection D1526 CO, unnamed formation, 115–128 feet above top of Antelope Valley Limestone, Ikes Canyon section, Nev.

Discussion.—The discrepancy in lengths of inner and outer pairs of pygidial spines is much greater in *Whittingtonia whittingtoni* Kielan than in this specimen from Ikes Canyon. Comparison with other species is impossible until more examples of pygidia are found.

Whittingtonia is previously reported only from Upper Ordovician strata in Ireland, Sweden, and Poland.

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[Italic page numbers indicate both major references and descriptions]

PLATES 1–19

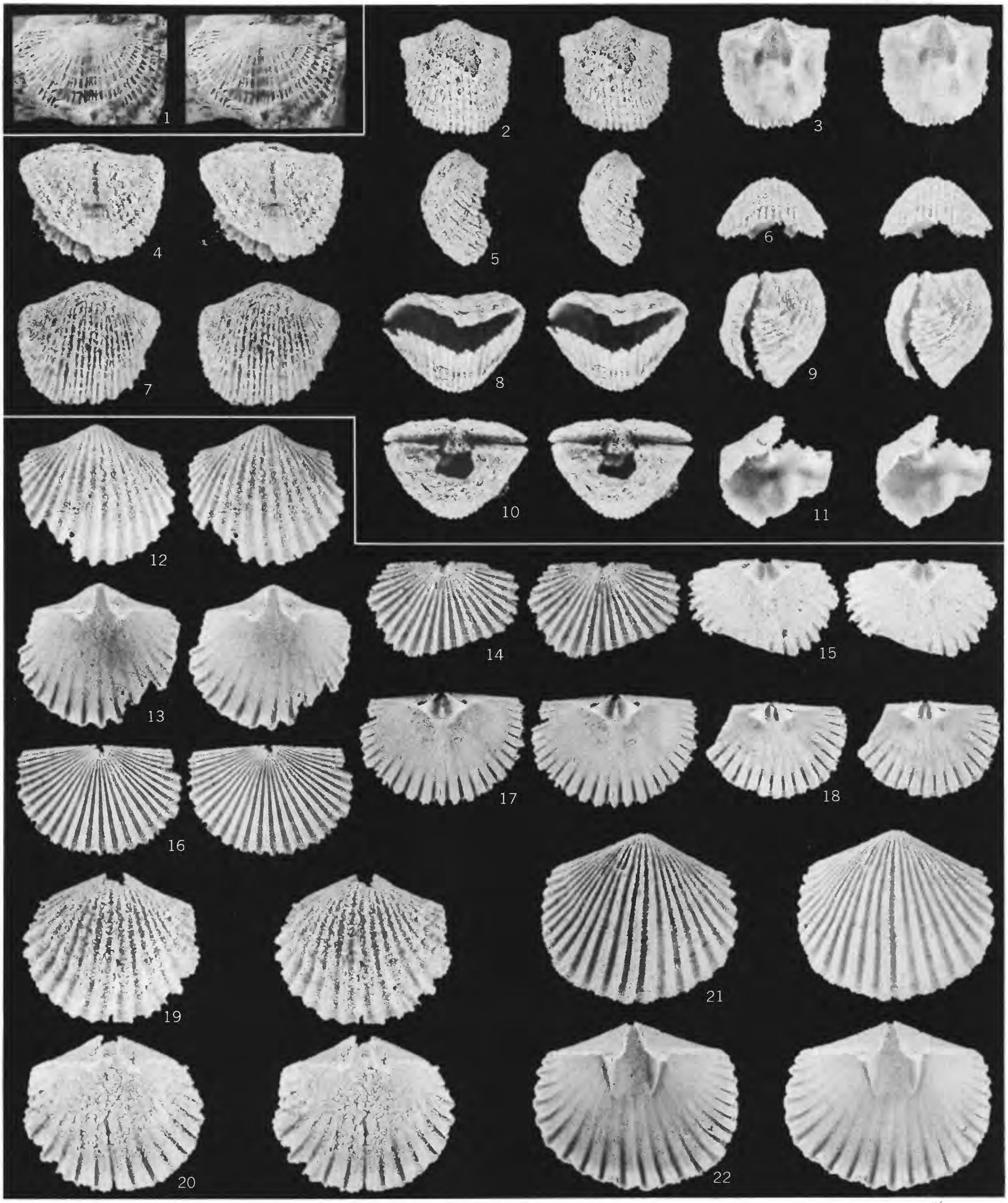
PLATE 1

[All illustrations are stereophotographs and were originally photographed with image separation of 50 mm; magnification × 3 unless otherwise indicated]

FIGURES 1. *Orthidium* cf. *O. bellulum* Ulrich and Cooper (p. 54).
USGS colln. D1514 CO, Ikes Canyon; brachial valve, exterior, × 5, USNM 160793.

2–11. *Orthidium barnesi* Ross, n. sp. (p. 53).
USGS colln. D1441, Specter Range.
2, 3, 5, 6. Pedicle valve, paratype, ventral, interior, lateral, and anterior views, × 5, USNM 160792a.
4, 7–10. Both valves, holotype, dorsal, ventral, anterior, lateral, and posterior views, X 6, umbo of pedicle valve broken away, USNM 160791.
11. Paratype, brachial valve, broken, interior view showing cardinalia, × 6, USNM 160792b.

12–22. *Hesperorthis* cf. *H. matutina* Cooper (p. 56).
12, 13. Pedicle valve, paratype, ventral and interior views, USGS colln. D1764 CO, Lone Mountain, USNM 160795a.
14, 15. Brachial valve, paratype, dorsal and interior views, USGS colln. D1764 CO, Lone Mountain, USNM 160795b.
16, 17. Brachial valve, paratype, dorsal and interior views, USGS colln. D1382 CO, Pahranagat Range, USNM 160795m.
18. Brachial valve, paratype, interior view, USGS colln. D375 CO, Lone Mountain, USNM 160795d.
19, 20. Pedicle valve, paratype, exterior and interior views, USGS colln. D375 CO, Lone Mountain, USNM 160795c.
21, 22. Pedicle valve, paratype, ventral and interior views, USGS colln. D1382 CO, Pahranagat Range, USNM 160795n.



ORTHIDIUM, HESPERORTHIS

PLATE 2

[All illustrations are stereophotographs; magnification is × 3, except figs. 11, 12 are × 6. All from Pahranagat Range]

FIGURES 1–10, 13–16. *Hesperorthis* cf. *H. matutina* Cooper (p. 56).

1, 3, 5, 7. Both valves, holotype, damaged, dorsal, ventral, posterior, and lateral views, USGS colln. D1382 CO, USNM 160794.

2, 4. Brachial valve, paratype, dorsal and internal views, USGS colln. D1674 CO, USNM 160795e.

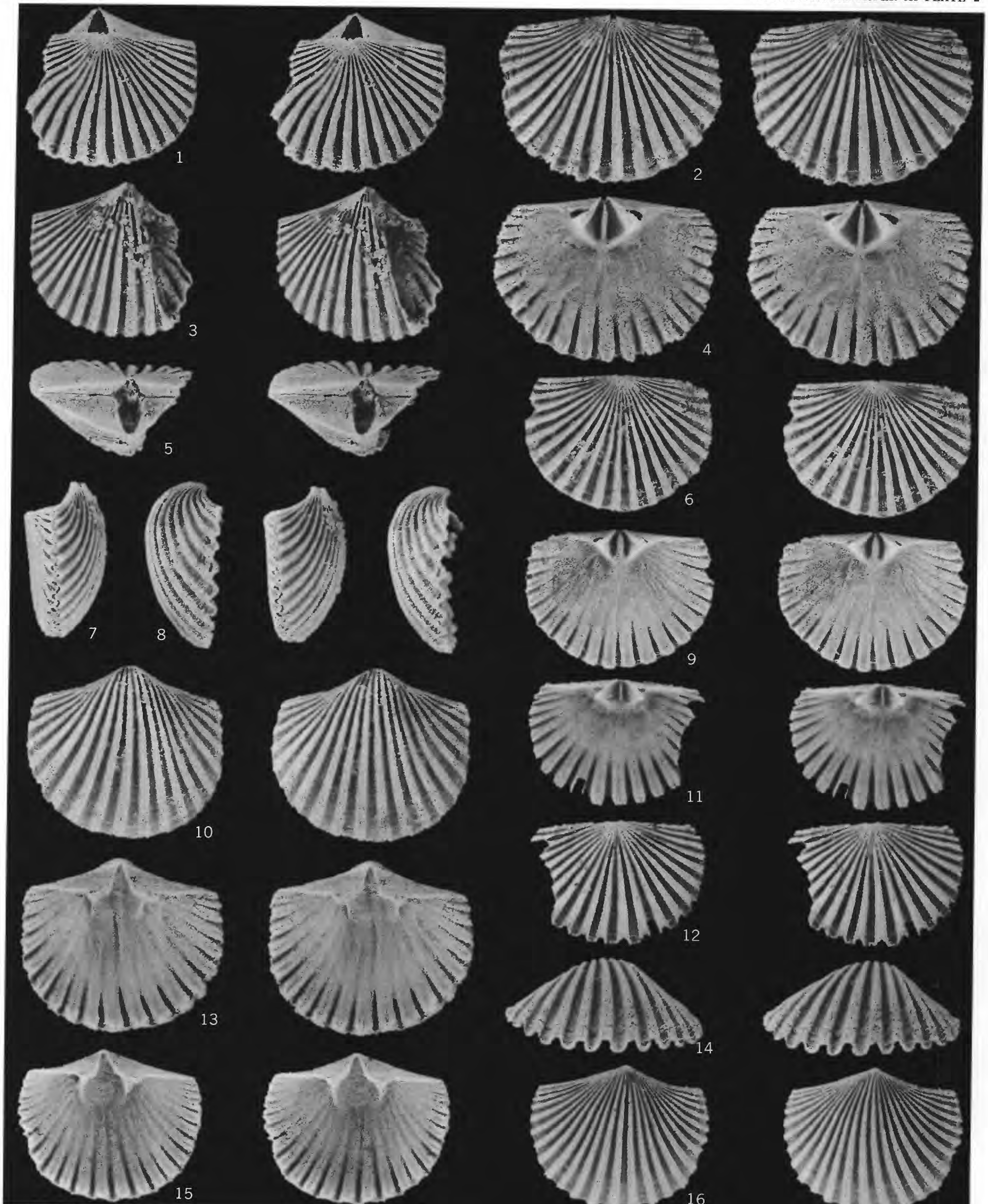
6, 9. Brachial valve, paratype, dorsal and internal views. Note thickened cardinal process. USGS colln. D1674 CO, USNM 160795f.

8, 10, 13, 14. Pedicle valve, paratype, lateral, ventral, interior, and anterior views, USGS colln. D1382 CO, USNM 160795p.

15, 16. Pedicle valve, paratype, interior and ventral views, USGS colln. D1382 CO, USNM 160795o.

11, 12. *Hesperorthis* aff. *H. matutina* Cooper.

Brachial valve, interior and dorsal views, USGS colln. D1382 CO, USNM 160795q.



HESPERORTHIS

PLATE 3

[All figures are stereophotographs]

FIGURES 1–3. *Hesperorthis cf. H. matutina* Cooper (p. 56).

USGS colln. D1382 CO, Pahranagat Range.

1. Brachial valve, paratype, interior view, × 3, showing thickening near tip of cardinal process, USNM 160795l.
2. Brachial valve, paratype, interior view, × 3, seemingly split shaft at end of cardinal process, USNM 160795g.
3. Brachial valve, pathologic, dorsal view, × 3, showing injury 3 mm from beak and subsequent development of low median fold composed of four costae, USNM 160795k.

4–19. *Orthambonites marshalli* (Wilson) (p. 54).

4–8. Complete specimen, ventral, dorsal, posterior, anterior, and lateral views, × 2, USGS colln. D1584 CO, southern Groom Range, USNM 160797a.

9. Pedicle valve, interior, × 3, showing muscle scars and pallial impressions, USGS colln. D1009 CO, Quartz Spring area, USNM 160797f.

