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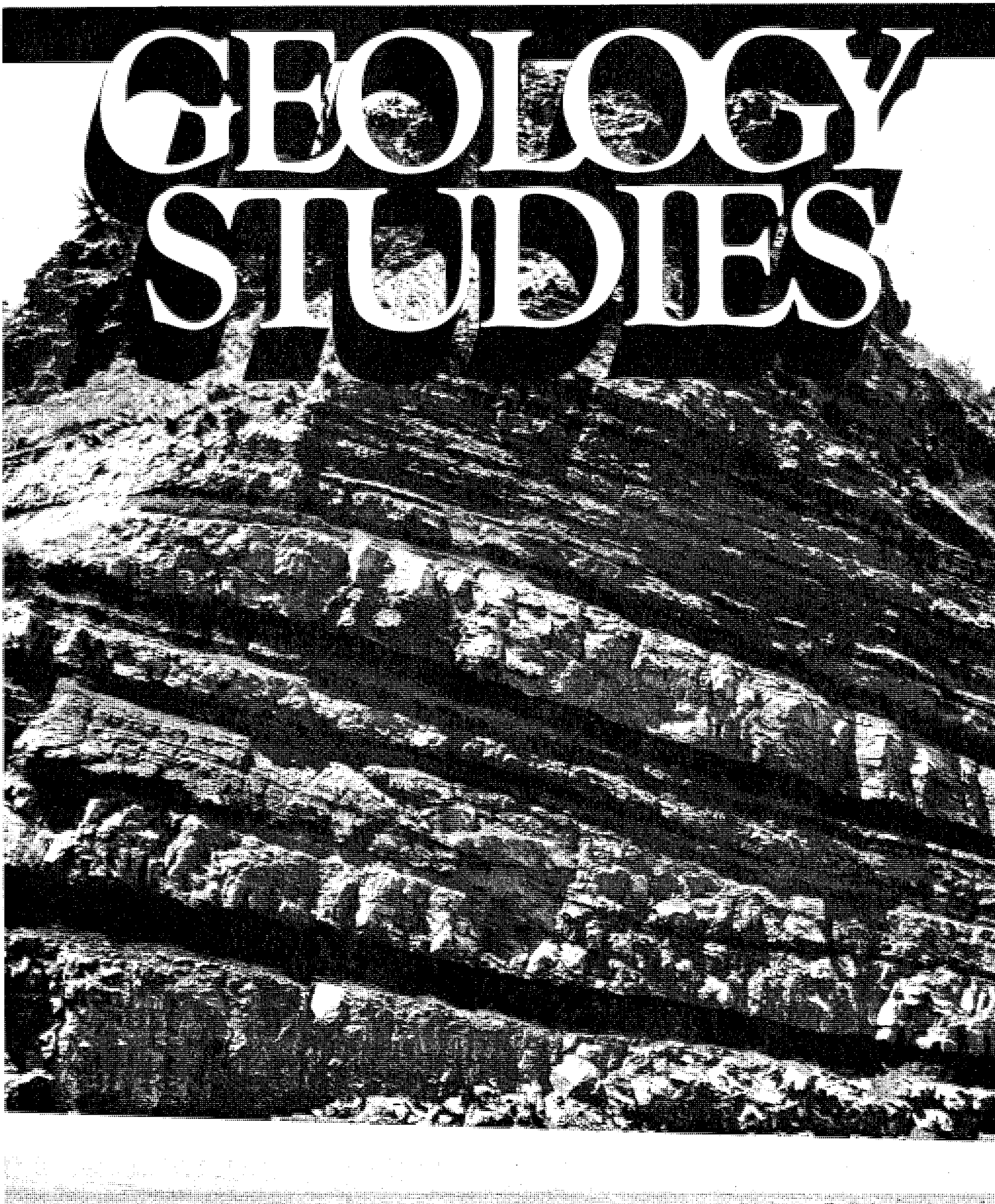
GEOLOGY STUDIES



VOLUME 26, PART 2

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THE GLORY OF GOD IS INTELLIGENCE

Cover: Cretaceous coals near Castle Gate, Utah.

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CONTENTS

Preliminary Zonations of Lower Ordovician of Western Utah by Various Taxa

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ABSTRACT.—Lower Ordovician strata of western Utah contain probably the most diverse and best-preserved fossil assemblages for rocks of this age found anywhere in the world. The trilobite zonation, established 25 years ago by Ross and Hintze, has been supplemented by zonations of other groups by various workers in recent years. Brachiopod zones were established by Jensen (1967), graptolite zones by Braithwaite (1976), and conodont zones for the lowest part of the section by Miller (1969), and for the remainder of the section by Ethington and Clark (1971). Other taxa that occur in this sequence have been documented: bryozoa by Hinds (1970), crinoids by Lane (1970), cystoids by Paul (1972), pelecypods by Pojeta (1971), some of the cephalopods by Flower (1968a, 1968b, 1976), some of the ostracodes by Berdan (1976a,b), and additional trilobites by Demeter (1973), Taylor (1971), Terrell (1973), and Young (1973). Sponge-algal patch reefs have been described by Roberts (1968) and Church (1974).

Some faunal elements are still in course of study and will be published as completed. These include conodonts by R. L. Ethington, sponges by J. K. Rigby, additional cephalopods by R. H. Flower, additional ostracodes by J. M. Berdan, as well as corals by J. K. Rigby, starfish by J. S. Branstrator, inarticulate brachiopods by A. J. Rowell, edrioasteroids by B. M. Bell, and gastropods and additional trilobites. Work by Miller (1969) and Taylor (1971) indicates that this section may be important in resolving worldwide Cambro-Ordovician boundary problems because it contains a sequence of trilobite and conodont faunas that straddle the boundary interval. An annotated bibliography summaizes work published on the Lower Ordovician of western Utah to date.

INTRODUCTION

Twenty-five years ago Reuben Ross and I, as students at Yale and Columbia universities, established trilobite zones for the Lower Ordovician strata in Utah. He worked in the Garden City Limestone in northeastern Utah (Ross 1951) and I in the Pogonip Group of western Utah and eastern Nevada (Hintze 1952). It ultimately became apparent that one particular area in western Utah, known as the Ibex area (see figure 1 for location), was probably the best place in North America to obtain, not only trilobites, but also a rather complete assemblage of almost all other life forms of Lower Ordovician age. The National Science Foundation funded a three-year cooperative study in 1965 aimed at documenting all the faunal elements, and this paper is a report on the current status of that documentation. It is not intended as a comprehensive comparative discussion of Ordovician zonations from other localities.

