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Ordovician Brachiopods from the Pogonip Group of Millard County, Western Utah*

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ABSTRACT.—Twenty-five species of brachiopods are described and zoned in the unusually complete section of Lower and Middle Ordovician Pogonip Group and related rocks in western Millard County, Utah. This study is the first extensive, systematic work on Ordovician brachiopods from western Utah. Collections are largely from the southern Confusion Range. The brachiopod fauna includes 22 previously described species and three new species, *Desmorthis ibexensis, Anomalorthis juabensis,* and *Finkelnburgia fillmorensis.*

House Limestone, the basal unit in the Pogonip Group, (Canadian) yields two brachiopod zones, the *Apheoorthis* zone in the lower one-fourth and the *Syntrophina* zone in the upper fifteen feet. Small inarticulate brachiopods occur throughout the formation. The overlying Fillmore, Wahwah, and Juab formations are part of a thick sequence of interbedded limestone and shale. The Fillmore Limestone can be zoned on the basis of faunas associated with the genera *Nanorthis, Diaphelasma, Finkelnburgia, Diparelasma,* and *Hesperonomia.* The most prolific fauna occurs in the upper part of the formation. Lower Wahwah Formation is characterized by *Hesperonomia,* middle Wahwah beds by *Syntrophopsis* and *Tritoechia,* and the upper part of the formation by a coquinoid bed of *Hesperonomiella.* The overlying Juab Limestone (Chazyan) is characterized by *Orthambonites, Idiostrophia* and a new species of *Anomalorthis.* The Kanosh Shale is predominantly a tan, calcareous shale containing thin interbeds of abundantly fossiliferous limestones. It is characterized by an association of *Orthidiella* at the base, and *Orthambonites, Anomalorthis,* and *Desmorthis* higher in the section. The Lehman Formation is distinguished by a new species of *Desmorthis.* The medial Crystal Peak Dolomite has produced silicified specimens of *Kirkina* and *Orthambonites.*

Brachiopod zonal distribution in western Utah varies somewhat from that outlined by Cooper (1956) for his Whiterock Stage in central Nevada. The zone of *Orthidiella* occurrence is much thinner in western Utah than in Nevada. *Anomalorthis* ranges from just below *Orthidiella* upward nearly to the lowest *Desmorthis* occurrence. *Desmorthis* in the Utah sections occurs above *Anomalorthis* rather than below it or with it, as reported by Cooper (1956) and Ross (1964) in Nevada.

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*A thesis submitted to the faculty of the Department of Geology, Brigham Young University in partial fulfillment of the requirements for the degree Master of Science, November 15, 1967.

ILLUSTRATIONS

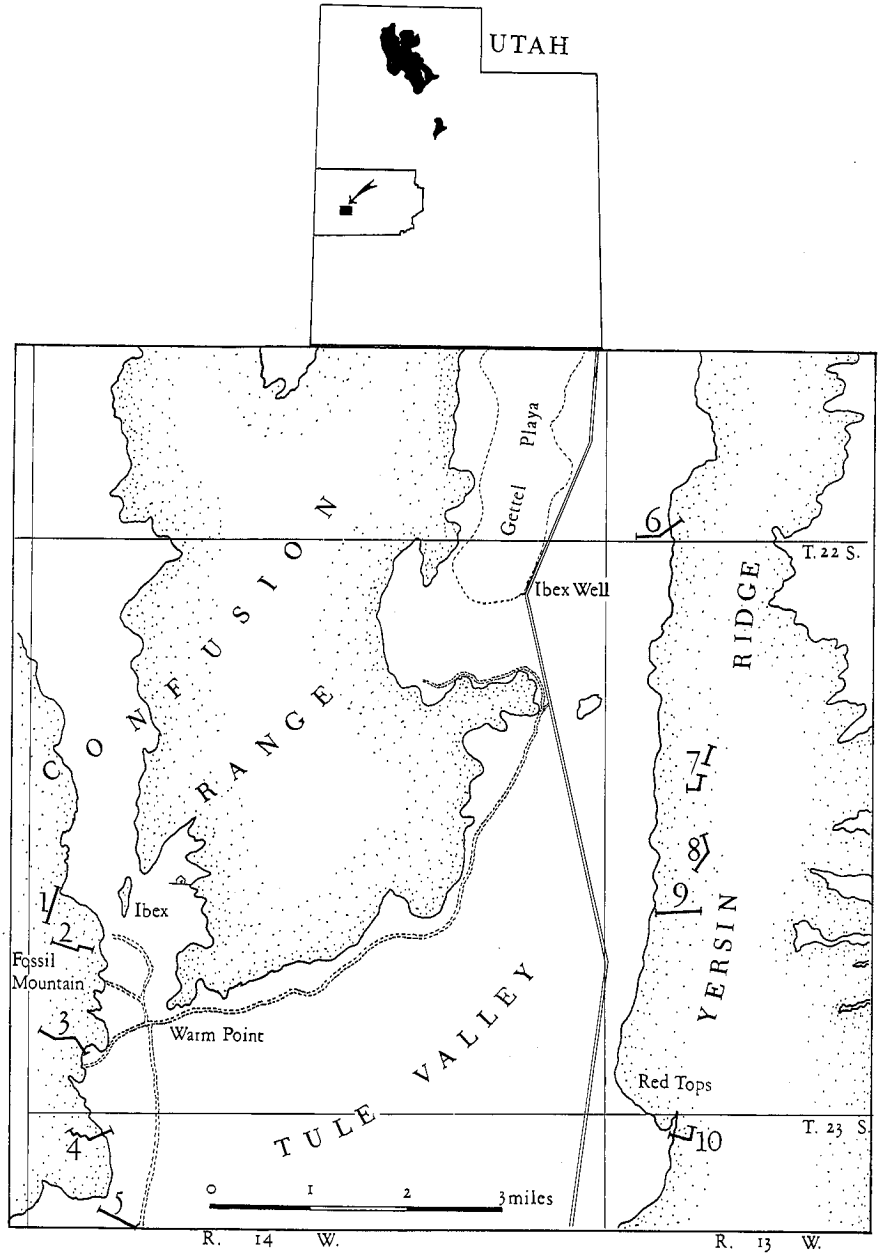
INTRODUCTION

The Pogonip Group and Eureka Group in the Ibex area of southwest Millard County are in the best exposed, most complete, and most fossiliferous Ordovician section in Utah. The Pogonip Group consists of more than 3,000 feet of miogeosynclinal limestone with intraformational conglomerate, shale, siltstone, and sandstone. It contains brachiopods in moderate abundance.

Several brachiopod species which occur in the Pogonip Group have been described by Ulrich and Cooper (1938), but they did not give the relative stratigraphic position of these species in western Utah. The present paper contains systematic descriptions of all the Lower and Middle Ordovician articulate brachiopod species known from the Ibex region of western Utah and presents a stratigraphic zonation controlled by collections from several measured sections. No detailed regional correlation has been attempted herein using the Lower and Middle Ordovician brachiopods, but this is planned as a later phase of the work following more extensive collecting within other parts of the Great Basin.

Hintze (1951, 1952) measured sections, described the trilobite fauna, and subdivided with Pogonip Group into the House Limestone, Fillmore Limestone, Wahwah Limestone, Juab Limestone, Kanosh Shale, and Lehman Formation. Webb (1958) divided the overlying Eureka Group into the Watson Ranch Tongue of the Swan Peak Quartzite, Crystal Peak Dolomite, and the Eureka Quartzite.

Brachiopods below the upper Fillmore Limestone are poorly preserved and are not abundant, but they do show distinct zones by which the section can be divided. The upper part of the section has a more diverse and abundant fauna



TEXT-FIGURE. 1.—Index map. The collected sections are numbered. 1-K north section, 2-K south section, 3-J section, 4-H section, 5-G section, 6- Square Top section, 7- Mesa section, 8-C section "offset," 9-C section, 10- Lava Dam north section. Figured brachiopods are from these sections except where noted.

of brachiopods. Locally they become very abundant in the Wahwah Limestone at Zone K (Hintze, 1951) where *Hesperonomiella minor* (Walcott) occurs in a coquinoid bed 18 inches thick. The Kanosh Shale also produces coquinoid beds of *Orthambonites michaelis* (Clark) and *Anomalorthis utahensis* Ulrich and Cooper. Brachiopods of this more fossiliferous part of the section are diagnostic and fall readily into zones.

Whiterockian brachiopod zones of Cooper (1956) are recognized in the upper part of the section. The *Orthidiella, Anomalorthis,* and *Desmorthis* Zones are very well represented in the Ibex section but the sequence of this occurrence does not follow that listed by Cooper for central Nevada. Cooper (1956) shows the occurrence of *Desmorthis* below *Anomalorthis.* Ross (1964) indicates that *Desmorthis* is a thin unit within the *Anomalorthis* zone. From the Ibex sections *Desmorthis* occurs above *Anomalorthis.*

The top of the Canadian and the base of the Chazyan are drawn by the writer on the basis of the first occurrence of the genus *Orthambonites;* i.e., *Orthambonites subalata* Ulrich and Cooper. The proposed boundary is 155 feet below the first occurrence of *Orthidiella,* which Cooper (1956) has noted as the base of the Whiterock Stage. There is an obvious vertical change in brachiopod faunas in beds below those containing *Orthambonites,* even in the continuous lithologic series. *Hesperonomia* appears in lowest beds and is replaced upward by *Hesperonomiella,* which in turn is replaced upward by *Orthambonites.* Cooper (1956) shows the first occurrence of *Orthambonites* at slightly below the basal Whiterockian boundary.

Kirkina and its associate, *Orthambonites perplexus* Ross, form a widespread faunal zone beneath the Eureka Quartzite observed by the writer in Utah and in eastern Nevada. *Kirkina* represents a more advanced brachiopod which, although known from several western Utah and eastern Nevada localities, has not yet been reported for central Nevada. Hence it is not surely known with which part of the Whiterock Stage the *Kirkina* zone may be correlated, but it is thought likely to be equivalent to Cooper's *Rhysostrophia* zone of his Whiterock Stage.

The field work for this problem consisted of extensively collecting the southern Confusion Range, Ibex sections during the summers of 1965, 1966, and 1967. Laboratory investigation and preparation were undertaken during the same period. All but a few of the brachiopods are unsilicified, compounding the problem of obtaining good specimens. Laboratory preparation involved removing matrix material from numerous interiors with dental tools under a binocular microscope. This method, of the many available for preparation, was the most successful. Potassium hydroxide and an Air-dent (miniature sandblaster) were also tried but were not very successful. Identification was made primarily from the work of Ulrich and Cooper (1938) and Cooper (1956).

All specimens described in this paper are deposited in the Brigham Young University paleontological repository of the Department of Geology.

Acknowledgments

Expenses for this study have been defrayed by a National Science Foundation Grant GB-3154 to Dr. Lehi F. Hintze of the Department of Geology at Brigham Young University. I express thanks to Dr. Hintze who has directed and assisted with much of the field work and given constant interest in the

work. Appreciation is expressed to Dr. J. Keith Rigby, thesis chairman, who offered helpful suggestions and guidance throughout the project, and to Dr. R. J. Ross of the United States Geological Survey who gave assistance with some of the brachiopod identifications.

I also express appreciation to my wife Christin, for her typing of the manuscript and understanding in all phases of the work.

STRATIGRAPHY

Lower and Middle Ordovician rocks in western Utah consist mostly of carbonates and shale of the Pogonip Group, with a great influx of quartz sand near the top forming the Eureka Group. Little compositional variation is encountered in the individual sections in the Ibex locality. The Canadian units, House Limestone, Fillmore Limestone, and Wahwah Limestone are generally characterized by intraformational conglomerate, calcarenite, calcisiltite, and interbedded shale. Chazyan units comprise the Juab Limestone, a fine calcarenite and calcisiltite with lesser amounts of shale; the Kanosh Shale, a predominantly tan, calcareous shale with thin interbeds of abundantly fossiliferous limestone; and the Lehman Formation, a thin- to thick-bedded calcilutite with interbeds of sandstone and quartzite. The Watson Ranch Tongue of the Swan Peak Quartzite is nearly unfossiliferous, containing rare *Orthambonites*. The Crystal Peak Dolomite Member of the Swan Peak Quartzite is considered to be of upper Whiterock or Marmor age because it contains the brachiopod *Kirkina*. The Eureka Quartzite at Ibex (Text-fig. 1) is a massive, cliff-forming quartzite overlying the Crystal Peak Dolomite Member and underlying the Upper Ordovician Fish Haven Dolomite. The latter dolomite is dark-grey to brown and is often cherty. This unit is one of the most persistent formations in the Great Basin.

House Limestone.—The House Limestone is the basal unit of the Pogonip Group and is the oldest totally Ordovician formation in the Confusion and House Ranges. The Cambrian and Ordovician boundary is questionable in the immediate region, but for the present time the boundary is placed below the lowest known occurrence of the *Symphysurina* faunal zone, or the first lithologic boundary below this zone. The House Formation consists of 500 feet of medium-bedded, cherty, light- to medium-gray calcilutite and calcisiltite, with lenses of calcarenites. The lower member is primarily thin- to medium-bedded, light-gray, calcilutite. The middle member consists of medium-gray calcisiltite and calcilutite with abundant irregular bodies of chert ranging from 1 to 5 inches thick occurring along the bedding planes. The upper member consists of light- to medium-gray calcilutite and calcisiltite, with occasional brownish-gray calcisiltite beds that weather to form slabby talus slopes.

Fillmore Limestone.—The most distinctive sedimentary rocks of the 1,800-foot, slope-forming Fillmore Limestone are abundant intraformational conglomerate beds. Other formations of the Pogonip Group have intraformational conglomerates but not in the abundance of the Fillmore Limestone. The unit is characteristically thin-bedded ledges of intraformational conglomerate weathering into 1 to 3 feet thick which are separated by thin interbeds of shale. Algal and sponge reefs of variable size are abundant. A shallow-water environment is attested to by the existence of these reefs as well as by intraformational con-

glomerates; abundant ripple marks and occasional mud crack surfaces are on bedding planes. Ripple marks often penetrate the conglomeritic particles of limestone, suggesting a soft pebble origin at the time of deposition of the coarse-grained rock.

The Fillmore Formation is divided into an upper and lower member for the purpose of mapping. The lower member consists of about 500 feet of interbedded calcarenite, calcisiltite, and medium dark-gray, thin-bedded, intraformational conglomerate. A prominent 12-foot algal bed consisting of light medium-gray, massive calcilutite forms a prominent marker bed 365 feet above the base. Above this is a brownish weathering zone of thin-bedded intraformational conglomerate with sandy fine pebbles in a medium-grained calcarenitic matrix. The upper member is similar to the lower but with more shale and calcisiltic nodular shale. Algal and sponge reefs also are more numerous than in the lower member.