10. Pedicle valve, interior, × 2, USGS colln. D1583 CO, southern Groom Range, USNM 160797c.

11. Brachial valve, interior, × 2, USGS colln. D1583 CO, southern Groom Range, USNM 160797d.

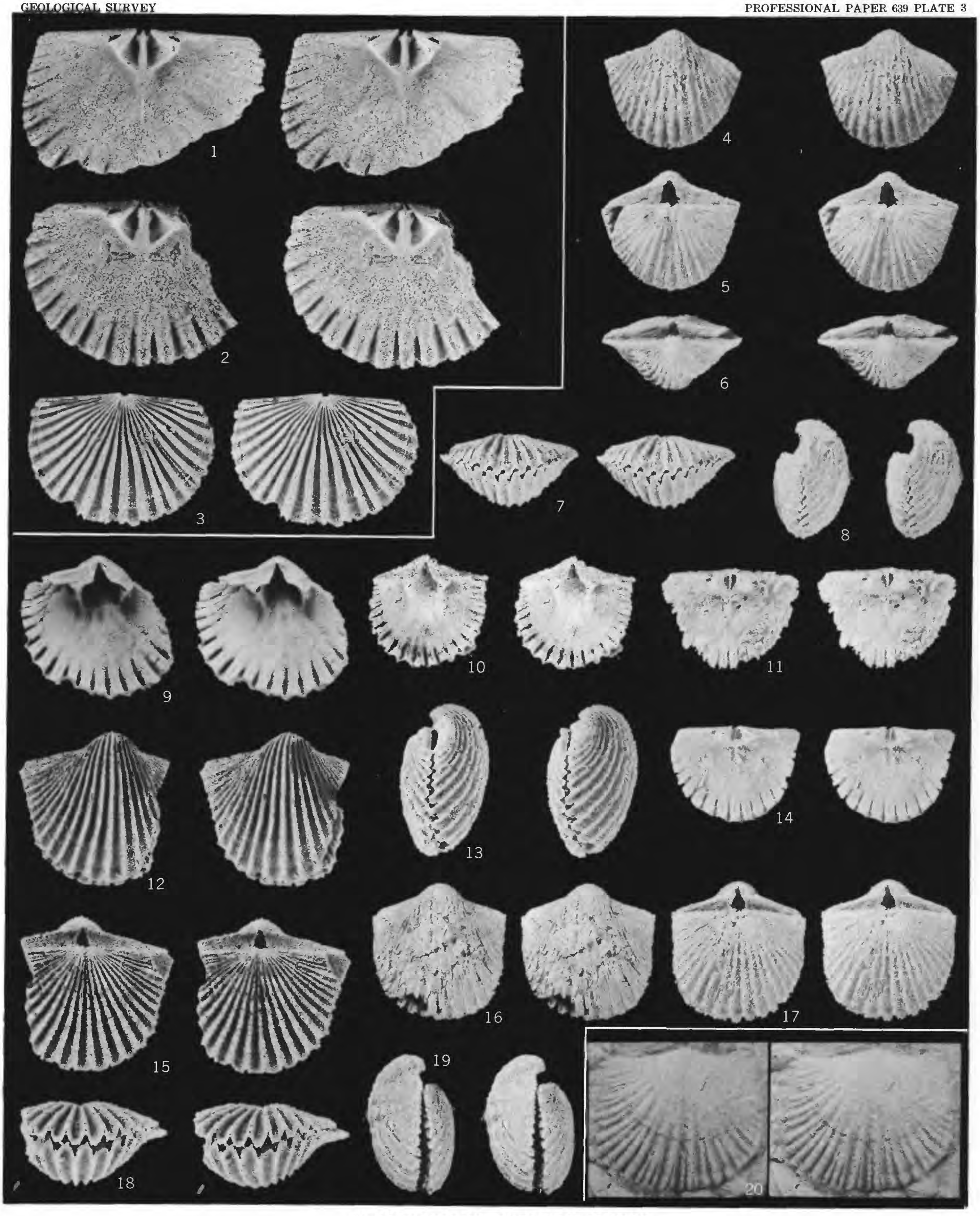
12, 13, 15, 18. Complete specimen, damaged, ventral, lateral, dorsal, and anterior views, × 3, USGS colln. D1009 CO, Quartz Spring area, USNM 160797h.

14. Brachial valve, interior, × 2, USGS colln. D1583 CO, southern Groom Range, USNM 160797e.

16, 17, 19. Complete specimen, ventral, dorsal, and lateral views, × 2, USGS colln. D1583 CO, southern Groom Range, USNM 160797b.

20. *Orthambonites bifurcatus* Cooper (p. 54).

USGS colln. D1507 CO, Ikes Canyon, brachial valve, dorsal view, × 3, USNM 160796.



HESPERORTHIS, ORTHAMBONITES

PLATE 4

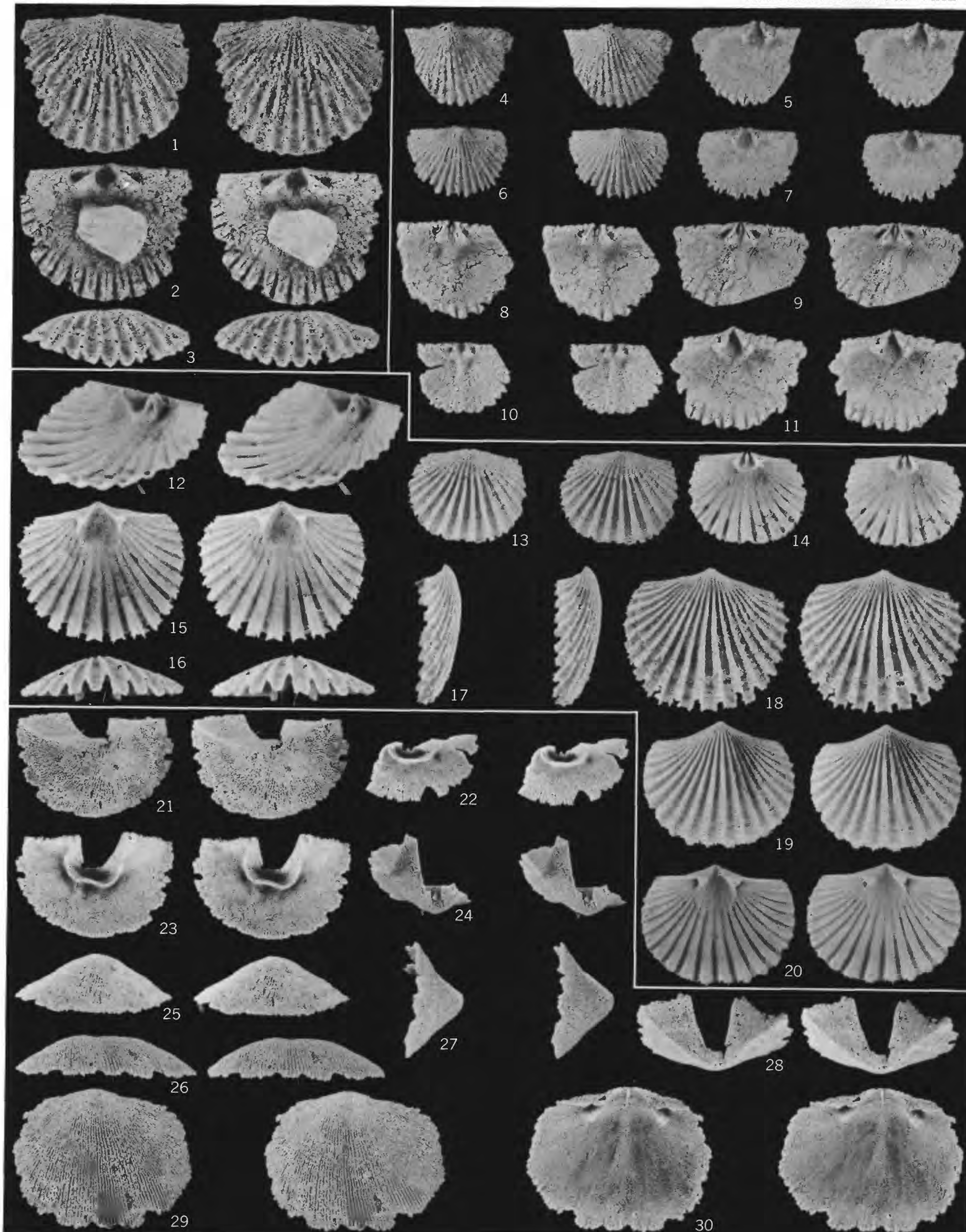
[All figures are stereophotographs]

FIGURES 1–3. *Orthambonites marshalli* (Wilson) (p. 54).
Brachial valve, dorsal, interior, and anterior views, × 3, USGS colln. D1009 CO, Quartz Spring area, California, USNM 160797g.

4–11. *Orthambonites minusculus* (Phleger) (p. 55).
USGS colln. D1520 CO, Ikes Canyon.
4, 5. Pedicle valve, broken, ventral and interior views, × 2, USNM 160798a.
6, 7. Pedicle valve, abraded, ventral and interior views, × 2, USNM 160798b.
8. Brachial valve, interior, showing small cardinal process, × 3, USNM 160798d.
9. Brachial valve, interior, showing well-developed cardinal process and callus below brachiophores, × 3, USNM 160798e.
10. Brachial valve, interior, showing no cardinal process, × 2, USNM 160798c.
11. Pedicle valve, interior, × 3, USNM 160798f.

12–20. *Plectorthis* cf. *P. perplexus* (Ross) (p. 57).
USGS colln. D1665 CO, Pahranagat Range.
12–14. Brachial valve, oblique view, × 5, showing primitive fulcral plates, dorsal and interior views, × 3, USNM 160799b.
15–18. Pedicle valve, interior, anterior, lateral, and ventral views, × 5, USNM 160799c
19, 20. Pedicle valve, ventral and interior views, × 3, USNM 160799a.

21–30. *Anomalorthis resoi* Ross, n. sp. (p. 61).
USGS colln. D1382 CO, Pahranagat Range.
21, 23, 25, 27, 28. Brachial valve, holotype, ventral, interior, anterior, lateral, and posteroventral views, × 2. Note pseudodeltidium in apex of delthyrium. USNM 160800.
22, 24. Pedicle valve, fragmentary, paratype, showing remains of pseudodeltidium, × 2, USNM 160801a.
26, 29, 30. Brachial valve, paratype, showing abraded margins, anterior, dorsal, and interior views, × 3, USNM 160801b.



ORTHAMBONITES, PLECTORTHIS, ANOMALORTHIS

PLATE 5

[All figures are stereophotographs]

FIGURES 1–10. *Anomalorthis resoi* Ross, n. sp. (p. 61).

USGS colln. D1382 CO, Pahranagat Range.

1, 4, 5, 8, 9, Paratype, complete specimen, immature, dorsal, ventral, lateral, posterior, and anterior views, × 3, USNM 160801c

2, 3, 6, 7, 10. Paratype, complete specimen, immature, posterior, dorsal, lateral, anterior, and ventral views, × 4. Note extreme proclination of cardinal area, USNM 160801d.

11–17. *Anomalorthis lonensis* (Walcott) (p. 61).

11, 15, 17. Pedicle valve, ventral, interior, and lateral views, × 3, USGS colln. D375 CO, Lone Mountain, USNM 160802a.

12–14, 16. Brachial valve, lateral, anterior, dorsal, and interior views, × 3, USGS colln. D1382 CO, Pahranagat Range, USNM 160802d.

18–25. *Anomalorthis fascicostellatus* Ross, n. sp. (p. 62).

USGS colln. D1764 CO, Lone Mountain.

18, 20, 22, 25. Paratype, pedicle valve, lateral, interior, ventral, and anterior views, × 3, USNM 160804.

19, 21, 23, 24. Holotype, brachial valve, dorsal, anterior, lateral, and interior views, × 3, USNM 160803.

26–31. *Anomalorthis* n. sp. A (p. 62).

USGS colln. southern Groom Range.

