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新疆中奧陶紀一個四射珊瑚新屬的發現及其意義

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1956 年春，新疆維吾爾自治區地質局某野外隊在庫魯克塔格山地的硫磺山（東經 88°30′，北緯 42°30′）的奧陶紀地層中，發現了一些形體細小，非常值得令人注意的珊瑚化石。這些化石標本均保存在紫紅色的泥質石灰岩中，與其共生的，尚有許多頭足類化石，其中經穆恩之、梁希洛先生鑑定的，計有 *Michelinoceras* (*Orthoceras*), *Discoceras*, *Troedssoneeras*, *Gobyoceras* 等屬，於是此紫紅色含化石地層之時代，應屬中奧陶紀無疑。該區下古生代地層的層序，根據野外隊的劃分，自上而下，大致可歸納如次：

上覆地層：　中生代——侏羅紀地層

〰〰〰不整合〰〰〰

志留系：

上志留系 (S_3)：　上部爲厚層，含海百合莖化石之石灰岩；下部爲灰黑色薄層及板狀石灰岩，厚 150 米。

中、下志留系 (S_{1+2})：　上部以綠色千枚岩及片岩爲主，中夾灰黃色灰岩(大理石化)透鏡體，灰岩透鏡體中富含 *Favosites*, *Plasmopora*, *Heliolites* 等床板珊瑚化石，中部爲厚層礫岩層，底部以千枚岩爲主，中夾淺黃色灰岩透鏡體(大理石化)，總厚 1,500 米。

中、上奧陶系 (O_{2+3})：　上部爲灰黑色石灰岩；下部爲綠色絹雲母石英片岩，局部可見火成岩侵入體；厚 250 米。

中奧陶系：　本系地層可細分爲二大部分：

上部 (O_2^2)：　頂部岩層大部受火成岩體侵入的影響，變質而成灰綠色片麻岩及砂質片岩；中部夾 60 米厚的紫紅色泥質結晶石灰岩，內含化石較多，本文描述的珊瑚化石以及與其共生的頭足類化石即產於這一層內。下部以綠色矽質岩及黃色與黑色薄層石灰岩爲主，局部可見花崗岩等侵入體；總厚 950 米。

下部 (O_2^1)：　以綠色砂岩及礫岩爲主，粗細相間，成複理式沉積，下未見底，露出部分 500 米。

在中奧紀珊瑚發育史上，以往一直認爲是一個萌芽時期，化石在世界各地相當地層中發現者不多，已知種屬亦極爲稀少，而在我國境內中奧陶紀的珊瑚直到目前爲止，發現者很少，並且尚未見有正式的記述和報導[1)]。就當前所發現的標本特性而言，不僅爲

1) 註：據樂森璕教授面告並示知其手存的標本，證明 *Columnaria* 在我國貴州省的中奧陶紀地層中確有存在。此項標本；樂森璕教授正着手研究，不久即將著文發表。

世界各地病未見到的新屬，而且顯示較高級的分類地位，似乎亦與同時代的其它珊瑚有着很大之區別。本新屬的發現，其意義不僅在我國係屬首次，而且在古生代早期四射珊瑚的發育史上，也增添了一個極為重要的代表。

本文目的在於描述這一個四射珊瑚新屬，並試就個體各階段切面所顯示的特點，討論其個體發育的情況。

種 屬 描 述

內溝珊瑚亞目 Suborder Zaphrentoidea Wang 1950

內溝珊瑚科 Family Zaphrentoididae Wang 1950

內溝珊瑚亞科 Subfamily Zaphrentoidinae Wang 1950

始內溝珊瑚屬(新屬) Genus *Protozaphrentis*

特點： 小型單體珊瑚，彎角狀至彎角柱狀。 外壁薄，具明顯的細橫紋及微弱的縱肋紋。主內溝位於個體的凹部。在個體發育的幼年階段，隔壁均呈連中心，有顯著加厚現象，尤以一級隔壁之內端，顯見膨大，互相集結，形成堅實緻密的假中軸。成年期的隔壁，除主隔壁外均以膨大的內端互相連結而成馬蹄形內壁，假中軸亦因此而消失。主內溝不太顯著，而與內壁增成的中心區相連。 主隔壁的兩側是明顯的對稱排列。 老年期的隔壁，均退縮而成突出於盂壁上的短脊，內端隔離，不再相連。 橫板及檔板均不發育。

屬型： *Protozaphrentis minor* Yu 新屬新種

中奧陶紀，新疆庫魯克塔格山地。 硫磺山(東經 88°30′，北緯 42°30′)。

討論： 本屬以其成年期個體所顯示的主內溝，隔壁內端加厚相連而成的馬蹄形內壁，以及隔壁排列明顯地兩側對稱和沒有橫板、檔板等等特點，無疑是應屬於內溝珊瑚目的原始種屬。

Carruthers 於 1910 年，曾系統而詳盡地研究了蘇格蘭地區下石炭紀地層中內溝珊瑚屬組(Genus of *Zaphrentoides*)的分佈及族類的演化規律，關於內溝珊瑚類的特點，他總結出下列幾點：(1) 一般的大小和形狀；(2) 外壁飾以清晰的縱肋紋；(3) 主內溝位於珊瑚體的凹方；(4) 橫板上凸而消失於內溝區；(5) 隔壁粗，內端顯著加厚；(6) 隔壁彎曲，彎曲部分，側向主內溝方向。 作者在總結以上這些特點的同時，並曾指出這一類珊瑚個體，在演化過程中，外形是漸趨於形成柱狀；而且隔壁亦往往退縮成為"ample-xoid" 型的排列方式。

