# DISCOVERY OF THE MIDDLE DEVONIAN (GIVETIAN) RUGOSE CORALS FROM THE MAYMYO FORMATION, PYINOOLWIN AND HSIPAW TOWNSHIPS

Khaing Khaing San*

## Abstract

Five species of Middle Devonian (Givetian) rugose corals are firstly described from the Pwepon Limestone of the Maymyo Formation at Pwepon (Pyinoolwin Township) and Kongtha (Hsipaw Township) areas. The Pwepon Limestone consists of grey to dark grey, well-bedded, hard micritic limestone intercalated with argillaceous limestone, siltstone and shale. This limestone in Pwepon and Kongtha areas is considered as the sandwiched unit of the Maymyo Formation. The Pwepon Limestone is richly fossiliferous including Eifelian and Givetian rugose coral faunas. The later, never reported before, include two new species: *Argutastrea pweponsensis* sp. nov., *Hexagonaria carinata* sp. nov. and three previously described species *Grypophyllum postprimum postprimum* from Late Givetian of Schweln-Kalk, NW Sauerland, Germay, *Disphyllum dispar* from Givetian, Dosey Limestone, Broken River Province, North Queensland, Australia and *Disphyllum caespitosum* from Givetian, Cürten Formation, Eifel Hill, Germany. The Myanmar Givetian species are compared with those from Europe and Australia.

**Keywords**: Middle Devonian, Pwepon, Kongtha, rugose corals

## Introduction

Marine Middle Devonian limestone is formerly as the very limited exposed unit in Myanmar (Padaukpin and Pwepon area). Two new discovered fossiliferous units of Middle Devonian age in Lashio area and Hsipaw area, northern Shan State provide an insight into changing lithology and faunal occurrences. The Pwepon area, Pyinoolwin Township is the occurrence of a slighter younger coral dominated Middle Devonian limestone, recorded in that area and is assigned to the Pwepon Limestone (Figure 1). Another occurrence of Pwepon Limestone continuously exposed along Mandalay – Lashio car-road mile post (156/3) in Kontha area, Hsipaw Township contains a diverse rugose coral fauna representing an in situ assemblage of complete and unfragmented specimens. Fossils recorded from this area are abundant rugose and tabulate corals and numerous brachiopods.

This study is primarily concerned with the systematatic description of the Middle Devonian (Givetian) rugose corals from the Pwepon Limestone of the Pyin Oo Lwin Township and Hsipaw Township. Five species are identified and described in this paper.

* Dr, Professor, Department of Geology, Yadanabon University

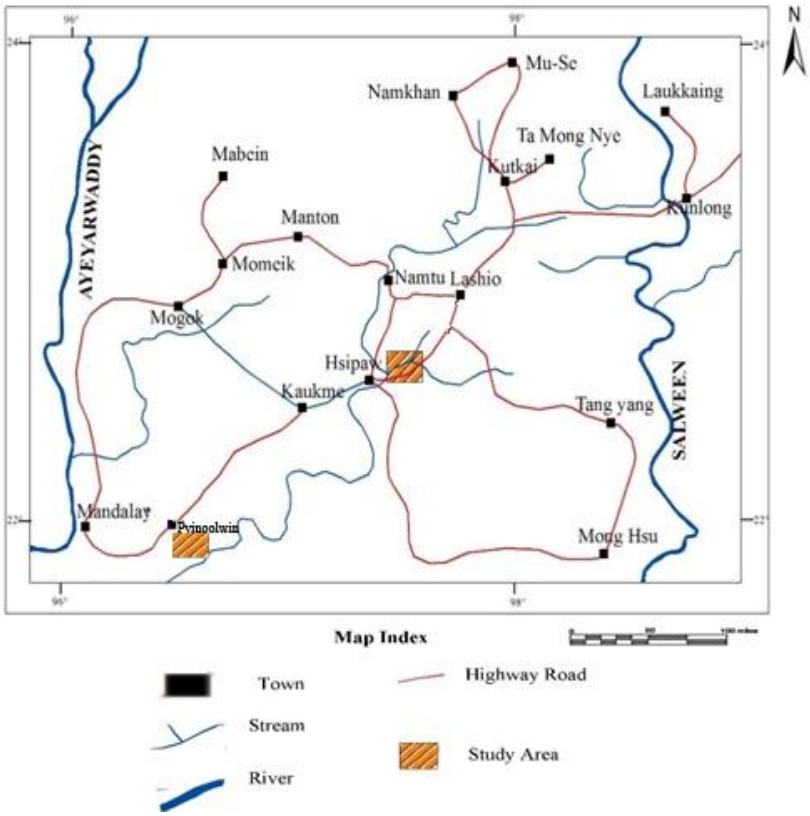


**Figure 1** Location map of the Study area.

**Stratigraphy of the Pwepon Limestone**

The Pwepon Limestone is restricted to expose in northern Shan State. The Pwepon area is located about 5 miles SE of Pyinoolwin which also lies between latitudes 21˚ 53′N to 22˚ 0′N and longitudes 96˚ 30′E to96˚ 35′E. It occupies the northern part of one-inch topographic map 93 C/9. The coral bearing limestone is situated at the Pwepon cave and it's environ,3473 ft. hill at the eastern part of the Pwepon cave and smooth, isolated hill (3200 ft.) at the western part of Pwepon cave and has the coordinates of N21˚ 53′E96˚33′.

The Pwepon Limestone is well-bedded, hard, micritic limestone and difficult to struck with hammer. It can be easily struck with hammer and giving the thin layers of small chips when the limestone has been subjected by weathering process. Its topography is very different from the neighborhoods by isolated hills of well–bedded character. The total thickness of the Pwepon Limestone is 174 meters (Figure 2A).

Lithologically, Pwepon Limestone is classified into eight subunits namely dolomitic limestone, micritic limestone, argillaceous limestone, stromatolitic limestone, limestone intercalated with crinoidal limestone, argillaceous limestone intercalated with silty shale or mud, micritic limestone with parallel lamination and silt partings and limestone with chert nodules. The detailed description for measured section of the Pwepon Limestone is shown in Figure 3. It is overlain by dolomitic limestone with relict fossils, argillaceous limestone, ferruginous dolomitic limestone, hematite, calcareous limestone and highly jointed and brecciated dolomitic limestone. The Pwepon Limestone is richly fossiliferous with rugose corals and the other

fossilsare the abundant tabulate corals, bryozoans, branchipods and conodonts (Khaing Khaing San, 2005).

Kong thaarea is bounded by north latitude 22°36′48"to 22°42′12" and East Longitude 97°24′to 97°32′20" in UTM map no. 2297 (6 - 10).In this area, Pwepon Limestone is mainly exposed in the south western part. The best exposures of Pwepon Limestone continuously exposed along road cut section at the mile post (156/5) of the Mandalay-Lashio car road (N22º53'36" and E96º40'50")and (62) meter in thickness (Swe Hnin Maung, 2018).

