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川西南晚奥陶世五峰期岩相古地理

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摘要:通过对川西南汉源—马边—雷波地区典型剖面上奥陶统五峰组沉积岩性特征、充填序列、沉积构造及室内分析等研究,并结合研究区晚奥陶世构造特征,将川西南地区五峰期分为 2 期,划分为潮坪、浅水陆棚和深水陆棚 3 种沉积相。指出在晚奥陶世五峰早期,受加里东构造运动影响,扬子与华夏陆块发生构造挤压碰撞,川中、黔中等边缘隆起抬升扩大,上扬子地区由克拉通海相盆地转为被隆起围限的隆后盆地,除川中隆起、川西—滇中隆起周缘沉积潮坪相白云质页岩、泥灰岩和白云质灰岩外,川西南绝大部分面积主要发育深水陆棚相炭质页岩和硅质页岩、含炭粉砂质页岩。五峰晚期,伴随着全球性冰期事件的发生,研究区乃至整个上扬子区发生大规模海退,大面积的深水陆棚相转为浅水陆棚沉积,岩性主要为粉砂质页岩、泥灰岩、钙质炭质页岩和硅质灰岩等,较前期钙质成分明显增多。

关键词:川西南;晚奥陶世五峰期;沉积相;岩相古地理

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Lithofacies palaeogeography in Late Ordovician Wufeng Age in southwestern Sichuan

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Abstract: According to the lithological characteristics, filling sequences, sedimentary structures and lab analysis of Late Ordovician Wufeng Formation, combined with the structural features, the authors divided the Wufeng Age in southwestern Sichuan into two periods, and the southwestern Sichuan can be divided into tidal-flat facies and deep shelf and shallow shelf facies. In the Late Ordovician early Wufeng Age, affected by the Caledonian Movement and the continuous extrusion and collision between Yangtze

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and Cathaysia blocks, the Central Sichuan and Guizhou were increasingly uplifted, and the Upper Yangtze region was submerged and transformed into carbonate ramp, and finally developed into the back-bulge basin confined by the marginal uplifts. Tidal flat facies were developed around Central Sichuan and Western Sichuan-Central Yunnan uplifts with dolomitic shales, muddy limestones and dolomitic limestones. Large areas of western Sichuan developed deep shelf facies which deposited carbonaceous shales, siliceous and carbonaceous-silty shales. In the late Wufeng Age of Late Ordovician, with the emergence of the worldwide glacial event, large-scale regression started in the study area and even in the whole Upper Yangtze area, shallow shelf facies replaced deep shelf facies with silty shales, muddy limestones, calcareous-carbonaceous shales and siliceous limestones, and they had more calcium in comparison with those in former periods.

Key words: southwestern Sichuan; Late Ordovician Wufeng Age; sedimentary facies; lithofacies palaeogeography

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奥陶系五峰组黑色页岩作为中国南方重要的烃源岩生烃层位之一,前人做过大量的研究工作^[1-8]。近年来,随着页岩气等非常规油气开发研究的不断深入,五峰组及其上覆层位龙马溪组下段发育的黑色页岩也逐步成为中国南方页岩气勘探研究的重点层位。为了更好地探究页岩气成藏特征,前人对该组页岩层厚度、埋藏深度、有机质含量、页岩含气性、页岩矿物组分、沉积相等方面展开了基础性研究。就四川盆地而言,川东南地区由于露头出露较多,加之交通相对便利,故对该区五峰组沉积岩性特征及古地理研究较为详细,川西南地区由于地处龙门山断裂带与上扬子地块交叉位置,构造复杂且断裂发育,五峰组地层出露较差,有关该区晚奥陶世五峰期沉积相及其沉积环境研究较少,笔者通过对川西南地区典型剖面的野外考察,尝试探讨该研究区晚奥陶世五峰期沉积相及古地理。

1 区域地质概况

川西南汉源—马边—雷波地区位于四川盆地的西南缘,地处扬子地块与龙门山断裂带的结合部位,属于扬子地块边缘地带。研究区因靠近龙门山冲断带、松潘甘孜褶皱带,内部断层发育,奥陶系五峰组断续分布于断层之间(图1)。四川盆地周缘钻有周公1、老龙1、窝深1等井,总体来说川西南地区晚奥陶世五峰组勘探研究程度较低,五峰组作为中上扬子地区广泛分布的主力烃源岩层位,目前为止对其在川西南地区的沉积相及古地理等基础地质问题认识程度不够,因此有必要对该地区五峰组沉