A number of papers have been published during the past decade describing aspects of Lower Ordovician strata of western Utah. Stratigraphic units have been redescribed (Hintze 1973) and geologic maps published (Hintze 1974a, 1974b). Various faunal groups have been documented: trilobites by Demeter (1973), Taylor (1971), Terrell (1973), Young (1973); brachiopods by Jensen (1967); graptolites by Braithwaite (1976); bryozoa by Hinds (1970); crinoids by Lane (1970); cystoids by Paul (1972); pelecypods by Pojeta (1971); some of the cephalopods by Flower (1968a, 1968b, 1976); some of the ostracodes by Berdan (1976); and some of the conodonts by Miller (1969). Sponge-algal patch reefs have been described by Roberts (1968) and Church (1974).

In addition to the work already published a number of important papers are in course of preparation. The status of such studies is given in the following pages as far as possible. Most of the fossil collecting upon which this work is based was done during the three-year period funded by the initial NSF grant. Subsequent mapping by Hintze was supported by the Utah Geological and Mineral Survey and the U.S. Geological Survey. Some contributors, notably Clark, Ethington, Flower, Miller, Rigby, and Taylor, have become involved through their own regional studies of particular faunal groups.

TRILOBITE ZONES

Ross's work in northeastern Utah preceded mine, and he established a series of letter faunal assemblage zones, shown in figure 2 and all subsequent figures, that I followed with slight modifications. He and I shared a fantastic sequence of trilobites which would probably have remained mostly undescribed except for the fortuitous circumstance that the trilobites were silicified throughout most of the Lower Ordovician stratigraphic section, around 1000 m (3000 feet) in thickness. This mode of preservation enabled us to collect trilobites in somewhat the same way one collects conodonts—by obtaining samples at closely spaced intervals throughout the section. Ross and I identified more than 100 trilobite species and about half that many genera. Seventy percent of the Utah trilobites are still known only from western North America. The remaining 30 percent have been recognized elsewhere. The lettered zones in

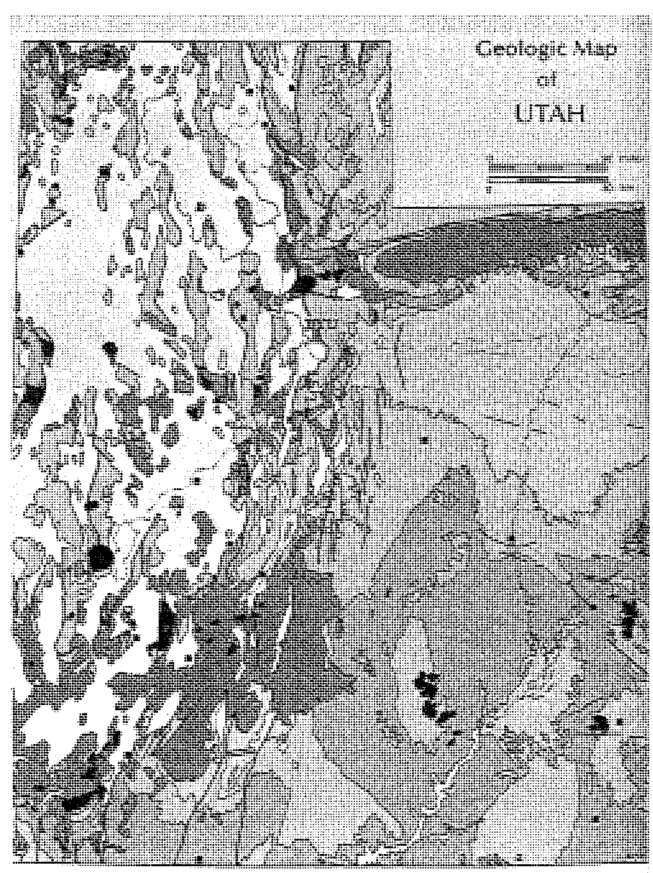

FIGURE 1.—Geologic map of Utah. Ibex area indicated by large black dot in west central part of the state.

the middle of figure 2 represent the stratigraphic interval through which each trilobite assemblage occurs. The zone ranges are shown in figure 2 juxtaposed against lithologic changes as indicated by formation and member boundaries. More than half the zone boundaries coincide with lithologic changes. Thickness of the lithologic units is shown in feet alongside the column.

In addition to the Ross-Hintze trilobite zones I have included below them the *Missisquoia* zone, currently recognized as lowest Ordovician, and three uppermost Cambrian trilobite zones. Trilobites are only occasionally found silicified in these four zones, and additional bed-by-bed collecting will be needed to establish the true extent of the zones here shown separated by some gaps. There are only two gaps between zones in the overlying Ordovician: the first is an unfossiliferous 30 m (100 ft.) beween zones D and E in the lower Fillmore Formation, and the second is in the quartzites above zone N. Zone O has not been identified by trilobites at Ibex. Its fauna consists chiefly of corals (*Eofletcheria*) and brachiopods.

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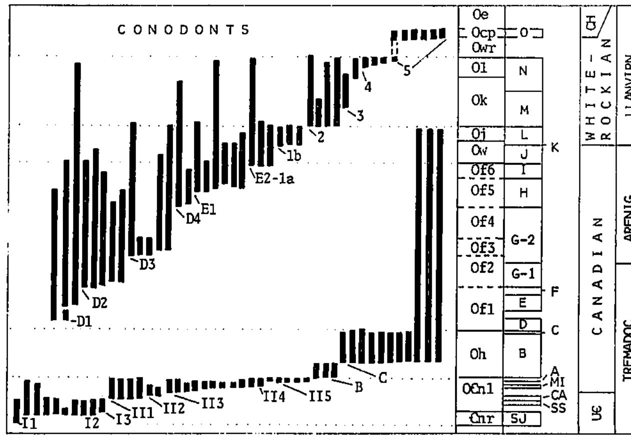

FIGURE 3.–Ranges of conodonts form-species.