In this area, the Pwepon Limestone is also the sandwiched unit of the Maymyo Formation which laterally passed into dolomite or dolomitic limestone. It is the escaped unit of the dolomitization. It consists of thin- to medium-bedded, buff colour, grey to black, fine- to medium-grained, soft and indurated, limestone, calcareous limestone, argillaceous limestone, carbonaceous shale and grey shale. Where shale or argillaceous materials is dominated, fossils fragments (Corals and Brachiopods) are most abundantly occurred and easily extracted from this unit. Detailed description for measured section of the Pwepon Limestone is shown in Figure 2B. This Limestone is the fossiliferous unit containing a number of corals (rugose and tabulate) and brachiopods.

The occurrence of faunal assemblage indicates that the age of the Pwepon Limestone in these two areas can properly be designated as the Middle Devonian (Eifelian to Givetian) age.

## Systematic Paleontology

### Methods of Study

The rugose corals are collected from the coral-bearing horizon of the upper part of the Pwepon Limestone in Pwepon area and Kong tha area. Most of the rugose corals show abrasion but no sign of reworked character. They included in the detrital limestone unit in Pwepon area and argillaceous limestone unit in Hsipaw area. All specimens described herein have been prepared the thin-section. Statistical methods are used for identification of the species.

The suprageneric classification used in this paper follows the classification of Hill (1981) except as noted under the relevant taxa. The rugose coral terminology follows that of Hill (1935, 1956, 1981). In solitary and fasciculate corals, the corallite diameter quoted is the mean diameter as measured in a transverse section. In cerioid corolla, the corallite diameters measured from the middle of one side to the middle of the opposite side.

Known distributions of the genus are summarized so as to indicate their biostratigraphic and paleogeographic significance. Figured specimens have been selected to show both inter- and intra- specific variation. The thin-sections were placed in the negative carrier and the image traced directly into drafting film.

All described rugose corals from Pwepon area are housed in the department of geology, Yadanabon University and from Kong tha area are housed in the department of geology, Lashio University. The repositories of the rugose corals from Pwepon area are prefixed by YDBPP and from Kontha area are prefixed by LSOKT.

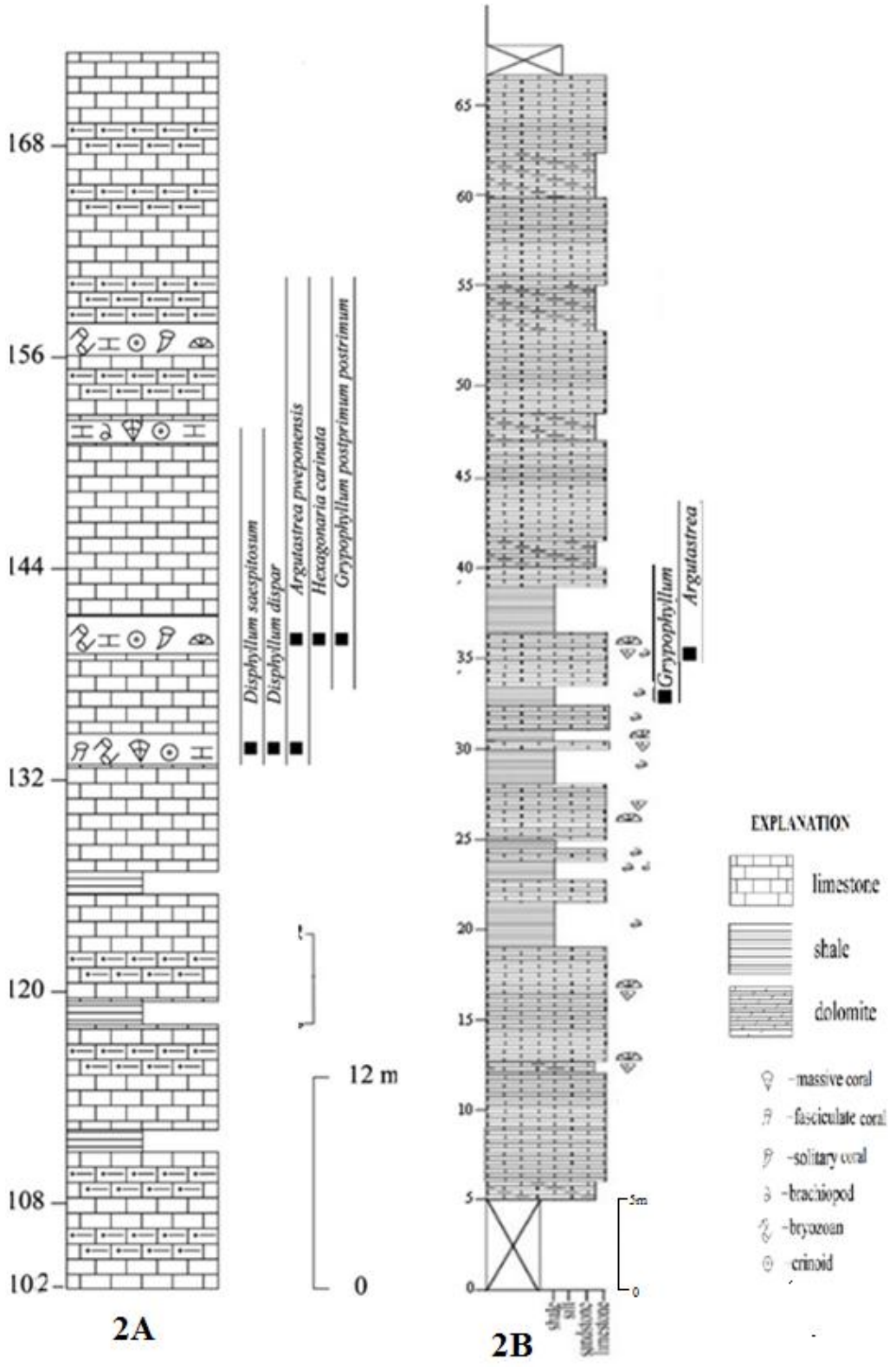


**Figure 2** Stratigraphic measured section of the upper part of Pwepon Limestone with the distribution of the rugose corals in Pwepon area (2A) and the Pwepon Limestone with the occurrence of fossils (mile-post 156/3 furlong) along Mandalay -Lashio Car-road in Kontha area (2B).

## Result and Discussion

Phylum Coelenterata Frey and Leukart, 1847

Class Anthozoa Ehrenberg, 1834

Subclass Rugosa Milne-Edwards and Haime, 1850

Order Cystiphyllida Wedekind, 1927

Family Ptenophyllidae Wedekind, 1922

Subfamily Ptenophyllinae Wedekind, 1922

Genus *Grypophyllum* Wedekind, 1922

*Grypophyllum* Wedekind, 1922, p.13

***Type species***. - *Grypophyllum denckmanni* Wedekind 1922; p.13-14, Text-figs. 13,14; Givetian, Bergisch-Gladbach, Germany.