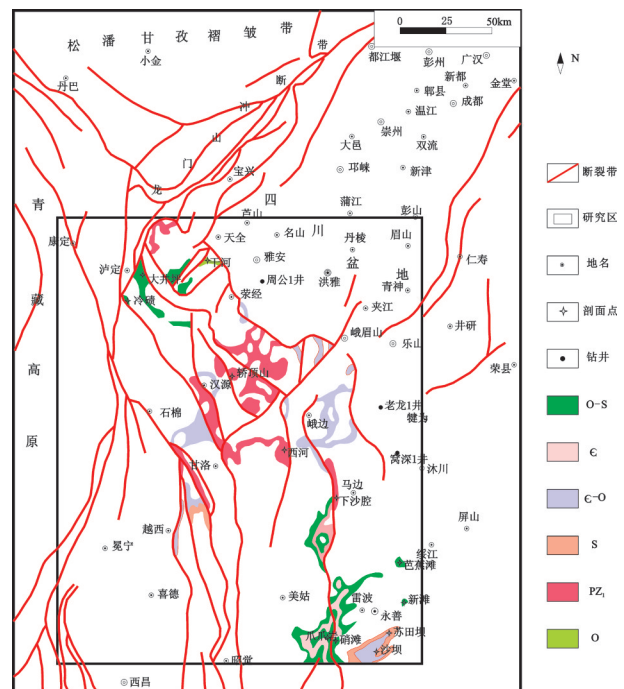


图1 研究区位置图

Fig.1 The location of the study area

积环境展开详细的研究工作。

2 地层特征

五峰组地层广泛分布于中上扬子地区,以沉积黑色炭质页岩,硅质页岩为特征,下与临湘组灰色、暗紫红色瘤状泥质灰岩、白云岩、钙质页岩整合接触,上与观音桥组介壳灰岩整合接触。在汉源轿顶山一带五峰组对应层位称之为大渡河组^[9-11],岩性下

段为菱锰矿,黑色炭硅质页岩、白云质页岩,页岩内含丰富的笔石,上段为锰灰岩、硅质藻灰岩、泥质藻灰岩等,其上南郑组主要沉积深灰色中厚层钙质粉砂岩,含生物骨屑灰岩透镜体,具有典型的“Hirnantia”动物群分子。

石棉—甘洛—美姑一线以西南越西、昭觉一带出露地层为大箐组,大箐组由于生物化石发现较少,所以其时代归属一直存有异议,云南省地质局区域地质调查队^[12]通过对四川金阳王家河坝剖面的考察,通过采获的化石类别指出大箐组下段大致对应于宝塔—临湘组,其上段又名“王家河坝组”对应于五峰组。大箐组在越西、碧鸡山均有出露,主要为一套广海相镁质碳酸盐岩沉积,下段主要为灰色、深灰色中粗晶白云岩、白云质灰岩,上段为灰色、灰白色含燧石结核白云质灰岩。

在研究区东、南部峨边、雷波等地五峰组下段主要为黑色炭质页岩、硅质页岩,发育笔石类化石,向上钙质及碎屑成分增多,发育了钙质粉砂岩、泥质灰岩、页岩等,具典型的向上变浅序列特征(图2)。

3 沉积相类型

中奥陶世晚期,伴随着加里东构造运动的发

生,除扬子北缘仍保持被动大陆边缘特征外,其他地区皆明显表现出挤压收缩构造背景的古地理轮廓^[1-3,13-17]。中奥陶世至早志留世早期,在古地理格局上最明显的特征是华南地区自东南向西北不断挤压碰撞,褶皱成陆,在四川盆地及周缘表现为川中、川西—滇中、黔中、江南—雪峰等边缘隆起不断抬升扩大,川西南地区处于川中隆起与川西—滇中隆起之间,海水流通不畅,整个海域大多处于滞流还原状态之中。由于构造挤压作用的持续进行,海湾内部构造基底本身起伏不平,有隆有凹^[18],隆凹相间的基底地形决定了沉积内充填序列的不同,沉积岩性及古生物组合也发生相应的变化。