Wahwah Limestone.—The Wahwah Limestone is 227 feet thick at the type section at Ibex. The unit is a ledge-forming, medium-gray, quartz silty calcisiltite, which weathers locally to a pale yellowish brown, and is commonly interbedded with tan, calcareous shale. The unit is more resistant than the underlying, slope-forming, Fillmore Limestone and forms five main resistant ledges and two prominent algal-sponge reefs. An 18 inch coquinoid bed of *Hesperonomiella minor* (Walcott) serves as an excellent marker bed 215 feet above the base.

Juab Limestone.—The 140-foot thick Juab Limestone is characteristically a slabby, medium-gray calcisiltite which weathers to a yellowish gray and dark yellowish orange. There are interbeds of yellowish gray, nodular calcisiltite. Fossil preservation is usually quite poor throughout the formation, but a few weathered-out, articulated brachiopod valves were found in rubble slopes. The Juab Limestone is included as the basal unit of the Chazyan on the basis of the occurrence of the genus *Orthambonites* within the formation.

Kanosh Shale.—The abundantly fossiliferous, slope-forming Kanosh Shale is 565 feet thick. It is predominantly a tan to olive-gray, calcareous shale with thin, intercalated beds of limestone, many of which are coquinoid beds of *Orthambonites michaelis* (Clark) and *Anomalorthis utahensis* Ulrich and Cooper. There are several medium-bedded, reddish orange-weathering calcisiltite beds.

Lehman Formation.—The Lehman Formation is about 200 feet thick and consists dominantly of blue-gray calcilutite with a few interbeds of calcisiltite and quartzite. The lower 150 feet is mostly a dense, medium-gray calcilutite. The upper few feet become silty and quartzitic.

Watson Ranch Tongue of the Swan Peak Quartzite.—This quartzite of the Eureka Group is about 250 feet thick. It is a reddish-brown weathering, white to gray orthoquartzite, locally crossbedded, with a few dolomitic interbeds near the top. The brachiopod genus *Orthambonites sp.* was collected from the limy beds.

Crystal Peak Dolomite.—This dolomite member of the Eureka Group is 85 feet thick and is mottled, bluish gray dolomite which weathers to a drab olive-brown color. A widespread brachiopod fauna of *Kirkina* and *Orthambonites* is known from the unit. It is thought to be of upper Whiterock or Marmor age by the writer, thus assignable to late Chazyan time.

Eureka Quartzite.—The maximum thickness yet found for the Eureka is at Ibex where the formation measures 537 feet (Hintze 1951, p. 22). The quartzite is white, vitreous, cliff-forming, and locally cross-laminated. The quartzite is completely unfossiliferous.

ZONATION

Brachiopods of the Ibex Pogonip support the trilobite zones of Hintze (1951) and Ross (1951). As an alternative, a brachiopod zonation is proposed here, beginning from the youngest down. Correlation of the zones is indicated in Text-figure 2.

Relative abundance of the brachiopods is indicated by abundant, common, and rare.

Kirkina Zone—Lower 40 feet of the Crystal Peak Dolomite. The following brachiopods are contained in this zone:

Kirkina millardensis Salmon, common.
Orthambonites perplexus Ross, common.

Desmorthis Zone—Upper 70 feet of the Kanosh Shale and through the Lehman Formation. This zone contains the following brachiopods:

Desmorthis nevadensis Ulrich and Cooper, common.
Desmorthis ibexensis n. sp., common.

Anomalorthis Zone—Juab Limestone and the lower 495 feet of the Kanosh Shale. The following brachiopod species are found in this zone:

Orthambonites michaelis (Clark), abundant.
Orthambonites subalata Ulrich and Cooper, common.
Anomalorthis utahensis Ulrich and Cooper abundant.
Anomalorthis lonensis (Walcott), common.
Anomalorthis nevadensis Ulrich and Cooper, rare.
Anomalorthis juabensis, n. sp., common.
Idiostrophia nuda Ulrich and Cooper, rare.
Syntrophopsis utahensis Ulrich and Cooper, rare.

Orthidiella Zone—Lower 6 feet of the Kanosh Shale. The brachiopod of this zone is *Orthidiella longwelli* Ulrich and Cooper, common.

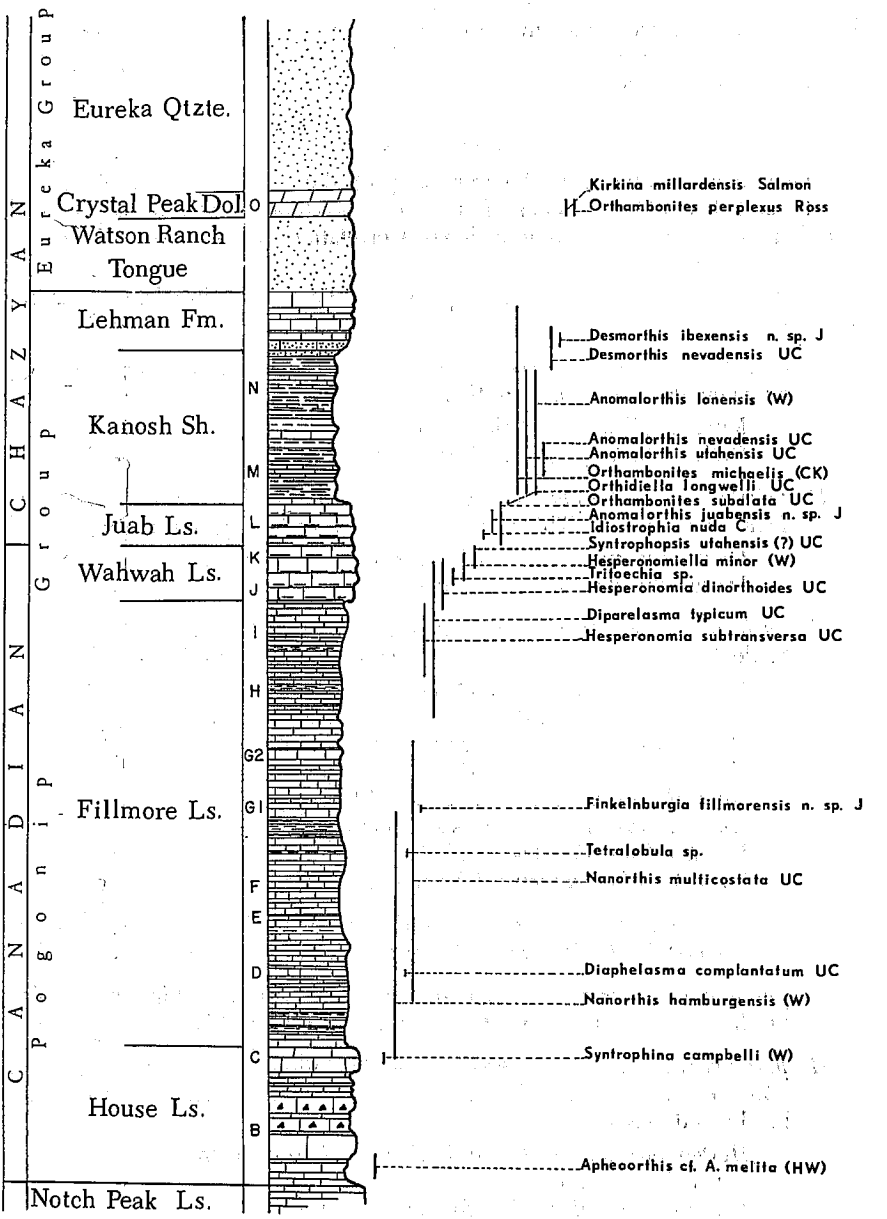
Hesperonomiella Zone—At 215 feet in the Wahwah Limestone. The brachiopod of this zone is *Hesperonomiella minor* (Walcott), abundant.

Hesperonomia Zone—Upper 300 feet of the Fillmore Limestone and lower 200 feet of the Wahwah Limestone. The zone contains the following brachiopod species:

Hesperonomia dinorthoides Ulrich and Cooper, common.
Tritoechia sp., rare.
Diparelasma typicum Ulrich and Cooper, common.
Hesperonomia subtransversa Ulrich and Cooper, rare.

Nanorthis Zone—Lower 1500 feet of the Fillmore Limestone. Brachiopods of this zone are the following:

Nanorthis multicostata Ulrich and Cooper, common.



TEXT-FIGURE 2.— Generalized stratigraphic section and brachiopod occurrences in the Lower and Middle Ordovician of the Ibex area of western Millard County, Utah. Correlation of brachiopod occurrences with the trilobite zones of Hintze (1951) is also shown. Abbreviations: C-Cooper, CK-Clark, HW-Hall and Whitfield, J-Jensen, UC-Ulrich and Cooper.

Finkelnburgia fillmorensis n. sp., rare.
Tetralobula sp., rare.
Diaphelasma complanatum Ulrich and Cooper, rare.
Nanorthis hamburgensis (Walcott), common.

Syntrophina Zone—Upper 10 feet of the House Limestone. The brachiopods of this zone are:

Syntrophina campbelli (Walcott), common.
Nanorthis hamburgensis (Walcott), common.

Apheoorthis Zone—Lower 75 feet of the House Limestone. The brachiopod contained in this zone is: *Apheoorthis* cf. *A. melita* (Hall and Whitfield), rare.

Fossils figured in the present paper were collected from the following measured stratigraphic sections except where otherwise noted.

Base of measured sections as shown on Text-fig. 1 are located on The Barn quadrangle, United States Geological Survey topographic map 1:62500, 1960.

Section 1. K-north, SW, SW, Sec. 19, T. 22 S., R. 14 W.
Section 2. K-south, SW, NE, Sec. 30, T. 22 S., R. 14 W.
Section 3. J section, SW, NE, Sec. 31, T. 22 S., R. 14 W.
Section 4. H section, NE, NE, Sec. 6, T. 23 S., R. 14 W.
Section 5. G section, NW, NW, Sec. 8, T. 23 S., R. 14 W.
Section 6. Square Top, SE, SW, Sec. 31, T. 21 S., R. 13 W.
Section 7. Mesa, NE, SE, Sec. 18, T. 22 S., R. 13 W.
Section 8. C-offset, SW, NW, Sec. 20, T. 22 S., R. 13 W.
Section 9. C section, SW, SE, Sec. 19, T. 22 S., R. 13 W.
Section 10. Lava Dam North, NW, NE, Sec. 6, T. 23 S., R. 13 W.
Section 11. Crystal Peak, not shown on index map, SW, NW, Sec. 24, T. 23 S., R. 16 W. Crystal Peak quadrangle, United States Geological Survey topographic map 1:62500, 1960.

SYSTEMATIC PALEONTOLOGY

Class ARTICULATA Huxley, 1869
Order ORTHIDA Schuchert and Cooper, 1932
Family BILLINGSELLIDAE Walcott and Schuchert, 1908
Genus *APHEOORTHIS* Ulrich and Cooper, 1936
APHEOORTHIS cf. MELITA (Hall and Whitfield)
Plate 1, figs. 1-3

Leptaena melita HALL & WHITFIELD, (1877) U. S. Geol. Expl. 40th par., v. 4, p. 208, pl. 1, fig. 13; WALCOTT, (1884), U. S. Geol. Surv., Mon. 8, p. 22.
Eoorthis melita WALCOTT, (1912) U. S. Geol. Surv., Mon. 51, p. 777.
Apheoorthis melita ULRICH & COOPER, 1938, Geol. Soc. Amer. Special Paper 13, p. 84, pl. 11A, figs. 1-4.

Description.—Shells are large for the genus; subelliptical in general outline. Hinge width is less than the greatest shell width. An average specimen is 8.8 mm long and 11 mm wide with a hinge width of 9.1 mm. Lateral margins are gently rounded; anterior margin broadly rounded. Shells are unequally biconvex with the ventral valve having the greater convexity. The surface orna-

mentation has several strong radii between which there are several fine costellae. On the anterior margin of a ventral valve 8 mm wide there are 10 to 12 costellae in 2 mm.

Ventral Exterior: The anterior profile is broadly convex with the convexity increasing to the midregion and then becoming flatly convex. Lateral slopes are moderately steep and become slightly concave to the cardinal extremities. Beak is strong and well developed, extending posteriorly past the interarea. Lateral profile is strong and unevenly convex, becoming flat from the midregion to the umbo.

Dorsal Exterior: Anterior profile is even and gently convex; lateral slopes are gently and slightly concave. A narrow, shallow sulcus is present from the beak to the anterior margin. Lateral profile is flatly convex; the midregion is the highest; beak is small.

Discussion.—As a consequence of the calcareous and poorly preserved specimens, good interiors have been unobtainable which necessitates a question as to the positive identification of the species *A. melita.* The costation, size, profiles, and stratigraphic occurrence appear to be similar.

Occurrence.—The occurrence of *A.* cf. *melita* at Ibex is the lowest of the articulates in the Pogonip Group. This species, though rare, occurs from 25 feet above the base of the House Limestone to about the 170 foot level.
Repository.—Figured specimens are BYU 1365, 1366, 1367, locality B-1 (Hintze, 1951).

Family CLARKELLIDAE Schuchert and Cooper, 1932
Genus *SYNTROPHINA* Ulrich, 1928
SYNTROPHINA CAMPBELLI (Walcott), 1908
Plate 1, figs. 4-9

Syntrophina campbelli WALCOTT, 1908, Smithson. Misc. Coll., v. 53, p. 107, 108, pl. 10, figs. 9, 9a-c; WALCOTT, 1912, U. S. Geol. Surv., Mon. 51, p. 801, fig. 73; ULRICH & COOPER, 1938, Geol. Soc. Amer. Spec. Paper 13, p. 218, pl. 46E, figs. 19-34.

Description.—Shell is small; width is greater than length and marked by concentric striae and a few strong lines of growth. A characteristic specimen is 6.5 mm long and 8 mm wide, with a hinge width of 4 mm. General form is transversely oval, unequally biconvex with a short hinge line which is slightly more than one-half the greatest shell width. Interarea is small and narrow.

Ventral Exterior: Valve moderately convex, exclusive of the prolonged frontal margin. Anterior profile is flatly convex and sulcate with lateral sides moderately swollen. The sulcus originates anterior to the beak, becoming wider and deeper anteriorly. The lateral lobes bounding sulcus are strongly convex, and the lateral slopes are steep. The highest portion of the valve is located slightly anterior to the midregion. Interarea is apsacline, short, and divided by a relatively large, open delthyrium.

Dorsal Valve: Evenly and steeply convex in lateral profile. Anterior profile is more gently inflated and trilobate. Fold is low, becoming steep at anterior margin. Fold originates in the umbo region and is evident from the midregion. Beak is incurved and extends slightly beyond the posterior margin.

Ventral Interior: Ventral valve shows a small, V-shaped spondylium supported on a high, thin, blade-like septum from the beak to about one-half the

distance to the anterior margin where it is also elevated on the median septum to be the highest point in the interior.

