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贵州石炭系黑色页岩层系沉积特征及分布规律研究

卢树藩[1],陈祎[2],罗香建[1],何犇[1],符宏斌[1]
1.贵州省地质调查院,贵阳 550081
2.贵州省油气勘查开发工程研究院,贵阳 550004

摘 要 随着我国页岩气勘探的推进,在局部地区已经取得突破并建成一定规模的产能,但天然气资源保障形势依然严峻,亟需加强拓展页岩气新层系沉积环境和富集规律,以进一步扩大页岩气的勘探范围和规模。贵州石炭系黑色页岩作为新发现的页岩气目标层,具有较好的页岩气勘探前景。由于受水城—紫云裂陷槽的控制,贵州石炭系沉积相变复杂,开展该页岩地层的沉积相和沉积模式研究,总结页岩沉积富集特征,有利于推进其页岩气勘探进程。本文通过研究揭示贵州石炭系页岩地层可划分为裂陷槽两侧边缘斜坡相,槽内过渡浅海—半深海相,裂陷槽内槽盆相,水城地区隆起浅海相,威宁地区潮坪—潟湖相沉积,总结具有裂谷边缘—槽盆滞留沉积模式。浅海相、浅海—半深海相、槽盆相、湖盆相是黑色页岩沉积富集的有利区,而具体地层厚度、黑色页岩发育、总有机碳含量(TOC)、干酪根类型受沉积环境和物源区的影响控制明显。

关键词 石炭系;页岩气;沉积相;沉积模式;页岩富集

第一作者简介 卢树藩,男,1984年出生,博士,高级工程师,页岩气成藏研究,E-mail: Lushufan-2004@163.com
通信作者 陈祎,男,高级工程师,E-mail: 240805933@qq.com

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0 引言

沉积学研究对于非常规天然气的发现和预测具有重要的意义,可为非常规油气勘探开发提供理论基础与技术支撑[1]。页岩气作为一种重要的非常规天然气,其黑色页岩的发育受到沉积作用的控制,研究页岩地层的沉积环境和富集规律,可助推页岩气勘探选区进程。近年来,在四川盆地寒武系、志留系之外取得了一系列页岩气的勘探发现[2-8],但尚未实现页岩气的规模开发,重要的原因之一是页岩沉积研究没有与页岩气的选区、勘探相结合。石炭系黑色页岩是贵州继龙马溪组之后发现最具有页岩气勘探开发潜力的目的层之一,该页岩地层从贵州南部至广西北部均有发育,明显受紫云—南丹断裂带的控制[9-10],胡东风等[11]认为桂中坳陷下石炭统黑色页岩具有较好的页岩气勘探前景。据近年贵州石炭系黑色页岩层系已实施的多口页岩气井,取得了较好的页岩气的发现,表明该地层具有实现页岩气勘探开发的良好希望[12-15]。但贵州石炭系黑色页岩沉积受水城-紫云裂陷槽的控制,沉积相变复杂,对黑色页岩的沉积富集有重要的控制和影响,黑色页岩富集规律不清。前人的研究显示不同的沉积环境。对黑色页岩的沉积富集具有重要的控制和影响,而不同沉积环境下的黑色页岩其储层特征和对页岩气富集特征也不同,对页岩气后期勘探开发影响很大[16-21]。因此,本文对贵州石炭系黑色页岩地层沉积环境、页岩富集特征、沉积模式进行探讨,希望对推进石炭系页岩气勘探开发有所帮助。

1 沉积背景

早泥盆世以来,滇黔桂相邻地区形成右江沉积盆地,北东部以水城—紫云—丹池断裂带作为边界,该断裂带从广西省河池—南丹向贵州省紫云、水城

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地区延伸(图1),控制了所经过区域泥盆系—二叠系的地层沉积作用。水城—紫云裂陷槽作为水城—紫云—丹池断裂带在贵州省内的一部分,其裂陷和沉积作用与右江盆地相似[22-24]。沿该裂陷槽早石炭世在贵州省南部、西部沉积了厚度较大的黑色页岩[25-26],该黑色页岩的发育分布受水城—紫云裂陷槽的控制,分布在罗甸—惠水—长顺—紫云—镇宁—普定—六枝—水城—威宁—普安—盘县—望谟围限的区域内,面积约为$2×10^4$ km^2。

贵州石炭系黑色页岩在水城至罗甸地区称为打屋坝组,往北西威宁地区称为旧司组。打屋坝组岩性为黑色页岩、灰岩、泥灰岩夹硅质岩、粉砂岩组合,可划分为4段,其中第一、第三段为黑色页岩发育段。威宁地区旧司组同样可发育4段,但黑色页岩厚度明显变薄,碳酸盐、砂岩夹层增多,并发育煤层。

