University of Nevada, Reno

Biostratigraphy and Structural Geology In The Marys Mountain Area, Carlin Trend, Eureka County, Nevada

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Geology

by

Brian R. Cellura

Dr. Paula J. Noble/Thesis Advisor

May, 2004

UMI Number: 1420199

INFORMATION TO USERS

The quality of this reproduction is dependent upon the quality of the copy submitted. Broken or indistinct print, colored or poor quality illustrations and photographs, print bleed-through, substandard margins, and improper alignment can adversely affect reproduction.

In the unlikely event that the author did not send a complete manuscript and there are missing pages, these will be noted. Also, if unauthorized copyright material had to be removed, a note will indicate the deletion.

UMI®

ProQuest Information and Learning Company
300 North Zeeb Road
P.O. Box 1346
Ann Arbor, MI 48106-1346

UNIVERSITY OF NEVADA RENO

THE GRADUATE SCHOOL

We recommend that the thesis
prepared under our supervision by

BRIAN R. CELLURA

entitled

Biostratigraphy and Structural Geology In The
Marys Mountain Area, Carlin Trend, Nevada

be accepted in partial fulfillment of the
requirements for the degree of

MASTER OF SCIENCE

Paula J. Noble, Ph.D., Advisor

James E. Faulds, Ph.D., Committee Member

Richard A. Schweickert, Ph.D., Committee Member

Tommy B. Thompson, Ph.D., Committee Member

Guy A. Hoelzer, Ph.D., Graduate School Representative

Marsha H. Read, Ph.D., Interim Associate Dean, Graduate School

May, 2004

ABSTRACT

Several localities within the Roberts Mountains allochthon in central and northeastern Nevada have been mapped as undifferentiated Ordovician through Devonian rocks of the western siliceous assemblage. The poor exposure, repetitive lithology, and structural complexity of the upper plate rocks have made their stratigraphic correlation and structural interpretation difficult. To address the problems, biostratigraphic work using radiolarians, graptolites, and conodonts was undertaken to provide critical age control, to differentiate stratigraphic units, and to resolve structural relationships within the allochthon in the Tuscarora Mountains in the Marys Mountains area of Eureka County, Nevada.

New collections of radiolarians, graptolites, and conodonts have significantly improved the age control on Paleozoic strata in this area. Radiolarian biostratigraphy has revealed eight distinct radiolarian assemblages ranging from Late Ordovician to latest Devonian/early Mississippian. Graptolites yield Middle to Late Ordovician (Caradocian) ages plus one Wenlockian (late Early Silurian) age. Two conodont assemblages, a Devonian (Lower Givetian to Frasnian) assemblage and a Late Devonian (Frasnian) assemblage, are now recognized in the Marys Mountain area.

New biostratigraphic data allows the detailed lithostratigraphy to be unraveled in upper plate rocks in the Marys Mountain area. Stratigraphic units include the upper portion of the Vinini Formation, the Elder Formation, and the Slaven Chert. Lithostratigraphic units recognized at Marys Mountain can now be correlated across a distance of over 150 km within the Roberts Mountains allochthon, from the REN property in the northern Tuscarora Mountains to Vinini Creek in the Roberts Mountains.

Structural features in these rocks include tight to isoclinal folds and imbricate thrust faults (presumably Paleozoic features related to emplacement of the Roberts Mountains allochthon) and high-angle normal faults (middle to late Cenozoic but possibly older as well). Marys Mountain can be divided into two structural domains: 1) a southwest domain defined by north-south striking steeply dipping strata with a high degree of structural imbrication, and 2) a northeast domain with northwest striking gently to moderately dipping strata and exhibiting less structural disruption.

ACKNOWLEDGEMENTS

I would like to acknowledge the following sources of funding for this project: The Geological Society of American summer research grants covered expenses incurred during the 1999 summer field season. The Ralph Roberts Center for Research in Economic Geology provided support in the form of a monthly stipend for the 1999-2000 academic years. I thank them for this support. I would like to thank the University of Nevada, Reno, Microscopy lab for the use of the Scanning Electron Microscope. I would like to thank Paula Noble, Gil Klapper and Stan Finney for help with fossil identification. I would like to thank my committee members for their wisdom, advice and for challenging me to reach further than I would have pushed myself; in particular, I would like to thank Paula J. Noble and James E. Faulds for assistance, guidance and lots of patience throughout this project. I would especially like to thank Kelly J. Cluer for his tutelage, thoughtful discussion, and moral support.

Table of Contents

List of Tables

List of Figures

Plate List

INTRODUCTION

This report summarizes biostratigraphic work done in the Tuscarora Mountains of northeast Nevada. The purpose of this study was to elucidate the stratigraphy and structure of the Roberts Mountains allochthon (RMA), the hanging wall rocks (upper plate rocks) of the Roberts Mountains thrust.

During the Late Devonian to Early Mississippian Antler orogenic event, western siliceous and volcanic assemblage rocks were thrust eastward up to 175 km over coeval eastern carbonate assemblage rocks along the Roberts Mountains thrust (Carpenter et al., 1994; Saucier, 1997). Merriam and Anderson (1942) first described the Roberts Mountains thrust in the Roberts Mountains. Since then the term Roberts Mountains thrust has been applied to the low angle thrust that separates Ordovician through Devonian rocks of the western siliceous and volcanic assemblage from time equivalent Ordovician through Devonian eastern strata of the carbonate assemblage (Stewart, 1980; Saucier, 1997). Evidence for the age of emplacement of the Roberts Mountains thrust (early Late Devonian 383 ma to late Mississippian 348 ma, Carpenter et al., 1994) can be ascertained in the Piñon Range, where the Mississippian Webb Formation lies unconformably over both the western siliceous assemblage (upper plate rocks) and the eastern carbonate assemblages (lower plate rocks) (Roberts et al., 1958; Smith and Ketner, 1968; Stewart, 1980; Saucier, 1997). Rocks from the Roberts Mountains allochthon crop out throughout most of the northern and central parts of Nevada as far south as the Toiyabe Range (Stewart, 1980; Saucier, 1997). Although the distinction between upper and lower plate rocks can be made with ease, the distinction between formations within the allochthonous rocks is more subtle.

The poor exposures, repetitive lithology, and structural complexity of the upper plate rocks, along with poor age control and a lack of distinct well-exposed marker units have made their structural interpretation and stratigraphic correlation difficult. Thus, large parts of the RMA have previously been mapped as undifferentiated Ordovician through Devonian western siliceous assemblage.

However, recent biostratigraphic work in selected areas of the allochthon has successfully used radiolarians, graptolites, and conodonts to aid in differentiating and recognizing distinct lithostratigraphic packages of upper plate stratigraphy (Finney et al., 1993; Cluer et al., 1997; Boundy-Saunders et al., 1999; Noble and Finney, 1999; Noble, 2000; Finney and Cluer, 2000; Peters, 2002). Radiolarians, marine protists that have persisted from the Cambrian to the Recent, have been instrumental for dating Paleozoic siliceous units (i.e. chert) throughout the allochthon (Noble, 2000). Chert units can typically be readily mapped along strike because of their resistant ridge forming nature. Conodonts, marine nektonic organisms present from the Cambrian through the Late Triassic (Clark, 1987), have been useful for dating calcareous units throughout the allochthon (e.g. Gilluly and Gates, 1965; Finney and Perry, 1991; Boundy-Saunders et al., 1999, and others). Graptolites, marine macroplankton ranging from the Cambrian through the earliest Devonian (Palmer and Rickards, 1991), have been invaluable for dating siltstone, shale, and calcareous sandstone units (Noble and Finney, 1999; Finney and Cluer, 2000). Collectively, these three fossil groups provide critical age control for the dominant lithologic units in the allochthon (Plate1).

Based on new biostratigraphic studies, the ages and probable correlation of chert, shale, siltstone, limestone, and sandstone units have been established in the Marys Mountain area of the southern Tuscarora Mountains, Eureka County, Nevada.

Marys Mountain is located 12 km west of Carlin and 45 km west-southwest of Elko on the Emigrant Pass 7.5′ Quadrangle (Figs. 1 and 2). This project has focused on the Paleozoic strata in an area east of the 559000 E line and north of the 4505000N line (UTM coordinates NAD 27 datum, Zone 11) within this quadrangle. Deformed strata of the RMA crop out in and around Marys Mountain and are overlain by Tertiary volcanic and tuffaceous sedimentary rocks. Reconnaissance during the fall of 1998 and spring of 1999 indicated that this area had the potential to yield new biostratigraphic data to help elucidate stratigraphic relationships in the Marys Mountain area.

Detailed mapping of Paleozoic strata on the Emigrant Pass 7.5' Quadrangle by Henry and Faulds (1999) was combined with biostratigraphic data produced during this study to elucidate the stratigraphic and structural relationships at Marys Mountain. The resulting refinements to the stratigraphy have revealed previously unknown faults and structural relations within the RMA in this area.

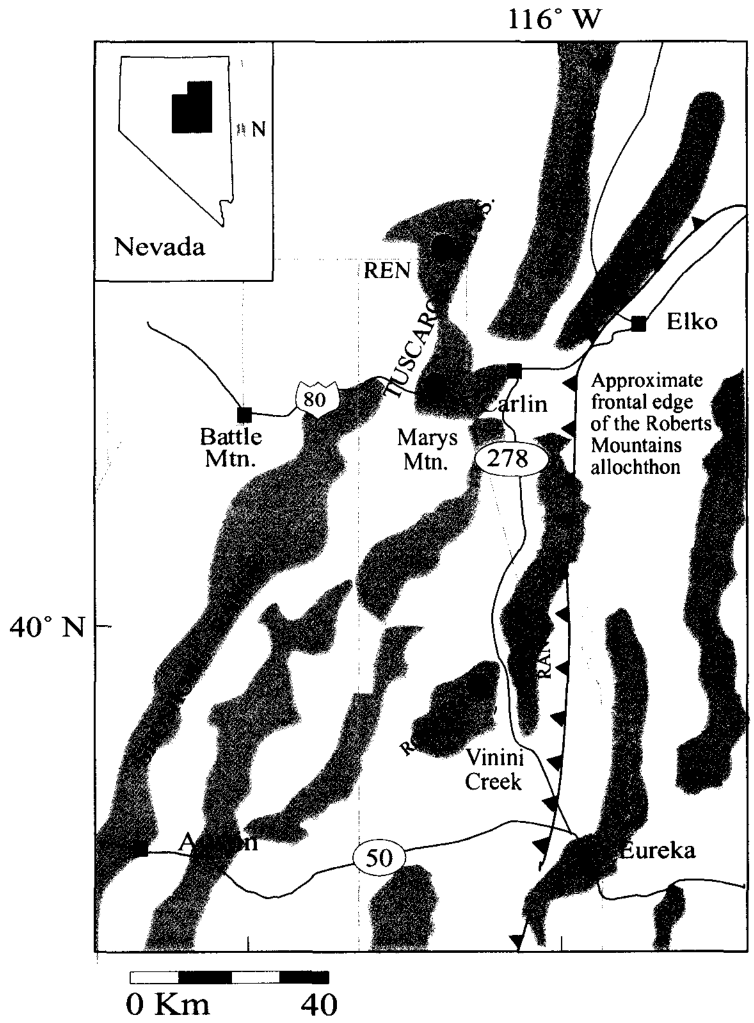


Figure 1
Generalized map of north-central and north eastern Nevada showing the approximate frontal edge of the Roberts Mountains allochthon and the location of Marys Mountain, the REN property, and Vinini Creek. Major mountain ranges shown in green. Modified from Noble (2000).

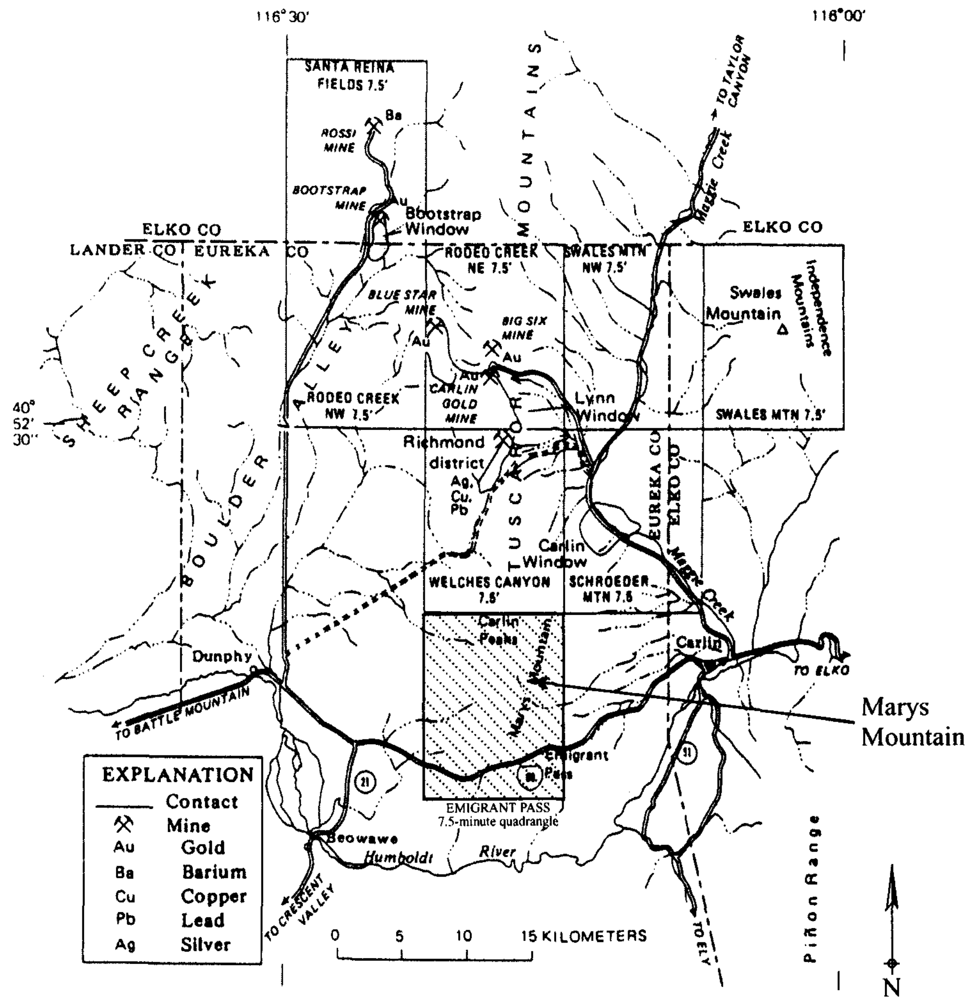


Figure 2.
Southern Tuscarora Mountains showing the location of the Emigrant Pass 7.5' Quadrangle and adjacent quadrangles. Modified from Evans (1974).

GEOLOGY OF MARYS MOUNTAIN, SOUTHERN TUSCARORA MOUNTAINS

Previous Work

A small number of paleontologic and stratigraphic studies have been conducted in the southern Tuscarora Mountains including Clark and Ethington's (1967) regional study of conodonts and Ross and Berry's (1963) study of Ordovician graptolites. A more comprehensive study of the stratigraphy in the southern Tuscarora Mountains was conducted by Evans in the 1970s. Evans produced geologic maps of the Welches Canyon and Rodeo Creek NE 7.5′ Quadrangles (Evans, 1974, Evans and Theodore, 1978). This was followed by a more detailed report, including supporting paleontologic data and stratigraphic descriptions (Evans, 1980). Craig (1987) published a short paper on the lithostratigraphy of the Tuscarora Mountains. Other stratigraphic studies in and around the Lynn window in the Schroeder Mountain (Evans and Cress, 1972) and Swales Mountain Quadrangles (Evans and Ketner, 1971) (Fig. 2) have been completed, but little paleontological data were obtained to support the proposed stratigraphic models.

Henry and Faulds (1999) mapped the Emigrant Pass Quadrangle and subdivided the Paleozoic strata by lithology into chert, siltstone, and limestone units. At that time, time biostratigraphic control was insufficient to determine accurately the number of stratigraphic horizons and their stratigraphic succession. Biostratigraphic data were limited to a few Middle to Late Ordovician graptolite localities (Ross and Berry, 1963) and one Late Devonian conodont locality (Clark and Ethington, 1967). The only other age control available was from the Welches Canyon Quadrangle located directly north of the Emigrant Pass Quadrangle, where several Devonian conodonts were reported from limestone beds mapped as lower plate eastern carbonate shelf facies rocks and interpreted as structural windows through the allochthon (Evans, 1974).

METHODS

The original geologic map compiled by Henry and Faulds (1999) was used as a base map to locate outcrops for a biostratigraphic study employing radiolarians, graptolites, and conodonts. One hundred and thirty-two samples were collected for this study, including 103 radiolarian samples with a 59% recovery rate, 13 conodont samples with a 19% recovery rate, and 16 new graptolite samples. Sample collecting was completed in two phases. The first phase was completed in 1999 when 90 samples were collected. The second occurred in 2000, when an additional 42 samples were taken to fill biostratigraphic gaps, where either data were missing or poor recovery rates characterized previously collected samples. Once compiled, the new age controls on units in the Marys Mountain area were incorporated into the 1:24,000, Emigrant Pass geologic map produced by Henry and Faulds (1999). A field check correlating fossil data and lithologic units was performed in 2001 to rectify geologic and structural contacts in the Marys Mountain area.

Radiolarian Processing

In the field, a preliminary check for radiolarians was made using a 14x-hand lens to view freshly broken rock surfaces. If the rock contained radiolarians, enough of the rock was collected to fill a 1000 ml plastic beaker; additional material was collected for description and possible future work with geochemistry and/or petrography. The method of Pessagno and Newport (1972) was used for processing all radiolarian samples and is briefly described herein. The rocks, once back at the lab, were broken into ≈ 1-3 cm chips to maximize the fresh surface area on the rock. Anything finer would potentially destroy the fossils. The 1000 ml beaker was filled with a dilute ≈ 3 % solution of hydrofluoric acid (HF) and allowed to sit in a HF bath for ≈ 24 hours. The sample was then decanted through a 63μm sieve to collect the fine residue. The HF was neutralized with sodium hydroxide (NaOH). The fine residue was rinsed and placed back in the beaker with the etched rocks. The sample was then rinsed and sieved through a nest of three sieves: 500μm; 180μm; and 63μm. The residue from the 180μm and 63μm sieves was saved as both coarse and fine fractions in filter papers to be picked later. The sample was then covered with a fresh dilute HF solution and allowed to soak for another ≈ 24 hours. This process was done three times, with each run successively etching more of the sample, thus releasing more microfossils.

The dried samples were sprinkled onto a black picking tray. Radiolarians were picked with a moist 000 paintbrush while looking through a binocular microscope. Those samples containing radiolarians were picked, mounted, and photographed using the Scanning Electron Microscope (SEM). Samples lacking or containing very poorly preserved radiolarians were termed "barren". It is important to note that not all rocks with visible radiolarians in hand sample produce recoverable radiolarians after processing. In the case of recrystallized cherts, radiolarians may fuse to the matrix, making their recovery nearly impossible. Therefore, rocks that are termed "barren" may have originally had fossils, but the fossils could not be separated from the siliceous matrix.

Graptolites

A total of 16 new graptolite collections were amassed to fill biostratigraphic gaps in the shale and siltstone units. Samples were sent to Stan Finney at California State University, Long Beach, for identification.

Conodonts

Thirteen limestone samples were collected and processed for conodonts. The samples were crushed (sizes ranging from 2 to 5 cm in diameter), and a standard 2 kg representative sample was separated for processing. Samples were placed in a five-gallon bucket and covered with a solution of 10% formic acid (HCOOH). The sample was allowed to react with the acid for about 20-24 hours. After the acid fully reacted with the carbonate and the reaction stopped, the residues were sieved through a set of 500 μm, 125 μm, and 63 μm sieves. Once in the sieves, the samples were washed with a gentle stream of water to remove clays. After sieving, the residues were transferred from the sieves to a set of 250 ml beakers, filled with water, and stirred to remove any algae. All floating material was decanted after the residues settled. Once the algae had been removed, the residues were transferred from the beaker into filter papers for picking. Once processed, all samples were sent to Gilbert Klapper, University of Iowa, for identification.

STRATIGRAPHY

Stratigraphy of the Marys Mountain Area

The stratigraphy of the Marys Mountain area includes Ordovician through Devonian strata assigned to the Vinini Formation, Elder Formation, and Slaven Chert (Fig. 3). The Paleozoic strata are unconformably overlain by Tertiary volcanic rocks. This project focuses only on the Paleozoic strata. The Vinini Formation at Marys Mountain is composed of shale, siltstone, minor chert, and porcellanite. Compositionally, a porcellanite consists of 25 -50 % silt and clay, with a ratio greater than 1:1 of carbonate material to authigenic silica (Gilbert, 1954). However, in this study a textural description for porcellanite will be used, whereby it is a dense siliceous rock having a conchoidal fracture and a dull luster similar to unglazed porcelain (Isaacs, 1982). Stratigraphically above the Vinini Formation lies the Silurian to Lower Devonian Elder Formation (Finney and Cluer, 2000), consisting of chert, porcellanite, and micaceous siltstone. Devonian strata at Marys Mountain are comprised of both siliceous (siltstone, chert, porcellanite, and chert breccia), and calcareous (limestone, limy mudstone, and calcareous sandstone) lithologies. The calcareous component is significant, comprising 20-30 % of the exposed Devonian strata at Marys Mountain.

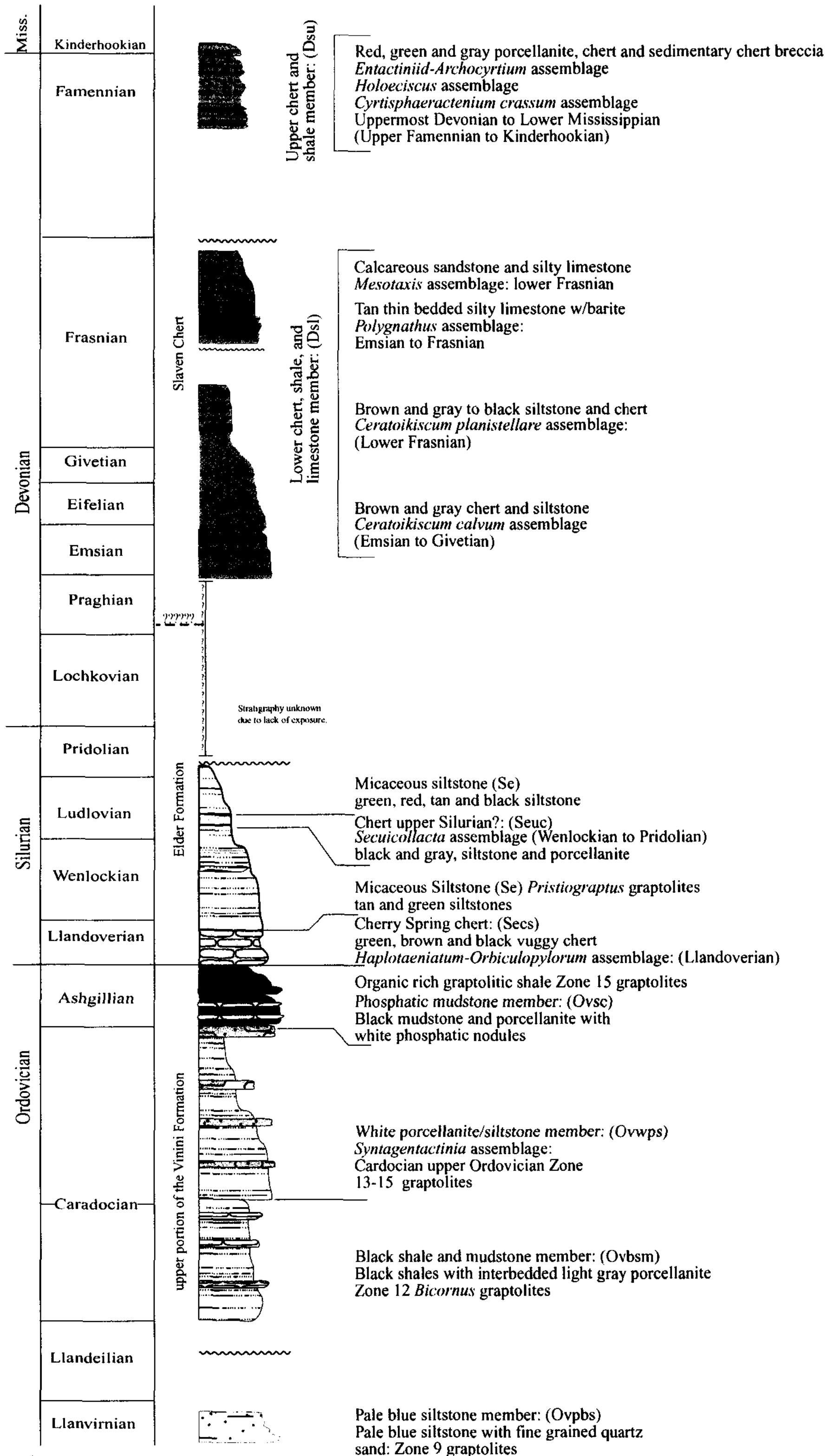


Figure 3.
Stratigraphic column of the Marys Mountain area, showing major mappable units and associated biostratigraphic assemblages. Vertical scale based on The Geological Society of America, 1999, Geologic Time Scale.

Vinini Formation

The Vinini Formation (Fig. 4) was first mapped by Merriam and Anderson (1942) at Vinini Creek in the Roberts Mountains, where it is relatively well exposed. Two informal members were recognized: a lower member dominated by quartzite and sandstone and an upper member dominated by shale and chert (Merriam and Anderson, 1942; Finney and Perry, 1991). Finney and Perry (1991) further described the lower member of the Vinini Formation in the Roberts Mountains and recognized a lower graptolite black shale ≈140 m thick, overlain by a sandstone sequence ≈ 1832 m thick. The latter consists of quartzite, quartz-arenite, quartz-wacke, calcareous sandstone, siltstone, shale, limestone, rare chert, and conglomerate units. The upper member of the Vinini Formation in the Roberts Mountains, ≈ 170 m thick, is dominated by shale, argillite, and chert with a noticeable absence of sandstone and limestone units (Finney and Perry, 1991).

At Marys Mountain, only the upper member of the Vinini Formation crops out. Locally, these strata are subdivided into four informal members at a scale of 1:12,000; a pale blue siltstone member (Ovpbs), a black shale and mudstone member (Ovbsm), a white porcellanite/siltstone member (Ovwps), and a black phosphatic mudstone member (Ovsc) (Fig. 4). Reference localities for these four units have been designated and appear on Plate 1 (localities 1 to 4).

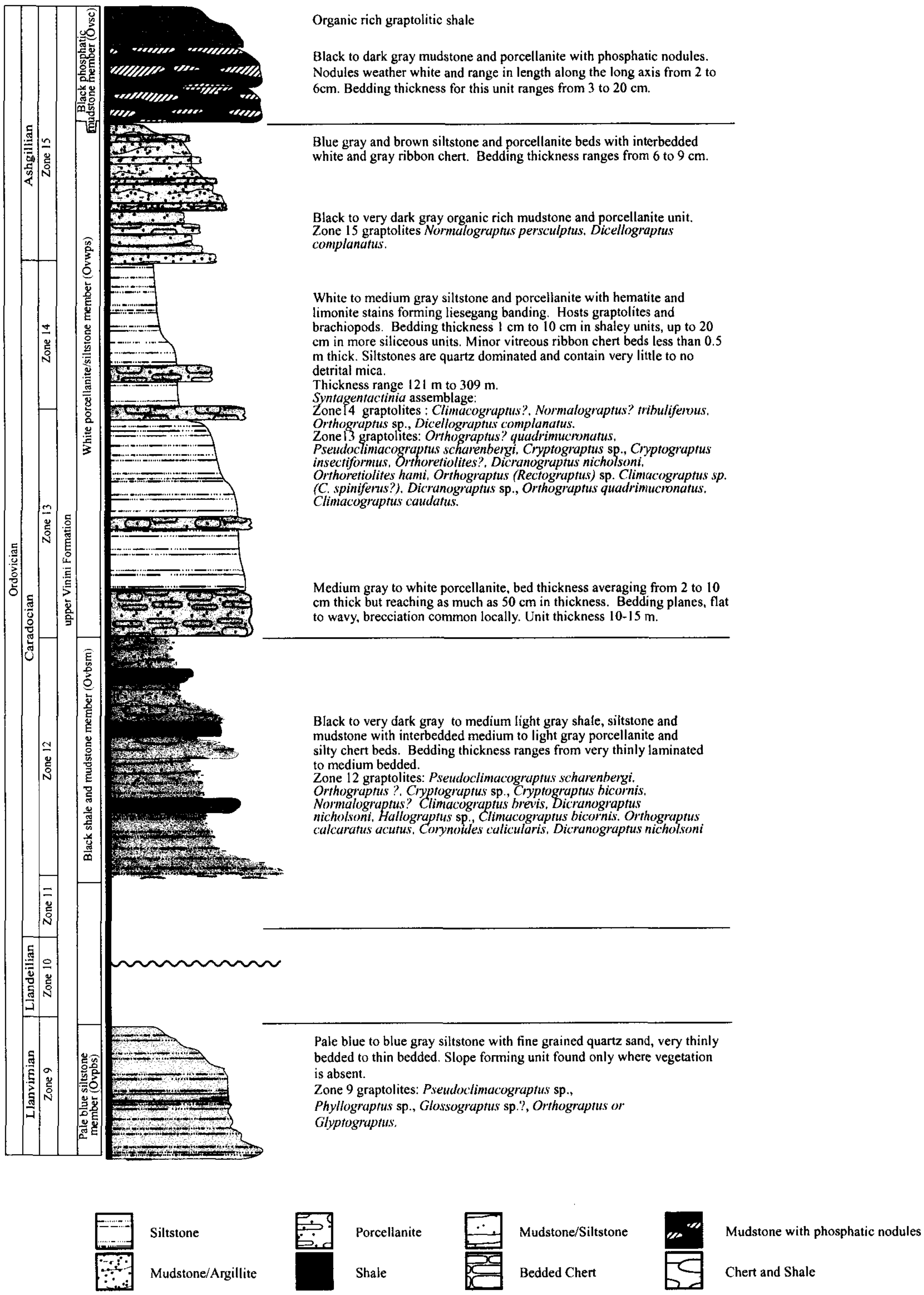


Figure 4.
Schematic stratigraphic column of the upper Vinini Formation in the Marys mountain area, showing lithology, sample locations and biostratigraphic assemblages. Vertical scale based on The Geological Society of America, 1999, Geologic Time Scale.

Pale Blue Siltstone Member (Reference Locality: 1) (Ovpbs): The lowest member of the Vinini Formation at Marys Mountain is the pale blue (5PB 7/2)[1] siltstone member. It contains planar beds of siltstone and shale with interbedded very fine-grained quartz sandstone beds. Bed thicknesses ranges from very thin bedded to thin bedded (1 to 3 cm) (Fig. 4). The pale blue siltstone member produces gentle slopes (<10°) and can only be observed where vegetation is lacking and soils are very thin. The overall thickness, interpreted from cross-section, is approximately 30 m. At its reference locality (locality-1) the pale blue siltstone member crops out on the west side of Marys Mountain, where a thin fissile shale and siltstone sequence dominates the lower hills. Float mapping along a N60W strike indicates a continuation of the pale blue siltstone member until it is covered by volcanics to the northwest and southeast. This is the oldest member seen on the Emigrant Pass Quadrangle and is located in the northeast domain of the quadrangle in a structurally imbricated zone. The top and bottom of this member are structurally bounded by the white porcellanite/siltstone member of the Vinini Formation. Age control for this unit is based on a graptolite collection made from sample Ep-00-g04. Graptolites, identified by Stan Finney, include *Pseudoclimacograptus* sp., *Phyllograptus* sp., *Glossograptus* sp.?, *Orthograptus or Glyptograptus*, indicating that this unit is lower Middle Ordovician, Llanvirnian, Zone 9 of the Marathon area (Berry, 1960). Lithologies hosting Zone 10 and 11 graptolites either are absent at Marys Mountain or were not recognized during this study.

[1] Munsell rock color chart codes given to reference colors for rock units

Black Shale And Mudstone Member (Reference Locality: 2) (Ovbsm): The black shale and mudstone member is a sequence of interbedded black to very dark gray to light gray (N1 to N3) shale, siltstone, and mudstone beds. Beds are planar and range in thickness from very thinly laminated (3 mm) to thinly bedded (3 cm) to medium bedded (10 cm). The black shale and mudstone member grades from a shale and siltstone dominated sequence in the lower part to a more siliceous mudstone and porcellanite dominated sequence higher in the section (Fig. 4). The change to a more siliceous lithology is accompanied by a corresponding increase in bedding thickness from thin beds (3 cm) to medium beds (10 cm).

The reference locality for the black shale and mudstone member can been found just east of Marys Creek on a west facing slope where both the base and top of the black shale and mudstone member are structurally bounded and or covered. At its reference locality (locality-2) the base of the black shale and mudstone member is defined by the first black siltstone/mudstone bed. The top of the black shale and mudstone member at its type locality is fault bounded with the Elder Formation and is therefore defined by the last black porcellanite bed. Exposure of the black shale and mudstone member is limited to the west side of Marys Mountain, where it crops out in two localities. Thickness for this member ranges depending on the degree of exposure and cover from surrounding colluvium but is typically around 10-20 m thick.