Dorsal Interior: Spondylium is small and shallow, supported by a median septum which extends one-third the valve length. Brachiophores are short and blade-like and slightly divergent.

Discussion.—This small brachiopod is not easily mistaken for other forms because of its distinctive characteristics and short vertical range. There is some similarity to *Diaphelasma complanatum,* but its smaller size and different shaped sulcus and fold make these species easily separated.

Occurrence.—*S. campbelli* occurs only in the upper 15 feet of the House Limestone and is significant as a zone fossil. It is characteristic of Zone C of Hintze (1951) and defines the approximate boundary of the House and Fillmore Formations.

Repository.—Figured specimens are BYU 1368, 1369, 1370, 1371, 1372, 1373, and are from the upper 15 feet of the House Formation at Section 9.

Genus *DIAPHELASMA* Ulrich and Cooper, 1936
DIAPHELASMA COMPLANATUM Ulrich and Cooper, 1936
Plate 1, figs. 10-13

Diaphelasma complanatum ULRICH & COOPER, 1936, Jour. Paleont., v. 10 no. 7, p. 629. ULRICH COOPER, 1938, Geol. Soc. Amer. Spec. Paper 13, p. 225, pl. 49C, figs. 26-36.

Description.—Shell is of moderate size. Shell width is considerably greater than the length. An average specimen is 9.5 mm long and 14 mm wide, with a hinge width of 8 mm. Valves are unequally biconvex with dorsal valves possessing the greater convexity and depth. The anterior commissure is uniplicate; shell surface is ornamented by very fine, radial costellae, no less than 10 per mm on a large adult specimen. Fine concentric growth lines and stronger growth varices also ornament the surface. Hinge line is narrow, one-half the valve width.

Ventral Exterior: Gently convex in lateral profile, umbo attaining highest elevation. Moderately sulcate in anterior profile. Sulcus originates at the umbo and rapidly diverges from the middle of the valve to become much wider and deeper toward the anterior margin. The areas bounding the sulcus are gently swollen and tend to disappear in the umbo region. Lateral slopes of the sulcus are gentle. Beak is obtuse, and the interarea is curved and apsacline.

Dorsal Exterior: Anterior profile is evenly rotund; fold is low, originating in the center of the valve at the point of greatest convexity. It forms a prominent dorsal flexture on the anterior edge. Sinuses defining the fold are shallow, beginning anterior to the middle. Lateral slopes are moderately and evenly swollen.

Ventral Interior: Spondylium is shallow and constricted at the front, forming a V with sides nearly flat but rising abruptly above the shell floor. The median septum is short and stout, flaring at the front. Teeth are prominent and slightly divergent.

Dorsal Interior: The notothyrial cavity is deep and supported at the front by two accessory septae; one on each side of a gap at the front margin of the

platform. Brachiopores are short, stout, and widely divergent. Sockets are shallow and lenticular.

Discussion.—The largest Canadian brachiopod to this horizon is found 360 feet into the Fillmore Formation, E Zone of Hintze (1951). This genus is closely related to *Syntrophina* and is apparently an offshoot from it. The principal differences between the genera are in the dorsal valve (Ulrich and Cooper, 1938). There are other very distinct morphological disimilarities in exteriors as well as interiors. The two lamellae of *Diaphelasma* are widely divergent or widely spaced. As in *Syntrophina* there is a diductor muscular callosity, but *Diaphelasma* does not show the strong thickening of the adductor field which is characteristic of *Syntrophina* (Ulrich and Cooper, 1938).

Occurrence.—The species is rare in the Ibex sections and has been found only at 360-365 feet above the base of the Fillmore Formation. It occurs immediately above a 6-foot algal-sponge reef in section C of Hintze. Some of the specimens are silicified, the only silicified brachiopods known from the Pogonip Group at Ibex.

Repository.—Figured specimens are BYU 1374, 1375, and 1376, from 360 feet above the base of Section 9.

Family FINKELNBURGIIDAE Schuchert and Cooper, 1932
Genus *FINKELNBURGIA* Walcott, 1905
FINKELNBURGIA FILLMORENSIS n. sp. Jensen
Plate 1, figs. 14-20

Description.—Shell is of medium size for the genus; transversely subelliptical in outline; hinge straight and long. Width is considerably greater than the length. A characteristic specimen of a ventral valve is 8.5 mm wide and 6.2 mm long. Cardinal extremities are right angled but range to more acutely pointed in some specimens. Sides rapidly converge anteriorly past the latero-median portion; anterior margin gently rounded. Anterior commissure is recti-marginate; surface ornamentation multicostellate; costellae of unequal size with groups of 3 to 4 small costellae between larger ones. There are about 14 unequal costellae in 3 mm on a valve 8.5 mm wide. Surface is corregated by several prominent growth rugae.

Ventral Exterior: Hemipyramidal, even and gently convex in lateral profile. Anterior profile is even and moderately convex; the umbo is full. Posterolateral slopes are steep and gently concave. Beak is prominent and extends past the posterior margin. Interarea is high and moderately long and apsacline.

Dorsal Exterior: Valve is even but more strongly convex in lateral profile, with swelling greatest in the midregion. Anterior profile is broadly and gently convex. A narrow, shallow sulcus begins near the beak and culminates at the anterior margin, covering only a small portion of the shell width. The beak is inconspicuous. Posterolateral slopes of the cardinal extremities are slightly concave.

Interiors: Ventral valve is marked by a wide and shallow pseudospondylium which is a thick callous deposit above the shell floor. A slender median septum extends anteriorly one-third the length of the valve. Brachiophore supporting plates form a shallow though thick, notothyrial cavity which is elevated at the

front above the shell floor. Brachiophores are short and stout; sockets are deep and form a very acute angle posteriorly.

Discussion.—*F. fillmorensis* is the only species of *Finkelnburgia* found at Ibex and is very rare. It is distinctive and not easily confused with other genera in the Ibex area. Occurrence of this brachiopod is environmentally controlled because it occurs only in thin calcarenite lenses of the Fillmore intraformational conglomerates. It is associated with *Nanorthis,* abundant cystoid fragments, and trilobite fragments. *F. fillmorensis* is most closely similar to *F. bellatula* Ulrich and Cooper and *F. buttsi* Ulrich and Cooper but it lacks the strongly hemipyramidal shape of the ventral valve of the former. In addition to the different shell outline and profile, *F. fillmorensis* has a more shallow notothyrial cavity and a longer and narrower pseudospondylium than *F. buttsi.*

The occurrence of *F. fillmorensis* at Ibex is the westernmost occurrence of *Finkelnburgia.*

Occurrence.—*Finkelnburgia* was found only near the middle of the Fillmore Limestone, 795 feet above the base at Section 9. It occurs only in a thin calcarenite lense at that position.

Repository.—Holotype, BYU 1383; paratypes, BYU 1378, 1379, 1380, 1381, 1382, 1384, 1385, all from Section 9, 795 feet above the base.

Genus *DIPARELASMA* Ulrich and Cooper, 1936
DIPARELASMA TYPICUM Ulrich and Cooper, 1936
Plate 2, figs. 1-6

Diparelasma typicum ULRICH & COOPER, 1936, Jour. Paleont., v. 10, no. 7, p. 623; ULRICH & COOPER, 1938, Geol. Soc. Amer. Spec. Paper 13, p. 154-55, pl. 28E, figs. 25-40.

Description.—Shell is not large, even in adult specimens; some immature specimens are unusually small. A characteristic adult is 7.5 mm long and 8.5 mm wide, with a hinge width of 6.5 mm. It is subcircular in outline; the hinge is narrower than the width. Shell is unequally biconvex, with the ventral valve having greatest convexity. Lateral and anterior profiles are lenticular. Surface ornamentation is multicostellate, with about 5 costellae in 1 mm at the anterior

EXPLANATION OF PLATE 1

APHEOORTHIS, SYNTROPHINA, DIAPHELASMA, FINKELNBURGIA
OF THE HOUSE AND FILLMORE LIMESTONES

FIGS. 1-3.—*Apheoorthis* cf. *A. melita* (Hall and Whitfield), X2, lower House Limestone. *1.* exterior of ventral valve, BYU 1365. *2.* exterior of dorsal valve, BYU 1366. *3.* exterior of ventral valve, BYU 1367.

FIGS 4-9.—*Syntrophina campbelli* (Walcott), figs. 4-7 X2, figs. 8-9 X3, upper House Limestone. *4.* exterior of dorsal valve, BYU 1368. *5.* interior of dorsal valve, BYU 1369. *6.* exterior of dorsal valve, BYU 1370. *7.* exterior of dorsal valve, BYU 1371. *8.* interior of dorsal valve, BYU 1372. *9.* interior of ventral valve, BYU 1373.

FIGS 10-13.—*Diaphelasma complanatum* Ulrich and Cooper, 1936, X2, lower Fillmore Limestone. *10.* exterior of dorsal valve, BYU 1374. *11.* partially eroded ventral ex-

terior, BYU 1375. *12.* interior of dorsal valve, BYU 1374. *13.* interior of ventral valve, BYU 1376.

FIGS. 14-20.—*Finkelnburgia fillmorensis* Jensen n. sp. X2, middle Fillmore Limestone. *14.* paratype, dorsal exterior, BYU 1378. *15.* paratype, ventral exterior, BYU 1380. *16.* paratype, ventral interior, BYU 1381. *17.* holotype, dorsal interior, BYU 1382. *18.* paratype, dorsal interior, BYU 1383. *19.* paratype, dorsal exterior, BYU 1384. *20.* paratype, dorsal interior, BYU 1385.

EXPLANATION OF PLATE 2

DIPARELASMA, TETRALOBULA, HESPERONOMIA, HESPERONOMIELLA OF THE FILLMORE AND WAHWAH LIMESTONES

FIGS. 1-6.—*Diparelasma typicum* Ulrich and Cooper, 1936. X2, upper Fillmore Limestone and lower Wahwah Limestone. *1.* ventral exterior, BYU 1386. *2.* ventral interior, BYU 1387. *3.* dorsal interior, BYU 1388. *4, 5, 6.* anterior, posterior, lateral views respectively of ventral valve, BYU 1386.

FIG. 7.—*Tetralobula* sp. X1, middle Fillmore Limestone. Exterior surface of ventral valve, BYU 1389.

FIGS. 8-12.—*Hesperonomia dinorthoides* Ulrich and Cooper, 1938. X2, upper Fillmore Limestone and Wahwah Limestone. *8, 9.* interior of dorsal and ventral valves, BYU 1391, 1392. *10.* posterior view of complete specimen, BYU 1390. *11.* exterior view of ventral valve, BYU 1390. *12.* exterior view of dorsal valve, BYU 1390.

FIGS. 13-15.—*Hesperonomia subtransversa* Ulrich and Cooper, 1938. X2, upper Fillmore Limestone. *13.* interior view of an incomplete valve, BYU 1395. *14.* exterior of ventral valve, BYU 1393. *15.* exterior view of an incomplete dorsal valve, BYU 1396.

FIGS. 16-19.—*Hesperonomiella minor* (Walcott), X2, upper Wahwah Limestone. *16.* exterior view of exfoliated ventral valve, BYU 1397. *17.* interior view of ventral valve, BYU 1398. *18.* interior view of dorsal valve, BYU 1399. *19.* exterior view of ventral valve, BYU 1400.

EXPLANATION OF PLATE 3

TRITOECHIA, SYNTROPHOPSIS, IDIOSTROPHIA, ORTHIDIELLA, ORTHAMBONITES OF THE WAHWAH AND JUAB LIMESTONES AND KANOSH SHALE

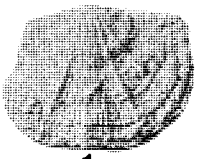
FIGS. 1-4.—*Tritoechia* sp., X2, middle Wahwah Limestone. *1, 2, 3.* exterior, posterior, and anterior views respectively of a ventral valve, BYU 1404. *4.* exterior view of exfoliated ventral valve, BYU 1405.

FIGS. 5-7.—*Syntrophopsis utahensis* (?) Ulrich and Cooper, 1938. X2, middle and upper Wahwah Limestone. *5.* exterior of eroded ventral valve exposing the spondylium, BYU 1414. *6.* exterior of partial ventral valve, BYU 1472. 7. exterior view of dorsal valve, BYU 1473.

FIGS. 8-10.—*Idiostrophia nuda* Cooper, 1956. X2, lower Juab Limestone. *8.* exterior view of ventral valve, BYU 1417. *9, 10.* anterior and lateral views of a complete specimen, BYU 1474.

FIGS. 11-16.—*Orthidiella longwelli* Ulrich and Cooper, 1936. X2, lower Kanosh Shale. *11, 12, 13.* exterior views of the ventral and dorsal valves and anterior view of a complete specimen, BYU 1475. *14.* interior view of ventral valve, BYU 1476. *15.* interior view of dorsal valve, BYU 1477. *16.* interior view of a dorsal valve, BYU 1478.