***Remarks*.** - The present specimens are closely resembled with the genus *Grypophyllum* Wedekind (1922) in the character of non-carinated septa, peripherally thickened and thin inwards, wide dissepimentarium with subglobose dissepiments steeply, adaxially inclined and narrow tabularium with incomplete tabulae, closely spaced and flat with a central depression.

***Occurrence***.- Middle Devonian for Europe (Germany, United Kingdom, Belgium, France, Czech.- Austria, Urals, N. Zemlya), Asia (Kuzbas NE, USSR, Pakistan, Kwandsi, Myanmar, China), North America (S. Mackenzie).

*Grypophyllumpostprimum postprimum* Birenheide and Lütte, 1990 (Figs. 3.1 - 3.2)

*Grypophyllum postprimum postprimum* Birenheide and Lütte, 1990, p. 14, pl. 5, figs 31-32

***Holotype*.** - *Grypophyllum postprimum postprimum* Birenheide and Lütte, 1990, SMF WDKD: Kat.- Nr. 7014-7015 (1QS, 1LS; pl.5, figs. 31a-b), Upper Givetian, Schwelm- Kalk; NW-Sauerland, Germany.

***Diagnosis*** - The subspecies of *Grypophyllum postprimum* with flat lying or irregularly curved and closely spaced tabulae and minor septa very short or redused to spines (modified after Birenheide and Lütte, 1990).

***Materials*.** - Figured specimen MUPP 0559 and LSOKT 250 from Middle Devonian (Eifelian-Givetian), upper part of the Pwepon Limestone PP (D), Maymyo Formation, Pyinoolwin township and and Hsipaw Township, Myanmar.

***Description***. - The material consists of fragment of solitary coralla, which may be cylindrical. Its height and external morphology cannot be observed because it is encrusted in the micritic limestone (MUPP 0559). LSOKT is cylindrical coral, length is 20 -24 mm, diameter ranges between 15- 40mm, gently sloping calical platform and moderately deep calical pit (LSOKT).The septa are non-carinate, slightly dilated throughout their length. Occasionally, they are thicker at the periphery; a triangular thickening may also appear against the outer wall. In some cases, the septa are discontinuous at the periphery or interrupted by a few lonsdaleoid dissepiments. Septa are arranged in two orders with 25-30 in each and peripherally dilated forming a relatively wide peripheral stereozone of 1mm thick. The major septa extend close to the axis of the corallum; their distal ends slightly curved and bilaterally arranged. Minor septa are

very short or reduced to spines and isolated fragments. Dissepiments are mainly concentric in tranverse sections. Dissepimentarium consists of 5 to 7 rows of elongate, adaxially inclined dissepiments, with a sharp boundary between the dissepimentarium and tabularium. Tabulae are incomplete, flat lying or irregularly curved and closely spaced. The diameter of the corallum ranges from 13-16mm. The width of the tabularium is 4mm.

***Remarks*** - These specimens are assigned to *Grypophyllum.* This species closely resembles with *G. postprimum postprimum* Birenheide and Lütte (1990), Givetian, Rheinisches Schicfergebirge, Burg-Berg section, Germany described by Schröder (2002), except the later in having rhopaloid major septa and herring-bone dissepiments. This is considered as a specific variation.

***Occurrence*** - This species occurs in Upper Givetian, Schwelm- Kalk; NW- Sauerland, Germany; Givetian, Rheinisches Schicfergebirge, Burg-Berg section, Germany and Middle Devonian (Eifelian-Givetian), Pwepon Limestone, "Maymyo Formation", Pyinoolwin and Hsipaw townships, Myanmar.

Suborder Columnariina Soshkina, 1941

Family Disphyllidae Hill, 1939

Genus *Disphyllum* De Fromentel, 1861

*Disphyllum* De Fromentel, 1861, p.302

***Type species*** (SD, by Lang and Smith, 1934). - *Cyathophyllum caespitosum* Goldfuss, 1826, p.60, Pl. 19, fig. 2b; = *Disphyllum goldfussi* (Geinitz, 1846); Givetian, Eifel, Germany.

***Remarks***. - Birenheide (1978, p.90-91) put the emphasis on the subcerioid nature of the holotype colony of *Disphyllumcaespitosum,* the type species of the genus, and assigned this species to *Columnaria* Goldfuss (1829). However, *Columnaria* (type species *C. sulcata* Goldfuss; see Birenheide, 1978, pl.12, fig.4) is cerioid and its dissepiments are so scarce, that they are often not in contact with each other. *Disphyllum* is dendroid, phaceloid to subcerioid commonly with more numerous dissepiments. Even if only one series is present, it forms a continuous zone at the corallite periphery. The forms described here agree exactly with that of the genus *Disphyllum.*

***Occurrence***. - Early Devonian (Emsian) for Asia (NE USSR); Middle Devonian (Eifelian) for Europe (Belgium), Asia (Myanmar, China); Middle Devonian (Givetian) for Europe (U.K.-Belg.-Ger.-Pol.-Czech.-Aus.) - Asia (Kazakh); Late Devonian (Frasnian) for South China, Tadjikistan.

*Disphyllum caespitosum* Goldfuss, 1826

(Fig. 3.4)

*Disphyllum caespitosum* Goldfuss, 1826, p. 60

***Holotype***. - *Cyathophyllum caespitosum* Goldfuss, 1826 = *Disphyllum caespitosum,* Goldfuss, 1826, Givetian, Eifel, Germany.

***Diagnosis*.** - Colonial rugose corals of *Disphyllum* with 23 major septa at a diameter of 10-12mm. Major septa leaving an axial space of 1-3mm, dissepimentarium composed of globose dissepiments about 3 to 6 rows. Tabulae is incomplete, bizonal (Schröder, 1998).

***Materials***. – MUPP 0533, MUPP 0578, MUPP 0590 from Middle Devonian (Eifelian-Givetian), upper part of the Pwepon Limestone (PP-D), Maymyo Formation, Pyinoolwin township, Myanmar.

***Description***. - Coralla is phaceloid to subcerioid and their size unknown because it included in the groundmass. The long, cylindrical corallites are locally in contact, and lateral offsets occur in the colony. The diameter of the corallite ranges from 8mm to 14mm (average 10-11.2 mm in diameter). Septa are 21 to 26 in each order, smooth and non-carinate, peripherally dilated in wedge-shape and embedded into walls and attenuating toward axis, three-fourths as long as the radius, leaving an axial space of 1-3 mm. Minor septa are short, nearly reaching or just extending into tabularium, one-fourth as long as the radius. Trabeculae are coarse monacanths, extending inwards and upwards at a low angle to the horizontal.

The dissepimentarium consists of 2 to 3 rows of small, inclined dissepimens adaxially toward the axis. Tabularium is two-third as wide as the corallite, 4.5-6mm wide and is composed of complete or incomplee, horizontal or slightly convex at centre with down-turned margin and occasionally supplementd with small peripheral tabellae; rather closely, but unevenly spaced, vertically there are 6 to 8 tabulae per 5mm.