Age control for this member comes from several graptolite collections made during this study. Samples Ep-99-G05, Ep-99-G10, and Ep-00-G06 have all produced *Climacograptus bicornis* (Zone 12) graptolites, restricting the age control of this unit to the early Caradocian in the early Late Ordovician. Poorly preserved Late Ordovician radiolarians such as *Syntagentactinia* were recovered from porcellanites corroborating the age of this member.

White Porcellanite/Siltstone Member (Reference Locality: 3) (Ovwps): The most widely recognized member of the Vinini Formation at Marys Mountain is the white porcellanite/siltstone member. The white porcellanite/siltstone member is white to light gray (N9 – N8) on weathered surfaces and medium gray (N6 – N4) on fresh surfaces. It contains beds of shale, siltstone, siliceous siltstone, porcellanite, and vitreous chert. Bedding thickness ranges from very thinly to thinly bedded (1 to 3 cm) in the more silty beds and medium to thick bedded (10 to 20 cm) in the porcellanite and chert beds (Fig. 4). Bedding planes range from planar in the more silty beds to wavy in the more siliceous beds. Finely disseminated hematite and limonite locally produce liesegang banding. Graptolites are common in this unit and can be found at nearly any outcrop (Figs. 5 and 6). Other fossils present include brachiopods, ichnofossils (i.e. burrows), and radiolarians in the more siliceous beds. At its reference locality (locality-3) the base of the white porcellanite/siltstone member is defined by the first white to medium gray siltstone/porcellanite bed; the top is defined by the last white to pink thick (> 30 cm) bedded chert bed.

At its reference locality on the west side of Marys Creek along a southeast facing slope on the north side of the draw, the white porcellanite/siltstone member sits structurally above the Silurian to Lower Devonian Elder Formation. Lower beds of the

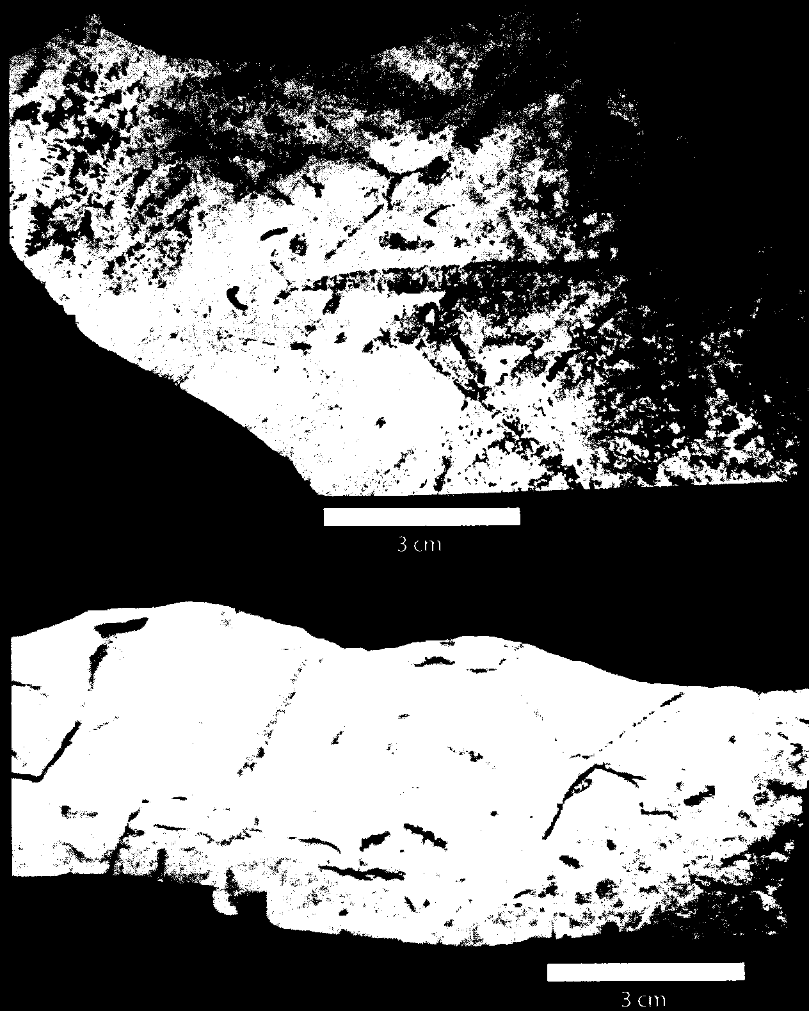


Figure 5
White porcellanite and siltstone unit (Ovwps), graptolites shown *Climacograptus* sp. (top) and *Dicellograptus complanatus?* (bottom). *Dicellograptus* are recovered from organic rich mudstone beds at the top of the Ovwps.

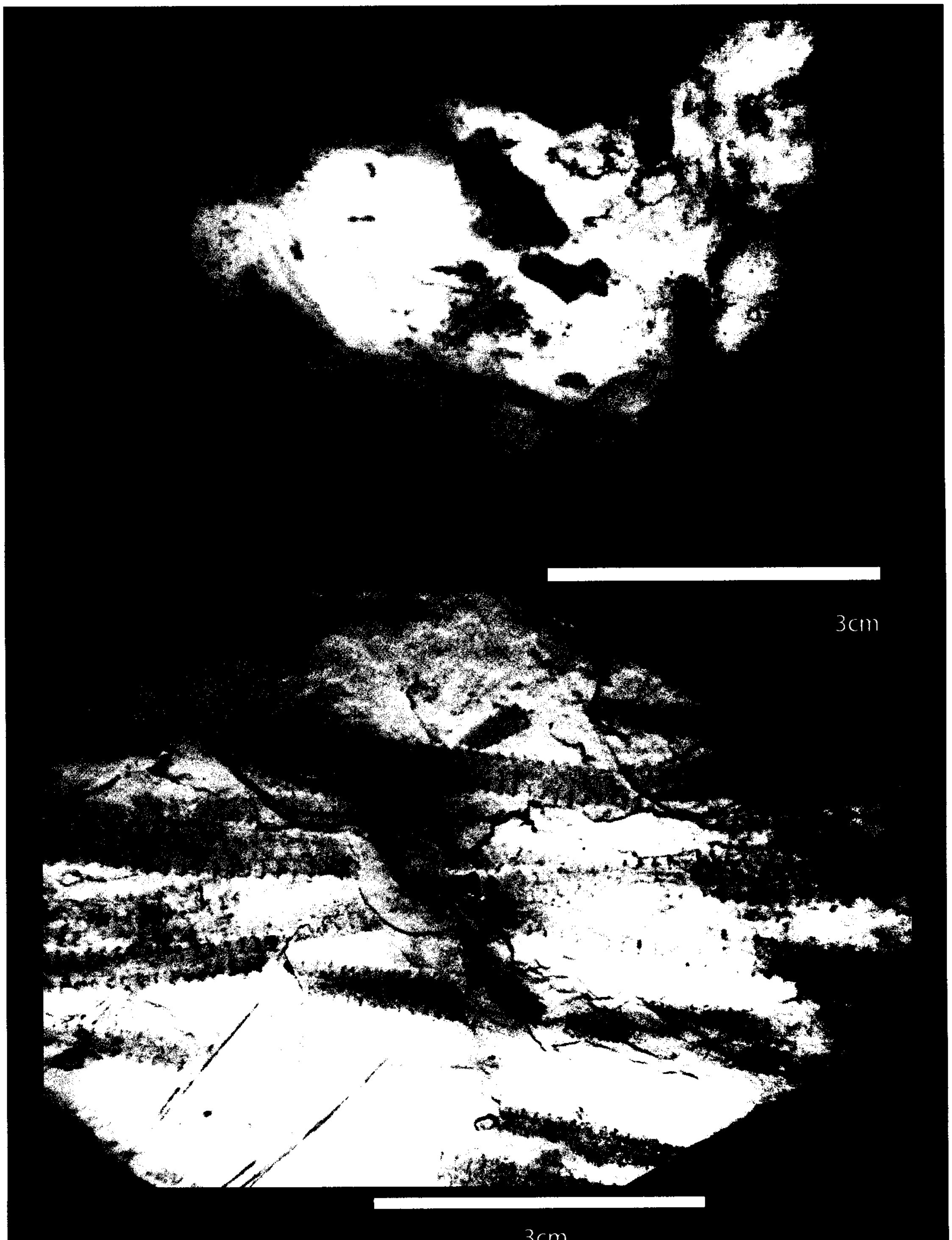


Figure 6.
White porcellanite and siltstone unit (Ovwps), graptolite genus shown is *Orthograptus* sp.

white porcellanite/siltstone member consist of medium gray to white porcellanite beds with thickness averaging from 2 to 10 cm thick but reaching as much as 50 cm, with flat to wavy bedding planes. Stratigraphically upsection is section of white to medium gray siltstone and porcellanite beds. This part of the white porcellanite/siltstone member typically forms moderately steep slopes. Bedding thicknesses range from 1 to 10 cm in shaley beds and up to 20 cm in the more siliceous beds. Minor vitreous ribbon chert beds 30-50 cm thick are interbedded with the siltstones. Siltstones are quartz dominated and contain very little to no feldspar or mica. Continuing up section at the reference locality is a section of black to very dark gray mudstone and porcellanite with abundant organic carbon. This lithology has only been observed at the reference locality and is not present in other areas where the white porcellanite/siltstone member crops out (Fig. 4). The white porcellanite/siltstone member can be traced laterally for hundreds of meters. Lateral variations of this member include the absence of the more siliceous beds and the increase in siltstone and mudstone beds. The thickness of the unit, as estimated from two cross-sections from the west and east sides of Marys Creek, ranges from a minimum of 30 m to a maximum of ≈ 100 m. A possible explanation for the large variation in thickness of the white porcellanite/siltstone member is that the member has been more highly structurally attenuated or excised by faults on the east side of Marys Creek, where fossil data suggest several north-striking faults in the area.

At Marys Mountain, the white porcellanite/siltstone member has graptolites (identified by Stan Finney) ranging from Zone 13 and 14, *Orthograptus amplexicaulis* (Zone 13), *Orthograptus quadrimucronatus* (Zone 14) through zone *Normalgraptus persculptus* (Zone15). Based on graptolite biostratigraphy, the white porcellanite/siltstone member is considered late Caradocian to early Ashgillian, (late Late Ordovician). In addition to the graptolites, radiolarians have been recovered from the porcellanite and chert beds. The *Syntagentactinia* assemblage contains rare *Protoceratoikiscum, Haplotaeniatum,* and *Syntagentactinia* providing further confirmation that the white porcellanite/siltstone member is upper Caradocian to lower Ashgillian.

Black Phosphatic Mudstone Member (Reference Locality: 4) (Ovsc): The uppermost member of the Vinini Formation at Marys Mountain is represented by a black mudstone with phosphatic nodules. The black phosphatic mudstone member is composed of black to dark gray (N1 to N3) thin bedded siltstone and shale beds with interbedded silicificed mudstones and silty chert beds containing white phosphate nodules and thin discontinuous white phosphatic streaks (Figs. 4 and 7). At its reference locality (locality-4) on the west side of Marys Creek along an east facing slope in low lying hills, the black phosphatic mudstone member rests stratigraphically above the white porcellanite/siltstone member. The base of the black phosphatic mudstone member when seen is defined as the first phosphatic chert bed. The black phosphatic mudstone member is poorly exposed and is commonly only seen as large angular blocks in float. Hence, laterally this unit appears to pinch and swell depending on the amount of cover in the area. The top of the black phosphatic mudstone member is defined as the last organic-rich shale below the Cherry Spring chert member of the Elder (Fig. 3). Thickness of this unit at Marys Mountain, taken from cross-sections, is 10 to 30 m.

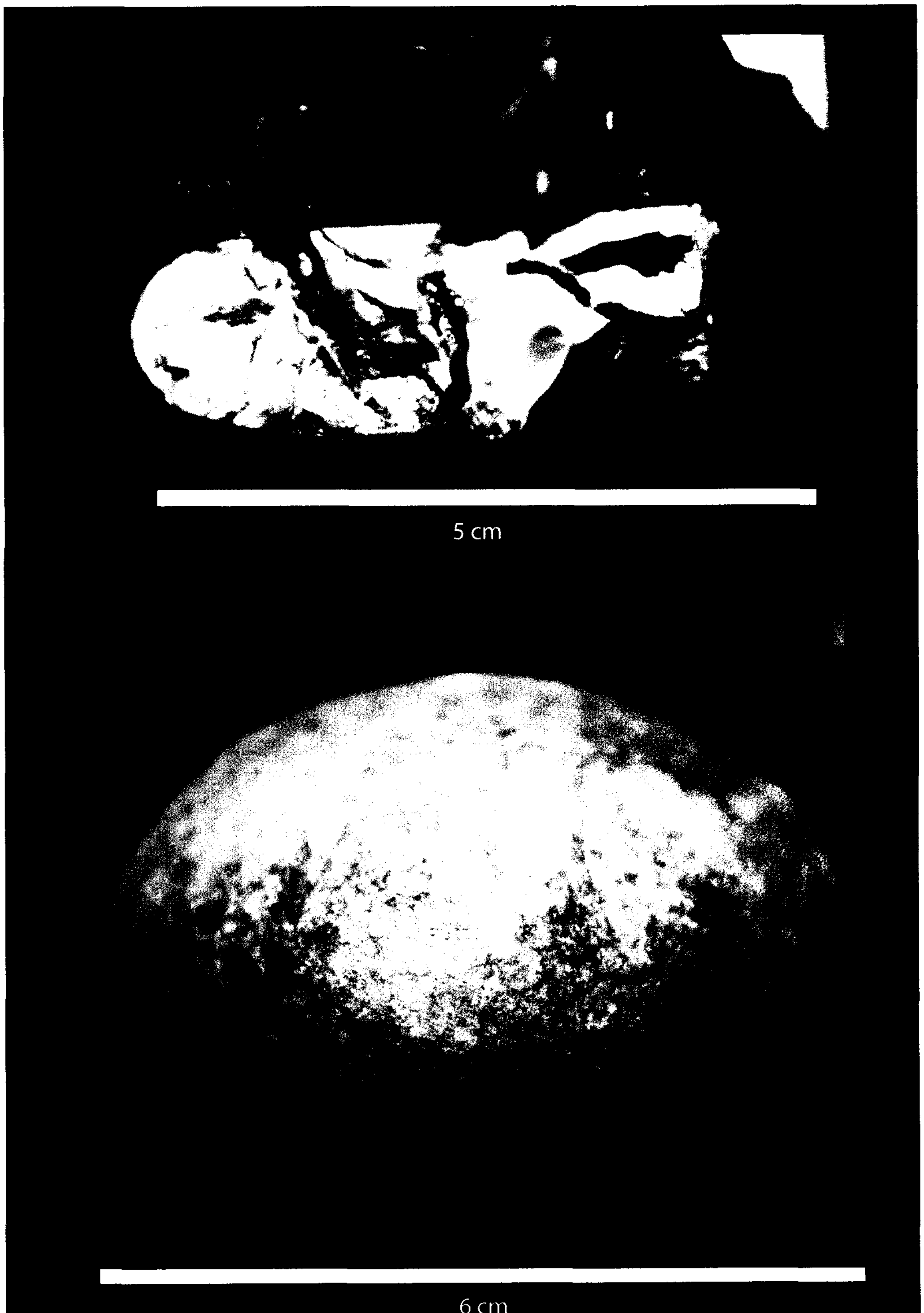


Figure 7.
(Top) Black phosphatic mudstone member (Ovsc). (Bottom) White phosphatic nodule; lower Upper Ordovician (Cardocian).

Elder Formation: (Se) (Fig. 8)

The Silurian Elder Sandstone was first defined by Gilluly and Gates (1965) at its type locality in the drainage basin of Elder Creek (Gilluly and Gates, 1965), later redefined, and renamed by Finney and Cluer (2000) as the Elder Formation. Both the base and the top of the Elder Sandstone were considered to be fault bounded (Gilluly and Gates, 1965), and thus stratigraphic relationships to underlying and overlying units were not clearly defined. Finney et al., (1993) provided a stratigraphic base for the Elder Formation at Vinini Creek, where the Elder Formation lies conformably on the Vinini Formation. Similarly, the top of the Elder Formation can be observed in depositional contact with the overlying Slaven Chert in a road cut in the Beaver Creek Quadrangle (Finney and Cluer, 2000). Dominant lithologies in the Elder Formation are sandstone and siltstone beds containing approximately 80 % quartz, 15-20 % potassium feldspar, and 5 % muscovite, with traces of albite. Other lithologies include interbedded chert and silty chert beds (Gilluly and Gates, 1965).

The Elder Formation at Marys Mountain is dominated by micaceous siltstone beds with two distinct chert intervals. The base of the Elder Formation at Marys Mountain is placed at the base of the Cherry Spring chert member (Secs) (Figs. 3 and 8). The second chert occurs up section within the micaceous siltstone (Figs. 3 and 8). The top of the Elder Formation is not exposed at Marys Mountain. Even though the upper contact has not been observed in the area of study, it is assumed that it is depositional, whereby the micaceous siltstone of the Elder Formation is directly overlain by the lower chert, shale, and limestone member (Dsl) of the Devonian Slaven Chert.

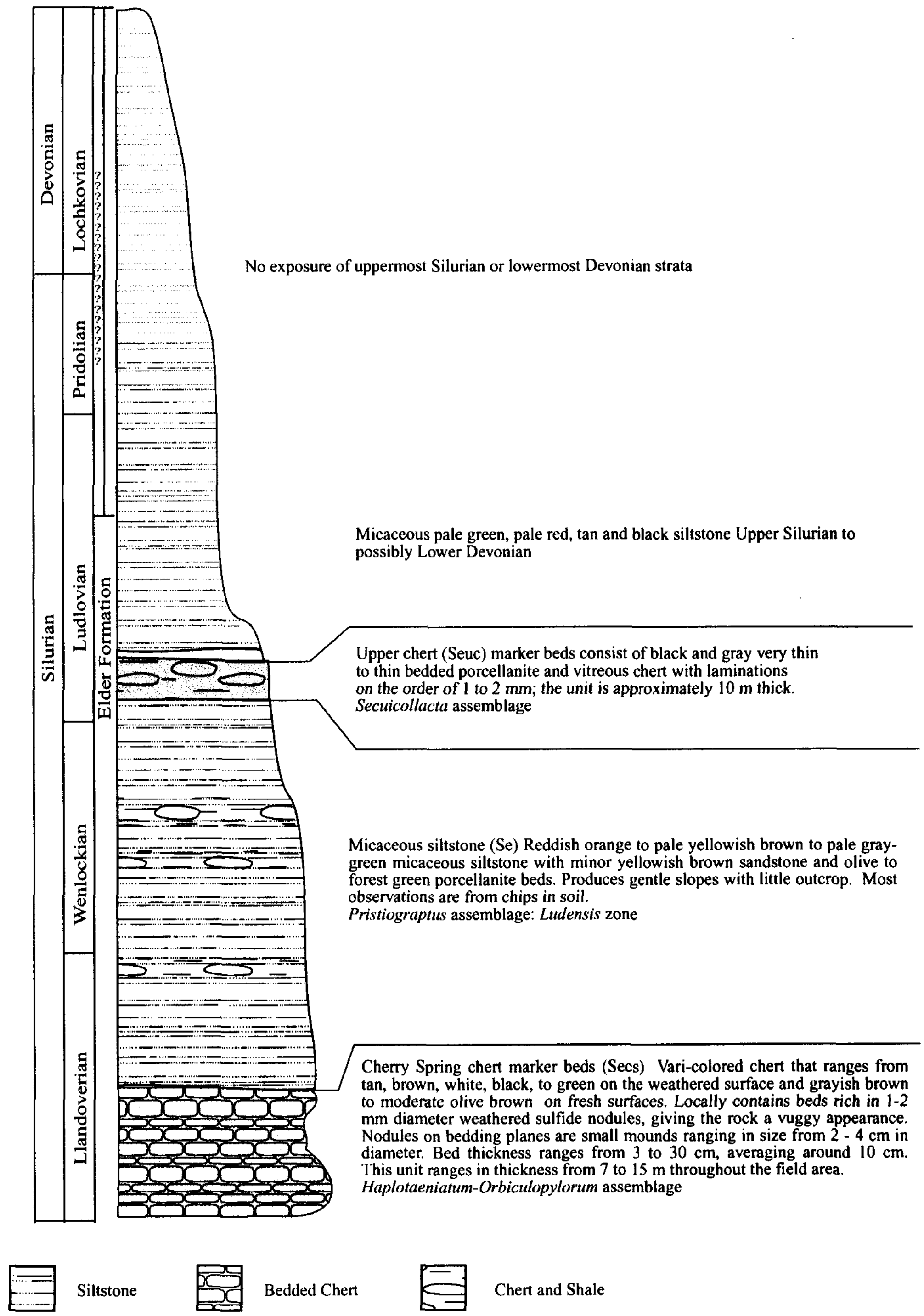


Figure 8.
Schematic stratigraphic column of the Elder Formation in the Marys Mountain area showing lithology and biostratigraphic assemblages. Vertical scale based on The Geological Society of America, 1999, Geologic Time Scale.

Reference localities for Elder Sandstone units have been designated and appear on Plate 1 (Localities 5, 6 and 7).

Cherry Spring chert Member (Reference locality: 5) (Secs): The Cherry Spring chert member (Secs) forms a prominent marker unit and is interpreted to represent the base of the Silurian strata throughout the Roberts Mountain allochthon (Ketner, 1991; Noble et al.,1997; Cluer et al., 1997; Finney and Cluer, 2000). Lower Silurian cherts were first described as a sequence of chert that contains sparse radiolarians and spicules, lacks organic matter, and locally includes silver bearing iron, lead, and zinc sulfides that suggest a gossan pattern (see lower Silurian strata of Ketner, 1991). Noble (1997) refined the age and description. A type locality was assigned for Cherry Spring chert member in the Northern Adobe Range. Additional studies of the Cherry Spring chert member have been conducted by Noble in localities such as Garden Pass and the Roberts Mountains (Noble and Aitchison 1995; Noble et al., 1997; Noble et al., 1998; Noble and Finney, 1999).

At Marys Mountain, the Cherry Spring chert member ranges in color along strike, from tan to brown, white to black, and yellow to green on the weathered surface and grayish brown (5YR 5/2) to moderate olive brown (5Y 4/4) on fresh surfaces. It locally contains beds rich in 1-2 mm diameter sulfide nodules (oxidized to goethite and jarosite), giving the unit a vuggy appearance (Fig. 9). Bedding surfaces range from nodular to wavy. Nodules on bedding planes range in size from 2 - 4 cm in diameter. Bed thickness ranges from 3 - 30 cm thick with a mean thickness around 10 cm. The

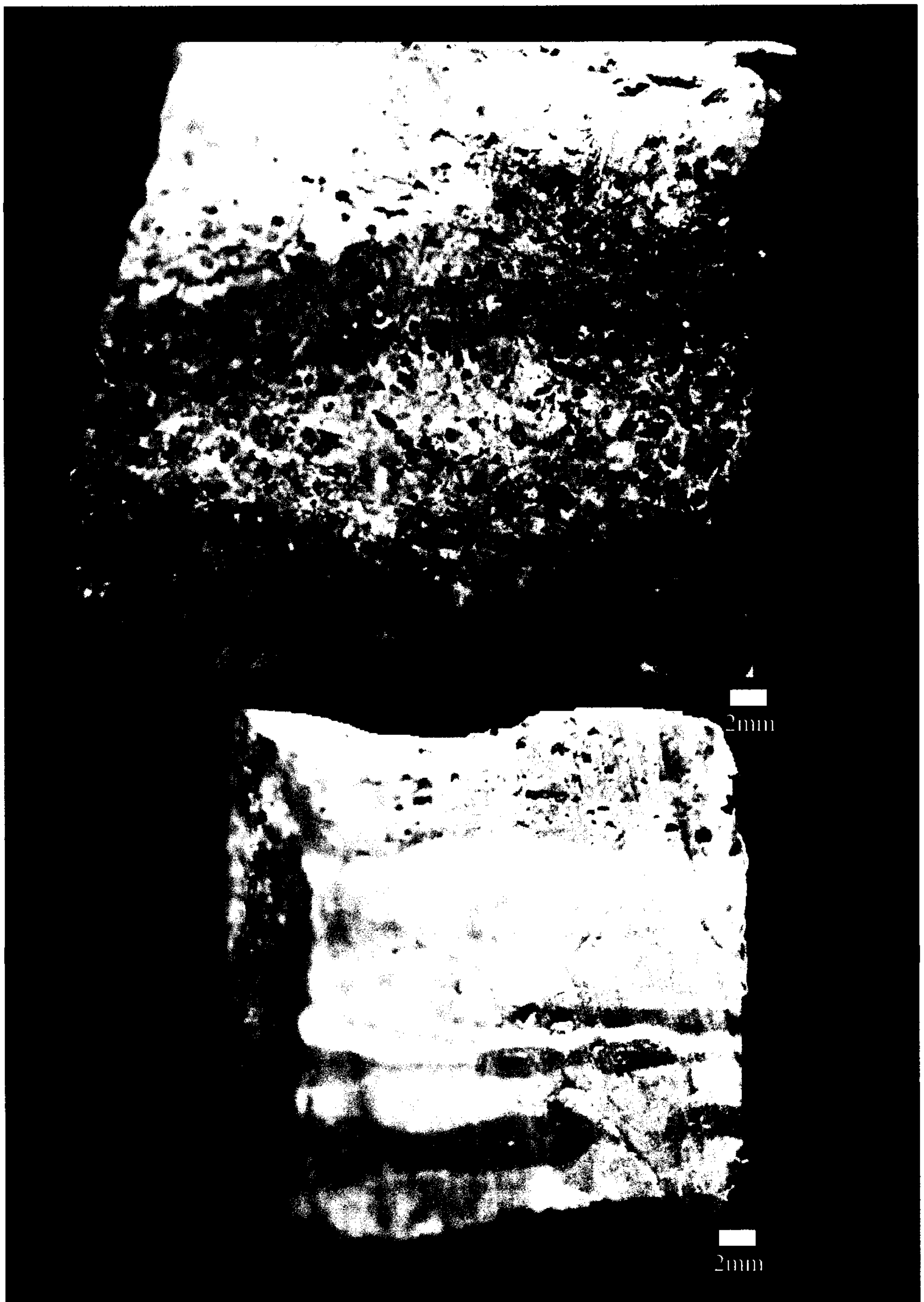


Figure 9.
(Bottom) Cherry Spring chert (Sees)- color of chert ranges from black to brown to gray and green. (Top) Cherry Spring chert- heavily coated with limonite and goethite, vugs approximetly 1 mm in diameter.

Cherry Spring chert member ranges in thickness from 5 -8 m throughout the field area. It is a ridge-forming unit and can be traced along strike for several hundreds of meters. Laterally, the Cherry Spring chert member may thin and thicken by a meter but typically remains at a constant thickness throughout the Marys Mountain area. The Cherry Spring chert member stratigraphically overlies the black phosphatic mudstone member of the upper Vinini Formation. At its reference locality (locality-5), on a west facing slope along the west limb of an anticline, the Cherry Spring chert member can be observed approximately 25 m east of a north trending drainage cutting through a draw and continuing along strike to the south. At the Cherry Spring chert member reference locality, the black phosphatic mudstone member has been structurally attenuated within a tight anticline, with Cherry Spring chert member on the east and west limbs and the white porcellanite/siltstone member along the hinge of the anticline. There, the Cherry Spring chert member is recognized by the lowest varicolored gossanous chert bed. The Cherry Spring chert member is stratigraphically overlain by micaceous siltstones of the Elder Formation; the upper contact of the Cherry Spring chert member is sharp and interpreted to be a conformable contact marked by the upper most varicolored gossanous chert bed.

Radiolarians are the only fossils recovered from the Cherry Spring chert member at Marys Mountain and are consistently assigned to the *Haplotaeniatum – Orbiculopylorum* assemblage (Noble, 2000), a distinct radiolarian fauna that, in Nevada, is restricted to the Cherry Spring chert member and is interpreted to be Llandoverian (Early Silurian) age (Noble et al., 1998; Noble, 2000).

Micaceous Siltstone Member (Reference Locality: 6) (Se): Volumetrically, the dominant lithology (70-80 %) in the Elder Formation is orange (10R 6/6), to pale yellowish brown (10 YR 6/2) micaceous siltstone beds that contains approximately 60-80% quartz silt; 10-20% feldspars; and 5-10% muscovite (Gilluly and Gates, 1965). The siltstone is poorly exposed and cannot be described comprehensively. Most observations are made from chips in the soil and limited gully exposures. Thus, the Elder Formation is difficult to trace laterally. Lithologic variations within the micaceous siltstone include the coarsening and fining of siliciclastic beds. Siliciclastic beds are dominated by yellowish brown sandstone beds and olive to grayish green (5GY 3/2) porcellanite beds (Fig. 10). At its reference locality (locality-6) a thick homogenous package of thin bedded planar laminated micaceous siltstone beds are exposed on the north side of a west-northwest-trending gully. The base of the micaceous siltstone at its reference locality is bounded by a low-angle thrust fault placing micaceous siltstone beds of the Silurian-Devonian Elder Formation on top of Devonian siltstone and chert beds of the lower chert, shale, and limestone member of the Devonian Slaven Chert. The top of the micaceous siltstone beds at the reference locality is covered but is interpreted to be the last siltstone bed stratigraphically below a sequence of Middle Devonian chert and siltstone beds.

Age control for the micaceous siltstones at Marys Mountain is sparse and is based on a single graptolite collection (sample Ep-00-G02) that occurs above the Cherry Spring chert member but below the upper chert. The graptolites are Wenlockian age (Late Early Silurian) (*Pristiograptus jaegeri, P. ludensis,* and *P. dubius*). No fossils have been recovered from the uppermost beds of micaceous siltstone found above the upper chert.

Figure 10.
Micaceous siltstone of the Elder Formation: (Se).

Consequently, it is unclear whether the age of the micaceous siltstone strata ranges into the early Devonian at Marys Mountain, as it does in strata on the Beaver Creek Quadrangle (Finney and Cluer, 2000).

Upper Chert Unit (Reference Locality: 7) (Seuc): The upper chert is the second set of traceable chert beds within the Elder Formation at Marys Mountain (Fig. 8). It occurs within the micaceous siltstone (Se), approximately 50-75 m above the top of the Cherry Spring chert member on the west side of Marys Creek. Only one exposure of the upper chert beds is recognized at Marys Mountain. Consequently, the upper chert cannot be used to separate underlying micaceous siltstone from the overlying micaceous siltstone. Instead, the upper chert beds are treated as a local marker unit within the micaceous siltstone unit. At its reference locality (locality-7), the upper chert unit is ≈ 10 m thick and is comprised of interbedded black and gray vitreous ribbon chert, porcellanite, and siltstone beds. Bedding thickness ranges from 2 to 5 cm in the siltstone and porcellanite beds and up to 10 cm in the chert beds. Bedding surfaces are very wavy and undulating. Bedding surface nodules up to 5 cm in diameter can be found locally. Both the lower and upper contacts are gradational. The lowermost beds of the upper chert beds are siltstone and porcellanite beds that grade upwards into vitreous chert and porcellanite. The upper contact is gradational over 5-10 m from porcellanite and chert into the overlying micaceous siltstone beds.

Radiolarians recovered from the upper chert marker beds are part of the *Secuicollacta* assemblage, a poorly preserved assemblage that contains both latticed and spongy spumellarians. The lack of spongy concentric sphaerellarians or bladed entactiniidae distinguishes this assemblage from both the Early Silurian *Haplotaeniatum – Orbiculopylorum* assemblage below in the Cherry Spring chert member and the *Ceratoikiscum calvum* assemblage above in the lower chert, shale, and limestone member of the Devonian Slaven Chert. Several *Secuicollacta* picked from the Seuc samples have similar morphologic features to Late Silurian (Ludloian to Pridolian) radiolarians described by Noble (1994) in the Caballos Novaculite, Marathon Uplift, in West Texas. The *Secuicollacta* assemblage is tentatively placed in the Upper Silurian based on the range and presence of *Secuicollacta solaria.*

Slaven Chert: (Fig. 11)

The Slaven Chert was first named after its type locality along the west side of Slaven Canyon in the Northern Shoshone Range in northeastern Nevada (Gilluly and Gates, 1965). Gilluly and Gates (1965) described the Slaven Chert as a sequence of black nodular chert beds with subordinate amounts of carbonaceous shale and brown poorly sorted limey sandstone with detrital fragments of chert, greenstone, and limestone. Both the top and bottom of the Slaven Chert in the Shoshone Range are considered fault bounded or unrecognizable due to poor exposure (Gilluly and Gates, 1965). The overall thickness of the Slaven Chert is thought to be 600 – 915 m (Gilluly and Gates, 1965). The age of the Slaven Chert in the Northern Shoshone Range is considered Devonian based on conodonts and radiolarians found in Slaven Canyon (Boundy-Saunders et al., 1999). Cluer et al., (1997), Noble (2000), and Cellura et al., 2001) have extended the name Slaven Chert to include Devonian chert and siltstone sequences in the Tuscarora Mountains.

At Marys Mountain, the Slaven Chert is a heterogeneous package of chert, siltstone, shale, chert breccia, calcareous sandstone, and limestone. It has been separated into two informal members (at a scale of 1:12,000): 1) a lower chert, shale, and limestone member (Dsl), and 2) an upper chert and shale member (Dsu). Locally the Slaven Chert is unconformably overlain by Tertiary volcanic rocks.