3.1 潮坪相

潮坪相在整个五峰期均有发育,主要分布在川中隆起、川西—滇中隆起的周缘,川中隆起及其周缘由于被中生代地层覆盖,基本见不到古生代地层出露,仅通过其周缘的钻井资料判定沉积岩性以白云质页岩和生物碎屑泥灰岩为主,生物多发育头足类、腕足类等。川西—滇中隆起东北缘越西碧鸡山以及滇东北巧家、鲁甸一带以大箐组灰—灰黑色中厚层白云岩,白云质灰岩为主,上段多含燧石条带,沉积构造有小型沙纹层理、波状层理等。总体

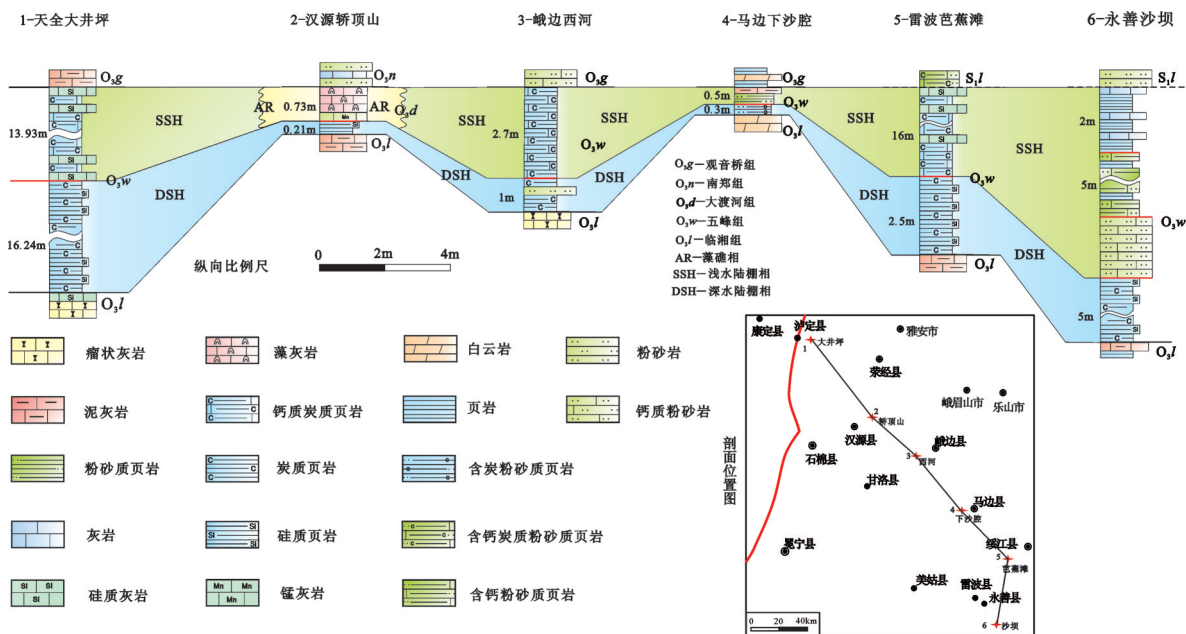


图2 川西南地区上奥陶统五峰组沉积相对比图

Fig.2 Geological section of sedimentary facies of Late Ordovician Wufeng Formation in southwestern Sichuan

水动力条件相对较弱,为局限低能的潮下环境。

3.2 深水陆棚相

深水陆棚相主要发育于五峰早期,占据了川西南绝大部分面积,以沉积含炭粉砂质页岩、炭质页岩和硅质页岩为主,生物以笔石类浮游生物为主,前已提及,川西南地区在早古生代虽属克拉通海相盆地,但构造挤压作用的持续,内部基底发生弱变形,呈现高低起伏的地形特征,在一些相对的水下隆起区以沉积灰黑色含炭粉砂质页岩为主,而在相应的凹陷区以沉积黑色炭质页岩和硅质页岩为主,虽然笔石生物群仍然为主要的生物群体,但硅质页岩内发育有放射虫和硅质海绵骨针,无论在相对隆起区抑或凹陷区岩石内部沉积构造均以水平层理

