

Official Publication of <u>Mid-America Paleontology Society</u> Volume 21 Number 4 EXPO XX EDITION, 1998





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M.A.P.S. DIGEST

EXPO XX EDITION

<u>MID-AMERICA</u> <u>PALEONTOLOGY</u> <u>SOCIETY</u> A LOVE OF FOSSILS BRINGS US TOGETHER

Western Illinois University Union Ballroom Macomb, Illinois 614665 April - 1998

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ACKNOWLEDGEMENT

CORALS

A Coral Reef is like a beautiful under water landscape. This artestry is an achievement of mother nature, and can only be created by her. If only we humans could create such a scene as effortlessly as she seems to. Corals have been the beauties of the seas from Ordovician to present. There are solitary individuals and colonial, The corallites in compound coralla may be crowded; in which case they are generally prismatic in form or they may be far apart. A good example of beautiful colonial coralla is the *Lithostrotionella* (Cover) of prismatic corallites. The Feather Corals, so beautiful and so delicate are new to me, I saw them for the first time at the 1997 EXPO, and of course I had to have a slab; another good example of this landscape is the photographs of Bob Guenther, Ernest Hammons and Jean-Guy Pellerin.

Imagine how pleased I was when I read Professor Sorauf's article and found that he also has an eye for their beauty.

It is with a greatful heart that I want to recognize the AUTHORS and ARTISTS of this issue of the EXPO Digest. The artistry of Don Auler has surpassed all expectations, he is so talented. The AUTHORS......well--- what can I say ?? Bruce Stinchomb, his earliest corals. Tom Witherspoon and the Canadian corals; Alan Goldstein with his identification lists; Robert Elias, corals of the Ohio Valley and Greenstein,with the comparison of life and death assemblages and their professional expertise; Albert Hines with his delightful field trip and Mark and Keith Behrendt with their terminology, but for them we would not have this EXPO EDITION. Each one, in their special way with their contributions make issues of the Digest a source of reference which aid in the identification of our specimens and a printed source for locations where we can collect them.

The Mid - America Paleontology Society was formed to promote popular interest in the subject of paleontology, to encourage the proper collecting, study, preparation and display of fossil material; and to assist other individuals, groups and institutions interested in the various aspects of paleontology. It is a non-profit society incorporated under the laws of the State of Iowa.

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COVER STORY

CORALS Front Cover - A rugose coral - Lithostrotionella Mississippian

age was found on an Esconi field trip twenty (20) years ago in southeast lowa. It was semi buried in an overgrown spoil pile on top of the quarry. A number of small clumps were found and three (3) large ones. I only found this one and it was the smallest of the three. The drawing is 3/4 actual size, preparation: just washing off the mud.

Back Cover, The **Pachyphyllum nevadense** was found in Gila County Arizona, Martin Limestone Formation, Devonian age. Found while hunting with the Konecny's a few years ago. The fossils are the same as Rockford Brick and Tile - Iowa, except there are several forms of **Pachyhyllum** and are more numerous than at Rockford.



P.A.

Chain coral - Halysites Glacial Drift N. Illinois



Hexagonaria Manchester, IA (Sil.)



Button coral Microcyclus thedfordensis Hungry Hollow Fm. Arkona Canada (Dev.)

Horn coral - Hungry Hollow Fm. (Sil.) Arkona. Canada (Dev.)

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CORALS, PAST AND PRESENT

James E. Sorauf Binghamton University, Binghamton, N.Y. 13902-6000

The greatest paleontologist Australia ever produced, Professor Dorothy Hill, died this past summer. All of her research efforts, which were prodigeous and lasted for more than a 60 year period, were focused on fossil corals and calcified sponges. She was the world expert on the overall aspects of Paleozoic corals, the Rugosa and Tabulata (Hill, 1956; Hill, 1981; Hill & Stumm, 1956). Why did she study fossil corals? In 1963 she told me that she had originally been attracted to corals because she found them aesthetically appealing. Later she realized that they are also very interesting research objects. The corals are truly beautiful, yes, and also important to our world ecosystems. 1997 was the year of the coral reef, emphasizing, among other things, that coral reefs have a major role as CO_2 sinks, as they tie up very large amounts of carbon in skeletal CaCO₃. If all modern coral reefs were put together in one place, their total area would be more than large enough to warrent labeling it another continent, perhaps larger than Greenland. The present day Great Barrier Reef of Australia is approximately 2000 km long with a width up to 280 km, occupying a total area of 105,000 km². In the geologic past we have had periods of reef building that would eclipse the present. Oil finders in western Canada explore in Devonian fringing and barrier reefs that total more than 5,000 km in length and as reservoirs have provided more than ¹/₂ of Canada's total oil reserves. The "Devonian Great Barrier Reef" of the Canning Basin in Western Australia is more than 400 km in length and up to 50 km in width, and this only accounts for the visible part of the reef complex. And, reefs are only the handiwork of billions and billions of very small coral polyps (plus other, associated reef organisms).

Corals: Zoological Classification.

When paleontologists refer to corals, they are almost invariably referring to modern and fossil "stony corals"(Text-fig.1), that is, cnidarians which have a carbonate exoskeleton built under the control of the basal flesh of polyps. The Phylum Cnidaria comprises animals characterized by two cellular layers in their flesh and by the presence of stinging cells which allow the animals to function as microcarnivores, capturing food with stinging cells in their tentacles (Text-fig.2) and ingesting it through their mouth. By far the greatest number of modern and fossil stony corals belong to the Class Scleractinia, which have a geologic history extending from early in the Mesozoic Era to the modern oceans, and the Class Rugosa and Class Tabulata , extinct Paleozoic corals which are present in the geologic record from the Ordovician System to the Late Permian.

The Phylum Cnidaria contains a variety of forms, many of which do not have fossilizable hard skeleton. These include both jellyfish (medusae) and polyps (Text-fig.2). The forms with skeleton (all are polyps) include modern Octocorallia and Paleozoic Heterocorallia as well as the groups with more numerous skeletal forms noted above. Additionally, in the past few years we have come to realize that skeletonized corals or coral-like animal polyps were involved in the earliest Cambrian radiation, when invertebrates first gained exoskeletons, 545 million years ago.

The individual coral skeleton is the result of daily, incremental addition, at the base of each polyp (commonly only several mm in diameter) of a film of calcium carbonate less than 1 mm

thick. The aggregate affect of this incremental growth of skeleton in numerous colonial coral polyps, or on a somewhat larger scale associated with a solitary coral polyp (Text-fig. 1), is the exoskeleton that we call the coral (actually more properly called the corallum), formed of longitudinal and transverse structures (Text-fig.3).

The age of solitary coral polyps can generally be measured in tens of years, but based on analysis of annual growth increments (bands), colonies have been calculated to survive to a maximum colony age of more than 500 years. One such modern colony is the so-called "Columbus Coral" which has been core drilled in the Florida Keys and estimated to have been alive when Columbus landed. Counting visible growth increments or daily growth lines on the coral exterior (Text-fig.1) has allowed calculating the number of days (Wells, 1963) or lunar months (Scrutton, 1965) within individual years in the Paleozoic periods (when years had a larger number of shorter days than at present due to changes in the rotation of the earth, which is slowing somewhat, apparently due to the gravitational pull of the moon).

As the life history of a coral or coral colony is recorded in the skeleton, it is readily available to us for the study of progressively earlier stages of coral growth as they are reflected by the skeleton. It is possible to study the (almost) complete post-larval life history of skeletogenesis in solitary corals (Text-fig. 4), thus finding how and in what sequence their skeletal structures were formed. In colonial corals it is possible to study the mode of asexual reproduction, where and how it occurred (whether lateral or axial to existing corallites), whether it was parricidal costing the parent its life, and in short, providing abundant information regarding the paleobiology of the fossil cnidarian organisms.

Because corals are "stay-at-homes", fixed in place, they also serve as excellent indicators of ancient geography and ancient climates. Just as highly mobile fossil faunas, such as those composed of swimmers (like cephalopods) are useful for their occurrences in a number of facies and useful for correlation of rocks from different environments, so the immobility of fossil corals is of great use in the study of marine environments, biogeography and faunal provinciality.

Corals: their history.

The history of the corals divides itself into periods of radiation accompanied by evolution of great diversity of forms (taxa), but punctuated by times of extinction, with the widespread disappearance of great lineages.

Triassic to Recent Scleractinia. The scleractinians first appeared on the geological scene during the Middle Triassic Epoch, the result of a non-calcified group of soft-coral (actinarian) polyps developing the ability to form skeleton. The group radiated to fill ecologic niches that had been left vacant by the Late Permian extinction of diverse faunas of Paleozoic corals. Many of the new Scleractinia had (and have) the added attraction of a symbiotic relationship with single-celled photosynthesizers, dinoflagellates referred to as zooxanthellae. This general term, zooxanthellae, covers a group of dinoflagellate species belonging to the genus *Gymnodinium* that live in the coral mesogloea and aid in the coral's metabolism, but when stressed escape through the gut, growing a flagellum to swim out the polyp mouth into seawater. Scleractinians thus fall into groups, one composed of zooxanthellate corals (Text-fig.5), requiring sunlight for photosynthesis by their symbionts, and the other the nonzooxanthellate corals (Text-fig.6), which have been found living nearly 6000 m deep (Chevalier, 1987, p. 655) in modern oceans and colonizing cold water shelf

areas as far north as Norway. There are also scleractinians which can be either zooxanthellate or nonzooxanthellate, depending on where they are living.

Scleractinians also are either colonial or solitary in their occurrences, and there are zooxanthellate solitary and colonial corals (Text-fig.5), and there also are nonzooxanthellate solitary and colonial corals (Text-fig.6). There is a preponderance of solitary and/or branching colonies within the nonzooxanthellate scleractinians, with many of them being solitary (or horn shaped). The zooxanthellate corals are the reef-dwelling (hermatypic) corals in large part, and massive colonial skeletons (Text-fig.5) or large solitary skeletons predominate among this group of genera and species.

The scleractinian corals are recognizable by the age of their occurrence, Triassic to Recent, and also because of their 6-fold symmetry, both internally and externally. Additionally, during their growth, they added mesentaries to their gut six (or a multiple of six) pairs at a time, thus their skeleton is marked generally by the appearance of septa six (or a multiple) at a time, as cycles (Text-fig.7a). The symmetry and cyclicity of septal development remains generally true, but as often is the case, in reality, some scleractinians vary from the straight cyclical mode of septal increase (Text-figs.7b-7f). Scleractinians also differ from Paleozoic rugosans in that they construct their skeleton from the unstable form of $CaCO_3$, the mineral aragonite, rather than more stable calcite.

Ordovician to Permian Rugosa and Tabulata. The rugose corals, or Rugosa are the Paleozoic septate corals (Text-fig.1), possessing blade-like septa within their coralla. It is assumed that these septa appeared between pairs of mesentaries, just as in the Scleractinia. However, the order of appearance of septa in the Rugosa is fundamentally different from their cyclical appearance in the Scleractinia (Oliver, 1996; Scrutton, 1997). The Rugosa have a rather particular mode of emplacement, first six protosepta, then the remainder of major septa which appear in four quadrants within the corallum (Text-figs. 8a-e), finally with a complete set of short septa called minor septa appearing simultaneously as a final cycle (Text-fig.8f). These skeletonized corals apparently arose from nonskeletonized polyps (Text-fig.9), much as the later scleractinian ancestors of Mesozoic and Cenozoic scleractinians. Rugosa occur both as solitary (or horn corals) and as colonies, while Tabulata lack septa, and are all colonial. The rugosans occur in all of the colonial forms that are recognized in the younger Scleractinia, and almost all of the forms seen in the exclusively colonial Tabulata.

We also recognize that the Paleozoic corals built their skeletons in roughly the same way as do younger scleractinians, although some have skeletal characters that are unknown in the Scleractinia (Text-fig.10). In all corals, the addition of skeletal carbonate to skeleton is incremental, generally added on a daily basis, and fossil taxa have the same types of framework structures as do the Scleractinia, both transverse and longitudinal in nature (Text-fig.3).

However, the Rugosa and Tabulata both constructed their skeletons with the stable form of $CaCO_3$, calcite, with minor amounts of magnesium present along with the preponderance of calcium in the calcium carbonate mix, while the Scleractinia utilize the less stable form of $CaCO_3$, aragonite, with trace amounts of strontium in the aragonite lattice, and do so with organic matrix proteins controlling the rate and configuration of the aragonite biocrystals. We also do not know for certain which groups of the Paleozoic corals were zooxanthellate, if any. In addition,

numerous questions exist regarding the early life history of rugosans, and most especially, the relationships between observable structures in fossilized skeleton and original, biogenic skeletal microstructure and later, diagenetically caused skeletal microstructures.

Cambrian coralomorphs and corals. In addition to the well-known Rugosa, Tabulata and Scleractinia, corals and coral-like skeletons have recently been studied from the Cordilleran Region of the U.S. and Canada, from Siberia, and from South Australia. Some of these were quite similar to younger corals and can be easily accepted as such, but some are quite different and probably don't represent skeletons of coral-like animals. Whether these were truly cnidarian polyps or not, they were reef and near-reef dwellers that produced a calcified skeleton in ways that are similar or identical to the ways that Paleozoic corals built skeleton. They are generally not accepted as belonging to the major groups of Paleozoic corals (the Rugosa and Tabulata) because of the time gap between Lower or Middle Cambrian occurrences of these, and the Lower Ordovician age of the oldest fossil corals widely recognized as Tabulata or Rugosa (Text-fig.9). The Lower Cambrian Tabulaconida and Middle Cambrian Cothoniida made their skeletons in very similar ways to younger corals. So, at the very least we have the record of an early experiment in making exoskeleton by coral-like polyps. At this time (Early Cambrian) of most profound change in multicellular invertebrates, when animals first formed hard parts, either shells or exoskeletons, cnidarian polyps formed exoskeleton. The reef-dwelling forms, the Tabulaconida, became extinct at the end of the Lower Cambrian Epoch, as did the other prominent type of reef dweller, the archaeocyathan calcified sponges.

Skeletal Structure and Skeletogenesis.

Skeletal elements are formed unilaterally and bilaterally, and are longitudinal and transverse (Text-fig.3). The longitudinal and bilateral skeletal elements of corals are intercorallite and some external walls (some of the latter are unilateral), present in all groups of corals, Scleractinia, Rugosa and Tabulata; and septa, present in the Scleractinia and Rugosa, but developed at the most as spines or spine-like structures on the walls of tabulate corallites. Unilateral transverse structures in the Scleractinia are platform like features developed and occurring between septa, called dissepiments. In the Rugosa, dissepiments also occur between septa, thus are generally restricted to the peripheral, non-axial portion of the corallite (the name for skeleton of an individual in a colony). In the axial area of rugose corals occurs an area characterized by tabulae, platforms formed just as dissepiments, but generally larger and more widely spaced than the dissepiments (Text-fig.3). The colonial Tabulata do not have septa or dissepiments, but rather, have tabulae, which give the name to the group, the Tabulata, because they dominate the interior architecture of individual corallites in tabulate colonies (Text-fig.11).

Tabulae and dissepiments of all three major groups of corals through history have been formed in very similar ways, as platforms of crystallites growing centripetally from walls or septa. These are truly analogous structures, and suggest that polyps of each group functioned in very similar ways to produce these skeletal elements. It is worrisome to some paleontologists that the Scleractinia make their skeleton of aragonite, while the Rugosa and Tabulata made theirs of calcite, suggesting to them that the biology of the fossil groups did not truly resemble that of modern corals. An example of this is the approach of Wang, who differentiated between two basically different types of skeletal microstructure in the Rugosa, in which one has fibrous crystallites as the basic building blocks, while another would have utilized "flakes" to build skeleton that is lamellar in nature (Text-fig.12). I do not agree with this position, but rather consider that all corals have built skeleton out of elongate, fibrous biocrystals under the control of organic matrix.

The study of biomineralization in modern and fossil corals has been fascinating for many researchers around the world. We are learning much about how skeleton is being formed in living corals and how it has been formed in ancient ones. It is now certain that the crystals that make up the modern coral skeleton are biocrystals, formed as composite crystals under the influence of matrix proteins secreted by the basal flesh of coral polyps (Text-fig.13). These matrix proteins have now been isolated in modern scleractinians and also from very well preserved scleractinians as old as Triassic (Text-fig.14) from corals with skeletons featuring a fibrous microstructure and an aragonitic mineralogy.

Geological record: Fossil Corals and Reefs.

When we think of the geological history of corals, we commonly are considering the geological record of reef-building. The corals are part of the reef-constructors guild, and additionally, were very prominent dwellers in warm, shallow waters wherever sufficient carbonate was available (remember that carbonate in sea water is less soluble with elevated temperatures). Modern corals occur in sea water of normal salinities, at depths from low tide to more than 6000 meters (Wells, 1956, Chevalier, 1987), thus, from extreme depths in equatorial waters to a maximum of 350 m on the Norwegian Shelf, depending on living conditions necessitated by symbiotic organisms. The geologic record of fossil corals and coral reefs is closely tied to the appearance of limestones and/or dolomites in the stratigraphic record, most especially reefal and peri-reefal carbonate rocks, in great part because these carbonate rocks are the geologic record of warm, tropical or subtropical marine shelf areas throughout time..

Lower Cambrian - In the Early Cambrian, reefs were first built by archaeocyath calcified sponges, but additionally we have noted numerous corals and coral-like organisms that likewise have skeletons. Some are very coral-like, such as one known as *Moorowipora* from South Australia. These first corals were probably not closely related to later Paleozoic tabulate corals, but were undoubtedly polypal animals who constructed skeleton in a very similar or identical way to that in some of the Tabulata (Text-fig.9).

Lower Ordovician - The geologic record preserved in Lower Ordovician rocks shows the beginnings of a tabulate coral record, and additionally, features the first coral reefs, in the Chazy Group of New York State. As we progress through the Ordovician, both tabulate and rugose corals become abundant, and both are important components of shallow water shelf faunas of the time. The latest Ordovician is marked by an extinction event which seems to be climate-related, with effects on tropical faunas that are not yet totally clear.

<u>Silurian</u> - There are Middle Silurian, Niagaran reefs encircling the Michigan Basin, thus occurring in Wisconsin, Illinois, Indiana and Michigan, as well as in Ontario (best exposed on Manitoulin Island). Reef and reef-associated deposits in northern Indiana and Illinois (as at Thornton Quarry) have been studied in detail. The subsurface of Illinois and Michigan has produced oil and gas, so that these reefs are also of interest economically.

Devonian - Huge reefs occur in the Williston Basin and also in Western Canada basins, in

Alberta, British Columbia and the Northwest Territories, where stromatoporoid sponges are major contributors to reef building, but where both rugose and tabulate corals are abundant. Closer to home, the shelf deposits of Illinois, Michigan and Iowa are characterized by abundant and interesting rugose and tabulate corals. At the boundary between the Frasnian and Famennian Stages (lower and upper, Upper Devonian) there was a major extinction event that is well documented, both in Rugosa and Tabulata (Text-fig.15), and this brought an end to widespread reef building..

<u>Mississippian, Pennsylvanian and Permian</u>. - After the late Frasnian extinction event, it was only towards the end of the Devonian Period (late Famennian), that the faunas of rugose and tabulate corals once again began to radiate and evolve into rather widespread faunas of the Mississippian limestones of the midcontinent region. There was a gradual overall decline in the Paleozoic coral groups, interrupted by evolutionary bursts in various parts of the world during the Permian Period, prior to their final exinction towards the end of the Permian.

<u>Triassic</u> - This is the time of appearance of the scleractinian corals, some of which were most certainly zooxanthellate, and beginning in the middle of the Triassic, large, modern-appearing reefs were constructed in the southern portion of today's Europe. Anyone who has traveled in the Alps has seen these reefs forming thick carbonate complexes of the Northern Limestone Alps.

<u>Jurassic and Cretaceous</u>. - After a minor extinction event the Scleractinia rebounded, but are only locally reef builders. Especially, the later Cretaceous was a time of widespread chalk deposition, with rudist bivalves forming reefs in Mexico and in Mediterranean regions, while the first compressional phases of Alpine deformation in Europe led to inhospitable conditions for reefbuilders, although some zooxanthellate corals are associated with reefs of the Alpine region. Nonzooxanthellate corals were also present in deeper parts of the alpine trough.

<u>Cenozoic</u> - Starting with the basal carbonate deposits of the Tertiary, the Danian, deep water reef-like thickets are abundant. From then, the scleractinian corals have evolved and radiated to occupy numerous niches today, in the late Quaternary. These niches vary from deep cold water shelves occupied by nonzooxanthellate corals, to reef and near reef environments in the Caribbean and Indo-Pacific regions. The great reefs of the Pacific are the largest organic edifaces of the modern world, and the dimensions of the Great Barrier Reef of Australia are most impressive.

Fossil Corals occurring in Mid-America.

Late Ordovician and Early Silurian. There have been an excellent series of studies of beautifully preserved Late Ordovician and Early Silurian corals by Bob Elias and Graham Young of Manitoba (1990,1995, among others). These two paleontologists have reported on some very detailed work, with large amounts of excellent geographic and stratigraphic information published along with the corals themselves. There is a mountain of work that can be done as followup research to what has been published, in order to understand the detailed effects of the Late Ordovician extinction event on faunas of the North American cratonic seas.

<u>Middle Silurian</u>. Corals are associated with Middle Silurian reefs of the Midcontinent area. How to study them has perplexed students of fossil corals for a long time because the carbonate rocks and included corals are dolomitized, thus many of them are preserved as molds.

Probably they are found perplexing by people such as me because we can't study them using the same (time-tested) methods that we generally use to study fossil corals. The time is right for an innovative study of these reef corals and coral reefs.

<u>Middle Devonian</u>. Throughout the southern midcontinent region, limestones of Middle Devonian age (Cedar Valley and equivalents) have lots of lovely, well-preserved corals. These can easily be studied in polished and etched sections by acetate peel methods. The Cedar Valley corals and equivalent faunas have only had one paper published on them (Pitrat, 1962) since the 1940's, when Merrill Stainbrook of Brandon, Iowa studied some of them (Stainbrook, 1940). The corals are readily seen at the Falls of the Ohio, and can be collected at limestone quarries in the area extending from Ohio through southern Indiana, as far west as Iowa. The carbonates have recently been restudied with a sequence stratigraphic approach, and additional coral studies are needed to place faunas into this new framework for understanding of depositional dynamics of the region.

<u>Upper Devonian</u>. The strata are quite well known, centering on northern Iowa. There are all sorts of things to do following up on the recent work of Sorauf (1998). Wherever possible, collect populations and do population statistics, as quality outcrops tend to be somewhat shortlived in this area. Look at variation within genera and species and make basic contributions to our knowledge of these corals. Study external forms and make inferences regarding life styles and living conditions (Text-fig.17). Illustrated and type specimens of all taxa can be seen in museums such as the Paleontological Research Institution and the Museum of Paleontology of the University of Iowa, the Field Museum of Natural History in Chicago and at the University of Michigan Paleontological Museum in Ann Arbor. There is still a lot to learn from these collections.

<u>Mississippian, Pennsylvanian and Permian</u>. There are numerous corals in the St. Louis Limestone of Mississippian age, and additionally, there are really interesting environments represented in these carbonate rocks (Text-fig.17). Nobody knows (apparently) what the exact distribution of genera and species of corals is within this sequence. In the Pennsylvanian and Permian cyclothems of Iowa, Missouri and Kansas there also are abundant corals, some of which have been studied by Jim Cocke, but many of which have not. There are lots of possibilities for research on these corals, especially in relating them to newly developed sequence stratigraphic interpretations of cyclothems. It is also possible to collect very large populations of some species, and one can again do some truly useful population studies of variation in these, as well as studying the early postlarval development of their coralla.

How "Part-time" Paleontologists can do Great Things.

There has been a hesitancy on the part of part-time paleontologists to deal seriously with fossil corals, probably in part because of a perceived necessity to deal with the technical side of making and photographing thin sections, microscopic study of thin sections, and perhaps also because of difficulties in defining species and genera of fossil corals. On the face of it, this is a daunting situation, and discourages a lot of amateur paleontologists from study of this group. Additionally, these are the difficulties that discourage full-time paleontologists from studying these fascinating fossils, especially those who lack the technical support of a research laboratory. But, there are ways! Be clever! Dieter Weyer, a friend and student of Devonian and

Carboniferous corals from Magdebourg, formerly in East Germany told me in 1979, "I am forced to work with simple tools, so I must choose my research topics carefully". So he did not use electron microscopes, but today he is very widely quoted, and he has made fundamental contributions to our understanding of the serial appearance of septa in the Rugosa. How about you? Be stratigraphically accurate, accurate about locality information, place fossil corals in described sequences of strata. If you don't have access to thin sectioning equipment, use acetate peels of acid-etched transverse and longitudinal sections of corals to study them and to illustrate them photographically (Sorauf & Tuttle, 1988). Make systematic studies of external features that reflect their biology and contribute to our understanding of the paleobology of Paleozoic corals (Text-fig.17). It also is immensely satisfying to present a well-documented collection of corals to a museum or a group of researchers, who will most certainly invite you to join in with their studies.

If you want to study specimens from a museum or use some equipment such as a microscopes, it might be necessary to get an "associate", a full-time paleontologist from your local college or university. They are remarkably friendly people who will welcome you into their midst, providing you wish to do serious work, even if you are only able to do it on a part-time basis. You will be surprised to find that many or most of the "full-time paleontologists" only get to spend a few hours a week at their research, which is also truly a labor of love for them.

Conclusions.

1.) You are blessed with numerous and interesting coral-bearing outcrops in the Mid-America region. In some instances much basic information about fossil coral species has already been collected (and you have convenient bases to build on); in other instances there is very little known, providing a real opportunity for new workers and new findings.

2.) One need not have a thin section laboratory to study fossil corals, but it helps to have access to a microscope and polishing equipment. To study the internal geometry of coral skeletons you will need to make thin-sections, acetate peels, or else figure out how to get information on internal architecture through external features.