***Remarks***. - This material closely resembles with *D. caespitosum* Goldfuss (1826) described by Schröder (1998, p.41, pl.5, Fig.35) from Givetian, Cürten Formation, Germany in all characters. This species is the type species of the genus. It is also similar to *Disphyllum dushanese* Yü and Liao in Kong and Huang (1978) described by Liao and Birenheide (1989, p.87, pl.4, fig.23) from the Frasnian of Tushan Province of Guizhou, South China but regular axial torsion of the thin major septa can serve to distinguish it from *D. caespitosum.*

***Occurrence*** - This species occurs in Middle Devonian (Eifelian-Givetian), Pwepon Limestone, Maymyo Formation, Pyinoolwin Township, Myanmar; Givetian, Bergishes Land and Sauerland, Ermberg-Rodert Formation, Eifel, Germany.

*Disphyllum dispar* Aung, 1991

(Fig. 3.3)

*Disphyllum dispar* Aung, 1991, p.208, pl.31, Fig. 2a-f; pl.32, Figs. 1a,b, 2a,b; pl.33, Figs.1a, b, 2a, b, 3a, b, 4.

***Holotype***. - *Disphyllum dispar* Aung, 1991, UQF 77635 from UQL5528, limestone lens B26, 400m west of the small creek, 500m south of the Broken River, 1km upstream from the jack Hills Gorge, Early Givetian, Dosey Limestone; Broken River Province, north Queensland, Australia.

***Diagnosis***. - Phaceloid to subcerioid *Disphyllum* with cylindrical corallites, 6-9 mm in diameter; increase both parricidal and lateral; septa number 38 - 45, consistently dilated in the dissepimentarium. Tabularium wide, consisting of closely spaced complete tabulae; tabularial floors flat, slightly convex or sagging; dissepiments small, single to multiple rows;? monacanthine trabeculae (Aung 1991, p.208).

***Materials.*** - MUPP 0541, MUPP 0577 from Middle Devonian (Eifelian-Givetian), upper part of the Pwepon Limestone (PP-D) of, Maymyo Formation, Pyinoolwin townsip, Myanmar.

***Description***. - Originally loose phaceloid colony of thin section with four of the cylindrical corallites and two incomplete corallites are available. Isolated corallites with a diameter between 5 and 8mm (average 5.5 to 5.25mm in diameter) are enclosed in limestone. Septa of both orders are 68-72. Major septa are usually short, half to the radius of the corallite, not reaching axis, smooth and non-carinate, peripherally dilated and attenuating in the tabularium. Minor septa are

very short and never reach the tabularium. Trabeculae are monacanths arranged in a broad asymmetrical half fan over the dissepimentarium.

Dissepimentarium is narrow with 1.5mm wide, typically consists of 2-3 rows of globose, small dissepiments, they are almost horizontal in arrangement. Tabularium is broad, 2.5-3mm in diameter about 2/3 of the corallite diameter. It is filled with complete tabulae which are horizontal, or slightly concave or convex, and in some adaxially incline large periaxial tabulae also occurred. Tabulae are rather closely, but unevenly spaced and vertically counting about 4-6 tabulae per 5 mm.

***Remarks***. - This species closely similar to *Disphyllum gemmiforme* Etheridge (1902) illustrated by Pickett (1967, pl.7, figs. 27-28) from ?Lower Middle Devonian, Cavan Bluff Limestone, near Taemas bridge, New South Wales, Australia but he did not describe it. Hill (1981, p. F280) described the genus *Zelolasma* Pedder (1964) with the type species of *Disphyllum gemmiforme* Etheridge (1902). The transverse section of this species is more or less the same but in the longitudinal section, it has smaller tabularial diameter and more closely spaced tabulae in the tabularium.

***Occurrence*** - This species occurs in Middle Devonian (Eifelian-Givetian), Pwepon Limestone, Maymyo Formation, Pyinoolwin Township, Myanmar and in Early Givetian, Burges Formation, and Dosey Limestone, Broken River Province, north Queensland, Australia.

Subfamily Disphyllinae Hill, 1939

Genus *Argutastrea* Crickmay, 1960

*Argutastrea* Crickmay, 1960, p.10

***Type species*** (SD, by Hill and Jell, 1970). – *Argutastrea arguta* Crickmay, 1960, Middle Devonian, Can., W. end of Carcajou Ridge, NW. Terr.

***Remarks***. - The genus *Hexagonaria* is easily distinguished from *Argutastrea* by septa typically carinate with spindle shaped dilation in the dissepimentarium, by calices with broad and flat peripheral platform and by numerous dissepiments, which are in horizontal in layers in the outer part of the dissepimentarium and steeply inclined in its inner part. The collected specimens show radially arranged long major septa, dilated in dissepimentarium with some knobby or spinose carinae, slightly declined dissepiments with monacanthine trabeculae and flat or convex axial tabulae. Therefore, it should be assigned to the genus *Argutastrea*.

***Occurrence***. - Latest Eifelian to Early Givetian (Australia); Eifelian to Givetian (Germany, Myanmar, China); Givetian (France); Givetian to Frasnian (Belgium); Eifelian to Frasnian (USSR).

*Argutastreapweponensis* new species

( Figs. 4.1 – 4.3, 5.1)

***Name derivation***. - This species is firstly found from the Pwepon Limestone.

***Diagnosis***. - A species of *Argutastrea* with corallites having 36 to 40 septa at a diameter of 5 mm to 10 mm. Septa dilated in the dissepimentarium. Septa of both orders are long, the minor ones traversing the full dissepimentarium.

***Materials*.** - Holotype: MUPP 05145, paratype: MUPP 0575, MUPP 0576, LSOKT 27-30 from Middle Devonian (Eifelian-Givetian), upper part of PP (D) of the Pwepon Limestone, Maymyo Formation, Pyinoolwin and Hsipaw townships , Myanmar.

***Description***. - The materials consist of cerioid corallum and their size unknown. Calical surface has been strongly weathered; the excavated calices are protruded like a calical boss, which are bordered by a moderately wide, flat calical platform (MUPP 05145, MUPP 0575-0576). LSOKT 027- 030 is colonial massive form, size ranges between 10 – 30 cm and largest form attain 60 cm. The walls between adjacent corallites are straight and sharp, medium line forming the polygonal corallites. There are 36 to 40 septa per corallite. Corallite diameter ranges from 5mm to 10mm (average 7 to 8.2 mm in diameter). The width of the tabularium varies commonly between 3.75 mm and 4.3 mm.