为主,页岩内部也含较多的结核状、层状及星散状黄铁矿,整体为低能还原的深水陆棚环境。

3.3 浅水陆棚相

浅水陆棚相主要发育于五峰晚期,该沉积相以钙质炭质页岩、硅质灰岩、粉砂质泥岩和泥灰岩为主,该相显著特征为碳酸盐岩和碎屑岩的混合沉积,且碎屑岩内部多含有钙质成分。生物除含有营浮游生活的笔石分子外,还见有腕足及三叶虫类生物发育,沉积构造仍以水平层理为主,较深水陆棚相相比,虽仍属浅海陆棚范围,但水体深度相对较浅,钙质成分较多。

3.4 藻礁相

藻礁相主要发育在五峰晚期,在汉源轿顶山、

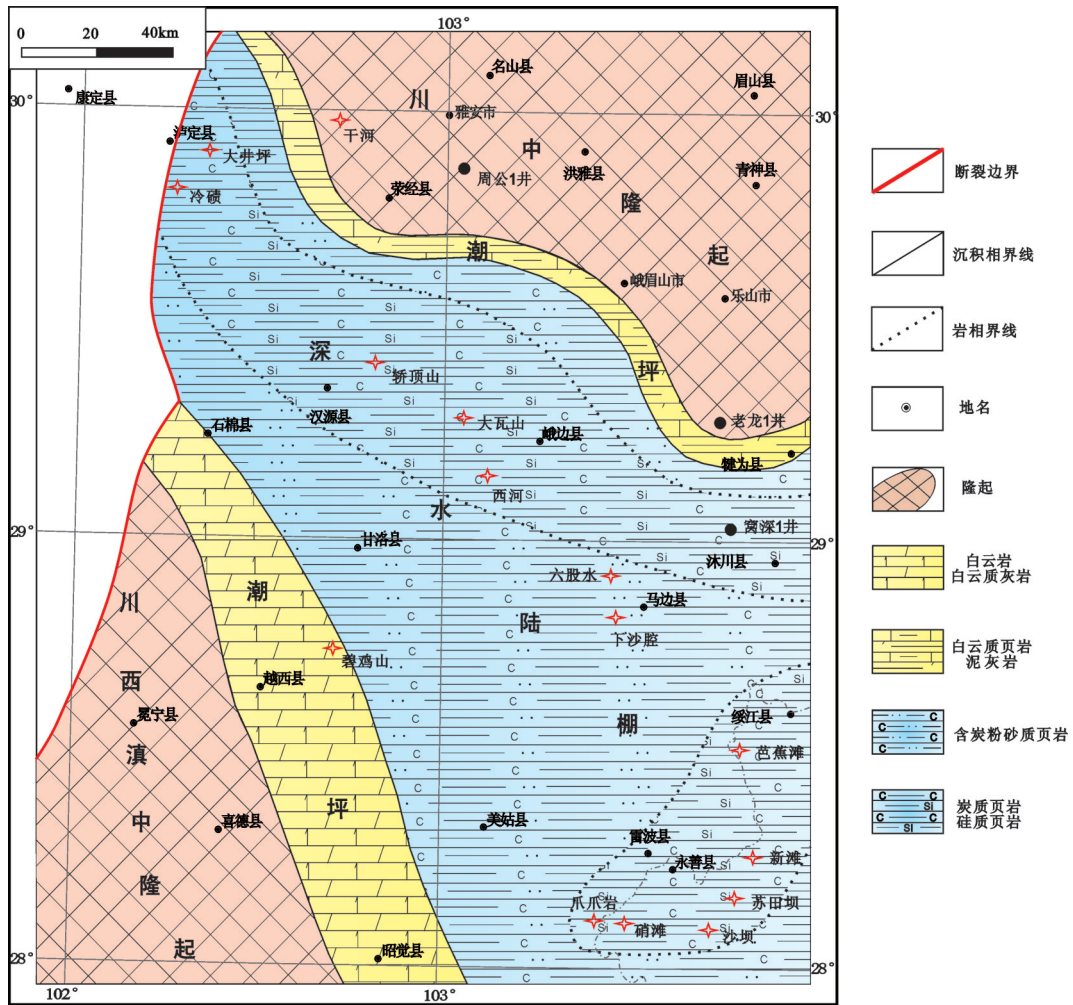


图3 川西南地区晚奥陶世五峰早期岩相古地理图

Fig.3 Lithofacies-paleogeographic map of Late Ordovician early Wufeng Age in southwestern Sichuan