26, 27, 28, 31. Brachial valve, lateral, dorsal, anterior, and interior views, × 3, USNM 160805.

29, 30. Brachial valve, dorsal and interior views, × 3, USNM 160806a.

ANOMALORTHIS

PLATE 6

[All figures are stereophotographs]

FIGURES 1, 4, 6–18. *Desmorthis crassus* Ross, n. sp. (p. 59).

USGS colln. D1674 CO, Pahranagat Range.

1, 4, 7, 8. Pedicle valve, paratype, ventral, interior, anterior, and lateral views, X 5, USNM 160808C.

6, 9. Brachial valve, holotype, dorsal and interior views, X 4, USNM 160807.

10–12, 15. Brachial valve, paratype, dorsal, lateral, interior, and anterior views, X 4, USNM 160808a.

13, 14, 16–18. Complete specimen, paratype, damaged, posterior, anterior, ventral, lateral, and dorsal views, X 5, USNM 160808d.

2, 3, 5. *Anomalorthis* n. sp. A (p. 62).

USGS colln. D1583 CO, southern Groom Range, pedicle valve, interior, ventral, and lateral views, × 3, USNM 16086b.

19–21. *Plectorthis*? *obesa* Cooper (p. 58).

USGS colln. D1877 CO, upper Part, Copenhagen Formation, Antelope Valley area. All are latex casts of topotype specimens.

19. Pedicle valve, interior, × 1, showing tripartite muscle field, USNM 160810a.

20. Brachial valve, interior, × 1, excavated only far enough to show septum at base of cardinal process, USNM 160810b.

21. Brachial valve, interior, × 1, showing enlarged cardinal process, fully excavated, USNM 160810c.

22, 23. *Plectorthis*? sp. (p. 58).

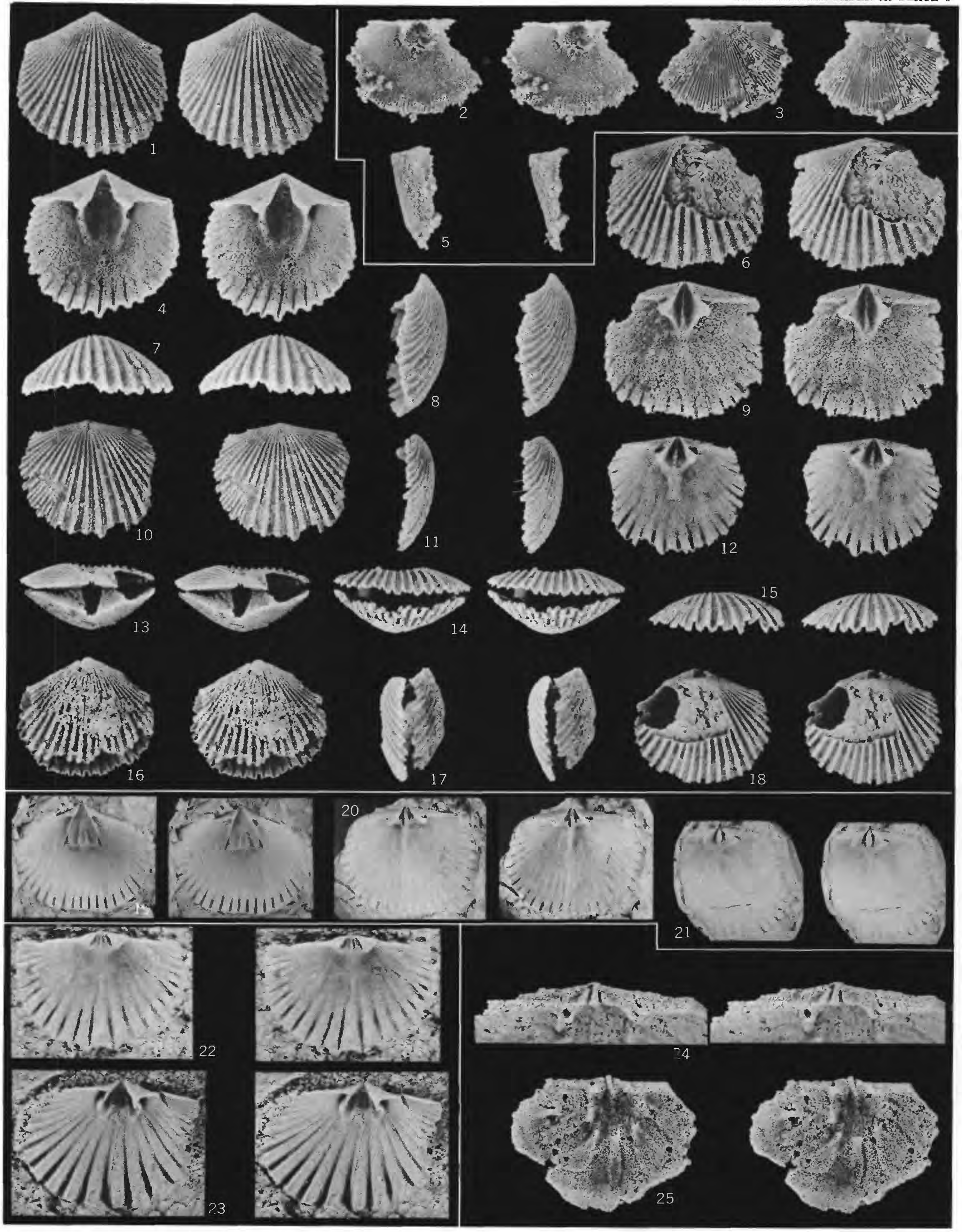
USGS colln. D1812 CO, Steptoe section. Specimens abraded and poorly preserved.

22. Brachial valve, interior, × 3, USNM 160809a.

23. Pedicle valve, interior, × 3, USNM 160809b.

24, 25. *Asymphylotoechia nolani* Ross, n. gen., n. sp. (p. 60).

USGS colln. D375a CO, Lone Mountain section, brachial valve, paratype, oblique view of hinge, × 5, and interior view, × 3, USNM 160812k.



DESMORTHIS, ANOMALORTHIS, PLECTORTHIS?, ASYMPHYLOTOECHIA

PLATE 7

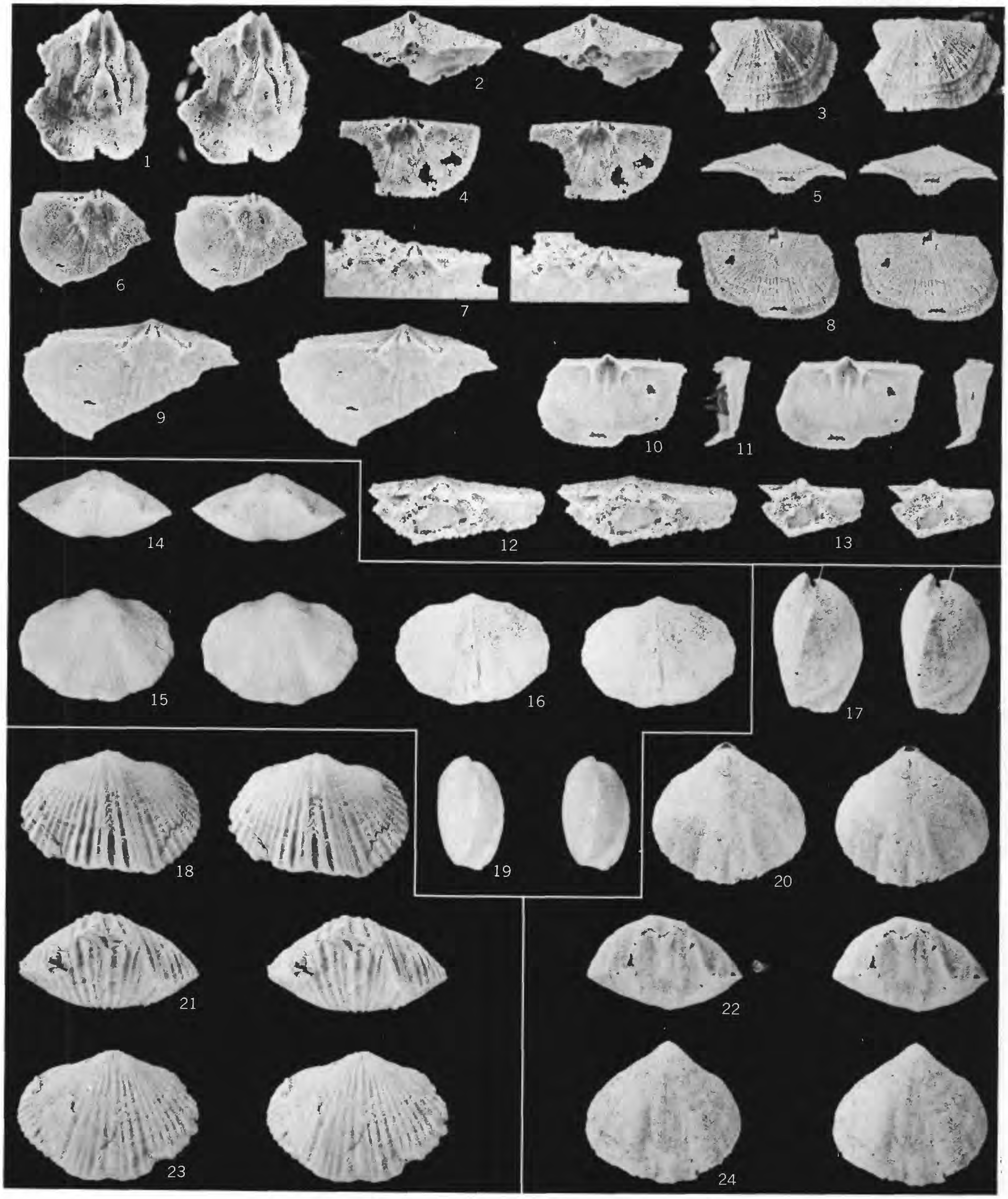
[All figures are stereophotographs]

FIGURES 1–13. *Asymphylotoechia nolani* Ross, n. gen., n. sp. (p. 60).
USGS collns, D375a CO, D1764 CO, Lone Mountain section.
1. Pedicle valve, paratype, interior of fragmentary shell, × 3, USNM 160812c.
2. Pedicle valve, paratype, posterior view, × 3, USNM 160812d.
3. Brachial valve, paratype, dorsal view, × 3, USNM 160812d.
4. Brachial valve, Holotype, interior, × 3, USNM 160811.
5, 8, 10, 11. Pedicle valve, paratype, anterior, ventral, interior, and lateral views, × 3, USNM 160812m.
6, 9. Brachial valve, paratype, interior, × 3, and posteroventral views, × 5, USNM 160812l.
7. Brachial valve, paratype, fragmentary, interior view of cardinalia, × 5, USNM 160812f.
12, 13. Brachial valve, paratype, fragmentary, posteroventral view, × 5, and interior view, × 3, showing complete chilidium, USNM 160812g.

14–16, 19. *Rhysostrophia occidentalis* Ulrich and Cooper.
(Not described.) USGS colln. D1004 CO, northern Inyo Range (Ross, 1964a, p. C40), anterior, ventral, dorsal, and lateral views, × 2, USNM 160814.

18, 21, 23. *Rhysostrophia nevadensis* Ulrich and Cooper (p. 68).
USGS colln. D1509 CO, Ikes Canyon, complete specimen, topotype, dorsal, anterior, and ventral views, × 2, USNM 160813.

17, 20, 22, 24. *Camerella* aff. *C. nuda* Cooper (p. 68).
USGS colln. D1634 CO, Ranger Mountains, Nevada Test Site (Ross, 1967a, pl. 11), holotype, complete specimen, lateral, dorsal, anterior, and ventral views, × 2, USNM 160815.