CONODONT ZONES

In terms of continuity of occurrence within the Ibex sequence the conodonts are the only fossil group other than the trilobites that forms a near-continuum. At the same time we were collecting at Ibex, D. L. Clark and R. L. Ethington were undertaking a conodont survey of the Great Basin. Ethington is currently describing the Ibex Ordovician conodonts; the Upper Cambrian conodonts have been described by Miller (1969). The zonation shown on figure 3 is tentative, derived in part from the preliminary zonation presented by Ethington and Clark (1971) and from Miller (1969) and from handout sheets that Miller prepared for a Friends of the Cambrian field trip to the Ibex area in 1975.

The conodont zonation shown in figure 3 is essentially first appearance or "Oppel-zonation" and thus different from the trilobite assemblage-zone. Ranges of about 90 conodont species are shown here, beginning with the oldest first appearance at the lower left in Miller's *Proconodontus muelleri* Subzone 1 of his *Proconodontus* Zone I. Miller's Roman-numeral zones and subzones are refinements of Fauna A of Ethington and Clark (1971). Their faunas B through E continue upwards to overlap the 1-2-3-4 system employed by Sweet, Ethington, and Barnes (1971) for Middle and Upper Ordovician conodont faunas. Most Ordovician conodont occurrences shown in figure 3 are derived from as yet unpublished conodont ranges supplied to me by R. L. Ethington. I have taken the liberty of designating subzones D1, D2 through E2 for the purpose of comparing the degree of correspondence of conodont zonation at Ibex with that of trilobites. This zonation is preliminary. Ethington will propose a more formal zonation later. Figure 4 compares the lithologic breaks on the left column, including footages, with the trilobite zones in the middle column, and the informal conodont zones in the right column. At the base of the section there are several horizons where the breaks in lithologies, trilobite zones, and conodont zones are the same:

1-2. Red Tops–*Saukiella junia*–Miller's Zone I, subzones 1 + 2

3-4. House Ls–B-C Zones–conodont faunas B + C

In the middle and upper parts of the chart, the breaks correspond at only three other horizons:

5. Base Of5–Zone H–Zone D4
6. Base Wah Wah–Zone J–Zone 1b
7. Base Kanosh–Zone M–Zone 2, almost

One of the most striking conodont first appearances is that marking the base of Fauna El. Note that this occurs within trilobite Zone H.

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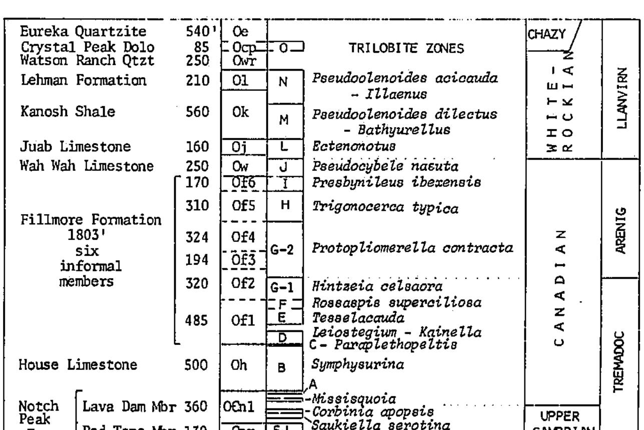

FIGURE Figure 2.–Trilobite zones in western Utah plotted against geologic formations; thickness indicated in feet.

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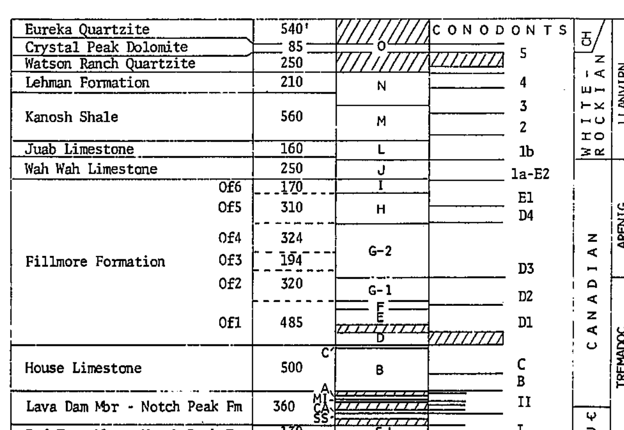

FIGURE 4.–Preliminary conodont zones plotted against geologic formations in western Utah. Thickness of formations shown in feet.

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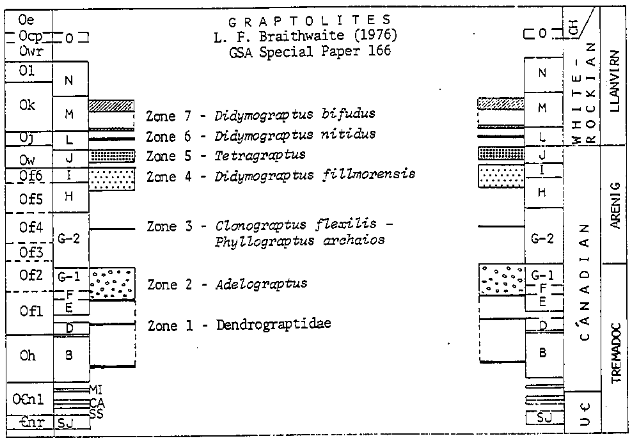

FIGURE 5.—Graptolite zones in western Utah plotted against trilobite zones.

The degree of zonation obtained using conodonts is about the same fineness as that using trilobites. Probably both could not be much further refined at Ibex without a great deal of additional collecting. Ethington (letter dated March 3, 1977) says that conodonts of the Juab Limestone mark the base of the Whiterock Stage as inferred from trilobites and brachiopods, and that conodonts of the Crystal Peak Dolomite are like those of the type Chazy Formation in New York.

GRAPTOLITE ZONES

Braithwaite's graptolite study done 10 years ago has finally been published (1976), and the results are summarized in figure 5. He identified 45 species from 13 genera and made valuable contributions to graptolite ontogenetic knowledge. The graptolites at Ibex occur in light olive shales interbedded within the limestones, and the graptolites are beautifully preserved as translucent, amber, resinous films. Unfortunately, there are many gaps in the graptolite record at Ibex. Braithwaite noted that there seemed to be more provinciality to the Ibex graptolites than he expected. He even noted that the western Utah graptolite assemblages differ somewhat from those of northeastern Utah.