金口河大瓦山发育点礁,礁体规模相对较小,大约20 m至数百米,小者仅2 m,保存最高者14 m。组成礁体的岩性主要为菱锰矿、含锰灰岩。岩石中含大量蓝绿藻、红藻和绿藻,并具大量隐藻组构(核形石、叠层石、凝块石、藻丝体等)^[18]。

4 岩相古地理分析

4.1 五峰早期古地理

中晚奥陶世开始,华南地区由先前的拉张背景转为挤压碰撞环境,东南侧华夏陆块与扬子陆块不断挤压碰撞,川中、川西—滇中、黔中等边缘隆起不断抬升扩大,整个上扬子克拉通盆地由先前的克拉通海相盆地逐渐变为受各隆起围限的隆后盆地^[2,8,19-21],原本平

坦的碳酸盐台地构造基底也因挤压碰撞作用的持续而出现隆凹相间的格局。总体来说受周缘隆起不断隆升挤压的影响,上扬子地区内部基底下降,较晚奥陶世宝塔—临湘组沉积时期海平面相对上升,川中隆起、川西—滇中隆起的周缘主要为潮坪相沉积,该相带大致呈环带状分布,岩性以灰色—灰黑色的白云质页岩、泥灰岩、白云岩、白云质灰岩为主,西南侧潮坪相延伸至石棉—越西—昭觉一线。该线之北东,犍为一峨眉—荣经一线之南西范围内主要为深水陆棚相沉积,岩性以含炭粉砂质页岩、炭质页岩和硅质页岩为主,泸定—峨边—汉源—沐川地区和绥江—雷波—永善地区可能属相应的基底凹陷区,主要沉积黑色炭质页岩和硅质页岩,而