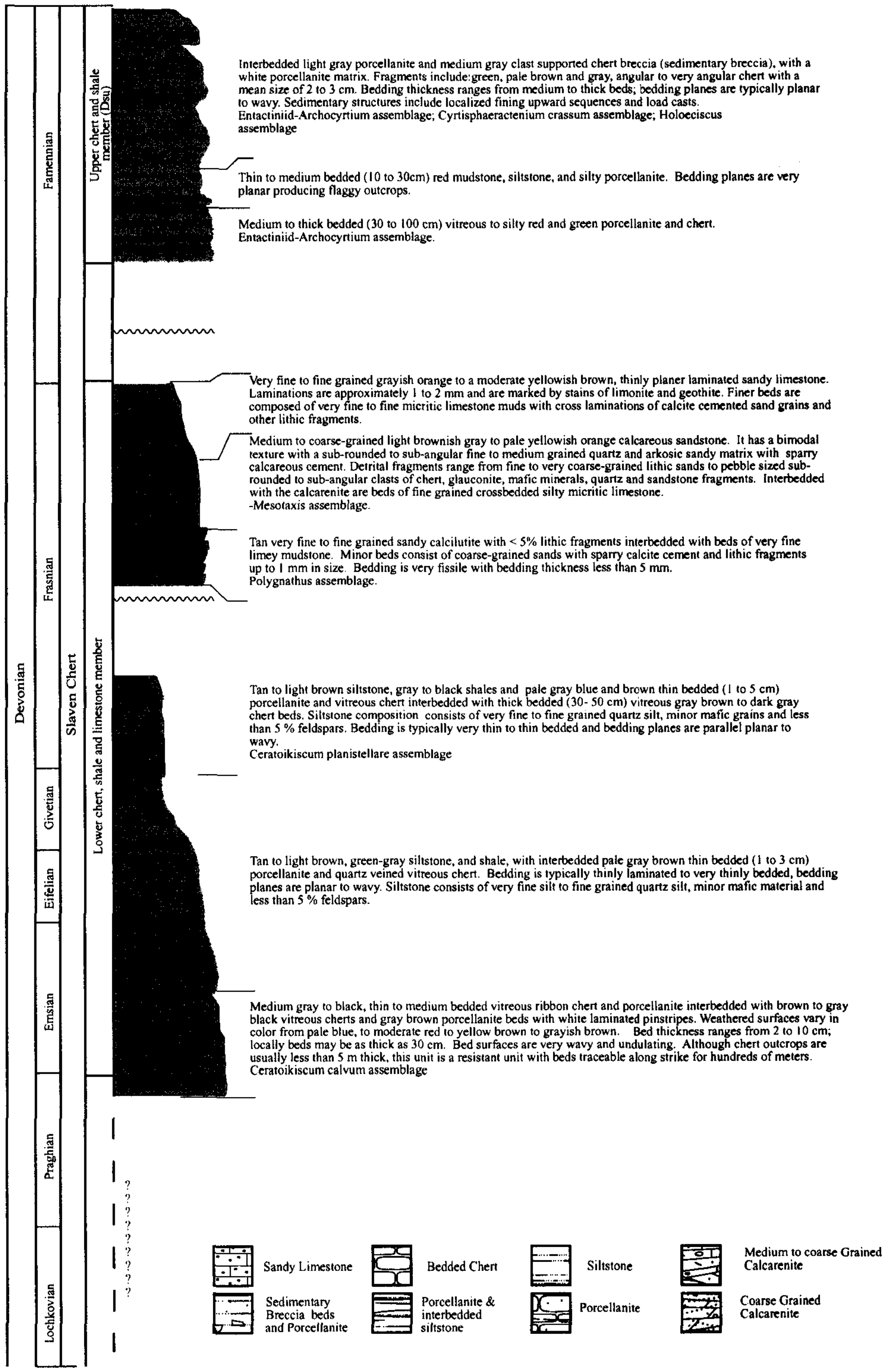


Figure 11.
Schematic stratigraphic column of the Devonian Slaven Chert in the Marys Mountain area, showing lithology, sample locations, and biostratigraphic assemblages. Vertical scale based on The Geological Society of America, 1999, Geologic Time Scale.

Lower Chert, Shale, And Limestone Member (Dsl): The lower chert, shale, and limestone member, (Dsl) represents over 70% of the total Devonian stratigraphy exposed at Marys Mountain. The lower chert, shale, and limestone member (Dsl) is a mixture of black, light to medium gray, tan to brown, and light pale green siltstone and shale with fissile planar beds to undulating laminations. Chert and porcellanite beds range in color from pale green, green-gray, yellowish brown, brown gray, black, to red and are thinly bedded to very thick bedded. Calcareous strata include thin bedded limestone, sandy limestone, crossbedded limestone and calcarenite, and coarse-grained calcarenite. The lack of distinct lithologic characteristics within the Dsl prevents any further stratigraphic subdivision of this member other than subdividing its siliceous and calcareous components (Plate 3). Three reference localities were established to show variations within the lower chert, shale, and limestone member.

Siliceous Beds Of The Lower Chert, Shale, And Limestone Member Of The Slaven Chert: (Reference Locality: 8): Several chert intervals throughout the Dsl cannot be reliably mapped on lithology alone and thus have been lumped into one unit (Plate 3). The most widely observed lithology of the siliceous beds are sequences of medium brownish gray to black (N4-N6), vitreous chert, porcellanites, and greenish gray to brownish gray siltstone beds (Fig. 11). Weathered surfaces may produce any variation of color including pale blue (5Pb 7/2), moderate red (5R 5/4), yellowish brown (10YR 6/2), and grayish brown (5YR 3/2). Bedding surfaces are very wavy and undulating and range in thickness from 2 to 10 cm; locally beds may be as thick as 30 cm. Although these siliceous sequences vary laterally in thickness, chert outcrops can commonly be traced laterally for hundreds of meters.

A reference locality is given for one of the presumably widespread chert horizons, which has been dated with radiolarian biostratigraphy and relative stratigraphic position with respect to overlying limestone beds. At its reference locality near Marys Creek (locality 8), the siliceous part of the Dsl is represented by a sequence of siltstones interbedded with gray brown to black silty chert and porcellanite. At the reference locality, a 6 m thick, thin to medium (5 to 10 cm) bedded brown to gray and black vitreous chert and gray brown porcellanite, with very thin white laminations, marks the base of the siliceous part of the Dsl (Fig. 12). Up section at the reference locality, cherts and porcellanite beds are replaced by more silty beds and an interbedded sequence of siltstone and porcellanite beds. Bed thickness ranges from 1 to 2 cm in the siltstone beds and 1 to 5 cm in the porcellanite beds. Thick vitreous chert beds with bed thickness of up to 50 cm are interbedded approximately every 3-5 m up section for approximately 15-20 m. Strata above this section are poorly exposed but are represented by interbedded shale and chert beds. The top of the siliceous component of the Dsl at its reference locality is marked by the last non calcareous planar laminated silty grayish orange siliceous siltstone/shale bed below calcareous siltstone beds of the calcareous section of the Dsl.

Radiolarians recovered from siliceous beds in the Dsl include the *Ceratoikiscum calvum* assemblage and the *Ceratoikiscum planistellare* (see paleontology section for more details). Some siliceous beds of the Dsl are interpreted to range from the late Early to Middle Devonian (Emsian to Eifelian) based on the presence of the *calvum* assemblage

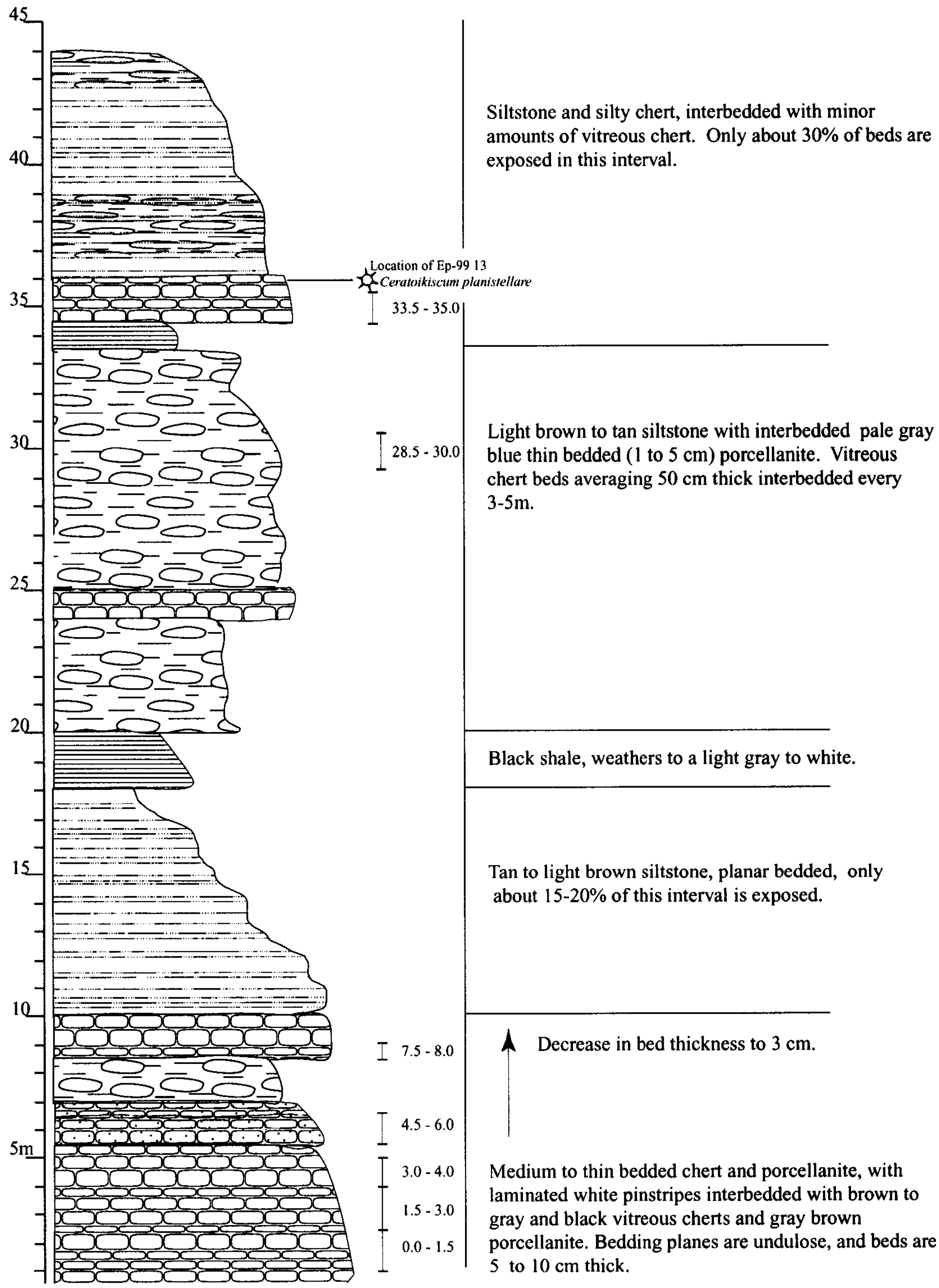


Fig. 12

Measured Section of Ep-99-13 locality.

Bracketed intervals show position of composite samples taken 11/99

(See paleontology section for more details), whereas others are younger and assigned a Frasnian age based on the presence of *Ceratoikiscum planistellare,* which appears to be restricted to the Frasnian (early Late Devonian) (Nazarov et al., 1983; Aitchison, 1993).

Calcareous Beds Of The Lower Chert, Shale, And Limestone Member Of The Slaven Chert: (Reference Locality: 9 And 10): The calcareous components of the Dsl are observed as lensoidal bodies throughout the Marys Mountain area (Plate 3). At reference locality 9, north of an old reclaimed drill road and along the southeast side of Marys Mountain, calcareous beds consist of tan very fine- to fine-grained sandy limestone with < 5% lithic fragments and interbedded coarse-grained calcareous sandstone and very thin beds of limey mudstone (Fig. 13). Bedding surfaces are typically laminar and platy with bed thickness less than 5 mm. Stratigraphically below the calcareous mudstone and calcarenite beds lie 10-20 cm thick beds of calcareous siltstone with medium-grained calcarenite beds containing up to 5% coarse-grained euhedral barite. This is the only locality in the Marys Mountain area where barite beds have been observed.

Conodonts (identified by Gil Klapper) were recovered from this section 5 m above the barite bed and are assigned to the *Polygnathus* assemblage, which is early Givetian to Frasnian in age (Ziegler et al., 1973, Higgins et al., 1985). About 1 km to the south-southwest of the Marys Mountain saddle is a slightly different calcareous component of the Dsl, containing no barite beds and a heterogeneous package of

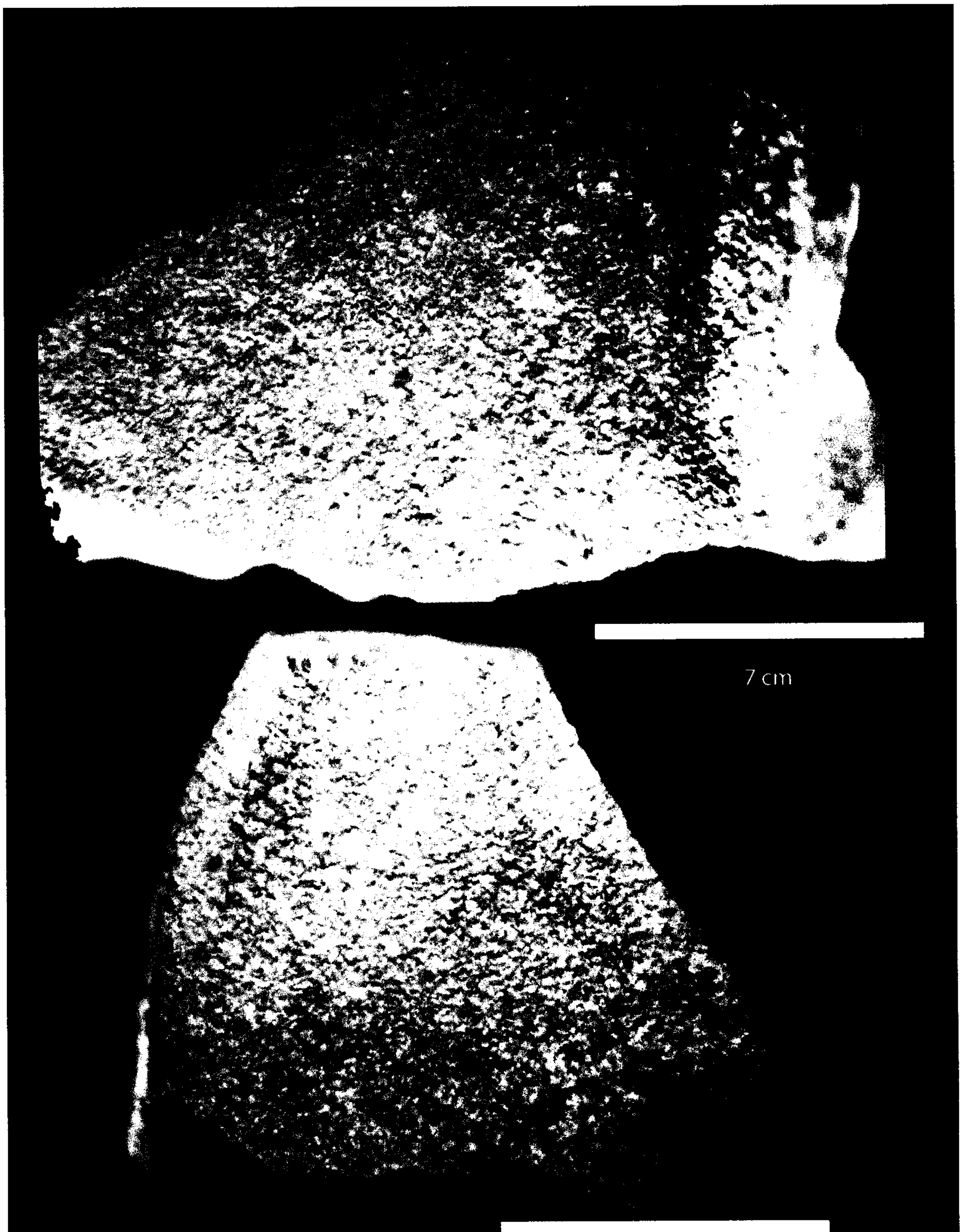


Figure 13.
Sample Ep-00-C5 a fine to medium grained limestone with coarse grained lithic fragments from the Lower chert, shale, and limestone member.

calcareous sandstone, calcareous siltstone, and siltstone as well as a distinct fine cross-laminated calcareous siltstone and cross laminated micritic limestones (Fig. 14).

The top of the calcareous strata and subsequently the top of the lower chert, shale, and limestone member of the Devonian Slaven Chert at Marys Mountain is marked by the highest occurrence of the planar laminated calcareous siltstone beds. Field relations between the lower chert, shale, and limestone member and the overlying Devonian Slaven upper chert and shale member are typically covered and cannot be precisely defined.

At reference locality 10 east of the main road cutting through Marys Mountain, the base of the calcareous component of the Dsl is marked by the lowest light brownish gray (5YR 6/1) to pale yellowish orange (10YR 6/6) calcareous sandstone beds (Fig. 14). It has a subrounded to subangular fine-medium-grained (2.5 to 1.5 ø) quartz and arkosic sand matrix with a sparry calcite cement. Up section (as observed by top indicators such as cross bedding) is a sequence of interbedded planar laminated limy sandstone and calcareous siltstone beds with cross-laminated silty limestone beds (Fig. 14). At reference locality 10 and elsewhere at Marys Mountain, this limestone package forms moderate to steep slopes and prominent ridge lines but typically produces small outcrops.

Variations of the calcareous beds in the Dsl unit include very fine to fine-grained grayish orange (10YR 7/4) to a moderate yellowish brown (10YR 5/4), thin planar laminated limy sandstone beds. Laminations are approximately 1 to 2 mm and are marked by iron oxide stains of limonite. Finer beds are composed of micritic limestone muds with planar millimeter size laminations consisting of quartz, feldspar, and lithic

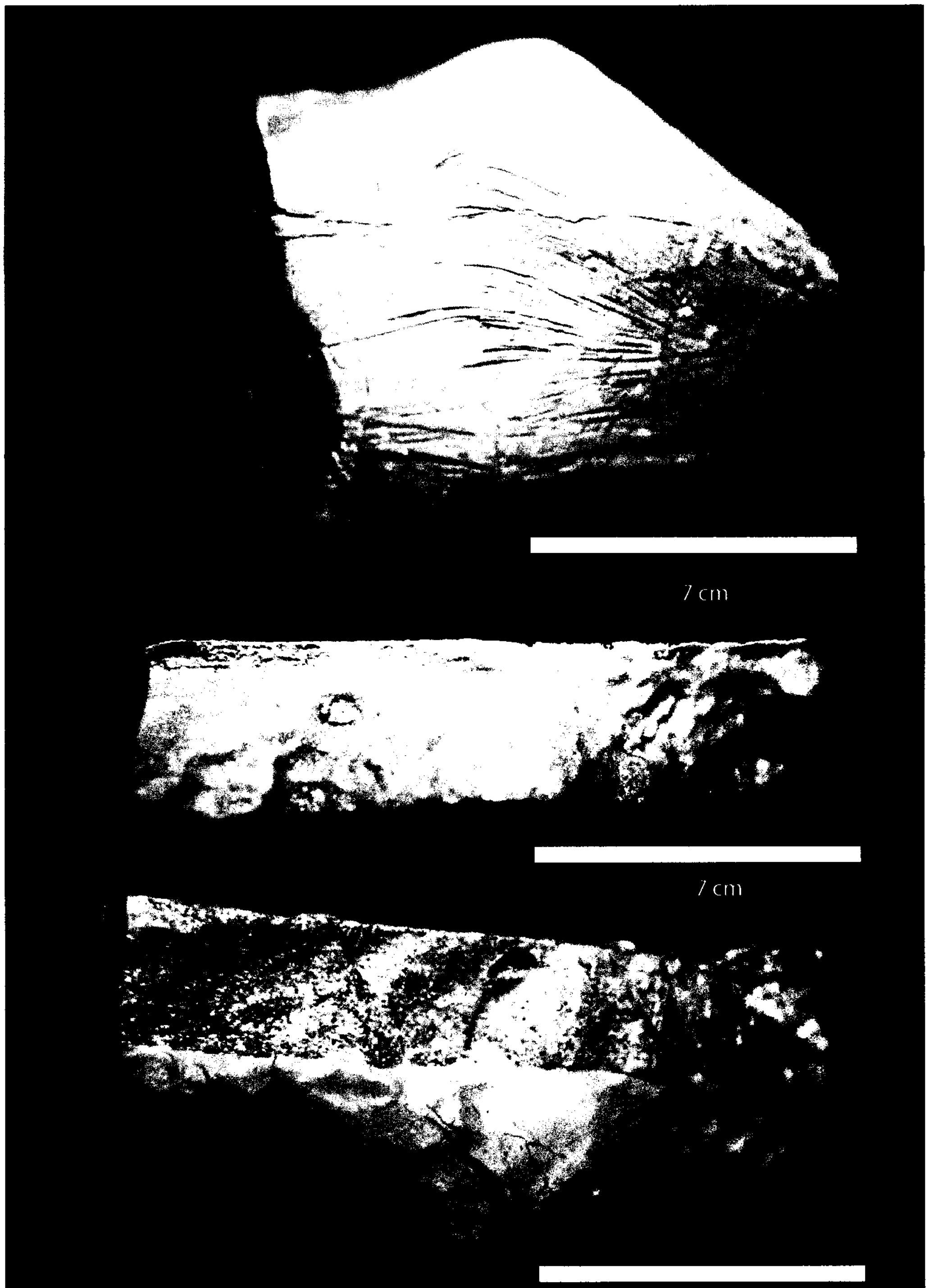


Figure 14.
Fine grained calcarenite and limestone samples from the lower chert, shale, and limestone member.

fragments. Thick lensoidal beds of coarse-grained limy sandstone containing 1 mm to 3 cm sized detrital fragments of subrounded to subangular clasts of chert, glauconite, mafic minerals, quartz grains, and other lithic and sandstone fragments are observed on the west side of Marys Mountain (Fig. 15). The similarities of the limestone packages and lack of distinctly different ages prevent any further subdivision of the calcareous portion of the Dsl.

Fossils recovered from the limestones at locality 10 include conodonts, sponge spicules, and cone shaped siliceous fossils. Conodonts (identified by Gil Klapper) from two samples from the east (Ep-99-C01) and west (Ep-99-C02) sides of Marys Creek produced a *Mesotaxis* assemblage containing species of *Mesotaxis ovalis*, *Mesotaxis* sp., and *Ancyrodella* sp. These conodonts are confined to the lower part of the Frasnian stage in the early Late Devonian.

Upper Chert And Shale Member (Reference Locality: 11) (Dsu): The upper chert and shale member (Dsu) is a siliceous package of chert, porcellanite, shale, and sedimentary chert breccia beds. At its reference locality (locality-11) the base of upper chert and shale member (Dsu) is defined by the lowest reddish gray and pale green massive vitreous chert and porcellanite bed above the calcareous strata of the lower chert, shale, and limestone member. Bedding commonly ranges in thickness from medium (10 cm) to thick bedded (30 cm) with more siliceous beds forming planar massive beds of 30 to 100

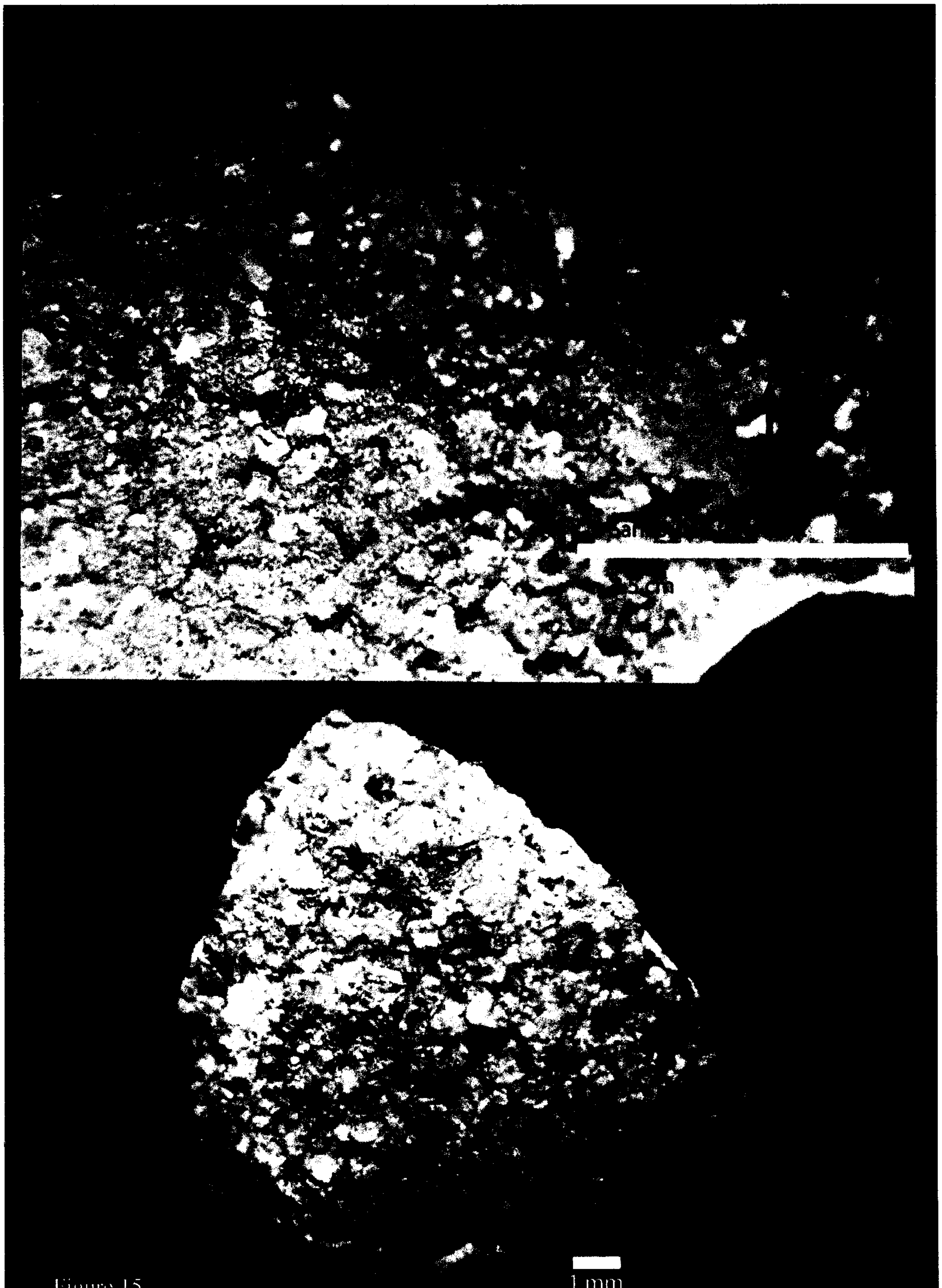


Figure 15.
A coarse grained lithic limestone from the lower chert, shale, and limestone member with clasts of sandstone and chert.

cm thick. Stratigraphically up section, the upper chert and shale member consists of interbedded medium gray silty cherts and siliceous shales, with a light gray (N7) to very light gray (N8) clast supported chert/porcellanite breccia with subangular to angular gray, green-gray, and brown-gray chert breccia fragments ranging in size from 0.2 cm to 2 cm (Fig. 16) with a light gray porcellanite matrix. Breccia beds range in thickness from thin to medium bedded (3- 9 cm) to thick bedded (40 cm). Beds exceeding 20 cm may exhibit sedimentary structures such as load casts and graded bedding (Fig. 16 and 17). Breccia beds are interbedded approximately every 10 to 20 m with siliceous shale and porcellanite. Bedding thickness for the interbedded shale and porcellanite ranges from 1 to 2 cm in the shales and 3 to 6 cm in the porcellanite. Bedding surfaces tend to be planar to wavy.

A second set of breccia beds was observed along an east west ridge east of the saddle at Marys Mountain. There, a chert conglomerate, containing angular to subangular clasts of pale green and brown chert and to a lesser degree siltstone occurs within a section that is interpreted to be part of the upper chert and shale member. The breccias mentioned above and the chert conglomerates described herein have similarities in clast composition, but their relative stratigraphic positions have not been established. The upper chert and shale member represents the highest stratigraphic unit exposed in the Devonian Slaven Chert at Marys Mountain. Hence, the top of the Dsu is undetermined. Radiolarians are the only fossils recovered from the Dsu and indicate an early Mississippian age, with the lower part possibly as old as latest Famennian (latest

Figure 16.
(Top) A clast supported chert breccia with a porcellanite matrix in the upper chert and shale member of the Slaven Chert.
(Bottom) - The bottom photo shows a load cast from the base of a breccia bed from the upper chert and shale member of the Slaven Chert.

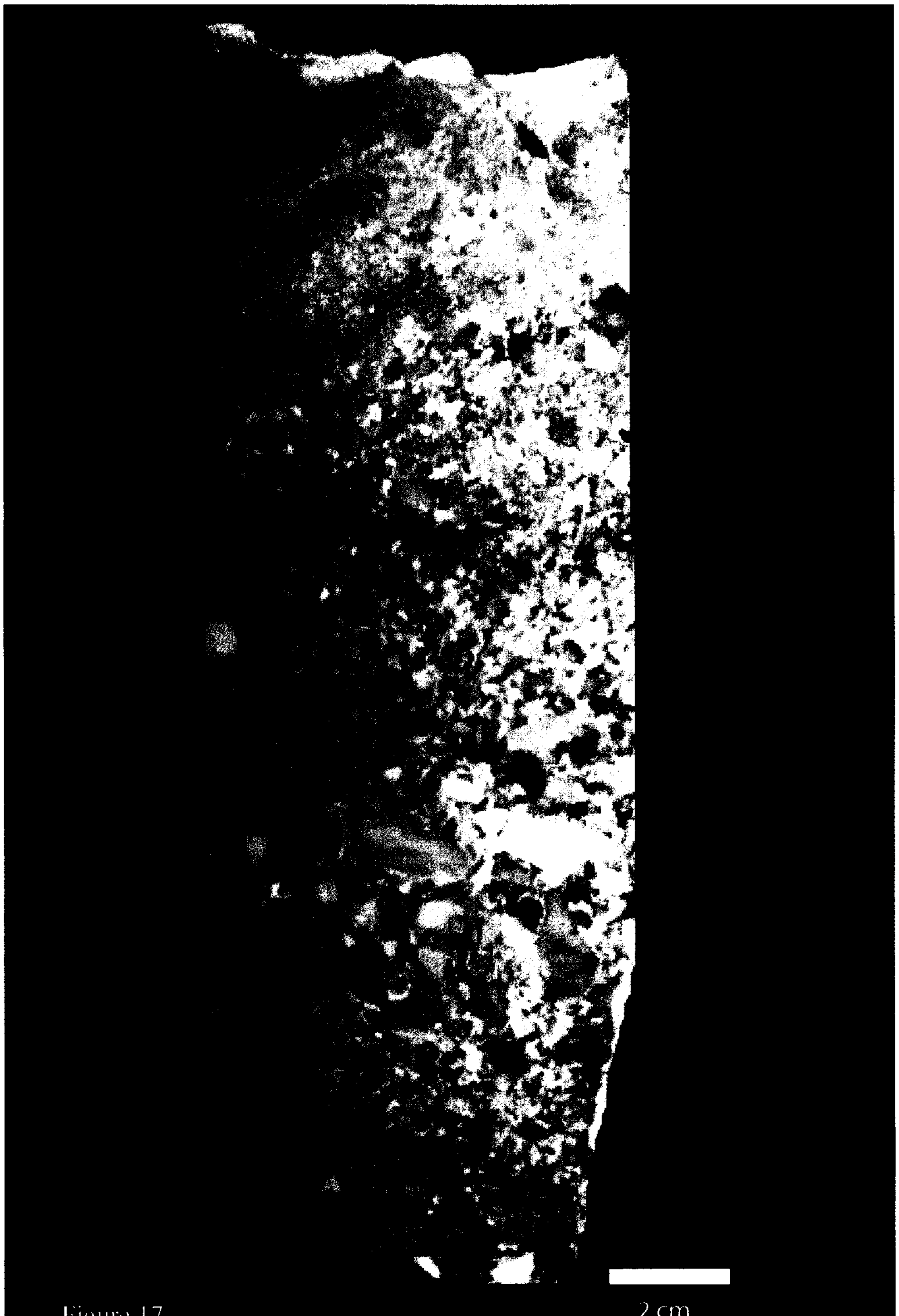


Figure 17.
A clast supported chert breccia with a porcellanite matrix in the upper chert and shale member fining upward from coarse chert clasts to a fine grained porcellanite.