上述 Carruthers 所總結出的這些特點，以及所指出的這種演化趨勢，基本上是與本屬的屬性相符合的。其中主要的區別，在於當前的標本中缺少橫板； 在縱剖面中，僅能

看到隔壁內緣加厚所形成的假中軸，而且個體亦遠較之在後期出現者爲小。這些原始的特點顯然與上部古生代出現的內溝珊瑚有所不同。從其在地質史上出現的時代較早，整個四射珊瑚類在族類演化史上，向處在一個原始低級階段等的情況下，基可以得到說明和解釋的。同時這也就基本新屬屬名創立的理由。

外部特徵：　單體珊瑚，角狀至角柱狀，個體基部常呈彎角錐形而至上部始成直立的圓柱形。　外形非常細小，長自 7—9 毫米，直徑最大者僅 4.0 毫米左右。　始部常埋於圍岩中或破碎而露出隔壁；　萼部亦常被泥質物充填。　外壁表面光滑，具環狀的生長細紋和微弱的縱肋紋。

個體切面的系統描述

爲了瞭解個體在發育過程中，隔壁之演變情況，試從始部至末部切製了一系列的橫剖面，其平均間隔約爲 1 毫米左右，並給予較爲詳細的描述如下：

標本 I

切面 Ia（圖版 I，圖 1a，登記號 *8925*）：剖面不完整，僅佔個體全部之 ⅓。隔壁由水平狀排列的羽櫛組成，基部圍以層狀組織。因填充物的掩覆不大顯著，隔壁全體顯著膨大，除圖下方四個隔壁以外其餘隔壁均在側方互相銜接，長達中心。其間僅有暗黑色的隔壁界綫尚能辨認，一級隔壁與次級隔壁則無法區分。

切面 Ib（圖版 I，圖 1b，登記號 *8926*）：剖面直徑 2.7 毫米；隔壁總數 20。主隔壁長達中心，基部較薄，內緣膨大成棒形；對隔壁較粗短，未達軸部，內緣亦未膨脹。四對分佈於主象限區內主隔壁之兩側，其餘五對則分佈於對隔壁的兩側，第五對隔壁，介於對象限區與主象限區之間，爲側隔壁。本剖面的一級隔壁與次級隔壁長短相間排列，普遍加厚，尤以一級隔壁軸端的羽狀組織，顯著膨大，在中心互相集結形成寬闊而緊實的假中軸，其直徑約佔全體切面直徑之 ⅓。　次級隔壁的長度爲一級隔壁之 ⅔，其末端與中軸相連。　對象限區內隔壁排列較爲緊密，而主象限區則大見疎散，但均各自分離，留下不同寬窄程度的隔壁間隙。

切面 Ic（圖版 I，圖 1c，登記號 *8927*）：剖面直徑增至 3.2 毫米，隔壁排列情況與上述切面相似。對象限區內隔壁加厚現象有所減退，除對隔壁右側四個隔壁規相接觸外，其餘隔壁僅軸端相連，均各自分離。　主隔壁軸端呈"纏繞"狀，膨大現象較其他隔壁爲劇。外壁由於隔壁基部層狀組織之加厚相連而顯著加厚。

切面 Id（圖版 I，圖 1d，登記號 *8928*）：切面直徑微有增長，隔壁數目仍爲 20。本剖面一級隔壁及次級隔壁的末端除主隔壁以外，均相連接成馬蹄狀的內壁，中心區空無

所有，未見任何組織。內壁以對隔壁及其近側者爲最厚，依次向主隔壁方向遞減。主隔壁微微加厚，孤立地伸延至內壁缺口處，成不明顯之主內溝，兩側對稱之隔壁排列形式亦極爲顯著。

切面 Ie（圖版 I，圖 1e，登記號 *8929*）：剖面直徑長達 3.4 毫米。隔壁加厚現象，全部開始減退。對象限區內隔壁的末端相連，組成新月狀不完整的內壁。主象限區內所有隔壁均自中心撤離，末端向對隔壁方向旋曲，且隔壁長度亦依次向主隔壁方向減縮。主隔壁及其近側的隔壁均已退縮成三角形的短脊。

切面 If（圖版 I，圖 1f，登記號 *8930*）：剖面之直徑爲 3.6 毫米，隔壁加厚現象顯著減退，新月形之內壁消失，隔壁內端互相脫離，不再連接。對隔壁平直，其兩側的隔壁末端，均向對隔壁方向旋曲，然長度却依次向主隔壁方向遞減。主象限區內的隔壁均已退縮成三角狀的短脊。

切面 Ig（圖版 I，圖 1g，登記號 *8931*）：爲經過莓部的剖面，直徑最長處達 3.9 毫米。全部隔壁強烈地委縮，對隔壁及其近側的隔壁，均呈相距的短脊，長度僅佔剖面半徑的⅓。組成隔壁的羽櫛在基部層狀組織之包圍中，微有彎曲。其餘在主象限區內的隔壁更短，呈寬三角形的短脊。