The septa are non-carinate or bear occasionally a few small spinose or knobby carinae. They are slightly thickened in the dissepimentarium-tabularium boundary and thinner in the peripheral and axial part. Sometimes, the septa are more thickened by schlerenchyme. The major septa reach the axis of the corallites or leave a free space in the center of the tabularium, which is usually small. Septa are mostly subequal and some united at the axis. The minor septa are usually long, travesing the full dissepimentarium about the two-third length of the majors. The dissepimentarium is wide composed of numerous, small dissepiments in the periphery and inner part, commonly occurred as the herringbone dissepiments in the transverse section. The dissepimentarium consists of 3 to 7 rows, which have two series; the peripheral dissepiments are large, subglobose and flat or horizontal and the inner dissepiments are small, elongated and adaxially steeply inclined. The tabulae are mostly incomplete with the axial part of flat or convex tabulae and the periaxial part of small, inclined tabulae. The trabeculae are monacanthine that are parallel or diverging upward and inward like a half-fan.

***Remarks***. - This species resembles *A.* sp. Aung (1991) from Early Givetian, Dosey Limestone, Broken River Province, North Queensland but differs in the later has peripherally dilated wedge-shape, dilated, shorter septa and wider axial area in the tabularium. The present Myanmar species is similar in character with *A.* (*Pseudohexagonaria*) *philomena* (Glinski, 1955) described by Schröder (1998) from the Middle Devonian (Eifelian), Junkerberg Formation, Dollendorfer Mulde, Eifel, Germany but it has lonsdaleoid dissepiments in the periphery. This species may possibly be a transitional form between Queensland sp. of *A.* sp. (Aung, 1991) and German, *A.* (*Pseudohexagonaria*) *philomena* (Glinski, 1955).

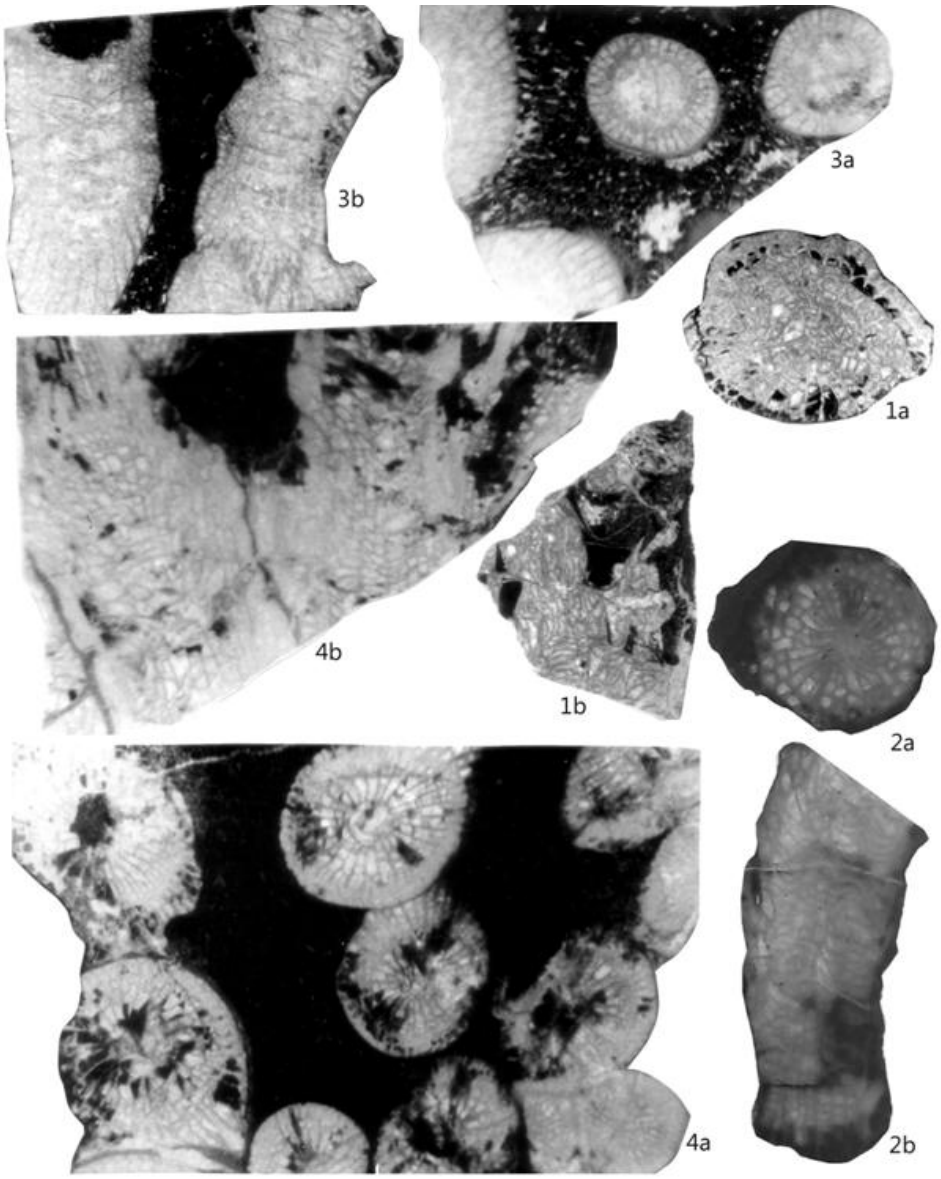


**Figure 3** **1-2,** *Grypophyllum postprimum postprimum*. 1a&1b, transverse and longitudinal sections, MUPP0559,x 2.8; 2a&2b, transverse and longitudinal sections, LSOKT 250, x 2.8; 3, *Disphyllum dispar*. 3a&3b, transverse section x 5 and longitudinal sections x3.5, MUPP0577; 4. *Disphyllum caespitosum* 4a&4b, ttransverse section x 2.5 and longitudinal sections x3, MUPP0533.

***Occurrence*** - This species occurs in the Middle Devonian (Eifelian-Givetian), Pwepon Limestone, Maymyo Formation, Pyinoolwin and Hsipaw townships, Myanmar.

Subfamily Hexagonariinae Bulvanker, 1958

Genus *Hexagonaria* Gürich, 1896

*Hexagonaria* Gürich, 1896, p.171

***Type species*** (SD, by Lang, Smith and Thomas, 1940). –*Cyathophyllum hexagonum* Goldfuss, 1826, p. 61, Upper Givetian or Lower Frasnian, Refrath beds, Germany, Bensberg.

***Remarks*.** - The present Myanmar specimens show cerioid, long, dilated in fusifom septa with closely carinae, mostly yardarm, radially arranged and fan shape monacanhine trabeculae,

numerous dissepiments and slightly convex axial tabulae. It closely resembles with the diagnosis of the genus *Hexagonaria*. Thus, it should be assignd to the *Hexagonaria* and this is the first occurrence of the genus *Hexagonaria* in Myanmar.

***Occurrence*** - *Hexagonaria* is a Givetian- Frasnian genus in the worldwide. Middle Devonian for Myanmar; Givetian – Frasnian for Europe (United Kindom, France, Belgium, Germany, Poland, Urals), Asia (Kuzbas-Yunnan), West Australia, North America (Washington, NW Ter.).