Broadly speaking, Braithwaite's zone 1 corresponds with Berry's *Anisograptus* zone of the Marathon region of west Texas. Zone 2 corresponds with Berry's *Adelograptus-Clonograptus* zone. Thereafter the correlation of the Texas-Utah section breaks down except for the useful *Didymograptus bifidus* zone, common to both regions. The Zone 5 *Tetragraptus* in Utah is no doubt comparable to some part of Berry's five *Tetragraptus* zones. The *Didymograptus bifidus* zone seems to establish the correlation with the British Llanvirnian.

BRACHIOPOD ZONES

Next to trilobites and conodonts, articulate brachiopods are the most continuously distributed fossils in the Ibex section. Figure 6 shows the range distribution of the 27 taxa obtained by Jensen (1967). Except for those at the very top (*Orthoambonites perplexus* in the Crystal Peak Dolomite), none of the brachiopods are silicified.

Figure 7 shows the eight brachiopod zones established by Jensen for western Utah. Most of the zones are characterized by scattered individual shells, but a few zones are coquinas, for example, *Syntrophina, Hesperonomiella minor,* and some horizons in the *Anomalorthis, Desmorthis* and *Kirkina* zones.

The sequence of appearance of brachiopods at Ibex is slightly different from that in the type Whiterock of central Nevada. Whereas *Orthidiella* occurs as the lowest Whiterock fauna in Nevada, it occurs in western Utah somewhat above the appearance of *Anomalorthis.* And whereas in Nevada *Anomalorthis* appears above *Desmorthis,* at Ibex the reverse is true.

Inarticulate brachiopods have not been pursued very vigorously at Ibex. They are not abundant and have yet to be described. A. J. Rowell identified the forms we sent him as shown in figure 8. Inarticulates seem to be more valuable for paleoenvironmental interpretation than for time indicators.

CEPHALOPOD ZONES

Cephalopods constitute an important but not abundant part of the Ibex faunas. Rousseau Flower has been working on these faunas since before the inception of the project and is still in course of publishing his results, having been distracted by other cephalopods elsewhere. The cephalopod identifications shown in figure 9 have been kindly furnished by Dr. Flower.

Flower identifies his "First Endoceroid" zone in the upper

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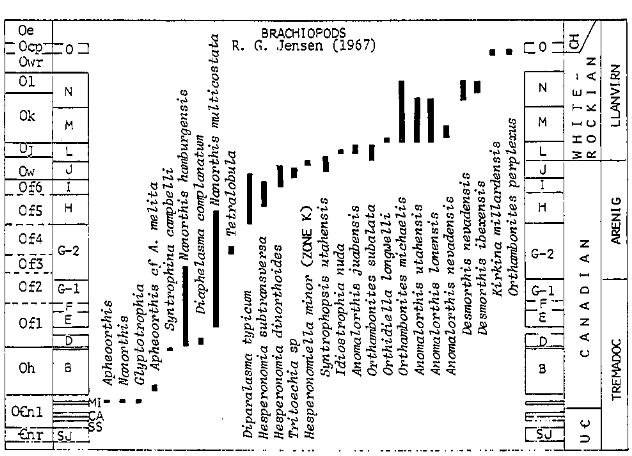

FIGURE 6.—Ranges of brachiopod species in western Utah.

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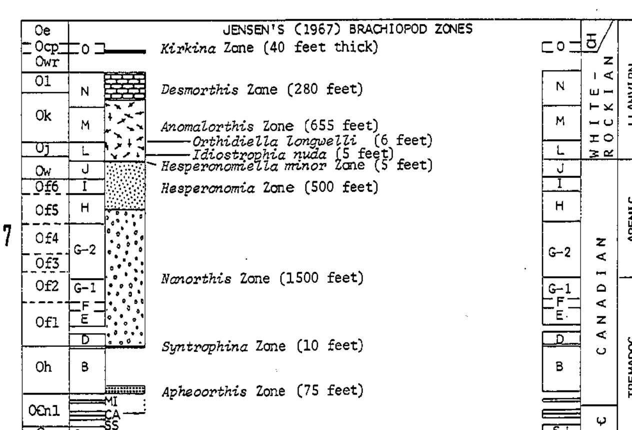

FIGURE 7.—Brachiopod zones in western Utah plotted against trilobite zones.

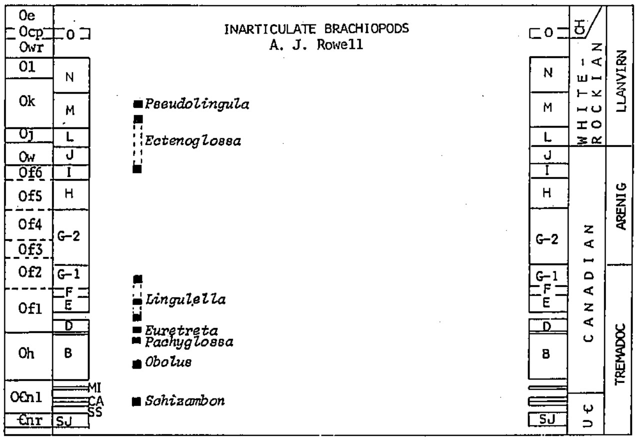

FIGURE 8.—Inarticulate brachiopod occurrences in western Utah.

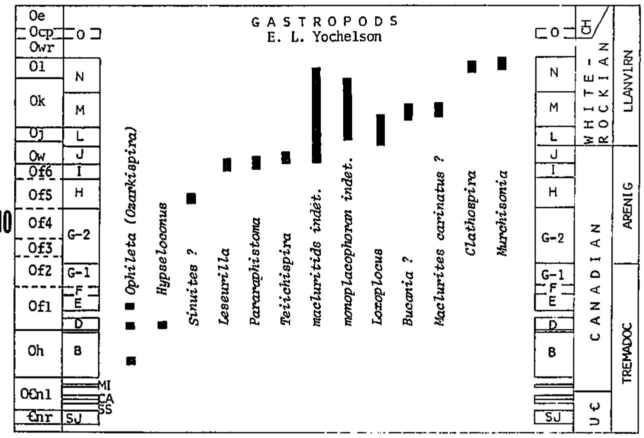

FIGURE 10.—Gastropod occurrences in western Utah.