Devonian). Sample Ep-99-70, recovered in the northeast part of the map area from 10 m below the top of this unit, is early Mississippian based on the presence of *Cyrtisphaeractinium crassum* (*Albaillella* 1 assemblage of Holdsworth and Jones, 1980). About 50-60 m below, theEp-99-25 sample yielded fragments of *Holoeciscus*, which is no younger than the latest Famennian (*Holoeciscus* 3 assemblage of Holdsworth and Jones, 1980). The *Holoeciscus*-bearing sample is a chert breccia. However, it is not clear whether *Holoeciscus* is contained in the matrix or in reworked chert clasts. At present, it is unclear whether this unit spans the latest Devonian through early Mississippian or whether it is limited to the early Mississippian and contains reworked latest Devonian radiolarians. Other radiolarian samples from this unit are less well constrained and assigned to the *Entactiniid-Archocyrtium* assemblage, which is Late Devonian through Mississippian age.

PALEONTOLOGY

Radiolarians At Marys Mountain

Eight distinct radiolarian assemblages ranging from Late Ordovician through Late Silurian and from Middle Devonian to Early Mississippian have been recognized at Marys Mountain in the southern Tuscarora Mountains (Fig. 18). Preservation of radiolarians in early Paleozoic chert can be highly variable. Some samples may produce very poorly preserved radiolarians, whereas others yield very well preserved but sparse radiolaria. Others may produce both abundant and well preserved radiolarians (Table 1). Fossil localities are shown on Plate 2.

Syntagentactinia Assemblage (Photo Plate 1)

Radiolarians recovered are specimens of *Haplotaeniatum*, *Syntagentactinia* and possible fragments of *Protoceratoikiscum*. All radiolarians were poorly preserved and sparse. Samples typically yielded less than a dozen identifiable fragments. The *Syntagentactinia* assemblage is believed to be equivalent to the *Haplotaeniatum spinatum* assemblage of Noble (2000) found in the Roberts Mountains and on the REN property in the Tuscarora Mountains.

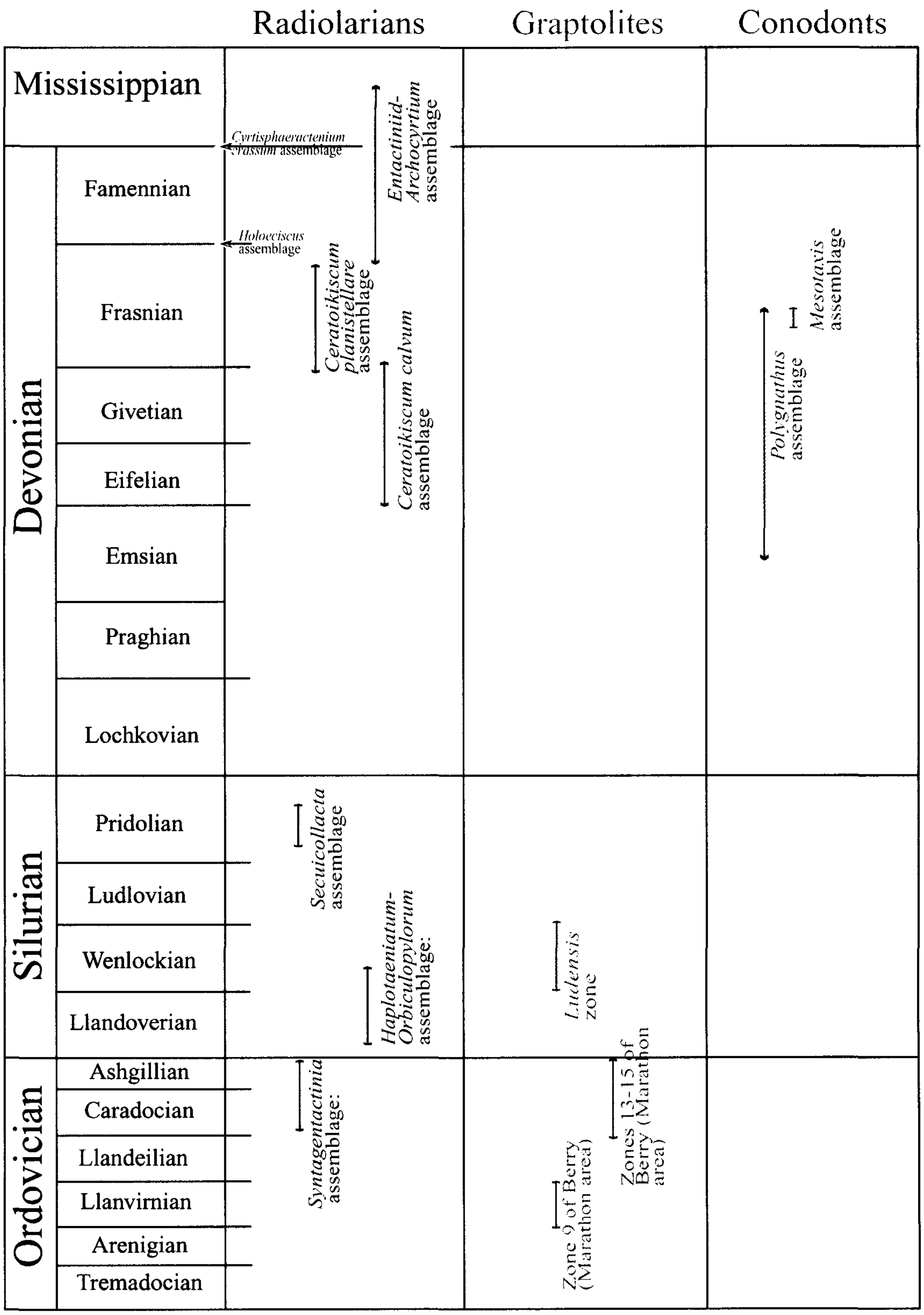


Figure 18.
Ranges of radiolarian, graptolite and conodont assemblages from the Marys Mountain area in the northeast quarter of the Emigrant Pass 7.5' Quadrangle.

Age And Zonal Assignment: The *Syntagentactinia* assemblage is interpreted to be Caradocian (Late Ordovician). Although the *Syntagentactinia* assemblage is missing *Kalimnasphaera*, the presence of *Protoceratoikiscum* and *Syntagentactinia* sp. suggest that the *Syntagentactinia* assemblage is best assigned to the Pylomate- large concentric sphaerellarian Zone 1 of Noble and Aitchison (2000) (Fig. 19). The Caradocian age is further substantiated by the occurrence of six graptolite collections from the white porcellanite/chert (Table 3).

Occurrence: This assemblage is restricted to the white porcellanite/siltstone member at Marys Mountain. Similarly, the *Haplotaeniatum spinatum* assemblage of Noble (2000) is associated with white chert and porcellanite strata in the Roberts Mountains and other parts of the Tuscarora Mountains (Noble, 2000). Samples from two localities (Ep-99-04, and Ep-99-07) at Marys Mountain were assigned to this assemblage, and one other sample (Ep-99-15) with poorer preservation was provisionally assigned (Table 1, Plate 2).

Haplotaeniatum-Orbiculopylorum- Assemblage (Photo Plate 2)

The *Haplotaeniatum-Orbiculopylorum* assemblage appears to be the same assemblage as that recovered from the Cherry Spring chert in other parts of the RMA (Noble et al., 1998; Noble, 2000). In the Marys Mountain area, samples contain sparse but well-preserved specimens of the following taxa: *Cessipylorum* sp., *Rotasphaera* sp., *Secuicollacta* sp., and *Orbiculopylorum sp.* (Table1).

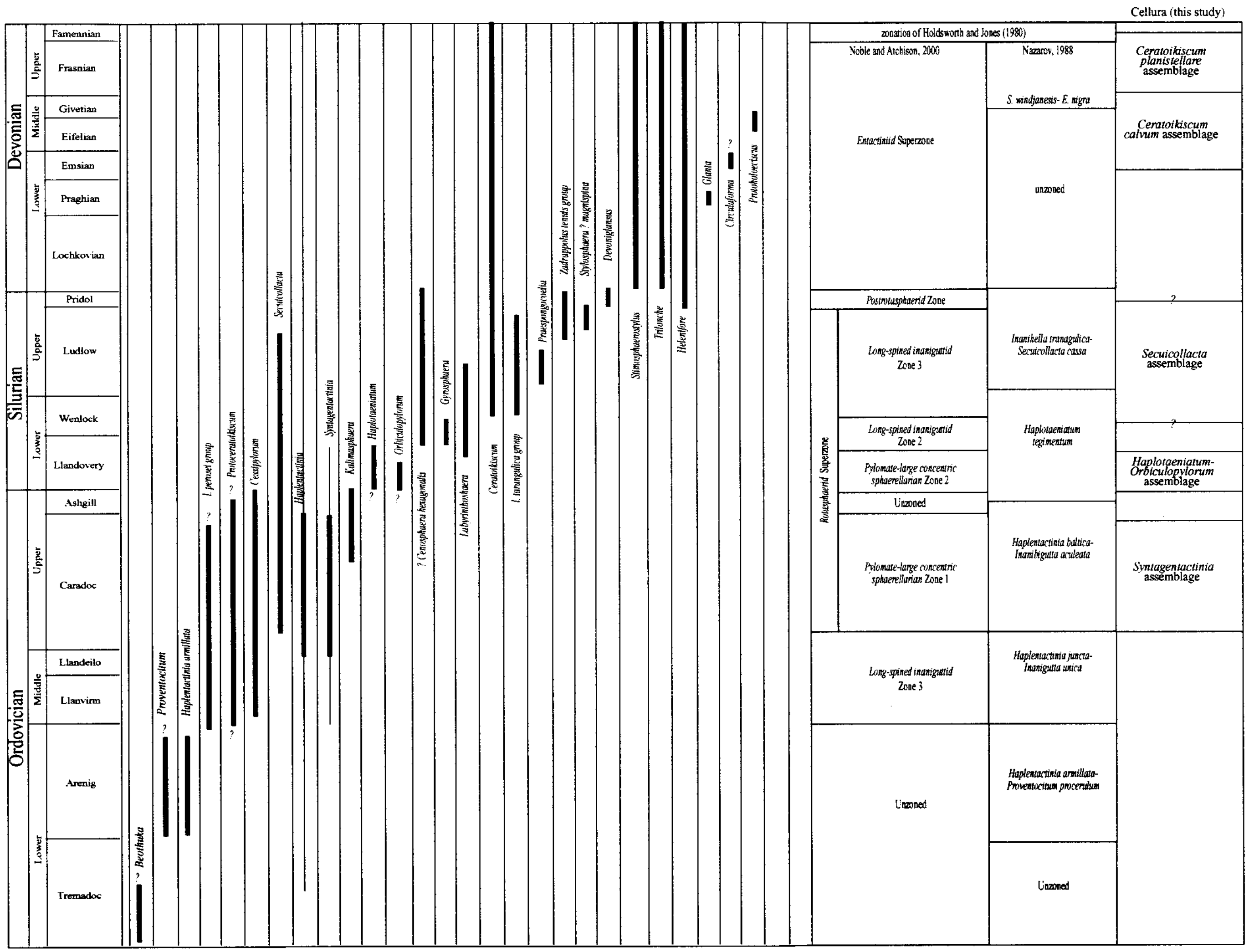


Figure 19.
Correlation of radiolarian assemblages this study with the lower Paleozoic radiolarian zonation from Noble and Aitchison (2000), and Nazarov and Ormiston (1983).

Age And Zonal Assignment: This assemblage is assigned to the Llandoverian (Early Silurian). Age control thus far has been based on correlation to Silurian faunas from Germany (Noble et al., 1998) the Ural Mountains (Nazarov and Ormiston, 1993), Alaska (Won et al., 2002), and from a sparse graptolite collection made from samples in the Adobe Range, northeastern Nevada, assigned to the *Monograptus cyphus* zone of early Llandoverian age (Noble et al., 1997). Based on the presence of *Cessipylorum* and *Orbiculopylorum* this assemblage may be assigned to the Pylomate- large concentric sphaerellarian Zone 2 of Noble and Aitchison (2000)(Fig. 19).

Occurrence: This fauna was recovered from samples Ep-99-02, Ep-99-12, Ep-99-05, Ep-99-37, Ep-00-14, and Ep-99-15, all taken from outcrops of the Cherry Spring chert at Marys Mountain.

Secuicollacta Assemblage (Photo Plate 3)

The *Secuicollacta* assemblage is a poorly preserved assemblage that contains both latticed and spongy spumellarians and *Secuicollacta* sp. that resembles Late Silurian *Secuicollacta* spp. from the Marathon uplift, west Texas (Noble, 1994). One sample tentatively contains *Secuicollacta solara.* This assemblage is reported from only one outcrop in the field area (see location of sample Ep-99-20, Plate 2). Other samples from this outcrop lack diagnostic Late Silurian taxa but also lack taxa diagnostic of younger and older assemblages, such as the robust spongy sphaerellarians of the Llandoverian or the bladed entactiniidae of the Devonian. The lack of these robust taxa precludes assignment of this assemblage to the older *Haplotaeniatum-Orbiculopylorum* or the *Ceratoikiscum calvum* assemblages. Although this assemblage is poorly preserved, it is of great importance, because it is the first reported occurrence of a Late Silurian *Secuicollacta*-bearing assemblage in the allochthon and provides additional information regarding the placement of the Silurian - Devonian boundary.

Age And Zonal Assignment: Radiolarians recovered from the *Secuicollacta* assemblage are very poorly preserved. Nevertheless, *Secuicollacta solara*? (Photo plate 3 no. 2) and other specimens of *Secuicollacta* resemble Late Silurian *Secuicollacta* species from *Rotasphaerid* Superzone from the Caballos Novaculite, Marathon Uplift, west Texas (Noble, 1994). The *Secuicollacta* assemblage is correlated to the *Secuicollacta* Superzone, and provisionally correlated to the Long-spined inaniguttid Zone 3 of Noble and Aitchison (2000) (Fig. 19).

Occurrence: The *Secuicollacta* assemblage is found in siliceous gray and black pin-stripped chert and porcellanite beds within the upper chert marker unit that lie conformably above a package of micaceous siltstone interpreted to be Silurian Elder Formation (Fig. 8).

Ceratoikiscum Calvum Assemblage (Photo Plate 4 & 5)

This assemblage contains *Ceratoikiscum calvum, Helenifore laticlavium,* and abundant *Trilonche* spp. with tri-bladed spines. It lacks other *Ceratoikisciids* that occur with *C. calvum* in late Early - Middle Devonian assemblages, such as *Circulaforma* *admissarius* and *Ceratoikiscum lyratum*, (Aitchison et al., 1999) which may be a function of preservation. The marker taxon from this assemblage is *Ceratoikiscum calvum*, which possesses a simple well-defined triangular frame with poorly developed caveal ribs except for one robust caveal rib.

Age and Zonal Assignment: This assemblage is assigned a late Early to early Late Devonian age (Emsian to Givetian), based on the range of *Ceratoikiscum calvum* and *Helenifore laticlavium* (Aitchison, 1993). This assemblage may correlate with a Middle Devonian assemblage in the Roberts Mountains, the *Ceratoikiscum lyratum* assemblage of Noble (2000). It is assigned to the middle part of the Entactiniid Superzone of Noble and Aitchison (2000). The age is further constrained by conodonts from the *Polygnathus* assemblage which occur up section. For more information on the age of the *Polygnathus* assemblage, refer to the conodont section of this report.

Occurrence: The *Ceratoikiscum calvum* assemblage is found within the lower chert, shale, and limestone member of the Devonian Slaven Chert, a widespread chert and siltstone package that makes up a large portion of the Devonian strata at Marys Mountain.

Ceratoikiscum Planistellare Assemblage (Photo Plate 6)

The *Ceratoikiscum planistellare* assemblage is defined by the presence of *Ceratoikiscum planistellare*, a distinct *Ceratoikiscum* that has six prominent extra triangular rods and a central triangular skeleton making six pointed star. The points on the star are connected by patagium (a lacy framework with a variety of openings) (Nazarov and Ormiston, 1983; Aitchison, 1993). Other taxa found within the assemblage include *paleoscenidiids* and *Trilonche* spp. This assemblage may correlate with an early Frasnian assemblage reported as the Slaven Chert in Slaven Canyon, Northern Shoshone Range, which also contains *Ceratoikiscum planistellare* (Boundy-Sanders et al., 1999).

Age And Zonal Assignment: This assemblage is assigned a Late Devonian (Frasnian - Famennian) age based on the range of *Ceratoikiscum planistellare* (Aitchison, 1993). Early Frasnian conodonts from limestone depositionally overlying this assemblage further constrain the *Ceratoikiscum planistellare* assemblage as Latest Givetian to the Early Frasnian (early Late Devonian) (Fig. 20 B).

Occurrence: This assemblage was recovered from sample Ep-99-13 at reference locality-8 in a conformable section of vitreous cherts and interbedded siltstone and porcellanite (the lower chert, shale, and limestone member of the Devonian Slaven chert), 9 m below the Frasnian? limestone beds.

Entactiniid-Archocyrtium Assemblage (Photo Plate 7)

These Latest Devonian to early Mississippian radiolarians at Marys Mountain are characterized by *Archocyrtium* sp. and the presence of bladed entactiniidae. *Archocyrtium* sp. is a pylomate with a single tri-radiate apical horn and three divergent feet surrounding the pylome margin (Cheng, 1986). Other radiolarians found within the

Entactiniid-Archocyrtium assemblage include *Paleoscenidium* sp., *Stigmosphaerostylus* sp.*, and Trilonche* sp.

Age And Zonal Assignment: *Archocyrtium* ranges from Late Devonian (Famennian) to Early Mississippian. There are four biozones during this time interval to which this assemblage might be assigned, but the lack of index fossils specific to these zones precludes such assignment. It is interpreted to be Late Devonian (Famennian) to Early Mississippian (Kinderhookian) based on the range of *Archocyrtium.*

Occurrence: This assemblage is found in both porcellanite and chert breccia beds of the upper chert and shale member of the Slaven Chert.

Holoeciscus Assemblage (Photo Plate 8)

The *Holoeciscus* assemblage is defined by the presence of *Holoeciscus* sp. Other taxa found within the assemblage include *Archocyrtium* sp., *Archocyrtium ormistoni, Paleoscenidium,* and *Trilonche* spp. (Cheng, 1986).

Age And Zonal Assignment: This assemblage is assigned a latest Devonian (latest Famennian) age based on the range of *Holoeciscus* (Cheng, 1986). Based on the presence of *Holoeciscus* sp. and *Archocyrtium* sp., this assemblage may be assigned to the *Holoeciscus*-3 (Ho-3) Zone of Holdsworth (Cheng, 1986) (Fig. 20).

Occurrence: This assemblage was recovered from samples Ep-99-24 and Ep-99-71 from of a sequence of gray and brown vitreous chert and porcellanite beds and from samples Ep-99-26 and Ep-99-73 from a sequence of breccia beds in the upper chert and shale member of the Slaven Chert at the topographically highest point at Marys Mountain.

Cyrtisphaeractenium Crassum Assemblage (Photo Plate 9)

The *Cyrtisphaeractenium crassum* assemblage is defined by the presence of *Cyrtisphaeractenium crassum*. Other taxa found within the assemblage include *Archocyrtium* sp. and *Trilonche* sp., (Cheng, 1986).

Age And Zonal Assignment: This assemblage is assigned a Late Devonian (Famennian) to Early Kinderhookian age based on the range of *Cyrtisphaeractenium crassum* (Cheng, 1986). Based on the presence and range of *Cyrtisphaeractenium crassum,* this assemblage may be assigned to the base of the *Albaillella* 1 (Ab1) zone or the top of the Ho3 zone of Holdsworth (Cheng, 1986) (Fig. 20A).

Occurrence: This assemblage was recovered from samples Ep-99-60, and Ep-99-70 in a sequence of gray and brown vitreous chert and porcellanite beds in the upper chert and shale member of the Slaven Chert.

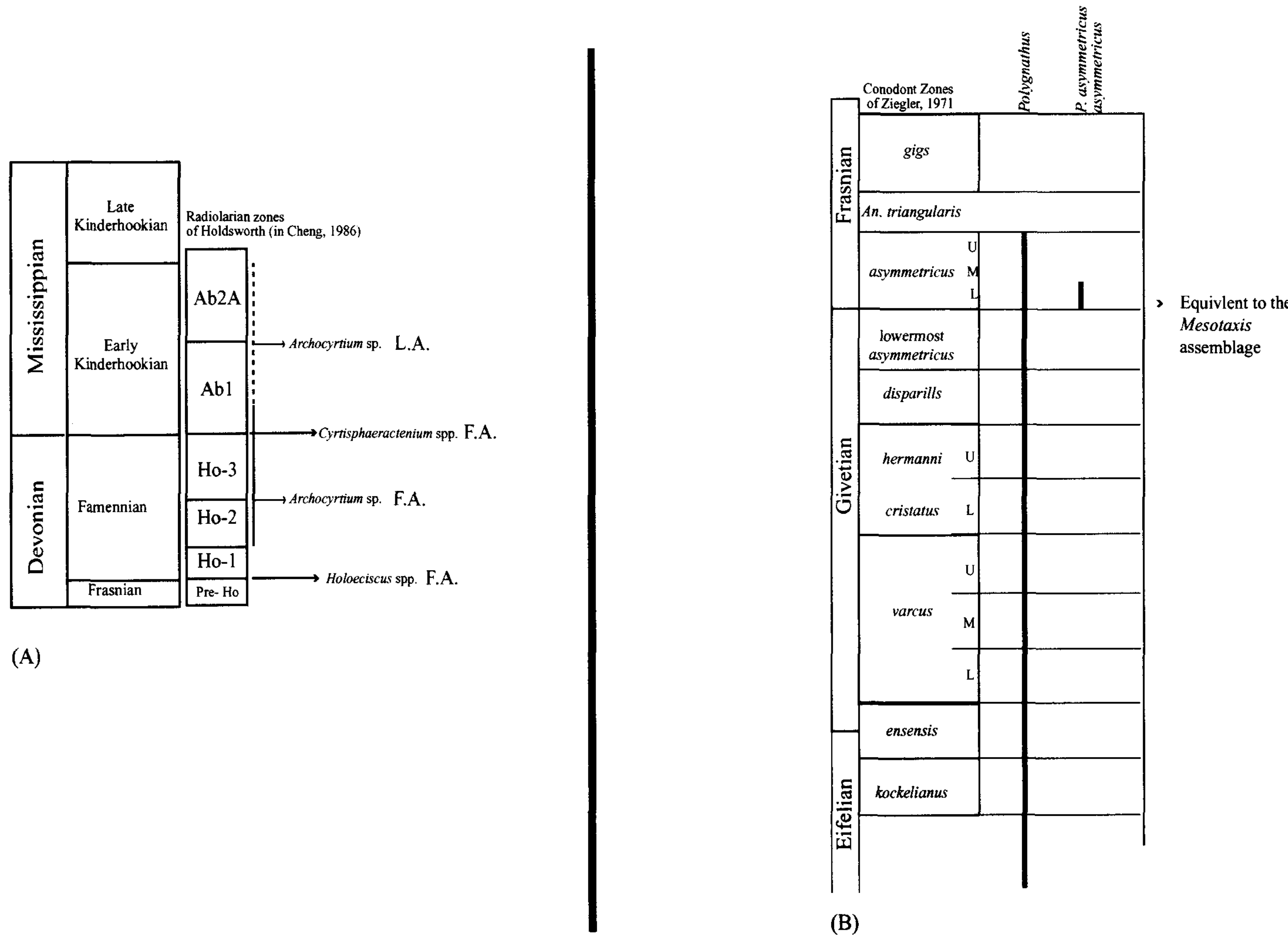


Figure 20.
(A) Uppermost Devonian to lowermost Mississippian radiolarian biozonation showing the F.A. of the *Holoeciscus,* the range of *Archocyrtium* and the range of *Cyrtisphaeractenium.* Modified from Cheng, (1986). F.A.= First Appearance, L.A.= Last Appearance (B) Middle and lower Upper Devonian range for *Polygnathus* and *Polygnathus asymmetricus asymmetricus.* Modified from Higgins and Austin, (1985). Original data compiled from Ziegler (1971) and Klapper and Ziegler (1979).

Table 1:
Taxon occurrence chart: radiolaria, Marys Mountain.

Sample #	*Archocyrtium ormistoni*	*Archocyrtium sp.*	*Ceratoikiscum calvum*	*Ceratoikiscum planistellare*	*Cyrtisphaeractenium crassum*	*Haplentactinia sp.*	*Haplotaeniatum aperturatum*	*Haplotaeniatum sp.*	*Helenifore laticlavium*	*Holoeciscus sp.*	*Inaniguttids sp.*	*Orbiculopylorum sp.*	*Paleoscenidium sp.*	*Protoceratoikiscum sp.*	*Secuicollacta sp.*	*Secuicollacta solara sp.*	*Stigmosphaerostylus sp.*	*Stylosphaera sp.*	*Syntagentactinia sp.*	*Trilonche sp.*	Abundance	Preservation	Rock unit	Assemblage
Ep-99-60		•			•															•	c	g	Slaven Chert	*Cyrtisphaeractenium crassum* assemblage
Ep-99-70		•			•	•														•	a	g		
Ep-99-24										•										•	r	f	upper chert and shale member	*Holoeciscus* assemblage
Ep-99-26	•	•								•										•	c	g		
Ep-99-71		•								•			•							•	c	g		
Ep-99-73		•								•			•							•	c	g		
Ep-99-40		•											•							•	r	g		*Entactinidae-Archocyrtium* assemblage
Ep-99-25		•																		•	c	p		
Ep-99-67		•															•				r	g		
Ep-99-69													•							•	c	f		
Ep-99-13				•																•	c	g	lower chert, shale and limestone	*Ceratoikiscum planistellare* assemblage
Ep-99-14																				•	r	p		
Ep-00-02			•										•								r	p		
Ep-99-11			•																	•	c	g		*Ceratoikiscum Calvum* assemblage
Ep-99-39			•														•			•	c	g		
Ep-99-43			•														•			•	a	g		
Ep-00-18			•																	•	c	f		
Ep-98-02									•											•	c	p		
Ep-99-61									•											•	c	f		
Ep-98-01																				•	r	f	Slaven Chert; lower chert, shale and limestone	*Entactinid* assemblage
Ep-99-01																	•			•	r	f		
Ep-99-27													•							•	c	g		
Ep-99-29													•							•	c	g		
Ep-99-30																				•	r	p		
Ep-99-32																				•	r	p		
Ep-99-33																		•		•	r	g		
Ep-99-34																	•			•	r	p		
Ep-99-41																				•	r	p		
Ep-99-59																				•	r	p		
Ep-99-65																				•	r	g		
Ep-99-66																				•	r	g		
Ep-00-08																				•	r	p		
Ep-99-21											•				•	•					r	g	Elder Formation; upper chert beds	*Secuicollacta* assemblage
Ep-99-20											•										r	f		
Ep-00-03											•										r	f		
Ep-99-02							•	•				•			•						c	g	Cherry spring chert	*Haplotaeniatum-Orbiculopylorum* assemblage
Ep-99-12							•					•			•				•		a	g		
Ep-99-05											•				•						r	f		
Ep-99-37												•			•						r	g		
Ep-00-14															•						r	g		
Ep-00-15															•						r	g		
Ep-99-04								•						•					•		r	g	Vinini Formation; white porcellanite/siltstone member	*Syntagentactinia* assemblage
Ep-99-07																			•		r	p		
Ep-99-15											•								•		r	p		

Legend

Abundance
r-rare
c-common
a-abundant

Preservation
p-poor
f-fair
g-good
e-excellent

Conodonts at Marys Mountain

Thirteen conodont samples were collected. Three samples yielded dateable conodonts (Table 2). One sample contains a Middle to Late Devonian *Polygnathus* assemblage, and the other two samples contain a Late Devonian *Mesotaxis* assemblage, which correlates with to the *Polygnathus dubia (=asymmetrica?)* assemblage (Clark and Ethington, 1967). All conodonts from this study were identified by Dr. Gill Klapper at the University of Iowa.

Polygnathus assemblage (Photo plate 10)

The *Polygnathus* sp. assemblage comes from sample Ep-00-c5 which had a low recovery rate and produced poorly preserved *Polygnathus sp. Polygnathus varcus?*

Age And Zonal Assignment: Klapper (written communication, 2000) assigned this sample to the *Polygnathus varcus* zone (Ziegler et al., 1973), which is restricted to the lower part of the Givetian (Middle Devonian) (Fig. 20) (Ziegler et al., 1973; Higgins and Austin, 1985). The poor preservation and low recovery rate for this assemblage raise caution to assigning these fossils to a particular biozone. Therefore, the age of the *Polygnathus* assemblage is considered to be no older than the *Polygnathus varcus* zone (Early Givetian) but could be as young as Early to Middle Frasnian spanning the range of *Polygnathus*.

Occurrence: The *Polygnathus* assemblage is found in a thin-bedded silty limestone unit taken 5 m above the barite beds that are part of the lower chert, shale, and limestone member of the Slaven Chert.

Mesotaxis Assemblage: (Plate 10)

The *Mesotaxis* assemblage is defined by the presence of *Mesotaxis ovalis*. Other species that occur within this assemblage include *Ancyrodella* sp. and *Icriodus subtermins* (Ziegler, 1971). This assemblage correlates with the *Polygnathus dubia (=asymmetrica?)* zone reported by Clark and Ethington (1967) (Klapper, written communication, 2000).

Age And Zonal Assignment: The range of *Polygnathus dubia (=asymmetrica?)* and *Mesotaxis ovalis* restrict this assemblage to the lower part of the Frasnian (lower Late Devonian) (Fig. 20) (Higgins and Austin, 1985; Irwin and Orchard, 1991).

Occurrence: The *Mesotaxis* assemblage is found in the calcareous beds of the lower chert, shale, and limestone member and has been recovered from two localities, samples (Ep-99-c1, and Ep-99-c2). This same fauna was also recovered in the Marys Mountains area by Clark and Ethington (1967), just north of the spring (SE1/4, NW1/4 Sec. 28, T33N, R51E) along the east side of Marys Mountain.

Table 2:
Taxon occurrence chart: conodonts, Marys Mountain.

Sample #	*Icriodus subtermins*	*Mesotaxis ovalis*	*Mesotaxis sp.*	*Polygnathus sp.*	*Polygnathus? varcus sp.*	Abundance	Preservation	Rock unit	Assemblage
Ep-99-c1			•			r	g	Slaven Chert, lower chert, shale and limestone member	Mesotaxis assemblage
Ep-99-c2	•	•	•			c	g		
Ep-00-c5				•	•	r	p		Polygnathus assemblage

Legend

Abundance
r-rare
c-common
a-abundant

Preservation
p-poor
f-fair
g-good
e-excellent

Graptolites At Marys Mountain

The majority of the graptolite collections were taken within the upper part of the Vinini Formation and yielded upper Middle to Late Ordovician age graptolites (Caradocian to Ashgillian) assigned to Zones 9 through 15 of Berry (1960, Table 3). One Early Silurian assemblage was recovered in the 2000 field season from the Elder Formation providing age constraints for this unit and the underlying Cherry Spring chert (Table 3). All graptolite determinations were made by Dr. Stanley C. Finney from California State University, Long Beach, California.

Zone 9 Graptolites

Collections of zone 9 graptolites from the Marys Mountains area contain: *Pseudoclimacograptus* sp., *Phyllograptus* sp., *Glossograptus* sp.?, *Orthograptus* or *Glyptograptus* sp. and *Hallograptus* sp.

Age And Zonal Assignment:

The range for zone 9 graptolites is restricted to the latest part of the Llanvirnum, late Middle Ordovician (Berry, 1960). Assignment of graptolites to zone 9 was based on the presence of *Hallograptus* sp. and *Glyptograptus* sp. (Finney, written communication, 2000; Table 3).

Occurrence: Zone 9 graptolites at Marys Mountain are found within the pale blue siltstone member of the upper part of the Ordovician Vinini Formation.

Zone 12 Graptolites:

Collections of zone 12 graptolites from the Marys Mountains area contain: *Pseudoclimacograptus scharenbergi, Orthograptus*?, *Cryptograptus* sp., *Cryptograptus bicornis, Normalograptus*? *Climacograptus brevis*, *Dicranograptus nicholsoni*, *Hallograptus* sp., *Climacograptus bicornis*, *Orthograptus calcaratus acutus, Corynoides calicularis, Dicranograptus nicholsoni.*

Age And Zonal Assignment: The range for zone 12 graptolites is restricted to the early part of the Caradocian, early Late Ordovician (Berry, 1960). Assignment of graptolites to zone 12 is based on the presence of *Climacograptus bicornis* (Finney, written communication, 2000; Table 3).

Occurrence: Zone 12 graptolites at Marys Mountain are found within the black shale and mudstone member of the upper part of the Ordovician Vinini Formation.

Zone 13 Graptolites

Collections of Zone 13 graptolites from the Marys Mountains area contain: *Orthograptus quadrimucronatus, Pseudoclimacograptus scharenbergi, Cryptograptus* sp., *Cryptograptus insectiformus, Orthoretiolites?, Dicranograptus nicholsoni, Orthoretiolites hami, Orthograptus* (*Rectograptus*) sp., *Climacograptus* sp. *(C. spiniferus?), Dicranograptus* sp., *and Climacograptus caudatus.*

Age and Zonal Assignment: The range for zone 13 and14 graptolites is restricted to the upper part of the Caradocian, Upper Ordovician (Berry, 1960). Graptolites assigned to zone 13 and 14 were done so based on the presence of *Orthograptus quadrimucronatus,* and *Dicranograptus* sp. (Finney, written communication, 2000; Table 3).