ASYMPHYLOTOECHIA, RHYSOSTROPHIA, CAMERELLA

PLATE 8

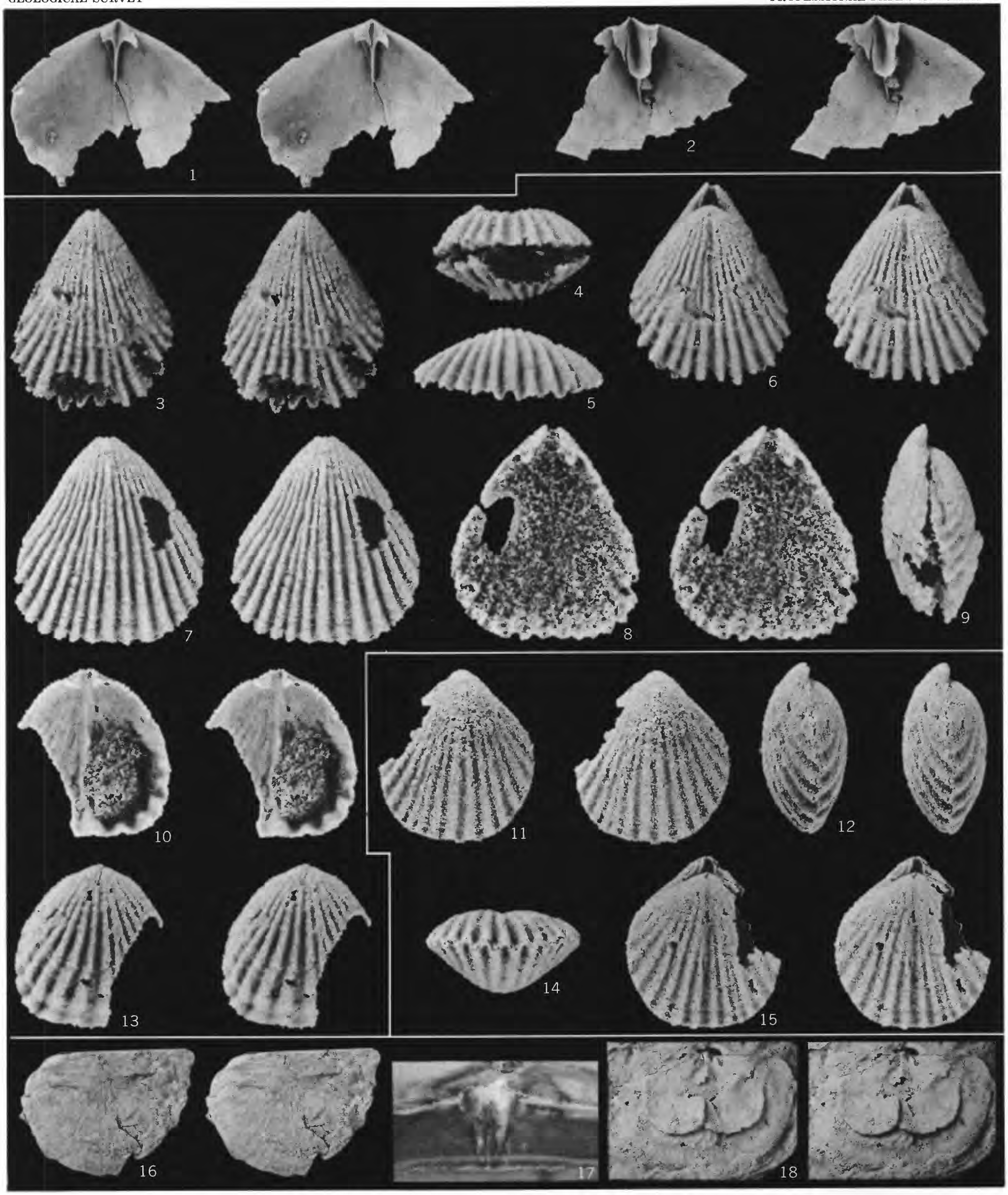
[All figures are stereophotographs, except figs. 4, 5, 9, 14, and 17]

FIGURES 1, 2. *Camerella* aff. *C. nuda* Cooper (p. 68).
USGS colln. D1634 CO, Ranger Mountains, Nevada Test Site (Ross, 1967a, pl. 11)
1. Brachial valve, fragmentary, paratype, interior, × 3, USNM 160816b.
2. Pedicle valve, fragmentary, paratype, interior, × 3, USNM 160816a.

3–9. *Sphenotreta* cf. *S. sulcata* Cooper (p. 69).
USGS colln. D1665 CO, Pahranagat Range.
3, 4, 6, 9. Complete individual, damaged, ventral, anterior, dorsal, and lateral views, × 10, USNM 160817a.
5, 7, 8. Pedicle valve, anterior, ventral, and interior views, × 10, USNM 160817c.
10, 13. Brachial valve, interior and dorsal views, × 10, USNM 160817d.

11, 12, 14, 15. *Dorytreta subcircularis* Ross, n. sp. (p. 69).
USGS colln. D1634 CO, Ranger Mountains, Nevada Test Site (Ross, 1967a, pl. 11), holotype, complete specimen, damaged, ventral, lateral, anterior, and dorsal views, × 10, USNM 160818.

16–18. *Toquimia kirki* Ulrich and Cooper (p. 63).
16, 17. Brachial valve, dorsal view, × 1, and posterior view of hinge, × 5, polished section to show structure of cardinal process; lower surface in view is dorsal surface of shell, USGS colln. D1511 CO, Ikes Canyon, USNM 160820b.
18. Brachial valve, interior view, × 1, showing knoblike cardinal process and pronounced visceral flange, USGS colln. D1508 CO, Ikes Canyon, USNM 160820a.



CAMERELLA, SPHENOTRETA, DORYTRETA, TOQUIMIA

PLATE 9

[All figures are stereophotographs]

FIGURES 1–4. *Aporthophyla typa* Ulrich and Cooper (p. 63).
USGS colln. D1656 CO, above Caesar Canyon, Toquima Range.
1, 2. Brachial valve, dorsal and interior views, × 1, USNM 160821a.
3, 4. Pedicle valve, interior and ventral views, × 1, USNM 160821b.

5, 7. *Leptellina occidentalis* Ulrich and Cooper (p. 65).
USGS colln. D1507 CO, Ikes Canyon.
5. Brachial valve, interior, × 4, USNM 160824b.
7. Pedicle valve, ventral view, × 3, USNM 160824a.

6. *Leptaena* cf. *L. ordovicica* Cooper (p. 66).
USGS colln. D1506 CO, Ikes Canyon, unnamed formation above Pogonip Group, pedicle valve, ventral view, × 1, USNM 160825.

8. *Isophragma* sp. (p. 64).
USGS colln. D1655 CO, Caesar Canyon, Toquima Range, brachial valve, immature, internal view, × 6, USNM 160822.

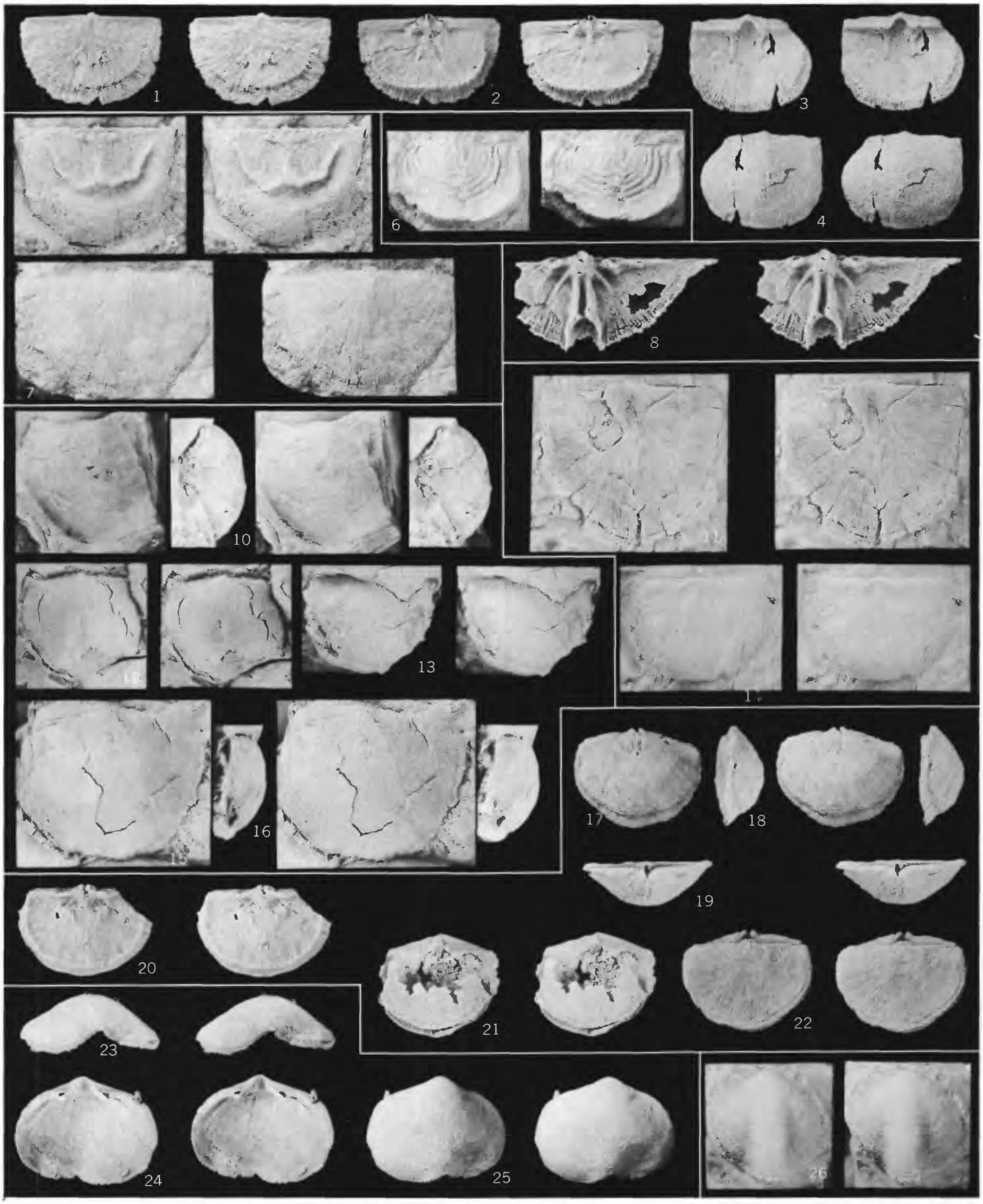
9, 10, 12, 13, 15, 16. *Öpikina* cf. *Ö. expatiata* Cooper (p. 66).
USGS colln. D1814 CO, Steptoe section.
9, 10. Pedicle valve, ventral and lateral views, × 1, USNM 160827a.
12. Pedicle valve, ventral view, × 1, USNM 160827b.
13, 16. Pedicle valve, ventral and lateral views, × 1. This specimen is overlain by the shell in figure 9. USNM 160827c.
15. Pedicle valve, ventral view, × 2, USNM 160827d.

11, 14. *Glyptomena*? sp. (p. 65).
USGS colln. D1813 CO, Steptoe section.
11. Brachial valve, dorsal view, × 2, USNM 160826b.
14. Brachial valve, interior of partly weathered specimen, × 1, USNM 160826a.

17–22. *Dactylogonia vespertina* Ross, n. sp. (p. 67).
USGS colln. D1559 CO, southern Groom Range, all × 2.
17–19, 22. Complete shell, paratype, ventral, lateral, posterior, and dorsal views, 160829a.
20. Brachial valve, holotype, interior view, USNM 160828.
21. Complete shell, paratype, brachial valve broken, dorsal view, USNM 160829c.

23–25. *Syntrophopsis* sp. (p. 67).
USGS colln. D1572 CO, southeast end of Groom Range, brachial valve, anterior, interior, and dorsal views, × 1, USNM 160832.

26. Genus and species indeterminate (p. 70).
USGS colln. D1506 CO, Ikes Canyon, unnamed limestone above Pogonip Group, brachial valve, dorsal view, × 3, USNM 160831.