Zone D at Ibex enabling its correlation with the Cooks Formation of the El Paso Group, the lower Manitou of Colorado, the Goodwin of Nevada, the lower Gorman of central Texas, the Roubidoux of Missouri, the Fort Ann of New York, and the Longview of Virginia.

His "First Pilocerid" zone occurs in Zone E at Ibex. This zone is also recognized in the El Paso, Manitou, and Garden City formations.

Zones F, G, and H at Ibex have yielded a few baltoceratids and protocycloceratids of poor correlation value. Zone I yielded forms which suggest correlation with the Fort Cassin of New York, the Smithville of Arkansas, and the Scenic Drive of El Paso.

Zone J, the Wah Wah Limestone, includes *Buttsoceras* which indicates latest Canadian and correlation with the Florida Formation of the El Paso Group and the Odenville of Alabama.

Zone L, Juab Limestone, contains a rather abundant cephalopod fauna comparable to that of the Oil Creek of Oklahoma.

Zone M of the Kanosh Shale has as its commonest form a *Rossoceras* similar to those in the *Palliseria* Zone of the Antelope Valley Limestone of Nevada.

Zone N contains cephalopods similar to those of the sponge beds at Ike's Canyon in central Nevada.

Zone O of the Crystal Peak Dolomite has not yielded cephalopods well enough preserved to be useful.

In all, although cephalopods are localized in relatively few horizons at Ibex, through Flower's efforts they have proved to be useful in long distance correlations.

OTHER FOSSIL GROUPS

Gastropods

Gastropods have been rather neglected at Ibex. This is probably because of the way they are preserved. None are silicified. Most are steinkerns. Only occasional specimens show external markings and form of the shell exterior.

Ellis Yochelson has dutifully provided the identifications shown in figure 10. What the gastropods at Ibex really need is a friend who has the interest and skill to coax some shell-bearing specimens out of these reluctant rocks.

Sponges

Sponges occur at only a few stratigraphic horizons at Ibex apparently because favorable conditions were attained only temporarily in the high-energy shallow-water environment represented by the clastic limestones that constitute most of the Ordovician section at Ibex. Sponges seem to enjoy an association with algae and quasialgal organisms, and together they formed patch reefs at certain horizons. The identifications shown in figure 11 were provided by J. K. Rigby, who is describing the

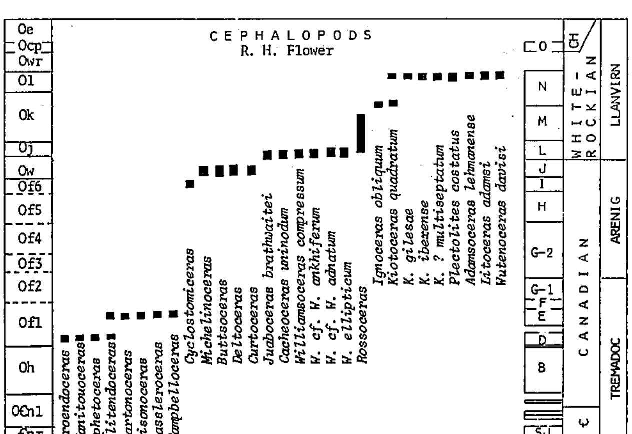

FIGURE 9.—Cephalopod occurrences in western Utah.

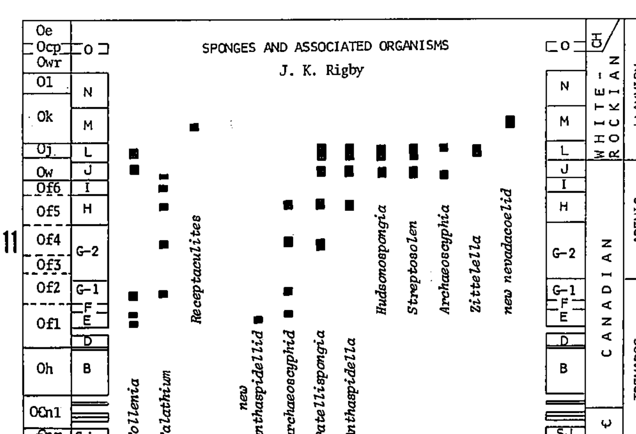

FIGURE 11.—Sponge occurrences in western Utah.

sponge fauna. Rigby (1962, 1965, 1971) has established a preliminary sponge zonation based on his collections from Ibex. He plans a comprehensive treatment of Ordovician sponges in the near future.

Ostracodes

Berdan (1976) has recently described the species whose distribution is charted in figure 12. These ostracodes occur in many Middle Ordovician sections in the Great Basin, and Berdan's formalization of their names will encourage their utility as time indicators elsewhere. Heretofore most published references called almost all Ordovician ostracodes from the west under the catchall "*Leperditia bivia*". Now that this ostracode sequence from western Utah has been described, an ostracode zonation may prove feasible as other sequential collections are examined.

Echinoderms

Echinoderm fragments are abundant as a component of some of the clastic limestones that constitute much of the Ordovician section at Ibex. Despite their relative abundance throughout the section, only a few specimens complete enough to be nameable have been found. The oldest, a cystoid, is known from several well-preserved specimens found on a bedding surface in the Lower Fillmore Formation and was discovered by Eugene Demeter who was searching for trilobites. This cystoid was described by Paul (1972) who noted that it was the first Ordovician cystoid reported from the western United States, and that it is the oldest pectinirhomb-bearing cystoid known.

Lane (1970) described the ten crinoid specimens found to date, most of them from the Kanosh Shale. Two edrioasteroids have been found, and one is currently being described by Bruce Bell. Jon Branstrator has the starfish under study.

Echinoderms are useful mostly in evolutionary studies. They are too scarce to be used for much else.

Bryozoa

Hinds (1970) documented the bryozoa at Ibex as shown in figure 14. He recognized six species, all new, but because of scarcity and poor preservation he named only two formal species. The bryozoa at Ibex are most like those in the Oil Creek and McLish formations of Oklahoma.