FIGS. 17-23.—*Orthambonites subalata* Ulrich and Cooper, 1938. X2, Juab Limestone and lower Kanosh Shale. *17.* ventral exterior of complete specimen, BYU 1479. *18.* interior view of a dorsal valve, BYU 1423. *19.* interior view of a ventral valve, BYU 1424. *20.* exterior view of the ventral valve of a complete specimen, BYU 1422. *21, 22, 23.* posterior, ventral exterior, and dorsal exterior of complete specimen, BYU 1422.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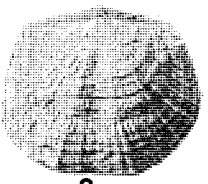
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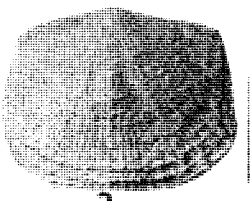
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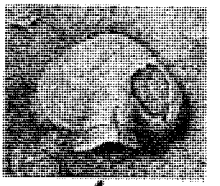
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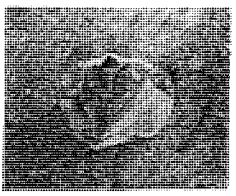
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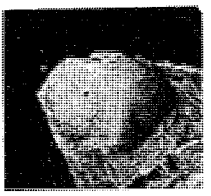
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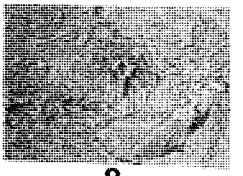
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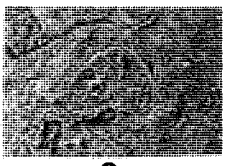
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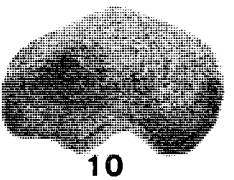
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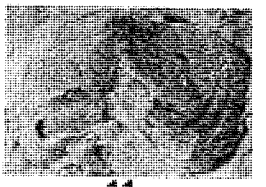
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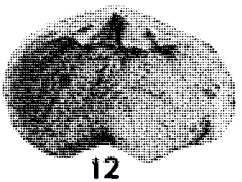
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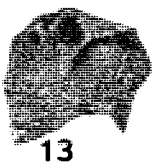
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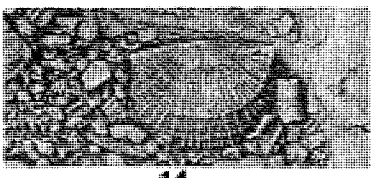
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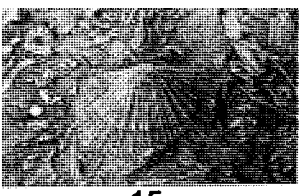
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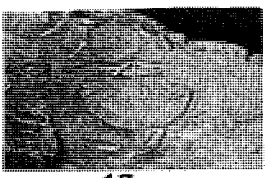
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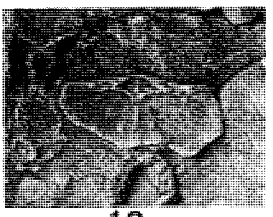
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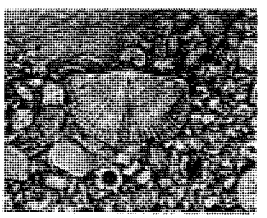
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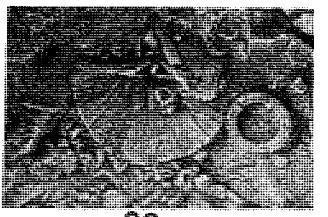
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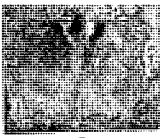
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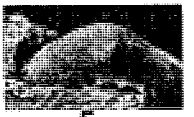
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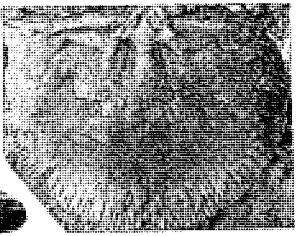
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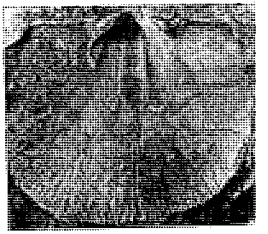
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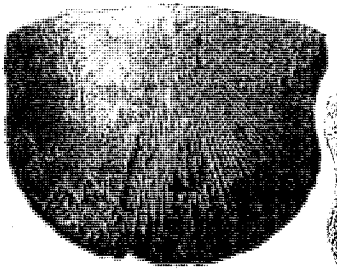
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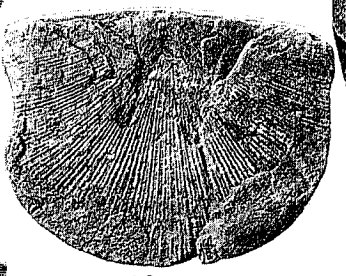
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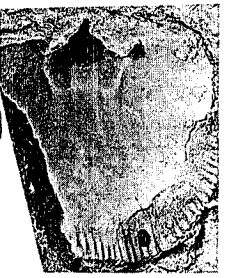
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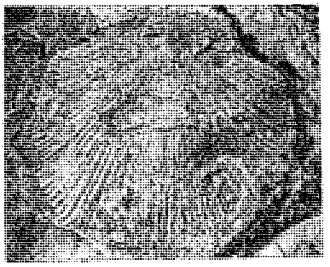
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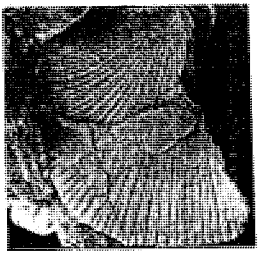
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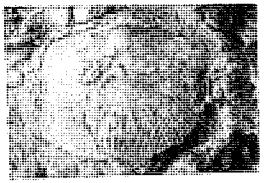
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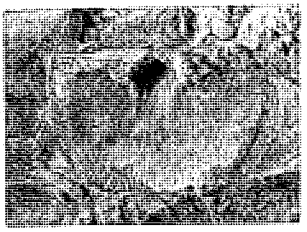
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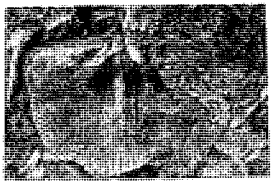
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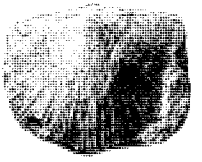
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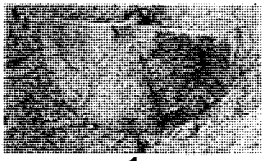
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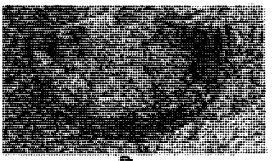
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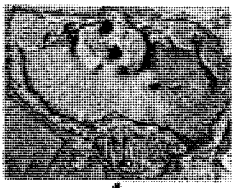
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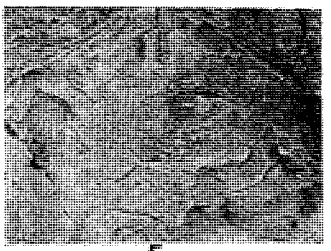
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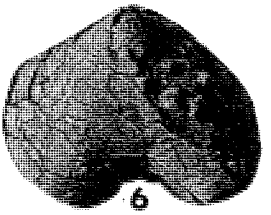
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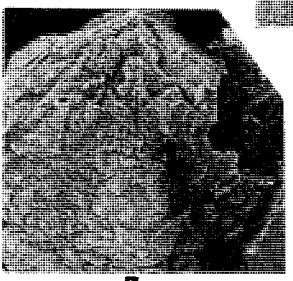
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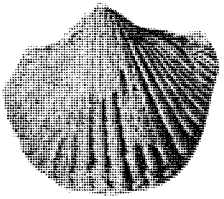
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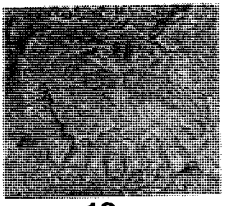
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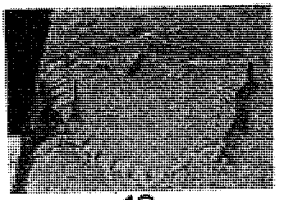
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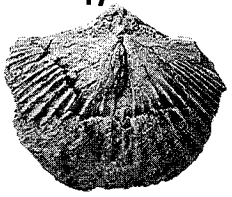
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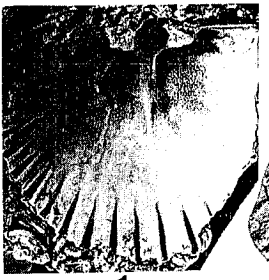
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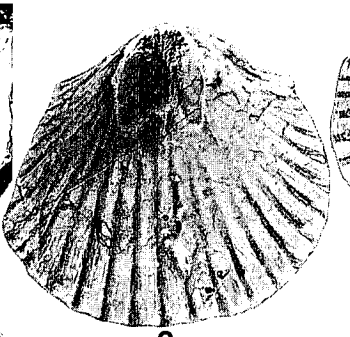
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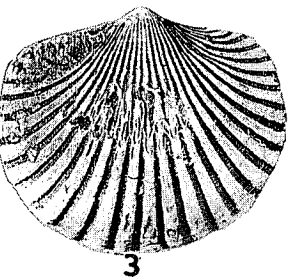
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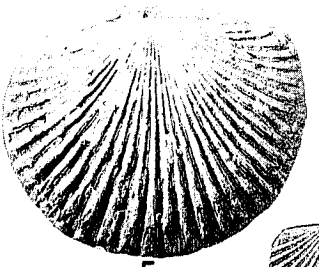
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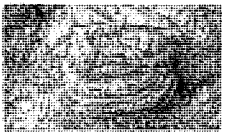
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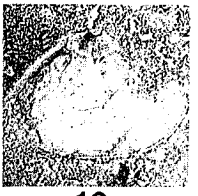
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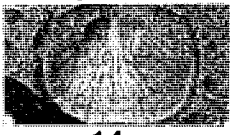
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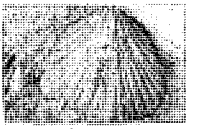
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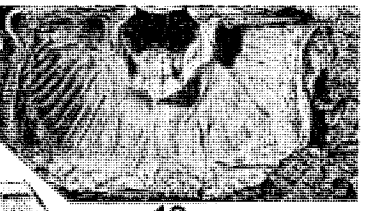
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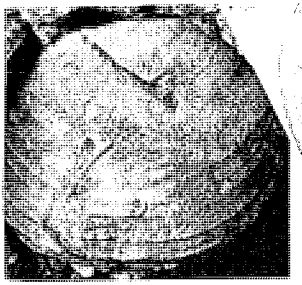
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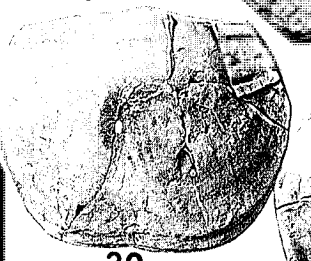
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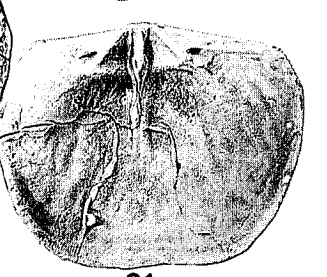
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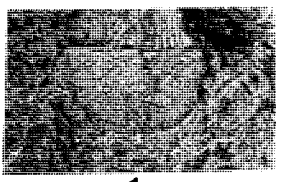
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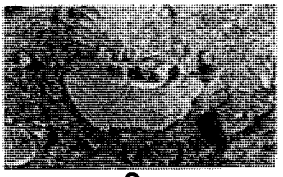
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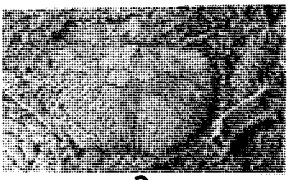
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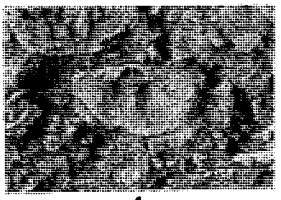
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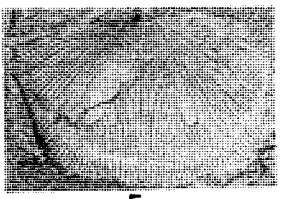
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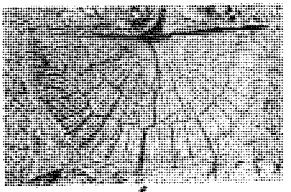
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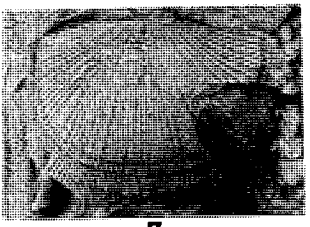
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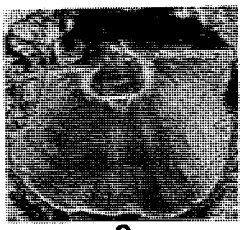
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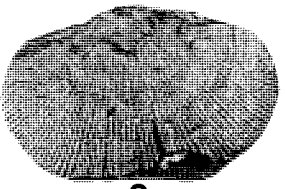
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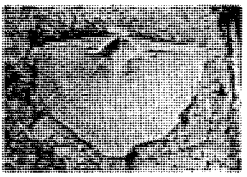
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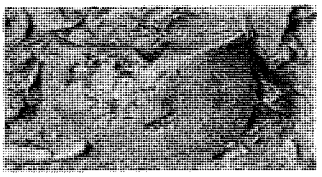
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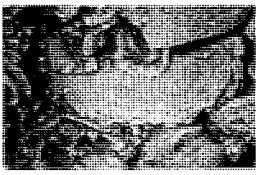
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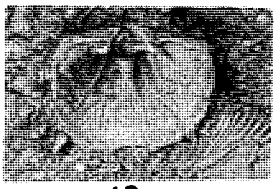
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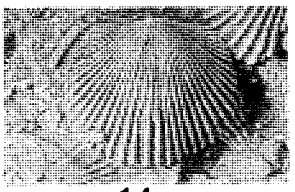
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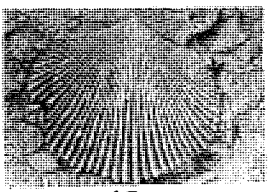
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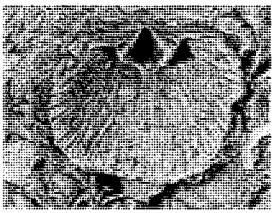
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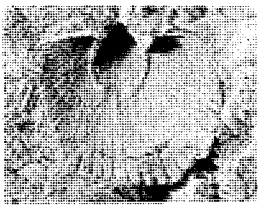
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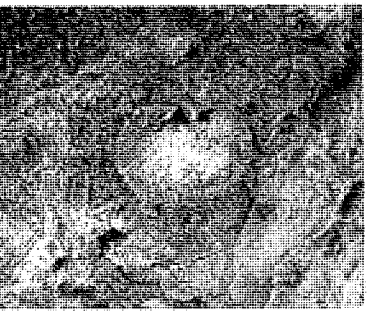

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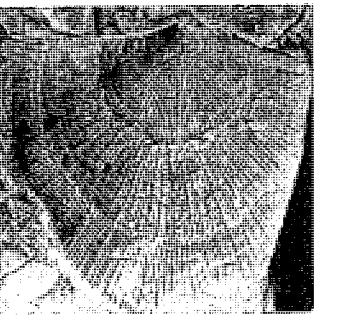

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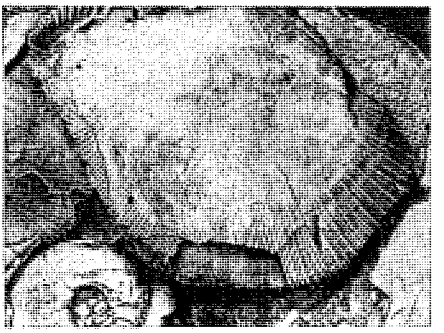

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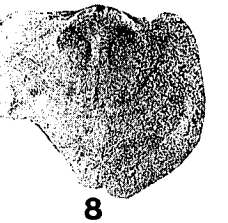

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EXPLANATION OF PLATE 4

ORTHAMBONITES, NANORTHIS, ANOMALORTHIS OF THE FILLMORE LIMESTONE, KANOSH SHALE, AND CRYSTAL PEAK DOLOMITE

FIGS. 1-5.—*Orthambonites michaelis* (Clark), 1935, X2, Kanosh Shale. *1.* interior view of a dorsal valve, BYU 1426. *2.* interior view of a ventral valve, BYU 1427. *3, 4.* ventral, posterior and dorsal views respectively of a complete specimen, BYU 1428. *5.* exterior view of a dorsal valve of a complete specimen, BYU 1429.