3.) Anyone living in the Mid-America region has multiple opportunities to collect large populations of fossil corals of Paleozoic age. This in turn offers possibilities for studies of variation and adaptation of coral species to varying sea-floor conditions. Studies of large populations of species are needed to evaluate species that are overly typological, that is, to much tied to an invariable (or little varying) species concept based on a single type specimen.

4.) Finally, as Dorothy Hill understood long ago, the corals really are lovely fossils from a purely esthetic point of view, and provide lots of joy to the students of them.

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TEXT FIGURES

Text-fig. 1.- *Bethanyphyllum robustum* (Hall), Hamilton Group, Middle Devonian, New York, x 1 magnification, changed somewhat from Hill, 1956. This is the corallum of a solitary rugosan, as shown in lateral view (a.), possessing a "horn" shape, which gave rise to the term "horn corals", but more importantly, illustrating the rugae, or growth crenulations on the corallum exterior, reflecting seasonal or more frequent change in coral diameter. In calicinal view (b.) the septa are apparent in the cup or calice of the corallum, the depression that housed the basal part of the coral polyp during life. Such solitary corals occur both in the Class Rugosa and in the Class Scleractinia.

Text-fig. 2.- Diagram to illustrate extremely simplified drawings of the two principle morphologies within the Phylum Cnidaria, polyps (a.) and medusae (b.). Focusing on the position of mouth and tentacles, it seems that one form approaches (but doesn't attain) the inverted image of the other. Since medusae (or jellyfish) are vagrant floaters, no attachment features are present, while the sessile polyps are fixed to substrate, and in the stony corals, form exoskeleton directly on solid substrate and are immobile. The three layered wall indicated here consists of two cellular layers, the endoderm and ectoderm, with a medial non-cellular layer the mesogloea (the jelly of jellyfish). This medial layer also provides a suitable place for symbiotic dinoflagellates (photosynthesizing protistans) which lodge there in numerous modern shallow water corals. Source of the diagram is Stearn and Carroll, 1993, p. 95.

Text-fig. 3.- A simplified diagram to show the relationship between the coral polyp and the coral skeleton. The coral polyp has tentacles, bodily extensions containing numerous stinging cells for protection or food gathering; an oral disk surrounding the gullet and mouth; and a gut which is divided by fleshy, blade-like mesentaries which provide substrate for an expanded area of digestive tissue and for attachment of longitudinal muscles for the retraction of coral polyps. Beneath the basal ectoderm of the polyp is formed the skeleton, formed of a bounding wall in most cases, axially positioned platforms termed tabulae (singular; tabula) and more laterally positioned platforms, the dissepiments. In the Paleozoic Rugosa and younger Scleractinia, blade-like septa (or sclerosepta) are formed between pairs of mesentaries. Thus the configuration of the septa, dissepiments and tabulae of the skeleton can be regarded as a biogenic cast, at any one time, of the configuration of the base of the polyp, its gut and the mesentarial divisions of the gut. Diagram taken from, and modified from Stearn and Carroll, 1993, p. 96.

Text-fig.4.- Growth sequence through an Upper Ordovician solitary rugose coral from Sweden, *Borelasma crassitanga* Neuman. Diagram taken from Hill, 1981, Figure 82, p. F151, but derived from Neuman, 1969. The outline (a.) of the corallum in longitudinal view shows the relative position of the series of transverse sections through the developing coral (b.-g.), illustrating the progressive increase in septal numbers and development of symmetry during the life history of the species, all drawings x3 magnification.

Text-fig.5.- Modern colonial zooxanthellate, reef-dwelling (hermatypic) corals, (a.), *Goniastrea* sp. and (b.), *Montastrea* sp. Each drawing taken from Chevalier, 1987, fig. 409, p. 715, both with magnifications unstated, but approximately x3 or x4. Massive colonial forms are very commonly seen in the zooxanthellate scleractinians.

Text-fig. 6.- Modern nonzooxanthellate scleractinian corals in external view, with solitary deep-water corals here typified by *Caryophyllia* sp. (Chevalier 1987, Fig. 415, p. 738), magnification unstated, but approximately 2x., and the colonial nonzooxanthellate branching colonial coral *Bathelia* sp., derived from Chevalier, 1987, Fig. 413, p. 727, with magnification approximating 0.7x. The solitary nonzooxanthellates are typically horn-shaped, and colonial forms are typically branching. These corals live in waters as deep as 6000 m and as far north as the Norwegian Shelf in the Atlantic Ocean.

Text-fig. 7.- Septal insertion in the Class Scleractinia. 7a, generalized diagram of septa illustrating perfectly cyclic insertion of 4 cycles of septa. 7b, generalized diagram of ovoid coral with additonal insertion of 5th cycle septa at elongate portion of corallum. 7c through 7f, diagrams to illustrate the development of an ovoid-shaped corallum with exaggerated insertion of 3rd, 4th and 5th cycle septa in the elongated portion of the corallum, where continued expansion provides space for additional septa. Diagram modified from Chevalier, 1987, p. 515.

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Text-fig. 1.- Bethanyphyllum robustum (Hall), Hamilton Group, Middle Devonian, New York, x 1 magnification, changed somewhat from Hill, 1956. This is the corallum of a solitary rugosan, as shown in lateral view (a.), possessing a "horn" shape, which gave rise to the term "horn corals", but more importantly, illustrating the rugae, or growth crenulations on the corallum exterior, reflecting seasonal or more frequent change in coral diameter. In calicinal view (b.) the septa are apparent in the cup or calice of the corallum, the depression that housed the basal part of the coral polyp during life. Such solitary corals occur both in the Class Rugosa and in the Class Scleractinia.



Text-fig. 2.- Diagram to illustrate extremely simplified drawings of the two principle morphologies within the Phylum Cnidaria, polyps (a.) and medusae (b.). Focusing on the position of mouth and tentacles, it seems that one form approaches (but doesn't attain) the inverted image of the other. Since medusae (or jellyfish) are vagrant floaters, no attachment features are present, while the sessile polyps are fixed to substrate, and in the stony corals. form exoskeleton directly on solid substrate and are immobile. The three layered wall indicated here consists of two cellular layers, the endoderm and ectoderm, with a medial non-cellular layer the mesogloea (the jelly of jellyfish). This medial layer also provides a suitable place for symbiotic dinoflagellates (photosynthesizing protistans) which lodge there in numerous modern shallow water corals. Source of the diagram is Stearn and Carroll, 1993, p. 95.



Text-fig. 3.- A simplified diagram to show the relationship between the coral polyp and the coral skeleton. The coral polyp has tentacles, bodily extensions containing numerous stinging cells for protection or food gathering; an oral disk surrounding the gullet and mouth; and a gut which is divided by fleshy, blade-like mesentaries which provide substrate for an expanded area of digestive tissue and for attachment of longitudinal muscles for the retraction of coral polyps. Beneath the basal ectoderm of the polyp is formed the skeleton, formed of a bounding wall in most cases, axially positioned platforms termed tabulae (singular; tabula) and more laterally positioned platforms, the dissepiments. In the Paleozoic Rugosa and younger Scleractinia, blade-like septa (or sclerosepta) are formed between pairs of mesentaries. Thus the configuration of the septa, dissepiments and tabulae of the skeleton can be regarded as a biogenic cast. at any one time, of the configuration of the base of the polyp, its gut and the mesentarial divisions of the gut. Diagram taken from, and modified from Stearn and Carroll, 1993, p. 96.





Text-fig.4.- Growth sequence through an Upper Ordovician solitary rugose coral from Sweden. *Borelasma crassitanga* Neuman. Diagram taken from Hill, 1981, Figure 82, p. F151, but derived from Neuman. 1969. The outline (a.) of the corallum in longitudinal view shows the relative position of the series of transverse sections through the developing coral (b.-g.), illustrating the progressive increase in septal numbers and development of symmetry during the life history of the species, all drawings x3 magnification.



Text-fig.5.- Modern colonial zooxanthellate, reef-dwelling (hermatypic) corals, (a.), *Goniastrea* sp. and (b.), *Montastrea* sp. Each drawing taken from Chevalier, 1987, fig. 409, p. 715, both with magnifications unstated, but approximately x3 or x4. Massive colonial forms are very commonly seen in the zooxanthellate scleractinians.



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NEW



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ODDITIES & BEAUTIES

of Corals

Robert L. Guenther 149 East Main Street Shelby, Ohio 44875

The forms of simple coelenterates that appear in the Pre-Cambrian sedimentary rock formations, through the processes of of evolution, that allowed each creature to adapt to the changing conditions of this planet, has caused an explosion into the many species of corals that can be found all over the world in which we exist today.

With the following pictures, and a few words of explanation, I hope that I can make it interesting enough that the amateurs who take time to read this article will also look at this part of the enjoyable hobby that is available for them

 $#_{6-93}$ - *Protarae richmondensis* is an odd looking coral that looks very much like a bryozoan, but is actually an encrusting compound coral, that is found in the Richmond Formation in the state of Indiana. This specimen shows the coral growing over a flat surface as well as the small horn coral.

#6-206 - is another specimen of *Protarae richmondensis* that is covering the shell of a brachiopod. I also have several specimens of snails that are completely covered with this odd coral.





6-193 x2

6-206 x2

6-209 x2

#6 -209 - is one of the common *Grewingkia canadensis* horn corals that can be found in the Richmond Formation in Indiana.



6-209 x2

#6-208 - is a specimen of *Grewingkia canadensis* that has been polished by Max Hollingsworth from Richmond, Indiana. It is cream colored internally with black and white markings which is probably caused by parasitic encrustations that were not only on the outside, but penetrated the coral's structure.



#6-52 -named *Tetradium approximatum* with long narrow corallites, that may be found in the entire Richmond Formation, but is especially abundant in the Saluda, upper Whitewater, and Elkhorn Formations



6**-**52

#6-205 - Palaccis cavernosa is an odd looking flat oval shape coral with seven to eight corallite indentations along the edge, that was found by Mrs. Margaret Kahrs in the Spickert Knob Formation, Borden Group, Mississippian period, in Morgan County Indiana.



#6-197 - Heterophrentis duplicates is a well silicified horn coral that shows good preservation of the internal septa, and is a Devonian coral from Oldham County Kentucky.

#6-136 Hadrophyllum d' orbignyi is a group of the odd looking button corals that are found in the Speed Quarry, Beechwood Formation, in Indiana. Showing how weathering can change the looks of these tiny fossil corals. These are from the Devonian period





#6-63 - *Phillipsastrea woodmani* is a colony coral that I found at the quarry on the edge of Rockford, Iowa. The quarry is now a fossil park, where you may hunt as long as you want, and it is all free, so have fun!!!

#6-72 - Heilophyllum solidum is another example of what may be found in the Rockford Quarry. It is one of over 15 different species of Devonian corals that are available here.

6-63 x2



6-72 x2



#6-11- Duncanella corealis Although quite small in size, is a mature adult horn coral that I collected in the Waldron Quarry, Shelby County Indiana many years ago, and is from the Silurian Period

#6-135 - *Favosites forbesi* is a colony coral that quite often can be found in the hemispherical shape. This is a Silurian fossil from the Waldron Formation in Bartholomew County Indiana.



6-135



#6-119 - *Zaphrentis* An internal cast showing the internal septa on matrix. This a Mississippian coral from the Meadville Formation, which is a member of the Cuyahoga Formation. Specimen found in Black River, near Homerville, Ohio.

#6-7 - Endopachys maclurii This small solitary coral is from the Gosport Horizon Formation and was collected from the Little Stave Creek near Jackson, Alabama.

6-7 x2



6**-**119 x2



#6-134 - This odd looking fossil is a geodized *Zaphrentis* coral Harrodsburg Ls. Formation, Mississippian Period, found in a stream bed in Lawrence County Indiana.



6-134 x2

#6-40 - *Cystiphyllum* is an odd horn coral that has no septa, and the outside shows that the cup has started growing all over several times, due to a process called rejuvenation. This specimen is from Lakeside, Ohio.

#6-207 - *Cystiphyllum* shows the cystlike blisters in the cup that gave it its name. This specimen also weathered out of the rock formation along Lake Erie shores at Lakeside, Ohio.



#6- 2 - Zaphrentis is one of the Mississippian horn corals that shows the smaller size and delicate structure that began their demise in the Permian Period

#6-178 - Halycites catenularia shows the unusual chain-like formation of the corallites, which gives it an odd but a very distinct appearance. These Silurian corals were found in Michigan.





#6-198 - Oculina virginea A colony type coral, is found in the Oligocene Formation near Jackson, Mississippi.

#6-199 - *Favosites* is a siliconized tabulate coral, from the river gravels of the Homochitto River south of Jackson, Miss.



6-198



5-199

#6-131 - Lithostrotionella castelnaui is a colony type of coral of the Mississippian Period, of Montgomery County Tennessee.

#6-158 - Montastrea annularis A colony type of coral that shows how the corallites grew right over the worm tube, enclosing the tube in the coral structure. This is a Pliestocene Period coral from the Key Largo, Florida area.



6-131



6-158

#6-147 - Siderastrae radians is a group of coral heads, they were found in Florida, and may be found in various Tertiary to Pleistocene formations. 6-147 was found where a cat had taken a dust- bath uncovering it; 6-195 was found where it had weathered out of a coral formation - in the abandoned quarry; 6-210 came out of sand near Sarasota, Florida.

6-148



6-210



#6-67 - Siderastrea pliocenica The world's first golf ball?? Not really, but some early *Homo sapien* might have picked up one of these coral spheres with the dimples, and got some idea of a new game. Who knows??

#6-27 - Septastrea marylandica this is an odd as well as one of the beautiful colony encrusting corals, that covered the shell of a snail. One book said that a wireworm had to occupy the shell before the coral would grow on the shell???









#6-166 - Montastrea annularis This chunk was over an inch in thiclness, and was one of many pieces lying around the floor of a quarry near Key Largo, Florida. It was only one of the many species of coral that had occupied this living coral reef back in the Pleistocene Period of time.



Rea

 $\#_{6-146}$ - *Diploria sarasotana* is a large coral head that has an odd top surface which is very different from the other corals. It is one of the Pleistocene corals from the Caloosahatchee River Formation.



Top View

Bottom View



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(1999) | - / #6-176 - Dichocoenia eminens is a triple fossil specimen, with a worm tube coiled on one side, and a small colony of the Oculina sarasotana securely fastened to the base and growing out the other side of the Dichocoenia eminens Specimen.

Top right view



Top left view

#6-84 - Septastrea crassa A portion of a hollow coral head, with the thin coral pattern on the outside, and the inside with a layer of chalcedony, making up the geode, from the silex beds of Tampa, Florida

Outside view showing coral pattern

Inside view - showing chalcedony lining



 $\#_{6-172}$. Diploria strigosa The coral pictured here is 51/2 in. in height, 10 in. width, and 12 in. in length. It was found on North Hollywood Beach, Florida in 1974 by Howard and Audry Covington of Toledo, Ohio. The coral is estimated to be from a Pleistocene Reef that is located offshore.

 $#_{6-167}$ Diploria strigosa is another of the "brain corals" that came out of a quarry near Key Largo, Florida and probably one million years ago was part of a large living coral reef that flourished in the tropic seas at that time.





#6-186 - Siderastrea dalli Another of the beautiful corals that are delightful to look at. This comes from the Caloosahatchee Formation of DeSota County Alabama and is possibly a Pliocene to Miocene fossil.



#6-70 - Solenastrea hyades Comes from the pinecrest Beds of near Sarasota, Florida and is of the Tertiary Period of time.

#6-116 - Dichocoenia caloosahatcheensis Is another one of the beautiful colony corals that came from the Tertiary Period of Florida.





#6-132 - Manicina areolata is another of the odd corals that look like it is infested with worm tubes that stick above the surrounding coral growth, and was turned into fossils also.



Top view

Bottom view

The bottom of the coral head that shows when the coral polyps settled to the ocean floor, and started to grow, they grew over sea shells, which left their impressions on and in the bottom of this coral. It is perfectly flat and must have been a fairly smooth surface on which to grow.



#6-150 - Agaricia agaricites One of the beautiful lacey varieties of corals that was found in a Pleistocene quarry near Key Largo, Florida

6-150

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CORAL TERMINOLOGY - Actual - Then Slightly Augmented

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PHYLUM - CNIDARIA - Includes coral, jelly fish, anemones & hydrozoa; radial symmetry, 2 layers soft tissue, tentacles, lack of organ systems- OR- Named after an ancient Creek philosopher who was first to observe and later study fossilized coral. He taught that these specimens were not great big rocks, rather they were "great big rocks with little bitty holes."

RADIAL SYMMETRY - Arrangement of body parts around a centera line ; in animals, a mouth to anal axis -OR- Wheel alignment of motile coral, most often in the order Coralysler.

COLONIAL vs SOLITARYY CORALS - Most coral was colonial, living in multi-animal groups sharing an exoskeleton, while solitary corals lived in separate "shells" usually cup or cone shaped - OR- while colonial coral have 2 or3 living levels (often with front porch) solitary live outside the main reef and have to commute.

EXOSKELETON - Aragonite or calcite construction -OR - slang for sunken shredded hull of an oil tanker near Alaska's coast.

CORALLUM - Structure secreted by the coral colony- OR -probably the best method to collect and detain free ranging corals.

CORALLITE - Structure secreted by individual coral- OR- All the exoskeleton of a regular coral with 20% less polyps.

POLYP - Individual soft- bodied animal that does the secreting - OR- What's found at the opening of the Pomouth.

MEDUSA - Individual soft- bodied animal that is free swimming - (Footnote) Related to the medusas are the wedusas which travel in swarms and the theydusas which generally lie on the beach and watch other sea life.

ORDER TABULATA - Basic traits include calcite construction found in mounds, branching, or an encrusting colonial coral, created ancient reef frame work -OR- Order which continuously keeps track of the other orders and trying to constantly one-up them.

ORDER HOLIOLITIDA - Basic tratits include calcite construction, lacks pores or connecting tubes between corallites, less common, Ordovician thru Devonian, small to massive, branching, in sheets, or hemispherical shape - OR- Named because of very light weight, often floating to the surface during calm water periods. Incidentially, this

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order was named after the Italian operetta by the same name, which celebrated the annual celebrations in some species of coral; the Christmas corals were particularly beautiful.

ORDER RUGOSA - Basic traits include solitary or colonial organism, septa located in 4 positions, in button and horn shapes for solitary forms, in branching or dome shapes for colonial - OR- An Italian pasta dish traditionally consumed before or after performances of Heliolitida.

SECTIONING - Microscopic examination to determine species and sometimes genus of coral - OR- A practice among public dining corals to separate those that liked to periodically expose their upper portions to open air from those that never took the risk. The sections were known as soaking and non-soaking.

SILURIAN PERIOD - The age of corals - (addendum) Early paleontologists believed this was sillier than any of the other periods.

REASONS COLLECTORS COLLECT TRILOBITES MORE OFTEN THAN CORAL

Trilobite found on block of rock size of house; Coral is the block of rock size of house.

Trilobite identified by use of book; Coral identified by invertebrate paleontologist with Ph.D.

Trilobite indentified and put in display case; Coral cut in half to identify under microscope.

Trilobite creates mental image of animal walking around ocean floor, doing arthropod things;

Coral creates mental image of sitting at bottom of ocean and just hanging out.

Trilobite prepares easily by removing matrix from exoskeleton and takes hours to finish Coral has countless tiny holes to expose and takes years to finish.

Trilobite is often beautiful artform; Coral is often a rocky blob.

Trilobites do not have a Crayola crayon named after them.

Marc Behrendt

CORALS IN THE CINCINNATIAN (UPPER ORDOVICIAN) OF THE CINCINNATI REGION (OHIO-INDIANA-KENTUCKY)

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INTRODUCTION TO CORALS

Imagine approaching our planet for the first time from space. Initially, you might not pay much attention to the continents, which occupy just over a quarter of the Earth's surface. You probably wouldn't notice a great city like Cincinnati, or other things that our species has built. But as you travelled over the vast oceans, you'd certainly be attracted to beautiful, large ring-like features that enclose areas of up to 840 square miles (2175 sq. km). They rise to sea level and cause waves to break. Outside each ring, the water is deep; inside there is a shallow, protected lagoon. Upon landing, you'd find that animals are involved in building these impressive structures, which control the environment around them. You've discovered an atoll, one of the types of coral reefs.

Coral reefs form the largest structures that animals have ever produced on this planet. For example, Australia's Great Barrier Reef is a linear feature with a length of 1250 miles (2000 km), a width of up to 200 miles (320 km), and a height as great as 400 feet (120 m). Corals live in marine environments having normal salinity and water circulation. Reef-building types thrive in shallow, tropical conditions. Their skeletons are bound together to form a rigid framework that is elevated above the surrounding areas. There are also many types of corals that don't build reefs. They live on the bottoms of oceans and seas around the world. Most are found in shallow, warm water, but some occur down to depths of nearly 4 miles (6.4 km), and at temperatures as low as almost freezing.

Corals are among the simplest animals. The soft body of an individual is called a **polyp** (Figure 1). It has just one opening, a **mouth** at the top center, which leads into a **digestive cavity**. A ring of **tentacles** surrounds the mouth. The surface of a polyp has many microscopic **stinging cells**,

especially on the tentacles. When these cells spring open, they can harpoon and poison other organisms. This is useful for defense and in helping the tentacles capture small animals for food. A polyp begins life as a tiny **larva** that moves through the water. The larva then settles on the bottom and develops into a polyp. A hard, external skeleton called a **corallum** forms beneath the coral polyp. It is composed of calcium carbonate. The corallum typically has an outer **wall**, and may have radially arranged structures known as **septa**, which extend from the wall toward the center of the corallum. The top of the corallum forms a **calice**, in which the polyp is located during life.

A solitary coral consists of a single polyp and its corallum (Figure 1). The diameter of such a coral is usually a fraction of an inch to several inches (1-10 cm), but may exceed a foot (30 cm). Colonial corals are more common (Figure 2). A colony consists of multiple polyps that make a single corallum. The part of a corallum that was produced by an individual polyp is called a corallite. A colony is started by a larva that develops into one polyp; the other polyps originate by budding within the colony. The diameter of each polyp is usually only a small fraction of an inch (a few mm), but the whole colony and the corallum it produces may become very large. Some colonial corals have dimensions of several yards (meters)! During life, a polyp adds to the top of the corallum and moves upward, commonly leaving behind a series of horizontal platforms known as tabulae. You can think of most coral skeletons as buildings. Polyps live in calices on the roof, not in the rooms formed by walls and tabulae inside their building.

When corals die, the soft polyps decay away rapidly, leaving their coralla behind. Because these hard parts are readily preserved as fossils, we have



FIGURE 1 — A solitary coral and its larval stages (based on Moore, Lalicker, and Fischer, 1952, figs. 4-1.2, 4-2.5, 4-2.6, 4-12.1). The front of the polyp is cut away to reveal internal structures. Part of the outer wall of the corallum is cut away to show the septa.

an excellent record of corals that extends as far back as the Cambrian Period, more than half a billion years ago. Let's now travel back about 445 million years to the Cincinnatian, a time interval late in the Ordovician Period. We'll visit the area that is now the Cincinnati Region of Ohio-Indiana-Kentucky - when it was situated in the tropics! The Cincinnati Region is world famous for the abundance, diversity, and excellent preservation of fossils of this age. Most collectors focus their attention on attractive groups such as trilobites, crinoids ("sea lilies"), and brachiopods ("lamp shells"). Corals tend to be overlooked, but many collectors are unaware of their beautiful internal structures.

CINCINNATIAN CORALS

A stratigraphic section of the Upper Ordovician rocks that record Cincinnatian time in the Cincinnati Region is illustrated in Figure 3. The strata (layers or beds) of rock represent



FIGURE 2 — Block diagram of a colonial coral, showing the relationship between polyps on the surface and the corallum beneath them (based on Moore, Lalicker, and Fischer, 1952, fig. 4-9.7). During life, a polyp is situated in the calice at the top of its corallite, which contains horizontal tabulae.

sediments that were deposited in a variety of environments within a sea that covered most of the continent. Water depths in the Cincinnati Region ranged from very shallow to moderately deep. The relatively soft **shale** layers were muds that came from sources on land. The harder **limestone** beds, composed of calcium carbonate, were derived mainly from skeletal remains of marine animals. **Dolostone**, composed of calcium-magnesium carbonate, typically indicates shallow-water conditions with abnormal salinity and restricted circulation, which were less favorable for life.

Fossil corals occur in the upper, younger part of the Cincinnatian, which is called Richmondian (Figure 3). They are found in units traditionally termed the Waynesville, Liberty, Whitewater, and Elkhorn formations. The area in which Richmondian rocks are exposed is outlined in Figure 4. You can find corals at many locations within this belt around Cincinnati. It is generally thought that corals do not occur in older Cincinnatian strata of the Cincinnati Region (Duncan, 1956; Flower, 1961). They have been listed from the Maysvillian and from the Arnheim Formation at the base of the Richmondian (Bassler, 1950), but this requires verification involving full documentation of specimens that have been





FIGURE 4 — Map showing the exposure belt of Richmondian rocks in the Cincinnati Region of Ohio-Indiana-Kentucky (based on Elias, 1982, fig. 3; Elias, 1983, fig. 1).

precisely located geographically and stratigraphically. Perhaps you can help me determine whether pre-Waynesville Cincinnatian corals exist in the Cincinnati Region (corals are present in pre-Cincinnatian, Middle Ordovician rocks of north-central Kentucky).

Based on their growth forms and modes of life, four major types of Cincinnatian corals can be recognized. Large, massive colonial corals are dominant in colonial coral beds, which occur in the southern and western part of the Richmondian exposure belt in Kentucky and Indiana. Unattached solitary corals, small attached solitary corals, and thin encrusting colonial corals are commonly found in and on limestone beds that are rich in fossils, particularly brachiopod shells and colonies of bryozoans ("moss animals"). Coral-bearing fossiliferous limestone beds are most common in Ohio, Indiana, and the western part of the exposure belt in Kentucky.