切面 Ih（圖版 I，圖 1h，登記號 *8932*）：爲近莓頂之切面：隔壁至此全部退縮，或由層狀組織構成的短脊。層狀組織在隔壁內部規則，而淺凹地向內方扭曲。

標本 II

切面 IIa（圖版 II，圖 1a，登記號 *8933*）：剖面直徑 2.5 毫米，隔壁共計 20 個。一級隔壁與次級隔壁相間排列，普遍加厚，前者均達中心。 組成隔壁之羽狀組織，在軸端顯著膨大，互相緊結形成截密聚質之假中軸，直徑約佔整個剖面的直徑之⅓。次級隔壁內端，亦與中軸相交，依附於其相鄰的一級隔壁之上。 主隔壁內端之膨大現象，較其他隔壁尤爲顯著。

切面 IIb（圖版 II，圖 1b，登記號 *8934*）：剖面直徑增至 2.8 毫米，隔壁排列情形與上述剖面相似。位於中部之假中軸，體部亦顯見增大。外壁由於組成隔壁的層狀組織的加厚，以及側向連接，亦見增厚。 所有隔壁除軸部及邊緣部以外，均各自分離不相銜接。

切面 IIc（圖版 II，圖 1c，登記號 *8935*）：剖面直徑爲 3.1 毫米。 隔壁內端，顯著加厚並相互連接，在個體中部，組成一近橢圓形中空的內壁，直徑約 0.3 毫米。內壁以對隔壁及其近側者爲最厚，依次向主隔壁方向遞減。 主隔壁之內端，有小部突入內壁，"鐘擺"狀之膨大現象，較其他隔壁特別顯著。

切面 IId（圖版 II，圖 1d，登記號 *8936*）：剖面直徑長達 3.3 毫米，馬蹄形內壁消失。對象限區內隔壁長度顯著退縮，僅達剖面半徑之 ⅔。對隔壁兩側第二、四對隔壁被其極隔壁夾長，末端均向對隔壁方向短曲。對隔壁左右二隔壁之軸端則又微微向外推曲，形成一不太明顯之對內溝。主象限區內隔壁均已退縮成三角形的短脊，突出於盃壁的上。

切面 IIe（圖版 II，圖 1e，登記號 *8937*）：爲通過莖部的剖面，直徑長 3.5 毫米。隔壁全體，均已退縮成肥厚的短脊，均在基部相連。組成隔壁之羽觴組織，已不復存在，而留下其基部的層狀組織，規則地向內方推曲。

切面 IIf（圖版 II，圖 1f，登記號 *8938*）：剖面不完整，隔壁排列情況與上述剖面相似。全部隔壁均已退縮成粗短之隔壁脊，突出於盃壁之上，一級隔壁及次級隔壁亦不能够分辨。

個體發育史簡述

根據上述兩個標本剖面的描述，可將本屬個體的發育階段，歸納成下列幾個時期，並賦簡述其各階段的特徵：

I. 幼年期（nepionic）及少年期初期（early neanic）：這時期的切面，由於標本形體太小，其幼態不易保存，筆者在試製的若干切面中，均未獲得顯示原始隔壁發生情況的薄片，因此這兩個階段，在個體系統切面中，沒有代表。

II. 少年期晚期（late neanic stage）：剖面 I_1 中所表現的特點，是應歸屬這一個時期的。隔壁在此階段，尚未發育健全，僅顯著地膨大增厚，除極少數隔壁以外，二側均互相緊密接觸，一級隔壁及次級隔壁，尚未能分辨。

III. 壯年期初期（early ephebic stage）：剖面 I_2，I_3 及 II_1，II_2 可爲這一時期的代表。珊瑚個體發育至此階段，隔壁發育已經健全，由其 20 個隔壁的數目，直至老年期均未有所增減，可爲證明。當此期中，一級隔壁與次級隔壁，相間排列；組成隔壁之羽狀組織，在末端顯著膨大，在中心相連形成緊密壓實之假中軸；外壁由於隔壁基部層狀組織之增加而顯著變厚。

IV. 壯年期中期（meta-ephebic stage）：本階段個體發育之特點可概括爲本屬的主要特點，剖面 I_4 可爲這一時期的典型代表。在這時期內除主隔壁以外，其餘隔壁的內端均相連而成馬蹄形的內壁。主隔壁延伸至內壁缺口處，留下窄而不明顯的主內溝，兩側對稱之隔壁排列形式極爲明顯。

剖面 II_4 中近橫置形內壁的出現，其厚度較大，直徑較小，而且主內溝亦並未出現，

這似乎應代表個體發育過程中，比 I_2 稍早，可以理解爲成年期初期向中期過渡的情況。

V. 壯年期末期（late ephebic stage）：典型的代表爲 I_2，II_0。隔壁開始退化，馬蹄形的內壁消失，代之以由對象限區內隔壁內緣相連而成的新月形內壁。繼而，對象限區內之新月形內壁亦由於隔壁內緣厚度的減退而消失，隔壁全體呈孤立狀，對象限區內的隔壁較主象限區者爲長。

這一時期中新月形內壁的出現，可作爲向老年期個體過渡的特點，但在第二號標本表現的個體發育過程，是直接由近圓形中空內壁的消失，而演變至全體成孤立狀隔壁的排列形式，其間缺失形成新月形內壁階段的代表，這是否由於個體發育過程中的加速演化（acceleration）抑或薄片未切經這一階段，筆者由於標本觀察不够，在此未敢遽下斷語。