APORTHOPHYLA, LEPTELLINA, LEPTAENA, ISOPHRAGMA, ÖPIKINA, GLYPTOMENA?, DACTYLOGONIA, SYNTROPHOPSIS

PLATE 10

[All figures are stereophotographs]

FIGURE 1. *Hesperomena leptellinoidea* Cooper (p. 64).
USGS colln. D1508 CO, Ikes Canyon, both valves, broken, anterior view, × 3, showing great overhang of cardinal process, USNM 160823.

2, 3. *Gacella*? sp. (p. 67).
USGS colln. D299e CO, Antelope Valley composite section.
2. Pedicle valve, ventral view, × 3, USNM 160830a.
3. Brachial valve, dorsal view, × 4, USNM 160830b.

4–9. *Geragnostus* sp. (p. 70).
USGS colln. D340i CO, Antelope Valley composite section.
4, 6, 8. Cephalon, dorsal, anterior, and lateral views, × 5, USNM 160833a.
5, 7, 9. Pygidium, dorsal, posterior, and lateral views, × 5, USNM 160833b.

10–13. *Paratolinella hecuba* (Walcott) (p. 71).
USGS colln. D289 CO, Antelope Valley composite section.
10–12. Cranidium, dorsal, anterior, and lateral views, × 2, USNM 160834a.
13. Free cheek, dorsal view, × 2, USNM 160834b.

14–19. *Hypermecaspis kolouros* Ross, n. sp. (p. 71).
USGS colln. D289 CO, Antelope Valley composite section.
14. Pygidium, paratype, dorsal view, × 4, USNM 160836b.
15, 16. Pygidium, paratype, dorsal and lateral views, × 3, USNM 160836a.
17–19. Cranidium, holotype, anterior, lateral, and dorsal views, × 2, USNM 160835.

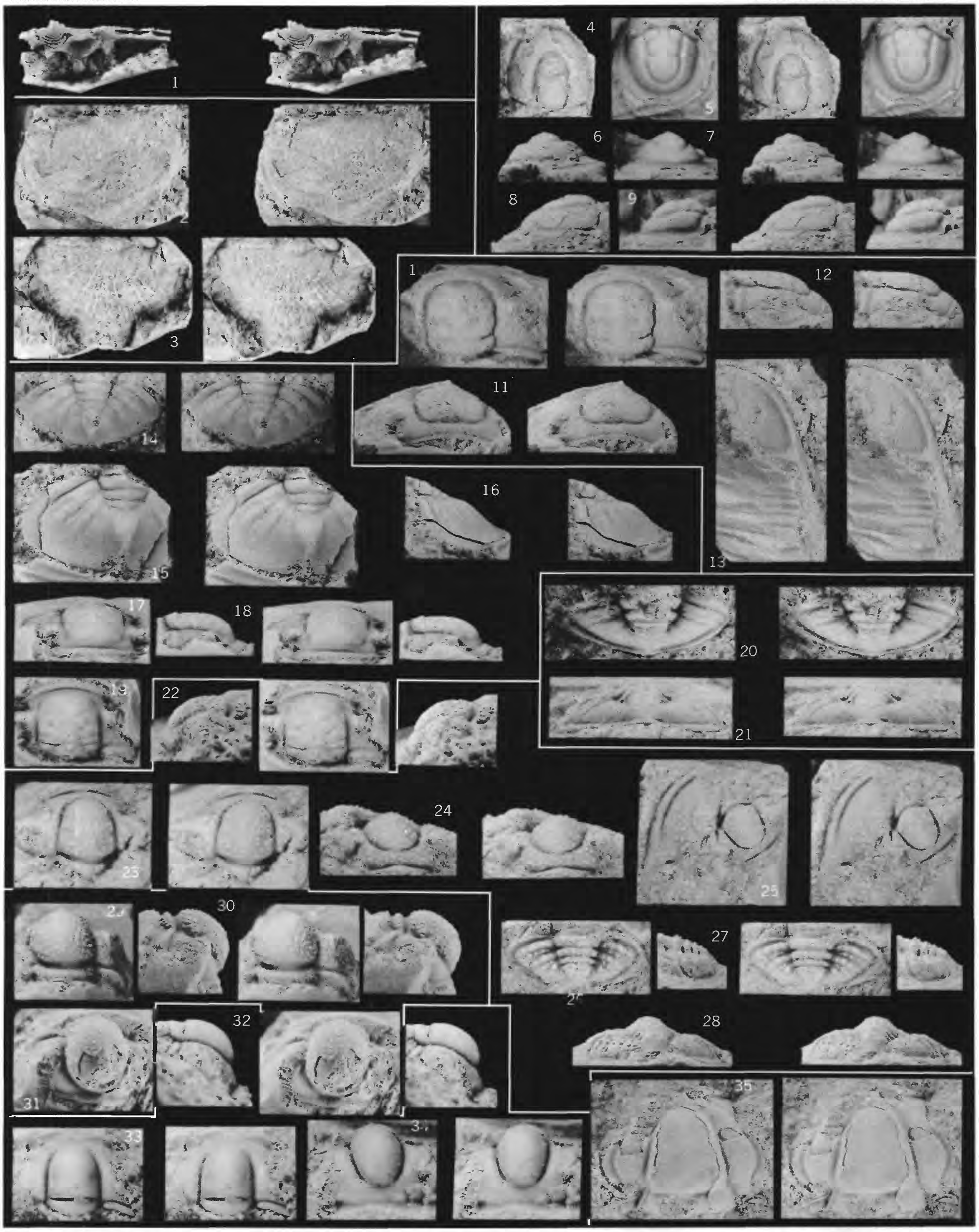
20, 21. Unidentified pygidium, hystricurid or olenid (p. 72).
USGS colln. D1835 CO, Steptoe section, dorsal and posterior views, × 5, USNM 160839

22–28. *Hystricurus* aff. *H. genalatus* Ross (p. 72).
USGS colln. D368h CO, Antelope Valley composite section.
22–24. Cranidium, lateral, dorsal, and anterior views, × 3, USNM 160838a.
25. Free cheek, dorsal view, × 2, USNM 160838b.
26–28. Pygidium, dorsal, lateral, and posterior views, × 3, USNM 160838c.

29–31. *Pseudohystricurus* sp. (p. 72).
USGS colln. D368h CO, Antelope Valley composite section, cranidium, dorsal, lateral, and anterior views, × 3, USNM 160840.

32–34. Undetermined hystricurid(?) species (p. 73).
USGS colln. D297 CO, Antelope Valley composite section, cranidium, lateral, dorsal and anterior views, × 6, USNM 160842.

35. *Hystricurus* cf. *H. oculilunatus* Ross (p. 72).
USGS colln. D1834 CO, Steptoe section, cranidium, damaged, dorsal view, × 5, USNM 160837.



HESPEROMENA, GACELLA?, GERAGNOSTUS, PARABOLINELLA, HYPERMECASPIS, HYSTRICURUS, PSEUDOHYSTRICURUS

PLATE 11

[All figures are stereophotographs]

FIGURES 1, 2. *Pseudohystricurus*? sp. (p. 73).
USGS colln. D1833 CO, Steptoe section, cranidium, dorsal and anterior views, × 5, USNM 160841.

3. Pygidium, indeterminate (p. 73).
USGS colln. D1507 CO, Ikes Canyon, dorsal view, × 10, USNM 160843.

4–11. *Leiostegium goodwinensis* Ross, n. sp. (p. 74).
USGS colln. D297 CO, Antelope Valley composite section.
4–6. Cranidium, holotype, lateral, dorsal, and anterior views, × 2, USNM 160844.
7, 9, 10. Pygidium, paratype, dorsal, posterior, and lateral views, × 6, USNM 160845b.
8. Free cheek, left, paratype, dorsal view, × 2, USNM 160845a.
11. Pygidium, paratype, dorsal view, × 1, USNM 160845c.

12–15. *Leiostegium tyboensis* Ross, n. sp. (p. 75).
USGS colln. D812 CO, Rawhide Mountain (Ross, 1964a, p. C69).
12. Holotype, pygidium, dorsal view, × 2, USNM 160846.
13–15. Cranidium, paratype, dorsal, anterior, and lateral views, × 2, USNM 160847.

16–20. *Apatokephalus* sp. (p. 75).
USGS colln. D812 CO, Rawhide Mountain (Ross, 1964a, p. C69).
16, 19. Pygidium, posterior and dorsal views, × 3, USNM 160848a.
17, 18, 20. Cranidium, lateral, anterior, and dorsal views, × 3, USNM 160848b.

21. *Aulacoparia* sp.
(Not described.) USGS colln. D827 CO, Meiklejohn Peak (Ross, 1967a, pl. 11), cranidium, dorsal view, × 4, USNM 160897.

22–25. *Aulacoparia* cf. *A. venta* (Hintze) (p. 76).
USGS colln. D340i CO, Antelope Valley composite section.
22. Cranidium, dorsal view, × 5, USNM 160850a.
23, 25. Cranidium, dorsal and anterior views, × 3, USNM 160850b.
24. Cranidium, dorsal view, × 3, USNM 160850c.

26. *Varvia*? sp. (p. 76).
USGS colln. D368k CO, Antelope Valley composite section, pygidium, dorsal view, × 3, USNM 160849.

27. *Basilicus mckeei* Ross, n. sp. (p. 77).
USGS colln. D1857 CO, Hot Creek Canyon, pygidium, rubber cast of ventral side showing extent of doublure, × 2, USNM 160851b.

PSEUDOHYSTRICURUS?, LEIOSTEGIUM, APATOKEPHALUS, AULACOPARIA, VARVIA?, BASILICUS

PLATE 12

[All figures are stereophotographs, except figs. 13, 15, 16, 18]

FIGURES 1–18. *Basilicus mckeei* Ross, n. sp. (p. 77).

Figs. 1–11 from USGS colln. D1884 CO, Antelope Valley Limestone, above saddle east of hill 7220, SW¼ sec. 10, T. 16 N., R. 46 E., Wildcat Peak quad., Nevada.

1–3. Cranidium, paratype, dorsal, anterior and lateral views, × 3, USNM 160853a.

4. Cranidium, paratype, dorsal view, × 3, USNM 160853b.

5. Cranidium, paratype, dorsal view, × 3, USNM 160853c.

6. Hypostome, paratype, ventral view, × 1, showing posterior emargination, USNM 160853d.

7, 8. Holotype, pygidium, dorsal and lateral views, × 3, USNM 160852.

9. Hypostome, paratype, posterior broken, ventral view, × 3, showing outline of middle body, USNM 160853e.

10, 11. Free cheek, lateral and dorsal views, × 3, USNM 160853f.

12. Cranidium, latex cast, dorsal view, × 3, USGS colln. D1508 CO, Ikes Canyon, USNM 160854a.

13, 15, 16, 18. Complete carapace, damaged, anterior, posterior, dorsal, and lateral views, × 2, USGS colln. D1857 CO, Hot Creek Canyon, USNM 160851a.