[←] FIGURE 3 — Generalized Cincinnatian stratigraphic section in Ohio and Indiana (based on Hay, 1977, fig. I-1), showing traditional names of Richmondian formations and the distribution of corals. Symbols for rock types: horizontal dashes = shale, vertical lines = limestone, diagonal lines = dolostone.

Cincinnatian corals belong to two major evolutionary groups, the **tabulate corals** and **rugose corals**. Both of these groups appeared more than 460 million years ago, during the great Ordovician evolutionary radiation. They disappeared about 245 million years ago, during the greatest of all mass extinctions at the end of the Permian Period. Rugose corals include solitary and colonial forms that typically have well-developed septa. Tabulate corals are all colonial, and are characterized by the absence or weak development of septa.

Massive Colonial Corals

Corals did not build true reefs in the Cincinnati Region during Richmondian time, but they did form several impressive colonial coral beds (Browne, 1964, 1965; Simmons and Oliver, 1967; Hatfield, 1968). Such beds have thicknesses of up to 12 feet (3.7 m) and some have been traced for tens of miles (many km). Massive colonial corals shaped like domes and lenses are the principal fossils in these beds (Figure 5). Single colonies have been found with diameters of up to 5 feet (1.5 m) and heights of 2 feet (60 cm); they are the largest fossils in the Cincinnatian of the Cincinnati Region.

When these beds were formed, living and dead massive colonial corals probably rose above the surrounding sea bottom by a foot or two (30-60 cm), reaching almost up to sea level. These are not considered to be true reefs because the corals were not bound together as a rigid framework. Nevertheless, they did control the environment around them. The colonial coral beds caused approaching waves to break, leading to the development of a protected, quiet-water lagoon on the other side. Some of the corals in these beds were preserved in upright growth positions, but others were overturned during storms by powerful waves and currents before they were buried.

Several different genera of massive colonial corals are found in these beds (Figure 6A-E). They can be distinguished by the size of corallites, the nature of the corallite walls, and the presence



FIGURE 5 — Exposure of a Richmondian colonial coral bed, showing massive coralla shaped like domes and lenses; Madison County, Kentucky. Length of the hammer is 10 inches (25 cm).



or absence of septa. Some specimens can be identified if characteristic structures can be seen on the exterior surface of the corallum. In other cases, it is necessary to cut a specimen open to reveal the structures. A slab of the fossil can be glued to a glass plate and then ground down until it is thin enough to see through. This thin section can be studied in detail under a microscope.

Some of the colonial coral beds are dominated by the rugose coral genus Cyathophylloides (identified as Favistella or Favistina in some reports). It occurs in association with one or more of the genera Calapoecia, Tetradium, Foerstephyllum, and Nyctopora (identified as Saffordophyllum in some reports). Other colonial coral beds are dominated by Foerstephyllum, together with Tetradium and Calapoecia. Some beds consist only of Tetradium, which had the greatest tolerance for abnormal conditions such as variable salinity and restricted water circulation. Foerstephyllum, Calapoecia, and Nyctopora are tabulate corals. Tetradium belongs to a poorly understood group that has generally been classified with the tabulate corals, but it is probably not a tabulate coral.

Unattached Solitary Corals

Unattached solitary rugose corals are the most conspicuous coral type commonly found in and on Richmondian fossiliferous limestone beds. They are often called "horn corals," because their coralla are shaped like slightly curved horns (Figure 7A). The basal end tapers to a point, and the calice in which a single polyp lived is located at the wide end. These coralla typically have lengths of more than an inch (a few cm); some

[←] FIGURE 6 — Close-ups of massive colonial corals (to scale), showing corallites as they appear on the external growth surface and in cross sections of the corallum. A, colonial rugose coral *Cyathophylloides* (based on Browne, 1965, pl. 150, fig. 1b); B, tabulate coral *Foerstephyllum* (based on Jull, 1976a, pl. 2, fig. 2a); C, tabulate coral *Calapoecia* (based on Jull, 1976b, pl. 3, fig. 2a); D, tabulate coral *Nyctopora* (based on Browne, 1965, pl. 151, fig. 4); E, tabulate coral(?) *Tetradium* (based on Copper and Morrison, 1978, fig. 5a).



FIGURE 7 — The unattached solitary rugose coral *Grewingkia canadensis* (to scale). A, B, exteriors of coralla: A, side view of a well-preserved corallum with the calice rim intact (from Foerste, 1909, pl. 11, fig. 1b); B, side view of a corallum with the calice rim broken, the surface smoothened by pre-burial abrasion, and the openings of *Trypanites* worm borings (black circles) (from Elias, 1982, pl. 9, fig. 10). C–G, cross-sections beneath the calices of five coralla, showing the outer wall, numerous septa, and the variable axial region (based on Elias, 1982, pl. 7, figs. 1, 7, 11, 17, 21, respectively).

have lengths over 5 inches (13 cm) and diameters of nearly 2 inches (5 cm). They are almost always found lying on their sides in the strata, and their surfaces usually show evidence of damage and abrasion that occurred prior to burial (Figure 7B).

During life, an unattached solitary coral was oriented upright in soft sediment, which supported the corallum (Figure 8A). It lived in a quiet-water, stable environment; sediment accumulated around the corallum, which slowly sank vertically as its weight increased during growth. Because the



FIGURE 8 — Reconstruction showing the unattached solitary rugose coral *Grewingkia canadensis*. A, a living coral in growth position; B, an abraded corallum in depositional orientation. Coralla are encrusted by bryozoan colonies and have annelid worms living in *Trypanites* borings (black circles in B are openings of vacant borings).

corallum was not firmly attached to a hard surface, it could be overturned by strong currents during storms. The coral was then deposited on its side and the polyp died. The surface of the corallum became damaged and abraded during transportation and exposure to currents prior to final burial (Figure 8B).

About half of these coralla were encrusted by bryozoan colonies, and more than a third have borings that probably housed annelid worms. Skeletons of the encrusting bryozoans look superficially like tiny colonial corals, but the openings on their surfaces are much smaller than the calices of corals. Each worm boring is a cylindrical drill-hole with a single, circular opening that usually has a diameter of less than 1/8 inch (3 mm) (Figure 7B). These borings are identified as the trace fossil genus Trypanites. The worms that made them were soft-bodied: they were not fossilized. Most of the encrustation and boring probably took place while the host corals were alive, but some occurred after death of the corals (Elias, 1982, 1983, 1986) (Figure 8). The relatively large coralla of unattached solitary corals provided stable, elevated, hard surfaces that were favorable for colonization by these bryozoans and worms.

The unattached solitary rugose corals belong to a single species, *Grewingkia canadensis* (identified

as *Grewingkia rustica* or *Streptelasma rusticum* in some reports) (Elias, 1982, 1983). The corallum is solid near its base, because the septa are thickened into contact with one another. Within and beneath the calices of relatively large specimens, the septa are thin and numerous (Figure 7C-G). The axial region at the center of the corallum is highly variable. It ranges from a large, complex axial structure with numerous highly contorted skeletal elements (Figure 7C), to a smaller, simpler axial structure (Figure 7G).

Attached Solitary Corals

Attached solitary rugose corals are usually found on the surfaces of Richmondian fossiliferous limestone beds, fastened to the skeletons of other animals such as brachiopods and especially bryozoans (Figure 9A–D). They are generally much smaller than the unattached solitary rugose corals. Their coralla typically have lengths between 1/4 and 1/2 inch (6–13 mm), and seldom have lengths exceeding 1 inch (25 mm) and diameters greater than 1/2 inch (13 mm).

These corals colonized stable, fossiliferous beds during periods when sediment was not being deposited. In many cases, the larvae attached to live hosts, selecting elevated positions above the sea floor that would have been advantageous for feeding. In other cases, larvae attached to skeletal remains on the surface of the bed. Most of these corals occur as isolated individuals, but some form small clusters. These usually developed because several larvae selected the same favorable attachment site, and the solitary corals grew into

→ FIGURE 9 — The attached solitary rugose coral Streptelasma divaricans. A–D, exteriors of clusters (to scale; arrows point to coralla): A, oblique view of coralla on a branching bryozoan (from Elias, 1983, pl. 2, fig. 30); B, top view of coralla on a fossiliferous limestone bed (from Elias, 1983, pl. 2, fig. 33); C, side view of coralla on a brachiopod shell (from Elias, 1983, pl. 2, fig. 32); D, top view of coralla on a brachiopod shell (from Elias, 1983, pl. 2, fig. 31). E–I, cross-sections beneath the calices of five coralla (to scale), showing the outer wall, thin septa, and the variable axial region (based on Elias, 1982, pl. 1, figs. 1, 5, 11, 36, 19, respectively). contact with one another. Small colonies that formed by budding are very rare. Many of these corals were killed and buried in growth position by influxes of mud.

The attached solitary rugose corals belong to a single species, *Streptelasma divaricans* (Elias, 1982, 1983). Their septa are thin from the base of the corallum to the calice. Within and beneath the calice, the axial region at the center of the corallum is variable. There may be a small axial structure (Figure 9E, F), or septa may extend to the axis (Figure 9G, H), or septa may shorten to leave an open axial region (Figure 9I).



Encrusting Colonial Corals

Tabulate corals that occur as encrustations on objects such as brachiopod shells can be found on Richmondian fossiliferous limestone beds and in shale layers between limestone beds. These encrusting corals had small polyps that produced thin coralla as the colonies expanded over hard surfaces (Figure 10A, B). The coralla are much



FIGURE 10 — The encrusting tabulate coral *Protaraea.* A, exterior of a corallum on a brachiopod shell (to scale) (from Foerste, 1909, pl. 10, fig. 2a); B, close-up of the exterior of a corallum, showing details of the small calices (to scale) (from Davis, 1985, pl. 6, fig. 23).

smaller than the massive type that formed colonial coral beds. Typically, diameters are about an inch (2.5 cm) and thicknesses are just a small fraction of an inch (a few mm). Corallum size and shape were commonly determined by the dimensions and form of the host object, which provided a stable surface for the coral to live on.

The most common and easily recognized encrusting colonial corals are assigned to the genus *Protaraea* (Figure 10). A poorly known encruster, formerly thought to have been a stromatoporoid sponge (e.g., Galloway and St. Jean, 1961, pl. 13, fig. 2), is now identified as the tabulate coral species *Ellisites glyptum* (Dixon, Bolton, and Copper, 1986).

CONCLUSIONS

Corals are a significant fossil group in Richmondian rocks within the Cincinnatian (Upper Ordovician) of the Cincinnati Region (Ohio-Indiana-Kentucky). Four major types are present. Large, massive rugose and tabulate forms are dominant in colonial coral beds. Unattached solitary rugose corals, small attached solitary rugose corals, and thin encrusting tabulate corals are commonly found in association with fossiliferous limestone beds. Colonial coral beds occur in the southern and western part of the Richmondian exposure belt in Kentucky and Indiana. Coral-bearing fossiliferous limestone beds are most common in Ohio, Indiana, and the western part of the exposure belt in Kentucky.

In ending our journey, let's imagine that we're flying high above what is now Chicago, looking back at the Cincinnati Region during Richmondian time (Figure 11). Rocks in the present exposure belt represent a shallow-water platform along the margin of a vast sea. Water depth on the platform increased slightly toward the north. The sea was significantly deeper on the western side of the platform, and there was a shoreline on the eastern side.

Cincinnatian corals were introduced to this region from the west. This happened during a major **transgression** (advance of the sea) early in the Richmondian, when deposition of the Waynesville Formation began (Elias, 1995). During the Richmondian, massive colonial coral



FIGURE 11 — Block diagram showing a three-dimensional reconstruction of the Cincinnati Region in mid-Richmondian time, as seen from the present northwest (vertical scale greatly exaggerated) (based on Elias, 1982, fig. 4). Dotted pattern = location of the present Richmondian exposure belt (see Figure 4). Other patterns show areas in which various deposits originated: dashed pattern = shale, brick pattern with vertical lines = limestone, brick pattern with diagonal lines = dolostone, dome pattern = colonial coral beds.

beds formed in very shallow water, mainly along the edge of the platform facing the open sea. The coral-bearing fossiliferous limestone beds formed in normal-marine, level-bottom environments on the platform.

At the end of Richmondian time, there was a major **regression** (retreat of the sea) and deposition of the Elkhorn Formation ceased. The entire Cincinnati Region became exposed above sea level, and these coral species and many other organisms became extinct. This marked the beginning of the great end-Ordovician mass extinction.

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CORALS OF NORTH AMERICA AND THEIR KIN

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Introduction

PHYLUM CNIDARIA - COELENTERATES

This article is intended as an introduction which treats the growth and habits of coral making animals, their place in nature showing the relations of families, genera and species following the salient trails of structure and function characterizing the skeletons of species of the same genus, on the modification of which the differentiation is based, showing the resemblances and differences of related genera.

This phylum includes a large and varied group of extinct and living organisms which throughout their long history reaching back to the beginning of the Pelaozoic era have lived in aquatic habitats, mainly as sessile organisms the majority have been marine, though a few now have adapted to fresh water.

This phylum includes both solitary and organisms with the colonial much more common. Corals introduce us to the coelenterates which with the exception of sponges are the simplest of coelenterates, that honor belongs to the modern hydra which inhabit quiet streams and fresh water pools.

The body plan of the hydra is simple but it has three great advantages - the first being efficiency, which enabled the animal to live and prosper for untold ages. The second plan is it can be changed in many ways producing creatures that range from delicate colonial organisms to massive polyps and free swimming jelly fish. Third, early relatives of hyrda were able to produce thin walled cells, either in the form of thin layers or in clusters, thus giving rise to all animals more complex than the phylum of coelenterates.

HYDROIDS: The first major group of Hydroids disappoint many collectors who want records of innovations made while they were new, hydrazoans like the hydra itself evolved early in the Precambrian times, and since specialized descendants of the hydra appear before the Paleozoic era began, this is not possible since simple hydrazoans are now and presumably have always been too soft to be fossilized, but their nearest relative achieved that state early in the Paleozoic or late in the Cambrian eras, in North America they are found from Texas to Virginia to New York.

MILLEPORES: Millepores or Hydrocoralines are colonial Hydrozoans that build up hard parts at their base where each colony contain two basic types of animals, Orozoids are one type of Gastrerozoids which captures food and swallows it. The second type is mouthless, and therefore gets its food second hand from the gastrerozoids. These noneaters are divided into long branched creatures (DOCTYLOZOIDS) who have long hollow tenacles that help gather food which they cannot eat themselves thus helping to feed the entire colony. They also have short reproductive zoids (impluses) whose task is to produce young in the form of tiny jellyfish, these in turn develop cells that give rise to new colonies. This entire new colony is then covered over with a thin fleshy sheet, that not only covers the new colony but also the stony base and the tubes that run through it. Fossil Millepores appear in Cretaceous rocks and continue into recent deposits, some are massive, not many branch. Their surfaces show many large pores that once housed the Dactylozoids and smaller pores which contained the productive polyps.

The skeletal structure of both these groups of calcarous Hydrazoans consists of finely porous deposits with enumerable inter connecting passageways, penetrated by much larger tubes that are circular or stellate and are intersected by transverse partitions called tabulae. Two distinct sizes of the tabulized tubes are observed. A large set which provide lodgement for the short feeding polyps, termed Gastrozooids and a small set which is occupied by the Dactylozooids. These Dactylozooids are equiped with numerous stinging cells which serve as protection for the colony, they also help with the food gathering

process.

STROMATOPOROIDS: These are the most abundant of fossil Hydrozoans even though they died out near the end of the Cretaceous. Their name which means layer-pores, refers to the fact that these fossils are made up of many layers which are made up of thin sheets or laminae held together by many pillars are tubes that may branch so many times that the layers seem to become networks. Typical Stromatoporoids also have structures that are called Astrorhizae (foot stars) which consist of central cavities or canals which resembles the cloacal cavities of fresh water sponges, and are the principal reason why some authors have placed them in the Phylum Porifera with the sponges. This did not happen officially until (1952) when the authors of "Invertebrate Fossils", made the change, much to the disappointment of many paleontologists who have made a special study of them, and maintain they should be ranged among the Hydrozoans (page 107, Inverterbrate Fossils.) the Stromatoporoids build massive incrustations of calcareous deposits among the corals, helping to build giant reefs. The upper surface is generally smooth except for a thin covering over the top of the tubes or pillars where it is a small raised surface over each tube or pillar called "MAMALONS", this is a sure fire identification mark for the Stromatroporoid.

CORALS AND THEIR KIN

SCHIZOCORALS: (schizo means split) Schizocorals reproduced by splitting of the parents, each part then grew upward into two or more coralites. One of the best known examples of this is the *Tetradium*, they build massive sheaf like or branched colonies composed of tiny prismatic coralites with four prismatic septa, and many tabulae, after fusion they came together at the center forming the outer walls of four new coralites. This is very prevalent in the Catheys Formation of the southern part of Marshall County Tennessee. They range from Mid Cambrian through the Ordovician in North America. We have at least five species of *Tetradium* common here in the central basin of Tennessee.

Some range in size from a few inches to a few feet in length. Some may also be a foot or more in height.

THALOCORALS Another tabulae, very similar to schizocorals, halysitids, the favositids or even the zoanathrarians which are also common in the Ordovician outcrop. We have said much about the colonial corals, now let me talk about the solitary coralites, which is a misnomer as it is not so simple. Actually it is a very complex organism.

LAMBEOPHYLLUM Lambeophyllum and Strepteplasma must have kept themselves upright by allowing their pointed tips to sink into the mud, which also piled up against the coral's body holding the coral in an upright position. As they grew upright and larger they began to lean over gradually taking the shape of a horn, thus we call them "Horn" corals.

HELIOPHYLUM, CATHYOPHYLUM, etc are very prevalent here in the Tennessee central basin. Dr.Charles Wilson, in his book Stratigraphy of Central Tennessee 1949, lists many corals including the scleractins (hexagons). As the name implies, the septa are arranged on a basic plan of six with successive cycles of six as 12,24 etc, thus the name "honeycomb" or "wasp nest" coral. Hexacorals are both solitary and colonial. There is a great variation of growth especially at the base of the exoskeletons. The single coralites of a colony may be uniformly round or hexagonal. This may be a small problem with identification.

TABULA A great many of the Paleozoic corals make up the subclass tabula or the tabulates. All its members are colonial consisting of small coralites that sometimes spread out like a chain or nets, but generally are so compact that they become prisms with four, or five sides. There are no dissepiments. Tabulae are well developed and extend from wall to wall, their septa are few and may be reduced to mere ridges or rows of spines.

TUBE or Chain Corals Tube, chain and honeycomb corals range from

Ordovician to Devonian but are especially characteristic of Silurian deposits. The genus *Catenipora* has small oval tubes that grew side by side in rows or ranks that resemble chains in cross section. At each tube a ridge septa but tabulae may appear.

FAVOSITES Honeycomb coral is aptly described by its popular name. Colonies consist of closely packed coralites, most of which are prismatic and have very thin walls which remain very distinct. There are many species of Favosites ranging from thin sheets to massive domes. Several other genera are grouped in one family with Favosites. Dr. Charles Wilson, Jr. (bulletin 56, 1956) lists many species of coral found in several formations of the Tennessee central basin.

PERAMOPORA found in the Cannon through the Cathey four different species of *Tetradium* alone, *Favosites niagarensis* and many others. There are also many *Stromatoporoids* which have recently been moved from corals to the sponges since the publication of Invertebrate Fossils.

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Invertebrate Fossils, 1952

Stratigraphy in Central Tennessee, Wilson

Polypi Zoantharia WM, J. Davis 1886

Richard Hamell and Gary Rakes assisted me with the arrangements.

I wish to thank Gilbert Norris and Tom Witherspoon for their photography.

I must state that all of these species are not now in my Museum.


1-2 Calvinastrea billingsi Calvin
3 Calvinastrea ingens (=? yandelli Rominger)

[from: Kentucky Geological Survey; Plate 118]

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MAPS DIGEST



- Ptychophyllum tropoeum 1-3
- Ptychophyllum diaphragma 4-5
- Ptychophyllum typicum 6-7
- 8-11 Ptychophyllum coniferum
- [from: Kentucky Geological Survey; Plate 106] 57

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Favosites hemisphericus et varietates

[from: Kentucky Geological Survey; Plate 11]

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Drymora nobilis (Billings)

[from: Kentucky Geological Survey; Plate 71]



A. Donacophyllum? sentumB. Cylindrophyllum belliC. Craspedophyllum adnatum

[from: Kentucky Geological Survey; Plate 108]

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1.Favosites 2.Tetradium, Lincoln & Marshall C.Tennessee



Calvinesrta, Marshall Co.TN 61

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Favosites, Catheys Fm. Marshall Co. TN



Tetradium, Lincoln Co. TN 62

Middle Ordovician fossilised corals from the Montreal area.

By: Jean-Guy Pellerin and Thérèse Séguin 2288 De lorimier Montréal, Québec Canada, H2K 3X3

INTRODUCTION:

Sedimentary rocks found in the Montreal area are the result of successive marine transgression which submerge this part of North America during the middle Ordovician.

Most of these sedimentary stratas are fossiliferous and contain a rich and diversified fauna, among those, CORALS.

Only the most common or representative species of Montreal area are talked about in this article.

STRATIGRAPHY:

In the Montreal area the middle Ordovician is divided in three geological distinct groups. The bottom part; **Chazy**, the middle part; **Black River** and the top part; **Trenton**.

TRENTON; 450 million years

Streptelasma corniculum Hall Favistella alveolata (Goldfuss)

Corals are relatively rare in the Trenton group*. This probably means a deepening of the ocean in the Montreal area. This change of living condition was unsutable for the surviving of corals.

*Some authors unite Trenton and Black River under the Mohackian name.

BLACK RIVER: 455 Million years

Favistella alveolata (Goldfuss) Foerstephyllum halli (Nicholson) Lambeophyllum profundum(Conrad) Streptelasma corniculum Hall

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Tetradium cellulosom Hall T. clarki Okulitch **T. fibratum** Safford T. minus Safford T. racemosum Raymond

T. syringoporoides Wilson

This geological group is particularely fossiliferous in the Lowville and Leray formation.

CHAZY: 460 Million years

Billingsaria parva (Billings) Eofletcheria incerta (Billings) E. sinclairi Okulitch Lichenaria heroensis (Raymond)

The most fossiliferous horizon in the Chazy of our area is without a doubt the St-Martin member of Laval formation.

ECOLOGY:

Now a days corals have a limited geographic distribution. They are found in a tropical belt area between the latitude 25N and the latitude 25S (Burton, 1984). In fact these very strict conditions are necessary for the survival of the corals and other organismes who live in this environment. Weather comprise between 25 C and 29 C, salt content of 34 to 36 per thousand and water deepness lower than 50m are primordial factors for their good development (Arduini & Teruzzi, 1986).

<u>RUGOSA</u>

The tetracorals or rugose corals are represented by *Lambeophyllum* and *Streptelasma* in our area. They appeared during the Ordovician about 450 million years ago, and are considered among the most ancient solitary corals in the world. This group had a world wide distribution and became extinct during the Permian, about 255 million years ago.

Habitually rugosas are small in size (1-4cm). The deep calix is shape like a funnel. From the outside it has a conic to subcylindric shape. The tip of the apex is sometimes curved. The calcarous wall surounding the polype has often transversal fold.

Lambeophyllum profundum(Conrad)



Period : Middle Ordovician Group : Black River Formation: Lowville Leray Ouareau

Actual size: Lenght = 15mm Diameter= 15mm

Lateral view

In our area the discovery of this specie is not frequent.

Streptelasma corniculum Hall



Period : Middle Ordovician Group : Black River Formation: Lowville Leray

Group : Trenton Formation: Deschambault

Actual size: Lenght = 30mm Diameter= 18mm

Lateral view

This specie is rarely found in the rocks of our area.

TABULATA

Tabulate corals also appeared during the Ordovician. *Billingsaria* and *Foerstephyllum* are found in the Montreal area.

A cross section of a colony habitually looks like a honeycomb and when seen as a whole is globular. The size of the colony can be 1m and more.

Billingsaria parva (Billings)



Period : Middle Ordovician Group : Chazy Formation: Laval Member : Saint-Martin

Actual size: Lenght= 30mm Width= 22mm

: Middle Ordovician

: Chazy

Formation: Laval

External view of the colony.

Billingsaria is considered one of the older known coral in the world.

Although this coral is of colonial type, it appears bulky, crusted over and looks like a carpet. Numerous encrustings (corallites) are visible on its surface. The aperture of these corallites are rounded or polygonal.

> Period Group

This specie is found in large number in some stratas of the Montreal area.

Eofletcheria incerta (Billings)

This specimen is not available, please refer to the Treatise p.472, Fig. 357.

Present in the Montreal area.

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Foerstephyllum halli (Nicholson)



Photo #1: Cross section. Actual size: Lenght= 27mm Width= 55mm



Period : Middle Ordovician Group : Black River Formation: Lowville Leray Ouareau

Photo #2: View of the colony surface. Actual size: Diameter 95mm

Sometimes present in abundance in some stratas of the Leray.

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Tetradium fibratum Safford



Period : Middle Ordovician Group : Black River Formation: Lowville Leray Ouareau

Actual size: Lenght= 65mm Width= 45mm

View of the colony surface.

Common in some levels of Lowville and Leray of the local area.

Favistella alveolata (Goldfuss)



Period : Middle Ordovician Group : Black River Formation: Lowville ? Leray

Size: X 2.5

Cross section, adapted from the Treatise.

It is somehow relatively rare in the rocks of our area.

CONCLUSION

If we admit that the conditions of life required for the formation of healthy coral reef remained the same through the ages, fossilised coral becomes a precious pointer for climates of the past for the study of paleoecology.

REMARK: Illustrations by Jean-Guy Pellerin.