FIGS. 6-10.—*Orthambonites perplexus* Ross, 1967, X2, Crystal Peak Dolomite. *6.* exterior view of a ventral valve, BYU 1430. 7. exterior view of a dorsal valve, BYU 1431. *8, 10.* interior and posterior views of a ventral valve, BYU 1432. *9.* interior view of a dorsal valve, BYU 1433.

FIGS. 11-14.—*Nanorthis multicostata* Ulrich and Cooper, 1938. X2, lower and middle Fillmore Limestone. *11.* exterior view of an eroded ventral valve, BYU 1434. *12.* interior view of a partially complete dorsal valve, BYU 1435. *13.* exterior of an exfoliated dorsal valve, BYU 1437. *14.* interior of a ventral valve, BYU 1438.

FIGS. 15-17.—*Nanorthis hamburgensis* (Walcott), X2, lower to middle Fillmore Limestone. *15.* exterior view of a ventral valve, BYU 1440. *16.* exterior view of a dorsal valve, BYU 1441. *17.* exterior view of a partially complete ventral valve, BYU 1442.

FIGS. 18-21.—*Anomalorthis utahensis* Ulrich and Cooper, 1936. X2, Kanosh Shale. *18.* interior view of a ventral valve, BYU 1444. *19.* exterior view of a ventral valve, BYU 1443. *20, 21.* exterior and interior views of a dorsal valve, BYU 1445.

EXPLANATION OF PLATE 5

ANOMALORTHIS, DESMORTHIS OF THE JUAB LIMESTONE, KANOSH SHALE, AND LEHMAN FORMATION

FIGS. 1-6.—*Anomalorthis juabensis* n. sp. Jensen, X2, Juab Limestone. *1.* paratype, exterior view of a ventral valve, BYU 1446. *2.* holotype, interior view of a ventral valve, BYU 1449. *3.* exterior view of a dorsal valve, BYU 1447. *4.* interior view of a dorsal valve, BYU 1448. *5, 6.* interiors of eroded dorsal and ventral valves, BYU 1450, 1451.

FIGS. 7-10.—*Anomalorthis lonensis* (Walcott), X2, Kanosh Shale. 7. exterior view of a dorsal valve, BYU 1452. *8.* interior of a ventral valve, BYU 1453. *9.* exterior of an imperfect ventral valve, BYU 1454. *10.* interior of a dorsal valve, BYU 1455.

FIGS. 11-13.—*Anomalorthis nevadensis* Ulrich and Cooper, 1938. X2, Kanosh Shale. *11.* exterior view of a ventral valve, BYU 1456. *12.* interior view of a ventral valve, BYU 1457. *13.* interior view of a dorsal valve, BYU 1458.

FIGS. 14-17.—*Desmorthis nevadensis* Ulrich and Cooper, 1936. X2, upper Kanosh Shale and Lehman Formation. *14.* exterior view of a dorsal valve, BYU 1459. *15.* exterior view of a ventral valve, BYU 1460. *16.* interior view of a dorsal valve, BYU 1461. *17.* interior view of a ventral valve, BYU 1462.

EXPLANATION OF PLATE 6

DESMORTHIS, KIRKINA OF THE LEHMAN FORMATION AND CRYSTAL PEAK DOLOMITE.

FIGS. 1-3.—*Desmorthis ibexensis* n. sp. Jensen, X2, lower Lehman Formation. *1.* holotype, exterior view of the ventral valve, BYU 1464. *2.* paratype, interior view of a dorsal valve, BYU 1463. *3.* paratype, exterior view of a ventral valve, BYU 1465.

FIGS. 4-8.—*Kirkina millardensis* Salmon, 1942. X2, Crystal Peak Dolomite. *4.* interior view of an imperfect ventral valve, BYU 1467. *5.* exterior view of a ventral valve, BYU 1468. *6.* exterior of an exfoliated ventral valve, BYU 1469. *7.* interior of an imperfect ventral valve, BYU 1470. *8.* interior view of an imperfect dorsal valve, BYU 1471.

margin of a mature specimen 8.5 mm in width. Costellae are narrowly rounded and increase by branching.

Ventral Exterior: Lateral profile is moderately and evenly convex with greatest convexity posterior to the midregion; umbo tends to appear flattened in lateral view, with umbonal slopes steeply and evenly rounded. Anterior view is lenticular, gently and evenly convex for the anterior two-thirds, and flattened posteriorly to the beak. Lateral slopes are steeply and evenly convex. Beak is nearly straight and interarea is apsacline.

Dorsal Exterior: Lateral profile is evenly and gently convex, with swelling greatest posterior to the midregion. Swelling is even in anterior profile, leveling out posterior to the middle. A shallow sulcus begins at the beak and widens anteriorly to cover one-third of the anterior margin.

Ventral Interior: Pseudospondylium is tripartate, and delthyrial cavity is deep. A narrow, low ridge at the front of the pseudospondylium extends anteriorly one-half the length of the shell. Diductor scars and ovate adductor scars are elongate and expanded at the front.

Dorsal Interior: Notothyrial cavity is narrow and deep, but the platform is thickened and raised. Cardinal process appears to be absent. Brachiophores are stout and elongate. Medial ridge is low and moderately wide, tapering and extending anteriorly slightly past the midregion.

Discussion.—Immature specimens of this species are abundant in the upper Fillmore, but are usually exfoliated and poorly preserved. *D. typicum* is not easily confused with any other species in the Ibex area because of its small size and fine ornamentation.

Occurrence.—*D. typicum* is found in the upper 475 feet of the Fillmore Formation at Section 6 and the lower 200 feet of the Wahwah Formation at Section 3.

Repository.—Figured specimens are BYU 1386, 1387, and 1388, from 310 feet above the base of Section 6.

Family TETRALOBULIDAE Ulrich and Cooper, 1936
Genus *TETRALOBULA* Ulrich and Cooper, 1936
TETRALOBULA sp.
Plate 2, fig. 7

Description.—Shell is small and transversely subelliptical in outline. Hinge line is narrower than the greatest shell width. The ventral valve is 8.8 mm wide and 6.5 mm long. The surface is beautifully multicostellate. Strongly imbricating lamellae are covered with fine, rounded, hollow costellae. There are 4 costellae in one millimeter on a ventral valve 8.8 mm wide.

In lateral profile the ventral valve is flatly convex. Lateral margins are gently rounded. Anterior profile is even and gently convex. Umbonal region is full and gently swollen, but greatest swelling is a little anterior to the umbo. Sulcus originates abruptly, a little posterior to the middle of the valve, and widens rapidly to occupy more than one-fourth of the valve width. The anterior commissure is uniplicate. Areas bounding the sulcus are gently rounded. Lateral areas are gently convex to slightly concave. The beak is obtusely pointed and prominent.

Discussion.—The genus *Tetralobula* is known in the present collections by a single ventral valve.

Occurrence.—This single specimen was collected from a one-inch calcarenite lens 960 feet above the base of the Fillmore Limestone in Section G in Zone G of Hintze (1951).

Repository.—Figured specimen is BYU 1399, from Section 5 at 600 feet above the base.

Family HESPERONOMIDAE Ulrich and Cooper, 1936
Genus *HESPERONOMIA* Ulrich and Cooper, 1936
HESPERONOMIA DINORTHOIDES Ulrich and Cooper, 1938
Plate 2, figs. 8-12

Hesperonomia dinorthoides ULRICH & COOPER, 1938, Geol. Soc. Amer. Spec. Paper 13, p. 117, pl. 19C, figs. 18-22.

Description.—Shell is large, subquadrate in outline, hinge forming the widest part, angular cardinal extremities. A characteristic ventral valve is 16.5 mm long and 19.5 mm wide, with a hinge width of 20.5 mm. In lateral profile it is concavo-convex with ventral valve gently convex and the dorsal valve slightly concave. Interarea is gently apsacline, delthyrium is broad. The surface is ramicostellate with low, rounded costellae of unequal size. There are about 16 costellae in 5 mm on the anterior margin of a large valve.

Ventral Exterior: Valve gently swollen with convexity greatest in the mid-region; umbo is narrow and slightly swollen; umbonal slopes are very gently convex. Anterior margin gently convex, convexity of lateral slopes less than at the anterior. Beak is nearly straight. Cardinal extremities are deflected a little laterally.

Dorsal Exterior: Dorsal posterior and cardinal extremities are flat, but the midportion is very gently concave. This valve has a slightly discernible sulcus which starts at the beak and diverges to encompass most of the anterior margin. The posterolateral portion is flat.

Ventral Interior: Delthyrial cavity is wide and ovate. The teeth are short and stout. Large, widely divergent diductor muscle scars extend anteriorly just short of the midregion. Dental lamellae are very narrow and hardly discernible.

Dorsal Interior: The notothyrial platform is strongly thickened to nearly fill the notothyrial cavity. The cardinal process is a low and narrow ridge. Brachiophores are low and slender due to the thickening of the notothyrial platform. The medial ridge is low and moderately wide, extending about one-third the length of the valve. The sockets are long and narrow.

Discussion.—This species is most abundant in the upper 15 feet of the Fillmore Formation and the lower 10 feet of the Wahwah Formation. It is easily distinguished from *H. subtransversa* (with which it occurs in the upper Fillmore beds) by its slightly larger size and more delicate ornamentation.

Occurrence.—This species occurs throughout the upper 350 feet of the Fillmore Formation at Section 6 and the lower 175 feet of the Wahwah Formation at Section 3.

Repository.—Figured specimens are BYU 1390, 1391, and 1392, from 10 feet above the base of Section 3.

HESPERONOMIA SUBTRANSVERSA Ulrich and Cooper, 1938
Plate 2, figs. 13-15

Hesperonomia subtransversa ULRICH & COOPER, 1938, Geol. Soc. Amer. Special Paper 13, p. 122, pl. 20B, figs. 5-8.

Description.—The shell is large, subquadrate in outline, with hinge width slightly less than midwidth of the shell. An average sized specimen is 13.5 mm long and 16 mm wide, with a hinge width of 15.5 mm. Cardinal extremities are subacute; lateral margins are nearly straight, converging a little from the center of the valve; anterior margin is rounded. Ventral valve is evenly and gently swollen in lateral profile with greatest convexity in the center of the valve. The ventral valve is more strongly convex in anterior profile. Beak is not prominent and extends only slightly past the posterior. The interarea is narrow and apsacline.

Dorsal valve is flat to slightly concave, with concavity deepest near the middle of the valve. The median sulcus is shallow and narrow. It originates at the umbo and becomes gradually shallower and wider toward the anterior margin.

Interiors: The ventral interior differs from that of *H. dinorthoides* by having a more restricted and narrower diductor muscular field. The field is slightly tripartate. The delthyrial cavity is a little longer and apexes in a sharper "V" than *H. dinorthoides.* A well-preserved dorsal interior has not been found in the collections.

Discussion.—*H. subtransversa* Ulrich and Cooper, is associated with *H. dinorthoides* in the upper Fillmore Formation. The most obvious difference between the species is the multicostellate surface ornamentation of *H. subtransversa* Ulrich and Cooper. There are 12 costellae in 3 mm on the ventral valve of a large specimen 16 mm wide, in contrast to 17 costellae in the same distance on *H. dinorthoides.*

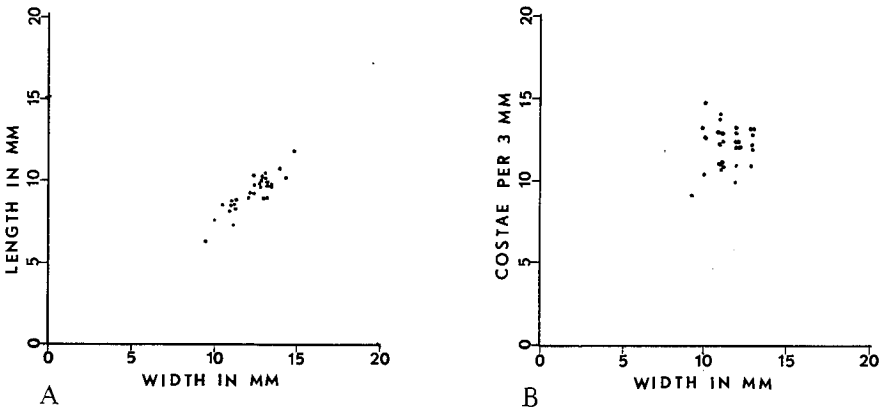
Occurrence.—This species is not too common in the Pogonip Group at Ibex. It occurs only in the upper 300 feet of the Fillmore Formation at Section 6, it makes its last known occurrence at the base of the overlying Wahwah Formation.

Repository.—Figured specimens are BYU 1393, 1394, and 1395, from 160, 150 and 140 feet respectively above the base of Section 6.

Genus *HESPERONOMIELLA* Ulrich and Cooper, 1936
HESPERONOMIELLA MINOR (Walcott)
Plate 2, figs. 16-19

Streptorhynchus minor WALCOTT, 1884, U. S. Geol. Surv., Mon. 8, p. 75, pl. 11, fig. 9
Strophomena (?) *minor* SCHUCHERT, 1897, U. S. Geol. Surv., Bull. 87, p. 432.
Hesperonomiella minor ULRICH & COOPER, 1938, Geol. Soc. Amer. Spec. Paper 13, p. 124, pl. 21H, fig. 28.

Description.—Shell is of moderate size and narrowly lenticular in lateral profile. Biconvex with ventral valve having slightly greater convexity. Hinge forms the widest part of the shell. Interarea is apsacline and quite small. Surface ornamentation is fine and delicate, multicostellate with 10 subangular costellae in 2 mm at the anterior margin of a shell 11.5 mm in width. The costellae



TEXT-FIGURE. 3.—A. Scatter diagrams of length to width of *Hesperonomiella minor* (Walcott) from 215 feet above the base of the Wahwah Limestone indicates good correlation. B. Scatter diagram of width to costae per 3 mm. Ratio of *H. minor* (Walcott) is a constant.

increase by branching near the middle of the shell. An average specimen is 9 mm long, 11 mm wide, and 13 mm wide at the hinge.

Ventral Exterior: Ventral valve is gently convex and lenticular in lateral profile. The anterior profile shows a more gentle convexity with the greatest swelling in the umbo. Lateral slopes are even and steep, becoming slightly concave near the cardinal extremities. Beak is obtuse and extends beyond the posterior.

Dorsal Exterior: Anterior profile is gently convex with a deep median sulcus which begins at the beak and broadens to encompass about one-third of the anterior margin. The areas bounding the sulcus are swollen, and slopes to the cardinal extremities are slightly concave near the lateral margin.

Interiors: The delthyrial cavity is shallow and small. Dental plates are short and thick and the teeth are large and blunt. A delthyrial platform is slightly developed, becoming thicker at the posterior.