*Hexagonariacarinata* new species

(Figs. 5.2 – 5.3)

***Diganosis***. - A species of *Hexagonaria* with corallites having 30-34 septa at a diameter of 8.5mm. Septa dilated in fusiform and closely carinated with yardarm. Dissepiments are globose, monacanthine trabeculae and incomplete tabulae.

***Materials***. - Holotype: MUPP 05116, paratype: MUPP 05114 from Middle Devonian

(Eifelian-Givetian), upper part of the Pwepon Limestone (PP-D), "Maymyo Formation", Pyinoolwin townsip, Myanmar.

***Description***. - The materials consist of a cerioid corallum and their size unknown. Calical surface has been strongly weathered. The walls between the adjacent corallite are curved. The corallites are polygonal to hexagonal in shape and are 8mm in diameter but ranging up to 10mm. The septa are long, dilated to fusiform in dissepimentarium-tabularium boundary and become thinner in their periphery and axial ends. The septa are closely carinated mostly wih yardarm carinae. The major septa reach more or less to the axis of the corallites, but often leave a small free space 1-1.5mm in the center of the tabularium. The minor septa are usually long about 2/3 lengths of the majors.

The dissepimentarium consists of 4-6 rows of horizontal, subglobose outer dissepiments and 2-4 rows of inner dissepiments, adaxially steeply inclind. The tabulae are incomplete consisting of two series; flat or convex axial tabulae and small, slightly inclind, peripheral tabulaeThere are 30-34 septa per corallite. The width of the tabularium varies commonly between 3mm and 3.5mm. Trabeculae are monacanthine, almost parallel and directed upward and inward from periphery like fan-shape.

***Remarks***. - This species resembles *H.* cf. *hexagona* Goldfuss (1826) described by Schröder (2002) from Upper Givetian, Burg-Berg section, east Sauerland, Germany but the later has more septa number and less carinated with knobby or spinose. The Chinese species of *H. beichuanensis* He (1978) described by Liao and Birenheide (1985) from Givetian of Dushan, Province of Guizhou, S. China differs from the present species by larger corallite diameter and more septa number, less carinated septa and flat or horizontal tabulae. According to the present investigation, this specimen differs from other known established species, so it ispresent investigation, this specimen differs from other known established species, so it is designated to the new species.

***Occurrence*** - This species occurs in the Middle Devonian (Eifelian-Givetian), Pwepon Limestone, Maymyo Formation, Pyinoolwin Township, Myanmar.

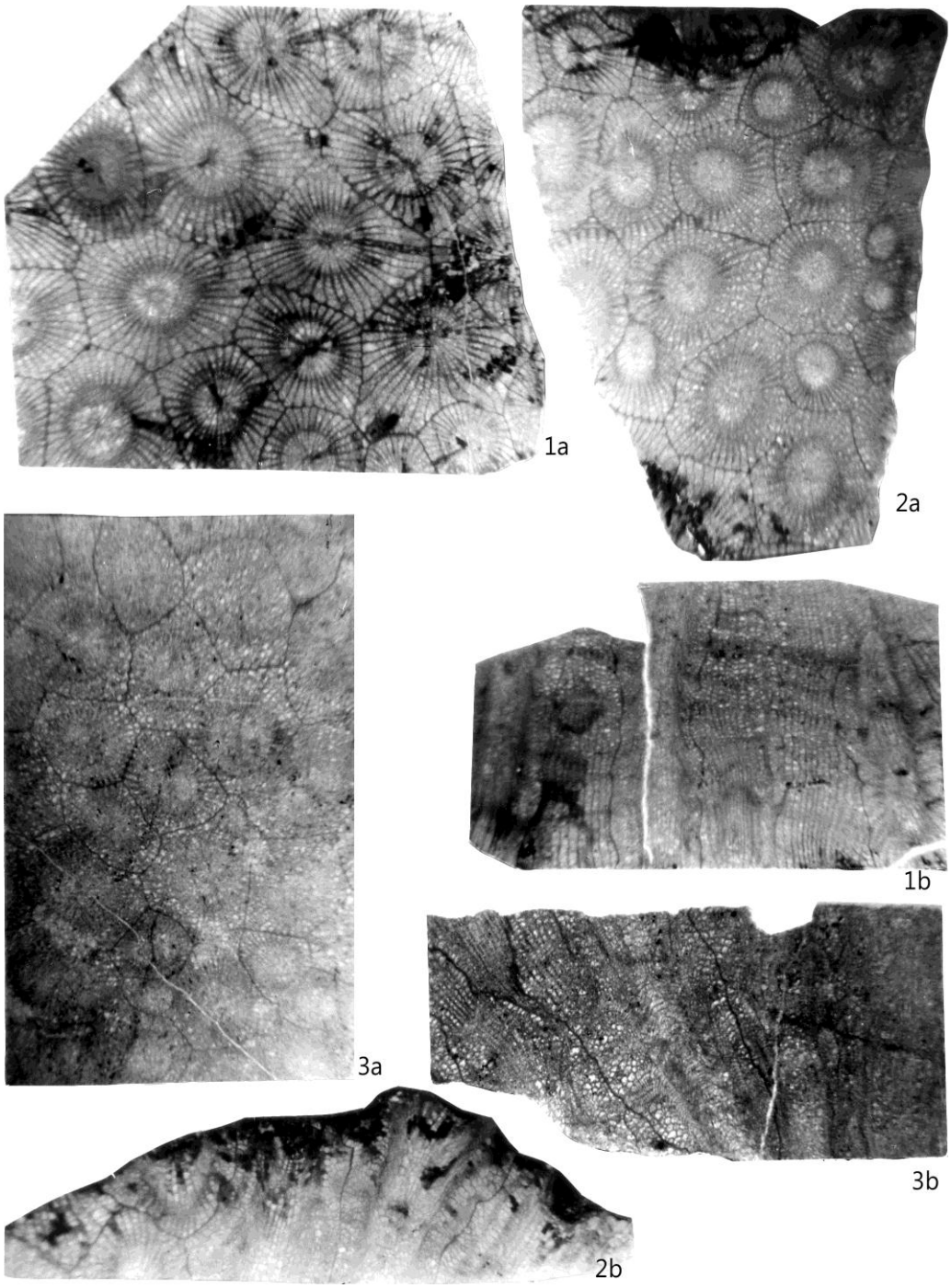


**Figure 4-1-3**,*Argutastrea pweponensis*. 1a&1b, transverse section x 2.5 and longitudinal sections x 3, MUPP0545; 2a&2b, transverse section x 2.25 and longitudinal sections x 2.7, MUPP0576; 3a&3b, transverse section x 2.2 and longitudinal sections x2.7, MUPP0575