2　地层及沉积相

2.1　地层特征

为了对贵州石炭系页岩地层相变特征进行全面控制,选取水城—紫云裂陷槽不同位置地层控制点开展岩石组合分析。具体代表点有紫云县北部猫营、西部罗岗、南东部四大寨,长顺县南部代化,水城县东部双水、南西部都格,盘县东部珠东。以上控制点中紫云县猫营、水城县都格位于裂陷槽外围,紫云县罗岗、长顺县代化位于裂陷槽北部,盘县珠东位于裂陷槽南西部,紫云县四大寨处于裂陷槽核部地区(图2)。

紫云县猫营位于水城—紫云裂陷槽外围北东侧,石炭系页岩地层相变为祥摆组,厚度仅为3 m,岩性为一套灰黑色页岩夹两套灰色薄—中层细粒石英砂岩(图3a),页岩内可见大量植物化石碎片,石英砂岩局部呈透镜状。而在该裂陷槽外围南西侧的水城县都格石炭系页岩地层同样发生相变,相变地层为祥摆组、旧司组、上司组,其中祥摆组厚度20余米,岩性为深灰色粉砂质泥岩夹灰黑色页岩、灰色泥质粉砂岩及少量深灰色中层状泥质灰岩,祥摆组之上为旧司组深灰色薄—中层泥质灰岩夹少量灰黑色页岩,上司组为灰色中层状燧石泥晶灰岩(图3b)。

在水城—紫云裂陷槽内北东边缘紫云县罗岗地区,下石炭统为一套深灰色薄—中厚层泥晶灰岩、泥质灰岩夹灰黑色钙质页岩,厚度为244 m(图3c),发育滑移变形构造(图4a,b),X衍射分析显示页岩中碳酸盐矿物含量一般在10%~40%之间。往裂陷槽内过渡为长顺县代化地区,该区域下石炭统地层岩性为灰黑色页岩夹灰色、深灰色泥晶灰岩、泥质灰岩及少量深灰色粉砂岩,厚度为208 m(图3d),黑色页岩发育水平纹层(图4c),常见黄铁矿,呈结核状、星点状、脉状,偶见少量化石,主要为腕足类、头足类、珊瑚等(图4d),泥岩镜下见少量少量泥晶方解石不均匀混杂分布,见含量小于10%的石英、长石碎屑、棘皮、介形、骨针类化石碎屑(图4e),灰岩夹层镜下同样可见到低于10%的石英等陆源碎屑矿物,含有孔虫、棘皮类、介形类、腕足类及苔藓虫等生物碎屑

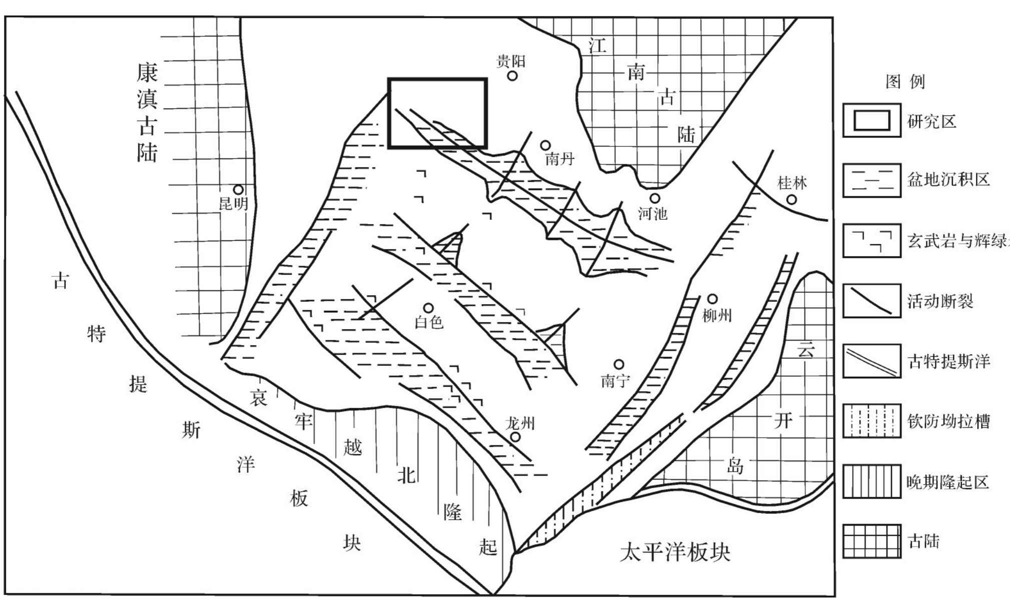

图1　研究区区域沉积构造位置图[22]

Fig.1　Sedimentary-tectonic settings[22]