The notothyrial cavity is small and narrow, and the platform is a thick callous of shell material. The cardinal process is simple and blade-like, and brachiophores are short and stout. The small and deep tear-shaped adductor field is divided by a wide and thick median ridge which extends one-third of the distance to the anterior margin.

Occurrence.—*H. minor* occurs in a 1½- to 2-foot coquinoid bed 215 feet above the base of the Wahwah Formation at Section 3, within Zone K of Hintze (1951), and as such this bed serves as a very useful marker horizon. A few rare specimens of *H. minor* have been collected stratigraphically 115 feet above the base of the Wahwah Formation at Section 3, but none have been noticed above the coquinoid bed.

Repository.—Figured specimens are BYU 1397, 1398, 1399, and 1400, from 215 feet above the base of Section 3.

Family TRITOECHIIDAE Ulrich and Cooper, 1936
Genus *TRITOECHIA* Ulrich and Cooper, 1936
TRITOECHIA sp.
Plate 3, figs. 1-4

Description.—Shell is of medium size; a typical ventral valve is 12.7 mm wide and 7.6 mm long. General outline is suboval to subquadrate. Hinge is long and straight and slightly shorter than the greatest shell width. Ventral interarea is long, high, uncurved, and straight. In lateral profile the valves are unequally biconvex. The anterior margin is rectimarginate. Surface is marked by fine radial lines, numbering 9 in 2 mm on the anterior margin of a ventral valve 15.5 mm wide.

The ventral valve in lateral profile is hemipyramidal, steep and flatly convex, with the beak tip reaching the highest elevation. Deltidium is curved and strongly elevated, tapering gradually to the beak; apical foramen is small. In anterior profile valve is gently convex with a full midregion. Lateral slopes are steep and slightly concave.

Interior: Only an exfoliated shell exposing a cast of the ventral interior is known. Delthyrial cavity is deep and slightly elevated at the front. Dental plates are strong and extend to the shell floor. A small median ridge extends past the midregion.

Discussion.—This genus is easily distinguished from others at Ibex because of its distinctive "lamp-shade" shape; there is no other genus that closely resembles it. *Tritoechia* is unusually rare; only two ventral valves are known.

Occurrence.—This species of *Tritoechia* is found in Zone J of Hintze (1951), 95 feet above the base of the Wahwah Limestone at Section 3. The total stratigraphic range is unknown because of its rarity.

Repository.—Figured specimens are BYU 1404 and 1405, from 95 feet above the base of Section 3.

Family SYNTROPHOPSIDAE Ulrich and Cooper, 1936
Genus *SYNTROPHOPSIS* Ulrich and Cooper, 1936
SYNTROPHOPSIS UTAHENSIS (?) Ulrich and Cooper, 1938
Plate 3, figs. 5-7

Syntrophopsis utahensis (?) ULRICH & COOPER, 1938, Geol. Soc. Amer. Special Paper 13, p. 238, pl. 52A, figs. 1, 5.

Description.—Shell is large, syntrophoid in outline, and transversely elliptical. The hinge is narrower than the widest part of the shell, and the width is greater than the length. A large ventral valve is 23.2 mm wide and 18.8 mm long. Surface of the specimens at hand are badly exfoliated so the ornamentation is not preserved. Valves are unequally biconvex, with the dorsal valve having the greater convexity. The anterior commissure is strongly uniplicate. Interareas are subequal and apsacline.

Ventral Exterior: Ventral valve is gently and flatly convex in lateral profile. Highest portion is posterior to the midregion. The umbo is slightly swollen. The shell is gently concave in anterior view because of the sulcus which originates near the middle of the valve. The sulcus is shallow and diverges rapidly to the anterior margin, and folds bounding the sulcus are even and gentle. Posterolateral margins are slightly concave. Beak is moderately prominent.

Dorsal Exterior: Dorsal valve is steeply and unequally convex in lateral profile. In anterior profile the shell is strongly convex with the greatest convexity anterior to the middle. Lateral slopes are steep and slightly concave. A strong fold originates one-third of the distance from the beak to the anterior margin. It is even and gently convex over the middle, but with steep slopes.

A partly preserved ventral interior is known in exfoliated material.

Discussion.—This is the only species of *Synthophopsis* known from the Ibex sections. The genus is similar in some general respects to *Syntrophina* and *Diaphelasma,* but is easily distinguished by its larger size and younger stratigraphic occurrence.

Occurrence.—This genus is extremely rare at Ibex; two poorly preserved ventral and dorsal valves are all the material on hand at the present time. These specimens were found 60 feet above the base of the Wahwah Limestone in Zone J of Hintze (1951), and at the base of the overlying Juab Limestone at Section 3.

Repository.—Figured specimens are BYU 1414, 1472, and 1473, from 60, 230, and 60 feet respectively above the base of Section 3.

Family CAMERELLIDAE Hall and Clarke, 1894
Genus *IDIOSTROPHIA* Ulrich and Cooper, 1936
IDIOSTROPHIA NUDA Cooper, 1956
Plate 3, figs. 8-10

Idiostrophia nuda COOPER, 1956, Smithsonian Misc. Coll., vol. 127, part. 1, p. 588.

Description.—Shell is small, though of medium size for the genus. General outline is triangular and obtuse on the posterior end, with the sides obliquely straight, and the remainder of the shell subovate. Width is slightly greater than length, and the hinge is narrow. A typical specimen is 7.1 mm long and 8.2 mm wide, with a hinge width of 6.1 mm. Valves are unequally biconvex, with the dorsal valve of greater convexity. Surface is nearly smooth, marked by extremely fine radial lines. Anterior one-seventh is marked by 15 even and broadly rounded costae. The anterior commissure is broadly uniplicate.

Ventral Exterior: Ventral valve is moderately convex in lateral profile and even and gently convex in anterior profile. Umbo is inflated and gently sloping to the midregion, with the gradient steeper toward the anterior margin. Beak is prominent and well developed, extending slightly past the posterior margin. Slopes to the lateral margins are moderately steep. A shallow groove extends along the lateral margin of the shell from a point near the beak to the anteriolateral extremities. The ridge defining the depression is small and hardly discernible.

Dorsal Exterior: The dorsal valve is slightly more convex than the ventral valve, with the greatest convexity in the umbonal region. The umbo is strongly swollen, but the rest of the shell is more gently swollen.

Lateral margins are defined by a low ridge, with a shallow concave area between the ridge and the lateral commissure. The anterior forms a broad fold which occupies the entire width.

Discussion.—*Idiostrophia nuda* Cooper is the only species of the genus known to occur in the Ibex sections. This species is characterized by its lack of ornamenta-

tion, excluding the very delicate and fine radial lines and the fine costae at the anterior margin.

Occurrence.—Because of the rarity of this species, the total stratigraphic range is not known. It has been found to date only in the lower part of the Juab Limestone in the Ibex sections at Section 3.

Repository.—Figured specimen is BYU 1474, from 245 feet above the base of Section 3.

Family ORTHIDIELLIDAE Ulrich and Cooper, 1936
Genus *ORTHIDIELLA* Ulrich and Cooper, 1936
ORTHIDIELLA LONGWELLI Ulrich and Cooper, 1936
Plate 3, figs. 11-16

Orthidiella longwelli ULRICH & COOPER, 1936, Jour. Paleont., v. 10, p. 621; ULRICH & COOPER, 1938, Geol. Soc. Amer. Spec. Paper 13, p. 109, pl. 17D, figs. 15-33.

Description.—Shell is small, subquadrate in outline, biconvex and unequal in depth with the ventral valve the deepest, and is marked by nearly straight lateral margins and gently rounded sulcate anterior margin. Interarea is long and slightly curved; delthyrium is small. The hinge line is the widest part of the shell with the width three-fourths of the length. The cardinal extremities form an acute angle. The shell surface is mulitcostellate, costellae increasing by branching and intercalation. There are 8 inverted V-shaped costellae in 3 mm of a ventral valve 8 mm in width. A characteristic specimen is 6.5 mm long, 8.5 mm wide and 9 mm wide at the hinge.

Ventral Exterior: Strongly convex in lateral profile, convexity being greatest in the middle. The greatest convexity is caused by a large, broad fold which occupys one-half the valve. Lateral margins are gently convex and slope evenly, with concave cardinal extremities. The beak is low and slightly incurved.

Dorsal Exterior: Anterior profile is moderately convex. A strong median sulcus extends from the beak and widens at the anterior margin to one-half the shell width. Lateral sides of the sulcus are gently convex with the slope less on the outer margin. Slopes to the cardinal extremities are slightly concave.

Interior: Delthyrial cavity is small and deep. Teeth have deep crural fossettes with an accessory tooth on the ventral side of the fossette. Diductor scars are elongated.

Inside the dorsal valve brachiophores are bound to the cardinal process by shell material uniting the structures. Brachiophores are short and stout; median ridge is short and thick, extending one-third the length of the valve. The adductor field is small and reniform shaped, divided by the median ridge.

Discussion.—There is no other species of *Orthidiella* found in the Pogonip Group at Ibex, and there is no other species which closely resembles it. Therefore, it is quite easily distinguished.

Occurrence.—*O. longwelli* is the only species of the genus found in the Ibex section and is found only in the basal five-foot ledge of the Kanosh Shale. As such it is extremely useful for identification of the basal Kanosh contact.

Repository.—Figured specimens are BYU 1475, 1476, 1477, 1478, from the base of Section 2.

Family ORTHIDAE Woodward, 1952
Subfamily ORTHINAE Schuchert and Cooper, 1931
Genus *ORTHAMBONITES* Pander, 1930
ORTHAMBONITES SUBALATA Ulrich and Cooper, 1938
Plate 3, figs. 17-23

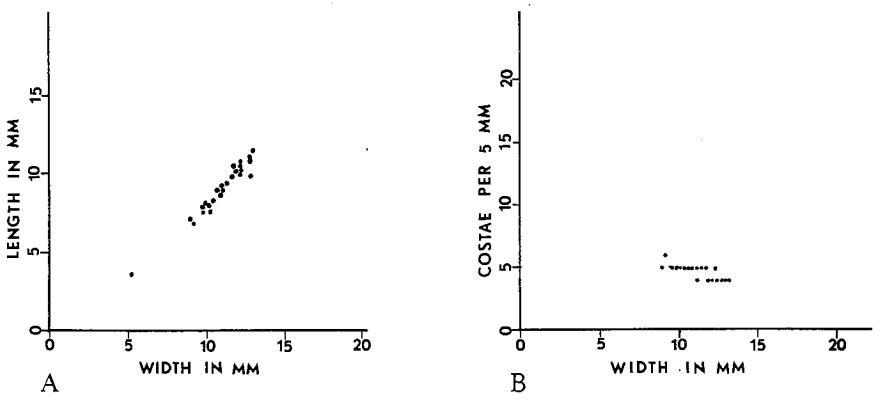
Orthambonites subalata ULRICH & COOPER, 1938, Geol. Soc. Amer. Spec. Paper 13, p. 103, pl. 15C, figs. 16-21.

Description.—Shell is medium size and wider than long due to the wide angular cardinal extremities. An average specimen is 9 mm long and 9 mm wide, with a hinge width of 11 mm and a thickness of 5 mm. Anterolateral margins are flatly convex with convexity rapidly increasing toward the midportion of the shell. Anterior margin is slightly sinuate. In lateral profile the shells are unequally biconvex with the ventral valve having by far the greater convexity and depth. Surface of the shells are covered by approximately 26 rounded, steeply convex, radiating costae, and both costae and interspaces are covered by fine radial lines.

Lateral profile of the ventral valve is moderately convex with convexity becoming greatest toward the midregion. Posteriolateral margins are slightly concave with steepest side adjacent to the inflated umbonal region. The hinge line is straight and forms the widest part of the shell. Delthyrium is moderately broad.

Lateral profile of the dorsal valve is very gently convex, with greatest convexity posterior to the midregion. The central portion of the valve is depressed to form a low, narrowly diverging sulcus which begins at the beak and broadens at the anterior where it includes 5-6 costae. Lateral margins of the shallow sulcus are gently convex but become slightly concave near the posterior margin.

Interiors: The delthyrial cavity is deep, and the platform is only slightly raised due to limited thickening of the shell material. Inside the dorsal valve the notothyrial cavity is narrow and shallow, brachiophores are short and stout,



TEXT-FIGURE 4.—A. Scatter diagram of length to width of *Orthambonites subalata* Ulrich and Cooper from the Juab Limestone, indicates good correlation. B. Scatter diagram of width to costae per 5 mm ratio of *O. subalata* Ulrich and Cooper which indicates very little variation in the species.

and the median ridge is low and extends anteriorly about two-thirds of the dorsal valve.

Discussion.—*O. subalata* is easily distinguished from *O. michaelis* by the angular cardinal extremities, more convex ventral valve, and coarser costation of *O. subalata.* This species is fairly common though usually not well preserved.

Occurrence.—*O. subalata* is found only in the Juab Limestone and the basal 20 feet of the overlying Kanosh Shale in the Ibex area. The Juab Formation is a mappable rock unit devised by the occurrence of this brachiopod fauna.

Repository.—Figured specimens are BYU 1479, 1423, 1424, and 1422, from 270, 270, 261 and 335 feet respectively above the base of Section 3.

ORTHAMBONITES MICHAELIS (Clark), 1935
Plate 4, figs. 1-5

Orthis michaelis CLARK, 1935, Jour. Paleont., v. 9, p. 242, pl. 24, figs. 5, 6; ULRICH & COOPER, 1938, Geol. Soc. Amer., Special Paper 13, p. 101, pl. 14C, figs. 11, 12, 21, 23, 25-29.
Orthambonites michaelis COOPER, 1956, Smithsonian Misc. Coll., v. 127, pt. 1, p. 304.

Description.—The Kanosh Shale of the Ibex area has an abundance of this species. It is the most abundant brachiopod of the area and is represented by specimens of excellent preservation, both articulated and disarticulated. The average size of a specimen is 18 mm long and 20 mm wide, with a hinge width of 15 mm. The hinge line and cardinal extremities are considerably narrower than the widest part of the shell. The beak is slightly incurved; delthyrium is narrowly triangular.

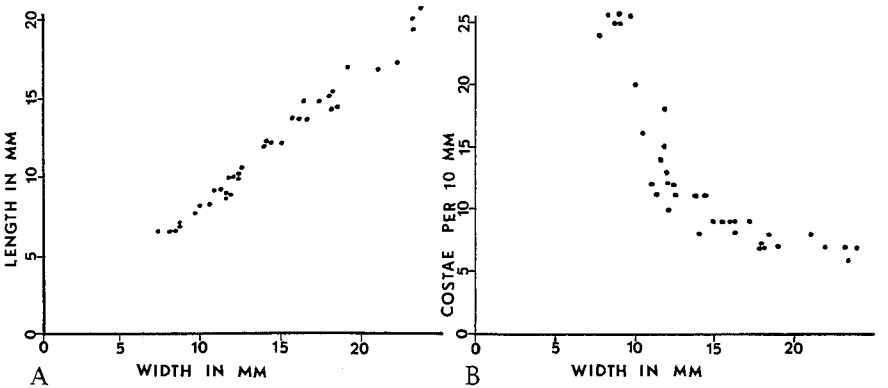
Some shells become quite large but there is an abundance of smaller immature specimens.