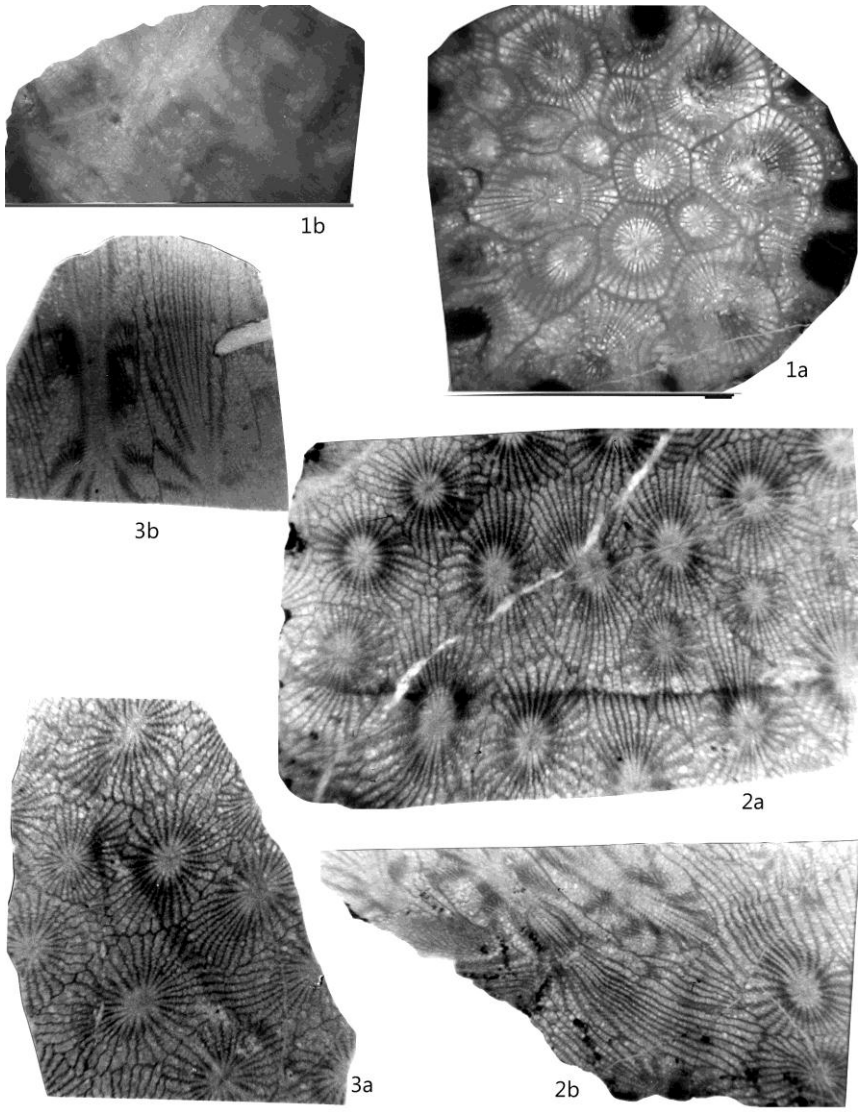


**Figure 5-1**, *Argutastrea pweponensis*. 1a&1b, transverse section x1 and longitudinal sections x 0.75 , LSOKT 0559,x2.8; 2-3, *Hexagonaria carinata*. 2a&2b, transverse section x3 and longitudinal sections x 2.6, MUPP0516,x2.8; 3a&3b, transverse section x 3 and longitudinal sections x2.6, MUPP0514

## Conclusion

The coral fauna characterized by the abundant occurrences of compound corals, such as of the *Grypophyllum*, *Argutastrea*, *Hexagonaria*, and *Disphyllum* dominated by disphyllids in the upper part of the Pwepon Limestone in Pwepon area and Hsipaw area. In this interval, fossils are less abundant and the fossiliferous bioclastic limestone is intercalated in the medium-bedded, light grey to grey, argillaceous limestone and calcareous limestone. The colonial massive forms of rugose corals become much widely distributed in the upper part. The associated fauna are the tabulate corals, brachiopods and bryozoans. The upper most part of the Pwepon Limestone is terminated with thin- to medium-bedded, grey, slightly dolomitized limestone with high calcitization and rare fossil horizon.

*Grypophyllum* is the first occurrence of Myanmar. It also widely distributed in the world. *Argutastrea* is confined to latest Eifelian to Givetian for Australia, Germany, China and Vietnam.

The new species of *A. powensis* is closely resembled with *A. periclada* Kramer (1982) (in Coen-Aubert and Lütte, 1990) from the Givetian of Torringen Formation, North Eifel Hills, Germany. *Hexagonaria* is a common element of Givetian- Frasnian in the worldwide especially in Europe, Asia, West Australia and North America. *H. carinata* resembles *H*. cf. *hexagon* Goldfuss (1826) (in Schröder, 2002) from upper Givetian, Burg-Beng section, Germany. *D. caespitosum* Goldfuss (1826) (in Schröder, 1998) is described from Givetian, Curten Formation, Eifel, Germany. *D. dispar* Aung (1991) occurred in early Givetian, Dosey Limestone, Broken River Province, north Queensland.

The composition of the present described rugose coral fauna allows assignment of ages to the limestone where conodont or shelly faunas are absent. The correlation of the faunas of upper part of the Pwepon Limestone and the occurrences from outside Myanmar allows age determination of the coral-bearing sequences as Middle Devonian (Givetian). Their correlation with the standard conodont zonation reaches from the *hemainsatus* to the middle *varcus* zone and has close affinities with contemporaneous faunas of Ardennes, northern France, Rheinisches Schiefegebirge, Eifel Hills and Broken River Privince.

## Acknowledgements

I greatly appreciate the help of Professor Dr. Marie Coen-Aubert, Belgium and Dr. Stefan Schroder (Geology and Paleontology Institute, Koln University), Germany for their supporting the literatures of the corals. Many thanks are due to Dr. Aye Ko Aung, Professor (Retd.), Department of Geology, Dagon University for his proper guidance and critical reading the manuscript.

## References

Aye Ko Aung. (1991). *Early to Middle Devonian rugose coral and conodont faunas of the Burges Formation, Broken River Province, north Queensland*. Ph.D. Thesis (unpublished), University of Queensland, Australia, 307p.

Birenheide, R. (1978). *Rugose Korallen des Devon*. Leitfossilien, 2. Gebriider Borntraeger, Berlin, Stuttgart: 265P.

Birenheide, R. and B.P.Lütte. 1990. Rugose Korallen aus dem Mittel - Givetium (MIttel - Devon) des Rheinischen Schiofergebirges. *Senckenbergiana lethaea*, 70 (1/3):1-28, 5.

Bulvanker, E.Z. (1958). Devonskie chetyrekhluchevye korally okrain Kuzetskogo basseyna, 2:212, pl.93. *Vsesoyuznyi Nauchno-issledobat'elskiy Geologicheskiy Institut* (*VSEGEI*), (Leningrad). [ Devonian tetradiate corals from the Kuznetsk basin].