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THE EARLIEST CORALS

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Representatives of the phylum Cnidaria or the coelenterata are some of the earliest animals to appear in the fossil record, depending upon how one interpretes the late Precambrian Ediacarian fossils. Sea-pen-like, stalked fossils occur as one of the major elements of the Ediacarian biota (biota rather than fauna as some paleontologists consider that the Ediacarian fossils are not animals). In Cambriam strata, fossil jellyfish and medusoid-like (jellyfish-like) fossils can be locally comon if preservational conditions have been right. Floats of

" by-the-wind" sailors can also be locally abundant fossils, fossils which have often been mistaken for other types of invertebrates such as mollusks (Yochelson, 1988).

Cnidarian fossils become frequent with the appearence of a mineralized exoskeleton and the group of Cnidarians which developed such a mineralized exoskeleton are members of the Class Anthozoa - the coral exoskeleton exhibits distinct anatomical structures such as septa and tabulae. Coral-like fossils first appear in the Cambrian of Australia but these are not convincung to all coral workers as representatives of true corals. The undoubted corals occur at the very beginning of the Ordovician Period, some of these are found in the Missouri Ozarks.

Licheneria sp.

Areas of North America where uplift (mountain building) has pushed up and exposed strata near the bottom of the stack of Paleozoic rocks will often have exposures of Cambrian strata. These Cambrian beds will grade into strata belonging to the Ordovician Period, the second period of the Paleozoic Era. In these bottom-most layers of the Ordovician are found what are considered by most paleontologists to be the oldest corals. Small and usually associated with reefs of stromatolites (Blue-green algae) rather than producing reefs themselves, these small groups of colonial corals are inconspicuous and are relatively rare fossils.

Colonial Paleozoic corals have tabulae, horizontal partitions which separate a single coralite into segments. These early corals from Missouri have such tabulae but they are very thin and usually are poorly preserved. Later Paleozoic colonial corals have much more strongly developed tabulae. Corals also have septa, radial partitions which divide a coralite into a series of sectors. Paleozoic corals have such septa in multiples of four, viz. 12,16 or 20 septa per coralite; these corals are appropriately called tetracorals; tetracorals are unique to the Paleozoic, Mesozoic, Centozoic and Recent. Corals have septa present in multiples of six and are referred to as hexacorals. In the earliest coral septa like tabulae are difficult to see, they are very small, thin and are not usually well preserved.

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- A. Reefs of fossil cyanobacteria (blue- green algae) in strata of the lower-most Ordovician. The oldest corals are associated with such stromatolites such as these in southern Missouri.
- B. <u>Lichenaria</u> cf. <u>L. cloudi.</u> the oldest) or one of the oldest coral depending upon how coral-like Cambrian fossils from Australia are interpreted). Lower Ordovician, Gasconade Formation southern Missouri.
- C. Enlarged view of <u>Lichenaria</u>. x27. Tabulae are very thin and poorly preserved. <u>Lichenaria</u> was a colonial tabulae coral.
- D. <u>Halysites</u> sp. chain coral. A mid Paleozoic "specialized" coral which, like other mid and late Paleozoic corals, had a "primitive" form like <u>Lichenaria</u> as an ancestor.
- E. Ediacarian fossils, Late Precambrian. Some paleontologists consider these to be Cnidarians and possibly ancestors to corals and other Cnidarians. Others consider Ediacarian organisms to represent a totally extinct major group of life forms, quite possibly not even animals. (of which Cnidarians are primitive examples). The "fern-like" forms (spindles) if Cnidarians might be early sea pens (soft corals), the radial fossil in the center of the picture a jellyfish. Note rock hammer form scale. Conception Group, Late Proterozoic, Cape Race, Newfoundland.

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COMPARISON OF RECENT CORAL LIFE AND DEATH ASSEMBLAGES TO PLEISTOCENE REEF COMMUNITIES: IMPLICATIONS FOR RAPID FAUNAL REPLACEMENT ON RECENT REEFS

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ABSTRACT

Marine ecologists and paleoecologists are increasingly recognizing that the Pleistocene and Holocene fossil record of coral reefs in the exclusive database from which an assessment of the long-term responses of reef communities to environmental peturbations may be obtained. The apparent persistence of coral communities in the face of intense fluctuations in sea level and sea surface temperature during glacial and interglacial stages of Pleistocene time is in marked contrast to dramatic fluctuations in reef community structure documented by short- term monitoring studies. We compare the taxonomic structure of live and dead coral communities on a modern patch reef currently undergoing a community transition to late Pleistocene facies exposed in the Cockburn Town fossil coral reef. Multidimensional scaling revealed that specific taxa and colony growth forms characterize life, death and fossil

assemblages. The recent decline of thickets of Acropora cervicornis is

represented by their abundance in the death assemblage, while *Porites porites* dominates the coral life assemblage. Although additional study of Pleistocene reefal facies is required, the greater similarity of the death assemblage to the fossil

assemblage suggest that the present Caribbean - wide decline of A. *cervicornis* is without an historical precedent.

INTRODUCTION

Community ecologists and paleoecologists are becoming increasingly aware that the fossil record is an exclusive and crucial database from which to interpret long term community patterns (Jackson, 1992; Ricklefs & Schluter, 1993; Jackson et al., 1996). During the last decade, paleoecological studies in terrestrial (e.g. Davis, 1986; Delcourt & Delcourt, 1991; Davis et al., 1994; Coope, 1995 and marine (e.g. Jackson, 1992; Buzas & Culver, 1994; Allmon et al., 1996; Jackson et al., 1996; Pandolfi, 1996) systems have demonstrated that the fossil record possesses a wealth of information applicable to current concerns for global environmental change as well as environmental perturbations on a local scale.

The Pleistocene fossil record of coral reefs over the last million years is a particularly valuable data repository because of its generally spectacular preservation, and because, with few exceptions, the same coral taxa that inhabit modern shallow water reef envoronments are present in Pleistocene deposits. Although this is in part due to the young geologic age of the interval, a great deal of qualitative (e.g. Mesollela, 1967; Mosellela et al., 1970; White et al., 1984; White & Curran, 1987; White, 1989; Johnson, et al., 1995; White & Curran, 1995) and quantitative (Greenstein & Moffat, 1996; Pandolfi, 1996) data suggest spetacular preservation is common for reef coral assemblages accumulation during at least the last 600 ka in both the Indo-Pacific and Caribbean provinces. The Caribbean shallow water coral (and mollusk) fauna has undergone little speciation or extinction since faunal turnover ended roughly a million years ago (Potts, 1984; Allmon et al., 1993; Jackson et al., 1993; Budd et al., 1994a, b), in spite of intensifying cycles in climate and sea level throughout the Pleistocene.

With the above as an underlying assumption, Pleistocene fossil coral reef deposits can potentially be used as a database with which to address a variety of cardinal issues facing reef ecologists and marine resource managers, whose frustations over the temporally myoptic view afforded by monitiring studies that rarely span a scientific career increasingly pervades the literature (e.g. Done; Jackson, 1992; Hughes, 1994; Bak & Nieuwland, 1995). Perhaps foremost among these issues, is an assessment of the response of coral reef communities to environmental perturbations. Important ecological influences on coral reefs may operate on a variety of temporal and spatial scales (Porter and Meier, 1992, including decadal time scales (Bak and Nieuwland, 1995; Done, 1992), and the need for long term data sets has been recognized by a variety of workers (e.g. Likens, 1987; D'Elia et al., 1991, Jackson, 1992).

Jackson (1992) suggested that the reef fossil record represents the exclusive database from which responses of coral communities to global change may be gauged. For example, in Barbados, preliminary qualitative data from the Pleistocene raised reef terraces suggests that similar coral communities and zonation patterns have prevailed for the past 600 ka (Jackson, 1992). In an overview of mollusk, reef coral and planktic foraminiferal communities, Jackson (1994 a) found little correlation between the magnitude of environmental change and subsequent ecological and evolutionary response during Pleistocene time. In a very detailed study that examined geographic and temporal changes in community composition, Pandolfi (1996) found limited community membership in Indo-Pacific reef corals from 125 - 30 ka. These studies give a very different picture of coral reef community structure and stability than that derived from traditional, small-scale ecological studies in modern environments.

Given the utility of the Pleistocene fossil record of coral reef community for assessing long-term responses to environmental perturbations, quantitative comparisons of these assemblages to modern reef communities is essential. Here, we compare the structure of communities of live and dead reef corals presently found on Telephone Pole Reef to that preserve in late Pleistocene age (Sangamonian) facies exposed near Cockburn Town to determine the accuracy with which the fossil record represents the taxonomic structure of a once-living coral community. Our results contrast with those obtained from similar companion studies, and suggest that the transition between coral communities currently occuring in Fernandez Bay (and indeed, throughout the Caribbean) may not have an historical precedent.

STUDY SITES AND SAMPLING METHODS

The regressive stratigraphic sequence exposed in the abandoned quarry in Cockburn Town, San Salvador, Bahamas, includes a coral rubblestone facies, composed predominantly of *Acropora cervicornis*, and a coralstone facies that contains abundant *in situ Acropora palmata*, *Montastrea annularis* and *Diploria strigosa*. These facies were defined by White et al., (1984) and Curran and White (1985) and suggested to represent back reef and reef tract environments, respectively. This fossil reef provides an excellent opportunity for a comparative

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taxonomic study because of its proximity to analogous modern reef environments (Fig.1) Telephone Pole reef, located in Fernandez Bay, is a mid-shelf patch reef that, in the past, was dominated by thickets of *A. cervicornis* set amidst larger heads of *Montastrea annularis* and other massive corals. Today, the degraded *A. cervicornis* thickets and rubble provide examples of the coral rubblestone facies described by White et al. (1984) and Curran and White (1985). The branching coral *A. cervicornis* has suffered a major decrease in abundance throughout the Caribbean region during the past two decades due to a combination of factors (see below). On Telephone Pole Reef, the once abundant stands of *A. cervicornis* have been significantly replaced by *Porites porites* (Curran et al., 1994).

Field Methods

We used the linear point intercept (LPI) method (Lucas and Seber, 1977) and constructed transects on Telephone Pole Reef and in the abandon quarry area of the Cockburn Town fossil reef. In order to adequately estimate cover for the widest range of coral growth forms and colony sizes, transects were 40 m long (Mundy, 1991), each separated by 20-50 m. At 20 cm intervals along each transect intercept was observed. From the modern reef environments, the following data were recorded if the transect intercepted a coral: species, colony size, colony orientation, growth form and whether the colony was alive or dead and whether whole or fragmented. Colonies that were partially dead and large enough to provide multiple intercepts were recorded as live or dead depending on what portion of the colony was intercepted by the transect. The same data (with the obvious exceptions of whether the coral colony was alive or dead) were collected from transects laid across the Pleistocene reef facies exposed in the quarry. Radiometric dates indicate that the Pleistocene reefs on San Salvador flourished between 119-131 ka (Chen et al., 1991).

In modern environments, we define the death assemblage as *in situ* dead coral material encountered along each transect (including dead portions of partially dead colonies) and coral rubble accumulating adjacent to the reef framework. Dead coral colonies encountered along the transect were indentified to the species level only if we could recognize them without breaking them open or peeling off any algae or other overgrowth. Bulk rubble samples composed of dead coral were taken at the 5,15, 25 and 35 m marks of each transect. This methodology allowed us to adequately sample the death assemblage as defined above. Rubble samples were placed in a 5 mm mesh bag contained by a 10 L bucket. Thus, coral species and growth form were recorded for each specimen 5mm in size that preserved morphology sufficient to permit identification. Taxonomic data obtained from the rubble samples was pooled with that obtained from dead corals encountered along each transect.

Data analyses

We constructed species sampling curves to investigate whether our methodlogy adequately accommodated the diversity present in the coral assemblages studied. Comparison of taxonomic composition was calculated using the Bray-Curtis dissimilarity coefficient (Bray and Curtis, 1957), which has been shown to be one of the most robust coefficients for the analysis of taxonomic composition data (Faith et al., 1987). Dissimilarity values range from 0 (for a pair of samples with identical taxonomic composition) to 1 (for a pair of samples with no taxa in common). Abundance data were transformed to their square root prior to the analysis, to reduce the influence of occasional large abundance values for some taxa (Field et al., 1982). In addition, the transformed abundance values for each taxon were standardized by the maximum attained by that taxon. This standardization equalizes the potential contributions of taxa to the overall dissimilarity in composition. Without standardization by taxon, the Bray-Cirtis values are dominated by those taxa that attain high abundances (Faith et al., 1987). The resulting Bray-Curtis matrix was subjected to an ordination technique that provided a visual summary of the pattern of dissimilarity values among the samples. The technique employed was global non-metric multidimensional scaling, or GNMDS (Kruskal, 1964), which has been shown to be one of the most effective methods available for the ordination of taxonomic composition data (Minchin, 1987). Each sample is represented as a point in a coordinate space with a given number of dimensions. The distances between each pair of points are, as far as possible, in rank order with the corresponding dissimilarites in taxonomic composition: points that are close together on the resulting scatter plot represent transects with similar coral constituents. The degree to which the distances on the scatter plot depart from a perfect rank order fit is measured by a quanity known as "stress". The lower the stress value, the better the representation of the samples in the multidimensional space [stress values less than 0.2 generally result in interpretable results (Clark and Warwick, 1994)]. The obtained stress value decreased minimally after a two dimensional analysis.

Species richness patterns were compared between life, death and fossil assemblages. To compute species richness, the number of species in each sample was counted and then corrected for sample size. Thus, species richness = $(S - 1) / (\log N)$, where S= the number of species present in a sample and N = total number of specimens counted.

RESULTS AND DISCUSSION

The limited size of the *A. cervicornis* - dominated thickets and rubble areas on Telephone Pole Reef allowed for construction of a total of four 40 m transects over modern life and death assemblages, while five transects were accommodated within the quarry area of the Cockburn Town fossil reef. The sampling curves indicate that four transects were insufficient to account for the full diversity of the life assemblage on Telephone Pole Reef (Fig. 2A). Sampling curves level off only between the final two transects for both the death and fossil assemblages (Fig. 2B, C); we hesitate to claim adequate sampling based on these results.

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Results of ordination reveal that samples from life, death and fossil assemblages are clearly distince from one another (Fig. 3). Moreover, the taxonomic composition of the death assemblage samples is more similar to samples from the fossil assemblages than samples from the life assemblages (Fig. 3). Analyses of species richness indicate that a significant decrease (F [2,10] = 121.31; p <0.0005) in species diversity occurs from life to death to fossil assemblages (Fig. 4)

The discrimination between the life assemblage and the death and fossil assemblages by the ordination technique is interpreted to be the result of the recent change in coral community structure on Telephone Pole Reef that is part of a Caribbean- wide phenomenon. Beginning at least as early as the 1980's. Acropora cervicornis has suffered an extreme decrease in abundance as a result of a confluence of factors including hurricans (Woodley et al., 1981), spread of macroalgae consequent to sea urchin mass mortality (Lessios, 1988), Coral diseases and coral bleaching (Brown and Ogden, 1993; Littler and Littler, 1996; Miller, 1996) and a variety of human-induced effects (Hughes, 1994). On Telephone Pole Reef, Acopora cervicornis has been replaced by large colonies of Porites porites. The previous A. cervicornis - dominated community is now manifested in the death assemblage (Fig. 5B), while *P. porites* is abundant only in the life assemblage (Fig. 5A). Additionally, the paucity of milleporids in either the death or fossil assemblage relative to the life assemblage further segregates life assemblage samples from those obtained from the fossil and death assemblages (compare Figures 5A- C). Susceptibility of these hydrozoans to the variety of physical, biological and chemical processes that tend to destroy potential fossil material possibly implicates phylogenetic differences between hydrozoan skeletal microstructure and scleratinian skeletal microstructure as a source of difference in the preservation potential of these taxa. The decrease in species richness from live to dead to fossil assemblage results from the absence of the three milleporids we distinguished in our surveys (Millepora complanata, M. squarrosa and M. alcicornis) as well as taxa that are rare in the life assemblage (e.g. Diploria clavosa, Siderastrea radians, S. siderea, Montastrea cavernosa, Meandrina meadrites and Dendrogyra cylindrus, Fig.5).

Constancy and Change in Reef Community Structure

The results we report here contrast with those obtained from companion studies comparing life and death assemblages occurring on modern Florida Keys reefs to Pleistocene reefs exposed in the Key Largo Limestone and on Great Inagua, Bahamas (Greenstein et al., in press and Greenstein & Curran, 1997, respectively). In those studies, life assemblages currently in the Florida Keys reef tract were demonstrated to be more similar to Pleistocene fossil assemblages than to their contemporary death assemblage. The striking difference obtained here is that the death and fossil assemblages are clearly most similar to each other in terms of the coral taxa they contain. There are three alternative hypotheses that explain the apparent failure of the Pleistocene assemblage exposed on San Salvador to accurately reflect the life assemblage currently in place offshore, while other Pleistocene strata we have studied apparently reflect modern reef coral life assemblages much more closely.

First, the demise of A. cervicornis in the Bahamas and Caribbean and subsequent replacement by other coral species (Telephone Pole Reef, P. porites), is without historical precedent. In Belize, the once abundant stands of A. cervicornis have been replaced by Agaricia tenuifolia (Aronson and Precht, 1997: Aronson and Plotnick, in press). Careful examination of cores taken through the reef sedimentary record in Belize revealed no recognizable signals (abrupt changes in coral taxa, or taphonomic evidence of an essentially monospecific death assemblage) of similar transitions, suggesting that the present drastic reduction of A. cervicornis has no precursor in the recent geological past (at least 3,800 years; Aronson and Precht, 1997). In the Florida Keys, we (Greenstein et al., in press; Greenstein and Curran, 1997) purposely chose modern reefs for our surveys that conformed to earlier (pre-1980) descriptions (for example Mulder, 1977) of the majority of the reef tract reefs (for example abundant live Acropora palmata in the shallowest zoans, grading to more diverse, deeper assemblages of living A. cervicornis, Porites astreoides, Montastrea annularis and strigosa). It is compelling that these "healthy" reef communities were reflected by the fossil assemblages in the Florida Keys and Great Inagua, where as the present Porites - dominated community on Telephone Pole Reef is not reflected by the fossil assemblage exposed on San Salvador. Moreover, it is sobering to consider the rapidity with which A. cervicornis - dominated communities have been altered. From this we can only conclude that, although the A. cervicornis - dominated coral association persisted during Pleistocene climatic fluctuations, it is apparently vulnerable to the array of perturbations currently being inflected on it.

A second hypothesis is that rapid change in coral dominance within a community commonly occur, but the fossil record does not have sufficient resolution to preserve these temporally short-term fluctuations in reef community structure. Shortterm studies of living coral reefs have recorded fluctuations of dominant species at virtually all spatial scales; ranging from meter guadrats (e.g. Hughes et al., 1987; Bak and Nieuwland, 1995), through individual reefs (e.g., Porter et al., 1081; Woodley et al., 1981) to entire provinces e.g., Lessios, 1988). Moreover, short-term fluctuations may be a prerequisite for long-term stability (Chesson & Huntly, 1989) and thus produce the type of long-term presistence of coral communities documented by Mesollela (1967), Jackson (1992), and Pandolfi (1996). We note here that several workers have outlined sedimentologic (e.g. White et al., White and Curran, 1987; Curran et al., 1989; White 1989; White and Curran, 1995) and taphonomic (e.g. Greenstein and Moffat, 1996) evidence for rapid burial of late Pleistocene bankbarrier and lagoonal reef systems of the Bahama Archipelago during the post-Sangamonoan regression. Thus live and dead corals were buried concurrently. Greenstein and Moffat (1996) demonstrated that specimens of A.cervicornis

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preserved in the quarry near Cockburn Town were actually less degraded than dead specimens accumulating on Telephone Pole Reef. In this case, the taphonomic evidence does not support a mass morality event of this species during Sangamon time. In any event, it seems likely to us that rapid transitions similar to those observed presently in the Caribbean would be preserved somewhere had they occured. The preliminary results reported by Aronson and Precht (1997), are encouraging in that they demonstrate that this hypothesis is eminently testable; and further microstratigraphic examination of Pleistocene coral-bearing strata should be undertaken. Formost among these strata should be the units described here, as well as those from which long-term stability of Caribbean and Indo-Pacific reef coral communities has been reported (e.g. Mesollela, 1967; Jackson, 1992, 1994a; Pandolfi, 1996).

A third alternative is that differences between the environmental setting of Telephone Pole Reef and the interpreted for the Cockburn Town fossil reef account for the differences we have obtained

. White et al., (1984) and Curran and White (1985 interpreted the main portion of the Cockburn Town fossil reef as a reef tract system, whereas Telephone Pole Reef is a patch reef. Thus, the physical environment may not have permitted a take over by *Porites porites* or *Agaracia tenuifolia* (e.g. Aronson and Precht, 1997). However,

Greenstein and Moffat (1996) examined the mode of preservation of both *Acropora* palmata and *A. cervicornis* collected from the Cockburn Town Reef fossil reef. Based on a variety of taphonomic criteria, they suggested that the fossil coral were derived primarily from a life assemblage that had been rapidly entombed. Had a die-off of *A. cervicornis* occurred during Sangamonian time, thickets of degraded *A. cervicorns*

might potentially be preserved during such an event, and yield a much different

taphonomic signal than that obtained by Greenstein and Moffat (1996). a two step alalysis of additional Pleistocene facies exposed in the Bahamas in needed to address this issue. First, to avoid circular reasoning, environmental interpretations of fossil reef assemblages should be made using criteria independent of coral content (for example constituent particle analyses coupled with detailed field descriptions [Pandofi et al., in review]). once a fossil assemblage has been determined to represent an environment like that currently hosting a reef undergoing transition in coral dominance, a comparative taxonomic study should be performed on both the modern and ancient assemblages.

SUMMARY

A comparison of the results of systematic censuses of live, dead and fossil coral assemblages occurring in and adjacent to Fernandez Bay had yielded insight into the importance of the Pleistocene fossil record of coral reefs as an instrument with which to determine whether the presently observed changes in patch reef community structure in the Caribbean region has an historical precedent. We have determined that the rapid decline of *Acropora cervicornis* observed on a Bohamian patch reef (and

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observed around the Caribbean region) may be a unique perturbation that contrasts with the long-term resistence of this taxon during Pleistocene and Holocene time.

CONCLUSIONS

Although the results of our species sampling curves dictate that our results must be interpreted cautiously, primarily owing to relatively small sample size, we offer the following conclusions:

1. The fossil assemblage exposed in the Cockburn Town quarry is less species rich than its living and dead counterparts in Fernandez Bay. This the result of two factors: a coral taxa that are rare in the life assemblage (e.g. *Diploria clivosa*, *Dendrogyra cylindrus*, *Meandrina* and *Montastrea cavernosa*) are increasingly

erased during the transition to the death and fossil assemblages; and 2) the thee species of hydrozoan common on the living reef are rare in the death and fossil assemblages.

2. Based on the assemblage of corals they conatin, the death and fossil assemblages are more similar to one another than either is to the living coral assemblage. This result is in stark contrast to similar comparisons reported from the Florida Keys and Bahamas. We submit that this is the result of comparing a reef currently undergoing a transition to a *Porites porites* - dominated coral assemblage from a *Acropora cervicornis* - dominated assemblage.

3. Further study of Pleistocene reef facies is needed to assess whether the current Caribbean - wide reduction in abundance of *Acropora cervicornis* has an historical precedent.

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FIGURE CAPTIONS

Figure 1 - Area of study, San Salvador Island, Bahamas. Telephone Pole Reef is located in Fernandez Bay, while the Cockburn Town fossil reef is located onshore at the north end of Fernandez Bay, in Cockburn Town.

Figure 2 - Cumulative diversity of reef coral species verses number of sampling intervals (trancets) from live (A), dead (B) and fossil (C) reef coral assemblages presenton San Salvador. Four transects accommodated the diversity present in both death and fossil assemblages, but were insufficient to account for the diversity present on the living reef. For all sampling curves, the solid line is a plot preceeding from the first transect through last transect sampled for each assemblage; the dashed lines are plots of five random sequences of transects drawn from each assemblage.

Figure3 - Two dimensional global nonmetric Multidimensional scaling (GNMDS) ordination of coral life death and fossil assemblages fron San Salvador, Bahamas. Points closest to one another represents

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samplies (transects) that are more similar in taxonomy composition than points farther away from one another. Note that each assemblage occupies a distinct portion of ordination space. the minimum stress value for the three dimensional analysis was 0.09.

Figure 4 - Comparison of coral diversity between life, death and fossil assemblages on San Salvador as measured by Species Richness. Decreasing species richness values are the result of the lack of milleporids and taxa that are relatively rare on the living reef. Error bars are standard errors of the mean.

Figure 5 - Histogram of the frequency distribution of common coral taxa in life (A) death (B) and fossil (C) assemblages preserved on San Salvador. Abundance data are transformed to square roots. Note the relatively high abundance of *Porites porites,* milleporids and *Montastrea annularis* in the life assemblage. The death assemblage comprises *Acropora cervicornis, A. palmata* and lower abundances of *M. annularis*. For this histogram, data codes (x-axis) are as follows:

- 1. Acropora palmata
- 2. Porites asteoides
- 3. Porites porites
- 4. Agarcia agaricites
- 5. Millepora sp.
- 6. Diploria strigosa
- 7. Favia fragum
- 8. Millepora squarrosa
- 9. Millepora complanata
- 10. Millepora alcicornis
- 11. Diploria clivosa
- 12. Siderastrea radians

- 13. Siderastrea siderea
- 14. Acropora cervicornis
- 15. Porites furcata
- 16. Mycetophylia lamarckiana
- 17. Montastrea cavenerosa
- 18. Mycetophylia danaana
- 19. Copohyllia natans
- 20. Dichocoenia stokesii
- 21. Diploria labyrinthiformis
- 22. Montastrea annularis
- 23. Meandrina meandrites
- 24. Solenastrea bournoni
- 25. Solenastrea hyades



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A Beginner's Guide to Collecting Coral

Albert Hines 602 Fleming Street N.Muskegon MI 49445

This brief article, as the title suggests, is an overview of collecting fossilized corals. As my background is neither in paleontology, geology, nor yet biological sciences, I offer my sincerest apologies to the Ph.D. community, who may find this treatise lacking technical depth. However, I am writing as one who has been actively collecting for over 30 years (Honey, could you go fetch the Geritol?), having begun before I was in first grade. So, rather than being able to fulfill the intellectual's quest for knowledge, I target an audience of amateurs whose heart, like my own, has primitive urges to gather pretty rocks.