Ventral Exterior: The lateral profile is unequally biconvex with the strongly convex ventral valve having greatest convexity in the umbonal regions in the center part of the valve and spreading to the anterior half. The lateral slopes are steepest in the posterior end near the umbo and beak. This valve is covered by approximately 36 abruptly elevated costae which are flatly convex at the top. The interspaces and costae are covered by fine radial lines. The interspaces are narrower than the costae.

Dorsal Exterior: In lateral profile the dorsal valve is gently convex with greatest convexity in the midregion. Anterior profile is very flatly convex. There are 34 costae on the dorsal valve which are shaped the same as those on the ventral valve.

Interiors: The spondylium is distinctly tripartite with lateral lobes extending farther anteriorly in some and distinctly bipartite in others. A faint medial septum is present. The dorsal interior is marked by a very narrow, blade-like cardinal process. Medial ridge is wide and short, narrowing to a fine point anteriorly. Notothyrial cavity is narrow and deep; brachiophores are wide and stout; posterior adductor scars are larger than the anterior.

Discussion.—Ulrich and Cooper (1936) distinguish from *O. michaelis* a very similar species called *O. swanensis* which is characterized by coarser ornamentation and a more narrowly oval ventral muscular region. This writer has noticed



TEXT-FIGURE 5.—A. Scatter diagram of length to width of *Orthambonites michaelis* (Clark) from the Kanosh Shale indicates good correlation. B. Scatter diagram of width to costae per 10 mm ratio of *O. michaelis* (Clark). The ratio is proportional to the growth of the individual.

the slightly coarser ornamentation but due to the very close similarity and because their stratigraphic range is the same I have not distinguished between the two.

Occurrence.—*O. michaelis* is found throughout the upper 564 feet of the Kanosh Shale and Lehman Formation of the Ibex area, where it occurs in coquinoid lenses at some horizons. It is most abundant in the Kansh Shale.

Repository.—Figured specimens are BYU 1426, 1427, 1428, and 1429, from 390, 380 and 220 feet respectively above the base of Section 2.

ORTHAMBONITES PERPLEXUS Ross, 1967
Plate 4, figs. 6-10

Orthambonites perplexus ROSS, 1967, U. S. Geol. Surv. Prof. Paper 523-D, p. 3, pl. 1, figs. 20-29.

Description.—Shell is subcircular in outline, biconvex with the ventral valve having the greater convexity. Shell width is greater than length, and hinge width less than shell width. Lateral margins are nearly straight, tapering slightly toward the posterior. Anterior margin is broadly rounded. Surface ornamentation is costate with 23 narrow, elevated, subangular costae on the front of a ventral valve 9 mm wide. A characteristic ventral valve is 9.1 mm long, 10.8 mm wide, and 7.6 mm wide at the hinge.

Ventral Exterior: Lateral profile is moderately and evenly convex. Anterior profile is strongly swollen in the central portion of the valve but flattened from the umbo to the beak. Lateral slopes are uneven and steep, and slopes to the cardinal extremities are slightly concave. Beak is prominent and slightly incurved, extending well past the posterior margin. Interarea is curved and apsacline.

Dorsal Exterior: Convexity is less than in the ventral valve; anterior profile is even and gently convex. Lateral profile nearly flat in the posterior two-

thirds of the shell. A very shallow sulcus starts at the beak, diverges and deepens anteriorly, and includes about one-fourth of the shell width. Flanks bounding the sulcus are gently convex with long, gentle, posteriolateral slopes.

Ventral Interior: Delthyrial cavity is moderately deep; platform is only slightly thickened by shell material. Dental lamellae are thin and receding. They are attached to the shell floor and diverge toward the lateral margins. Teeth are long and moderately acute. Muscular field is bilobed.

Dorsal Interior: Notothyrial cavity is narrow and shallow. Brachiophores are moderately long and stout. Cardinal process is rudimentary, usually quite blade-like. Median ridge is low and wide, extending about one-third the valve length.

Discussion.—This species is part of a silicified fauna found only in the Crystal Peak Dolomite of the Eureka Group. *O. perplexus* is associated with *Kirkina millardensis* in the only well-silicified fauna of brachiopods in the Ibex area.

Occurrence.—This species has been found only in the lower 6 feet of the Crystal Peak Dolomite of the Eureka Group at the Crystal Peak section, where it is relatively common.

Repository.—Figured specimens are BYU 1430 and 1431, from 710 feet above the base of the Crystal Peak section.

Genus *NANORTHIS* Ulrich and Cooper, 1936
NANORTHIS MULTICOSTATA Ulrich and Cooper, 1938
Plate 4, figs. 11-14

Nanorthis multicostata ULRICH & COOPER, 1938, Geol. Soc. Amer. Spec. Paper 13, p. 90, pl. 12D, figs. 12-13.

Description.—Shell is large for the genus, 7 mm long and 8.5 mm wide, with a hinge width of 7 mm, and is subcircular to subelliptical in outline. Shells are unequally biconvex with the ventral valve exhibiting the greater convexity. The hinge line is narrower than the widest part, which occurs slightly anterior to the middle. The surface is finely multicostellate. Larger primary costellae are separated by several smaller secondary costellae. Rugae form several concentric wrinkles around the surface exterior.

Ventral Exterior: The lateral profile is moderately and evenly convex, and the anterior profile is evenly and gently swollen. Lateral slopes are even and moderately steep. Interarea is apsacline; beak extends slightly past the hinge line.

Dorsal Valve: Flatly convex and shallower than the ventral valve. The median part is marked by a moderately deep sulcus, extending from the beak but disappearing before reaching the anterior margin.

Interiors: The delthyrial cavity is shallow and the muscular field is slightly thickened and raised above the shell floor. A wide, anteriorly expanding, median ridge extends anteriorly one-half the shell length. Greater detail of the ventral valve is not known because of poor preservation and the dorsal interior is unknown in the Ibex material.

Discussion.—This species is easily distinguished from *N. hamburgensis* by its larger size and its finer and more even ornamentation. These two species of *Nanorthis* overlap in upper occurrences of *N. hamburgensis* and lower occurrences of *N. multicostata.*

Occurrence.—*N. multicostata* occurs in the Fillmore Formation from 175 to 1475 feet above the base at section 9 where it occurs on bedding planes of thin-bedded, platy, calcisiltites. It is generally poorly preserved with only a mold remaining. This species is quite rare and requires some diligent effort in locating it.

Repository.—Figured specimens are BYU 1434, 1435, 1438, and 1437, from 350 feet above the base of Section 9.

NANORTHIS HAMBURGENSIS (Walcott)
Plate 4, figs. 15-17

Orthis hamburgensis WALCOTT, 1884, U. S. Geol. Surv., Mon. 8, p. 73, pl. 2, fig. 5.
Nanorthis hamburgensis (WALCOTT) ULRICH & COOPER, 1938, Geol. Soc. Amer. Special Paper 13, p. 89, pl. 12F, figs. 19-26.

Description.—Shell is small and subcircular to slightly elliptical in general outline. Shells unequally biconvex with ventral valve having greater convexity. Hinge width is less than the greatest width, and length is greater than width. A typical specimen is 11 mm long and 7 mm wide, with a hinge width of 5.5 mm. Radial surface ornamentation is fascicostellate, with costellae arranged in bundles. The ventral valve, which is larger than the dorsal valve, has 50 costellae at the margin of a large valve. Including all the secondary costellae, and the dorsal valve has approximately 32.

The ventral valve is sublenticular in lateral profile and subcarinate in anterior profile. Posterolateral slopes subjacent to cardinal extremities are steep, with steepness lessening toward the anterior. Beak is incurved and extends beyond the apsacline interarea.

The dorsal valve is moderately but flatly convex. The valve is marked by a shallow, median sulcus which extends from the beak to the anterior margin, covering about one-third of the shell width. Slopes bounding the sulcus are gently convex. Areas subjacent to the cardinal extremities are slightly concave. The beak is small and inconspicuous.

An adequate description of interior features cannot be given because of poor preservation of the material at hand.

Discussion.—*N. hamburgensis* (Walcott) is easily distinguished from *N. multicostata* by its smaller size and coarser and more uneven ornamentation.

Occurrence.—This species is found in ledges of the upper 15 feet of the House Formation and in the lower 900 feet of the overlying Fillmore Formation at Section 9. The species is common in calcarenite lenses of the basal ledges of the Fillmore. A few rare specimens of this species are found associated with *Syntrophina campbelli* of the upper House Formation.

Repository.—Figured specimens are BYU 1440, 1441, and 1442, from 15 feet above the base of Section 9.

Family ANOMALORTHIDAE Ulrich and Cooper, 1936
Genus *ANOMALORTHIS* Ulrich and Cooper, 1936
ANOMALORTHIS UTAHENSIS Ulrich and Cooper, 1938
Plate 4, figs. 18-21

Anomalorthis utahensis ULRICH & COOPER, 1936, Jour. Paleont., v. 10, no. 7, p. 622; ULRICH & COOPER, 1938, Geol. Soc. Amer., Special Paper 13, p. 129, pl. 22C, figs. 11-13, 16, 17, 19-24.

Description.—This species is the largest *Anomalorthis* from the Ibex area. An average specimen is 12 mm long and 18 mm wide, with a hinge width of 18.5 mm. The hinge forms the widest part of the shell. Cardinal extremities on the ventral valve form indentations on the lateral sides of the shell. Cardinal extremities are acute to nearly a right angle. The lateral profile is unequally biconvex, with the dorsal valve having the greater convexity. Surface of the valves is covered by radiating fine, elevated, rounded costellae, about 5 or 6 in 1 mm near the anterior margin. Many of the costellae are swollen and hollow.

Ventral Exterior: Hemiconical, the lateral profile is a gradual nearly flat convexity, with the convexity greatest at the umbo. Interarea is broad, triangularly shaped, and strongly apsacline. Delthyrium is wide, occupying a large percentage of the posterior portion of the valve. Medial portion of the valve is marked by a shallow sulcus. Anterior profile is strongly convex but flattened near the middle.

Dorsal Exterior: Moderately convex with greatest convexity near the middle of the valve.

Interior: Sessile spondylium is well developed in the ventral valve and is moderately elevated at the front and with a barely discernible medial septum. Muscle scars extend anteriorly three-fourths of the valve. Vascula media are plainly evident. Dorsal interior is marked by a large and broad notothyrium. The cardinal process is long and slender. Brachiophores are flattened, rod-like plates, and well-developed sockets are located above the sloping outer surface. Adductor muscle scars are reniform shaped and extend to the medial portion of the valve. Pallial markings are evident.

Discussion.—This species is easily distinguished from *A. lonensis* and *A. nevadensis,* moderately similar forms, by its larger size and more delicate ornamentation.

Occurrence.—This species is found only in the Kanosh Shale from approximately 25 to 495 feet above the base at Section 2. It is extremely abundant at some horizons where it forms coquinoid lenses.

Repository.—Figured specimens are BYU 1443, 1444, and 1445, from 130, 150, and 130 feet respectively above the base of Section 1.

ANOMALORTHIS JUABENSIS n. sp. Jensen
Plate 5, figs. 1-6

Description.—Shell is small for the genus, an average specimen being 8.2 mm long and 12.3 mm wide, with a hinge width of 14.8 mm. The valves are unequally biconvex with the brachial valve having the greater depth. The hinge extends well beyond the widest part of the valve. Cardinal extremities are acute, forming a sharp point at the lateral margin. Surface ornamentation is finely costellate with about 10 gently rounded costellae in 2 mm on the anterior margin of an average sized valve.

Ventral Exterior: Hemipyramidal and flatly convex in lateral profile, with flat lateral slopes. Anterior profile is carinate, moderately steep and broadly convex. Anterior margin is even and widely rounded. Beak is the highst portion of the valve, with it and the umbo forming a narrow ridge that extends anteriorly one-third the valve length. Lateral slopes are moderately steep to the cardinal

extremities. The interarea is wide and long and procline. Delthyrium is wide and V-shaped.

Dorsal Exterior: In lateral profile the valve is gently and unevenly convex. Slopes to the cardinal extremities are concave and slope gently to the acute ears of the cardinal extremities. Anterior profile is convex with swelling greatest in the midregion, but sloping posteriorly. Center of the valve is marked by a shallow sulcus which begins at the beak and diverges to occupy about one-fourth the valve width at the anterior margin. Areas which bound the sulcus are gently swollen. The beak is small and slightly incurved.

Ventral Interior: The only interiors available in the present collection are those of immature specimens. The delthyrial cavity is moderately deep and wide and slopes rapidly to the posterior. A sessile spondylium is abruptly elevated on a thick callous deposit anteriorly. Teeth are small and pointed, dental lamellae recede posteriorly and attach to the spondylium.

Dorsal Interior: Notothyrial cavity is shallow and built on a thick callous deposit of shell material. Cardinal process is small and rudimentary. Brachiophores are short and stout, supported by the notothyrial platform. A heavy and moderately elevated medial ridge extends over one-half the shell length in the anterior.

Discussion.—Anomalorthis juabensis is the oldest species of this genus yet discovered. It occurs below *A. utahensis, A. lonensis,* and *A. nevadensis;* it also occurs a few feet below the *Orthidiella* zone. It would appear that this early species gave rise to the larger and more complex species such as *A. utahensis.* The new species is easily differentiated from *A. utahensis* by its smaller size, coarser ornamentation, more acute cardinal extremities, and less pronounced dorsal sulcus. The convexity is less than *A. lonensis* and the interarea is less procline than *A. nevadensis.*

Occurrence.—Anomalorthis juabensis is found only in the upper 90 feet of the Juab Formation at Section 3, and occurs with the lowest fauna of *Orthambonites* (*O. subalata*). The species does not extend into the overlying Kanosh Shale but the genus is represented there by *A. utahensis.*

Repository.—Holotype, BYU 1449, paratypes, BYU 1446, 1447, 1448, 1450, 1451, and 1438, from 355 feet above the base of Section 3.

ANOMALORTHIS LONENSIS (Walcott)
Plate 5, figs. 7-10

Orthis lonensis WALCOTT, 1884, U. S. Geol. Surv., Mon. 8, p. 74, pl. 11, figs. 6, 6a.
Anomalorthis lonensis ULRICH & COOPER, 1938, Geol. Soc. Amer. Spec. Paper 13, p. 127, pl. 21E, figs. 18, 22-25, 27.