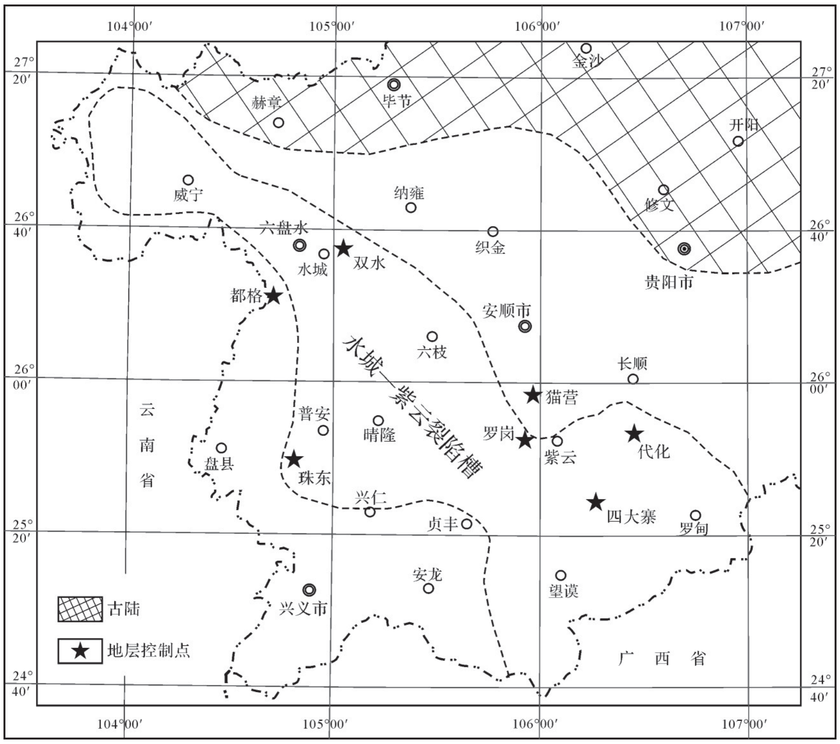

图2 贵州省下石炭统地层控制点分布图

Fig.2 Distribution of Lower Carboniferous points in Guizhou Province

(图4f),X衍射分析页岩矿物组成显示方解石含量为3%~20%,较罗岗地区明显降低。继续往水城—紫云裂陷槽核部为紫云县四大寨,该位置石炭系页岩地层厚度221 m(图3e),岩性为灰黑、黑色页岩、粉砂质页岩夹少量灰黑色薄层硅质岩,该位置打屋坝组页岩段无灰岩、砂岩夹层,水平纹层发育(图4g),见大量的硅质岩。页岩镜下观察发现与其它沉积区有较大的物质组成差异(图4h),页岩由黏土矿物、陆源碎屑及石英、黄铁矿、有机质、铁质等组分构成,黏土矿物镜下分布较为均匀,陆源碎屑约占样品总量8%。X衍射分析显示页岩内碳酸盐岩矿物含量很低,一般含量小于3%。

靠近水城—紫云裂陷槽南西缘的盘县珠东地区,石炭系页岩地层厚214.8 m,岩性为灰色、深灰色粉砂质泥岩夹深灰色、灰黑色页岩及少量深灰色硅质岩(图3f)。该位置岩石中砂质含量较高,页岩厚度变薄,黑色页岩连续性较差,发育有少量滑移变形构造及楔状交错层理(图4i,j),但沉积变形构造不如裂陷槽北东缘(紫云罗岗)强。

水城—紫云裂陷槽北西部水城县双水地区,下石炭统页岩地层出露不完整,未见底,厚度超过228 m,岩性为深灰色、灰黑色钙质页岩夹灰色生物屑泥晶灰岩及少量浅灰黄色粉砂岩,可分为四段,但特征不如其他地区明显(图3g)。双水地区石炭系页岩颜色明显变浅(图4k),镜下盐酸盐岩矿物和生物碎屑较为丰富(图4l),灰岩夹层较多,页岩内钙质含量较高。利用X衍射分析显示页岩内方解石矿物含量为4%~39%,并含有丰富的白云石矿物。

根据研究区内下石炭统不同沉积区域地层厚度、岩性组合建立地层格架图(图5,6)。在水城—紫云裂陷槽北东边缘,紫云猫营祥摆组地层厚度仅为3 m,裂陷槽边缘向内部地层厚度快速增加至300余米(图7),地层内滑移变形、包卷层理较为发育,显示沉积地形为一斜坡,海水快速变深;而在裂陷槽南西边缘,与潮坪相、台地相具有数十米—百余米的地层相变,显示裂陷槽两侧相变后地层特征并不一致,该裂陷槽具有北东盘高、南西盘低的沉积地貌。在靠近水城—紫云裂陷槽边缘区灰岩、粉砂岩夹层比例高,页岩碳酸盐矿物含量高,灰岩、粉砂岩夹层减少;往裂陷槽内地层厚度继续增大,黄铁矿逐渐增多,开始发育放射虫等浮游生物;继续往裂陷槽核心区,处于裂谷半深海滞留沉积区内,碳酸盐矿物含量很低,甚至消失,而硅质岩矿物大量增加,藻类、放射虫等浮游生物更加发育,水平纹层发育。