Having established my goals, let me now diverge briefly to give a personal background. This should give the reader a sense of where I am coming from in terms of perspective. I was born in Montgomery, Alabama. My older sister was primarily responsible for my interest in collecting. When she was in elementary school, she would collect and show off shark's teeth she found in the school playground while the other kids swang and played kickball. At the age of 5, we moved to the Ordovician hills of the central basin of middle Tennessee. The rolling hills from Nashville down to the Alabama line are chock full of road cuts and outcroppings literally dripping with marine invertebrate fossils. Therefore, my experience and collection has been primarily concentrated upon the Paleozoic tableland of the east central United States. Much of our young adulthood was expended seeking that complete trilobite (which I will confess I never found in middle Tennessee, but I will one day!)

I realize this is not following the topic, but I really must mention an interesting story here. One day while passing through Cincinnati for the first time. I was impressed by the huge limestone cliffs along the highways. *Mental note: fossils in Cincinnati.* Years later, I got back for that second visit, but just in for one day on business. On my morning walk, I began my trek from the hotel on the north side of town frantically searching for a road cut. No such luck. I only found open fields with construction going on. However, I desperately grasped a few local chunks of limestone strewn from somewhere into the wet clay. "AH HA, brachiopods, just as I suspected, and Ordovician at that!" Well, I purposed my third visit would be different. Still just a callow youth now living in Knoxville, Tennessee (where I did find my first complete trilobite, a pair of doozies. (That's technical talk for pliomerops), I planned a visit to a friend for one night while passing through. I dropped the newlywed wife off at the mall and promised I would pick her up in a couple of hours. Like a madman, I recklessly careened toward Hamilton, where I was told by reputable sources that a nest of angry flexicalymene was carelessly overturned by innocent construction workers building a new Kroger. (Needless to say, it took quite a crew to exterminate the beasts and rid the world of the carnage.) Oh, too bad. Nothing but manicured mulch and boxwood at that site. However, on the way back, driving down US 23 I think it was, there they were big as life: cliffs by the road, in the southbound lane. Quick as a flash, I pulled over in the emergency lane (hey, it was an emergency), bounded out of the car, grabbed the pick hammer and immersed myself in the warm embrace of weathering bedrock. No it

can't be, only 45 minutes left to pick up my wife. Oh, the fickleness of life. I ended up staying there only 1 hour. But I found my third complete trilobite! A small, unimpressive flexicalymene, but it's mine all mine.

WO! Corals, Albert corals. I'm terribly sorry. Flashbacks can be so vivid. I really will try to keep on track. I was trying to say that I grew up in middle Tennessee, but the rocks of Cincinnati are incredibly similar, the same age, fossil distribution and preservation. More trilobites in Cincinnati, but more coral in Tennessee. Coral? Did someone say coral? Yes, that reminds me of another story! Our grandparents lived in our hometown of Columbia, Tennessee. They had property at the bottom of a tall, round hill with exposed cliffs from which would weather out wonderful corals, nautiloids. bryozoan, etc. Anyway, while playing in the woods nearby, we discovered that someone had used the area to dump their garbage. So there were 50 year-old bottles and other rubbish laying just beneath the surface - exactly the kind of thing kids love. We were kicking through the leaves and what did my sister find? It was a perfectly preserved spherical foerstephyllum (?) colony 10 inches in diameter. Apparently, someone's kid had found it weathered out and taken it home to mom and dad. "Oh, that's nice dear." Out with the garbage it went as soon as they weren't looking! So this twice found fossil now adorns my cluttered basement. Well, my sister's rock appeal has long since waned. Hence I have appropriated it, with the story, into my personal belongings.

See, that wasn't so bad, was it? It even had to do with coral. By the way, did you know that there are three types of coral? They are called rugose, scleractinian, and tabulate. I apologize for the long weird names, especially "scleractinian", but it's not my fault. I promise. The differences can be very hard to appreciate for the novice (like me!) and are not always obvious. To make matters worse, there is another critter that can look exactly like a coral and yet is not. That is a bryozoan, which are often found in great abundance along with corals. Without delving into the briny depths of zoology, I will try to give the casual and intermediate fossil collector the necessary information to distinguish these without the use either of stereo microscopes or advanced degrees.

Referring to figure 1, a typical cross section is drawn of a hypothetical rugose coral. As a very general rule with many exceptions, rugose coral have stronger radial septa than they do transverse platforms. If I may relate an individual coral tube to an orange, the septa may be thought of as the clear membrane separating the slices. They converge in the center and radiate outward from there. Baby corallites are born (OK, they aren't born, they bud asexually) with four cute little septa. As baby corallite grows, his calice becomes larger and the septa begin to spread further apart. So, two new septa are added (kind of like baby teeth) first. As he continues to grow, four septa at a time are added to maintain a rigid structure. For this reason, rugose coral are also called tetracoral, since tetra means four.

Long, long ago little rugose corallite babies played together in the deep blue sea (OK, they didn't often run around, but they did build reefs.). The very first rugose coral was

created in the Ordovician. They enjoyed a long and happy life, building reefs all over the world. Then, a very terrible thing happened. It was at the end of the Permian, I believe it was, something just dreadful happened. Someone outlawed all rugose coral from ever building another reef. And being very humble animals, the rugose coral, sadly, never came back to play.

Many legends remain of the rugose coral. Stories passed down for generations. Everyone knows of the famous prismatophyllum and hexagonaria, which are now loving referred to as "Petosky stones" because of their abundance in Petosky, Michigan. Michigan even bestowed upon them the honor of "State Stone". Then there are the grewinkia and their kinfolk, common in the upper Ordovician limestone of middle Tennessee and Cincinnati, as well as in the Silurian and Devonian deposits across New York, Ontario, and Michigan. Acrocyathus forms huge masses in the Mississippian highlands of the Cumberland plateau and is found both weathering out of the escarpment and as rounded creek rock. Rugose coral may grow either individually (horn coral) or together in colonies, as with the Petosky stone.

Then there are the tabulate corals. Tabulate coral have (again with exceptions) stronger transverse plates than septa. By transverse plate, I mean a membrane which cuts across the longitudinal axis, see figure 2. The soft body parts of the coral were supported by this platform. As the rim of the corallite grew taller, the coral would secrete a new higher platform in order to remain sitting at the top, where food was available. In the figure, I have drawn an individual corallite to help visualize. However, tabulate corals rarely occur individually.

Tabulates were really quite home bodies. They almost never played by themselves, but grew up in neighborhoods or colonies, side by side with their tabulate buddies. And rightly so. Without strong radial septa, their structural rigidity was quite limited. The margin of figure 2 shows a typical corallite arrangement in tabulate coral. The section is parallel to the longitudinal axis. The calices at the top often form polygonal (honeycomb) patterns at the surface (hence the popular name of honeycomb coral.). Rugose corals also got together sometimes in colonies, but often stood alone.

Being the socially dependent individuals that they were, tabulates often poked holes (OK, they grew holes) in their corallite walls to talk with, steal food from and spy upon their corallite neighbors. Although leaving little privacy, this behavior seemed to work well. Tabulates are abundant in Paleozoic marine sediment worldwide. Unfortunately, the same fate which eradicated the rugose coral from the face of the earth also affected the tabulates. They coexisted with their rugose cousins from the Ordovician to the Permian extinction.

The most commonly found tabulate is the favosites. Some of the many favosites localities I know of are: the Ordovician, Silurian, and Devonian limestone of Tennessee, Kentucky and Ohio, the Silurian / Devonian belt from New York to Michigan, and Silurian Iowa (like Coralville). Favosites is, in my unqualified opinion, the archetypal

tabulate coral. They commonly form spheroidal colonies that range from very small to immense.

Now, if you think the differences in tabulate and rugose corals are exciting, just wait until hear about scleractinian coral! (You may want to be sitting down for this.) Once again, refer to the diagram in figure 3. Like rugose coral, platforms are weak or absent. But baby scleractinians are born with (and here's the thrilling part) six septa. Septa are then added between existing adjacent pair, hence 6,12, 24, 48 ... at a time.

Scleractinian corals first appeared in the Triassic, but were fairly gun shy after the Permian holocaust. They did not become abundant until the Jurassic. Now, you may wonder how, if every coral on earth was suddenly killed, they could have reappeared at a later date with almost identical structure. Well, most people admit that no one really knows. Some think a sea anemone converted to coralism and started a whole new sect. Or perhaps there may have been a mutant, renegade rugose coral hiding out at a deserted south pacific island until after the dawn of the Mesozoic. Whatever happened, scleractinia is now the only remaining coral subclass. It forms reefs in tropical climates around the world, especially off the eastern coast of Australia.

Scleractinia is hard to distinguish visually from rugosa (the officially sanctioned subclass name), but is simple to determine if you know the locality. If the locality is Mesozoic or Cenozoic, it is scleractinian. If it is Paleozoic, it is either rugose or tabulate. If you aren't sure the age of the host rock, get a good geologic map if possible, or ask local knowledgeable sources.

Corals have soft body parts that are not usually well preserved in the fossil record. Their bodies were somewhat similar (biologically that is) to jellyfish, sea fans, and sea anemones. Most varieties of colonial coral form roughly spherical colonies at first. However as time progressed for the colony, preferential growth would lend itself to many forms: branchlike, sheetlike, or often similar to a lava flow, slowly engulfing everything in its path such as other rocks or animal skeletons. Solitary corallites are normally conical, either straight or curved. There may be either circumferential or longitudinal ridges, indicative of the septa and platforms present on the inside.

Commonly, corals may be misidentified by beginners because of these distinct shapes. Horn coral are often thought to be teeth, since teeth and claws are the most common naturally occurring conical objects in our life. Many a branching colonial coral, especially if the corallites are small, has been proudly brought home (or to museums!) as a "dinosaur bone." But even if they are not as dramatic as a tyrannosaurus rex, coral fossils can be quite impressive and attractive. And because of their relative abundance and durability, can be collected by amateurs easily and in many localities.

I had promised earlier to help distinguish between corals and bryozoa. This is not always an easy task. Without careful microscopic analysis, coral with very small corallites can have the same external shape and fibrous appearance. Normally, however, anything with "holes" (corallites for coral, zooecium for bryozoa) 1mm or larger will be a coral. Also, corallites typically open to the surface of the colony with a "cheese grater" roughness, whereas a bryozoan will normally have a smoother external surface. These two guidelines work in about 99% of the cases. The other 1% is best taken to a university geology department or good fossil museum curator.

Well, enough technical content, let's have some more stories! I moved up to the frozen north (west Michigan that is) about seven years ago. I had never lived in a place without abundant bedrock outcroppings before. It has been a shock to be certain. Gone are the days when afternoons were spent scaling road cuts, enduring chiggers, broken bottles, ticks, curious policemen, copperheads, and the insults of passing motorists all for the glory of bringing home a neater rock than the day before.

My first trip north of Cincinnati brought me along highway I-75 en route to Detroit to meet my future in-laws. Well, I figured I would stop at famous Silica, Ohio (famous to fossil collectors, anyway). I drove around and was surprised to find that the landscape was flat as a pancake and the only possible collecting would be in the quarries. So I pulled into the main quarry office, walked in, introduced myself and being the southern bumpkin I am, asked if I could collect and that I would be willing to pay, if they wished. One of the men (whom I have seen later in fossil shows) kept silent. The other fellow said there might be a quarry in Lucky (an hour back south) that would permit collecting. But that if he caught me on his property again, he would call the police! Welcome to northern hospitality!

Well, once again, I am straying from my topic. And since you now know at least as much as I do about coral, the time has come to bring this article to a close. I must admit, I rarely go collecting for the specific purpose of looking for coral. There are more kudos from fellow fossil hunters for finding a perfect nautiloid, trilobite, or even gastropod than a "mere" coral. Yet because it forms huge durable reefs, coral represents a major and important portion of the fossil record. Here's wishing you many enjoyable hours of hunting that may bring you coral specimens worthy to show off to friends and relatives.

Portions of the technical content of this article were taken from <u>The Audubon Society</u> <u>Field Guide to North American Fossils</u>, published by Alfred A. Knopf, New York, NY.

Illustrations by the author.

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Figure 2.Idealized Tabulate Coral

corallite



Figure 3. Idealized Scleractinian Coral

Types & growth habits of Devonian corals at the Falls of the Ohio and surrounding areas

by Alan Goldstein, Falls of the Ohio State Park

Corals in the Devonian rocks in the Indiana and Kentucky grow in a variety of habits. Tabulates resemble the modern scleractinian corals in their growth habits. Rugose corals, especially the colonial varieties, resemble massive hemispherical forms, like the brain coral. Septal structure (the diagnostic internal characteristic for identifying individual species) of rugose coral resemble modernal scleractinians, but the symmetry is different. Rugose coral septae have bilateral and modern corals have radial symmetry (Oliver, 1996.)

Jeffersonville Limestone (in normal type) North Vernon Limestone (in boldface type) (Includes the Speed, Silver Creek and Beechwood members) and Boyle Limestone of central Kentucky

Order Rugosa

"Horn" corals describe the solitary form of rugose corals, although not all are shaped like an animal's horn. Colonial forms are well-known. Some corals may increase by asexual budding, but are often found as solitary. Coral forms are illustrated at the end of this article (plate 1.)

rs = rugose, solitary (d = discoidal, p = patelloid, t = trochoid, c = ceratoid, y = cylindrical or subcylindrical) See illustrations on plate 1. A hyphen indicates a range of forms. rc1 = rugose, colonial phaceloid (corallites separated) rc2 = rugose, colonial ceroid/semi-ceroid (corallites abut one another, share coral wall)

rc3 = rugose, colonial asteroid (corallites abut one another, without a common wall)

Acinophyllum mclareni Fagerstrom	rc 1
Acinophyllum stokesi (Milne-Edwards & Haime)	rc1
Acrophyllum clarki Davis	rsc-t
Acrophyllum conigerum (Greene)	rsc
Acrophyllum ellipticum Davis	rst-c
Acrophyllum oneidaense (Billings)	rsc-y
Aemuliophyllum exiguum (Billings)	rsp
Aemuliophyllum exiguum elongatum (Davis)	rst
Amplexiphyllum cruciforme (Hall)	rsy
Amplexiphyllum(?) simplex (Hall)	rsc
Amplexiphyllum tenue (Hall)	rsy
Aulacophyllum conigerum Davis	rst
Aulacophyllum mutabile Davis 99	rst

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Aulacophyllum perlamellosum (Hall)	rst
Aulacophyllum pinnatum Hall	rst
Aulacophyllum sulcatum (d'Orbigny)	rst
Bethanyphyllum arctifossa (Hall)	rsc-t
Bethanyphyllum depressum (Hall)	rsc
Bethanyphyllum nanum (Davis)	rsc-t
Bethanyphyllum pocillum (Davis)	rsc-t
Bethanyphyllum prateriforme (Hall)	rst
Bethanyphyllum robustum (Hall)	rsc-t
Bethanyphyllum validum (Hall)	rst
Bethanyphyllum vesiculatum (Hall)	rsc
Blothrophyllum romingeri Stumm	rsy
"Blothrophyllum" trisulcatum (Hall)	rsy-c
Bordenia knappi (Hall)	rst,c,y
"Breviphrentis" halli (Edwards & Haime)	rsc-t
"Breviphrentis" nitida (Hall)	rsc
"Breviphrentis" ovalis (Hall)	rsc-y
Breviphrentis(?) planima (Hall)	rsy-c
Bucanophyllum ohioense (Nicholson)	rsy
Cayugaea(?) subcylindricum Stumm	rsy
Cladionophyllum cicatriciferum (Davis)	rsy
Coleophyllum romingeri (Hall)	rsy-c
Compressiphyllum davisana (Miller)	rst
Craterophyllum adnascens (Greene)	rst
Craterophyllum(?) latiradium (Hall)	rst
Craterophyllum magnificum (Billings)	rst-p
Cyathocylindricum gemmatum (Hall)	rc1
Cyathocylindricum opulens Oliver	rc 1
Cystiphylloides americanum (Edwards & Haime) rsc-y
Cystiphylloides crassatum (Greene)	rsd,y
Cystiphylloides hispidum (Davis)	rsy-c
Cystiphylloides infundibuliformis (Greene)	rsy
Cystiphylloides limbatum (Davis)	rsy
Cystiphylloides nanum (Hall)	rsy
Cystiphylloides plicatum (Davis)	rsc
Cystiphylloides pustulatum (Hall)	rst
Cystiphylloides quadrangulare (Hall)	rsc
Cystiphylloides tenuiradium (Hall)	rsy
Diplochone greenei (Miller)	rsy-c
Disphyllum cohaerens (Hall)	rcl
"Disphyllum" synaptophylloides Stumm	rci
Eaapnopnyllum dijurcatum (Hall)	rst-c-y
Enallophrentis concava (Hall)	rsc
Enallophrentis (?) curvata (Hall)	rsy-c
Enallophrentis (!) cyathiformis (Hall)	rst
Enallophrentis auplicata (Hall)	
Enallophrentis (i) Jouana (nall)	180 ret

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Enallophrentis simplex (Hall)	rsc-t
Enallophrentis trisutura (Hall)	rst
Eridophyllum apertum (Hall)	rs - rc1
Eridophyllum archaici (Billings)	rc l
Eridophyllum coagulatum (Davis)	rc1-2
Eridophyllum seriale Edwards & Haime	rc1
Eridonhyllum tumidulum (Hall)	rst
Hadronhyllum nettelrothi (Davis)	rsd
Hadronhyllum orbignyi Edwards & Haime	rsd (smallest
coral. disk-shaped, typically	1 cm in diameter)
Hallia strigata (Greene)	rsc-t
Heliophyllum agassizi Greene	rst
Heliophyllum alternatum Hall	rsc
?Heliophyllum coalitum (Rominger)	rc l
Heliophyllum denticulatum Hall	rsv-c
Heliophyllum ethelanum (Davis)	rsv-c
Heliophyllum gurlevi Greene	rst. rc1
Heliophyllum halli Edwards & Haime	rst-c
Heliophyllum incrassatum Hall	rsv-c
Heliophyllum infundibulum Hall	rsc
Heliophyllum ingens (Davis)	rc3
Heliophyllum insigne (Davis)	rst-D
Heliophyllum latericrescens Hall	rs - rc1
Heliophyllum pocillum (Davis)?	rst-c
Heliophyllum tenuiseptatum Billings	rsc-t
Heliophyllum venatum Hall	rsc
Heliophyllum verticale Hall	rsy-c
Heliophyllum yandelli (Rominger)	rc3
"Heterophrentis" annulata (Hall)	rsy
"Heterophrentis" colletti (Hall)	rsc-t
"Heterophrentis" irregularis (Hall)	rsy-c
"Heterophrentis" rafinesqui (Edwards & Haime)	rsy-c
"Heterophrentis" subcompressa (Hall)	rsc
Homalophyllum fusiformis (Hall)	rsc
Homalophyllum herzeri (Hall)	rsc
Homalophyllum ungulum (Rominger)	rsc
Iowaphyllum knotti (Davis)	rc2
Kionelasma coarcticum (Hall)	rsc
Kionelasma conspicuum (Hall)	rst
Kionelasma mammiferum (Hall)	rsc-t
Odontophyllum convergens (Hall)	rsp
Prismatophyllum bella (Davis)	rc2
Prismatophyllum conjunctum (Davis)	rc2
Prismatophyllum ovoideum (Davis)	rc2
Prismatophyllum prisma Lang & Smith	rc2
Prismatophyllum truncata Stewart	rc2
Scenophyllum(?) coniferum (Greene)	rsy-c
Scenophyllum conigerum (Rominger)	rsc

Schlotheimophyllum typicum (Davis)	rsc-t
Schlotheimophyllum versiforme (Hall)	rst
Siphonophrentis elongata (Rafinesque & Clifford)	rsy (largest
solita	ry coral known)
Siphophrentis yandelli (Edwards & Haime)	rsy
"Skoliophyllum" squamosum (Nicholson)	rsp
Stauromatidium trigemma (Davis)	rsy - rcl
Stereolasma(?) exile (Davis)	rsc
Stereolasma gallicalcar (Davis)	rsc
Stereolasma parvulum (Davis)	rsy-c
Stereolasma rectum (Hall)	rsc
Tabulophyllum(?) bellicinctum Greene	rsc
Tabulophyllum(?) greeni (Davis)	rsy
Tabulophyllum perplicatum (Hall)	rsy
Tabulophyllum(?) sinuosum Hall	rsy
Tabulophyllum(?) tripinnatum (Hall)	rsy
Tabulophyllum zaphrentiforme Davis	rsy-c
Triplophyllum terebrata (Hall)	rsy-c
Zaphrentis phrygia Rafinesque & Clifford	rst-c

Order Tabulata

Tabulates include the "honeycomb" corals and their kin. Growth habits are not unlike the modern scleractinian corals. Modern corals are not decendants of tabulate corals.

A relationship exists between modern coral forms and their location in the coral reef. Stout corals occur where the surf and currents are the strongest. Delicate corals are found in cloistered areas. The Devonian (Emsian - Eifelian - Givetian) ecosystem was not a true reef. The distribution of growth habits have not been found to be correlated with any major marine topographic features, but additional studies may reveal some on a smaller scale features.

tc	= tabulate, cylindrical
tđ	= tabulate, discoidal
te	= tabulate, encrusting
th	= tabulate, hemispherical
ti	= tabulate, irregular growth
tp	= tabulate, palmate growth
tr l	= tabulate, ramose (branching, <1 cm thick)
tr2	= tabulate, ramose (branching, >1 cm thick)

Alveolites asperus (Rominger)		tr 1
Alveolites constans Davis		t h
Alveolites expatiatus (Rominger)		tr 1
Alveolites goldfussi Billings		t h
Alveolites minimus Davis		th - td
Alveolites mordax Davis	102	t h

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Alveolites squamosus Billings	th - td
Alveolites winchellana (Miller)	tr l
Antholites speciosus Davis	t h
Aulocystis auloporoidea (Davis)	te
Aulocystis fascicularis (Davis)	te
Aulocystis frutectosa (Davis)	te
Aulocystis(?) incrustans (Davis)	te
Aulocystis jacksoni (Grabau)	te
Aulocystis nobilis (Billings)	te
Aulocystis(?) procumbens Davis	te
Aulocystis transitorius Stumm	te
Aulopora culmula Davis	te
Aulopora edithana Davis	te
Aulopora tubiporoides (Yandell & Shumard)	te
Bractea arbor (Davis)	tr2, ti
Bractea frutex (Davis)	tr 1
Bractea impedita (Davis)	tr1
Chonostegites clappi Edwards & Haime	t h
Chonostegites tabulatus (Edwards & Haime)	t h
Cladopora acupicta Davis	tr l
Cladopora bifurca Davis	tr1, 2
Cladopora(?) gracilis Davis	tr 1
Cladopora gulielmi Davis	tr l
Cladopora(?) imbricata Rominger	tr1, 2
Cladopora labiosa (Billings)	tr l
Cladopora(?) robusta Rominger	tr2
Favosites argus Hall	td - th
Favosites biloculi Hall	td, th, ti, tp
<i>Favosites clausus</i> Rominger	tr 1
Favosites clelandi Davis	t d
Favosites goldfussi d'Orbigny	t h
Favosites hamiltoniae Hall	td - th
Favosites mundus Davis	td - th
Favosites patellatus Stumm	t h
Favosites pirum Davis	t h
Favosites placentus Rominger	t d
Favosites proximatus Stumm	tp - tr2
Favosites quercus Davis	tr2
Favosites ramulosus Davis	tr 1
Favosites rotundituba Davis	t h
Favosites turbinatus Billings	t h
Favosites "Emmonsia" amplissima (Davis)	t h
Favosites "Emmonsia" arbuscula (Hall)	ti - trl
Favosites "Emmonsia" bacula (Davis)	tc
Favosites "Emmonsia" convexa (Davis)	th
Favosites "Emmonsia" cymosa (Davis)	t1
Favosites "Emmonsia" emmonsi (Rominger)	th
Favosites "Emmonsia" epidermata (Rominger) 103	td

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Favosites "Emmonsia" eximia (Davis)	t h
Favosites "Emmonsia" ocellata (Davis)	t h
Favosites "Emmonsia" radiciformis (Rominger)	ti
Favosites "Emmonsia" ramosa (Rominger)	tr2
Favosites "Emmonsia" tuberosa (Rominger)	th - tc
Lecfedites canadensis (Billings)	t d
Platyaxum foliatum Davis	tp
Platyaxum frondosum (Nicholson)	tp
Platyaxum orthosoleniskum (Werner)	tp
Platyaxum undosum Davis	tp
<i>Pleurodictyum cornu</i> Stumm	t h
Pleurodictyum cylindricum (Michelin)	t h
Pleurodictyum insigne (Rominger)	th
Pleurodictyum maximum (Troost)	t h
Pleurodictyum michelinoides (Davis)	t h
Pleurodictyum papillosa (Davis)	t h
Pleurodictyum planum (Davis)	t h
Pleurodictyum spiculata (Greene)	• th
Pleurodictyum wardi Greene	t h
Romingeria commutata Beecher	te
Romingeria fasciculata Davis	te
Romingeria umbellifera (Billings)	te
Romingeria uva Davis	te
Striatopora(?) alba Davis	tr1
Striatopora bellistriata Greene	tr 1
Striatopora cavernosa Rominger	tr1 - 2
Syringopora hisingeri Billings	t h
Syringopora perelegans Billings	t h
Thamnopora distans (Nicholson)	tr 1
Thamnopora limitaris (Rominger)	tr1 - 2
Thamnoptychia alternans (Rominger)	tr1
Thamnoptychia tuberculata (Stumm)	tr l
Thamnoptychia vermiculosa (Leseur)	tr1

References

Oliver, W. M., Jr., 1976, Noncystimorph colonial rugose corals of the Onesquethaw and lower Cazenovia stages (Lower and Middle Devonian) in New York and adjacent areas: U. S. Geological Survey Professional 869, 156 p., 108 pls.