Occurrence: Zone 13 and 14 graptolites at Marys Mountain are found within the white siltstone/porcellanite member of the upper part of the Ordovician Vinini Formation.

Zone 14 and 15 Graptolites

Zone 14 graptolites from the Marys Mountains area contain: *Normalograptus tribuliferous, Orthograptus, Climacograptus, Dicellograptus complanatus.* Collections of zone 15 graptolites from the Marys Mountains area contain *Normalograptus persculptus* and *Dicellograptus complanatus.*

Age And Zonal Assignment: The range for zone 14 and 15 graptolites is restricted to the Ashgillian, late Late Ordovician (Berry, 1960). Assignment to zone 15 is based on the presence of *Dicellograptus complanatus* (Finney, written communication, 2000; Table 3).

Occurrence: Zone 14 and 15 graptolites at Marys Mountain are found within the shaley parts of the black phosphatic mudstone member of the upper part of the Ordovician Vinini Formation.

Lower Silurian Graptolites (Ludensis Zone)

Collections of Early Silurian (Wenlockian) graptolites from the Marys Mountains area contain *Pristiograptus jaegeri, Pristiograptus dubius, and Pristiograptus ludensis.*

Age and Zonal Assignment: The range for the Early Silurian graptolites is restricted to the upper part of the Wenlock, upper Early Silurian (Berry and Murphy, 1975). Assignment of graptolites to the ludensis zone is based on the presence of *Pristiograptus* dubius and *Pristiograptus ludensis* (Finney, written communication, 2000; Table 3).

Occurrence: Ludensis zones graptolites at Marys Mountain are found within the micaceous siltstone member of the Silurian Elder Formation.

Table 3:
Taxon occurrence chart: graptolites, Marys Mountain, graptolites zones set by Berry (1960) in the Marathon uplift area.

Sample #	*Climacograptus bicornis*	*Climacograptus brevis*	*Climacograptus caudatus*	*Climacograptus sp.*	*Climacograptus spiniferus?*	*Corynoides calicularis*	*Cryptograptus bicornis*	*Cryptograptus insectiformus*	*Cryptograptus sp.*	*Dicellograptus complanatus*	*Dicranograptus nicholson*	*Dicranograptus sp*	*Glossograptus sp.*	*Glyptograptus sp.*	*Hallograptus sp.*	*Normalograptus persculptus*	*Normalograptus sp.*	*Normalograptus tribuliferous*	*Normalograptus tubuliferus*	*Orthograptus calcaratus acutus*	*Orthograptus quadrimucronatus*	*Orthograptus sp.*	*Orthoretiolites hami*	*Orthoretiolites sp.*	*Phyllograptus sp.*	*Pristiograptus dubius*	*Pristiograptus jaegeri*	*Pristiograptus ludensis*	*Pseudoclimacograptus scharenbergi*	*Pseudoclimacograptus sp.*	Rock unit	Assemblage
Ep-00-g02																										•	•	•			Elder Formation	Ludensis Zone
Ep-99-g02																•															Vinini Formation: black phosphatic mudstone siltstone member	Zone 14-15
Ep-99-g06										•																						
Ep-99-g04				•														•				•										
Ep-99-g01									•												•								•		Vinini Formation: white porcellanite/ siltstone member	Zone 13
Ep-99-g03								•			•										•			•					•			
Ep-99-g07																					•								•			
Ep-00-g01						•						•						•				•	•									
Ep-00-g03			•																		•											
Ep-00-g05			•																		•											
Ep-99-g05								•	•		•											•							•		Vinini Formation: black shale and mudstone member	Zone 12
Ep-99-g10							•		•								•					•							•			
Ep-00-g03		•									•				•																	
Ep-00-g06	•					•					•				•					•												
Ep-00-g04													•	•								•			•					•	Vinini Formation: pale blue siltstone member	Zone 9

Legend

Abundance
r-rare
c-common
a-abundant

Preservation
p-poor
f-fair
g-good
e-excellent

Marys Mountain Structural Interpretations

Structural Overview

Detailed geologic mapping by Henry and Faulds (1999) highlighted several of the structural features in the Marys Mountain area, including a major low-angle fault that separates two distinct structural domains in the Marys Mountain area. In an unpublished report, Henry and Faulds (1999) described east-verging tight to isoclinal folds, imbricate thrusts, and high-angle reverse faults that record Paleozoic contractional deformation (Henry and Faulds, 1999, Faulds written comm., 1999) (Fig. 21, plate 1). In addition, Henry and Faulds (1999) mapped steeply dipping normal faults that are typically associated with middle to late Cenozoic extension and cut both Paleozoic and Tertiary strata. The high-angle normal faults and reverse faults commonly parallel bedding in Paleozoic strata. Biostratigraphic data obtained in this study permit more accurate placement of previously mapped faults and document additional faults shown on Plate 1.

Marys Mountain is divided into northeast and southwest domains. The boundary between the two domains is interpreted to be a major thrust fault, here termed the Marys Mountain thrust, which is inferred to sole into the Roberts Mountains thrust at depth (Figs. 21 and 22). These two domains differ principally in their structural style and, to a lesser extent, in their internal stratigraphy.

The southwest domain has a thin Paleozoic section ranging from the Ordovician through Latest Devonian/Early Mississippian. The strata are tightly folded and internally disrupted such that continuous sections are typically less than 250 m thick. Beds have

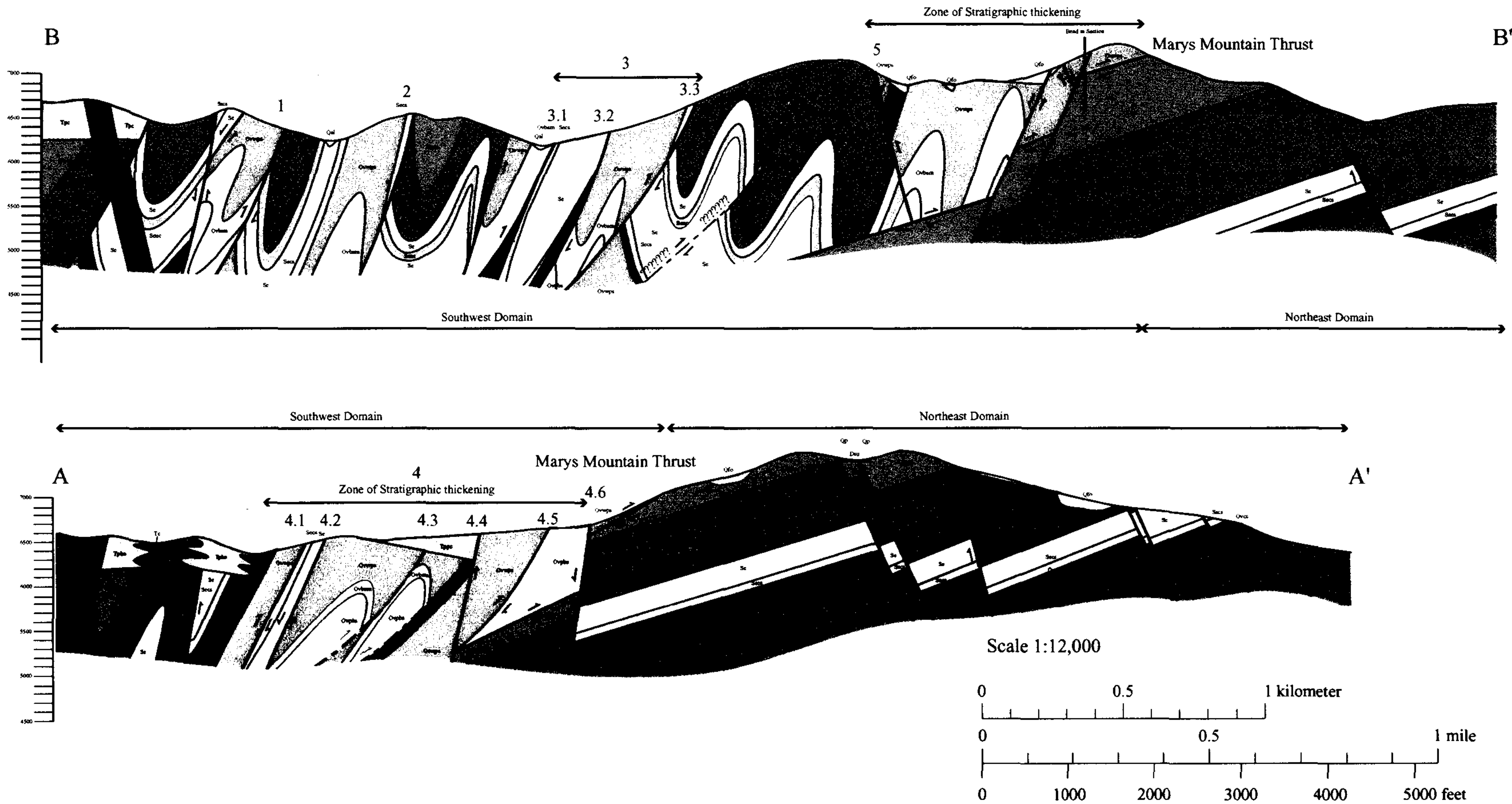


Figure 21.
Cross section of the Marys Mountain area, Although the isoclinal folds and imbricate reverse thrust faults were inferred by Henry and Faulds (1999), the biostratigraphic work permitted the precise location of many of the faults and folds. Locations of cross sections are shown on Plate 1.

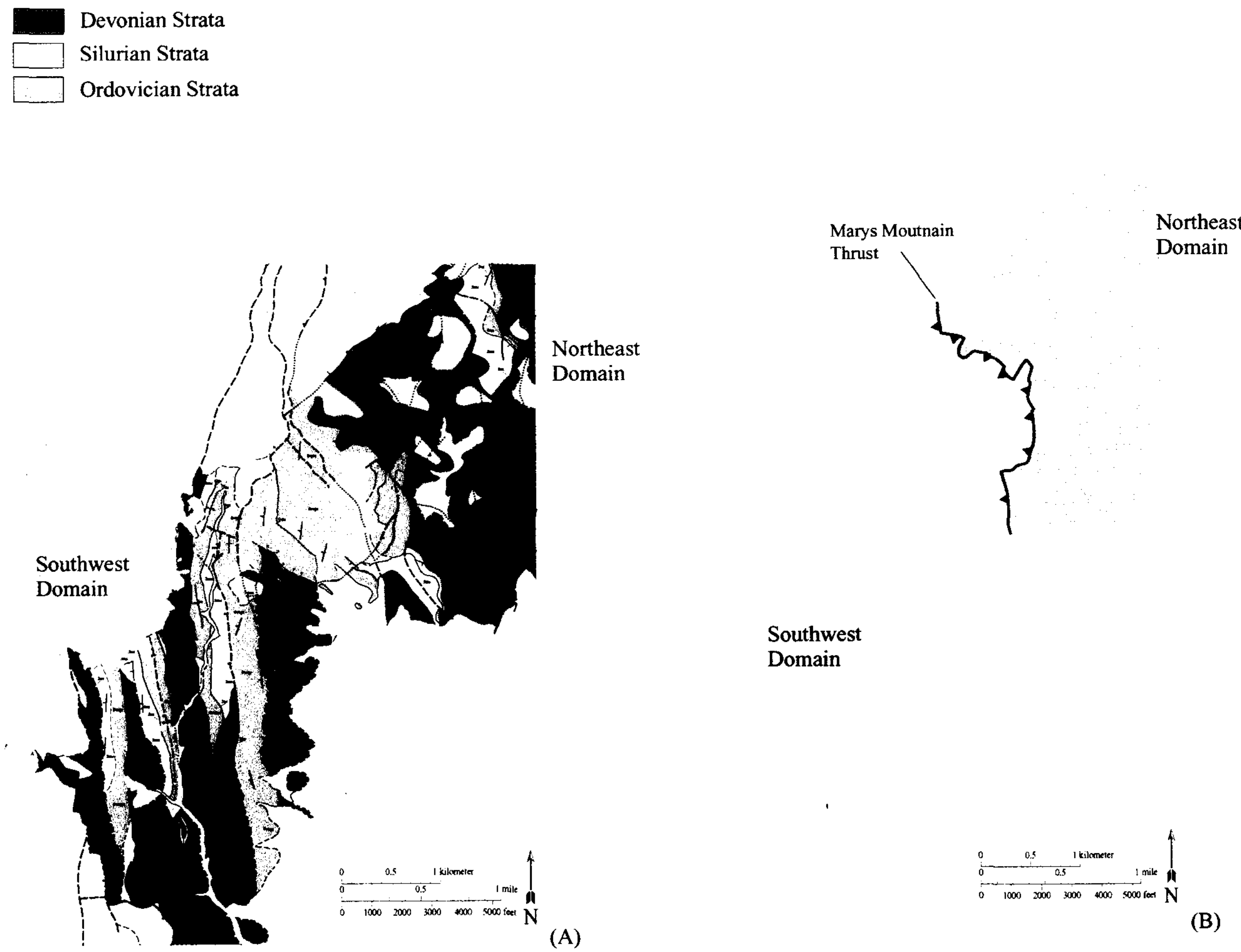


Figure 22.
(A) Generalized geologic map of the Marys Mountain area showing the relative proportions of Ordovician , Silurian and Devonian units. (B) Domain boundaries based on differences in stratigraphy and structural styles.

steep to vertical dips and are associated with isoclinal, north-trending, east-verging folds (Faulds, written comm., 1999). Several mappable units are bounded by north-striking, west-dipping high-angle normal and reverse faults (Fig. 21, Plate 1) that commonly omit stratigraphic units, have minimal surface expression, and are typically recognized by juxtaposed stratigraphic units of differing ages (Fig. 21, Plate 1). The southwest domain is interpreted as a thrust sheet, the upper plate of the Marys Mountain thrust, which structurally overlies the northeast domain.

Similar to the southwest domain, the northeast domain consists of a stratigraphic package ranging from Ordovician through Latest Devonian/Early Mississippian. The area of exposure of Devonian strata in this domain is roughly two to three times that in the southwest domain. The northeast domain is characterized by gently west-dipping strata (< 20°) and fewer imbrications (Fig. 21, Plate 1). The stratigraphy is internally disrupted, although not as extensively as in the southwest domain. The northeast domain is cut by east-dipping high-angle normal faults.

Structural Features

Biostratigraphic work contributed to the confirmation of numerous steeply dipping normal and reverse faults cutting Paleozoic strata. Some of the major faults recognized by this study are labeled 1 to 4 in Fig. 21. In addition, this study has helped to trace more accurately some of the Tertiary faults recognized by Henry and Faulds (1999) into the exposed Paleozoic sequence (reference locality 12 on plate 1 and 3). Of particular interest is the major structure separating the two domains. The complex structural history of the Tuscarora Mountains including folding and faulting from the

Antler orogenic event, and later extension during the Cenozoic allow for numerous potential explanations that could be applied to interpret movement along faults in the area. For this report, interpretations of fault movement were made based on the presence of older over younger relationships.

Fault 1 (Plate 1, cross section B-B'; Fig. 21) lies near the west edge of the exposed Paleozoic strata. There, west dipping strata from the Upper Ordovician Vinini Formation overlie Frasnian strata of the Devonian Slaven Chert (Fig. 21, Plate 1). Based on the older over younger relationship, this fault is interpreted as a high-angle west-dipping reverse fault. Fault 2 cuts the east limb of a well exposed tightly folded anticline of the Ordovician white porcellanite/siltstone member and the Silurian Cherry Spring chert member. Stratigraphically, the phosphatic mudstone member is missing and is interpreted to have been removed during the folding process. The east limb is bounded by a steeply west-dipping reverse fault placing Llandoverian (Early Silurian) strata over upper Famennian (Late Devonian) strata of the upper chert and shale member of the Slaven Chert.

Fault set 3 (3.1, 3.2, 3.3) represents a series of high-angle reverse faults showing the imbricate style characteristic of the southwest domain. The westernmost fault (3.1) lies near the base of Marys Creek, where it places a thin slice of west-dipping Vinini strata over the west limb of an east-verging syncline largely composed of the Elder Formation. Along the east limb of the syncline, the Cherry Spring chert member has been omitted by a steeply dipping fault (3.2) placing micaceous siltstones from the Elder Formation in contact with the white porcellanite and siltstone member of the Vinini Formation. The resulting movement on fault 3.2 is unclear and could be interpreted as either a normal or a reverse fault. Fault 3.2 is interpreted to be a high-angle reverse fault, possibly a small imbricate thrust fault breaking along the east limb of the syncline because of the relatively small offset and its proximity to fault 3.1. To the east, an upright section of upper Vinini Formation lies in contact with the lower chert, shale, and limestone member of the Slaven Chert. The contact between these two units is interpreted to be a high-angle reverse fault (3.3) placing older over younger strata.

As shown on both cross sections A-A' and B-B' (Fig. 21), the white porcellanite and siltstone member (Plate 1) is interpreted to be repeated by a series of imbricate thrust and reverse faults, (e.g. fault set 4 - 4.1, 4.2, 4.3, 4.4, 4.5, 4.6). Cross section A-A' shows a sequence of the white porcellanite and siltstone member repeated four times as it is dissected by both older over younger reverse faults and younger over older high-angle normal faults. Although this part of Marys Mountain has very poor exposure, a transect of graptolite samples has revealed a shuffled Ordovician sequence. Along the west edge of the zone, an upright section of steeply west-dipping lower Silurian and upper Ordovician strata are displaced along a west-dipping high-angle reverse fault (4.1). The east edge of the Elder Formation is truncated by another high-angle fault (4.2) juxtaposing Silurian strata of the Elder Formation over the white porcellanite and siltstone member of the Ordovician Vinini Formation. Movement sense along fault 4.2 is unclear, but the younger over older relations and the high angle nature of the fault suggest the fault is a high-angle normal fault that dips to the west. East along cross section A-A', west dipping strata from the white porcellanite and siltstone member overlie the black mudstone with phosphatic nodules member. There, the contact between the two members is interpreted to be a high-angle reverse fault (4.3) placing older Ordovician strata over younger Ordovician strata (Plate 1). Continuing to the east, the white porcellanite and siltstone member (hosting zones 13 and 14 graptolites; Upper Ordovician) is juxtaposed by a high-angle normal fault (4.5) with the pale blue siltstone member (Zone 9 graptolites, Upper Middle Ordovician). The eastern contacts of both the pale blue siltstone member as well as the black mudstone are interpreted to be high-angle normal faults (4.4 and 4.6) mapped by Henry and Faulds (1999) that merge with normal faults cutting the overlying volcanic strata. Although the sense of movement on fault 5 on cross section B-B' is unclear, fault 5 juxtaposes Middle Devonian strata to the west against Upper Ordovician strata to the east in what is tentatively interpreted to be a high-angle back thrust dipping to the east.

As mentioned previously the Marys Mountain thrust is a major structure separating the southwest and northeast domains. This contact is interpreted to be a low-angle thrust fault, dipping approximately 23° to the west, and is herein termed the Marys Mountain thrust (Fig. 21, plate 1). Ordovician through Devonian stratigraphic units on the west side (southwest domain, upper plate of the Mary Mountain thrust fault) of the Marys Mountain thrust are tightly folded and cut by several steeply west-dipping, north-striking, normal and reverse faults, producing a broad zone of imbricated stratigraphy that typically dips 60 to 90° to the west. Strata on the east side (northeast domain) of the Marys Mountain thrust fault dip to the west, with dips ranging from 10-39°, and are cut by steep east-dipping normal faults that repeat sections to the east and are interpreted to be a result of Cenozoic extension. Structurally, the northeast domain is much less complex than the southwest domain. Along the east side of Marys Mountain, a truncated section of the Silurian-Devonian Elder Formation and the Ordovician Vinini Formation overlies middle Devonian strata from the lower chert, shale, and limestone member of Slaven Chert (Plate 1). This contact is poorly understood as it lies on the edge of the map area but is interpreted as a thrust fault that represents another thrust sheet in the northeast domain.

The overall geometry and fabric of the westward dipping strata, the east-verging folds, and faults record geometry similar to that discussed by Evans and Theodore (1978); Carpenter et al., (1994); Peters, (1995) and Saucier, (1997) that records the eastward transport of siliceous rocks over coeval autochthonous shelf rocks. Chert marker units form tight to isoclinal folds with an east vergence (Faulds and Henry, unpublished data) and may be repeated several times along a traverse perpendicular to strike. Folded chert beds have hingelines that trend north-northwest to north. Similarly, high-angle reverse faults strike north to north-northwest, and the Marys Mountain thrust fault strikes northwest. Tertiary deformation includes high angle normal and reverse faults that locally cause dips of up to 45 degrees in a westerly direction. The pre-Tertiary structural fabric of the Marys Mountain area is therefore interpreted to have formed during the emplacement of the Roberts Mountain allochthon during the Late Devonian to Mississippian Antler orogenic event.

DISCUSSION

An Ordovician through Devonian sequence of RMA strata is now documented in the Marys Mountain area, and contains stratigraphic features similar to other parts of the allochthon. The successful subdivision of the stratigraphy in the Marys Mountain allows for better clarification of local and regional structures and, in turn facilitates exploration efforts in the local mineral industry. Whereas previous exploration along major gold trends in northeast Nevada has been focused near tectonic windows into lower plate carbonate rocks, future exploration of deeper targets will require accurate predictions of subsurface structure and stratigraphy (Cluer, 1999). Detailed mapping (e.g. Henry and Faulds, 1999) combined with biostratigraphic work, has helped to illuminate previously overlooked surface structures aiding in the identification of structurally complex zones in and around exploration projects. With the help of lithologic data collected from previous drilling and accurate surface control, exploration groups can readily generate three-dimensional models of local geological features and exploration targets. A study of this nature was done on the REN property (northern Tuscarora Mountains), where detailed mapping and biostratigraphy helped define structural zones that were targeted in a 1997 drill program. Results from this drill program included two deep intercepts; a 19.81 m (65 ft) interval of 0.068 ounces per ton (opt) with 3.048 m (10 ft) of 0.307 opt and a 38.10 m (125 ft) interval of 0.045 opt with a 1.54 m (5 ft) interval of 0.125 opt (Romarco, 1997). Continued drilling in subsequent years has expanded these targets (V. Spalding, personal comm., 2000).

The work at Marys Mountain is the initial step in an exploration program. The pertinent questions that need answering are 1). What is the thickness of the upper plate?

2).What are the major structures, their orientation, and how much duplication is in the upper plate? These questions were answered at the REN property through a multi-step process that includes achieving accurate surface maps followed by trenching and drilling programs that add additional control. At Marys Mountain, an accurate surface map has been produced taking advantage of all available exposure and biostratigraphic data. Cross sections have been constructed and extrapolated to a depth of 475.2 m (1500 ft) based on the surface control. These cross sections are models that can be further tested with follow-up studies. Additional structural data (Faulds, unpublished data) will further refine the cross sections. Acquisition of more surface control through trenching and depth to structures seen through drilling will provide subsurface control and allow for further refinement and extrapolation of cross sections to greater depth.

The Marys Mountain thrust appears to be the largest structural feature in the map area as it forms the boundary between two structural domains (Fig. 23). Strata in the southwest domain are tightly folded and steeply dipping. In contrast, the northeast domain is characterized by gently dipping strata and significantly less deformation. Structurally, the southwest domain is much more complicated, including more imbrication, and high-angle faulting. The Marys Mountain thrust forms the base of a duplex structure of allochthonous rocks in the Marys Mountain area, with the northeast domain representing the footwall and the southwest domain representing the hanging wall of the thrust. The complex structures in the southwest domain are attributed to shortening and imbrication of strata as the Marys Mountains thrust plate moved eastward

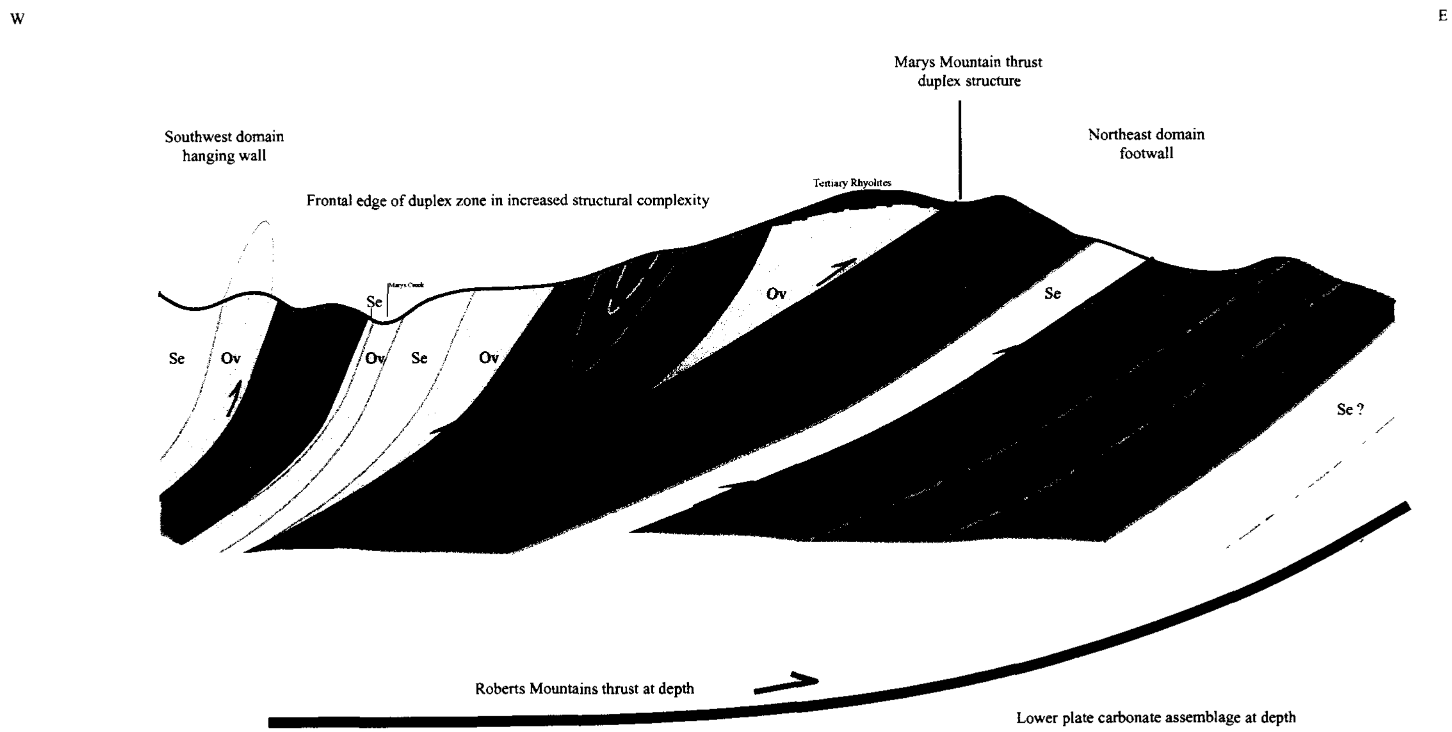
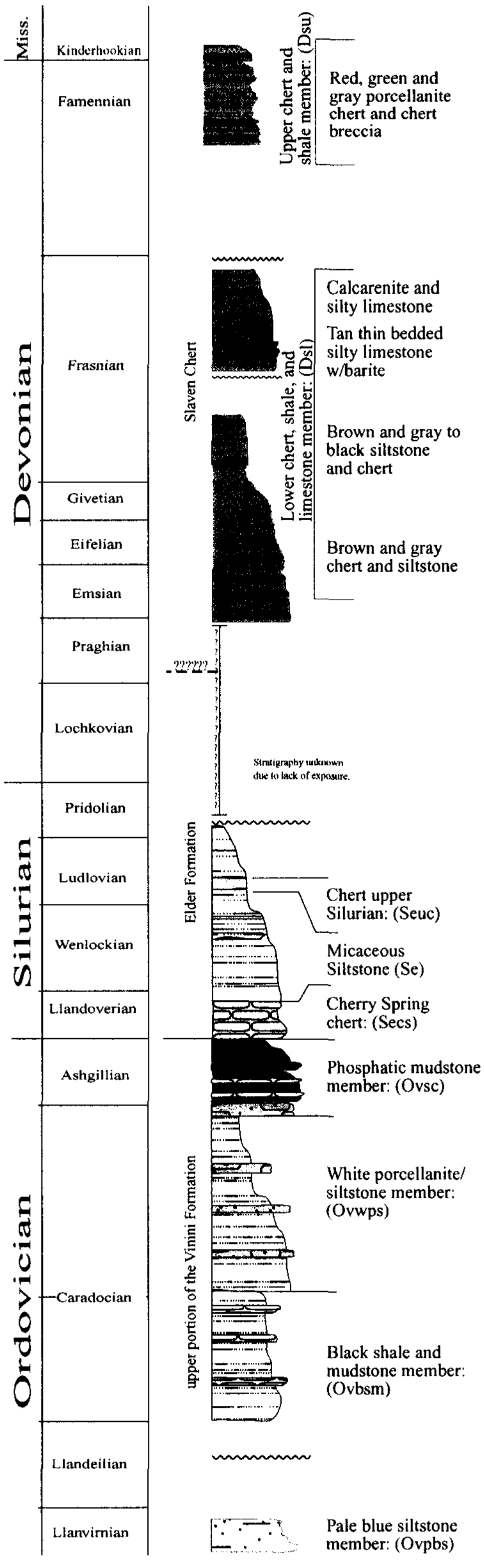


Figure 23.
Cartoon cross-section of a duplex structure. The gently dipping less imbricated beds on the east side of Marys Mountain make up the lower thrust sheet. The steeply dipping beds and high degree of imbrication on the west side of Marys Mountain representing a duplex structure. Not all faults are depicted on this cartoon section.

during the Antler orogenic event (Fig. 23). Although the Marys Mountain thrust appears to be a prominent structural feature, there does not appear to a significant amount of transport along the Marys Mountain thrust, based on a comparison of the stratigraphy between the two domains. In a fold and thrust belt, one can expect to see telescoping of the basin where more distal facies are transported inboard and emplaced on proximal basin and slope facies (Carpenter et al., 1994). In such circumstances, there should be differences in the stratigraphy in adjacent thrust sheets.

A comparison of the stratigraphy between the two domains shows some differences but does not suggest telescoping. Differences between domains is attributed largely to the structure. There is more stratigraphy exposed in the southwest domain than in the northeast domain (Fig. 24) and locally in the southwest domain, the oldest units are very prominent in their surface exposure. In the northeast, the oldest unit exposed is the phosphatic chert unit, whereas on the southwest domain, there are three additional older units exposed. The white porcellanite is particularly prominent in the southwest domain and comprises 70% of the surface exposure. Another difference is the extent of the upper chert and shale member. It comprises 40% of the stratigraphic exposure in the northeast domain, but comprises less than 10% of the exposed stratigraphy in the southwest domain.

These differences in exposed stratigraphy give the appearance of a more substantial difference in stratigraphy between domains than what actually exists. When comparing the internal stratigraphy of the units between the two domains no significant facies changes are observed, nor are there differences in thickness of units, as might be expected if the Marys Mountain thrust were to have juxtaposed different parts of the basin. The



	Southwest Domain	Northeast Domain
Exposure of Devonian Stra tigraphy	70-80 % of the total Devonian stratigraphic package is exposed in the southwest domain; the lower chert, shale and limestone member dominates exposure.	60-70 % of the total Devonian stratigraphic package is exposed in the northeast domain; the upper chert member dominates exposure.
Lithologic Comparison Devonian Strata	Exposed lithologies, included: chert, porcellanite, shale, siltstone, and calcarenites	Exposed lithologies, included: chert, porcellanite, shale, siltstone, calcarenite and chert breccia beds
Exposure of Limestone beds	Calcarenite and silty limestone	Calcarenite and silty limestone Tan thin bedded silty limestone w/barite
Sedimentary Structure present in Devonian Limestones	Abundant cross beds Graded bedding	Sparse cross beds Graded bedding
Exposure of Silurian Stratigraphy	100 % of the total Silurian stratigraphic package is exposed in the southwest domain: the, Cherry Spring chert, the micaceous siltstone, and the upper chert beds dominate exposure.	20- 30 % of the total Silurian stratigraphic package is exposed in the northeast domain: the, Cherry Spring chert, and a small fraction of the micaceous siltstone member dominate exposure.
Lithologic Comparison Silurian Strata	Exposed lithologies include chert, and porcellanite, with minor amounts of siltstone.	Exposed lithologies include minor chert and siltstone beds.
Age comparison of Silurian strata	Silurian strata in the southwest domain range in age from Early Silurian to the Late Silurian.	Whereas only the Early Silurian is exposed in the northeast domain.
Exposure of Ordovician Stratigraphy	100% of the total Ordovician stratigraphic package is exposed in the southwest domain, of which the White porcellanite/siltstone member dominates 80% of the total exposure of Ordovician strata in the southwest domain.	Less than 20% of the total Ordovician stratigraphic package is exposed in the northeast domain.
Age comparison of Ordovician strata	Ordovician strata in the southwest domain range in age from the Middle to Late Ordovician.	Whereas only the late Late Ordovician i exposed in the northeast domain.
Total stratigraphic exposure	The southwest domain contains 90% all the informal members are exposed in the southwest domain.	The only unit not seen in the southwest domain but seen in the northeast domair is the chert breccia beds from the upper chert member of the Devonian Slaven Chert.