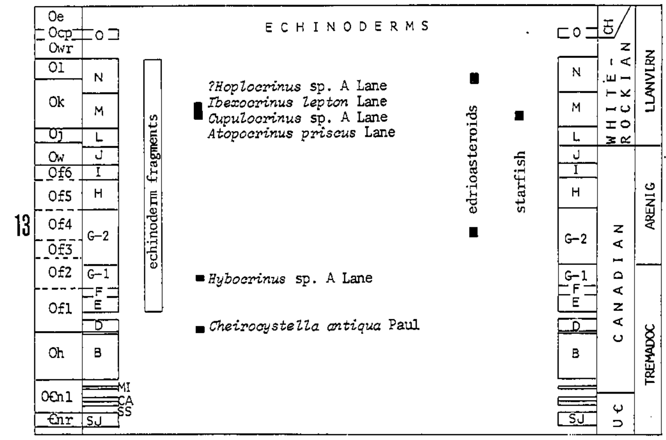

FIGURE 13.—Echinoderm occurrences in western Utah.

Pelecypods

Pelecypods are scarce in the Utah Ordovician, and none have been found well enough preserved for more than generic assignment. *Modiolopsis* is the most common form. It occurs in mattes of thin, crushed shells in the upper Kanosh and Lehman formations. Pelecypod identifications shown in figure 14 were provided by John Pojeta.

Corals

Corals make their appearance near the top of the pre-Eureka rocks at Ibex as shown in figure 14. They are some of the oldest corals known. *Lichenaria*, the oldest, occurs as small, thumbnail-size specimens in the Lehman Formation. *Eofletcheria* forms bedded masses up to 1.5m (5 feet) thick in the Crystal Peak Dolomite. These forms have been described by Rigby and Hintze (1977).

SUMMARY

The figures accompanying this paper express the range of fossils known from the Lower Ordovician reference section in western Utah. Most of the forms have now been described, but a few important groups, notably the conodonts, remain to be published. When the task is completed, the documentation of the several taxa from the same stratigraphic sequence will materially assist with correlation problems in other areas.

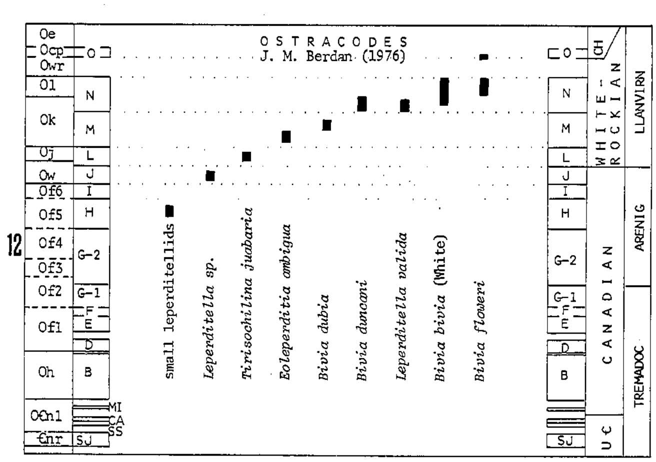

FIGURE 12.—Ostracod occurrences in western Utah.

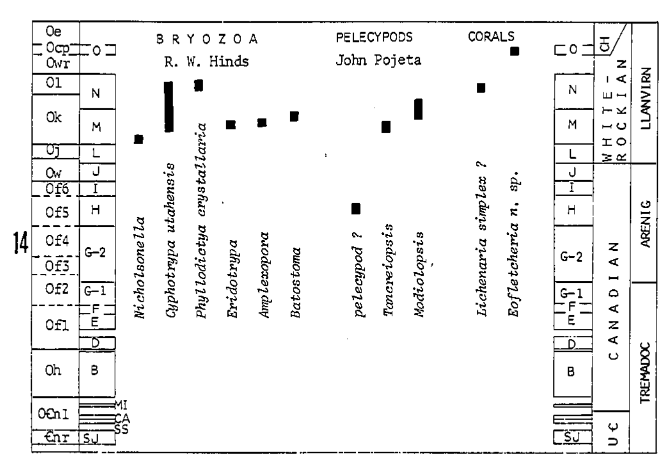

FIGURE 14.—Occurrences of bryozoa, pelecypods, and corals in western Utah.

ANNOTATED LIST OF PUBLICATIONS

RELATED TO LOWER ORDOVICIAN OF WESTERN UTAH

Berdan, J. M., 1976a, Middle Ordovician Leperditicopid ostracodes from the Ibex area, Millard County, western Utah: Brigham Young University Geology Studies, v. 23, pt. 3, p. 37–65.
Described 8 taxa including 2 new genera, *Bivia* and *Tirisochilina*, and 5 new species.

Berdan, J. M., 1976b, Middle Ordovician ostracodes from the Great Basin: Geological Society of America Abstracts with Programs, v. 8, no. 6, p. 773.

Braithwaite, L. F., 1976, Graptolites from the Lower Ordovician Pogonip Group of western Utah: Geological Society of America Special Paper 166, 106p.
Recognized 45 species from 13 genera; described 15 new species; traced 12 ontogentic and/or early astogentic developmenral stages; established 7 graptolite zones for this area.

Church, S. B., 1974, Lower Ordovician patch reefs in western Utah: Brigham Young University Geology Studies, v. 21, pt. 3, p. 41–62.
Stromatolitic algae stabilized the substrate providing a base for anthaspidellid sponge reef framework which harbored trilobites, brachiopods, gastropods, nautiloids, crinoids, and burrowing organisms.

Demeter, E. J., 1973, Lower Ordovician pliomerid trilobites from western Utah: Brigham Young University Geology Studies, v. 20, pt. 4, p. 35–65.
Traced evolution of 7 genera of pliomerid trilobites through 412 m (1,350 feet) of Fillmore Formation. Defined 3 new species and reassigned several species.

Duncan, H., 1956, Ordovician and Silurian coral faunas of western United States: U.S. Geological Survey Bulletin 1021-F. p. 209–36, pls. 21–27.
Pages 214–16 listed *Eofletcheria* from Crystal Peak Dolomite.