Groups and the Origin of the Scleractinia, p. 107 - 134.

Stumm, E. C., 1965, Silurian and Devonian corals of the Falls of the Ohio: Geological Society of America Memoir 93, 184 p., 80 pls.



Current Proper Names of Devonian Corals at the Falls of the Ohio

by Alan Goldstein, Naturalist, Falls of the Ohio State Park

Coral identification is very difficult, and usually requires thinsectioning and a detailed examination of the internal structure. Nonetheless, many collectors make attempts to identify corals using external features. To facilitate identification, this list will provide the currently accepted name. Confusing the situation is the fact that early description efforts were inadequate and authors might give two or three different corals the same name. Recent studies indicate that the names of some of the genera are not accurate. Most of the corals need further study. New genera and species names would likely result.

The coral to the right of the equal sign (=) is the proper name. A question mark (?) located to the left of the name indicates the current usage may not be accurate. Some of these may need further study and be redescribed. A question mark (?) located to the right of the genus name indicates additional study is needed to determine if the genus assigned is accurate. "Quotation marks" indicate the genus name needs to be revised. Some species can not be determined based on the types, they are listed in the section under "Obsolete Names" with Indeterminate or something similar to that in the right column "Valid Name."

Silurian corals (about 70 species) are not included in this paper.

Names in Current Use

Rugose Corals

Comments

Acinophyllum mclareni Fagerstrom Acinophyllum stokesi (Milne-Edwards & Haime) Acrophyllum clarki Davis Acrophyllum conigerum (Greene) Acrophyllum ellipticum Davis Acrophyllum oneidaense (Billings) Aemulophyllum exiguum (Billings) Aemulophyllum exiguum elongatum (Davis) Amplexiphyllum cruciforme (Hall) Amplexiphyllum tenue (Hall) Aulacophyllum conigerum Davis Aulacophyllum mutabile Davis Aulacophyllum perlamellosum (Hall) Aulacophyllum pinnatum Hall Aulacophyllum sulcatum (d'Orbigny) Bethanyphyllum arctifossa (Hall) Bethanyphyllum depressum (Hall) Bethanyphyllum nanum (Davis) Bethanyphyllum pocillum (Davis) 106

Bethanyphyllum prateriforme (Hall) Bethanyphyllum robustum (Hall) Bethanyphyllum validum (Hall) Bethanyphyllum vesiculatum (Hall) Blothrophyllum romingeri Stumm "Blothrophyllum" trisulcatum (Hall) [Neither Blothrophyllum or Tabulophyllum according to W.A. Oliver, Jr.] Bordenia knappi Hall "Breviphrentis" halli (Edwards & Haime) "Breviphrentis" nitida (Hall) "Breviphrentis" ovalis (Hall) Breviphrentis(?) planima (Hall) [further study needed] Bucanophyllum ohioense (Nicholson) Cayugaea(?) subcylindricum Stumm Cladionophyllum cicatriciferum (Davis) Coleophyllum romingeri (Hall) Compressiphyllum davisana (Miller) Craterophyllum adnascens (Greene) Craterophyllum(?) latiradium (Hall) "Craterophyllum" magnificum (Billings) Cyathocylindricum gemmatum (Hall) Cyathocylindricum opulens Oliver Cylindrophyllum gradatum (Greene) Cystiphylloides americanum (Edwards & Haime) Cystiphylloides crassatum (Greene) Cystiphylloides hispidum (Davis) Cystiphylloides infundibuliformis (Greene) Cystiphylloides limbatum (Davis) Cystiphylloides nanum (Hall) Cystiphylloides plicatum (Davis) Cystiphylloides pustulatum (Hall) Cystiphylloides quadrangulare (Hall) Cystiphylloides tenuiradium (Hall) Diplochone greenei (Miller) "Disphyllum" synaptophylloides Stumm Edaphophyllum bifurcatum (Hall) Enallophrentis concava (Hall) Enallophrentis ? curvata (Hall) Enallophrentis ? cyathiformis (Hall) Enallophrentis duplicata (Hall) Enallophrentis ? foliata (Hall) Enallophrentis inflata (Hall) Enallophrentis simplex (Hall) Enallophrentis trisutura (Hall) Eridophyllum apertum (Hall) Eridophyllum archaici (Billings) Eridophyllum coagulatum (Davis) Eridophyllum seriale Edwards & Haime

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Eridophyllum tumidulum (Hall) Hadrophyllum orbignyi Edwards & Haime Hadrophyllum nettelrothi (Davis) Hallia strigata (Greene) Heliophyllum agassizi Greene Heliophyllum alternatum Hall ?Heliophyllum coalitum (Rominger) Heliophyllum denticulatum Hall Heliophyllum ethelanum (Davis) Heliophyllum gurleyi Greene Heliophyllum halli Edwards & Haime Heliophyllum incrassatum Hall Heliophyllum infundibulum Hall Heliophyllum ingens (Davis) Heliophyllum insigne (Davis) Heliophyllum latericrescens Hall Heliophyllum pocillum (Davis)? Heliophyllum tenuiseptatum Billings Heliophyllum venatum Hall Heliophyllum verticale Hall Heliophyllum yandelli (Rominger) "Heterophrentis" annulata (Hall) [Heterophrentis is not a valid genus.] "Heterophrentis" colletti (Hall) "Heterophrentis" irregularis (Hall) "Heterophrentis" rafinesqui (Edwards & Haime) "Heterophrentis" subcompressa (Hall) Homalophyllum fusiformis (Hall) Homalophyllum herzeri (Hall) Homalophyllum ungulum (Rominger) Iowaphyllum knotti (Davis) Kionelasma coarticum (Hall) Kionelasma? conspicuum (Hall) Kionelasma mammiferum (Hall) Odontophyllum convergens (Hall) Prismatophyllum bella (Davis) Prismatophyllum conjunctum (Davis) Prismatophyllum ovoideum (Davis) Prismatophyllum prisma Lang & Smith Prismatophyllum truncata Stewart Scenophyllum(?) coniferum (Greene) Scenophyllum conigerum (Rominger) Schlotheimophyllum typicum (Davis) Schlotheimophyllum versiforme (Hall) Siphonophrentis elongata (Rafinesque & Clifford) Siphonophrentis yandelli (Edwards & Haime) "Skoliophyllum" squamosum (Nicholson) [Probably new genus] Stauromatidium trigemma (Davis) Stereolasma(?) exile (Davis) 108

Stereolasma gallicalcar (Davis) Stereolasma parvulum (Davis) Stereolasma rectum (Hall) Tabulophyllum? bellicinctum Greene Tabulophyllum? greeni (Davis) Tabulophyllum? perplicatum (Hall) Tabulophyllum? sinuosum Hall Tabulophyllum? tripinnatum (Hall) Tabulophyllum? tripinnatum (Hall) Tabulophyllum zaphrentiforme Davis Triplophyllum terebrata (Hall) Zaphrentis phrygia Rafinesque & Clifford

[Tabulophyllum not listed from the Eifelian stage in the *Treatise*, but indicated by Oliver as being the proper genus name for most species of *Blothrophyllum*.]

Tabulate Corals

Alveolites asperus (Rominger) Alveolites constans Davis Alveolites expatiatus (Rominger) Alveolites goldfussi Billings Alveolites minimus Davis Alveolites mordax Davis Alveolites squamosus Billings Alveolites winchellana (Miller) Antholites speciosus Davis Aulocystis auloporoidea (Davis) Aulocystis fascicularis (Davis) Aulocystis frutectosa (Davis) Aulocystis(?) incrustans (Davis) Aulocystis jacksoni (Grabau) Aulocystis nobilis (Billings) Aulocystis(?) procumbens Davis Aulocystis transitorius Stumm Aulopora culmula Davis Aulopora edithana Davis Aulopora tubiporoides (Yandell & Shumard) Bractea arbor (Davis) Bractea frutex (Davis) Bractea impedita (Davis) Chonostegites clappi Edwards & Haime Chonostegites tabulatus (Edwards & Haime) Cladopora acupicta Davis Cladopora bifurca Davis Cladopora(?) gracilis Davis Cladopora gulielmi Davis Cladopora(?) imbricata Rominger [often confused with Cladopora labiosa (Billings) Alveolites winchellana (Miller)] Cladopora(?) robusta Rominger Favosites "Emmonsia" amplissima (Davis)

Favosites "Emmonsia" arbuscula (Hall) Favosites "Emmonsia" bacula (Davis) Favosites "Emmonsia" convexa (Davis) Favosites "Emmonsia" cymosa (Davis) Favosites "Emmonsia" emmonsi (Rominger) Favosites "Emmonsia" eximia (Davis) Favosites "Emmonsia" epidermata (Rominger) Favosites "Emmonsia" ocellata (Davis) Favosites "Emmonsia" radiciformis (Rominger) Favosites "Emmonsia" ramosa (Rominger) Favosites "Emmonsia" tuberosa (Rominger) Favosites argus Hall Favosites biloculi Hall Favosites clausus Rominger Favosites clelandi Davis Favosites goldfussi d'Orbigny Favosites hamiltoniae Hall Favosites mundus Davis Favosites patellatus Stumm Favosites pirum Davis Favosites placentus Rominger Favosites proximatus Stumm Favosites quercus Davis Favosites ramulosus Davis Favosites rotundituba Davis Favosites turbinatus Billings Lecfedites canadensis (Billings) Platyaxum foliatum Davis Platyaxum frondosum (Nicholson) Platyaxum orthosoleniskum (Werner) Platyaxum undosum Davis Pleurodictyum cornu Stumm Pleurodictyum cylindricum (Michelin) Pleurodictyum insigne (Rominger) Pleurodictyum maximum (Troost) Pleurodictyum michelinoides (Davis) Pleurodictyum papillosa (Davis) Pleurodictyum planum (Davis) Pleurodictyum spiculata (Greene) Pleurodictyum wardi Greene Romingeria commutata Beecher Romingeria fasciculata Davis Romingeria umbellifera (Billings) Romingeria uva Davis Striatopora(?) alba Davis Striatopora bellistriata Greene Striatopora cavernosa Rominger Syringopora hisingeri Billings 110

Syringopora perelegans Billings Thamnopora distans (Nicholson) Thamnopora limitaris (Rominger) Thamnoptychia alternans (Rominger) Thamnoptychia tuberculata (Stumm) Thamnoptychia vermiculosa (Leseur)

Obsolete Name

Acinophyllum davisi Stumm

Acrophyllum rugosum Greene Alveolites crassus Stumm Alveolites dispansa Greene Alveolites dispansus Stumm Alveolites distans Nicholson Alveolites frondosa Nicholson Alveolites gurleyi Stumm Alveolites scandularis Davis Alveolites subangularis Davis Amplexus yandelli Edwards & Haime

Amplexiphyllum(?) simplex (Hall) Antholites bridghami Stumm Aulacophyllum bilaterale Hall Aulacophyllum convergens Hall Aulacophyllum cruciforme Hall Aulacophyllum enorme Herzer Aulacophyllum inflexum Stumm Aulacophyllum insigne Davis Aulacophyllum parvum Davis

Aulacophyllum poculum Hall Aulacophyllum praeciptum Hall Aulacophyllum prateriforme Hall Aulacophyllum princeps Hall Aulacophyllum reflexum Hall

Aulacophyllum tripinnatum Hall Aulacophyllum trisulcatum Hall Aulacophyllum unguloideum Davis Aulopora cornuta Davis Aulopora procumbens Davis Aulopora serpens Davis

Aulopora umbellifera Billings= Romingeria umbellifera (Bill
Billingsastraea ingens (Davis)Billingsastraea ingens (Davis)= Heliophyllum ingens (Davis)Billingsastraea yandelli (Rominger)= Heliophyllum yandelli (Rominger)Blothrophyllum approximatum Davis= "Blothrophyllum" trisulcatumBlothrophyllum bellicinctum Greene= Tabulophyllum? bellicinctum Greene? Blothrophyllum bucculentum Greene= Tabulophyllum zaphrentiforme

Blothrophyllum cinctutum Davis Blothrophyllum cingulatum Greene Blothrophyllum(?) coniferum Greene

Valid Name

= Acinophyllum stokesi (Milne-Edwards & Haime) = Acrophyllum oneidaense (Billings) = Alveolites expatiatus (Rominger) = Alveolites goldfussi Billings = Alveolites winchellana (Miller) = Thamnopora distans (Nicholson) = Platyaxum frondosum (Nicholson) = Alveolites expatiatus (Rominger) = Alveolites goldfussi Billings = Alveolites goldfussi Billings = Siphonophrentis yandelli (Edwards & Haime) = Indeterminate = Antholites speciosus Davis = "Blothrophyllum "trisulcatum (Hall) = Odontophyllum covergens (Hall) = Aulacophyllum perlamellosum (Hall) = Aulacophyllum perlamellosum (Hall) = Tabulophyllum? tripinnatum (Hall) = Bethanyphyllum validum (Hall) = In part Aulacophyllum pinnatum Hall & Aulacophyllum sulcatum (d'Orbigny) = Tabulophyllum? tripinnatum (Hall) = Bethanyphyllum prateriforme (Hall) = Bethanyphyllum prateriforme (Hall) = Aulacophyllum perlamellosum (Hall) = "Heterophrentis "rafinesqui (Edwards & Haime) = Tabulophyllum?tripinnatum (Hall) = "Blothrophyllum" trisulcatum (Hall) = Aulacophyllum perlamellosum (Hall) = Aulocystis transitorius Stumm = Aulocystis(?) procumbens (Davis) = Aulopora tubiporoidea (Yandell & Shumard) = Romingeria umbellifera (Billings) = Heliophyllum ingens (Davis) = Heliophyllum yandelli (Rominger) = "Blothrophyllum" trisulcatum (Hall) =Tabulophyllum? bellicinctum Greene (Davis) = Tabulophyllum? sinuosum (Hall) = Tabulophyllum?sinuosum (Hall)

= Scenophyllum(?) coniferum (Greene)

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Blothrophyllum conigerum Greene	= Tabulophyllum zaphrentiforme
Blothrophyllum corium Davis	= Rethanynhyllum arctifossa (Hall)
Blothrophyllum decorticatum Rominger	= Blothronhyllum romingeri Stumm
Blothrophyllum flerosum or flerusum	Greene – Tahulonhullum
biointophyllum flexosum of flexuosum	anhrantiforma (Davis)
Blathronhullum(2) araani (Davia)	– Tahulonhullum? araani (Davia)
Bioinrophyllum(?) greeni (Davis)	= Iubulophyllum? greeni (Davis)
Bioinrophylium houghioni Greene	= Tabulophyllum? perplicatum (Hall)
Bioinrophyllum incultum Greene	= labulophyllum zaphrentiforme
	(Davis)
Blothrophyllum liratum Davis	= Heliophyllum incrassatum (Hall)
Blothrophyllum louisvillense Davis	= Tabulophyllum? sinuosum (Hall)
Blothrophyllum parvulum Davis	= Stereolasma parvulum (Davis)
Blothrophyllum perplicatum (Hall)	= Tabulophyllum? perplicatum (Hall)
Blothrophyllum promissum Hall	= Tabulophyllum? sinuosum (Hall)
Blothrophyllum sessile Davis	= Tabulophyllum? tripinnatum (Hall)
Blothrophyllum sinuosum Hall	= Tabulophyllum? sinuosum (Hall)
Blothrophyllum tripinnatum (Hall)	=Tabulophyllum? tripinnatum (Hall)
Blothrophyllum zaphrentiforme Davis	= Tabulophyllum zaphrentiforme
	(Davis)
Bucanophyllum gracile Ulrich	= Bucanophyllum ohioense (Nicholson)
Calostylis(?) trigemma (Davis)	= Stauromatidium trigemma (Davis)
Calamopora epidermata Rominger	= Favosites "Emmonsia" epidermata
	(Rominger)
Calamopora maxima Troost	= Pleurodictvum maximum (Troost)
Caninia punctata d'Orbigny	= Zaphrentis phrygia Rafinesque &
	Clifford
Caninia sulcata d'Orbigny	= $Aulacophyllum sulcatum (d'Orbigny)$
Carvonhyllia cornicula Leseur	- Zanhrentis nhrvaja Rafinesque &
Caryophyttia conficulta Lescul	Clifford
Camonhullia gigantea Leseur	- Sinhononhrentis elongata
Caryophyllia gigantea Lescul	(Definesque & Clifford)
Constances conclamanata Granna	(Kannesque & Chnolu) -Auloopotig(2) incrustong (Dovig)
Ceratopora conglomerata Greene	= Autocystis(!) incrustants (Davis)
Ceratopora flabellata Greene	= Autocystis autoporoided (Davis)
Ceratopora jacksoni Gradau	= Aulocysus jacksoni (Grabau)
Ceratopora nanus Greene	= Aulocystis frutectosa (Davis)
Ceratopora separata Greene	= Aulocystis frutectosa (Davis)
Chonophyllum capax Hall	= "Craterophyllum" magnificum
	(Billings)
Chonophyllum curvatum Herzer	= Schlotheimophyllum versiforme
	(Hall)
Chonophyllum cylindricum Herzer	= Schlotheimophyllum typicum (Davis)
and possibly	? Bethanyphyllum nanum (Davis)
Chonophyllum greenei Stumm	= Bethanyphyllum nanum (Davis)
Chonophyllum infundibulum Greene	= Bethanyphyllum nanum (Davis)
Chonophyllum magnificum Billings	= "Craterophyllum" magnificum
•••••	(Billings)
Chonophyllum multiplicatum Davis	= <u>Indeterminate</u>
Chonophyllum nanum Davis	= Bethanyphyllum nanum (Davis)
Chonophyllum pygmaeum Greene	= Indeterminate
Chonophyllum typicum Greene	= Bethanyphyllum nanum (Davis)
Cladopora alcicornis Davis	= Platvaxum frondosum (Nicholson)
Cladopora alpinesis Davis	= Alveolites winchellana (Miller)
Cladopora aspera Rominger	= Alveolites asperus (Rominger)
Cladonora hillingsi Davis	= Alveolites winchellana (Miller)
Cladopora canadansis Rominger	= Platvarum frondosum (Nicholson)
Cracepora canaacasts Rominger	- aryanan jionaosan (monorson)

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Cladonora crassa Dovis	- Alugalitas gragitatus (Pominger)
Cladenerg emptodeng (Deminger)	- Alveolites expatiatus (Rominger)
Cladenena dentata Davie	= Alveolites expanditus (Rominger)
Claaopora aentata Davis	= Alveolites expanditus (Rominger)
Cladopora disquamata Davis	= Claaopora bijurca Davis
Cladopora dispansa Davis	= Alveolites winchellana (Miller)
Cladopora expatiata Rominger	= Alveolites expatiatus (Rominger)
Cladopora fimbrata Davis	= Cladopora bifurca Davis
Cladopora francisci Davis	= Alveolites winchellana (Miller)
Cladopora frondosa Lambe	= Platyaxum frondosum (Nicholson)
Cladopora gurleyi Davis	= Alveolites expatiatus (Rominger)
Cladopora intermedia Greene	= Alveolites winchellana (Miller)
Cladopora iowaensis Davis	= Alveolites expatiatus (Rominger)
Cladopora lichenoides Rominger	= Alveolites winchellana (Miller)
Cladopora linneanna Rominger :	= Striatopora bellistriata Greene [In part]
Cladopora ninguis Davis	= Alveolites winchellana (Miller)
Cladopora pulchra Davis	= Alveolites winchellana (Miller)
Cladopora radula Davis	– Alveolites winchellana (Miller)
Cladopora ricta Davis	- Alveolites ernatiatus (Dominger)
Cladopora rimaga Davis	- Cladonora acunista Douis
Clademente normani Davis	= Clauopora acapicia Davis
Claaopora roemeri Davis	= Alveolites winchellana (Miller)
Cladopora tela Davis	= Alveolites winchellana (Miller)
Cladopora winchellana Miller	= Alveolites winchellana (Miller)
Clisiophyllum conigerum Hall = Sceno	phyllum conigerum (Rominger)
Clisiophyllum oneidaense Billings	= Acrophyllum oneidaense (Billings)
Colephyllum pyriforme Hall	= Edaphophyllum bifurcatum (Hall)
?Craspedophyllum americanum Dybows	ski = Eridophyllum seriale Edwards &
	Haime
Crepidophyllum archiaci Nicholson &	Thompson = Eridophyllum archaici
• • •	(Billings)
Cvathophyllum arctifossa (Hall)	= Bethanyphyllum arctifossa (Hall)
Cyathophyllum brevicorne Davis	= Heliophyllum venatum Hall
Cyathophyllum canaliculatum Hall	= unidentified <i>Bethanynhyllum</i>
2 Cuathonkullum canar Herzer	- Bethenunhullum arctifossa (Holl)
Cuathonhullum coalitum Dominger	- Deinanyphytium arctijossa (Hall) - Halionhyllum coalitum (Domingor)
Cyathophyllum cohanna (Hall)	- Dianhullum achgeneng (Hell)
Cyathophyllum conderens (Hall)	= Disphyllum conderens (Hall)
Cyathophyllum colligatum Davis	= Prismatophyllum prisma Lang &
	Smith
?Cyathophyllum concentricum Hall	= Bethanyphyllum(?) prateriforme
	(Hall)
Cyathophyllum coralliferum Davis	= ?Cylindrophyllum compactum (Hall)
Cyathophyllum corniculum Rominger	= Zaphrentis phrygia Rafinesque &
	Clifford
?Cyathophyllum crotaliforme Stewart	= Bethanyphyllum arctifossa (Hall)
Cyathophyllum depressum Hall	= Bethanyphyllum depressum (Hall)
Cyathophyllum davidsoni Davis	= Prismatophyllum ovoideum (Davis)
Cyathophyllum detextum Davis	= Heliophyllum verticale Hall
Cyathophyllum ethelanum Davis	= Heliophyllum ethelanum (Davis)
Cyathophyllum exfoliatum Hall	= unidentified Bethanvnhvllum
Cyathonhyllum exiguum Davis	= Aemulionhvllum eriouum (Rillinge)
Cyathonhyllum fimhratum Davis	- Rethanynhyllum arctiforra (Unll) In
Cyumophynant Jinoraian Davis	- Beinanyphynani urchjossa (nall), [11] part] & Halionhyllum varticala Uall
	[In nart]
Cuathanhullum flas Davis	in parij - Zanhrentis nhrvaja Dofinosavo k
Cyumophymum jios Davis	- Lupireniis piirygiu Raillesque &
Construction and an I was Hall	
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Cyathophyllum	gigas Clapp (in Yandell	& Shumard) = Siphonophrentis elongata (Rafinesque & Clifford)
Cyathophyllum ?Cyathophyllum	greeni Davis impositum Hall	= Enallophyllum(?) greeni (Davis) = Bethanyphyllum(?) prateriforme (Hall)
Cvathophyllum	infoveatum Davis	= Heliophyllum ethelanum (Davis)
Cyathophyllum	insigne Davis	= Heliophyllum insigne (Davis) [In part]
Cyathophyllum	juvene Rominger	= Heliophyllum tenuiseptatum Billings
?Cyathophyllum	lacus Stewart	= Bethanyphyllum arctifossa (Hall)
Cyathophyllum	ligatum Davis	= Heliophyllum verticale Hall
Cyathophyllum	multicrena Davis	= Eridophyllum apertum (Hall) [In
Cyathophyllum	multigemmatum Davis	= Heliophyllum ingens (Davis), [In part], & Heliophyllum verticale Hall [In part]
Cvathophyllum	oedinus Davis	= ?Cvlindrophyllum compactum (Hall)
Cvathophyllum	ovoideum Davis	= Prismatophyllum ovoideum (Davis)
Cvathophyllum	perfossulatum Hall	= unidentified <i>Bethanynhyllum</i>
Cvathophyllum	? perlamellosum Hall	= $Aulacophyllum perlamellosum$ (Hall)
Cvathophyllum	perplicatum Hall	= Blothrophyllum perplicatum (Hall)
Cvathophyllum	pocillum Davis	= Bethanyphyllum pocillum (Davis),
	•	[In part] & Heliophyllum halli Edwards & Haime [In part]
Cyathophyllum	pumilis Davis	= Zaphrenthis aequus (Hall) = Indeterminate rugose coral [In part]. &
		Helionhyllum venatum Hall [In part]
9 Cuathon hullum	nustulosum Davis	- Heliophyllum ethelanum (Davis)
Cyathonhyllum	rectum Edward & Haime	- Stereolasma rectum (Hall)
Cyathophyllum	robusta Hall	= Bethanynhyllum rohusta (Hall)
Cvathophyllum	rugosum Davis	= Prismatonhyllum ovoideum (Davis)
Cyathophyllum	rugosum Edwards & Hair	me = Prismatophyllum prisma Lang &
Cuathonhullum	scalonum Uall	- unidentified Rathanynhyllum
Cyainophyllum Cyainophyllum	scurenum Hall	$= \underline{undentified}_{Detnunyphyttum}$
Cyainopnyllum	scypnus Davis	(Hall) or Bethanyphyllum robusta
Cvathophyllum	septatum (Hall)	= Silurian $Entelophyllum$
Cyathophyllum	tornatum (Davis)	= Odontophyllum tornatum (Davis) [In
~ _ ~		part]
Cyathophyllum	trauthanum Davis	= Heliophyllum halli Edwards & Haime
Cyathophyllum	vesiculatum Hall	= Bethanyphyllum vesiculatum (Hall)
Cyathophyllum	winchelli Davis	= Heliophyllum denticulatum Hall
Cylindrophyllun	n compactum (Hall)	= <u>Indeterminate zaphrentid coral</u>
Cylindrophyllun	n confluens Stewart	= Cyathocylindricum opulens Oliver
Cystiphyllum a	mericanum Davis	= Cystiphylloides infundibuliformis
~ · · · ·		(Greene) (except fig. 9)
Cystiphyllum a	mericanum Edwards & H	aime = Cystiphylloides americanum
	·····	(Edwards & Haime)
Cystiphyllum be	isalis Herzer	= Cystipnyliolaes plicatum (Davis)
Cystipnyllum b	<i>ijurcatum</i> Hall	= Euaphophylium oljurcalum (Hall)
Cystipnyllum b	ipurilium Hall	= Cysupnyuoiaes!
Cysupnyllum C	icuiricijerum Davis	(Davis) [In part] & Custinhulloides
		(Davis), [III pail] & Cystiphyllolaes
Custinhullum	lavatum Greene	- Custinhulloides limbatum (Davie)
Cysupnynum Cl		4