Description.—Shells are transversely suboval of medium size for the genus, 12.2 mm long and 16.5 mm wide, with a hinge width of 16.5 mm. Width is considerably greater than the length, and the hinge line about equal to the greatest shell width. Surface is multicostellate, increased by intercalation. There are 9 costellae in 3 mm on the surface of a large valve 16.5 mm wide. Interarea of the ventral valve is wide and high, with a delthyrium which is wide and triangular. In anterior profile the shell is gently convex, with greatest swelling at the umbo. A very shallow sulcus originates at the umbo and widens

anteriorly to about one-third of the anterior margin. The beak is low and small, projecting slightly past the hinge line. Lateral slopes are gently convex, and the region subjacent to the cardinal extremities is slightly concave.

Dorsal valve is moderately convex with the greatest convexity posterior of the middle.

Interiors: Delthyrial platform is raised at the front and is prominent, but dental plates are small. A slight thickening of shell material suggests a median ridge in the ventral valve. Brachiophores are small and blade-like. Sockets are deep and form a very narrow V-shaped depression. Notothyrial cavity is wide, with a strongly thickened platform. Median ridge is narrow and short, extending one-third the valve length.

Discussion.—This species is associated with *A. utahensis* and is similar in many respects, especially the internal structure. It occurs much more rarely relative to the local profusion of *A. utahensis*. *A. lonensis* is easily distinguished from *A. utahensis* by its much coarser ornamentation. *A lonensis* is larger and has much coarser ornamentation than *A. nevadensis*. Well-preserved interiors in this unsilicified material are difficult to locate in this moderately rare species.

Occurrence.—This species has about the same stratigraphic range as *A. utahensis* throughout the lower 495 feet of the Kanosh Shale except for the basal 25 feet at Section 2. It is rare in comparison to the latter species. *A. lonensis* is found associated with *A. utahensis* and *A. nevadensis*.

It is evident that there is a facies control of some of the species. The writer has noticed the occurrence of *A. lonensis* in the upper Lehman equivalent in the Ely Springs Range of the Pioche mining district, which would give this species a considerably longer stratigraphic range.

Repository.—Figured specimens are BYU 1452, 1453, 1454, and 1455, from 180, 180, 180, and 65 feet respectively above the base of Section 1.

ANOMALORTHIS NEVADENSIS Ulrich and Cooper, 1938
Plate 5, figs. 11-13

Anomalorthis nevadensis ULRICH & COOPER, 1938, Geol. Soc. Amer. Special Paper 13, p. 127, pl. 21D, figs. 13-17.

Description.—This species is of medium size for the genus. An average ventral valve is 8.5 mm long and 12.5 mm wide, with a hinge width of 12.4 mm. The surface is covered by fine, elevated, rounded costellae spaced 10 or 11 in 2 mm at the front margin of a ventral valve 12.5 mm in width. The interarea is wide and deep; delthyrium is wide but the apex is not as pointed as the Utah species. Hinge width is the same as the widest portion of the shell. The beak apex is located in front of the posterior margin.

In anterior profile the ventral valve is steep but slightly concave, whereas *A. utahensis* is steep but slightly convex. The dorsal valve appears to lack the shallow sulcus of the Utah species. There appears to be no significant difference in the internal structure of the two species. The reader is referred to the interior description of *A. utahensis*.

Discussion.—This species of *Anomalorthis* is associated with *A. utahensis* and *A. lonensis,* but is exceedingly rare in comparison to the Utah species. In a

complete specimen the ventral valve is distinguished from *A. utahensis* by its smaller size and procline interarea, whereas the Utah species has a strongly apsacline interarea. The more procline interarea and much more delicate ornamentation distinguish it from *A. lonensis.*

Occurrence.—This species is very rare and quite difficult to differentiate from *A. utahensis* without complete specimens. It occurs only in the Kanosh Shale from 130 to 275 fete above the base at Section 2. The writer has noticed a much longer stratigraphic range of this species in the Ely Springs Range in the Pioche mining district of Nevada. Here it ranges from the lower Tank Hill Formation into the Crystal Peak Dolomite equivalent, a few feet below the Eureka Quartzite.

Repository.—Figured specimens are BYU 1457, 1458, and 1459, from 145, 180 and 145 feet respectively above the base of Section 2.

Family PLECTORTHIDAE Schuchert and Cooper, 1931
Subfamily PLECTORTHINAE Schuchert, 1929
Genus *DESMORTHIS* Ulrich and Cooper, 1936
DESMORTHIS NEVADENSIS Ulrich and Cooper, 1936
Plate 5, figs. 14-17

Desmorthis nevadensis ULRICH & COOPER, 1936, Jour. Paleont., v. 10, p. 624; ULRICH & COOPER, 1938, Geol. Soc. Amer. Special Paper 13, p. 159, pl. 30A, figs. 1-16.

Description.—Shell is subcircular in outline; width is about twenty percent greater than the length. The hinge line is straight and is narrower than the widest part of the shell. The valve outline is gently rounded, including the cardinal extremities. Profile is lenticular; shells are unequally biconvex, with ventral valve possessing the greater convexity. Costellae are evenly divided, multicostellate, increasing by interstitial addition. There are about 10 abruptly rounded, hollow, steep-sided costellae on the margin of a ventral valve which is 12 mm in width. A characteristic specimen is 10 mm long and 11.5 mm wide, with a hinge width of 8.5 mm.

Ventral Exterior: Lateral profile is moderately and evenly convex, convexity greatest in the mid-umbo region. Anterior profile is unevenly convex, with steepened umbonal slopes and with slopes to the cardinal extremities being the steepest. Beak is well formed and prominent, extending well beyond the posterior margin.

Ventral Exterior: Lateral profile is moderately and evenly convex, convexity profile is unevenly convex, with swelling greatest in the middle of the valve. The umbo is gently convex, with lateral slopes moderately steep. A shallow medial sulcus starts at the beak and widens anteriorly, but becomes almost indiscernible at the anterior margin. The beak is small and extends slightly past the posterior margin.

Interiors: The ventral valve is marked by a deep and narrow delthyrial cavity, in which the platform is very slight with a gentle thickening to the posterior. Dental lamellae are strong, subparallel, and extend one-third the length of the valve floor. Musculature is tear-shaped, tapering at the anterior end. Inside the dorsal interior the notothyrial cavity is deep and forms an abrupt V at the posterior. The chamber is divided by a low, thin, ridge-like cardinal process. The platform has an abrupt ridge at the front and the callous

deposit is much thicker than in the ventral platform. Brachiophores are subparallel and blade-like. The sockets are narrow and deep. Adductor scars are deep and subcircular. The moderately wide medial ridge extends one-half way to the posterior margin.

Discussion.—This species occurs in a few thin coquinoid lenses in the upper Kanosh at the 495-foot horizon of Section 2. The Lehman fauna is much less common. *D. nevadensis* is similar to the new species of *Desmorthis* which is found only in the lower Lehman Formation. *D. nevadensis* can be distinguished from the new species by its larger size and coarser ornamentation.

Occurrence.—*D. nevadensis* is found in the upper 70 feet of the Kanosh Shale and the Lehman Formation at Section 2. It is more abundant, however, in the upper Kanosh beds.

Repository.—Figured specimens are BYU 1460, 1461, 1462, and 1463, from 495 feet above the base of Section 2.

DESMORTHIS IBEXENSIS n. sp. Jensen
Plate 6. figs. 1-3

Description.—Shell is small, subcircular to transversely ovate; hinge is straight and narrower than the greatest shell width. The width is also greater than the length. A typical specimen is 6.5 mm long and 7.5 mm wide, with a hinge width of 5.2 mm. Profile is lenticular; shells are unequally biconvex, with the ventral valve obtaining the greater convexity. Anterior commissure is rectimarginate and surface ornamentation is finely multicostellate, increasing by interstitial addition. There are 14 abruptly rounded, hollow, steep-sided costellae in 3 mm on the margin of a ventral valve 6 mm in width.

Ventral Exterior: Anterior profile of the ventral valve is unevenly convex and is lenticular to subcarinate, greatest elevation posterior to the midregion. Lateral slopes are even and moderately steep. The beak is prominent, well formed, and extends well beyond the posterior margin.

Dorsal Exterior: Anterior profile of the dorsal valve is unevenly convex with swelling most pronounced in the midregion of the valve. The umbo is gently convex. Lateral profile is very gently and evenly convex. Lateral slopes are moderately steep. A shallow median sulcus starts at the beak region and widens anteriorly but is almost indiscernible at the anterior margin. The beak is small and extends slightly past the posterior margin.

Observed interiors clearly show that the specimens belong to the genus *Desmorthis* but well-preserved interiors are not now known.

Discussion.—This new species occurs in the *Desmorthis* zone and is associated with *Desmorthis nevadensis*. It occurs about 40 feet above the first appearance of *Desmorthis*.

This new species is easily distinguished from *Desmorthis nevadensis* by its much finer multicostellate ornamentation and smaller size.

Occurrence.—This species of *Desmorthis* occurs well within the *Desmorthis* zone. The oldest known and most abundant occurrence is 15 feet above the basal ledge of the Lehman Formation at Section 2. The species ranges to about

85 feet above the base of the Lehman. This new species is associated with *Desmorthis nevadensis* throughout the 70-foot occurrence.

Repository.—Holotype, BYU 1464; paratypes, BYU 1465 and 1466, from 579 feet above the base of Section 2.

Order STROPHOMENIDA Öpik, 1934
Family STROPHOMENIDAE King, 1846
Genus *KIRKINA* Salmon, 1942
KIRKINA MILLARDENSIS Salmon, 1942
Plate 6, figs. 4-8

Kirkina millardensis SALMON, 1942, Jour. Paleont. v. 16, no. 5, p. 599, pl. 87, figs. 34, 35.

Description.—Shell is large and almost semicircular in outline. Profile is concave-convex, hinge forms the widest portion of the shell. Shell width is greater than the length. A typical ventral valve is 17.7 mm long and 19.5 mm wide. The shell is finely pseudopunctate, with the pseudopunctae crowded closely together. Surface ornamentation is delicate, with 12 evenly spaced costellae in 3 mm on the anterior margin of a ventral valve 19.5 mm in width.

Ventral valve is even and gently rounded in lateral profile, with convexity greatest in the center of the valve. Anterior profile exhibits a gentle and even convexity over the shell center. Lateral slopes are evenly sloping though steeper this outlines a prominent ridge traversing most of the length of shell becoming indiscernible at the anterior margin. Lateral margins are straight, but gradually converge to the moderately rounded anterior margin. Slopes to the cardinal extremities are concave. Beak is not prominent and slightly incurved.

Dorsal valve is flatly concave with concavity greatest in the central portion of the valve.

Ventral interior is not well preserved in the material presently on hand. The delthyrium is fairly narrow; delthyrial cavity is deep and is set in a slight depression on the shell floor. Dental lamellae are narrow, receding, diverging, and attached to the shell floor.

The dorsal interior exhibits a thickened notothyrial platform, a bilobed cardinal process, and a wide, low, median ridge. Brachiophores are short, low ridges built up from the notothyrial platform. Adductor scars gradually deepen toward the posterior.

Discussion.—*K. millardensis* is found in abundance with *O. perplexus* in the lower few feet of the Crystal Peak Dolomite. It, as well as *O. perplexus,* is silicified but because of the unusually delicate preservation good specimens are difficult to obtain.

Occurrence.—At the present time the only unit from which this brachiopod has been found is the Crystal Peak Dolomite of the Eureka Group. The exact stratigraphic range within the member is unknown, but it is known to occur in the lower few feet. It does not occur below the Crystal Peak Dolomite, however, in the Ibex area.

Repository.—Figured specimens are BYU numbers 1467, 1468, 1469, 1470, and 1471, from 735 feet above the base of the Crystal Peak section.

REFERENCES CITED

Clark, T. H., 1935, A new Ordovician graptolite locality in Utah: Jour. Paleont., v. 9., no. 3, p. 239-246.

Cooper, G. A., 1956, Chazyan and related brachiopods: Smithsonian Misc. Coll., v. 127, Part 1 and 2, 1245 p., 269 pls.

Hall, James, and Whitfield, R. P., 1877, Paleontology: U. S. Geol. Expl. 40th par., v. 4, p. 197-302.

Hintze, L. F., 1951, Lower Ordovician detailed stratigraphic sections for western Utah: Utah Geol. Min. Survey Bull. 39, 99 p.

———, 1952, Lower Ordovician trilobites from western Utah and eastern Nevada: Utah Geol. Min. Survey Bull. 48, 249 p., 28 pls.

Ross, R. J., Jr., 1951, Stratigraphy of the Garden City Formation in northeastern Utah, and its trilobite faunas: Yale Univ. Peabody Mus. Nat. Hist. Bull. 6, 161 p., 36 pls., 4 text-figs.

———, 1964, Relations of Middle Ordovician time and rock units in Basin Ranges, Western United States: Amer. Assoc. Petrol. Geol., v. 48, no. 9, p. 1526-1554, 10 text-figs., 1 table.

———, 1967, Some Middle Ordovician brachiopods and trilobites from the Basin Ranges, Western United States: U. S. Geol. Survey Prof. Paper 523-D, 43 p., 11 plates.

Salmon, E. S., 1942, Mohawkian Rafinesquinae: Jour. Paleont., v. 16, no. 5, p. 564-603.

Schuchert, C., 1897, A synopsis of American fossil Brachiopoda including bibliography and synonymy: U. S. Geol. Survey Bull. 87, p. 1-464.

Ulrich, E. O., and Cooper, G. A., 1936, New genera and species of Ozarkian and Canadian brachiopods: Jour. Paleont., v. 10, no. 7, p. 616-631.

———, 1938, Ozarkian and Canadian brachiopods: Geol. Soc. America Special Paper 13, 323 p., 57 pls.

———, 1942, New genera of Ordovician brachiopods: Jour. Paleont., v. 16, no. 5, p. 620-626, pl. 90.

Walcott, C. D., 1884, Paleontology of the Eureka district: U. S. Geol. Survey Monograph 8, 298 p., 24 pl.

———, 1908, Cambrian geology and paleontology. 3. Cambrian Brachiopoda, descriptions of new genera and species; 4. Classification and terminology of the Cambrian Brachiopoda: Smithson. Misc. Coll., v. 53, 137 p., 4 pl.

———, 1912, Cambrian brachiopoda: U. S. Geol. Survey, Mon. 51, pt. 1, 872 p., 76 text-figs., pt. 2, 363 p., 104 pl.

Webb, G., 1958, Middle Ordovician stratigraphy in eastern Nevada and western Utah: Amer. Assoc. of Petrol. Geol. Bull., v. 42, no. 10, p. 2335-2377, 13 figs.

Williams, Alwyn, *et al.*, 1965, Part H., Brachiopoda: Treatise on invertebrate paleontology (Moore, R. C., editor), Geol. Soc. Amer. and Univ. of Kansas Press, 927 p., 198 figs.

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