Stratigraphic represenation in the southwest and northeast domains

Northeast Domain
Southwest Domain

Figure 24.
Stratigraphic column of the Marys Mountain area, showing major mappable units. Vertical bars compare stratigraphic exposure as seen in the southwest and northeast domains Vertical scale based on The Geological Society of America, 1999, Geologic Time Scale.

stratigraphy therefore does not support significant transport along the Marys Mountain thrust.

The stratigraphy exposed at Marys Mountain is typical of that seen throughout the allochthon with one notable exception; the large percentage of limestone present in the Slaven Chert. The Devonian limestone beds at Marys Mountain make up 40-50% of the stratigraphic thickness in the Slaven Chert. The limestone beds are intercalated with deep-water lithologies (i.e. chert and shale) and are clearly part of the basinal section. These relations demonstrate that calcareous strata locally can be a substantial component of the upper plate Devonian section. This interpretation contrasts with that of Evans (1974), who mapped Devonian limestone to the north on the Welches Canyon 7.5′ Quadrangle as windows into the lower plate. A quick field examination of the limestone beds in the Welches Canyon 7.5′ Quadrangle shows them to be lithologically indistinguishable from the limestone in the Marys Mountain area, and are likewise part of the upper plate.

Large amounts of limestone in a basinal section does not require the invention of structural windows nor major oscillations in facies to explain their presence. It is not uncommon to find calcarenites in basinal settings as a result of transport of shallow water carbonate debris by gravity driven processes. For example, the Caballos Novaculite is a chert and shale unit that contains allodapic limestone beds interpreted to be deposited in this fashion (McBride and Thomson, 1970; Barrick and Noble, 1995). Similar to the Slaven Chert, the Caballos Novaculite is part of a passive margin sequence of parautochthonous strata (Viele, 1989) deposited in an analogous basinal setting.

The limestones in the Marys Mountain area are graded calcarenites displaying sedimentary structures, such as graded bedding, sharp planar beds and well developed trough cross bedding features that are commonly associated with calcareous turbidites, (James and Bourque, 1993; Meischner, 1974). These calcarenites (also called allodapic carbonates) most likely formed from isolated high-energy events allowing transport into a low-energy system by gravity driven processes. The localized nature of these deposits, their lenticular geometry, the coarseness of the sediments, and their intercalation with deep-water shales and radiolarian cherts, all support the idea that the calcarenites can be interpreted as turbidite beds within the basinal sequence at Marys Mountain. Aside from turbidity flows, allodapic carbonates may also be deposited into deeper facies as grain flows; unstable accumulations of lime sands near the platform margin that are set in motion and spill over into the basin with little erosive power (James and Bourque, 1993). Deposition of allodapic grain flows can occur during the initial phase of a transgression as overflow when carbonate production increases in response to sea level rise (James and Kendall, 1992) or may purely be associated with progradation of shelfal carbonates with no change to relative sea level.

A third explanation for the formation of the limestone beds is that they are distal tempestites deposited below wave base as isolated events as a result of storms. Tempestites are fine grained to very fine grained calcarenites that are most commonly deposited along the inner shelf environment (Ito et al., 2001). Tempestites form large broad sheet deposits ranging in thickness from .01 m to 10 m, decreasing sand supply results in thinner tempestites (i.e. distal tempestites) (Einsele, 1996). One the most dominant features of a tempestites is the present of hummocky cross-stratification (Ito et al., 2001). Proximal or sandy tempestites typically form at or above storm base in shallow water (20-30 m) shelf environments (Wetzel et al., 2003). Deposits of this nature reflect deposition under oscillatory flow that produce sedimentary structures with basinal intervals of flat laminae overlain by hummocky cross-stratification, and wave ripples (Duke et al., 1991). Distal tempestites deposited below the storm base are recognized by homogenous packages of mud mixed with siltstone and sandstone (Aigner and Reineck, 1982). They often contain inter fingering relationships of mudstone and sandstone, and display a shortened hummocky cross-stratification wavelengths, ranging only 1- 2 m, significantly less than that of the proximal tempestites (3-6 m λ) (Aigner and Reineck, 1982: Ito et al., 2001; Wetzel et al., 2003). The occurrence and frequency of tempestites is a function of terrigenous sediment input and or carbonate production (Einsele, 1996). These calcarenites were deposited in the basin and hummocky cross-bededing was not observed, so it is unlikely that these beds are tempestites.

A recent study northeast of Mary Mountain in the Carlin Trend suggests a 6-7 million year depositional hiatus, when deposition of platform carbonate sediments ceased during a sea level drop in the Frasnian (Furley, 2001). The calcarenite beds in the Slaven Chert are roughly time equivalent with the hiatus proposed by Furley, within the broad resolution afforded by conodont biostratigraphy, and may possibly be the deeper water equivalent of that hiatus (Fig. 25). If the allodapic carbonates are turbidites or tempestites, they may have been deposited during periods of low sea level if the carbonate shelf was subaerially exposed and eroded (James and Kendall, 1992, Boggs, 1995). During lowstands, one might expect to see evidence of reworked of older

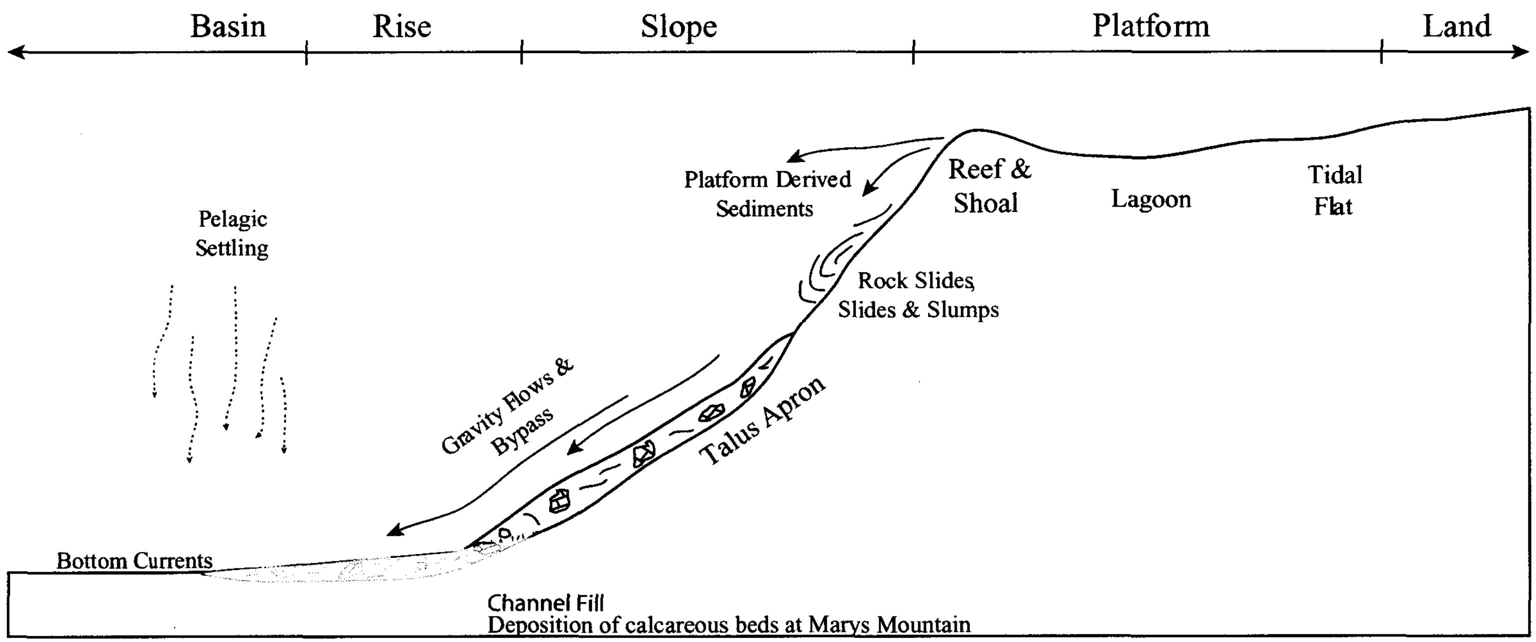


Figure 25.
Generalized carbonate platform-slope-basin showing deposition of calcareous material as turbidites deposited along the toe of the slope and as channel fills in the deeper parts of the basin (modified from Cook, 1983).

carbonate material in the calcarenites. No extensive petrography was done to support or refute such reworking, however conodont analysis revealed no significant reworked elements.

There are two separate calcarenite intervals within the lower chert, shale, and limestone member. Although the age control from these units is not sufficient to separate the two units, they are separated by siliciclastic material deposited between the two units, thus representing two distinct events. The lack of reworked conodonts suggests that the calcarenites are less likely to have been deposited from shelfal erosion during a low stand period

The most plausible explanation for the calcarenites is that they were set in motion by some other event such as slope failure, possibly associated with tectonic activity. At convergent plate boundaries where magmatic arcs tend to rise effecting sedimentary processes in forearc and backarc basins, there may be slope failure caused by oversteepening and/or undercutting by contour currents that are deflected from their previous position (Einsele, 1996). Although the age of the calcarenite is Frasnian, predating the commonly concurred start of the Antler orogeny (Carpenter et al., 1994), it is possible that these events represent some early effects of contractional deformation.

REGIONAL CORRELATION

Using biostratigraphy, several lithostratigraphic packages from Marys Mountain can be correlated laterally over 150 km from the Tuscarora Mountains to the Roberts Mountains. This demonstrates that some of the units, although thin, are regionally extensive (Fig. 26). The following descriptions of correlative strata are taken from locations where detailed biostratigraphic work has been applied to upper plate rocks including: the northern Tuscarora Mountains (the REN property, Cameoc U.S.A., Inc Exploration), Marys Mountain (southern Tuscarora Mountains), Vinini Creek (Roberts Mountains), and Slaven Canyon (northern Shoshone Range) (Cluer et al., 1997; Noble and Finney, 1999; Boundy-Saunders et al., 1999) (Fig. 1).

Ordovician Vinini Formation

Three lithostratigraphic units from the upper part of the Vinini Formation can now be correlated from Marys Mountain to other parts of the RMA (Fig. 26): 1) the black shale and mudstone member, 2) white porcellanite/siltstone member, and 3) black mudstone with phosphatic nodules. Although no fossils have been recovered from the black mudstone with phosphatic nodules member, this unit it is considered correlative based on the distinct lithologic characteristics and its consistent stratigraphic position above the white porcellanite/siltstone throughout the RMA.

The main difference between sections of Vinini throughout the RMA is the amount of carbonate. Significant amounts are found in the section at Vinini Creek

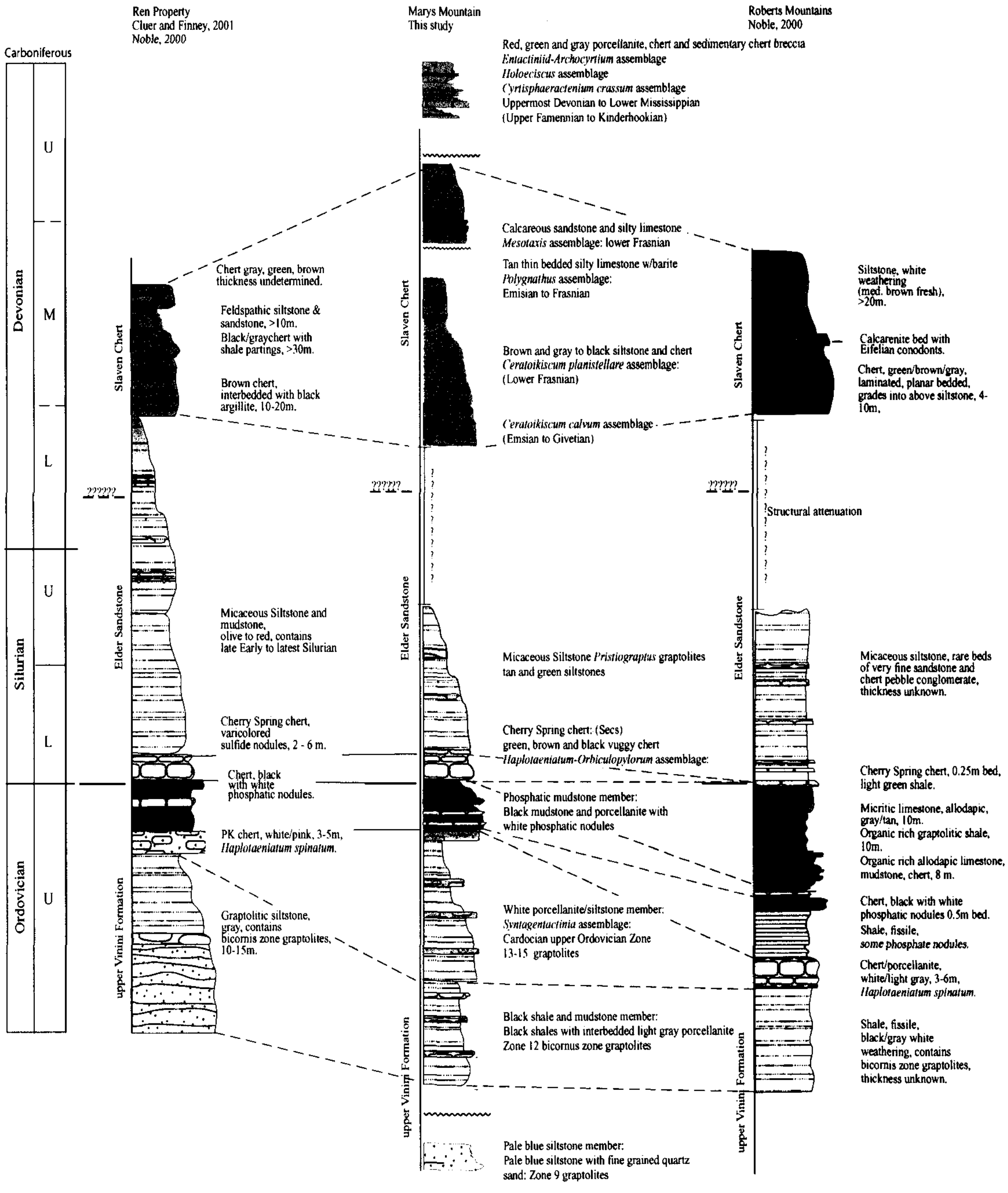


Figure 26.
Correlative stratigraphy in the Roberts Mountain allochthon, from the northern Tuscarora Mountains to the Roberts Mountains; correlation based on similar lithologies and time equivalent fossil assemblages. Refer to locality map (Fig. 1) for location of sections.

in contrast to the Tuscarora Mountains where less than 10% of the Vinini is carbonate strata. Prevalence and thickness variations of siliciclastic components may be due to exposure and degree of structural complexity within the sections, as well as variation in stratigraphic thickness.

Silurian to Devonian Elder Formation

Silurian to Devonian strata assigned to the Elder Formation is typified throughout much of the allochthon by micaceous siltstone beds with subordinate chert marker units. Sandstone and other siliciclastic units are present but are typically uncommon (Fig. 26). The Cherry Spring chert member is distinctive. Although thin, it is correlative throughout several mountain ranges including the Northern Adobe Range (Noble et al., 1997), Independence Mountains, Sulfur Springs Range (Noble et al., 1998), Roberts Mountains, and other parts of the Tuscarora Mountains (Noble, 2000).

Although there are lithologic similarities between micaceous siltstone beds from the Tuscarora Mountains to the Roberts Mountains, the high variability in color, lack of lithologically distinct beds, and the lack of fossil control prevents any confident correlation of siltstone beds throughout the allochthon.

Devonian Slaven Chert

Devonian strata assigned to the Slaven Chert have been grossly lumped as a sequence of chert and siltstone beds. Detailed biostratigraphic work has allowed for the Devonian Slaven Chert at Marys Mountain to be divided into two distinct lithostratigraphic packages (Fig. 26). The lower chert, shale, and limestone member is lithologically correlative as well as time equivalent (based on radiolarian and conodont fossil assemblages) to the Slaven Chert as described in the Roberts Mountains (Noble and Finney, 1999), at Slaven Canyon (Boundy-Saunders et al., 1999), and in the northern Tuscarora Mountains (Cluer et al., 1997).

A conspicuous difference in this unit observed in the Marys Mountain area, compared to other localities throughout the RMA, is the amount of carbonate interpreted to result from local turbidites in the lower chert package. The carbonate component makes up a significant part of the Devonian strata throughout the Marys Mountain area. This relatively high ratio of carbonate to siliciclastic strata seems to be localized to the southern Tuscarora Mountains. Similar stratigraphy has been observed in the Welches Canyon Quadrangle (Evans, 1974), suggesting that upper plate Devonian strata are more common in the quadrangles to the north than originally interpreted. The upper chert and shale member has not been recognized in other areas of the allochthon and is currently considered the youngest part of the Devonian Slaven Chert in the RMA. Hence, no correlation of the upper chert and shale member can be made at this time.

CONCLUSIONS

New collections of radiolarians, graptolites, and conodonts provide critical age control for the Paleozoic strata in the Marys Mountain area of the southern Tuscarora Mountains. Radiolarian biostratigraphy has revealed eight radiolarian assemblages ranging from Late Ordovician to latest Devonian/Early Mississippian. Graptolite collections yield Middle to Late Ordovician (Caradocian) ages plus one Wenlockian (late Early Silurian) age. Two conodont assemblages, yielding a late Middle Devonian (Lower Givetian to Frasnian) age and a Late Devonian (Frasnian) age have also been obtained. Collectively, these constraints provide subdivision, correlation and reveal additional structural information about the allochthon.

Biostratigraphic work as a follow-up to detailed mapping (Henry and Faulds, 1999) allows a detailed lithostratigraphy in the Marys Mountain area to be established. These units consist of the upper part of the Ordovician Vinini Formation, the Silurian-Devonian Elder Formation, and the Devonian Slaven Chert.

- The Vinini Formation at Marys Mountain is composed of shale, siltstone, minor chert, and porcellanite. The most widely exposed member of the Vinini Formation at Marys Mountain is the white porcellanite/siltstone member, which contains abundant graptolites.
- The Silurian- Devonian Elder Formation consists of chert, porcellanite, and micaceous siltstone. The Elder Formation at Marys Mountain is dominated by micaceous siltstone beds with two distinct chert intervals, including the Cherry Spring chert member, which can be correlated to strata found across a

distance of 150 km from the Northern Adobe Range to the Roberts Mountains.

- The Devonian Slaven Chert in the Marys Mountain area is comprised of 1) a lower member that is represented by siltstone, chert, porcellanite, and calcarenite beds, and 2) an upper member composed of chert, porcellanite, shale, and sedimentary chert breccia beds.

Many of the units recognized within the Marys Mountain area, including thin (2-4m) siliceous marker beds, can be correlated many tens of kilometers to other parts of the allochthon, including the REN property in the Tuscarora Mountains to the north, parts of the Northern Adobe Range and Independence Mountains to the west, and to the Roberts Mountains and Sulphur Springs range to the south.

Pre-Tertiary structural features in the Marys Mountain area include multiple meter to kilometer scale, east-vergent tight to isoclinal folds, and many poorly exposed imbricate thrusts and high-angle reverse faults. The orientation of folds and reverse faults indicate that they are Antler age contractional deformation.

Marys Mountain can be divided into two structural domains: 1) a southwest domain defined by north-striking, steeply west-dipping strata with a high degree of structural imbrication and 2) a northeast domain characterized by northwest-striking gently to moderately west-dipping strata and less structural disruption. These two domains differ principally in their structural style and, to a lesser extent, in their internal stratigraphy. The boundary between the two domains is interpreted to be a duplex thrust (the Marys mountains thrust) with the allochthonous rock in the Marys Mountain area, which formed during the emplacement of the Roberts Mountains allochthon during the Antler orogenic event.

References:

Albino G.V., 1994, Geology and lithogeochemistry of the REN gold prospect, Elko County, Nevada-the role of rocks sampling in exploration for deep Carlin-type deposits, Journal of Geochemical Exploration 51 (1994), pp.37-58.

Aitchison, J.C., Davis, A.M., Stratford, J.M. and Spiller, F.C., 1999, Lower and middle Devonian radiolarian biozonation of the Gamilaroi terrane New England Orogen, eastern Australia, Micropaleontology, vol.45 no.2 pp.138-162.

Aitchison, J., 1993, Devonian (Frasnian) Radiolarians for the Gogo Formation, Canning Basin, Western Australia, Palaeontographica, Abteiling-Palaeozoologie-Stratigraphie, 288 (4-6): 105-128.

Berry, W.B.N. and Murphy, M, 1975, Silurian and Devonian graptolites of central Nevada, University of California Publications in Geological Sciences, no.110, 109 pp., 1975.

Berry, W.B.N., 1960, Graptolite faunas of the Marathon Region, West Texas: Texas University, Bureau of Economic Geology, publication 6005, 179 pp.

Boggs, S., Jr., 1995, Carbonate and Marine Environments: *In* Principles of Sedimentology and Stratigraphy: published by Prentice Hall Inc. Upper Saddle River, New Jersey, 774 p.

Boundy-Saunder, S.Q., Sandberg, C.A., Murchey, B.L. and Harris, A.G., 1999, A late Frasnian (Late Devonian) radiolarian, sponge spicule, and conodont fauna for the Slaven Chert, northern Shoshone Range, Roberts Mountains, allochthon, Nevada , Micropaleontology, vol.45 no.1 pp.62-68.

Cellura, B.R., Faulds J.E., Noble, P.J., and Henry, C.D. 2001, Biostratigraphy and Structural Geology in the Marys Mountain Area, Carlin Trend, Nevada, *In*, Shaddick, D.R., Zbinden, E.A., Mathewson, D.C., and Prenn, C., eds. Regional Tectonics and Structural Control of Ore: The Major Gold Trends on Northern Nevada, Geological Society of Nevada, Special Publication 33, 349-355p

Cheng, Y.N., 1986 Taxonomic studies on Upper Paleozoic Radiolaria. National Museum of Natural Sciences, Taiwan Special Publication1: 311 p.

Clark D.L., 1987, Conodont the final fifty million years, *In* Aldridge, R.J., eds., British Micropaleontology Society Series, Paleobiology of Conodonts, pp. 165-175.

Clark, C.L. and Ethington R.L., 1967, Conodonts and zonation of the Upper Devonian in the Great Basin, *In*, The geological society of America Memoir v. 103, 94 pp.

Cluer, J.K., 1999, Future of Gold exploration in the Roberts Mountains Allochthon, Nevada: Role of structural geology and biostratigraphy, Geological Society of America Abstracts with Program, v. 31, no. 4 p. 87.

Cluer, J.K., Cellura, B.R, Keith, K.B., Finney, S.C., S.C. and Bellert, S.J., 1997, Stratigraphy and Structure of the Bell Creek Nappe (Antler Orogen), REN Property, Northern Carlin Trend, Nevada, *In* Perry, A.J., and Abbott E.A., eds. Roberts Mountains thrust, Elko and Eureka Counties, Nevada, Nevada Petroleum Society Field Trip Guide, p.41 -53.

Coles, K.S. and Synder, W.S., 1985, Significance of lower and middle Paleozoic phosphatic chert in the Toquima Range, central Nevada: Geology: v. 13, p573-576.

Cook, H. E., 1983, Ancient carbonate platform margins, slopes, and basins, *in* Cook, H. E., Hine, A. C., and Mullins, H. T., eds., Platform Margins and Deep-Water Carbonates: Society of Economic Paleontologists and Mineralogists Short Course 12, p. 1-189.

Craig, R.R., 1987, Stratigraphy of the Tuscarora Mountains, *In* Cuffney, B., Atkinson, R., Buffa, R., eds., Northern Carlin Trend, Big Springs, Special Publications –Nevada Bureau of Mines and Geology, vol. 6 pp. B8-B10.

Dunham, R.J., 1962, Classification of carbonate rocks according to the depositional textures, *in* Ham, W.E. ed., Classification of carbonate rocks: American Association Petroleum Geologist Memoirs v. 1, Table 1, p.117.

Evans, J.G., 1980, Geology of the Rodeo Creek NE and Welches Canyon Quadrangle, Eureka, County, Nevada, U.S. Geological Survey Bulletin 1473, 78 p.

Evans, J.G., 1974, Geologic map of the Welches Canyon quadrangle, Eureka County, U.S. Geological Survey Geologic Quadrangle, map GQ-1117, scale 1:24,000.

Evans, J.G., and Cress, L.D., 1972, Geologic map of the Schroeder Mountain quadrangle Eureka and Elko Counties, Nevada: U.S. Geological Survey Misc. Field Studies Map MF-324, scale 1:24,000.

Evans, J.G., and Ketner, K. B., 1971, Geologic map of the Swales, Mountain quadrangle and part of the Adobe Summit quadrangle, Elko County, Nevada: U.S. Geological Survey Misc. Geol. Inv. Map I-667, scale 1:24, 000.

Evans, J.G. and Theodore, T.G., 1978, Deformation of the Roberts Mountains allochthon in north-central Nevada: U.S. Geological Survey Professional Paper 1060, 18 p.

Finney S.C., and Cluer, J.K., 2000 Stratigraphy, Correlation, and Paleogeography of the Silurian-Lower Devonian Elder Formation, Roberts Mountains Allochthon, Central Nevada *In* J.K. Cluer, J.G. Price, E.M. Struhsacker, R.F. Hardyman, and C.L. Morris eds. GEOLOGYAND ORE DEPOSITS 2000: The Great Basin and Beyond Symposium Proceedings Volume I.

Finney, S.C., Perry, B.D., Emsbo, P. and Madrid, R.J., 1993, Stratigraphy of the Roberts Mountains allochthon, Roberts Mountains and Shoshone Range, Nevada, *in* Lahren, M.M., Trexler, J.H., Jr., and Spinosa, C., eds., Crustal evolution of the Great Basin and Sierra Nevada: Reno, University of Nevada, Department of Geological Sciences, p.197-230.

Finney, S.C. and Perry, B.D., 1991, Depositional settings and paleogeography of Ordovician Vinini Formation, central Nevada, *In* Cooper, J.D., Stevens, C.H., eds, 1991, Paleozoic paleogeography of the Western United States-II: Pacific Section SEPM, v.67, p.747-766.

Folk, R.L., 1974, Petrology of Sedimentary Rocks, Hemphill Publishing Company, Austin, Texas, 159 p.

Furley R.A., 2001, Sequence Stratigraphic Framework For The Silurian-Devonian Bootstrap Limestone, Roberts Mountains, And Devonian Popovich Formations, Northern Carlin Trend, Elko And Eureka Counties, Nevada, Unpublished Master of Science M.S. Thesis, Colorado School of Mines, Golden, Colorado, 208 p.

Gilbert, C.M., 1954, Rock *Names for Mixture of Sedimentary Rocks*, *in,* Williams, Turner, and Gilbert, 1954, *Petrography:* San Francisco, W.H. Freeman and Co., p.270.

Gilluly, J. and Gates, O., 1965, Tectonic and igneous geology of the northern Shoshone Range, Nevada, *with section* on Gravity in Crescent Valley, by D. Plouff *and* Economic geology, by K.B. Ketner: U.S. Geological Survey Professional Paper 465,153p.

Henry, C.D. and Faulds, J.E., 1999, Geologic map of the Emigrant Pass Quadrangle, Nevada; Nevada Bureau of Mines and Geology Open file report 99-9.

Higgins, A.C. Austin R.L.,1985, The upper Devonian series, *In,* Higgins, A.C., Austin R.L., eds., A Stratigraphic index of Conodonts , British Micropaleontology Society Series, Table 5, p. 246-247.

Holdsworth, B.K. and Jones, D.L. 1980, Preliminary radiolarian zonation for late Devonian through Permian time. Geology, 8:281-285.

Irwin, S.E.B. and Orchard, M.J., 1991, Upper Devonian – Lower Carboniferous conodont biostratigraphy of the Earn Group and overlying units, northern Canadian Cordillera, *In* Ordovician to Triassic Conodont Paleontology of the Canadian Cordillera, M.j. Orchards and A.D. McCracken (eds.) Geologic Survey of Canada, Bulletin 417, p.185-213.

Isaacs, C.M., 1982, Influence of rack composition on kinetics of silica phase changes in the Monterey Formation, Santa Barbara area, California, Geology, 10: p. 304-308.

Kennet, J. P., 1982, Marine Geology, Biogenic and Authigenic Oceanic Sediments: Phosphorites p. 502 *In* Marine Geology published by Prentice Hall Inc, Englewood Cliffs NJ, 812 p.

Ketner, K.B., 1991, Stratigraphy, sedimentology, and depositional conditions of Lower Paleozoic western facies rocks in northeastern Nevada, *In* Cooper, J.D., Stevens, C.H., eds., 1991, Paleozoic paleogeography of the Western United States-II: Pacific Section SEPM, v.67, p.735-746.

Ketner, K.B., 1991, Depositional settings and paleogeography of Ordovician Vinini Formation, central Nevada, *In* Cooper, J.D., Stevens, C.H., eds, 1991, Paleozoic paleogeography of the Western United States-II: Pacific Section SEPM, v.67, p.747-766.

Ketner, K.B., 1990, Stratigraphy and Strata- Bound Lead-Zinc- Barium mineralization of Lower Paleozoic Western Facies Rocks in Northeastern Nevada, *In* Rains, G., Lisle, .R., eds., Geology and Ore Deposits of the Great Basin, p.p. 539-551.

Madrid, R., J.J., 1987, stratigraphy of the Roberts Mountains allochthon in northern central Nevada: PhD. Thesis, Stanford University Stanford, California, 342p.

Merriam, C.W. and Anderson, C.A., 1942, Reconnaissance survey of the Roberts Mountains, Nevada: Geological Society of America Bulletin, v.53, no.12, pt. 1 p. 1675-1725.

Nazarov, B. B. and Ormiston, A.R., 1983, Upper Devonian (Frasnian) Radiolarians fauna from the Gogo Formation, Western Australia, Micropaleontology, 29: 454-466.

Noble, P.J., 2000, Revised stratigraphy and structural relationships in the Roberts Mountain allochthon of Nevada (USA) based on radiolarian cherts, *In* J.K. Cluer, J.G. Price, E.M. Struhsacker, R.F. Hardyman, and C.L. Morris eds. GEOLOGY AND ORE DEPOSITS 2000: The Great Basin and Beyond: Geological Society of Nevada Symposium Proceedings Volume I, May 15-18, p.439-566.

Noble, P.J., Carlson, D.H., Finney, S.C. and Bratt, S.M., 1997, Revised ages for cherts in the Vinini Fm., Roberts Mtns., NV, Geological Society of America, Cordilleran section meeting, Abstracts with Programs, v.29, p. 55, no. 4369.

Noble, P.J., 1994, Silurian radiolarian zonation for the Caballos Novaculite, Marathon Uplift, West Texas, Bulletin of American Paleontology, v. 106, pp. 55.

Noble, P.J. and Aitchison, J.C., 2000, Early Paleozoic radiolarian biozonation, Geology, April 2000, v. 28; no.4 p. 367-370.

Noble, P.J. and Aitchison, J.C., 1995, Status of Ordovician and Silurian radiolarian studies in North America, p.19-30. *In* C.D. Blome et al. (conveyors), Siliceous Microfossils. Paleontological Society Short Courses in Paleontology, 8.

Noble, P.J., Braun, A. and McClellan, W.G., 1998, *Haplotaeniatum* fauna from the Llandoverian of Nevada, and Germany: Neues Jahrbuch fur Geologie und Palaontologie Abhandlungen, p 705-726.

Noble, P.J. and Finney, S.C., 1999, Recognition of fine-scale imbricate thrust in lower Paleozoic orogenic belts- An example from the Roberts Mountains allochthon, Nevada, Geology, v.27, no.6 p 543-546.

Noble, P.J., Ketner, K.B. and McClellan, W., 1997, Early Silurian radiolaria from northern Nevada, USA, Marine Micropaleontology, v.30 p.215-223.

Palmer, Douglas, Rickards and Barrie, 1991, What are they? What do they look like? *In* Boydell Press, Woodbridge, United Kingdom (GBR),Graptolites; writing in the rocks, Fossils Illustrated, vol.1, pp.1-5, 1991.

Pessagno, E.A., Jr. and Newport, R.L.,1972, A technique for extracting Radiolaria from radiolarian cherts- Micropaleontology., 34(3):260-267.

Peters S. G., 2002, Geology of the Bob Flat Quadrangle, Eureka County Nevada: Text and References for Nevada Bureau of Mines and Geology Map 138 p13

Peters, S. G. and Evans, J.G., 1995, Megascopic and mesoscopic fabric geometries in parts of the Carlin Trend, Eureka and Elko counties, Nevada *in:* Geology and ore deposits of the American Cordillera; a symposium: Geological Society of Nevada, United States. pg. 61-62.

Peters, S.G., 1998, Evidence for the Crescent Valley-Independence Lineament, North-Central Nevada, *In* Tosdal, R.M. ed., 1998, Contribution to the Gold Metallogeny of Northern Nevada Open File Report 98-338, p106-117.

Poole, F.G., and Claypool, G.E., 1984, Petroleum source-rock potential and crude-oil correlation in the Great Basin, *In* Woodward, J., Meissner, F.F., and Clayton, J.L. (eds.), Hydrocarbon source rocks of the Great Rocky Mountain Region: Boulder, Rocky Mountain Association of Geologist, p. 179-229.