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Cystiphyllum conspicuum Greene	= Cystiphylloides plicatum (Davis) [In
part],	in part Silurian C. granilineatum Hall
Cystiphyllum constrictum Greene	= Cystiphylloides?
Cystiphyllum corrugatum Hall	= Cystiphylloides americanum (Edwards
Constanting the line of a stand for the stand	& Haime) - Custin hulloidea, americanum (Edwards)
Cystipnyllum craterijorme Hall	= Cysuphyliolaes americanum (Edwards
Custinhullum cranatum Greene	– Cystinhylloides nlicatum (Davis)
Cystiphyllum cuvagense [sic] Davis	= Cystiphylloides pustulatum (Hall)
Cystiphyllum cylindricum Hall	= Cystiphylloides americanum (Edwards
	& Haime)
Cystiphyllum decurrens Greene	= Cystiphylloides limbatum (Davis)
Cystiphyllum discoideum Herzer	= "Skoliophyllum" squamosum
	(Nicholson)
Cystiphyllum diversum Greene	= Cystiphylloides americanum (Edwards
Custin hullum adminianum Davia	& Halme) - Custinhulloides, plicatum (Davis)
Cystiphyllum eawinianum Davis	= Cystiphytioldes pilcalum (Davis)
Cystipnytium expansion Ofcene	\simeq Skollophyllum squamosum (Nicholson)
Cystinhyllum fulcratum Davis	= Cystiphylloides hispidum (Davis)
Cystiphyllum gemmatum Greene	= Cystiphylloides americanum (Edwards
	& Haime)
Cystiphyllum gemmiferum Greene	= Cystiphylloides pustulatum (Hall)
Cystiphyllum grande Davis	= Cystiphylloides limbatum (Davis)
Cystiphyllum greenei Miller	= Diplochone greenei (Miller)
Cystiphyllum hispidum Davis	= Cystiphylloides hispidum (Davis)
Cystiphyllum infundibuliformis Greene	= Cystiphylloides infundibuliformis
Custinhullum invacinatum Greene	- Custinhulloidas amaricanum (Edwards
Cystiphytium invaginatum Greene	= Cystiphytiolaes untertaintin (Edwards & Haime)
Cystiphyllum laciniatum Greene	= Cystinhylloides?
Cystiphyllum lamellatum Greene	= Cystiphylloides?
Cystiphyllum latiradium Hall	= Craterophyllum(?) latiradium (Hall)
Cystiphyllum latiradius Hall	= Craterophyllum(?) latiradium (Hall)
Cystiphyllum limbatum Davis	= Cystiphylloides limbatum (Davis)
Cystiphyllum multicrenatum Greene	= Craterophyllum(?) latiradium (Hall)
Cystiphyllum muricatum Hall	= Edaphophyllum bifurcatum (Hall)
Cystiphyllum nanum Hall	= Cystiphyllum nanum Hall
Cystiphyllum netteiroini Davis	= Haarophyllum netterroini (Davis)
Cystiphyllum obiognse Nicholson	- Bucanophyllum objarcalum (Mall)
Cystiphyllum os Davis	= Cladionophyllum cicatriciferum
	(Davis)
Cystiphyllum osculum Greene	= Cystiphylloides?
Cystiphyllum ossiculum Greene	= Cystiphylloides americanum (Edwards
	& Haime)
Cystiphyllum parasiticum Greene	= Cystiphylloides plicatum (Davis)
?Cystiphyllum perlamellosum Herzer	= Edaphophyllum bifurcatum (Hall)
Cysupnyllum plicatum Davis	Coloonhallum naminani (II-II)
-	= Coleophyllum romingeri (Hall) [In part] Cystinhylloides plicatum (Dovic)
-	= Coleophyllum romingeri (Hall) [In part], Cystiphylloides plicatum (Davis) [In part]
Cystinhyllum prostratum Herzer	= Coleophyllum romingeri (Hall) [In part], Cystiphylloides plicatum (Davis) [In part] = Bucanophyllum obioense (Nicholson)
Cystiphyllum prostratum Herzer Cystiphyllum pustulatum Hall	= Coleophyllum romingeri (Hall) [In part], Cystiphylloides plicatum (Davis) [In part] = Bucanophyllum ohioense (Nicholson) = Cystiphylloides pustulatum (Hall)
Cystiphyllum prostratum Herzer Cystiphyllum pustulatum Hall Cystiphyllum quadrangulare Hall	= Coleophyllum romingeri (Hall) [In part], Cystiphylloides plicatum (Davis) [In part] = Bucanophyllum ohioense (Nicholson) = Cystiphylloides pustulatum (Hall) = Cystiphylloides quadrangulare (Hall)
Cystiphyllum prostratum Herzer Cystiphyllum pustulatum Hall Cystiphyllum quadrangulare Hall Cystiphyllum retrorsum Herzer	= Coleophyllum romingeri (Hall) [In part], Cystiphylloides plicatum (Davis) [In part] = Bucanophyllum ohioense (Nicholson) = Cystiphylloides pustulatum (Hall) = Cystiphylloides quadrangulare (Hall) = "Skoliophyllum" squamosum
Cystiphyllum prostratum Herzer Cystiphyllum pustulatum Hall Cystiphyllum quadrangulare Hall Cystiphyllum retrorsum Herzer	= Coleophyllum romingeri (Hall) [In part], Cystiphylloides plicatum (Davis) [In part] = Bucanophyllum ohioense (Nicholson) = Cystiphylloides pustulatum (Hall) = Cystiphylloides quadrangulare (Hall) = "Skoliophyllum" squamosum (Nicholson)
Cystiphyllum prostratum Herzer Cystiphyllum pustulatum Hall Cystiphyllum quadrangulare Hall Cystiphyllum retrorsum Herzer Cystiphyllum romingeri Hall	= Coleophyllum romingeri (Hall) [In part], Cystiphylloides plicatum (Davis) [In part] = Bucanophyllum ohioense (Nicholson) = Cystiphylloides pustulatum (Hall) = Cystiphylloides quadrangulare (Hall) = "Skoliophyllum" squamosum (Nicholson) = Coleophyllum romingeri (Hall)

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?Cystiphyllum scyphus Herzer	= Cystiphylloides americanum (Edwards & Haime)
Cystiphyllum squamosum Nicholson	= "Skoliophyllum" squamosum (Nicholson)
Cystiphyllum sulcatum Davis	= Edaphophyllum bifurcatum (Hall)
Cystiphyllum supraplanum Hall	= Cystiphylloides tenuiradium (Hall)
Cystiphyllum tenuiradium Hall	= Cystiphylloides tenuiradium (Hall)
Cystiphyllum theissi Davis	= Cystiphylloides pustulatum (Hall)
Cystiphyllum tumidosum Davis	- Crateronhyllum(?) latiradium (Hall)
Cystiphyllum varians Hall	- Cystinhylloides americanum (Edwards
	& Haime)
Cystiphyllum vesiculosum Davis	= Cystiphylloides limbatum (Davis)
Cystiphyllum vesiculosum Nicholson	= Cystiphylloides americanum (Edwards & Haime)
Dendropora alternans Rominger	= Thamnoptychia alternans
	(Rominger)
Dendropora neglecta Davis	= Thamnoptychia vermiculosa (Leseur)
Dendropora ornata Rominger	= Thamnoptychia vermiculosa
	(Leseur)[In part]
Dendropora osculata Davis	= Thamnoptychia alternans
Denaropora oscarara Davis	(Rominger)
Dendropora proposcidalis Davis	= Striatopora hellistriata Greene
Dinhyphyllum adjunctum Greene	= Prismatonhyllum conjunctum (Davis)
Diphyphyllum adnatum Hall	- Fridenhyllum archaici (Billings)
Diphyphylium anartum Hall	- Fridophyllum apertum (Hall)
Diphyphyllum archiaci Billings	– Fridenhyllum archaici (Billings)
Diphyphytium architect Diffings	- Prismatonhyllum hella (Davis)
Diphyphylium breve Hall	= Fridonhyllum apertum (Hall)
Diphyphyllum coagulatum Davis	= Eridophyllum coggulatum (Davis)
Diphyphyllum coalascans Davis	- Prismatonhyllum conjunctum (Davis)
Diphyphyllum colletti Greene	= Fridonhyllum apertum (Hall)
Diphyphyllum conjunctum Davis	- Prismatonhyllum conjunctum (Davis)
Diphyphyllum cylindraceum Hall	- Fridonhyllum archaici (Billings)
Diphyphyllum dilatum Greene	= Eridophyllum tumidulum (Hall)
Diphyphyllum arnansum Greene	= Eridophyllum apertum (Hall)
Diphyphyllum expansion Orecne Diphyphyllum eigas Davis	= Heliophyllum latericrescens Hall
Diphyphyllum Jarum Greene	= Fridophyllum archaici (Billings)
Diphyphyllum panicum Davis	= Prismatophyllum bella (Davis)
Diphyphyllum prolatum Greene	= Fridophyllum archaici (Billings)
2Dinhynhyllum robustum Greene	= Eridophyllum apertum (Hall)
Diphyphythan rocustan Greene Diphyphythan strictum Davis	= Eridophyllum coagulatum (Davis)
Diphyphyllum tumidulum Hall	= Eridophyllum tumidulum (Hall)
Diphyphyllum unicum Greene	= Eridophyllum tumidulum (Hall)
Diphyphyllum verneuilanum Davis	= Eridophyllum seriale Edwards &
Dipnypnytium verneutiunum Duvis	Haime
Diphyphyllum wadsworthi Greene	= Eridophyllum archaici (Billings)
Disphyllum cohaerens (Hall)	= Indeterminate zaphrentid coral
Drymopora auloporoidea (Davis)	= Aulocystis auloporoidea (Davis)
Drymopora commensalis Davis	= Aulocystis fascicularis (Davis)
Drymopora fascicularis Davis	= Aulocystis fascicularis (Davis)
Drymopora frutectosa Davis	= Aulocystis frutectosa (Davis)
Drymopora incrustans (Davis)	= Aulocystis (?) incrustans (Davis)
Drymopora(?) intermedia Davis	= Aulocystis nobilis (Billings) [In part],
· · · ·	Aulopora tubiporoides (Yandell &
	Shumard), [In part]
Drymopora nanus Greene	= Aulocystis frutectosa (Davis)
1.	LO

= Aulocystis nobilis (Billings) Drymopora nobilis Davis Drymopora(?) procumbens (Davis) = Aulocystis(?) procumbens (Davis) Edaphophyllum bipartitum (Hall) = Cystiphylloides? Edaphophyllum(?) laciniatum Greene = Cystiphylloides? = Favosites pirum Davis Emmonsia agarica Stumm Emmonsia? cylindrica Edwards & Haime = Pleurodictyum cylindricum (Michelin) Emmonisa decora Stumm = Favosites "Emmonsia" epidermata Rominger = Favosites "Emmonsia" Emmonsia globosus Stumm eximia (Davis) Emmonsia hemispherica Edwards & Haime = Favosites "Emmonsia" emmonsi (Rominger) = Favosites "Emmonsia" eximia (Davis) ?Emmonsia kentuckyensis Stumm Emmonsia pirum Stumm = Favosites pirum Davis = Favosites "Emmonsia" Emmonsia spiculata Stumm epidermata Rominger = Eridophyllum archaici (Billings) Eridophyllum adnatum Stumm = Acinophyllum stokesi (Milne-Edwards Eridophyllum arundinaceum Davis & Haime) Eridophyllum (?) bellis Stumm = Prismatophyllum bella (Davis) Eridophyllum coalescens Stumm = Eridophyllum conjunctum (Davis) Eridophyllum colligatum Stumm = Prismatophyllum conjunctum (Davis) Eridophyllum conjunctum (Davis) = Prismatophyllum conjunctum (Davis) Eridophyllum cylindraceum Stumm = Eridophyllum archaici (Billings) Eridophyllum dilatum Stumm = Eridophyllum tumidulum (Hall) Eridophyllum expansum Stumm = Eridophyllum apertum (Hall) Eridophyllum obliquum Stumm = Eridophyllum coagulatum (Davis) = Eridophyllum apertum (Hall) ?Eridophyllum robustum Stumm Eridophyllum simcoense Davis = Disphyllum synaptophylloides Stumm Eridophyllum typicale Stumm = Eridophyllum coagulatum (Davis) Eridophyllum unicum Stumm = Eridophyllum tumidulum (Hall) Eridophyllum verneuilanum Edwards & Haime = Eridophyllum seriale Edwards & Haime = Eridophyllum archaici (Billings) Eridophyllum wadsworthi Stumm Favosites agaricus Greene = Favosites pirum Davis = Favosites "Emmonsia" amplissima Favosites amplissimus Davis (Davis) Favosites arbuscula Hall = Favosites "Emmonsia" arbuscula (Hall) Favosites arbor Davis = Bractea arbor (Davis) = Favosites "Emmonsia" Favosites baculus Davis bacula (Davis) Favosites canadensis Billings = Lecfedites canadensis (Billings) Favosites canadensis Rominger = Bractea arbor (Davis) [In part], Lecfedites canadensis (Billings) [In part] Favosites cariosus Davis = Thamnopora limitaris (Rominger) Favosites cavernosus Davis = Striatopora cavernosa Rominger [In part] Favosites clausus Rominger = Bractea arbor (Davis) [In part], Favosites ramulosus Davis [In part] = Favosites "Emmonsia" bacula (Davis) Favosites clavatulus Greene Favosites convexus Davis = Favosites "Emmonsia" convexa (Davis) [In part], Favosites "Emmonsia" epidermata (Rominger), [In part] ?Favosites corticosus Fenton & Fenton = Favosites biloculi Hall Favosites cylindrica Michelin = *Pleurodictyum cylindricum* (Michelin) 117 = Favosites "Emmonsia" cymosa (Davis) Favosites cymosus Davis

Heliophyllum rowleyi Greene = Tabulophyllum? greeni (Davis) ? Heliophyllum papulosum Greene = Aulacophyllum conigerum Davis Heliophyllum partitum Greene = (?) Prismatophyllum ovoideum (Davis) Heliophyllum parvulum Greene = Bethanyphyllum(?) prateriforme (Hall) = Heliophyllum venatum Hall Heliophyllum scyphulus Hall Heliophyllum seamani Greene = Heliophyllum latericrescens Hall Heliophyllum sherzeri Greene = Heliophyllum denticulatum Hall Heliophyllum sordidium Hall = Aulacophyllum sulcatum (d'Orbigny) = Bethanyphyllum validum (Hall) ?Heliophyllum spiculatum Greene Heliophyllum sulcatum Greene = Aulacophyllum sulcatum (d'Orbigny) = Heliophyllum latericrescens Hall Heliophyllum superlatum Greene ?Heliophyllum superlatum Greene =Heliophyllum verticale Hall Heliophyllum tenuimurale Hall = Zaphrenthis aequus (Hall) = Indeterminate coral species = Odontophyllum convergens (Hall) Heliophyllum tripartitum Greene Heliophyllum tumidulum Greene = Acrophyllum clarki Davis Heliophyllum turgidum Greene = Bethanyphyllum robusta (Hall) Heliophyllum vesiculatum Greene = Zaphrentis phrygia Rafinesque & Clifford Heliophyllum zenkeri Greene = Odontophyllum tornatum (Davis) Heterophrentis (Compressiphyllum) davisana Oliver = Compressiphyllum davisana (Miller) = Enallophrentis concava (Hall) Heterophrentis concava (Hall) = "Enallophrentis" curvata (Hall) = "Enallophrentis" cyathiformis (Hall) Heterophrentis curvata (Hall) Heterophrentis cyathiformis (Hall) Heterophrentis duplicata (Hall) = Enallophrentis duplicata (Hall) = "Enallophrentis" foliata (Hall) Heterophrentis foliata (Hall) = Enallophrentis inflata (Hall) Heterophrentis inflata (Hall) Heterophrentis irregularis (Hall) = Not Heterophrentis = "Breviphrentis" nitida (Hall) = "Breviphrentis" ovalis (Hall) *Heterophrentis(?)nitida*(Hall) Heterophrentis ovalis (Hall) = Breviphrentis? planima (Hall) ?Heterophrentis planima Stewart = Enallophrentis inflata (Hall) Heterophrentis prolifica Stewart Heterophrentis spissa Stewart = Enallophrentis inflata (Hall) = Enallophrentis simplex (Hall) Heterophrentis simplex Hall Heterophrentis(?) terebrata (Hall) = Triplophyllum terebratum (Hall) = Enallophrentis trisutura (Hall) Heterophrentis trisutura (Hall) Hexagonaria bathycalyx Stumm = (?)Prismatophyllum ovoideum (Davis) = Prismatophyllum bella (Davis) Hexagonaria bella Davis = Prismatophyllum prisma Lang & Hexagonaria cincta (Stainbrook) Smith = Prismatophyllum truncata Stewart Hexagonaria curta Stumm = Prismatophyllum ovoideum (Davis) Hexagonaria ovoidea (Davis) Hexagonaria partita (Greene) = (?)Prismatophyllum ovoideum (Davis) Hexagonaria ponderosa (Greene) = ?Heliophyllum coalitum (Rominger) = Prismatophyllum prisma Lang & Hexagonaria prisma Stumm Smith = Eridophyllum conjunctum (Davis) Hexagonaria prism Carman Homalophyllum exiguum Stumm = Aemuliophyllum exiguum (Billings) = Thamnoptychia vermiculosa (Leseur) Madrepora limbata Eaton exiguum Oliver = Aemuliophyllum exiguum Metriophyllum (Aemuliophyllum) 118^(Billings)

= Favosites "Emmonsia" tuberosa ?Favosites cystoides Herzer (Rominger) = Favosites "Emmonsia" epidermata Favosites decorus Greene Rominger = Favosites "Emmonsia" arbuscula Favosites digitatus Davis (Hall) = Favosites "Emmonsia" emmonsi Favosites emmonsi Rominger (Rominger) = Favosites "Emmonsia" emmonsi Favosites (Emmonsia) emmonsi Ross (Rominger) = Favosites biloculi Hall, [In part] & Favosites epidermatus Rominger Favosites "Emmonsia" epidermata (Rominger) [In part] ?Favosites epidermatus var. corticosus Hall = Favosites biloculi Hall Favosites frutex Davis = Bractea frutex (Davis) = Favosites "Emmonsia" eximia (Davis) Favosites globosus Greene Favosites goodwini Davis = Favosites clausus Rominger Favosites hemispherica var. recta Hall = Favosites turbinatus Billings = Favosites turbinatus Billings [In part] Favosites hemisphericus Rominger Favosites hemisphericus? Troost = Favosites patellatus Stumm = Bractea impedita (Davis) Favosites impeditus Davis Favosites maxima Yandell & Shumard = Pleurodictyum maximum (Troost) Favosites mundus var. placentoideus Davis = Favosites mundus Davis = Favosites "Emmonsia" ocellata (Davis) Favosites ocellatus Davis ?Favosites perplexa Clapp = Favosites biloculi Hall = Favosites clausus Rominger Favosites placenta forma ramosa Ross = Favosites placentus Rominger Favosites placenta forma typica Ross Favosites placenta forma diametrica Ross = Favosites rotundituba Davis Favosites placenta Rominger = Favosites placentus Rominger [In part], Favosites rotundituba Davis, [In part] Favosites proximus Davis = Favosites proximatus Stumm Favosites radiatus Davis = Favosites "Emmonsia" epidermata Rominger Favosites radiciformis Davis = Favosites "Emmonsia" radiciformis (Rominger) & Bractea impeditus (Davis) [In part] Favosites rotundituba Greene = Favosites proximatus Stumm = Favosites "Emmonsia" convexa (Davis) Favosites rotundus Greene Favosites seamani Greene = Thamnopora limitaris (Rominger) Favosites spiculatus Davis = Favosites "Emmonsia" epidermata Rominger = Thamnopora limitaris (Rominger) [In Favosites limitaris Rominger part] = Favosites "Emmonsia" tuberosa Favosites tuberosus Rominger (Rominger) Fistulipora canadensis Billings = Lecfedites canadensis (Billings) = Hadrophyllum nettelrothi (Davis) Hadrophyllum linguloideum Herzer Haimeophyllum ordinatum Billings = Chonostegites clappi Edwards & Haime = Heliophyllum venatum Hall Heliophylloides brevicorne Stumm Heliophyllum acuminatum = Heliophyllum? Hall Heliophyllum adnascens Greene = Craterophyllum adnascens (Greene) Heliophyllum aequale Hall = Heliophyllum verticale Hall = Zaphrentis aequus (Hall) Heliophyllum aequum Hall Indeterminate Heliophyllum ampliatum Greene = Heliophyllum incrassatum Hall 119 = Heliophyllum verticale Hall Heliophyllum annulatum Hall

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Heliophyllum	beecheri Greene	= Heliophyllum gurleyi Greene
Heliophyllum	bordeni Greene	= Heliophyllum tenuiseptatum Billings
Heliophyllum	brevicorne Werner	= Heliophyllum venatum Hall
Heliophyllum	collatum Greene	= Prismatophyllum bella (Davis)
Heliophyllum	compactum Hall	= ?Cylindrophyllum compactum (Hall)
Heliophyllum	conditum Greene	= Heliophyllum tenuiseptatum Billings
Heliophyllym	conglomeratum Greene	= (?)Prismatophyllum ovoideum
		(Davis)
Heliophyllum	conigerum Greene	= Acrophyllum conigerum (Greene)
Heliophyllum	convergens Greene	= Odontophyllum convergens (Hall)
Heliophyllum	congregatum Greene	= Heliophyllum latericrescens Hall
Heliophyllum	corniculum Hall	= Zaphrentis phrygia Rafinesque &
		Clifford
Heliophyllum	corniculum var. diaphrag	gma Greene = Zaphrentis phrygia
		Rafinesque & Clifford
Heliophyllum	crotalum Greene	= Bethanyphyllum robusta (Hall)
Heliophyllum	dianthum Greene	= Heliophyllum latericrescens Hall
Heliophyllum	dispansum Greene	= Bethanyphyllum robusta (Hall)
Heliophyllum	distans Hall	= Heliophyllum halli Edwards & Haime
Heliophyllum	expansum Greene	= Heliophyllum latericrescens Hall
Heliophyllum	exiguum Billings	= Aemuliophyllum exiguum (Billings)
Hellopnyllum	exiguum Kominger	= Homalophyllum nerzeri (Hall) [In
TI . 1		partj Helienkultur in menetor Hell
Heliopnyllum	<i>Jasciculatum</i> Hall	= Heliophylium incrassatum Hall
Heliophyllum	fecunaum Hall	= ? Cylinarophylium compacium (Hall)
Heliophyllum	Jissuratum Hall	= Heliophylium venalum Hall
Heliophyllum	gemmatum Hall	= ? Cylinarophyllum compactum (Hall)"
Heliophyllum	graaatum Greene	= "Cylinarophylium compacium (Hall)"
Heliophyllum	haiii Davis hamiltonensis Groops	= Heliophyllum incrassalum Hall
Heliophyllum	hammalli Groopo	= Reliophyllum insigne (Davis)
Heliophyllum	ignotum Greene	= Rethemin bullum robusta (Hall)
Heliophyllum	imbrigatum Holl	- Helionhyllum increasedum Holl
Heliophyllum	inconditum Greene	- Heliophyllum verticale Hall
Haliophyllum	inflorum Greene	- Tahulophyllum? tripinnatum (Holl)
11enopnynum 9 Halionhyllum	intersculptum Greene	- Acrophyllum conjegrum (Greene)
?Heliophyllum	intersculptum Greene	- Acrophyllum conigerum (Greene)
Helionhyllum	invaginatum Hall	= Heliophyllum verticale Hall
Heliophyllum	lemoni Greene	= Heliophyllum verticale Hall
Heliophyllum	ligatum Werner	= Heliophyllum verticale Hall
Heliophyllum	iacksoni Greene	= Heliophyllum alternatum Hall
9 Helionhyllum	minusculum Greene	= Tabulophyllum?tripinnatum (Hall)
Heliophyllum	minutem Greene	= Heliophyllum ethelanum (Davis)
Heliophyllum	mirum Greene	= Bethanyphyllum robusta (Hall)
Heliophyllum	multicrena Werner	= Eridophyllum apertum (Hall)
Heliophyllum	nanum Greene	= Acrophyllum clarki Davis
Heliophyllum	nettelrothi Hall	= Heliophyllum incrassatum Hall
Heliophyllum	nilesi Greene	= Zaphrentis phrygia Rafinesque &
1 2		Clifford [In part]
Heliophyllum	obesum Greene	= Heliophyllum gurleyi Greene
Heliophyllum	obliguum Greene	= "Blothrophyllum "trisulcatum (Hall)
Heliophyllum	osculatum Greene	= Heliophyllum ingens (Davis) [In
. /		part], & Heliophyllum halli Edwards &
		Haime [In part]
Heliophyllum	patellatum (Holmes)	= Odontophyllum patellatum (Holmes)
Heliophyllum	pocillatum Hall	= Heliophyllum halli Edwards & Haime?
Heliophyllum	proliferum Hall 120	= Heliophyllum gurleyi Greene