VI. 老年期（Gerontic stage）：個體發育至此階段，隔壁全體退縮，形成突出於鈣壁上的短脊，組成短脊者僅屬隔壁基部之層狀組織，規則地傾向內方排齒。

結 論

由這次在新疆中奧陶紀地層中所發現的標本來看，它與世界各地在同一個地質時代發現的四射珊瑚，不獨在屬性上看所不同，而且在較高級的分類性質上也是大異其趣。前已述及中奧陶紀四射珊瑚在世界各地已發現者不多，已知種屬亦極爲稀少。在以往的文獻中所見到的大抵是屬於 *Streptelasma* 及 *Columnaria* 一類的珊瑚（見 Okulitch, 1934—1938 及 Foerste, 1929 等）。Hill 於 1952 所著"奧陶紀珊瑚"一文中，曾將世界各地已發現的奧陶紀四射珊瑚歸納成二個大類——拴心珊瑚目（Streptelasmaidae Nicholson 1889）及十字珊瑚目（Stauriidae E. and H. 1850）；前者包括 *Lambeophyllum* Okulitch 1938，*Streptelasma* Hall 1847，*Grewingkia* Dybowski 1893，*Brachyelasma* Lang, Smith and Thomas 1940，*Palaeophyllum* Billing 1858，*Holophragma* Lindstrom 1896 等屬；而後者僅包括 *Favistetella* Dana 1846 一屬。其中除 *Grewingkia*，*Brachyelasma*，*Holophragma* 等屬外，其餘均在中奧陶紀找到過。嗣後，於 1953 年，Hill 又在挪威奧斯陸地區之中奧陶紀地層中，發現了 *Streptelasma Grewingkia* 及 *Tryplasma* 等屬，作者將前二者歸入 Streptelasmacea 超科內後者則歸入 Cystiphyllacea 超科。蘇聯古生物學者 Иванов 與 Миркова 1950 年以及 Иванов 於 1955 年均在烏拉爾中部所被的奧陶紀地層中，發現並描述若干四射珊瑚，其中除 *Streptelasma*，*Dybowskia* 及 *Columnaria* 等屬外，Иванов（1955）又創立了一個採自該區中奧陶紀地層中之新體四射珊瑚新屬——*Viacheria* Ivanov。查其性質亦屬近於 *Columnaria* 一類之珊瑚而應隸屬於 Streptelasmacea

超科之下。

上述這些屬名，就筆者所知，是世界各地中奧陶紀地層中已發現的重要四射珊瑚代表。按古生代四射珊瑚的分類迄今各家尚未取得完全一致的意見，分類系統的建立，也基各家不一。根據王鴻禎教授在其巨著"A revision of the Zoantharia Rugose in the light of their minute skeletal structure"一文中，曾對古生代的四射珊瑚給予較爲完整的分類系統。根據王教授的分類，將四射珊瑚大到之爲四大亞目 Streptelasmacea, Zaphrentoidea, Caninacea 以及 Cystiphyllacea。其中除 Streptelasmacea 亞目在中奧陶紀時已有許多重要代表以外，Zaphrentoidea，Cystiphyllacea 二個亞目，爲自志留紀才興起，而 Caninacea 之代表自石炭紀才有出現。 後來 Hill 於 1953 年在奧斯陸地區發現有 Cystiphyllacea 的代表，證明該亞目在中奧陶紀時已有存在。目前比較典型的 Zaphrentoidea 代表，在我國中奧陶紀地層中發現，意味着那個時期的珊瑚類，更增添了一個新的重要組成分子，並證明了在當時的環境下，三個重要的亞目，在後期的發展史上，屬於平行演化各分支的代表均已存在。

此外值得興趣的是，本屬個體發育各個階段在形態上表現的演化趨勢，與該亞目後期各地質時代的代表中所表現的演化趨勢，大致是符合的。 例如本屬在個體發育早期階段所表現的隔壁內端彫痕相連而成的假中軸，以及由此而演變成的近圓形中空內牆等特點在志留紀 *Syringaxon* 等屬類的成年期以及趨近成年期的個體的切面中均可找到非常類似的特點，而且在 *Syringaxon* 屬之成年期個體中隔壁之演變趨勢亦大致是和本屬幼年期向成年期過渡階段隔壁排列形式的變遷情況相符的。至泥盆紀晚期及下石炭紀，Zaphrentoidea 亞目漸趨繁盛，許多重要代表中如 *Hapsiphyllum*, *Zaphrentoides* 一類珊瑚之成年期所具有的一些重要特點，如馬蹄狀內壁之出現，典型主內溝之存在，以及隔壁順著二個對稱排列等，基本上是和本屬成年期的個體特點相符。 又在下石炭紀極爲繁盛的 *Zaphrentoides*，其屬組在地層中自下而上演變的趨勢大致相似，此點可從 Carruthers 進行這類的研究工作中，得到對證，例如下石炭紀底部 *Zaphrentoides delanouei* 和 *Z. parallela* 中，馬蹄形內壁的存在，繼而在上部地層中個體內壁之消失，以及隔壁之在主象限區內者較對象限區者退縮爲先。最後，在上部地層中出現的個體，其成年期則已全部退縮成爲短脊，即所謂的 *amplexoid* 型。

以上的事實說明了本族個體的演化與其族類演化的關係，基本上是一致的，一方面，證明了本屬之歸屬於 *Zaphrentoides* 這一大類之正確性，而另一方面亦爲這一大類的演化關係上，增添了一個重要的例證。