Ethington, R. L., and Clark, D. L., 1971, Lower Ordovician conodonts in North America: In Sweet, W. C., and Bergström, S. M., Symposium on conodont biostratigraphy: Geological Society of America Memoir 127, p. 63–82.
Identified 5 Cambro-Ordovician conodont assemblages in western Utah and listed typical representatives.

Flower, R. H., 1968a, The first great expansion of the actinoceroids: New Mexico Bureau of Mines and Mineral Resources Memoir 19, pt. 1, p. 1–16, 13 pls.
Described 2 new species from western Utah, *Wutinoceres davisi*, and *Adamsoceras lehmanense.*

Flower, R. H., 1968b, Some additional Whiterock cephalopods: New Mexico Bureau of Mines and Mineral Resources Memoir 19, pt. 2, p. 19–55, 17 pls.
Described 2 new species from western Utah, *Juaboceras braithwaitei*, and *Plectolites costatus.* Noted occurrence of *Williamsoceras* and *Rossoceras* in the Juab Limestone.

Flower, R. H., 1971, Cephalopods of the Whiterock Stage: Smithsonian Contributions to Paleobiology, v. 3, p. 101–11.
Noted occurrence of *Kiotoceras* in Zone N at Ibex, and *Buttsoceras* in Zones J and K at Ibex.

Flower, R. H., 1976, Some Whiterock and Chazy endoceroids: New Mexico Bureau of Mines and Mineral Resources Memoir 28, pt. 2, p. 13–39, 16 pls.
Described 9 new species from western Utah: *Kiotoceras gilesae, Kiotoceras ibexense, Kiotoceras multiseptatum, Ignoceras obliquum, Williamsoceras* cf. *ankhiferum, Williamsoceras ellipticum, Cacheoceras uninodum.*

Flower, R. H., 1977, Late Canadian (zones J and K) cephalopod faunas from southwestern United States: New Mexico Bureau of Mines and Mineral Resources Memoir 32, 102p., 21 pls.
Described 6 new genera and 19 new species from the Wah Wah Limestone of western Utah and the Florida Mountains Formation of Texas-New Mexico. The new genera were *Amsleroceras, Rangeroceras, Veneficoceras, Bakeroceras, Wardoceras,* and *Enigmoceras.* The new species were *Amsleroceras gracile, Rangeroceras hintzei, Rhabdiferoceras planiseptatum, Veneficoceras susanae, Protocycloceras laswelli, P. Rhabdiferum, Catoraphiceras ibexense, C. pearsonae, C. sinuatum, C. staceyae, Kyminoceras kottlowskii, Rudolfoceras keadyi, R. russelli, Bakeroceras wahwahense, Manchuroceras lemmonei, Michelinoceras floridaense, M. melleni, Wardoceras orygoforme,* and *Enigmoceras diaboli.*

Flower, R. H., and Duncan, H. M., 1975, Some problems in coral phylogeny and classification: American Paleontological Bulletin, v. 67, no. 287, p. 175–92.
Page 182 noted occurrence and correlation of Ordovician corals of Utah-Nevada.

Fortey, R. A., 1974, A new pelagic trilobite from the Ordovician of Spitsbergen, Ireland, and Utah: Palaeontology, v. 17, pt. 1, p. 111–23.
Lists free check of *Opipeuter inconnivus* from Fillmore Limestone Zone I of western Utah. Reassigned Utah *Remopleuridiella* species, for example Young's Remopleuridiella angularis, to *Opipeuter.*

Hinds, R. W., 1970, Ordovician bryozoa from the Pogonip Group of Millard County, western Utah: Brigham Young University Geology Studies, v. 17, pt, 1, p. 19–40.
Recognized 6 genera of bryozoans from western Utah. Described 2 new species, *Dianulites utahensis* and *Phyllodictya crystalaria.*

Hintze, L. F., 1951, Lower Ordovician detailed stratigraphic sections for western Utah and eastern Nevada: Utah Geological and Mineralogical Survey, Bulletin 39, 99p.
Established 6 new Ordovician formations and traced their extent in western Utah and eastern Nevada.

Hintze, L. F., 1952, Lower Ordovician trilobites from western Utah and eastern Nevada: Utah Geological and Mineralogical Survey Bulletin 48, 249p.
Established 15 faunal zones in Ordovician Pogonip Group; named 50 new trilobite species belonging to 42 genera; named 5 new genera.

Hintze, L. F., 1973, Lower and Middle Ordovician stratigraphic sections in the Ibex area, Millard County, Utah: Brigham Young University Geology Studies, v. 20, pt. 4, p. 3–36.
Redescribed and redefined in greater detail some of the stratigraphic sections and formations originally treated in Hintze 1951.

Hintze, L. F., 1974a, Preliminary geologic map of The Barn Quadrangle, Millard County, Utah: U.S. Geological Survey Miscellaneous Field Studies, MF 633, scale 1: 48,000.
Differentiated 38 map units of Cambrian through Devonian, Tertiary, and Quaternary ages. Accompanying stratigraphic column listed thickness, lithologies, and common fossils.

Hintze, L. F., 1974b, Preliminary geologic map of the Notch Peak Quadrangle, House Range, Millard County, Utah: U.S. Geological Survey Miscellaneous Field Studies, MF 636, scale 1: 48,000.
Differentiated 40 map units of Cambrian through Devonian, Jurassic, Tertiary, and Quaternary age. Accompanying stratigraphic column listed thicknesses, lithologies, and common fossils.

Hintze, L. F., Braithwaite, L. F., Clark, D. L., and Ethington, R. L., 1968, A fossiliferous Lower Ordovician reference section from western United States (abs.): International Geological Congress, 23rd, Prague 1968, Report, Sec. 9, p. 256.
Summary of results of Lower Ordovician Project to 1966.

Hintze, L. F., Braithwaite, L. F., Clark, D. L., Ethington, R. L., and Flower, R. H., 1972, A fossiliferous Lower Ordovician reference section from western United States: International Paleontological Union Proceedings for 23rd International Geological Congress, Prague, 1968, p. 385–99, Warszawa, Instytut Geologiczny.
Exrended summary of results of Lower Ordovician Project to 1966.