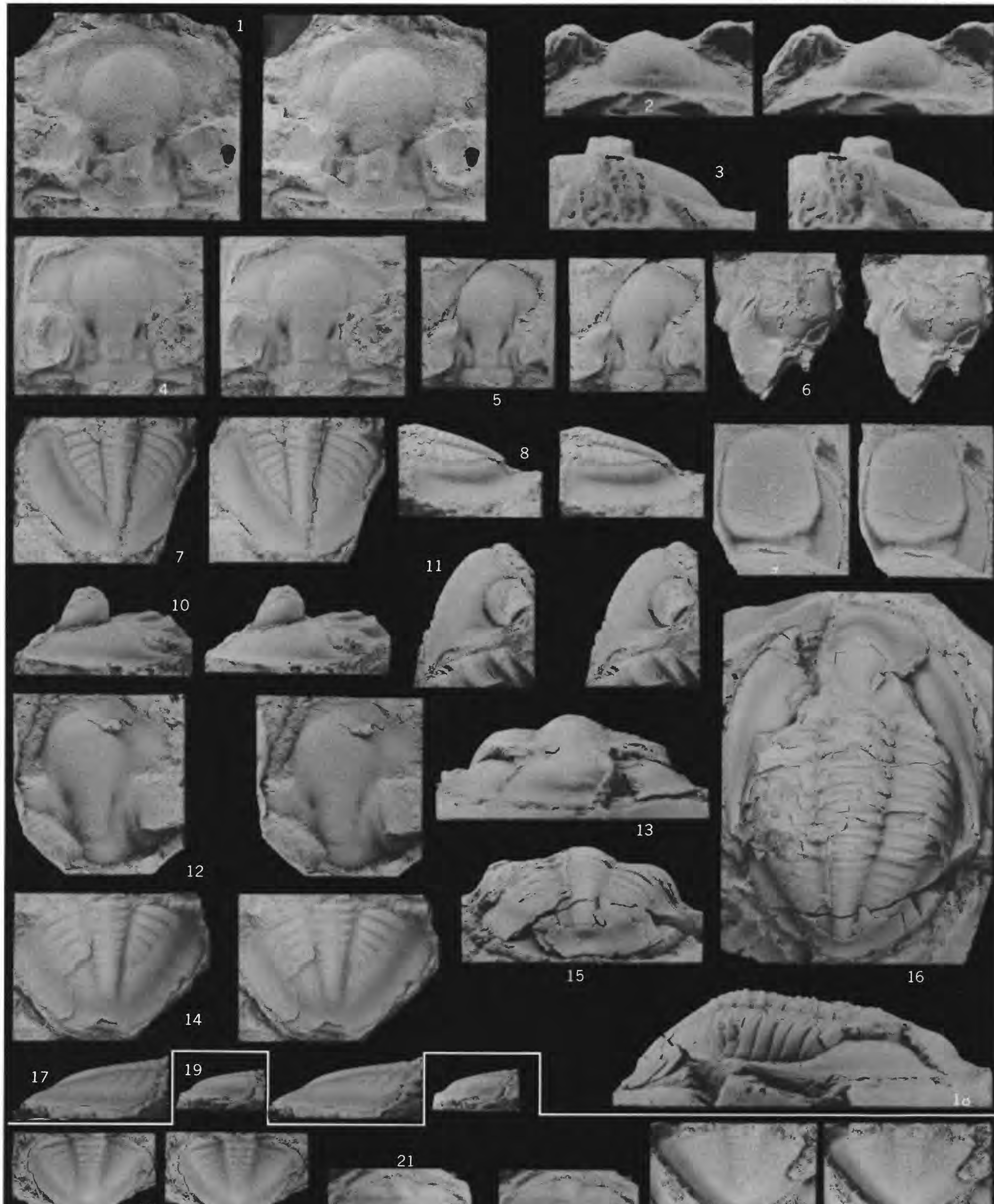
14, 17. Pygidium, dorsal and lateral views, × 2. Collected by G. A. Cooper of U.S. National Museum from "*Leptellina* beds, Ikes Canyon," USNM 160854b.

19–22. *Asaphellus* sp. 1 (p. 79).

USGS colln. D1833 CO, Steptoe section. 19

19–21. Pygidium, lateral, dorsal and posterior views, × 2, USNM 160859b.

22. Pygidium, dorsal view. × 3. USNM 160859a.



BASILICUS, ASAPHELLUS

PLATE 13

[All figures are stereophotographs]

FIGURE 1. *Apatokephalus* sp. (p. 75).
USGS colln. D812 CO, Rawhide Mountain (Ross, 1964a, p. C69), free cheek, left, dorsal view, × 3, USNM 160848c.

2. *Asaphellus* sp. 1 (p. 79).
USGS colln. D1833 CO, Steptoe section, hypostome, ventral view, × 6, USNM 160859c.

3, 5, 7, 10. *Isotelus*? *spurius* Phleger (p. 78).
USGS colln. D710a CO, Ranger Mountains, Nevada Test Site (Ross, 1967a, pl. 11).
3. Cranidium, dorsal view, × 7, USNM 160855a.
5. Pygidium, dorsal view, × 3, USNM 160855b.
7, 10. Pygidium, dorsal and lateral views, × 3, USNM 160855c.

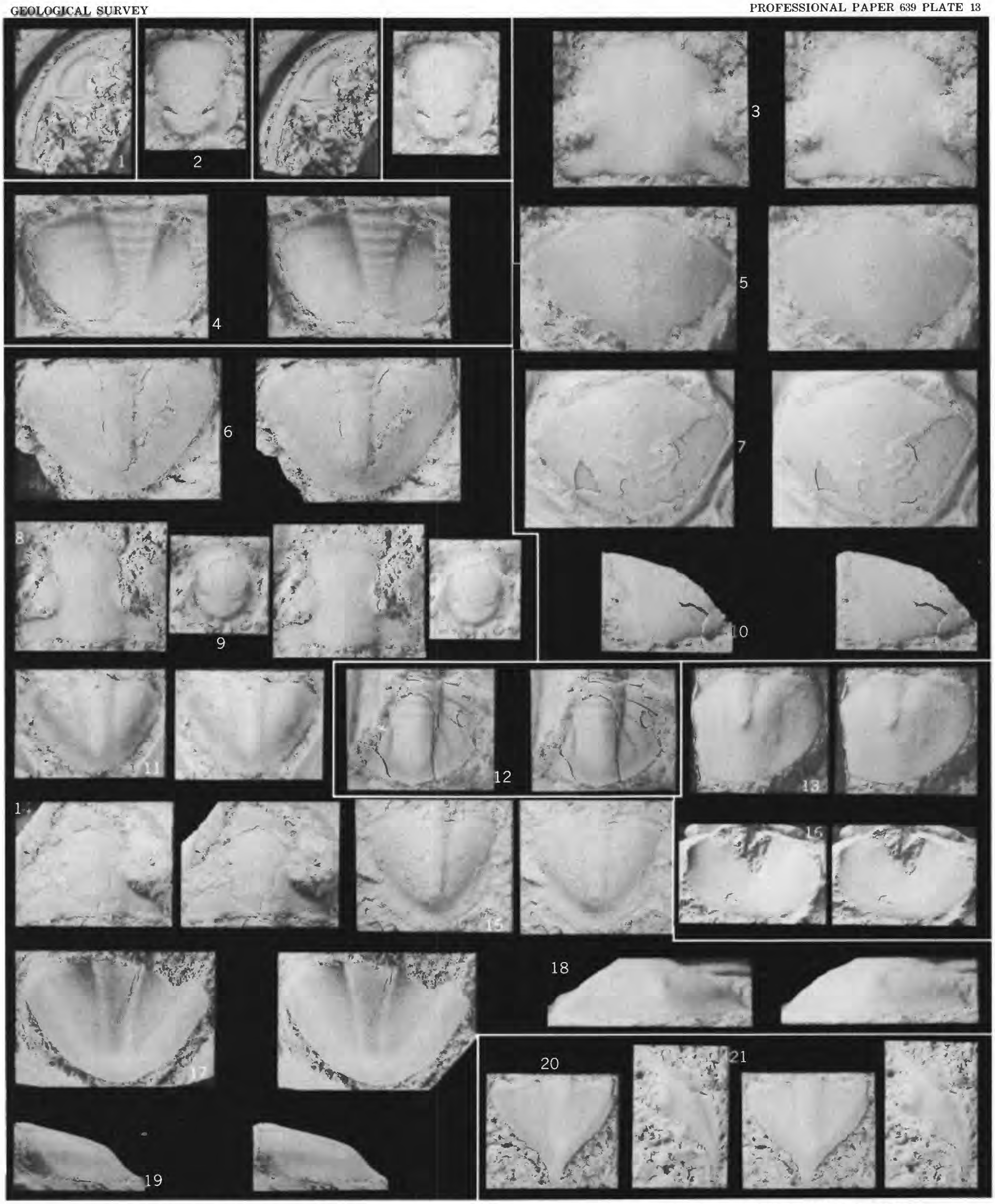
4. *Asaphellus* cf. *A. eudocia* (Walcott) (p. 78).
USGS colln. D1832 CO, Steptoe section, pygidium, dorsal view, × 2, USNM 160856.

6, 8, 9, 11, 14, 15, 17–19. *Asaphellus* cf. *A. riojanus* Harrington and Leanza (p. 79).
6. Pygidium, dorsal view, × 2, USGS colln. D812 CO, Rawhide Mountain (Ross, 1964a, p. C69), USNM 160857a.
8. Cranidium, dorsal view, × 3, USGS colln. D812 CO, USNM 160857b.
9. Hypostome, probably assignable to this species, ventral view, × 5, USGS colln. D812 CO, USNM 160857e.
11. Pygidium, dorsal view, × 4, USGS colln. D368j CO, USNM 160858a.
14. Cranidium, dorsal view, × 3, USGS colln. D812 CO, USNM 160857c.
15. Pygidium, dorsal view, × 2, USGS colln. D368i CO, USNM 160858b.
17–19. Pygidium, dorsal, posterior, and lateral views, × 3, USGS colln. D812 CO, USNM 160857d.

12. *Bathyurus* cf. *B. extans* (Hall) (p. 85).
USGS colln. D1651 CO, Ibex area, Utah, pygidium, dorsal view, × 2, USNM 160874a.

13, 16. Genus and species undetermined (p. 80).
USGS colln. D340m CO, Antelope Valley composite section.
13. Pygidium, dorsal view, × 1, USNM 160860a.
16. Pygidium, ventral view, × 1, USNM 160860b.

20, 21. *Megistaspis* (*Ekeraspis*) *nevadensis* Ross, n. sp. (p. 80).
USGS colln. D812 CO, Rawhide Mountain (Ross, 1964a, p. C69).
20. Pygidium, paratype, immature, dorsal view, × 3, USNM 160862h.
21. Free cheek, paratype, dorsal view, × 3, USNM 160862g.



APATOKEPHALUS, ASAPHELLUS, ISOTELUS?, BATHYURUS, MEGISTASPIS (EKERASPIS)

PLATE 14

[All figures are stereophotographs except figs. 8–10]

FIGURES 1–10. *Megistaspis* (*Ekeraspis*) *nevadensis* Ross, n. sp. (p. 80).

USGS colln. D812 CO, Rawhide Mountain (Ross, 1964a, p. C69).

1. Pygidium paratype, fragmentary, dorsal view, × 2, USNM 160862a.
2. Pydidium, holotype, latex cast of partly decorticated specimen, dorsal view, × 1, USNM 160861.
3. Cranidium, paratype, front portion only, showing great extent of preglabellar area, dorsal view, × 2, USNM 160862b.
4. Cranidium, paratype, fragmentary, dorsal view, × 1, USNM 160862c.

5, 8. Cranidium, paratype, damaged, dorsal and lateral views, × 3, USNM 160862d.

6. Hypostome, paratype, ventral view, × 5, USNM 160862e.

7, 9, 10. Pygidium, dorsal, lateral, and posterior views, × 3, USNM 160862f.

11–13, 15. *Megistaspis* (*Ekeraspis*) *floweri* Ross, n. sp. (p. 81).

USGS colln. D340i CO, Ninemile Formation, Antelope Valley composite section.

11, 13. Pygidium, holotype, dorsal and lateral views, × 1, USNM 160863.

12. Pygidium, paratype, dorsal view, × 2, USNM 160864b.

15. Cranidium, paratype, dorsal view, × 3. This specimen may be somewhat deformed. USNM 160864a.

14. *Niobella* sp. (p. 82).

USGS colln. D368i CO, Antelope Valley composite section, cranidium, dorsal view, × 2, USNM 160867.

16–18. *Niobella*? sp. (p. 82).

USGS colln. D297 CO, Antelope Valley composite section, pygidium, dorsal, posterior, and lateral views, × 2, USNM 160868.

19. *Hunnebergia*? sp. (p. 82).

USGS colln. D340l CO, Antelope Valley composite section, pygidium, dorsal view, × 3, USNM 160866.