本文是在樂森璕教授的指導下完成的，樂教授並曾抽暇審閱和修正了原稿；在研

究過程中承王鴻禎教授給予寶貴指示,最後並審閱和修正了原稿,作者謹向他們表示衷心的感謝。 趙金科、盧衍豪、穆恩之三位教授不時給予寶貴指示和鼓勵,作者亦深表謝意。最後,計承道、王壽岩二位先生代爲磨製薄片,劉雪筠、龐茂芳二位先生代爲攝製圖影,一併附此致謝。

附註: 此文寫成後,筆者最近又見到蘇聯全蘇地質研究所編輯的"古生物學新科新屬資料"一書。在珊瑚部分 Д. Кальо 分別描述了 *Primitophyllum*, *Leolasma* 以及 *Sclerophyllum* 等三個採自波羅的海沿岸奧陶紀地層中的新屬。就發現於中奧陶紀地層中的二個新屬來看,作者將其歸入 Tryplasmidae (S. Lato) 科下的 *Primitophyllum* 似乎應屬於 Cystiphyllacea 亞目,而 *Leolasma* 一屬,將其置於 Streptelasmidae 科下那樣應屬 Streptelasmacea 亞目。兩者均與本文所描述的新屬性質相差很遠。

值得提及的是該文作者在討論 *Leolasma* 一屬時,曾言及"從這些原始型珊瑚的特點看來,在某種程度上似乎可以證實 Б. С. Соколов 的意見,即'四射珊瑚和牀板珊瑚一樣,在初原發育階段是沒有牀板的'"。 作者又從比較 *Lambeophyllum profundum* 及 *Leolasma* 二屬的隔壁發生情況,試證明四射珊瑚骨骼的基本變化過程是通過牀板的發生。從當前標本的骨骼性質來看,其隔壁性質顯然是較其他同時代的四射珊瑚隔壁性質複雜得多。然而與其他原始型四射珊瑚基本上相似之處,也同樣是在於鱗板和牀板的缺失。 就這個意義來說,當前的標本似乎或多或少地替 Д. Кальо 的論點提供了一些證據。但是目前已知的材料究屬有限,對於這樣一個重要的論點,正如 Д. Кальо 在文末所述的那樣,有待於將來研究更多的資料後才能得出最後確切的結論。

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ON THE OCCURRENCE OF A NEW RUGOSE CORAL FROM THE MIDDLE ORDOVICIAN OF SINKIANG PROVINCE, N. W. CHINA

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(With 2 Plates)

In the Spring of 1956, a field party of the Sinkiang geological Bureau found a number of rugose corals from the Ordovician strata of Liu-Wang-shan in the Kuluk-tag mountain Range, Sinkiang province (at Long. 88°30′, and Lat. 42°30′). All the fossil corals are rather small. They are embedded in the purplish-red argillaceous limestone and in association with many specimens of Nautiloids, which were determined by Messrs A. T. Mu and S. L. Liang as *Michelinoceras* (*Orthoceras*), *Discoceras*, *Treadwanoceras*, *Gobyoceras* etc. This fossiliferous purplish-red limestone can thus undoubtedly be referred to Middle Ordovician in age. The early Paleozoic stratigraphical sequence exposed in this area, as subdivided by the field geological party may be summarized as follows in descending order:—