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Metriophyllum (Aemuliophyllum) exigu	um elongatum Oliver = Aemuliophyllum exiguum elongatum (Davis)
Michelinia bridghami Greene	= Antholites speciosus Davis
Michelinia clappi Hall	= Chonostegites clappi Edwards & Haime
	[In part], Pleurodictyum cylindricum
	(Michelin) [In part]
Michelinia corrugata Rominger	= Pleurodictyum cylindricum
Michalinia aulinduina Domin	(Michelin) - Blauradiatuum maximum (Traast) [In
Michelinia cylinarica Davis	= <i>Fieuroaiciyum maximum</i> (1100si) [In
Michelinia cylindrica Rominger	= Pleurodictvum cylindricum
interestina cythiartea resimager	(Michelin)
Michelinia dividua Hall	= Pleurodictyum insigne (Rominger)
Michelinia favositoidea Davis	= Pleurodictyum maximum (Troost)
Michelinia insignis Rominger	= Pleurodictyum insigne (Rominger)
Michelinia intermittens Billings	= Chonostegites clappi Edwards & Haime
Michelinia minuta Greene	= Pleurodictyum insigne (Rominger)
Michelinia neglecta Greene	= Pleurodictyum papillosa (Davis)
Michelinia papulosa Greene	= Pleurodictyum spiculata (Greene)
Michelinia problematica Greene	= Pleurodictyum pianum (Davis)
Michelinia problematica Greene	[In part] Antholites speciosus Davis
	[In part]
Michelinia spiculata Greene	= Pleurodictvum spiculata (Greene)
Michelinia tantilla Greene	= Antholites speciosus Davis
Michelinia wardi Greene	= Pleurodictyum wardi Greene
Milleporites vermiculosa Leseur	= Thamnoptychia vermiculosa (Leseur)
Odontophyllum convergens Stewart	= Aulacophyllum sulcatum (d'Orbigny)
Odontophyllum patellatum (Holmes)	= Odontophyllum convergens (Hall)
Odontophyllum tornatum (Davis)	= Odontophyllum convergens (Hall)
Pachypora frondosa Nicholson	= Platyaxum frondosum (Nicholson)
Pachypora (Platyaxum) orthosolenika	Werner = Platyaxum orthosoleniskum
Bachyporg (Platyarym) prokrana Worn	(werner) er - Platuarum undasum Davis
Phillipsastraga gigas Davis	- Helionhyllum vandelli (Rominger)
Phillipsasraea incens Davis	= Heliophyllum ingens (Davis)
Phillipsastraea vandelli Rominger	= Heliophyllum vandelli (Rominger)
Phymatophyllum nanum (Davis)	= Bethanyphyllum nanum (Davis)
Phymatophyllum multiplicatum (Davis)	= <u>Indeterminate</u>
Platyaxum? alcicornis Stumm	= Platyaxum frondosum (Nicholson)
Platyaxum canadense Davis	= Platyaxum frondosum (Nicholson) [In
	part], Platyaxum orthosoleniskum
	(Werner)
Platyaxum corioideum Davis	= Platyaxum undosum Davis
Platyaxum dispansum Stumm	= Alveolites goldfussi Billings
Platyaxum jischeri Davis Platyaxum turgidum Davis	= Platyaxum jollalum Davis
Pleurodictvum (Antholites) hridohami	Stumm – Antholites speciosus Davis
Pleurodictyum dividuum Fenton & Fent	on = Pleurodictvum insigne (Rominger)
Pleurodictyum minutum Stumm	= Pleurodictvum insigne (Rominger)
Pleurodictyum (Antholites) speciosus St	umm = Antholites speciosus Davis
Prismatophyllum cinctum Stainbrook	= Prismatophyllum prisma Lang &
• •	Smith
Prismatophyllum rugosum Simpson	= Prismatophyllum prisma Lang &
	Smith

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Procteria michelinoides Davis Procteria papillosa (Davis)	= Pleurodictyum michelinoides (Davis) = Pleurodictyum papillosa (Davis) [In
	part], & Pleurodictyum spiculata
	(Greene) [In part]
Procteria spiculata Greene	= Pleurodictyum spiculata (Greene) [In
Dauch on hulling on iforum Douis	partj Kionolasma mammifomm (Holl) (In
Flychophyllum conferum Davis	= Kioneiusma mammijerum (Hall) [III
	(Hall) [In part]
Ptychonhyllum dianhranna Dovis	- Englionbrantis duplicata (Hall) [In
Flychophyllum alaphragma Davis	= Enuilophreniis aupiicaia (Itali) [Ill
Ptychonhyllum dianhragma Davis	– "Brovinhrantis" nitida (Hall) [In
Tiyenopnytium ataphragma Davis	- Dieviphieniis nitiau (IIaii) [iii
Ptychonhyllum gemmatum Greene	= Schlotheimonhyllum tynicum (Davis)
Ptychophyllum knanni Hall	= Schlotheimophyllum versiforme (Hall)
Ptychophyllum robustum Greene	- Fnallonhrentis inflata (Hall)
Ptychophyllum trongeum Davis	= Kionelasma coarticum (Hall) [In
regenophytium republic Duris	part] Kionelasma conspicuum (Hall)
	[In part]
Ptychophyllum typicum Davis	= Schlotheimophyllum typicum (Davis)
Ptychophyllum?typicum Stumm	= Schlotheimophyllum typicum (Davis)
Ptychophyllum versiforme Hall	= Schlotheimophyllum versiforme
y	(Hall)
Ptvchophyllum versiforme Stumm	= Phymatophyllum nanum (Davis)
Ouenstedtia umbellifera (Billings)	= Romingeria umbellifera (Billings)
Romingeria umbellifera Davis	= Romingeria commutata Beecher [In
	part], Romingeria umbellifera
	(Billings) [In part]
Romingeria incrustans Davis	= Aulocystis(?) incrustans (Davis)
Scenophyllum conigerum Simpson	= Scenophyllum conigerum
	(Rominger)
Schistotoecholasma obliquus Stewart	= Eridophyllum coagulatum (Davis)
Schistotoecholasma typicalis Stewart	= Eridophyllum coagulatum (Davis)
Siphonophrentis gigantea O'Connell	= Siphonophrentis elongata
-	(Rafinesque & Clifford)
Siphonophrentis halli (Edwards & Haime	e) ="Breviphrentis" halli (Edwards &
	Haime)
Siphonophrentis planima (Hall)	= Breviphrentis? planima (Hall)
	[further study needed]
Stereolasma (Homalophyllum) linneyi	Diver = Homalophyllum herzeri (Hall)
Stereolasma (Homalophyllum) reynolasi	Oliver = Homalophyllum Jusiformis
	(Hall)
Stereolasma (Homalophyllum) ungulum	Oliver = Homalophyllum ungulum
	(Rominger)
Streptelasma coarticum Hall	= Klonelasma coarlicum (Hall)
Streptelasma conspicum Hall	= Kioneiasma conspicuum (Hall)
Streptelasma craterijorme Hall	=Enallophrentis inflata (Hall)
Streptelasma involutum Hall	- Stereolasma rectum (Hall)
Streptetustitu involututi Mali Streptelasma mammiferum Hall	= Kionelasma mammiferum (Hall)
Streptetusnia maningeram Hall Streptelasma papillatum Hall	= Kionelasma mammiferum (Hall)
Strontolasma rocta Hall	= Stereolasma rectum (Hall)
Strontolasma simpler Hall	= Amplerinhyllum(?) simpler (Hall)
Strontolasma tonuo Hall	= Amplexiphyllum tenue (Hall)
Strigtopora (Thampontychia) limbata	A = Thamnoptychia vermiculosa
(Leseur)	
Stombodes ? rectus Hall 122	= Stereolasma rectum (Hall)
122	

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Strombodes knotti Davis Strombodes helianthoides Hall Strombodes simplex Hall Syringapora (sic) tubiporoides Yandell d	= Iowaphyllum knotti (Davis) = Heliophyllum halli Edwards & Haime = Enallophrentis simplex (Hall) & Shumard = Aulopora tubiporoides (Yandell & Shumard)
Syringopora bouchardi Davis	= Chonostegites tabulatus (Edwards & Haime)
Syringopora elegans Billings	= Syringopora perelegans Billings
Syringopora nobilis Billings	= Aulocystis nobilis (Billings)
Syringopora straminea Davis	= Syringopora hisingeri Billings
Syringopora tabulata Edwards & Haime	= Chonostegites tabulatus (Edwards & Haime)
Syringopora tubiporoides Davis	= Syringopora perelegans Billings (in part)
Thamnopora? impeditus Stumm	= Bractea impeditus (Davis)
?Thecia kentuckyensis Herzer	= Favosites "Emmonsia" eximia (Davis)
Thecia ramosa Rominger	= Favosites "Emmonsia" ramosa
	(Rominger)
Trachypora alternans (Rominger)	= Thamnoptychia alternans
	(Rominger)
Trachypora (Thamnoptychia) limbata S	tumm = Thamnoptychia vermiculosa
Turnehum ann an lata Starman	(Leseur)
Trachypora osculata Stumm	= Inamnopiyenia allernans
Trachunora romingari Doss	- Thampontuchia vermiculosa (Losour)
Trachypora tubarculata (Stumm)	- Thamnoptychia vermiculosa (Leseul)
Trachypora varmiculosa (Leseur)	- Thamnoptychia uarmiculosa (Leseur)
Trinlonhyllum terebratum Simpson	= Trinlonhyllum terebratum (Hall)
Turbinolia buceros var. elongata Rafine	sque & Clifford = Sinhononhrentis
	elongata (Rafinesque & Clifford)
Turbinolia (Zaphrenthis) phrygia Rafine	esque & Clifford = Zaphrentis
	phrygia Rafinesque & Clifford
Vermipora incrustans Okulitch	= Aulocystis(?) incrustans (Davis)
Zaphrenthis acuminatus Hall	= Heliophyllum?
Zaphrentis acuticornis Greene	= Stereolasma gallicalcar (Davis)
Zaphrentis aequus (Hall)	= <u>Indeterminate</u>
Zaphrentis albacornis Greene	= Enallophrentis simplex (Hall)
Zaphrentis albersi Greene	= Enallophrentis duplicata (Hall)
Zaphrentis albus Greene	= ?Breviphrentis yandelli (Edwards &
	Haime)
Zaphrentis alveolatus Greene =	"Breviphrentis" halli (Edwards & Haime)
Zaphrentis ampla Hall	= Enallophrentis simplex (Hall)
Zaphreniis amplicatus Greene	= Enallophrentis! joliata (Hall)
Zaphreniis(!) ampiexijormis Greene	= <u>indeterminate</u>
Zaphrentis annulata Hall	= "Heterophrentis" annulata (Hall)
Zaphrentis orevicornis Greene =	<i>Englianhantia inflata</i> (Hall)
Zaphrentis callosus Greene	= Enallophreniis influid (Hall) - Sinhononhrentis, elongata
Lapinennis cunosus Groene	(Rafinesque & Clifford)
Zaphrentis catactus Greene	= Enallophrentis? cvathiformis (Hall)
Zaphrentis colletti Hall	= "Heterophrentis" colletti (Hall)
Zaphrentis compressa Rominger	= Compressiphyllum davisana (Miller)
Zaphrentis concava Hall	= Enallophrentis concava (Hall)
Zaphrentis conigera Rominger	= Scenophyllum conigerum
	(Rominger) [In part]
Zaphrentis convoluta Hall	= Kionelasma conspicuum (Hall)
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Zaphrentis	cornalba Davis	= Enallophrentis concava (Hall)
Zaphrentis	cornicula Edwards & Ha	ime = Zaphrentis phrygia Rafinesque &
		Clifford
Zaphrentis	(amplexus?) cruciformis	Hall = Amplexiphyllum cruciforme (Hall)
Zaphrentis	curtus Greene	= Enallophrentis inflata (Hall)
Zaphrentis	curvata Hall	= Enallophrentis?curvata (Hall)
Zaphrentis	cyathiformis (Hall)	= "Heterophrentis "cyathiformis (Hall)
Zaphrentis	davisana (Miller)	= Compressiphyllum davisana (Miller)
Zaphrentis	deformis Hall	= Bordenia knappi (Hall)
Zaphrentis	duplicata Hall	= Enallophrentis duplicata (Hall)
Zaphrentis	elegans Hall	= Enallophrentis inflata (Hall) [In part]
Zaphrentis	elegans Hall	= "Breviphrentis" nitida (Hall) [In
r		partl
Zaphrentis	exigua Rominger	= Aemuliophyllum exiguum (Billings)
Zanhrentis	erilis Davis	= Stereologma(?) erile (Davis)
Zanhrentis	ernlana Davis	= Fnallonhrentis simpler (Hall)
Zanhrentis	foliata Hall	- Englionhrentis? foliata (Hall)
Zaphrentis	frequentata (Hall)	- Engliophrentis? cuathiformis (Hall)
Zaphrentis	allicalcar Davis	- Stereolasma gallicalcar (Davis)
Zaphrentis	guincur Davis	- Sinhononhrentis elongata
Lupinennis	gigunica Laward & Ham	(Rafinesque & Clifford)
Zanhrantis	aravis Hall	- Englionhrentis?curvata (Hall)
Zaphrentis	gravis Hall	- Engliophrentis duplicata (Hell)
Zaphrentis	greenunu Davis	- Stareolasma callicalcar (Dovio)
Zaphreniis	grosbucht Greene	= Stereolusmu guilicaicur (Davis) -"Browinkrentis" halli (Edwards & Hoime)
Zaphreniis	ham (Edwards & Hame)	= breviphreniis naili (Edwards & Hallie)
Zaphrentis	nerzeri Hall	= Homalophyllum herzeri (Hall)
Zaphrentis	hobbsi Greene	= Siphonophrentis yanaelli (Edwards &
a ,		Haime)
Zaphrentis	humilis Greene	= Enallophrentis concava (Hall)
Zaphrentis	immanis Davis	= Siphonophrentis elongata
		(Ratinesque & Clifford)
Zaphrentis	ischypus Greene	= "Heterophrentis" subcompressa (Hall)
Zaphrentis	inflata Hall	= Enallophrentis inflata (Hall)
Zaphrentis	inflexus Greene	= Enallophrentis duplicata (Hall)
Zaphrentis	insolens Greene	= "Breviphrentis" halli (Edwards & Haime)
Zaphrentis	<i>intortus</i> Greene	= "Breviphrentis" halli (Edwards & Haime)
Zaphrentis	<i>invaginatus</i> Greene	= "Breviphrentis" halli (Edwards & Haime)
Zaphrentis	irregularis Hall	= "Heterophrentis" irregularis (Hall)
Zaphrentis	knappi Hall	= Bordenia knappi (Hall)
Zaphrentis	labyrinthicus Greene	= "Breviphrentis" halli (Edwards & Haime)
Zaphrentis	lamasteri Greene	= "Breviphrentis" halli (Edwards & Haime)
-		[in part]
Zaphrentis	limatus Greene	= Stereolasma rectum (Hall)
Zaphrentis	linneyi Davis	= Homalophyllum herzeri (Hall)
Zaphrentis	maconathi Davis	= In part, Siphonophrentis elongata
r		(Rafinesque & Clifford) or ?
		Breviphrentis?planima (Hall)
Zaphrentis	nanus Greene	= Stereolasma gallicalcar (Davis)
?Zanhrenti	s neptun Herzer	= Acrophyllum oneidaense (Billings)
Zaphrentis	nettelrothi Davis	= Stereolasma rectum (Hall)
Zanhrentis	nitida Hall	= "Breviphrentis" nitida (Hall)
Zanhrontie	nodulosa Davis	= "Heterophrentis" irregularis (Hall)
Zanhrontia	obliguatus Greene	= Siphonophrentis vandelli (Edwards &
Lapmenus	oonquunas cicenc	- Siphonophichnis Junucini (Duwards & Haime)
Zanhrantis	abscurus Greene	= Engliophrentis?cvathiformis (Hall)
Lupnienus	UUSUNINS GIGGIG	[In nart]
Zanhuantia	ovalis Hell	- "Brevinhrentie" ovalie (Hall)
Laphrenus	ovalis nali	124 – Dievipilienius Ovans (Itali)

Zaphrentis planima Hall	= Breviphrentis? planima (Hall)
?Zaphrentis ponderosa Hall	= Siphonophrentis elongata
• •	(Rafinesque & Clifford)
Zaphrentis profunda Hall	= Breviphrentis? planima (Hall)
Zaphrentis prolifica Davis	= Enallophrentis inflata (Hall)
Zaphrentis prolixus Greene	= Enallophrentis inflata (Hall)
Zaphrentis pusillus Greene	= Enallophrentis inflata (Hall)
Zaphrentis radicans Davis	= Amplexiphyllum tenue (Hall)
Zaphrentis rafinesqui Edwards & Haime	e = "Heterophrentis" rafinesqui
	(Edwards & Haime)
Zaphrentis reynoldsi Davis	= Homalophyllum fusiformis (Hall)
Zaphrentis romingeri Davis	= Enallophrentis duplicata (Hall)
?Zaphrentis scitulus Greene	= "Heterophrentis" rafinesqui (Edwards
•	& Haime)
Zaphrentis sellersi Greene	= "Heterophrentis" subcompressa (Hall)
Zaphrentis simplex Hall	= Enallophrentis simplex (Hall) [In part]
Zaphrentis spissa Hall	= Enallophrentis inflata (Hall)
Zaphrentis(?)strigatus Greene	= Hallia strigata (Greene)
Zaphrentis subcentralis Greene	= Enallophrentis concava (Hall)
Zaphrentis subcompressa Hall	= "Heterophrentis" subcompressa (Hall)
Zaphrentis terebrata (Hall)	= Triplophyllum terebrata (Hall)
Zaphrentis torquata Davis	= Bordenia knappi (Hall)
Zaphrentis torta Hall	= Enallophrentis inflata (Hall)
Zaphrentis trigemma Davis	= Stauromatidium trigemma (Davis)
Zaphrentis trisunuatus Greene	= Triplophyllum terebrata (Hall)
Zaphrentis trisutura Hall	= Enallophrentis trisutura (Hall)
Zaphrentis undata Hall	= "Heterophrentis" annulata (Hall)
Zaphrentis ungula Simpson	= Homalophyllum ungulum (Rominger)
Zaphrentis varians Greene	= Enallophrentis concava (Hall)
Zaphrentis venusta Hall	= Enallophrentis inflata (Hall)
Zaphrentis weberi Greene	= Triplophyllumterebrata (Hall)
Zaphrentis yandelli (Edwards & Haime)	= Siphonophrentis yandelli (Edwards &
_	Haime)

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William A. Oliver, Jr. proofread several drafts of this manuscript and provided valuable updated information from recently published papers not previously seen by the author.

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TWO UNIQUE CORALS FROM THE MIDDLE DEVONIAN OF SOUTHWESTERN ONTARIO, CANADA

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When the theme of the 1998 Expo XX was announced I promised to write an article on two unique corals that I have come to love and prize very much. They are Favosites placenta Rominger and Microcyclus thedfordensis Bassler. Both of which I have found at Hungry Hollow, 2 miles east of Arkona and the Thedford Tileyard, just west of Thedford in Ontario, Canada.

In 1960 I discovered a wonderful guide and amazing mentor who was then 80 years old . His sight, keen mind and ready wit were always enjoyed by everyone who knew him. This incredible man, Charlie Southworth, knew all the fossil collecting places around Arkona and Thedford. Many hunting days were spent with Charlie, and his wife Annie, tramping to special fossil spots. Sometimes Charlie wasn't able to go hunting with me but always would remind me to check back with all the new goodies that I had collected.

The first time I found a beautiful small, complete coral with some small round corallites less than 1 mm in diameter with clusters of smaller ones scattered about, I knew I had something interesting and Charlie confirmed this by exclaiming, "Oh Tom! this is a rare beauty, a Favosites placenta!" I have looked for other specimens every time I hunt the Hungry Hollow fm.

Favosites placenta Rominger (below)





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The other unique fossil is a medium to small flattened buttonshaped solitary coral, which is usually attached and limited to definite horizons in the Arkona Shale formation, Hamilton Group, Middle Devonian of North America. They are rarely conspicuous or especially abundant. At Hungry Hollow near Arkona, and the Tileyard at Thedford, Ontario the Microcyclus beds are commonly crowded with non fossiliferous calcareous flat nodules in a light, thin yellowish shale layer.

> Microcyclus thedfordensis Bassler (below) i_{10} i_{11} i_{11} i_{12} i_{12} i_{13} i_{14} i_{10} i_{10} i_{11} i_{12} i_{12} i_{14} i_{14} i_{15} i_{16} i_{16} i_{17} i_{18} i_{18} i_{18} i_{19} i_{19} i_{19

Figure 10. Microcyclus thedfordensis Bassler; top view of a specimen from the Arkona shale, Tile Yard, Thedford, Ontario. G.S.C. No. 10211, x 2. (Page 5.)

Figures 11, 12. Microcyclus thedfordensis Bassler; top and bottom views of a specimen from the Arkona shale, Hungry Hollow, near Arkona, Ontario. G.S.C. No. 10212, x 2. (Page 5.)

Figure 13. Microcyclus thedfordensis Bassler; bottom view of a specimen showing attachment to a small Mucrospirifer, Arkona shale, Hungry Hollow, Ontario. G.S.C. No. 10213, x 1¹/₂. (Page 5.)

Figure 14. Microcyclus thedfordensis Bassler; bottom view of a specimen showing attachment to a small shell fragment; Arkona shale, Hungry Hollow, Ontario. G.S.C. No. 10214, x 14. (Page 5.)

Figure 15. *Microcyclus thedfordensis* Bassler; top view of a specimen showing marginal rim extending beyond the outer ends of the septa; Arkona shale, Hungry Hollow, Ontario. G.S.C. No. 10215, x 2. (Page 5.)

Figures 16, 17. Microcyclus thedfordensis Bassler; top views of two specimens from the Arkona shale, Rock Glen, Arkona, Ontario. G.S.C. Nos. 10216-10217, x 2. (Page 5.)

Figures 18, 19. *Microcyclus thedjordensis* Bassler; top views of two specimens from the Arkona shale, Hungry Hollow, Ontario. G.S.C. Nos. 10218-10219, x 1⁴/₄. (Page 5.)

Figure 20. Microcyclus thedfordensis Bassler; top view of twins from the Arkona shale, 15 feet below the top, Rock Glen, Arkona, Ontario. G.S.C. No. 10220, x 2½. (Page 5.)

Figures 21, 22. Microcyclus thedfordensis Bassler; top views of two specimens showing rejuvenation; Arkona shale, Hungry Hollow, Ontario. G.S.C. Nos. 10221-10222, x 1¹/₂. (Page 5.)

Figure 23. Microcyclus thedfordensis Bassler; top view of a specimen showing turned up rim or margin; Arkona shale, Hungry Hollow, Ontario. G.S.C. No. 10223, x 12. (Page 5.)

Stauffer, Clinton R. (1952): The Coral Microcyclus and some of its Devonian Species; Geol. Survey Canada, Bulletin 24, pp. 20-21, Pl. II, figs. 10-23.
AMPLEXUS Bruce L. Stinchcomb 3400 Pershall Road St. Louis MO 63135

Mississippian cherts weathered from cherty limestones of that age surround the Ozark Uplift and can occur as reminants (outliers) throughout parts of the uplift. These cherts are often fossiliferous and within the Ozarks these localized fossil fauna can be rich in mollusks. This is in constrast to the fact that mollusks are a phylum which is often under-represented in Mississippian strata in other parts of the midwest. Often associated with these cherts are fossils of the pecular coral genus Amplexus. Amplexus sp. is an elongate coral, it looks somewhat like a calamite stem section with parallel ridges running lengthwise the length of the fossil. Also like a calamite stem Amplexus is partitioned into a series of tabulae which suggest the nodes of this prehistoric plant. In fact Amplexus corals are sometimes mistaken for calamites fossils, but of course not withstanding the fossils themselves, <u>Amplexus</u> is a marine animal and will be found in rocks types, (chert limestones and dolomite) which were deposited in a marine environment. Calamites will be found in sandstones and shales which were not deposited in the ocean.

Apparently <u>Amplexus</u> of the Ozarks grew upright, the top of the coralite being fringed by extended coral polyps, probably brightly colored like marine life which lives today in clear, warm waters of tropical seas. Isolated occurrences of <u>Amplexus</u> "stems" are the rule, however sometimes groups of these pecular and attractive corals are found in chert boulders. When this is the case, small blastoids (<u>Globoblastus</u>) can also be found but few other fossils. These <u>Amplexus</u> groupings (they are much to sparce to be called reefs) seems to occur just above the top of the Burlington Formation, just above where it grades into the more slabby beds of the Keokuk Formation. Chert boulders stratigraphically above the <u>Amplexus</u> bearing zones carry a distinctive guide fossil of the Keokuk Formation, the flat brachiopod <u>Orthotetes keokuki</u>. The presence of these brachiopods indicate that

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these chert boulders weathered from the overlying Keokuk Formation, <u>Amplexus</u> however, is also characteristic of the Burlington Formation, the crinoids of which are world famous in both number and diversity. The coral <u>Amplexus</u> is a distinctive and reasonably common fossil in Missouri and might have made a good state fossil for Missouri, however a unique crinoid from the Kansas City area now has that honor.

Interesting "scatterings" of <u>Amplexus</u> can be accessed from parts of the Cedar Creek trail west of Fulton Missouri. Lots of hiking and a keen eye are required to spot the coral bearing boulders, however when prepared properly they make attractive specimens for ones collection.

Group of specimens of <u>Amplexus</u> from chert boulders exposed in small valleys in bluffs along Cedar Creek near Paris Church west of Fulton, Missouri. These attractive corals can be found in Mississippian age cherts (Koekuk Formations) over many parts of the Ozarks.









Pachyphyllum nevadense MARTIN LIMESTONE FM. GILA CO. ARIZONA DEVONIAN