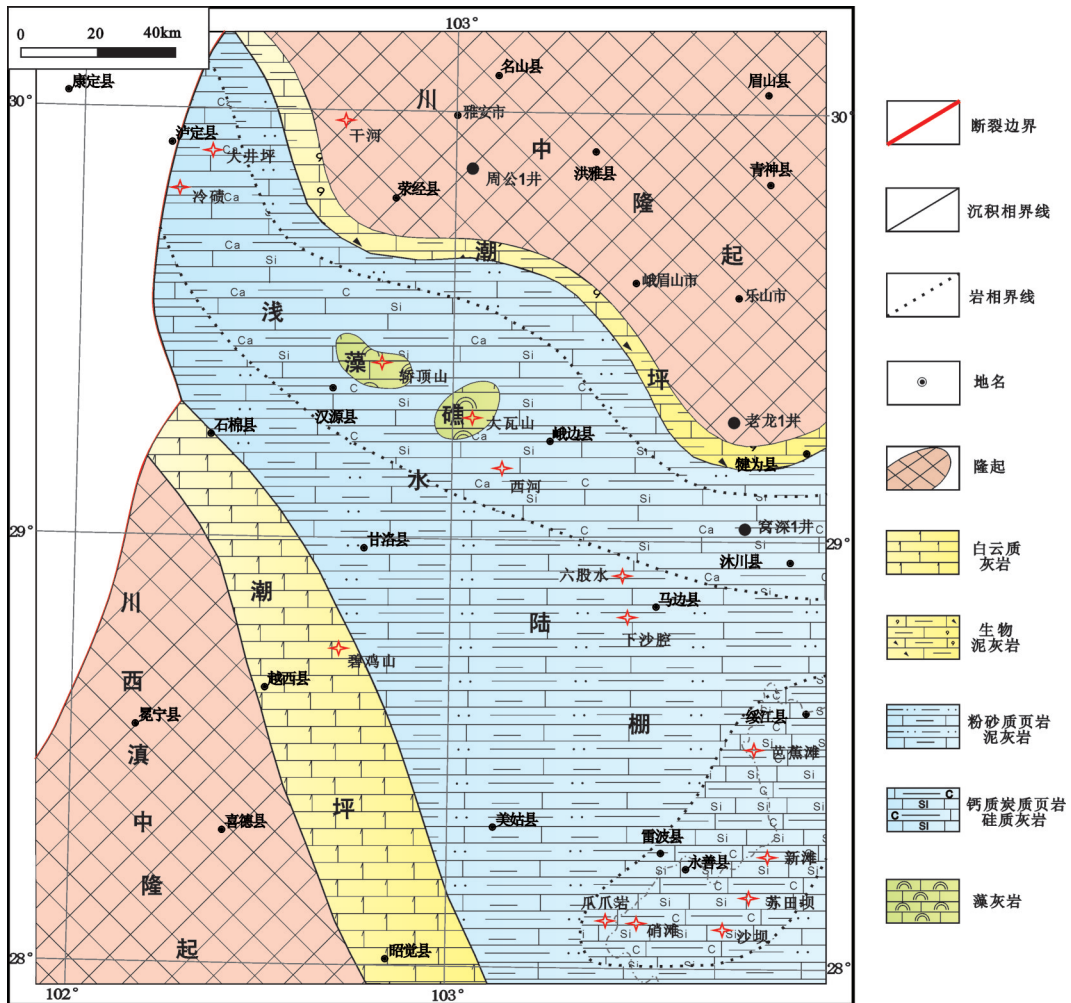


图4 川西南地区晚奥陶世五峰晚期岩相古地理图
Fig.4 Lithofacies-paleogeographic map of Late Ordovician late Wufeng Age in southwestern Sichuan

在马边—甘洛—美姑一带为基底水下隆起区以含炭粉砂质页岩沉积为主(图3)。

4.2 五峰晚期古地理

晚奥陶世五峰晚期,北非、南非、南欧、中欧、西亚等地区均发生大陆冰川活动,冰盖的形成引起海平面大幅度下降^[22],尽管晚期扬子、华夏陆块挤压碰撞作用继续,周缘川中—川西—滇中隆起面积不断增大,上扬子地区内部基底依旧不断沉降,但由于全球冰期事件的到来,海平面下降速度大于基底的沉降速度,五峰晚期川西南地区海水体现变浅特征,川中、川西—滇中等边缘隆起的面积相应扩大,早期广泛分布的深水陆棚相变为浅水陆棚相沉积,在沉积岩性上主要特点是虽然仍有陆缘细碎屑岩沉积,但碳酸盐岩含量大幅增多,以硅质灰岩、泥灰岩、粉砂质泥岩、白云质页岩为主,在汉源轿顶山、金口河大瓦山两个地区发育藻礁相,两地区恰构造基底相应的水下隆起附近,发育大量的藻类,在藻类的生长过程中,捕集海水中的锰质而形成“轿顶山式”或“大瓦山式”锰矿。川西—滇中隆起与川中隆起的周缘依旧发育潮坪相白云质灰岩和泥灰岩等,整个五峰晚期川西南地区大部较早期水体变浅,处于浅水陆棚环境中,石棉—甘洛—美姑之北东,汉源—马边之南西沉积粉砂质泥岩和泥灰岩,泸定—峨边—沐川地区以及绥江—雷波—永善之北东则主要沉积钙质炭质页岩和硅质灰岩(图4)。

5 结 论

(1)通过对川西南汉源—马边—雷波地区典型剖面上奥陶统五峰组沉积岩性特征、充填序列、沉积构造及室内分析等研究,将川西南地区五峰期划分为潮坪、浅水陆棚和深水陆棚3种沉积相。

(2)五峰早期,受华南内部构造挤压作用的影响,川中隆起、川西—滇中隆起、黔中隆起等边缘古隆起不断抬升,上扬子地区由先前的克拉通海相盆地逐渐变为受各隆起围限的隆后盆地,川西南地区主要表现为除隆起周缘沉积边缘潮坪相的白云岩、白云质灰岩及泥灰岩外,该研究区绝大部分面积沉积深水陆棚相炭质页岩、硅质页岩和含炭粉砂质页岩。五峰晚期,全球大部分地区均发生大陆冰川事件,冰盖的形成引起海平面大幅度下降,川中隆起、川西—滇中隆起面积扩大的同时,原本在五峰早期沉积的深水陆棚相也

变为浅水陆棚沉积,钙质成分增加,以沉积钙质炭质页岩、泥灰岩和硅质灰岩为主。

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