Super-formation: Mesozoic-Jurassic strata

~~~~~unconformity~~~~~

Silurian series:

Upper Silurian Series (S_3): the upper part consists of thick-bedded limestones with Crinoid stems, while the lower part comprises greyish-black, thin bedded and slaty limestones. 1500 m

Middle and lower Silurian series (S_{1+2}): the upper part is composed mainly of green phyllite and schist, intercalated with lenses of greyish-yellow limestone, the lenticular limestone being marbleized and yielding numerous Tabulate corals such as *Favosites*, *Plasmopora* and *Heliolites* etc. The middle part of this series is characterized by thick-bedded conglomeratic beds, and the lower part consists mainly of phyllites with intercalations of yellow, lenticular limestones. 1500 m

Middle and upper ordovician (O_{2+3}): yellow and greyish-black limestone in the upper part, graded to greenish sericite-quartzitic schists in the lower and locally intruded by igneous rocks. 750 m

Middle ordovician series: this series comprises the following two subdivisions:—

The upper division (O_2^2): the upper part of this division is rather metamorphosed, owing to the intrusion of igneous rocks. It consists mainly of greyish-green gneiss and sandy-schists, with an intercalation of purplish-red and crystallic argillaceous limestones, almost 60 m. thick in the middle portion, in which a number of new rugose corals have been found in association with the Nautiloids fauna; While the lower part comprises mainly of green sandy rocks and yellow black thin-bedded limestones. The lower division (O_2^1): of this is an alternation of conglomerates and sandstones, forming the typical flysh deposit. Exposed thickness 500 m
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Since Middle Ordovician rugose corals have not yet been reported in China* and the occurrence of them hitherto in corresponding formations from other part of the world as a whole are also very scanty, the discovery of these fossils seems to be of special paleontological significance. The present specimens, as determinded by the writer, belong to a new genus under the family Zaphrentoididae.

The purpose of this paper is to describe the interesting new form, and an attempt is also made to demonstrate its ontogenetic development as revealed by series of thin sections.

Description of Species

Suborder Zaphrentoidea Wang 1950
Family Zaphrentoididae Wang 1950
Subfamily Zaphrentoidinae Wang 1950
Genus *Prolozaphrentis* Yu (gen. nov.)

Diagnosis: Simple minute coral with conical to conico-cylindrical corallum. Surface of wall marked with strong wrinkles rather weak vertical grooves. Epitheca thin but subsequently thicked by the inflated bases of the septa; Septa bilaterally symmetrical, conspicuously dilated, especially at the axial ends of the major septa during neanic stage, which meet in the center to form a stereo-columella, on ephebic stage, a horse-shoe-like inner wall is represented by connecting the dilated septal ends, but leaving a more or less aborted cardinal septum free, where an inconspicuous cardinal fossula and a conspicuous central hollow-space come into existence. The cardinal septum usually appear on the concave side of the corallum. The septa become amplexoid in the gerontic stage. No dissepiments and tabulae.

Discussion: According to the characteristic features of our new form presented in its adult stage, such as the inconspicuous cardinal fossula, the pronounced horse-shoe-like inner wall by the union of the dilated axial ends of the major septa and the lacking of tabulae and dissepiments etc., it is doubtless that the present form should be assigned under the family Zaphrentoidea.

In 1910 Carruthers had made a systematic study and splendid discussion on the genus of *Zaphrentoides* from the lower Carboniferous strata of Scotland. The said author had pointed out their characteristic features as follows: (1) the average size and shape; (2) an epitheca with clearly marked longitudinal ribbings; (3) situation of the cardinal fossula on the concave side of the corallum; (4) spacing and character of the tabulae, which are arched upwards and strongly depressed into the fossula; (5) stout septa thickened at the inner end, and (6) curvature of the septa convex to the cardinal fossula. In addition to these, the author had also pointed out

*Recently, Prof. S. S. Yoh has shown the writer several specimens of *Columnaria* which had already been discovered from the middle Ordovician of Kwei-chow Province, S. W. China. The materials are going to be studied by Prof. Yoh.

that one of the evolutional trends of the genus of *Zaphrentoides* is being cylindrical in their later stage in which the septa are retreated into amplexiomorphy.

Judging from the above statements, our form presents features much resembling the genus discovered in Scotland. However the main differences revealed in our new form rest on the much mintue size and the lacking of both tabulae and Dissepiments. These may be easily explained by the fact that our specimens represent a rather primitive form that had originated in an much earlier geological period as compared with those from Scotland, and hence the present form is called the present generic name.

Protozaphrentis minor Yu (gen. and sp. nov.)

External form: A large number of specimens have been obtained all belonging to the same genus and species. The corallum is simple and very mintue, about 7—9 mm in length and 4 mm in their maximum diameter. They are conical or conico-cylindrical in form and often conical in the proximal end but becoming cylindrical when growing upwards. The epithecal surface is marked with numerous strong rounded wrinkles, as well as fine growth lines crossed by rather weak grooves and very few longitudinal striae.

Description of Serial Transverse Sections

A series of transverse sections has been prepared to show the growth stages of the septal arrangement. All the sections are taken at intervals about 1 mm from each other and the diameter of their sections are given as follows:

Specimen I.

Section	Cat. No.	Diameter of Sections		Number of Septa
		Dorsal-ventral	Transverse	
Ia	8925			
Ib	8926	2,7	2,8	
Ic	8927	3,2	3,1	
Id	8928	3,4	3,5	
Ie	8929	3,4	3,6	20
If	8930	3,6	3,6	
Ig	8931	3,9	3,7	
Ih	8932	4,1	4,3	

Section Ia (Pl. I, Fig. 1a): This section is incomplete and only about 2/3 represented. Septa are long, all reached the center and composed of horizontal trabeculae embedded within the lamellae at the peripheral region. They are as a whole strongly dilated and laterally contiguous with one another, except a few leave certain small tear-drop like loculi between them, but among the contiguous ones a dark line of demarcation can still be observable.