Ressel, M.W., Noble, D.C., Heizler, M.T., Volk, J.A., Lamb, J.B., Park, D.E., Conrad, J.E., and Mortensen, J.K., 2000, Gold-mineralized Eocene dikes at Griffin and Meikle: bearing on the age and origin of deposits of the Carlin Trend, Nevada, in Cluer, J.K., Price, J.G., Struhsacker, E.M., Hardyman, R.F., and Morris, C.L., eds., Geology and Ore Deposits 2000: The Great Basin and Beyond: Geological Society of Nevada Symposium Proceedings, May 15-18, 2000, p. 79-101.

Roberts, R. J., Hotz, P.E., Gilluly, James, and Ferguson, H.G., 1958, Paleozoic rock of north-central Nevada: Am. Assoc. Petroleum Geologists Bull., v.42, no.12, p.2813-2857.

Romarco Minerals Inc. 1997, Romarco Minerals announces REN drill results and new land acquisitions, Press release transmitted by Canadian Corporate News, August 20, 1997, Romarco.com, http://www2.cdn-news.com/scripts/ccn-release.pl?1997/08/20/0820013n.html?cp=r

Ross, R.J., and Berry, W.B.N., 1963 Ordovician graptolites of the basin ranges in California, Nevada, Utah, and Idaho: U.S. Geological Survey Bull. 1134.

Saucier, A.E., 1997, The Antler Thrust System in Northern Nevada, *In* Perry, A.J., and Abbott E.A., eds. Roberts Mountains thrust, Elko and Eureka Counties, Nevada, Nevada Petroleum Society Field Trip Guide, p.41 -53.

Smith, J.F. Jr., and Ketner, K.B., 1968, Devonian and Mississippian rock and the date of the Roberts Mountains thrust in the Carlin Piñon Range area, Nevada, U.S. Geological Survey Bulletin 1251-I 18p.

Stewart, J. H., 1980, Geology of Nevada, A Discussion to the Accompany the Geologic Map of Nevada, Nevada Bureau of Mines and Geology Special Publication 4, 136 pp.

Teal, L., and Jackson, M., 1997, Geologic overview of the Carlin trend gold deposits and descriptions of recent deep discoveries: SEG Newsletter, no. 31, p. 1, 13-25, also in Vikre, P., Thompson, T.B., Bettles, K., Christensen, O., and Parratt, R., eds., Carlin-Type Gold Deposits Field Conference: Society of Economic Geologists Guidebook Series, v. 28, p. 3-38.

Twiss, R.J., and Moores, E.M., 1992, Ductile Deformation , Description of Folds, *In* Structural Geology eds. Twiss, R.J. and Moores, E.M., Chapter 11 p231.

Won M. Z., Blodgett R.B.,and Nestor V., 2002, Llandoverian (Early Silurian) radiolarians from the Road River Formation of east-central Alaska and the new family Haplotaeniatumidae: Journal of Paleontology 76, no.6 (2002) p. 941-964.

Ziegler, W., 1971, Conodont stratigraphy of European Devonian. *In* Sweet, W.C.and Bergstrom S.M., eds., Symposium On Conodont Biostratigraphy, in Memoirs, Geooligcal.Society of America, 127, 227-284.

Ziegler, W.D., Klapper G., Lindstrom, M., and Sweet, W.C., 1973, Catalogue of conodonts, E. Schweizerbart'sche Verlagsbuchhandlung, v. I, 504 pp.

Photo plate 1

Syntagentactinia assemblage

Photo #	Sample Number	Taxa	Magnification	Scale Bar μm
1	Ep-99-04	*Syntagentactinia sp.?*	300	100
2	Ep-99-07	*Syntagentactinia sp.?*	350	100
3	Ep-99-07	*Spumellarian*	500	50
4	Ep-99-04	*Haplotaeniatum sp.?*	350	100

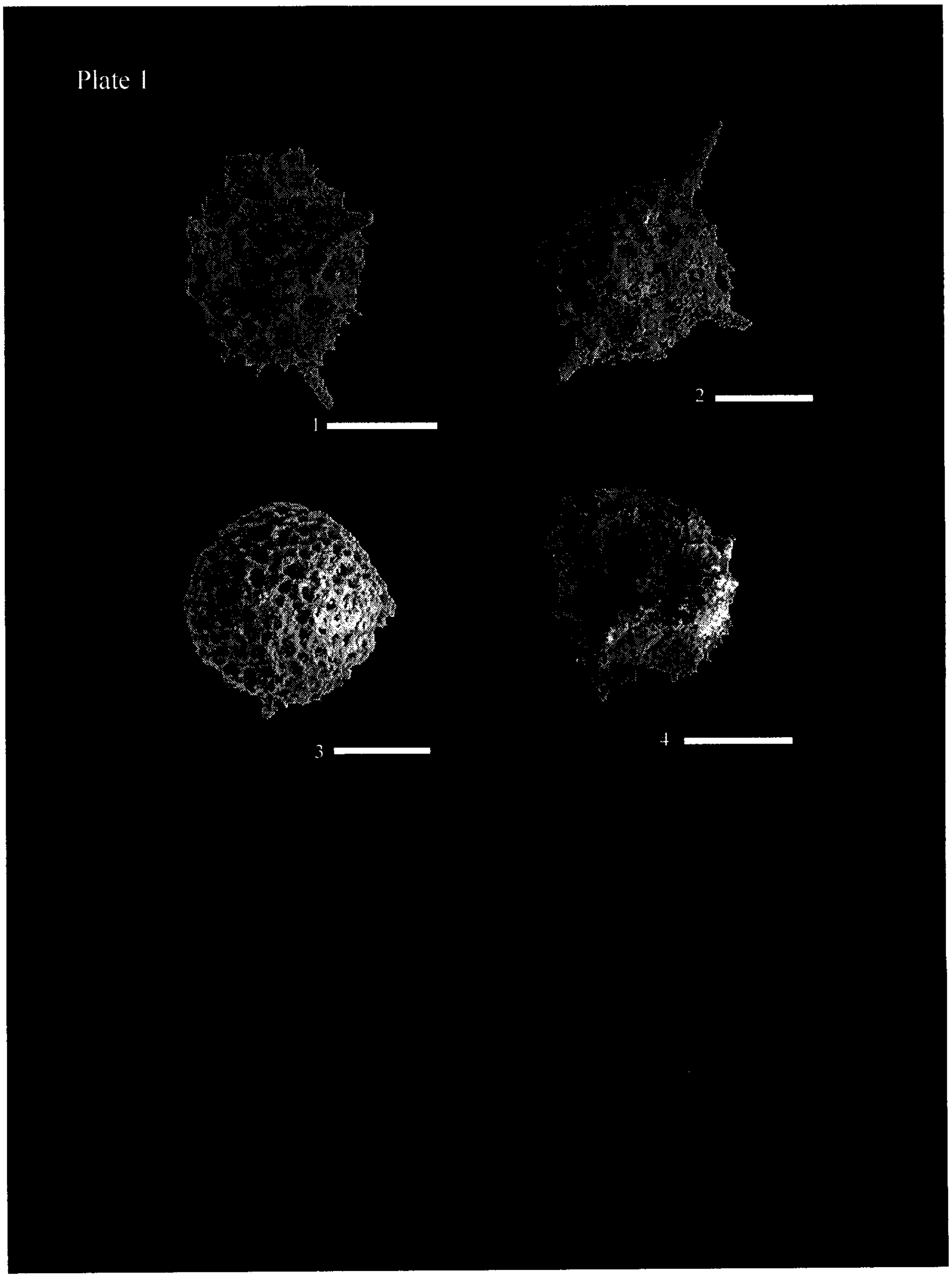


Plate 1
1
2
3
4

Photo plate 2

Haplotaeniatum-Orbiculopylorum assemblage

Photo #	Sample Number	Taxa	Magnification	Scale Bar µm
1	Ep-99-12	*Orbiculopylorum sp.?*	400	50
2	Ep-99-02	*Orbiculopylorum sp.?*	200	100
3	Ep-99-12	*Secuicollacta sp.*	400	50
4	Ep-99-12	*Secuicollacta sp.*	300	100
5	Ep-99-12	*Syntagentactinia sp.?*	350	100
6	Ep-99-12	*Haplotaeniatum aperturatum*	250	100

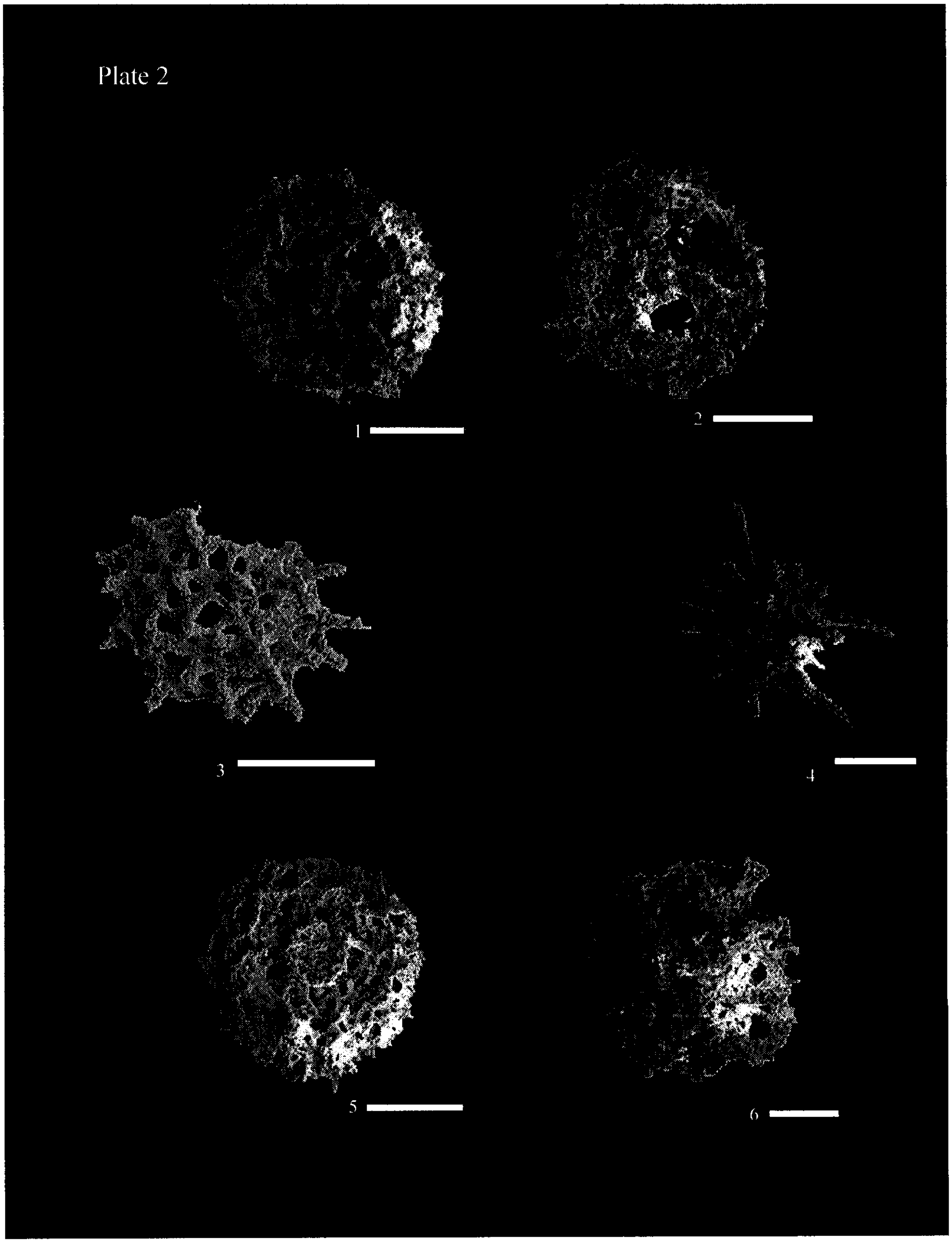


Plate 2
1
2
3
4
5
6

Photo plate3
Secuicollacta assemblage

Photo #	Sample Number	Taxa	Magnification	Scale Bar µm
1	Ep-99-59	*Entactiniidae*	250	100
2	Ep-99-20	*Secuicollacta solara?*	450	50

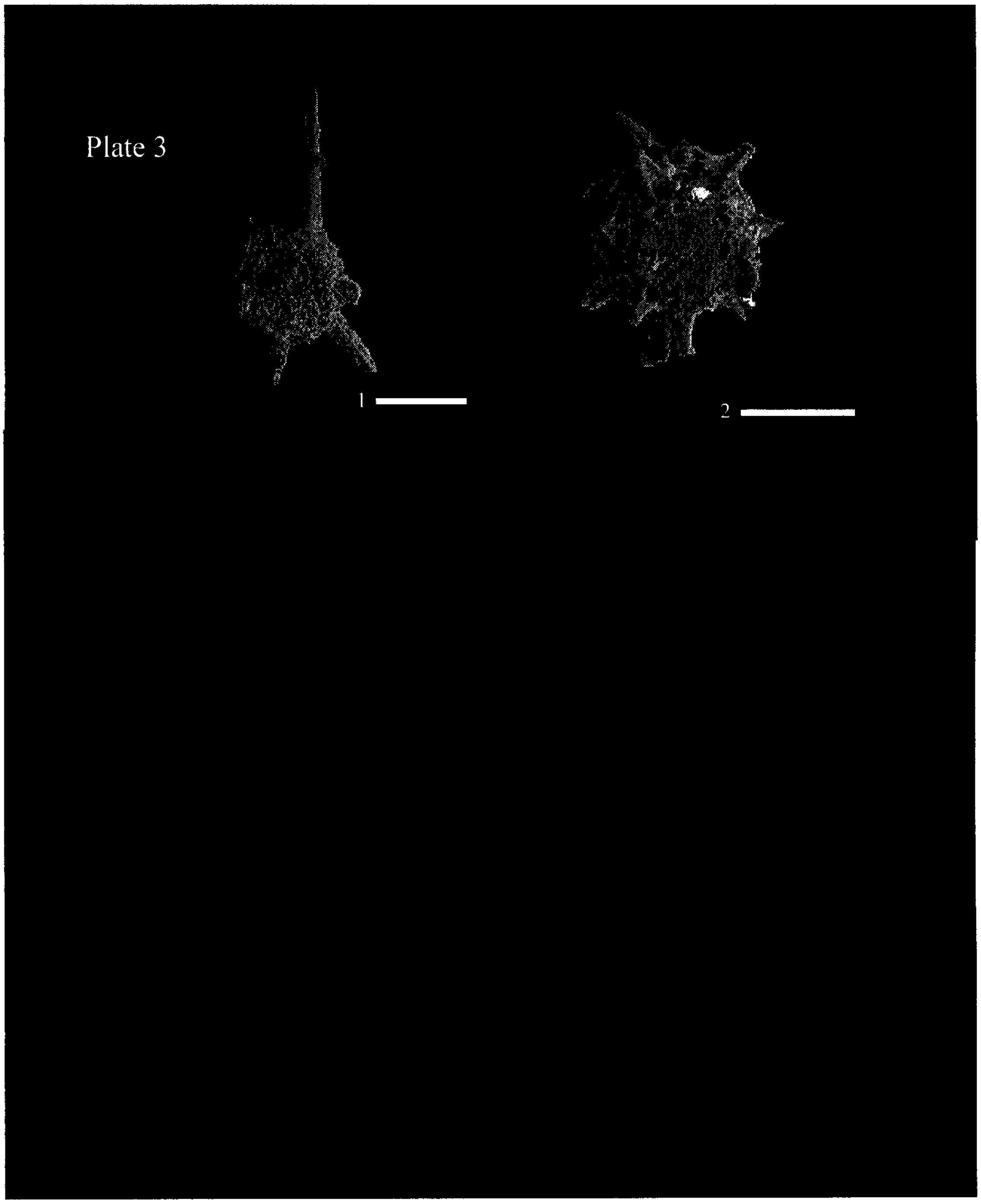


Plate 3
1
2

Photo plate 4

Ceratoikiscum calvum assemblage

Photo #	Sample Number	Taxa	Magnification	Scale Bar μm
1	Ep-99-61	*Trilonche sp.*	500	50
2	Ep-99-11	*Ceratoikiscum sp.?*	650	50
3	Ep-99-61	*Trilonche sp.*	500	50
4	Ep-98-02	*Helenifore laticlavium*	350	100
5	Ep-99-61	*Trilonche sp.*	400	50
6	Ep-99-39	*Stigmosphaerostylus sp.*	400	40
7	Ep-99-11	*Trilonche*	300	100
8	Ep-99-11	*Trilonche*	300	100
9	Ep-00-18	*Trilonche sp.*	250	100
10	Ep-99-11	*Palaeoscenidiidae*	300	100
11	Ep-00-18	*Trilonche sp.*	250	100
12	Ep-00-18	*Trilonche sp.*	250	100

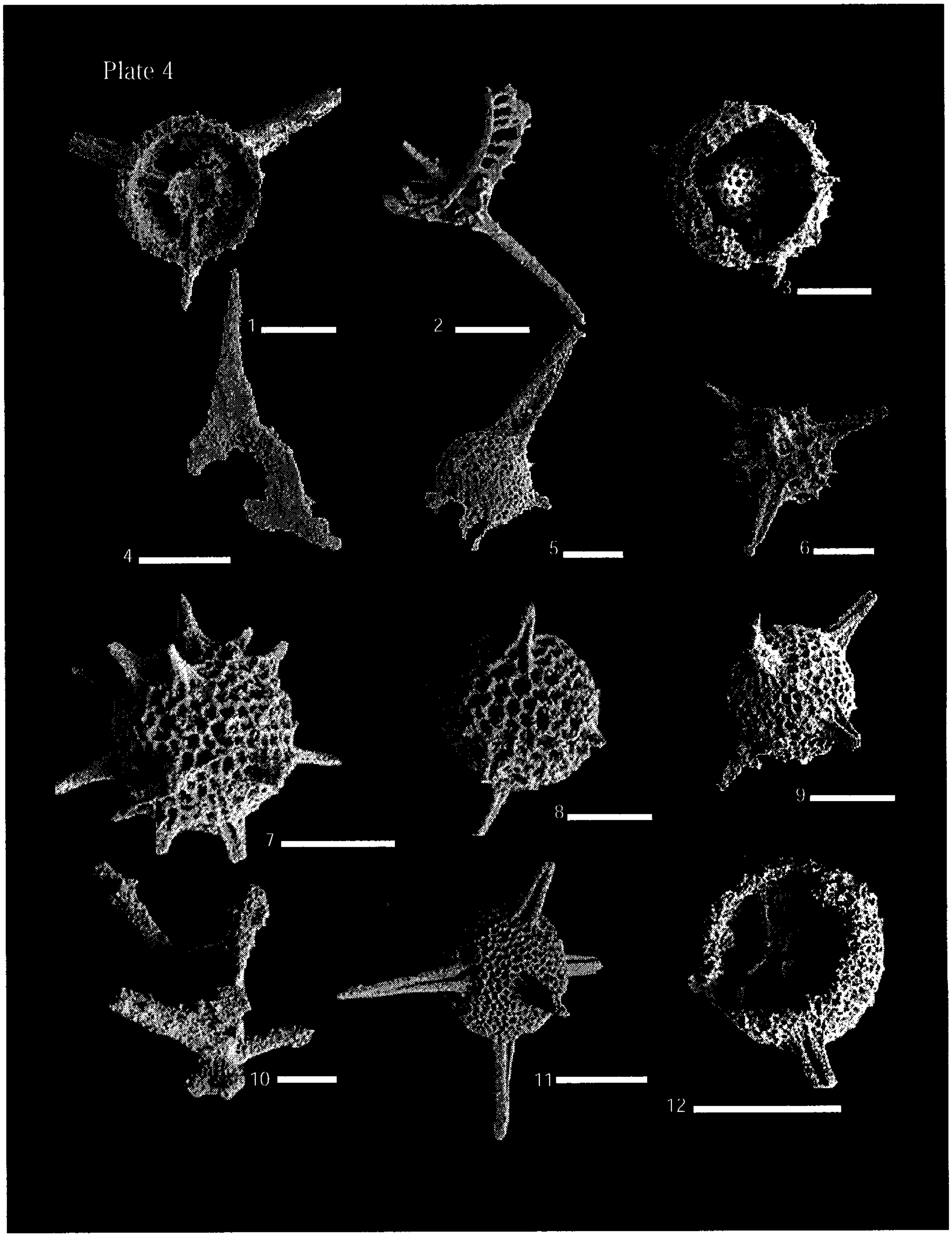


Plate 4
1
2
3
4
5
6
7
8
9
10
11
12

Photo plate 5

Ceratoikiscum calvum assemblage

Photo #	Sample Number	Taxa	Magnification	Scale Bar µm
1	Ep-99-43	*Ceratoikiscum calvum*	400	50
2	Ep-99-43	*Ceratoikiscum calvum*	450	50
3	Ep-99-11	*Ceratoikiscum calvum*	500	50
4	Ep-99-39	*Ceratoikiscum calvum*	550	50
5	Ep-00-18	*Ceratoikiscum calvum*	270	100
6	Ep-99-43	*Ceratoikiscum calvum*	400	50
7	Ep-99-11	*Ceratoikiscum calvum*	450	50
8	Ep-99-11	*Ceratoikiscum calvum*	500	50

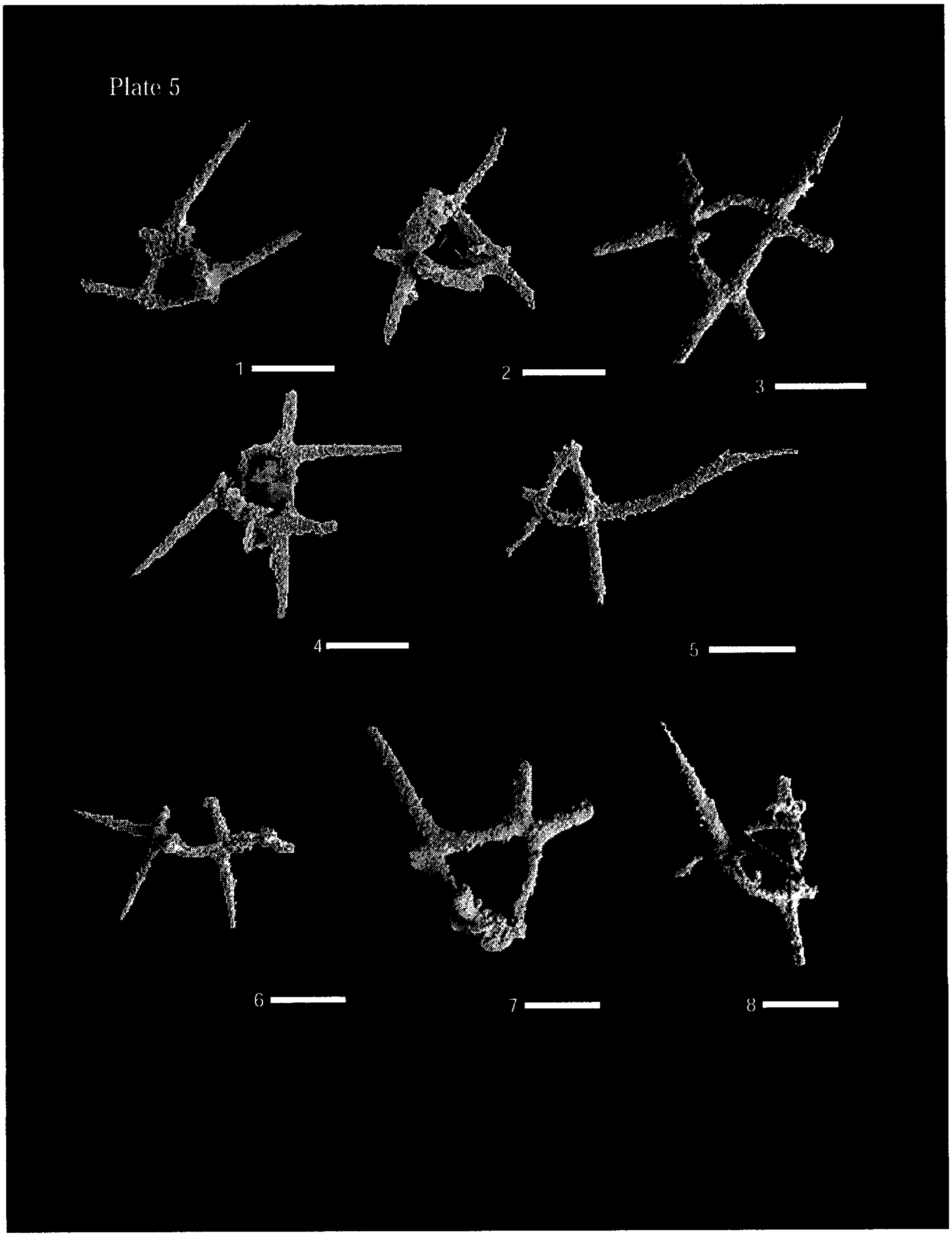


Plate 5
1
2
3
4
5
6
7
8

Photo plate 6

Ceratoikiscum planistellare assemblage

Photo #	Sample Number	Taxa	Magnification	Scale Bar µm
1	Ep-99-13	*Ceratoikiscum planistellare*	350	100
2	Ep-99-13	*Ceratoikiscum planistellare*	450	50
3	Ep-99-13	*Ceratoikiscum planistellare*	350	100
4	Ep-00-02	*Ceratoikiscum calvum*	330	100
5	Ep-00-02	*Ceratoikiscum?*	450	50
6	Ep-00-02	*Entactinia gogoense*	300	100
7	Ep-00-02	*Trilonche sp.*	300	100
8	Ep-99-13	*Trilonche sp.*	350	100
9	Ep-99-13	*Trilonche sp.*	300	100

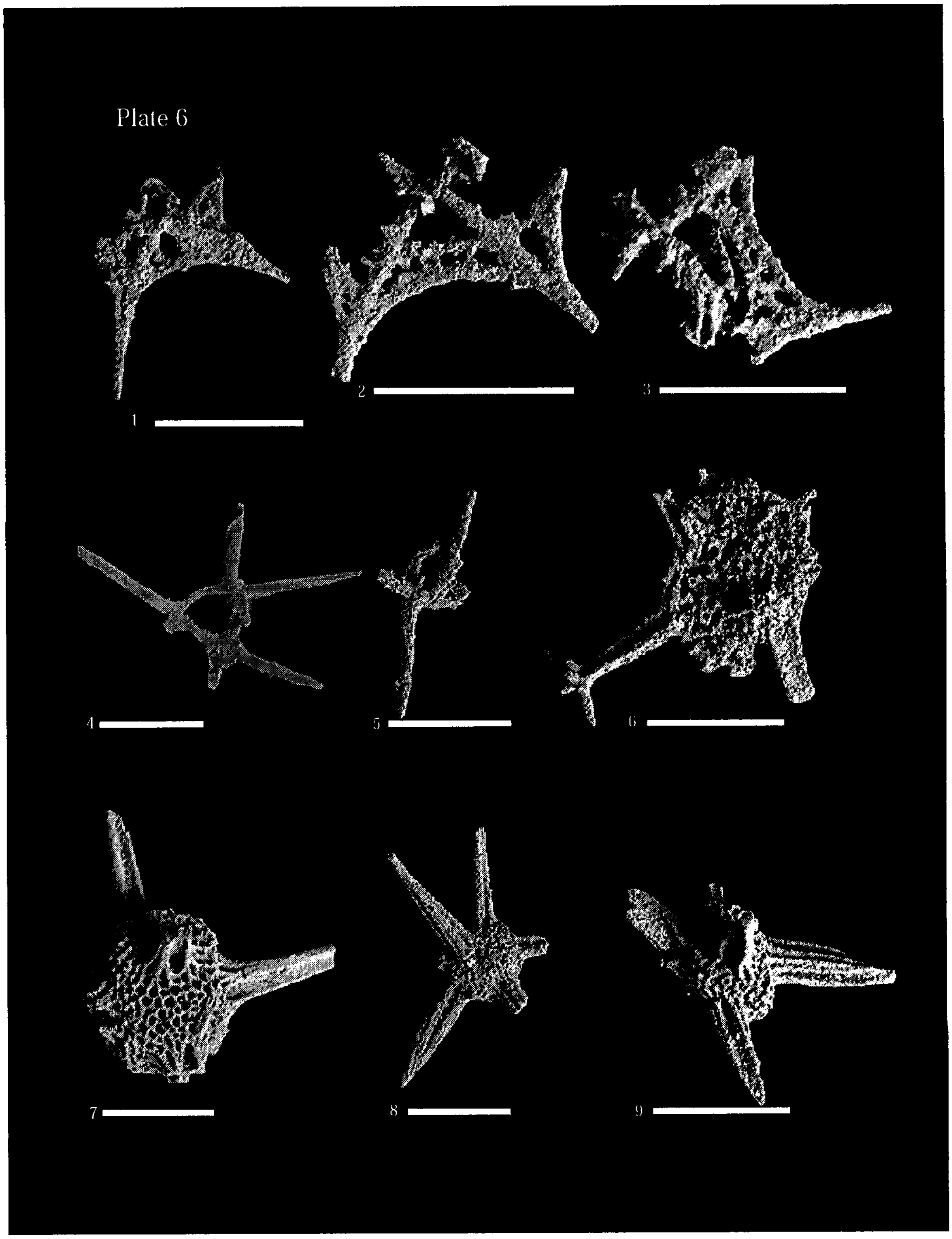


Plate 6
1
2
3
4
5
6
7
8
9

Photo plate 7

Entactiniidae- Archocyrtium assemblage

Photo #	Sample Number	Taxa	Magnification	Scale Bar μm
1	Ep-99-60	*Archocyrtium sp.*	700	50
2	Ep-99-60	*Archocyrtium sp.*	700	50
3	Ep-99-40	*Paleoscenidium sp.*	500	50
4	Ep-99-27	*Paleoscenidium sp.*	500	50
5	Ep-99-24	*Trilonche sp.*	500	50
6	Ep-99-27	*Trilonche sp.*	270	100

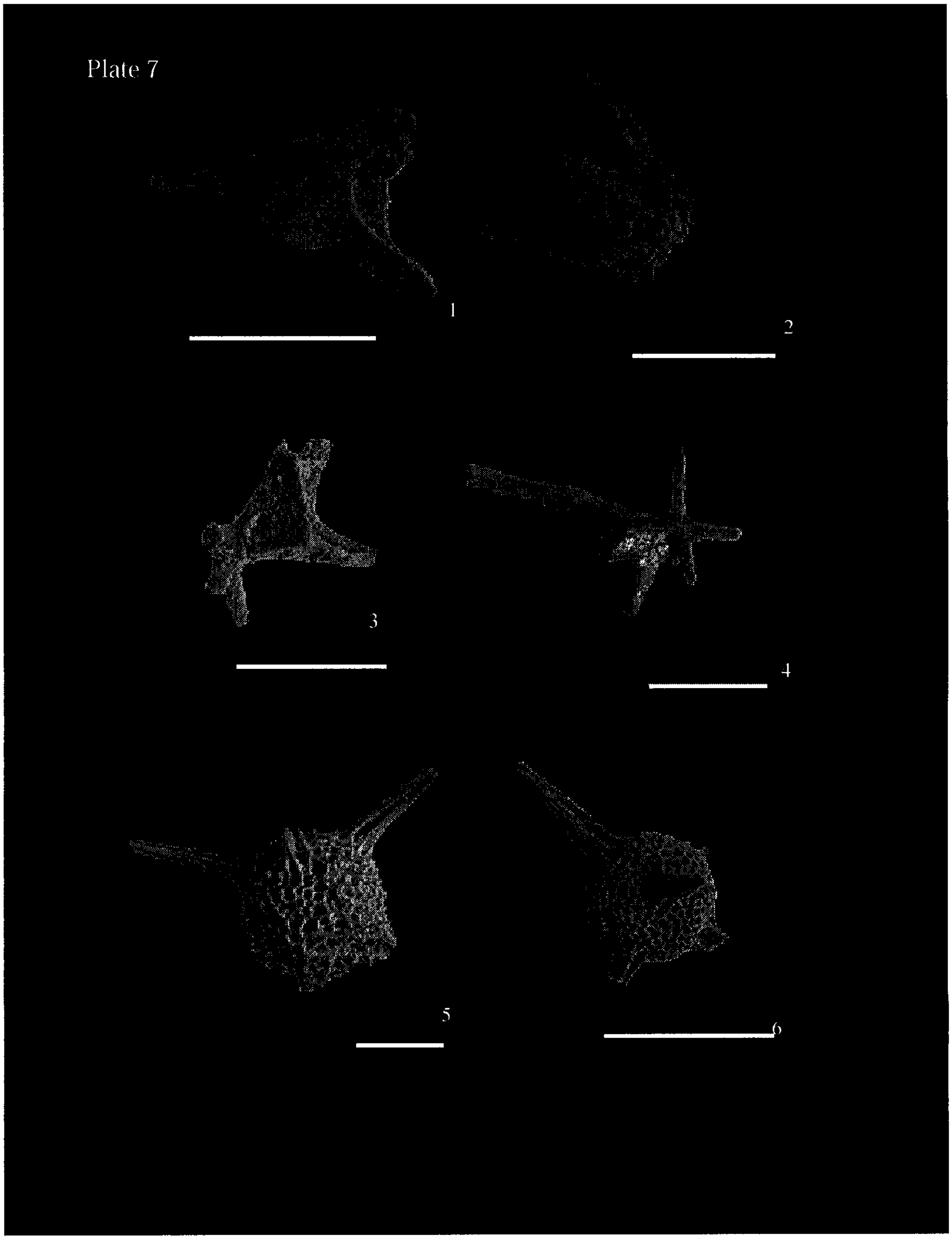


Plate 7
1
2
3
4
5
6

Photo plate 8

Holoeciscus assemblage

Photo #	Sample Number	Taxa	Magnification	Scale Bar μm
1	Ep-99-71	*H- frame Holoeciscus sp.*	700	50
2	Ep-99-73	*H- frame Holoeciscus sp.*	550	50
3	Ep-99-24	*Trilonche sp.*	500	50
4	Ep-99-26	*Archocyrtium sp.?*	600	50
5	Ep-99-26	*Archocyrtium ormistoni sp.?*	700	50