Hintze, L. F., and Jaanusson, V., 1956, Three new genera of asaphid trilobites from the Lower Ordovician of Utah: Upsala Geological Institute Bulletin, v. 36, p. 51–57.
Defined *Aulacoparia, Aulacoparina,* and *Stenorhachis.*

Hook, S. C., and Flower, R. H., 1976, *Tajaroceras* and the origin of the Troedssonellidae: Journal of Paleontology, v. 50, p. 293–300.
Described *Tajaroceras,* n. gen. of orthoconic nautiloid from the Wah Wah Limestone, correlating it with the Florida Mountains Formation of Texas.

Jensen, R. G., 1967, Ordovician brachiopods from the Pogonip Group of Millard County, western Utah: Brigham Young University Geology Studies v. 14, p. 67–100.
Recognized 25 brachiopod species in western Utah and assigned them to 9 zones listed in descending order: *Kirkina, Desmorthis, Anomalorthis, Orthidiella, Hesperonomiella, Hesperonomia, Nanorthis, Synthrophina,* and *Apheoorthis.* Described three new species, *Desmorthis ibexensis, Anomalorthis juabensis,* and *Finkelnburgia fillmorensis.*

Lane, N. G., 1970, Lower and Middle Ordovician crinoids from west-central Utah: Brigham Young University Geology Studies, v. 17, pt. 1, p. 3–17.
Described 10 specimens assigned to 5 genera; named 2 new genera and species: *Ibexocrinus lepton* and *Atopocrinus priscus.*

Miller, J. F., 1969, Conodont fauna of the Notch Peak Limestone (Cambro-Ordovician), House Range, Utah: Journal of Paleontology, v. 43, p. 413–39.
Primarily concerned with Upper Cambrian conondonts but included conodonts from the *Missisquoia* and lower *Symphysurina* trilobite zones.

Paul, C. R. C., 1972, *Cheirocystella antiqua* gen. et sp. nov. from the Lower Ordovician of western Utah, and its bearing on the evolution of the Cheirocrinidae (Rhombifera: Glyptocystitada): Brigham Young University Geology Studies v. 19, pt. 1, p. 15–63.
Described the first Ordovician cystoid reported from western United States and identified it as the oldest pectinirhomb-bearing cystoid known. Established 2 new cystoid genera. Discussed cystoid group relationships.

Pojeta, John, Jr., 1971, Review of Ordovician pelecypods: U.S. Geological Survey Professional Paper 695, 46p. 20 pls.
Figured *Modiolopsis* cf. *M. pogonipensis* Walcott from Lehman Formation of Ibex area.

Rigby, J. K., 1958, Lower Ordovician graptolite faunas of western Utah: Journal of Paleontology, v. 32, p. 907–17.
Figured *Dictyonema, Tetragraptus Phyllograptus,* and *Didymograptus* from western Utah. Established correlation of graptolites with Hintze trilobite zones.

Rigby, J. K., 1962, Canadian and Chazyan receptaculitids from Utah and Nevada (abs.): Geological Society of America Special Paper 68, p. 51–52.
Noted occurrence of elongate conico-cylindrical types in lower Pogonip Group and platter-shaped types in higher Pogonip.

Rigby, J. K., 1965, Evolution of Lower and Middle Ordovician sponge reefs in western Utah (abs.): Geological Society of America Special Paper 87, p. 137.
Noted 4 lithistid sponge reef horizons in the lower Fillmore Foundation, *Calathium* reefs in the upper Fillmore. Lithistid bioherms noted at 4 horizons in the Wah Wah Limestone, and sponge bioherms noted in upper Juab Limestone.

Rigby, J. K., 1971, Sponges and reefs and related facies through time: North American Paleontological Convention, Chicago 1969, pt. J., p. 1374–88, 9 figs.
Summarized occurrence of sponge genera in western Utah Ordovician strata and correlated them with occurrences at other North American localities.

Rigby, J. K., and Hintze, L. F., 1977, Early Middle Ordovician corals from western Utah: Utah Geology, v. 4, no. 2, p. 105–11.
Described *Lichenaria* and *Eofletcheria* species, noting the transitional characteristics of the *Eofletcheria* species.

Roberts, H. H., 1968, Survey of reef-like structures in the Pogonip Group (Ordovician) of southwestern Utah (abs.): Geological Society of America Special Paper 115, p. 442.
Summarized progressive upward change from algal head to sponge-algal associations.

Ross, R. J., Jr., 1951, Stratigraphy of the Garden City Formation in northeastern Utah, and its trilobite faunas: Peabody Museum of Natural History, Yale University, Bulletin 6, 161p.
Established letter trilobite zones and described their component faunas.

Sweet, W. C., Ethington, R. L., and Barnes, C. R., 1971, North American Middle and Upper Ordovician conodont faunas: In Sweet, W. C., and Bergström, S. M., Symposium on conodont biostratigraphy: Geological Society of America Memoir 127, p. 163–93.
Faunas 1–5 reported in this paper were based on the conodonts of the Wah Wah through Crystal Peak.

Taylor, M. E., 1971, Biostratigraphy of the Upper Cambrian (Upper Franconian-Trempealeauan stages) in the central Great Basin, Nevada and Utah: Ph.D. dissertation, University of California–Berkeley, 427p., 19 pls.
Documented upper Cambrian and lowermost Ordovician (*Missisquoia*) trilobites in North Peak Formation of western Utah.

Terrell, F. M., 1973, Silicified trilobite zonation in the lower Fillmore Formation in western Utah: Brigham Young University Geology Studies, v. 20, pt. 4, p. 67–90.
Traced 14 genera through sparsely fossiliferous lower 122m (400 feet) of Fillmore Formation through zones D and E, here subdivided into E-1 and E-2.

Yochelson, E. L., and Jones, C. R., 1968, *Teiichispira,* a new Early Ordovician gastropod genus: U.S. Geological Survey Professional Paper 613-B, 15p.
Listed occurrence of this genus in Wah Wah Limestone of western Utah.

Young, G. E., 1973, An Ordovician (Arenigian) trilobite fauna of great diversity from the Ibex area, western Utah: Brigham Young University Geology Studies. v. 20, pt. 4, p. 91–115.
A 13-cm (5-inch) limestone bed in Zone H in Fillmore Formation yielded 21 trilobite species assigned to 18 genera. Named 9 species and 1 new species. Listed 30 contemporaneous conodont species.