Section Ib (Pl. I, Fig. 1b): In this section there are 20 septa alternatively major and minor. 4 pairs can be distinguished on both sides of cardinal septum in the cardinal quadrants, and 5 pairs on both sides of the counter septum in the rather accelerated counter quadrants. The forth pair near the counter quadrants represents the alar septa. All the septa are considerably dilated, those in the counter quadrants are laterally contiguous and closely packed. Major septa extend as a rule, from cepiphery to the center where they meet all eogether with their bulb-like inner ends due to the expansion of the fibro-tissue, forming a thick pseudo-columella about 2/3 the diameter of the whole section. Minor septa almost 2/3 as long as the major, and in contact with the columella near the centre.

Section Ic (Pl. I, Fig. 1c): The septa in this section are still 20 in number and remains so throughout all growth stages. The bilateral arrangement of septa is the same as in the preceeding section. Four laterals in the counter quadrants are now obviously more stronger in septal dilation, and four in its right counter quadrant are still in close contact, while the rest of the septa leave more or less wide loculi among themselves. The bulb-like expanded ends of the cardinal septum is remarkably distinct than all the others.

Section Id (Pl. I, Fig. 1d): In this section all the septa, except the little shorter cardinal septum are united with their axial ends to form a typical horse-shoe-like inner wall at the central portion, and with an open space toward the cardinal septum, where a more or less narrow and ill-defined fossula is formed. The thickest part of the inner wall is the inflated ends of the counter septum and its two laterals and gradually reduced toward the cardinal side. The bilaterally symmetrical arrangement of the septal insertion is still well-shown.

Section Ie (Pl. I, Fig. 1e): In this section the septal dilation begins to reduce, and the thickened inner wall also becomes somewhat depressed. The counter septum and its 5 pairs, of secondaries are connected with their axial ends to form a rather thick crescentic inner wall, while those septa in the cardinal quadrants are entirely free from one another and bend their ends slightly toward the counter side. The alars and the others are regularly and progressively shorter toward the cardinal septum, which appears as a very short triangular ridge, projecting a little to the center. It is noticeable from this section, the counter quadrants with crescentic inner wall can be sharply separated from the cardinal quadrants, in which all the septa are short and free.

Section If (Pl. I, Fig. 1f): In this section the septa are all free. Those in the cardinal quadrants have been much reduced in length, and represented merely by short ridges, but those in the counter quadrants, however, are still remained longer. The septa in counter quadrants turn slightly their curved axial ends toward the counter septum, making a crescentic arrangement near the central portion, though they are not in contact with each other.

Section Ig (Pl. I, Fig. 1g): This section is cut across the lower part of the calyx, the septa have now been much retreated by asumming somewhat "ampleximorphy" in arrangement. They all appear as stout, short ridges, but those in the counter quadrants are slightly longer

than those in the cardinal quadrants. The stout trabeculae embedded in the lamellae tissue of several septa are slightly flexuous and can be remarkably discernible in the section.

Section Ih (Pl. I, Fig. 1h): This is cut through near the top of calyx. Here the septa are all reduced to triangular and apprantly composed entirely of lamellar tissue with shallow and regular folding.

Specimen II.

Section	Cat. No.	Diameter of Section		Number of Septa
		Dorsal-ventral	Transverse	
IIa	8933	2.5	2.4	20
IIb	8934	2.8	3.1	
IIc	8935	3.1	3.1	
IId	8936	3.3	3.2	
IIe	8937	3.5	3.2	
IIf	8938	2.7(incomplete)	3.4	

Section IIa (Pl. II, Fig. 1a): There are 20 septa alternatively major and minor in this section. The major septa reach the center, where the fibrous tissue are extremely expanded and caused the septal ends laterally united to form a wide compacted central pseudocolumella about 1/3 the radius of the section. Minor septa are shorter and extended in contact with the pseudocolumella.

Section IIb (Pl. II, Fig. 1b): The general character of the septal arrangement is the same as the preceding. Here the pseudocolumella seem to be more expanded and the epitheca is more thick owing to the lamellar tissue at the peripheral part of the septa which are strongly dilated and then laterally connected.

Section IIc (Pl. II, Fig. 1c): In this section all the septa are united with their thickened extremities to form a subcircular inner wall, the longer diameter of which is about 0.3 mm. The axial ends of counter septum and its two laterals represent the thickest part of the inner wall which are gradually reduced toward the cardinal side. The cardinal septum projects a little way into the wall and its bulb-like inner end is more remarkable than all the others.

Section IId (Pl. II, Fig. 1d): The thickening of the septa have now been retarded, the inner wall are disappeared and all the septa are set free. Those in the cardinal quadrants project a rather short distance into the thecarium, but the septa in the counter quadrants, however, are remained still much longer, usually turn their inner ends toward the counter septum and leave a hollow space, though they are not connected with each other. The counter septum in this section is somewhat shortened, resulting in the formation of a narrow ambiguous fossula.

Section IIe (Pl. II, Fig. 1e): In this section the septa are all strikingly degenerated and appear as stout, broad triangular bases in the periphery. They are entirely composed of lamellar

tissue.

Section IIf (Pl. II, Fig. 1f): The conditions of septal arrangement are similar to the preceding. All the septa are now alike, so that it is not possible to distinguish whether are the majors or the minors.

Ontogenetic stages

Based on the foregoing descriptions of the transverse sections as a whole, we may now summarize what we have observed from the ontogenetic stages of our new genus.

I. The nepionic stage and the early neanic stage: Owing to the minute size and the wanting of proximal portions of our specimens, we fail to find out representative sections of the early stages of septal development.

II. The late neanic stage: Section Ia may probably be referable to this stage. The septa are here not wholly developed. They are as a whole much dilated and laterally contiguous and yet no remarkable demarcation of the major and minor septa can readily be discernable.