20. Megalaspid hypostome (p. 81).

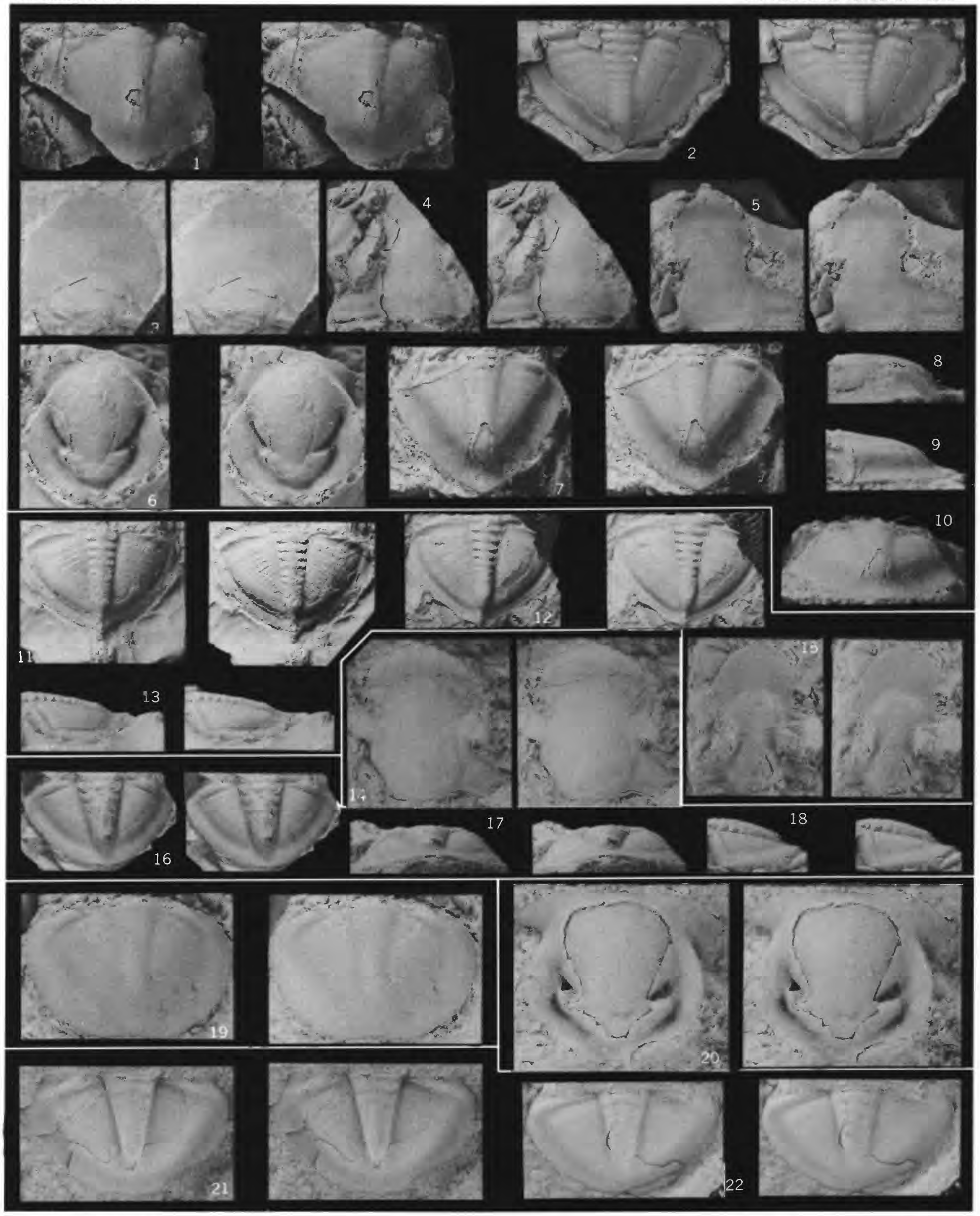
USGS colln. D297 CO, Antelope Valley composite section, central view, × 6, USNM 160865.

21, 22. *Peraspis erugata* Ross, n. sp. (p. 83).

USGS colln. D1603 CO, Ikes Canyon.

21. Pygidium, paratype, dorsal view, × 3, USNM 160870a.

22. Pygidium, paratype, dorsal view, × 3, USNM 160870b.



MEGISTASPIS (EKERASPIS), NIOBELLA, HUNNEBERGIA?, PERASPIS

PLATE 15

[All figures are sterephotographs]

FIGURES 1–5. *Peraspis erugata* Ross, n. sp. (p. 83).
USGS colln. D1603 CO, Ikes Canyon.
1. Free cheek, paratype, retaining most of yoking doublure across front, dorsal view, × 2, USNM 160870d.
2. Pygidium and posterior part of thorax, latex cast of paratype, dorsal view, × 1.5, USNM 160870c.
3. Fragmentary free cheek, paratype, showing size of eye, × 3, USNM 160870e.
4. Holotype, cranidium, dorsal view, × 6. Note splits in sides of glabella in front of palpebral lobes, USNM 160869.
5. Hypostome, associated and probably belonging to this species but possibly to *Niobe*, ventral view, × 6, USNM 160870f.

6, 7, 10. *Illaenus* sp. 1 (p. 84).
USGS colln. D1578 CO, southern Groom Range, cranidium, anterior, dorsal, and lateral views, × 2, USNM 160872.

9, 12, 13, 15. *Illaenus* cf. *I. alveatus* Raymond (p. 83).
USGS colln. D1509 CO, Ikes Canyon.
9, 12, 13. Cranidium, anterior, dorsal, and lateral views, × 1.5, USNM 160871a.
15. Pygidium, excavated to show extent of doublure, × 1.5, USNM 160871b.

8, 11, 14. *Raymondaspis*? sp. (p. 84).
USGS colln. D1812 CO, Steptoe section.
8. Fragmentary free cheek, showing length of genal spine, × 6, USNM 160873a.
11. Pygidium, dorsal view, × 5, USNM 160873b.
14. Cranidium, latex cast, dorsal view, × 2, USNM 160873c.

16–19. *Bathyurus* cf. *B. extans* (Hall) (p. 85).
USGS colln. D1563 CO, southern Groom Range.
16. Pygidium, dorsal view, × 4, USNM 160874b.
17. Cranidium, damaged, dorsal view, × 3, USNM 160874c.
18. Pygidium, dorsal view, × 3, USNM 160874d.
19. Cranidium, fragmentary, showing size of palpebral lobe, × 2, USNM 160874e.

20–24. *Bathyurus extans* subsp. *emaciatus* Ross, n. subsp. (p. 85).
USGS colln. D1810 CO, Steptoe section.
20, 22, 23. Cranidium, holotype, dorsal, anterior and lateral views, × 3, USNM 160875.
21, 24. Pygidium, paratype, posterior and dorsal views, × 3, USNM 160876.

25. *Uromystrum*? sp. (p. 87).
USGS colln. D209 CO, Swan Peak Formation, lower member, Green Canyon, Logan, Utah, pygidium, dorsal view, × 2, USNM 160880.

PERASPIS, ILLAENUS, RAYMONDASPIS?, BATHYURUS, UROMYSTRUM?

PLATE 16

[All figures are stereophotographs except figs. 14, 17, 23, and 24]

FIGURES 1–5. *Bathyurus acutus* Raymond (p. 86).
Lower Pamelia Formation at Westboro, near Ottawa, Ontario.
1, 2. Cranidium, paratype, dorsal and anterior views, × 2, GSC 7821a.
3, 4, 5. Pygidium, holotype, lateral, dorsal, and posterior views, × 3, GSC 7821.

6–12. *Bathyurus acutus* subsp. *angustus* Ross, n. subsp. (p. 86).
USGS collin. D1814 CO, Steptoe section.
6, 8, 12. Pygidium, paratype, lateral, dorsal, and posterior views, × 3, USNM 160878a.
7. Pygidium, paratype, dorsal view, × 3, showing extent of terminal spine, USNM 160878b.
9–11. Cranidium, holotype, dorsal, anterior, and lateral views, × 2, USNM 160877.

13, 14, 17. *Goniotelina*? sp. (p. 87).
USGS colln. D1816 CO, Steptoe section, pygidium, dorsal, posterior, and lateral views, × 4, USNM 160881.

15, 18. *Bathyurus* sp. (p. 87).
USGS colln. D1816 CO, Steptoe section.
15. Free cheek, dorsolateral view, × 2, USNM 160879a.
18. Pygidium, dorsal view, × 3, a latex cast, USNM 160879b.

16, 19–21. *Astroproetus* sp. (p. 88).
16. Pygidium, dorsal view, × 5, USGS colln. D1506 CO, Ikes Canyon, USNM 160883a.
19. Free cheek, dorsal view, × 10, USGS colln. D1506 CO, USNM 160883b.
20. Cranidium, less mature and possibly a different species than in fig. 21; dorsal view, × 10, USGS colln. D1506 CO, USNM 160883c.
21. Cranidium, dorsal view, × 5, USGS colln. D1526 CO, Ikes Canyon, USNM 160883d.

22. *Licnocephala*? sp. (p. 88).
USGS colln. D1830 CO, Steptoe section, pygidium, dorsal view, × 5, USNM 160882.

23–27. *Lonchodomas paenepennatus* Ross, n. sp. (p. 88).
USGS colln. D710a CO, Ranger Mountains, Nevada Test Site (Ross, 1967a, pl. 11).
23, 24, 26. Cranidium, paratype, lateral, anterior, and dorsal views, × 5, USNM 160885a.
25. Cranidium, paratype, dorsal view, × 8, USNM 160885b.
27. Pygidium, paratype, dorsal view, × 7, USNM 160885c.

BATHYURUS, GONIOTELINA?, ASTROPROETUS, LICNOCEPHALA?, LONCHODOMAS

PLATE 17

[All figures are stereophotographs except figs. 4 and 5]

FIGURES 1, 2. *Lonchodomas paenepennatus* Ross, n. sp. (p. 88).
USGS colln. D710a CO, Ranger Mountains, Nevada Test Site (Ross, 1967a, pl. 11), pygidium, holotype, dorsal and posterior views, × 7, USNM 160884.

3–7, 10. *Xystocrania* cf. *X. perforator* (Billings) (p. 89).
USGS colln. D1606 CO, Ikes Canyon, except fig. 10.
3, 6. Cranidium, dorsal and lateral views, × 1, USNM 160887a.
4, 5, 7. Cranidium, anterior, lateral, and dorsal views, × 1, USNM 160887b.
10. Pygidium, dorsal view, × 1, USGS colln. D1514 CO, Ikes Canyon, USNM 160887c.