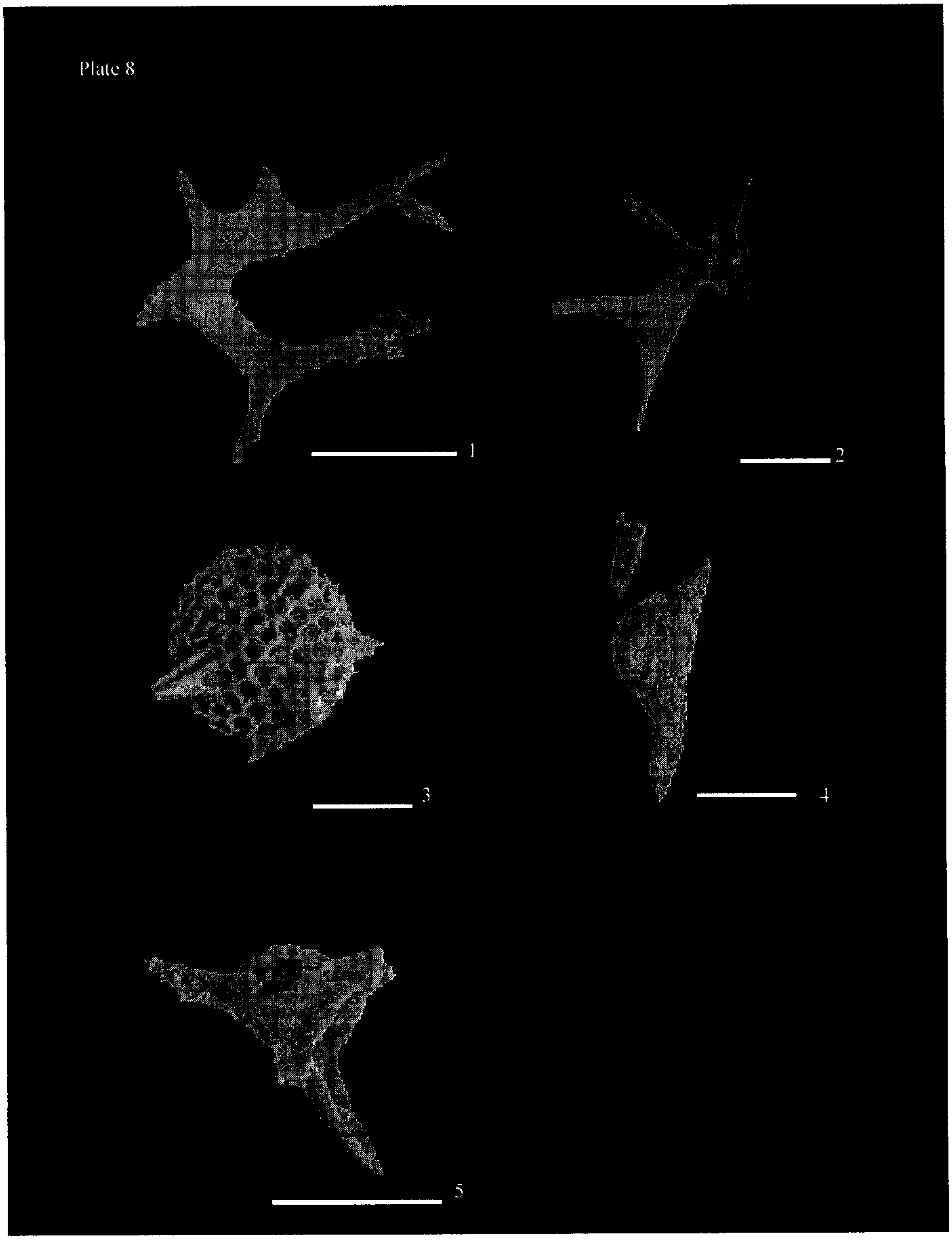


Plate 8
1
2
3
4
5

Photo plate 9

Cyrtisphaeractenium crassum assemblage

Photo #	Sample Number	Taxa	Magnification	Scale Bar μm
1	Ep-99-60	*Entactiniidae sp. tri radiate*	200	100
2	Ep-99-70	*Haplentactinia sp.*	500	50
3	Ep-99-67	*Stigmosphaerostylus sp.*	500	50
4	Ep-99-70	*Archocyrtium sp.*	600	50
5	Ep-99-70	*Archocyrtium sp.*	800	50
6	Ep-99-70	*Cyrtisphaeractenium crassum*	500	50
7	Ep-99-70	*Cyrtisphaeractenium crassum*	500	50
8	Ep-99-60	*Cyrtisphaeractenium crassum*	700	50

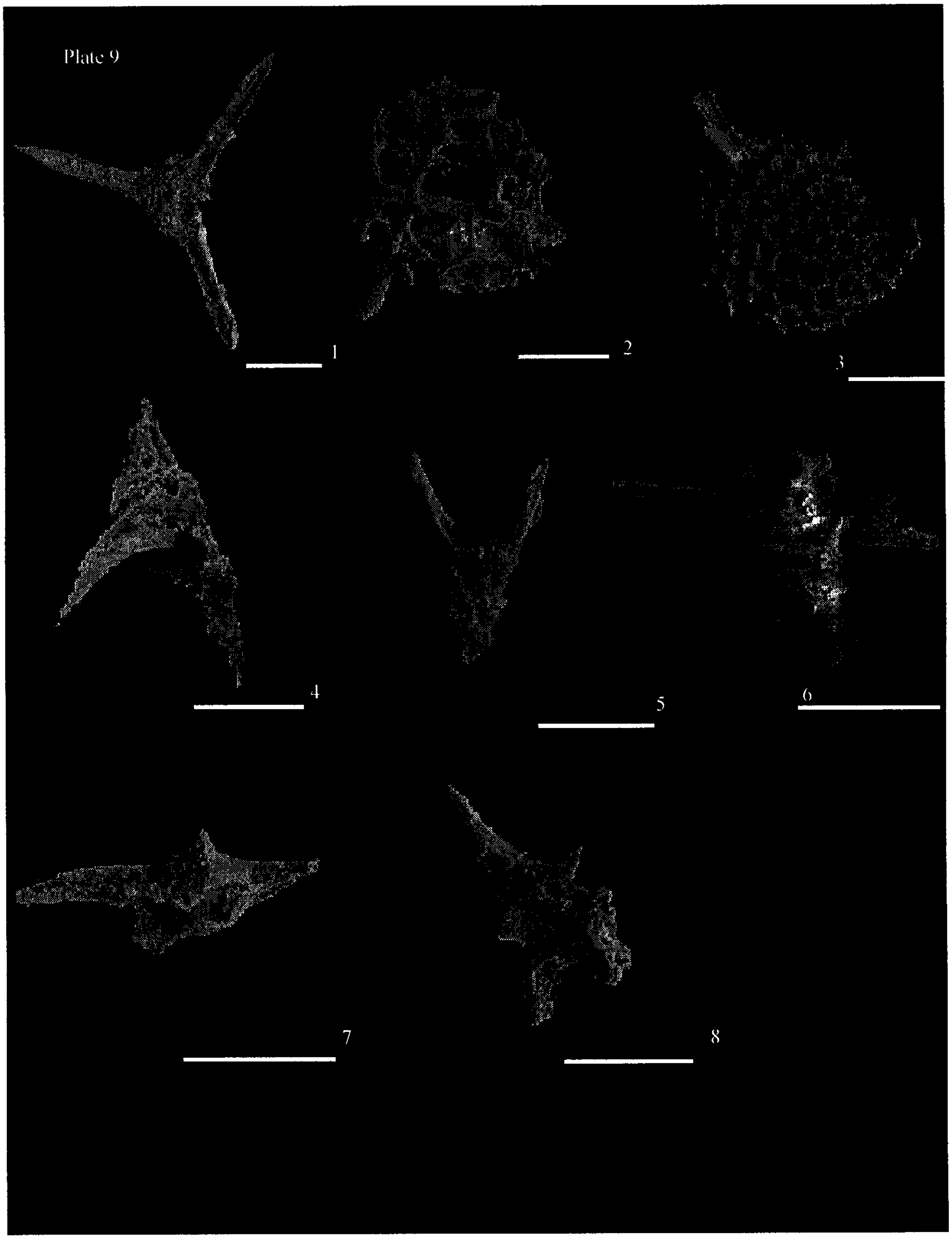


Plate 9
1
2
3
4
5
6
7
8

Photo plate 10

Mesotaxis assemblage

Photo #	Sample Number	Taxa	Magnification	Scale Bar µm
1	Ep-99-C1	*Mesotaxis sp.*	100	100
2	Ep-99-C1	conodont fragment	80	100
3	Ep-99-C2	*Mesotaxis sp.*	200	100
4	Ep-99-C2	*Ancyrodella*	200	100
5	Ep-99-C2	conodont fragment	190	100

Polygnathus assemblage

Photo #	Sample Number	Taxa	Magnification	Scale Bar µm
6	Ep-00-C05	conodont fragment	180	100
7	Ep-00-C05	Polygnathus	200	100

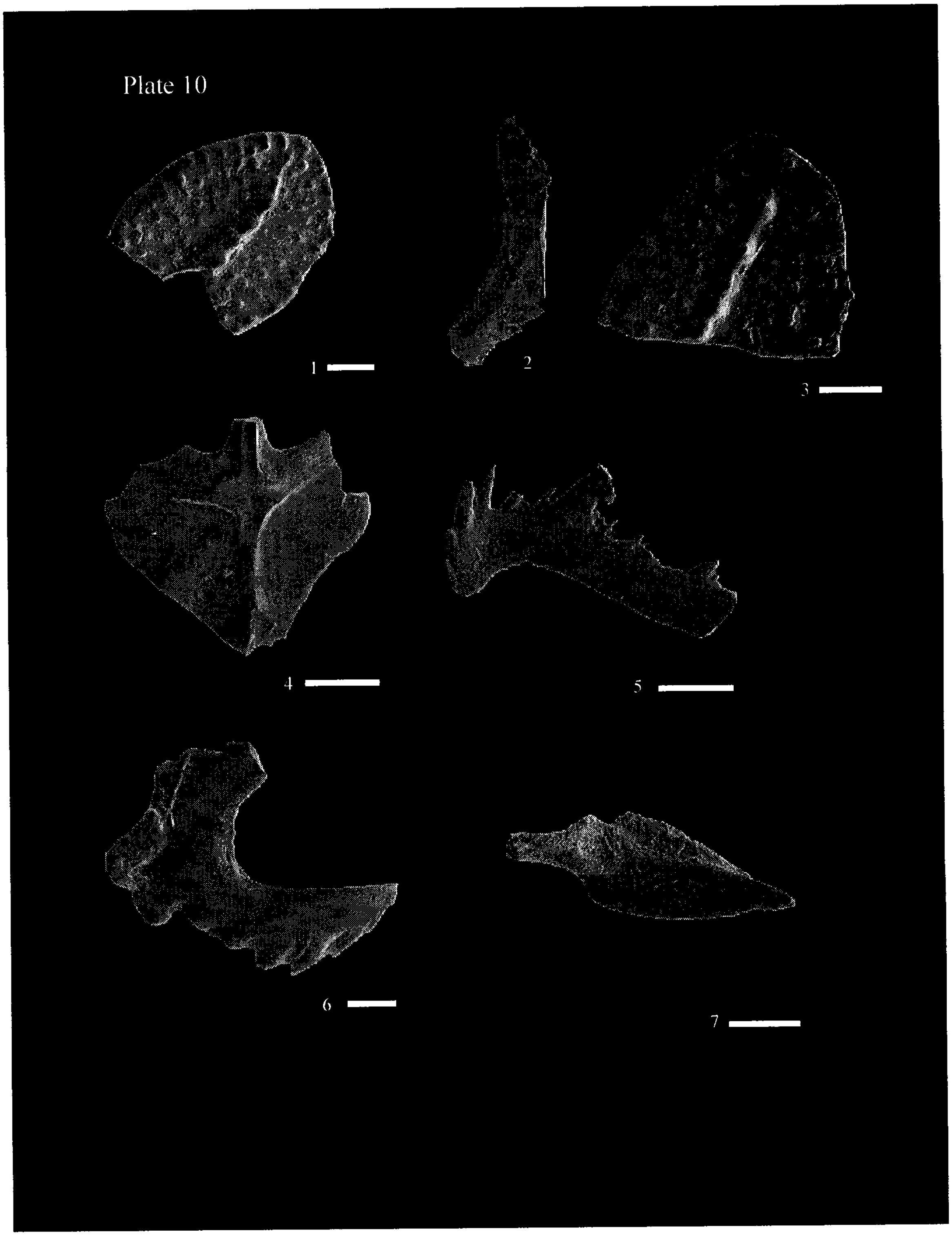


Plate 10
1
2
3
4
5
6
7

Appendix A

Radiolarian data from the Marys Mountain area, in the northeast quarter of the Emigrant Pass 7.5" quadrangle.

All age and fossil determinations made by Brian R. Cellura with assistance from Dr. Paula J. Noble, University of Nevada Reno, Nevada.

SAMPLE NUMBER	UTM NORTH COORDINATE	UTM EAST COORDINATE	TAXA PRESENT	PERIOD/EPOCH	FORMATION
Ep-98-01	4503440	562598	Bladed *entactiniidae*. This sample is located off the selected field area, the 98-series samples were used to determine the viability of the project. The project area was reduced at a later date.	Devonian or younger	Devonian Slaven equivalent
Ep-98-02	4505177	560246	*Helenifore laticlavium* *Entactiniidae* sp.? *Entactiniidae*	Devonian or younger Emsian to Eifelian	Devonian Slaven equivalent
Ep-98-04	4504177	562236	*Entactiniidae* This sample is located off the selected field area, the 98-series samples were used to determine the viability of the project. The project area was reduced at a later date.	Devonian or younger	Devonian Slaven equivalent
Ep-98-06	4503432	562600	Barren This sample is located off the selected field area, the 98-series samples were used to determine the viability of the project. The project area was reduced at a later date.		
Ep-99-01	4508355	560008	*Entactiniidae* sp.? *Stigmosphaerostylus* sp.?	Devonian or younger	Devonian Slaven equivalent

SAMPLE NUMBER	UTM NORTH COORDINATE	UTM EAST COORDINATE	TAXA PRESENT	PERIOD/EPOCH	FORMATION
Ep-99-02	4508405	560133	*Haplotaeniatum* sp.? *Orbiculopylorum* sp.? *Haplotaeniatum aperturatum* *Secuicollacta* sp.? Spumellarians	Silurian or older Llandoverian	Silurian Elder equivalent
Ep-99-03	4508208	560133	Age call based on lithologic comparison to other similar cherts around the project: e.g. Ep-99-02; Ep-99-05; Ep-00-25	Silurian or older	Silurian Elder equivalent
Ep-99-04	4508069	560173	*Protoceratoikiscum* - (lost) *Syntagentactinia* sp.? *Haplotaeniatum* sp.? Spumellarians	Ordovician	Ordovician Vinini equivalent
Ep-99-05	4508113	560173	*Secuicollacta* sp.? *Inaniguttids* sp.?	Silurian or older	Silurian Elder equivalent
Ep-99-06	4508152	560201	Barren		
Ep-99-07	4508510	560586	*Syntagentactinia* sp.? Spumellarians Age based on graptolite collection at Ep - 99-g03.	Ordovician	Ordovician Vinini equivalent
Ep-99-08	4508516	560737	Barren		

SAMPLE NUMBER	UTM NORTH COORDINATE	UTM EAST COORDINATE	TAXA PRESENT	PERIOD/EPOCH	FORMATION
Ep-99-09	4508394	561015	Barren		
Ep-99-10	4507921	561119	Age determination based on Ep - 9911.	Devonian Lower Middle Eifelian	Devonian Slav en equivalent
Ep-99-11	4507872	560884	*Ceratoikiscum Calvum* *Trilonche* sp.? *Entactiniidae* sp.?	Devonian Lower Middle Eifelian	Devonian Slaven equivalent
Ep-99-12	4507346	559807	*Secuicollacta* sp.? *Syntagentactinia* sp.? *Orbiculopylorum* sp.? *Haplotaenia tum aperturatum* Conical bulbous shaped grooved radiolarians.	Silurian Llandoverian	Silurian Elder equivalent
Ep-99-13	4507278	560073	*Ceratoikiscum planistellare* *Trilonche* sp.?	Devonian Upper Late Frasnian to Famennian	Devonian Slaven equivalent
Ep-99-14	4507093	560102	*Entactiniidae* sp.? Age determination based on Ep-99 13.	Devonian Upper Late Famennian	Devonian Slaven equivalent
Ep-99-15	4507149	560234	Age based on graptolites found at Ep-99 g5. Spongy *inaniguttid* *Entactiniidae* sp.?	Ordovician Caradocian	Ordovician Vinini equivalent
Ep-99-16	4507127	560409	Barren		

SAMPLE NUMBER	UTM NORTH COORDINATE	UTM EAST COORDINATE	TAXA PRESENT	PERIOD/EPOCH	FORMATION
Ep-99-17	4506536	560388	Barren		
Ep-99-19	4507326	559628	Barren		
Ep-99-20	4507514	559220	Spumellarians (latticed) Barren		
Ep-99-21	4506797	559581	*Secuicollacta* sp. Latticed Spumellarians	Silurian or older	Silurian Elder equivalent
Ep-99-22	4508975	562128	Barren		
Ep-99-23	4509070	562186	Barren		
Ep-99-24	4509172	562237	*Entactiniidae* sp.? *Holoeciscus* sp.?, H -frame	Devonian Famennian	Devonian Slaven equivalent
Ep-99-25	4509545	562257	*Archocyrtium* sp.? *Entactiniidae* sp.?	Devonian to Mississippian Famennian	Devonian Slaven equivalent
Ep-99-26	4509822	561827	*Archocyrtium* sp.? *Entactiniidae* sp.? *Holoeciscus* sp.?- H-frame *Trilonche* sp.? *Archocyrtium ormistoni*	Devonian to Mississippian Famennian	Devonian Slaven equivalent

SAMPLE NUMBER	UTM NORTH COORDINATE	UTM EAST COORDINATE	TAXA PRESENT	PERIOD/EPOCH	FORMATION
Ep-99-27	4509230	562003	*Entactiniidae* sp.? *Paleoscenidium* sp.?	Devonian or younger	Devonian Slaven equivalent
Ep-99-28	4509223	561994	Barren		
Ep-99-29	4508075	562104	*Trilonche* sp.? *Entactiniidae* sp.? *Paleoscenidium* sp.?	Devonian or younger	Devonian S laven equivalent
Ep-99-30	4507803	562399	*Entactiniidae* sp.?	Devonian or younger	Devonian Slaven equivalent
Ep-99-31	4507854	562553	Barren		
Ep-99-32	4507824	562617	Sponge spicules *Entactiniidae* sp.?	Devonian or younger	Devonian Slaven equivalent
Ep-99-33	4507830	562815	*Entactiniidae* sp.? *Stylosphaera* sp.?	Devonian or younger	Devonian Slaven equivalent
Ep-99-34	4507919	562857	*Entactiniidae* sp.? *Stigmosphaerostylus* sp.	Devonian or younger	Devonian Slaven equivalent
Ep-99-35	4508325	562113	Barren		
Ep-99-36	4506423	559440	Barren		

SAMPLE NUMBER	UTM NORTH COORDINATE	UTM EAST COORDINATE	TAXA PRESENT	PERIOD/EPOCH	FORMATION
Ep-99-37	4506317	559297	*Secuicollacta* sp.? *Orbiculopylorum* sp.?	Silurian or older	Silurian Elder equivalent
Ep-99-38	4506309	559232	Large spongy spumellarians.	Silurian or older	Silurian Elder equivalent
Ep-99-39	4506243	559149	*Entactiniidae* sp.? *Stigmosphaerostylus* sp.? *Ceratoikiscum calvum*	Devonian Eifelian	Devonian Slaven equivalent
Ep-99-40	4506276	558873	Sponge spicules *Entactiniidae* morphotype B *Trilonche* sp.? *Entactiniidae* morphotype A *Paleoscenidium* sp. *Archocyrtium* sp.?	Devonian Famennian	Devonian Slaven equivalent
Ep-99-41	4505540	559302	*Entactiniidae* sp.?		
Ep-99-43	4505127	560170	*Trilonche* sp.? *Ceratoikiscum calvum* *Stigmosphaerostylus* sp.	Devonian Eifelian	Devonian Slaven equivalent
Ep-99-44	4505213	559949	*Ceratoikiscum* sp.?	Devonian or younger	Devonian Slaven equivalent
Ep-99-45	4508518	561941	Barren		
Ep-99-46	4508872	561830	Spongy spum ellarians.		

SAMPLE NUMBER	UTM NORTH COORDINATE	UTM EAST COORDINATE	TAXA PRESENT	PERIOD/EPOCH	FORMATION
Ep-99-47	4509021	561906	*Haplotaeniatum* sp.? Silicified conodonts	Ordovician	Ordovician Vinini equivalent
Ep-99-58	4507246	559522	Barren		
Ep-99-59	4507246	559524	*Entactiniidae* sp.	Silurian or Devonian	Silurian Elder equivalent
Ep-99-60	4507283	559846	*Archocyrtium* sp. *Entactiniidae* sp.? *Entactiniidae* sp.? (tri-radiate) *Cyrtisphaeractenium crassum*	Devonian to Mississippian Famennian to Kinderhookian *Holoeciscus* 3 zone	Devonian Slaven equivalent
Ep-99-61	4507275	559981	*Trilonche* sp.? *Helenifore laticlavium* or *pilodisius*? *Entactiniidae* *Entactiniidae*	Devonian or younger Frasnian to Famennian	Devonian Slaven equivalent
Ep-99-62	4508140	560196	Barren		
Ep-99-63	4509048	562088	Barren		
Ep-99-64	4509045	561098	Barren		
Ep-99-65	4509365	561622	*Trilonche* sp.? *Trilonche ehinata*	Devonian or younger	Devonian Slaven equivalent

SAMPLE NUMBER	UTM NORTH COORDINATE	UTM EAST COORDINATE	TAXAPRESENT	PERIOD/EPOCH	FORMATION
Ep-99-66	4509366	561625	*Entactiniidae* sp.?	Devonian or younger	Devonian Slaven equivalent
Ep-99-67	4509821	561827	*Archocyrtium* sp.? *Stigmosphaerostylus* sp.?	Devonian to Mississippian Famennian to Kinderhookian *Holoeciscus* 3 zone.	Devonian Slaven equivalent
Ep-99-68	4509797	561800	*Entactiniidae*	Devonian or younger *Holoeciscus* 3 zone.	Devonian Slaven equivalent
Ep-99-69	4509746	561724	*Entactiniidae* sp.? *Paleoscenidium* sp.?	Devonian to Mississippian Holoeciscus 3 z one	Devonian Slaven equivalent
Ep-99-70	4509825	561660	*Archocyrtium* sp.? *Haplentactinia* sp.? *Cyrtisphaeractenium crassum* *Entactiniidae*. sp.?	Devonian to Mississippian Famennian to Kinderhookian *Holoeciscus* 3 zone	Devonian Slaven equivalent
Ep-99-71	4509839	561560	*Holoeciscus* sp.? H - frame *Paleoscenidium* sp.? (lost) *Archocyrtium* sp.? *Entactiniidae* sp.?	Devonian to Mississippian Famennian to Kinderhookian *Holoeciscus* 3 zone	Devonian Slaven equivalent
Ep-99-72	4509753	562012	Barren		
Ep-99-73	4510020	562030	*Holoeciscus* sp.? H - frame *Archocyrtium* sp.? *Entactiniidae* sp.? *Paleoscenidium* sp.? *Trilonche* sp.?	Devonian to Mississippian Famennian to Kinderhookian *Holoeciscus* 3 zone	Devonian Slaven equivalent

SAMPLE NUMBER	UTM NORTH COORDINATE	UTM EAST COORDINATE	TAXA PRESENT	PERIOD/EPOCH	FORMATION
Ep-99-74	4510230	562000	Barren		
Ep-00-01	4507886	560035	Barren		
Ep-00-02	4507694	560057	Spumellarian (tight lattice) *Paleoscenidium* sp.? *Ceratoikiscum calvum*	Devonian or younger Eifelian	Devonian Slaven equivalent
Ep-00-03	4507380	560252	Very poor preserved spumellarians	Silurian or older	Silurian Elder equivalent
Ep-00-04	4508795	560219	Very poor preserved radiolarians. Correlation bases on lithology and stratigraphic position.	Silurian Llandoverian	Silurian Elder equivalent
Ep-00-05	4508105	561739	Barren		
Ep-00-06	4507839	562659	Barren		
Ep-00-07	4507830	562797	Barren Age based on Ep -99-33.	Devonian or younger	Devonian Slaven equivalent
Ep-00-08	4508113	562695	*Trilonche* sp.?	Devonian or younger	Devonian Slaven equivalent
Ep-00-09	4509054	562497	Age call made from correlative conodont sample Ep -00-c05, sample taken from the same lithologic unit.	Devonian Eifelian to Givetian	Devonian Slaven equivalent

SAMPLE NUMBER	UTM NORTH COORDINATE	UTM EAST COORDINATE	TAXA PRESENT	PERIOD/EPOCH	FORMATION
Ep-00-11	4510784	563023	Barren		
Ep-00-12	4510751	562913	Age call made by association from radiolarians found in Ep -00-15.	Silurian Llandoverian	Silurian Elder equivalent
Ep-00-13	4510826	562912	Age call made by association from radiolarians found in Ep -00-15.	Silurian Llandoverian	Silurian Elder equivalent
Ep-00-14	4510923	562905	*Secuicollacta* sp. Spongy spumellarian	Silurian Llandoverian	Silurian Elder equivalent
Ep-00-15	4510681	562915	Large spongy spumellarians *Secuicollacta* sp. Silicified conodont	Silurian Llandoverian	Silurian Elder equivalent
Ep-00-16	4505854	561109	Barren		
Ep-00-17	4505986	560935	Barren		
Ep-00-18	4506369	560491	*Entactiniidae* sp.? *Ceratoikiscum calvum* *Trilonche* sp.	Devonian Eifelian	Devonian Slaven equivalent
Ep-00-19	4506527	560541	Barren		
Ep-00-24	4510724	562386	Barren		
Ep-00-25	4510099	562840	Barren		

Appendix B
Conodont data from the Marys Mountain area, in the northeast quarter of the Emigrant Pass 7.5" quadrangle.
All age and fossil determinations made by Dr. Gilbert Klapper, Iowa State University, Iowa.

SAMPLE NUMBER	UTM NORTH COORDINAT	UTM EAST COORDINATE	TAXA PRESENT	PERIOD/EPOCH	FORMATION
Ep-99-c1	4507384	560000	*Mesotaxis* sp.	Devonian-Lower upper Frasnian- lower	Devonian Slaven equivalent
Ep-99-c2	4507982	562029	*Mesotaxis ovalis* *Mesotaxis* sp. *indeterminate* *Ancyrodella* sp. *indeterminate*, *A recta* or *A. alata* *Icriodus subtermins:*	Devonian-Lower upper Frasnian- lower	Devonian Slaven equivalent
Ep-99-c3	4508710	562802	Barren		
Ep-99-c4a	4507181	560008	Barren- same lithologic unit as Ep-99-c1	Devonian	Devonian Slaven equivalent
Ep-99-c4b	4507181	560008	Barren-same lithologic unit as Ep-99-c1	Devonian	Devonian Slaven equivalent
Ep-00-c1	4506755	559470	Barren		
Ep-00-c2	4506421	559715	Barren		
Ep-00-c3	4506287	559628	Barren		
Ep-00-c4	4506364	559495	Barren		
Ep-00-c5	4509032	562545	*Polygnathus* sp.? *Polygnathus varcus* sp.?	Devonian- Middle Eifelian to Frasnian	Devonian Slaven equivalent
Ep-00-c6	4510896	563261	Barren		

SAMPLE NUMBER	UTM NORTH COORDINAT	UTM EAST COORDINATE	TAXA PRESENT	PERIOD/EPOCH	FORMATION
Ep-00-c7	4507192	561091	Barren		
Ep-00-c8	4510891	563261	Barren		

Appendix C

Graptolite data from the Marys Mountain area, in the northeast quarter of the Emigrant Pass 7.5' quadrangle.

All determinations made by Dr. Stanley C. Finney, California State University, Long Beach California.

SAMPLE NUMBER	UTM NORTH COORDINATE	UTM EAST COORDINATE	TAXA PRESENT	PERIOD/EPOCH	FORMATION
Ep-99-g01	4508330	560118	*Orthograptus ? quadrimucronatus* *Pseudoclimacograptus scharenbergi* *Cryptograptus* sp.	Ordovician Caradocian Zone 13	Ordovician Vinini equivalent
Ep-99-g02	4508242	560129	*Normalograptus persculptus.*	Ordovician Ashgillian Zone 15	Ordovician Vinini equivalent
Ep-99-g03	4508503	560481	*Orthograptus ? quadrimucronatus* *Pseudoclimacograptus scharenbergi* *Cryptograptus insectiformus* *Orthoretiolites ?* *Dicranograptus nicholsoni*	Ordovician Caradocian Zone 13	Ordovician Vinini equivalent
Ep-99-g04	4507638	560211	*Climacograptus ?* *Normalograptus ? tribuliferous* *Orthograptus* sp.	Ordovician Caradocian Zone 13 - 14	Ordovician Vinini equivalent
Ep-99-g05	4507100	560227	*Pseudoclimacogr aptus scharenbergi* *Cryptograptus insectiformus* *Orthoretiolites ?* *Dicranograptus nicholsoni* *Cryptograptus* sp.	Ordovician Caradocian Zone 12 - 13	Ordovician Vinini equivalent

SAMPLE NUMBER	UTM NORTH COORDINATE	UTM EAST COORDINATE	TAXA PRESENT	PERIOD/ EPOCH	FORMATION
Ep-99-g06	4506652	559867	*Dicellograptus complanatus* ?	Ordovician Caradocian to Ashgillian Zone 14 - 15	Ordovician Vinini equivalent
Ep-99-g07	4507349	559655	*Pseudoclimacograptus scharenbergi* *Orthograptus quadrimucronatus* ?	Ordovician Caradocian Zone 13	Ordovician Vinini equivalent
Ep-99-g08	4508726	561900	Several species indicative of Zone 13 of Berry	Ordovician Caradocian Zone 13	Ordovician Vinini equivalent
Ep-99-g09	4506211	562671	Several species indicative of Zone 13 of Berry	Ordovician Caradocian Zone 13 - 14	Ordovician Vinini equivalent
Ep-99-g10	4508186	560165	*Pseudoclimacograptus scharenbergi* *Orthograptus* ? *Cryptograptus* sp. *Cryptograptus bicornis* *Normalograptus* ?	Ordovician Caradocian Zone 12	Ordovician Vinini equivalent
Ep-00-g01	4506908	559303	*Orthoretiolites hami* *Normalograptus tubuliferus* *Orthograptus (Rectograptus)* sp. *Climacograptus* sp.(*C. spiniferus*) ? *Dicranograptus* sp.	Ordovician Caradocian Zone 13 or the *spiniferus* zone of the eastern U.S.	Ordovician Vinini equivalent

SAMPLE NUMBER	UTM NORTH COORDINATE	UTM EAST COORDINATE	TAXA PRESENT	PERIOD/EPOCH	FORMATION
Ep-00-g02	4508468	560361	*Pristiograptus jaegeri* *Pristiograptus dubius* *Pristiograptus ludensis*	Silurian Wenlockian Ludensis Zone	Silurian E lder equivalent
Ep-00-g03	4506146	560629	(Zone 13) *Orthograptus quadrimucronatus* *Climacograptus caudatus* (Zone 12) *Climacograptus brevis* *Dicranograptus nicholsoni* *Hallograptus*	Ordovician Caradocian Zone 13 Zone 12	Ordovician Vinini equivalent
Ep-00-g04	4509385	561076	*Pseudoclimacograptus* sp. *Phyllograptus* sp. *Glossograptus* sp.? *Orthograptus or Glyptograptus*	Ordovician Llanvirnian Zone 9	Ordovician Vinini equivalent
Ep-00-g05	4508050	561350	*Orthograptus quadrimucronatus* *Climacograptus caudatus*	Ordovician Caradocian Zone 13	Ordovician Vinini equivalent
Ep-00-g06	4507881	560627	*Climacograptus bicornis* *Orthograptus calcaratus acutus* *Hallograptus* sp. *Corynoides calicularis* *Dicranograptus nicholsoni*	Ordovician Caradocian Zone 12	Ordovician Vinini equivalent