III. The early ephebic stage: In this stage (section Ib, Ic, and IIa, IIb) all the septa have now been fully developed, as evidenced by the fact that the number of septa amounting to 20 would have not increased furthermore in their succeeding growth stages. The major septa are alternatively arranged with the minor ones, and all extented to the center where the fibrous tissues are extremely expanded and laterally fused with their inner ends, forming a solid pseudo-columella.

IV. Meta- ephebic stage: In this stage all the septa except the cardinal have connected with their thickened axial ends to form a horse-shoe-like inner wall, but leaving an open space for the cardinal septum. Meanwhile as the cardinal septum have retreated a little near the inner wall a narrow fossula is thus formed. Bilateral symmetry of the septal arrangement are quite conspicuous, so far as shown in section Id.

In section IIc the coral shows in the center a rather pronounced median tube formed by the union of inner ends of the septa. The wall is rather thick and more or less circular in outline and the cardinal fossula being depressed. It seems to the writer that the present form may be a transitional from the early Epehic to meta-Ephebic stage.

V. Gerontic stage: All the septa are obviously much reduced and represented in the section merely by shortened ridges.

Conclusion

Based on the foregoing descriptions and discussions we may draw the following conclusions.

In the generic affinity, the present form is distinct from any known rugose corals so far found in the corresponding strata in the world. As already mentioned, the rugose corals occurred in the Middle Ordovician of the world are very scanty. So far as the rugose corals ever found

in the Middle Ordovician were forms all referred to the 2 genera——*Streptelasma* and *Columnaria* (Okulitch, 1934—1938; Foerste, 1929, etc.). In her work on "The ordovician corals" Hill had made a thorough study on the distribution and classification of the ordovician corals, from which she had grouped all the Ordovician rugose corals into 2 great categories . . Order Streptelasmaidae nicholson 1889 and Order Stauriidae E. and H. 1850. The former order includes genera: *Lambeophyllum* Okulitch 1938, *Streptelasma* Hall 1847, *Grewingkia* Dybowski 1873, *Brachyelasma* Lang, Smith and Thomas 1940, *Palaeophyllum* Billings 1858, *Holophragma* Lindstrom 1896 etc. and the later contains only one genus——*Favistella* Dana. Among these corals except the genera *Grewingkia*, *Brachyelasma* and *Holophragma*, the rest forms have all been found in the Middle Ordovician strata. Later on, in the year 1953, the same author had further discovered some specimens of *Streptelasma*, *Grewingkia* and *Tryplasma* from the Middle Ordovician strata in the Oslo region, Norway. The former two genera were referred to Superfamily Streptelasmacea and the last one to Superfamily Cystiphyllacea. Recently, in 1955, the Soviet Palaeontologist Evanova had made a important contribution to the discovery of some corals from the Ordovician Strata of the western slope of the middle Ural. Except the well known corals, such as *Streptelasma*, *Columnarie* and *Brachylasma* etc. the Soviet author had established a new compound coral genus named *Vischeria* from the Middle Ordovician strata of that region. So far as its characteristic generic features are concerned the present writer is inclined to believe that the Soviet new form may also be referable to the superfamily Streptelasmacea.

These are the fossil corals ever discovered from the Middle Ordovician strata in the world known to the present writer. Unfortunately, there exists great divergence of opinions in the Palaeozoic rugose corals especially the taxonomy of the families. In his excellent and valueable work on "A revision of the Zoantharia Rugose in the light of their minute skeletal structures", Dr. H. C. Wang had carried out a rather complete and rational classification of the Palaeozoic corals. According to Wang the Palaeozoic rugose corals as a whole may fall into 4 suborders. They are Streptelasmacea, Zaphrentoidea, Caniniacea and the suborder Cystiphyllacea. Among these corals the suborder Streptelasmacea has its more important representatives in the Ordovician period. Both the Zaphrentoidea and the Cystiphyllacea are considered to rise from the Silurian, and the Caniniacea is to make their first appearance later in the Devonian time. Since the discovery of *Tryplasma* from the Middle Ordovician in the Oslo region had proved that the Cystiphyllacea had already been in existence in the Middle Ordovician time. A representative of Zaphrentoidea now seem to occur in the Middle Ordovician formation in N. W. China, and this serves to indicate also that there had already been three independent and well-defined groups of Rugose corals existed during that period.

In addition it is interesting to note that from the ontogenetic study of our new form as a whole, we may find out that the main trend of its ontogenetic evolution is almost in consistence

with the phylogenetic evolution of later Zaphrentoid corals. This may be evidented by the fact that there are nearly all the characteristic features of our form in its different growth stage agreeable with the phyllogeny of those descendent members under the same suborder in the later geological times. As for instances, the arrangement of the septa, the formation of a solid pseudocolumella, the appearance of a circular inner wall in the young stages of our form may be exactly comparable with the adult stages of the Silurian *Syringaxon*. Furthermore, the characteristic features of a typical cardinal fossula and a well-remarked inner wall of the Devonian and Lower Carboniferous Zaphrentoid and Hapsiphyllid corals have also found in the ephebic stages of our form. Finally, the main evolutional trends of the gens of the *Zaphrentoides* as pointed out by Carruthers may also be found in our form.

The writer is greatly indebted to Prof. S. S. Yoh and to Prof. H. C. Wang who have incessantly guided him and kindly read through the manuscript.

P. S.—As the present paper is going to be published, the writer has recently received a memoir edited by Soviet Geological Institute under the title of "Materials for Palaeontology: new families and genera". In this paper, D. Kalio discribed 3 new genera i.s. *Primitophyllum*, *Leolaima* and *Sclerophyllum* from the Ordovician strata of Prebaltic Province, U. S. S. R. They differer greatly from the present form in the generic affinity.

圖　版　說　明

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Protozaphrentis minus Yü (新屬、新種)所有圖影均放大 10 倍

圖 1a—h. 同一個體不同階段的橫切面。

1a. 少年期晚期階段的剖面。登記號：*8925*

1b. 壯年期初期階段的剖面。登記號：*8926*

1c. 壯年期初期階段的剖面。登記號：*8927*

1d. 壯年期中期階段的剖面。登記號：*8928*

1e. 壯年期末期階段的剖面。登記號：*8929*

1f. 壯年期末期階段的剖面。登記號：*8930*

1g. 老年期階段的剖面。登記號：*8931*

1h. 老年期階段的剖面。登記號：*8932*

圖 2. 另一個體之縱剖面。登記號：*8939*

產地：新疆庫魯克塔克山地，硫磺山(東經 88°30′，北緯 42°30′) 時代：中奧陶紀。