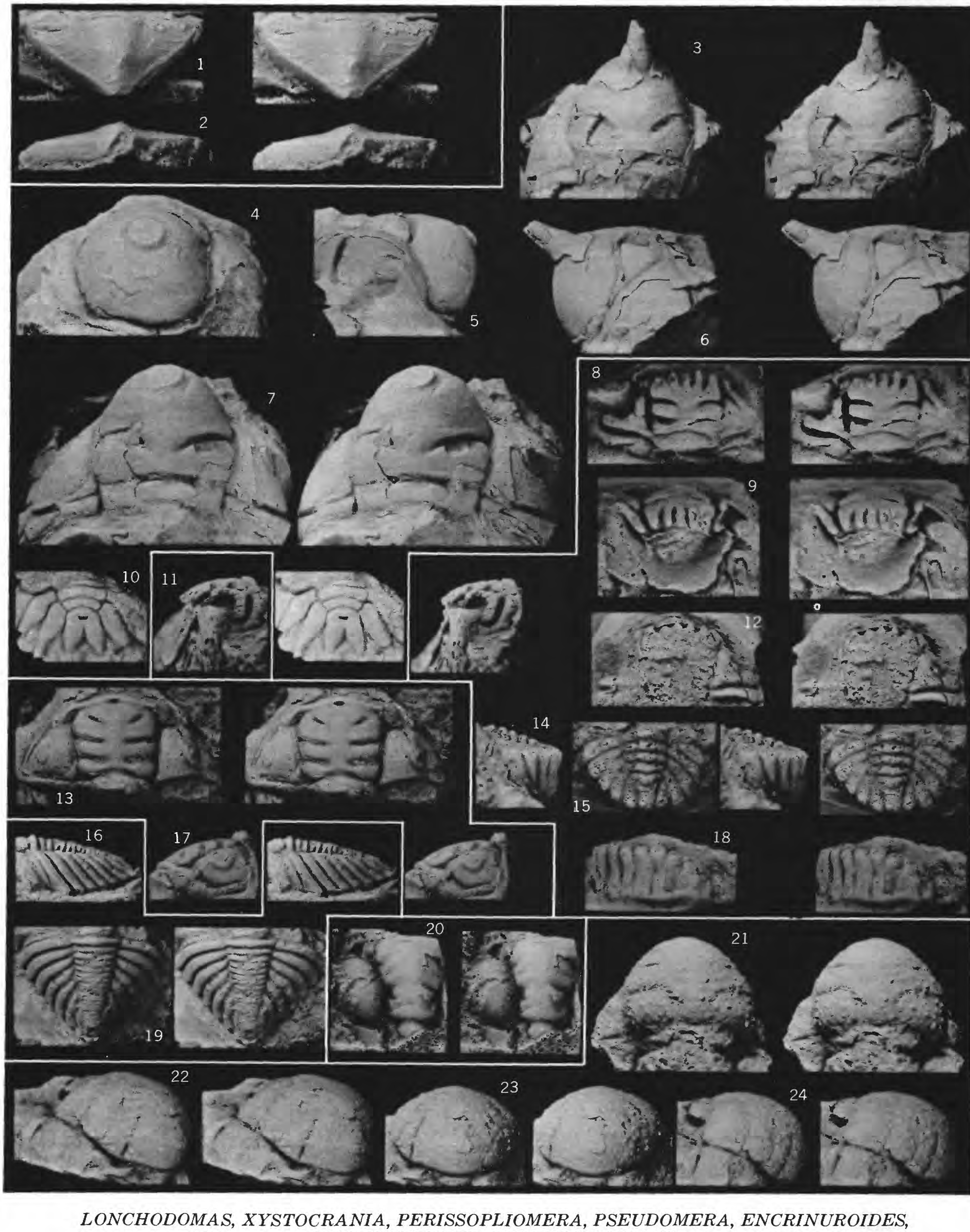
8, 9, 11, 12, 14, 15, 18. *Perissopliomera maclachlani* Ross, n. gen., n. sp. (p. 90).
8, 9, 11. Cranidium, holotype, dorsal, anterior, and lateral views, × 4, USGS colln. D299e CO, Antelope Valley, USNM 160889.
12. Cranidium, paratype, dorsal view, × 3. Note dimples in anterior border. USGS colln. D1858 CO, Hot Creek Canyon, USNM 160890a.
14, 15, 18. Pygidium, paratype, lateral, dorsal, and posterior views, × 4, USGS colln. D1858 CO, Hot Creek Canyon, USNM 160890b.

13, 17. *Pseudomera* cf. *P. barrandei* (Billings) (p. 91).
USGS colln. D1606 CO, Ikes Canyon, cranidium, dorsal and lateral views, × 1.5, USNM 160891.

16, 19. *Encrinuroides* sp. (p. 91).
USGS colln. D1506 CO, unnamed formation, above Pogonip Group, Ikes Canyon, pygidium, lateral and dorsal views, × 2, USNM 160892a.

20. *Perischoclonus* sp. (p. 89).
USGS colln. D1603 CO, Ikes Canyon, partial cranidium, dorsal view, × 3, USNM 160886.

21–24. *Cydonocephalus* sp. (p. 90).
USGS colln. D1514 CO, Ikes Canyon, cranidium, dorsal, anterolateral, anterior, and lateral views, × 4, USNM 160888.



LONCHODOMAS, XYSTOCRANIA, PERISSOPLIOMERA, PSEUDOMERA, ENCRINUROIDES, PERISCOCLONUS, CYDONOCEPHALUS

PLATE 18

[All figures are stereophotographs except fig. 21]

FIGURE 1. *Encrinuroides* sp. (p. 91).
USGS colln. D1506 CO, unnamed formation, Ikes Canyon, hypostome, ventral view, × 3, USNM 160892b.

2–5. *Protocalymene* sp. (p. 92).
USGS colln. D1520 CO, Ikes Canyon.
2, 3. Cranidium, dorsal and dorsolateral views, × 10, USNM 160894a.
4. Pygidium, oblique view, × 10, USNM 160894b.
5. Free cheek, lateral view, × 6, USNM 160894c.

6. Aff. *Miracybele* sp. 1 (Ross, 1967a, pl. 8, fig. 23) (p. 92).
USGS colln. D1603 CO, Ikes Canyon, cranidium, dorsal view, × 6, USNM 160893.

7–10. *Brongniartella* n. sp. (p. 92).
Unnamed formation above Pogonip Group, Ikes Canyon.
7. Partial cephalon, dorsal view, × 1.5, USGS colln. D1526 CO, USNM 160895a.
8, 9. Pygidium, lateral and dorsal views, USGS colln. D1506 CO, USNM 160895b.
10. Hypostome, ventral view, × 5, USGS colln. D1506 CO, USNM 160895c.

11, 12, 14, 16–18. *Kawina* sp.
(Not described.) USGS colln. D1884 CO, upper member, Antelope Valley Limestone, above saddle east of hill 7220, SW¼ sec. 10, T. 16 N., R. 46 E., Wildcat Peak quad., Nevada (McKee and Ross, 1969).
11, 12, 14. Cranidium, lateral, dorsal, and anterior views, × 4.
16–18. Pygidium, lateral, posterior, and dorsal views, × 4.

13. *Whittingtonia* sp. (p. 93).
USGS colln. D1526 CO, unnamed formation above Pogonip Group, Ikes Canyon, partial thorax and pygidium, × 3, USNM 160896.

15. *Bathyurellus* sp.
(Not described.) USGS colln. D1884 CO, upper part, Antelope Valley Limestone, above saddle east of hill 7220, SW¼ sec. 10, T. 16 N., R. 46 E., Wildcat Peak quad., Nevada (McKee and Ross, 1969). Pygidium, × 2.

19–24. *Nileus* cf. *N. affinis* Billings.
(Not described.) USGS colln. D1884 CO, upper part, Antelope Valley Limestone, above saddle east of hill 7220, SW¼ sec. 10, T. 16 N., R. 46 E., Wildcat Peak quad., Nevada (McKee and Ross, 1969).
19, 23. Free cheeks, dorsal and lateral views, × 2.
20, 22. Pygidium, lateral and dorsal views, × 3.
21, 24. Cranidium, lateral and dorsal views, × 3.

ENCRINUROIDES, PROTOCALYMENE, aff. *MIRACYBELE, BRONGNIARTELLA, KAWINA, WHITTINGTONIA, BATHYURELLUS, NILEUS*

PLATE 19

[All figures are stereophotographs]

FIGURES 1–4. *Desmorthis nevadensis* Ulrich and Cooper (p. 58).

USGS colln. D374 CO, Antelope Valley Limestone, Lone Mountain, Nev.

1, 2. Brachial valve, topotype, interior and dorsal views, × 4, USNM 162054a.

3, 4. Pedicle valve, topotype, interior and ventral views, × 4, USNM 162054b.

5–8. *Desmorthis* n. sp. (p. 59).

USGS colln. D1600 CO, Antelope Valley Limestone, uppermost 3 ft, Meiklejohn Peak, Nev.

5, 6. Brachial valve, dorsal and interior views, × 5, USNM 162055a.

7, 8. Pedicle valve, ventral and interior views, × 5, USNM 162055b.

9–15. *Orthambonites minusculus* (Phleger) (p. 55).

USGS colln. D1656 CO, Antelope Valley Limestone, on ridge east of Caesar Canyon, Nevada coords., central zone: E. 470,400 ft, N. 1,548,850 ft. Wildcat Peak quad., Nevada.

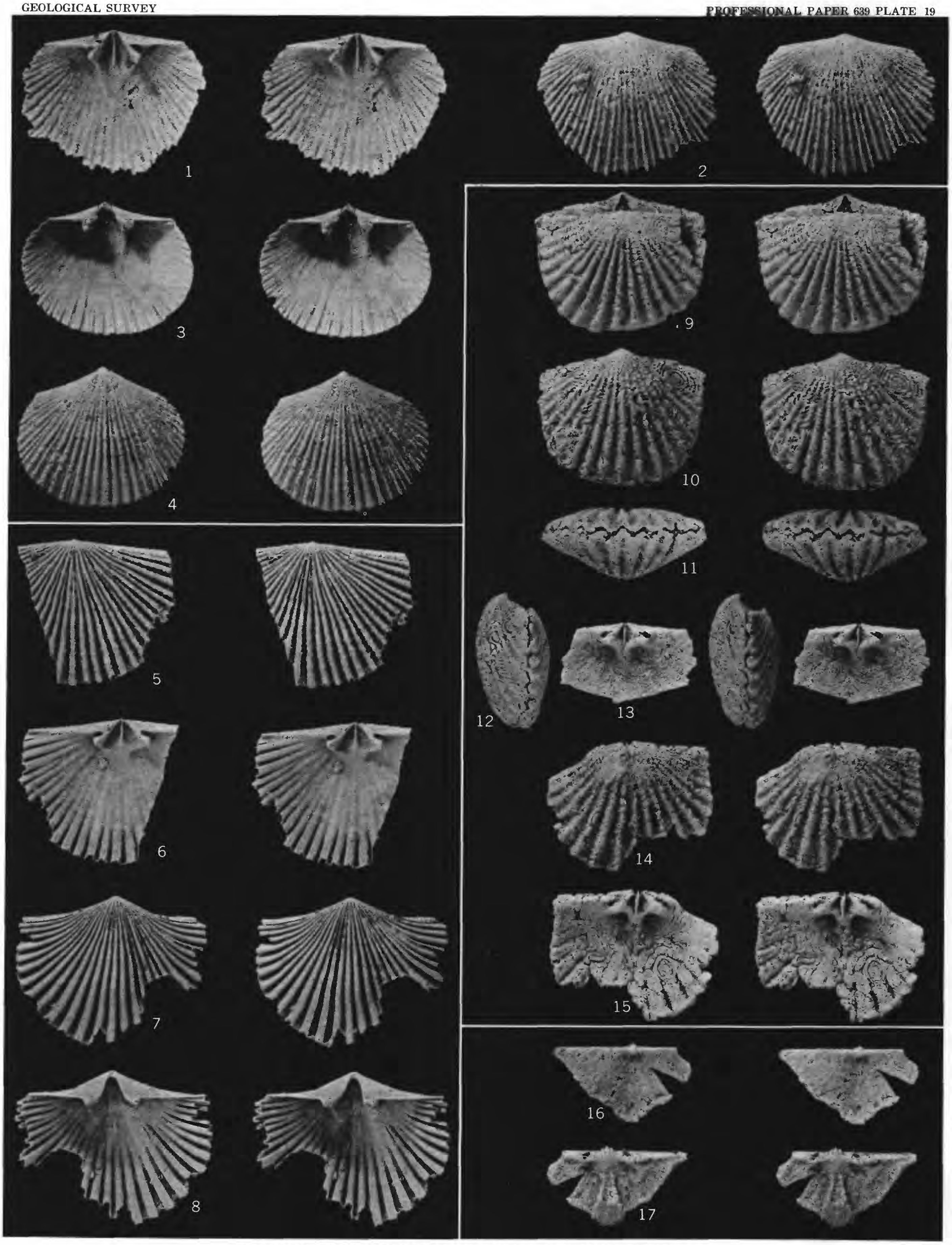
9–11, 13. Complete shell, dorsal, ventral, anterior, and lateral views, × 3, USNM 162056a.

12. Brachial valve, fragmentary, interior, showing secondary deposit partially engulfing brachiophores, × 3, USNM 162056b.

14, 15. Brachial valve, fragmentary, dorsal and interior views, × 3, USNM 162056c.

16, 17. *Taphrodonta parallela* Cooper (p. 65).

USGS colln. D1518 CO, Ikes Canyon, Nev., brachial valve, broken, dorsal and interior views, × 5, USNM 162057.



DESMORTHIS, ORTHAMBONITES, TAPHRODONTA