Coen-Aubert, M. and B. P.Lütte. (1990). Massive rugose corals from the Middle Devonian of the North Eifel Hills (Rheinisches Schiefergebirge, West Germany). *Geologica et Palaeontologica*, 24:17-39.

Crickmay, C. H. (1960). *The older Devonian faunas of the Northwest Territories*. 21, 11pl. Evelyn de Mille Books (Calgary).

De Fromentel, E. (1861). *Introduction à l' etude des polypiers fossils*. Savy, Paris, 357p.

Ehrenberg, C.G. (1834). Beitrange zur physiologischen Kenntnis der Corallen. Thiere im allgemei en, and besonders des rothen Meeres, nebst einem Versuche zur physiologischen Systematik derselben. *Konigliche Akdemie der Wissenschaften zu Berlin, Physiolog Abhandlungen* 1832:225-380.

Etheridge, R. JR. (1902). Additions to the Middle Devonian and Carboniferous corals in the Australian Museum. *Records of Australian Museum*., 4:253-262.

Frey, H. and Leuckart, C.G.F.R. (1847). Beitrage zur Kenntniss wirbelloser Thiere mit besonderer Beruck Sichtigung der Fauna des Norddeutschen Meeres: vii +170p. Verlag von Fried-rich Vieweg nd Sohn (Braunschweig).

Geinitz, H.B. (1846). Gudriss der versteinernerungs, 401-813, Arnold (Dresden, Leipzig).

Glinski, A. (1955). Cerioide Columnariidae (Tetracoralla) aus dem Eifelium der Eifel und des Bergischen Landes. *Senckenbergiana lethaea*, 36(1/2):73-114.

Goldfuss, G.A. (1826), *Petrefacta Germaninae*. Erster Thell. -1 (1-4): XS. (nicht pagintert). 1-252. 71 Taf.; Dusseldoaf (Arnz and Comp).

Goldfuss, G.A. (1829). *Petrefacta Germaniae*, I: 77-164; pl.xxvi-1, Arnz and Co. (Düsseldorf).

Gürich, G. (1896). Das Paläozoicum des polnischen Mittelge birges.*Berhandlungen der Russisch kaiserlichen Mineralogischen Gesellschaft zuSt. Petersburg*, Ser. 2, 32:1-539.

He, Y.-X. (1978). Rugosa. In: Southwest China Institute of Geological Science (Edt.): *Atlas of fossils of Southwest China. Sichuan* 1:1-x, 1-617.

Hill, D. (1939). The Middle Devonian rugose corals of Queensland, 1: Douglas and Drummaond Creek., Clermant. District. *Proceedings of the Royal Society of Queensland*, 50: 55-65.

Hill, D. (1956). Rugosa. In: R. C. Moore (ed.), *Treatise on Invertebrate Paleontology, Part F, Coelenteratea*, p.F 233-F327, text-fig. 165-221, Geological Society of America and University of Kansas (New York, Lawrence).

Hill, D. (1981). Rugosa and Tabulata In: Teichert. C. (ed), *Treatise on Invertebrate Paleontology, Part F, Coelenterarta*, Supplement. 1: F1 - 429. The Geological Society of America. Inc and University of Kansas, Boulder, Colorado and Lawrence, Kansas.

Hill, H. (1935). British terminologyfor Rugose Corals. *Geological Magazine*, 72, 857, 481-619.

Khaing Khaing San. (2005). *Middle Devonian Rugose Corals of the Padaukpin Limestone, Pyinoolwin Township, Mandalay Division*. Unpublished Ph.D. Thesis, University of Mandalay, 282p.

Kong Lei and Huang Yunming, (1978), Tetraceralla. In: Gui 2 hou Stratigraphy and Paleontology Work Team (ed) *Atlas of the Paleontology of the Southwestern Region of China, Guizhou*. Vol.1 Camgrian Devonian: 35-161.

Krämer, T.J. (1982). Cerioide Rugosa aus dem Devon der Bergisch Gladbach – Paffrather Mulde (Rheinisches Schiefergebirge). *Neues Jahrbuch für Geologie und Paläntologie, Monatschefte*., 1982 (11): 648-666.

Lang, W.D and S. Smith. (1934), Ludwig's corallen aus Paläolithischen formationen' and the genotype of *Disphyllum* de Fromentel. *The Annals and Magazine of the Natural History*. Ser 10, 13: 78-81.

Lang, W.D., S. Smith and, H.D Thomas. (1940). *Index of Paleozoic coral genera*. British Museum, Natural History, London, 231 p.

Liao, W.-H. and R. Birenheide. (1985). Rgose Korallen aus dem Givetium von Dushan, Provinz Guizhou, S. China. 2: Kolonien der Columnariina. *Senckenbergiana lethaea*, 65(4/6) : 265-295.

Liao, W.-H. and R. Birenheide. (1989). Rugose corals from the Frasnian of Tushan, Province of Guizhou, South China. *Courier Forschungsinstitut Senckenberg*, 110:81-103.

Milne-Edwards, H. and. J. Haime. (1850). A monograph of the British fossil corals. First Part. Introduction; Corals from the Tertiary and Cretaceous Formations. *Paleontographical Society Monographs*, 3(2): 7.

Pedder, A.E.H. (1964). Correlation of the Canadian Middle Devonian Hume an Nahanni Formations by tetracorals. *Palaeontology*, 7, (3): 430-451, pl. 62-73.

Pickett, J. (1967). Untersuchungen zur Familie Phillipsastreidae. *Senckenbergiana lethaea* 48 (1): 1- EED, C. F. R. 1920.

Schröder, St. (1998). Rugose Korallen and Stratigraphie des oberen Eifelium and unteren Givetium der Dolendorfer Mulde/ Eifel. (Mittel-Devon; Rheinisches Schiefergebirge). *Courirer Forschungs – Institut Senckenberg* 208: 135 p.

Schröder, St. (2002). Neue Daten zur Gattung *Tabulophyllum* Fenton and Fenton 1924 im Devon (Givetium, Frasnium) von Europa und Nord Afrika. *Senckenbergiana lethaea*, 82(2):515-543.

Soshkina, E. D. (1941). Sistematika srednedevonskikh Rugosa Urala. *Trudy Paleontologicheskii Institut Akademiya Nauk SSSR*, 10(4): 1-54.

Swe Hnin Maung (2018). *Stratigraphy and Paleontology of the Nan un- Kong tha area, Hsipaw Township, northern Shan State*. MSc Thesis ( unpublished), Lashio University.

Wedekind, R. (1922). Zur Kenntnis der Stringopyyllen des oberen Mittel Devon.- Sitzungs. *Berichte der gesamten Naturwissenschaften zu Marburg*. 1921(1): 1-16.

Wedekind, R. (1927). Die Zoantharia Rugosa von Gotland (Bes. Nordogotland). Nebst Bemerkungen zur Biostratigraphic des Gotlandium. *Sveriges Geologiska Undersokning.* Ser. Ca, No. 19, 35p.