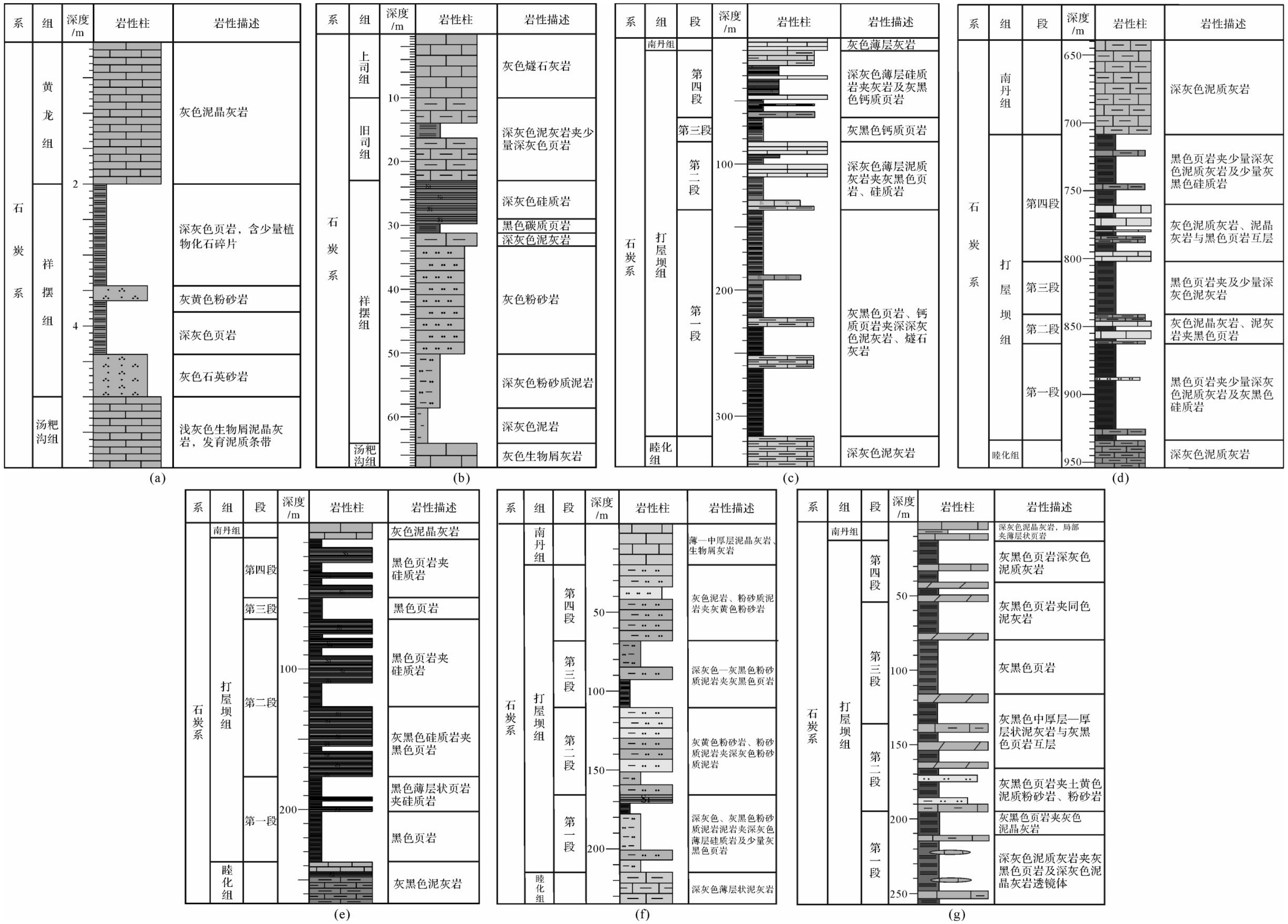

图3 贵州下石炭统不同沉积区地层岩石组合图征

(a)紫云县猫营下石炭统地层岩石组合特征;(b)水城县都格下石炭统地层岩石组合特征;(c)长顺县代化下石炭统地层岩石组合特征;(d)紫云县罗岗下石炭统页岩地层岩石组合特征;(e)紫云县四大寨下石炭统页岩地层岩石组合特征;(f)盘县珠东下石炭统页岩地层岩石组合特征;(g)水城双水下石炭统地层岩石组合特征

Fig.3 Stratigraphic characteristics from different sedimentary areas of Lower Carboniferous in Guizhou province

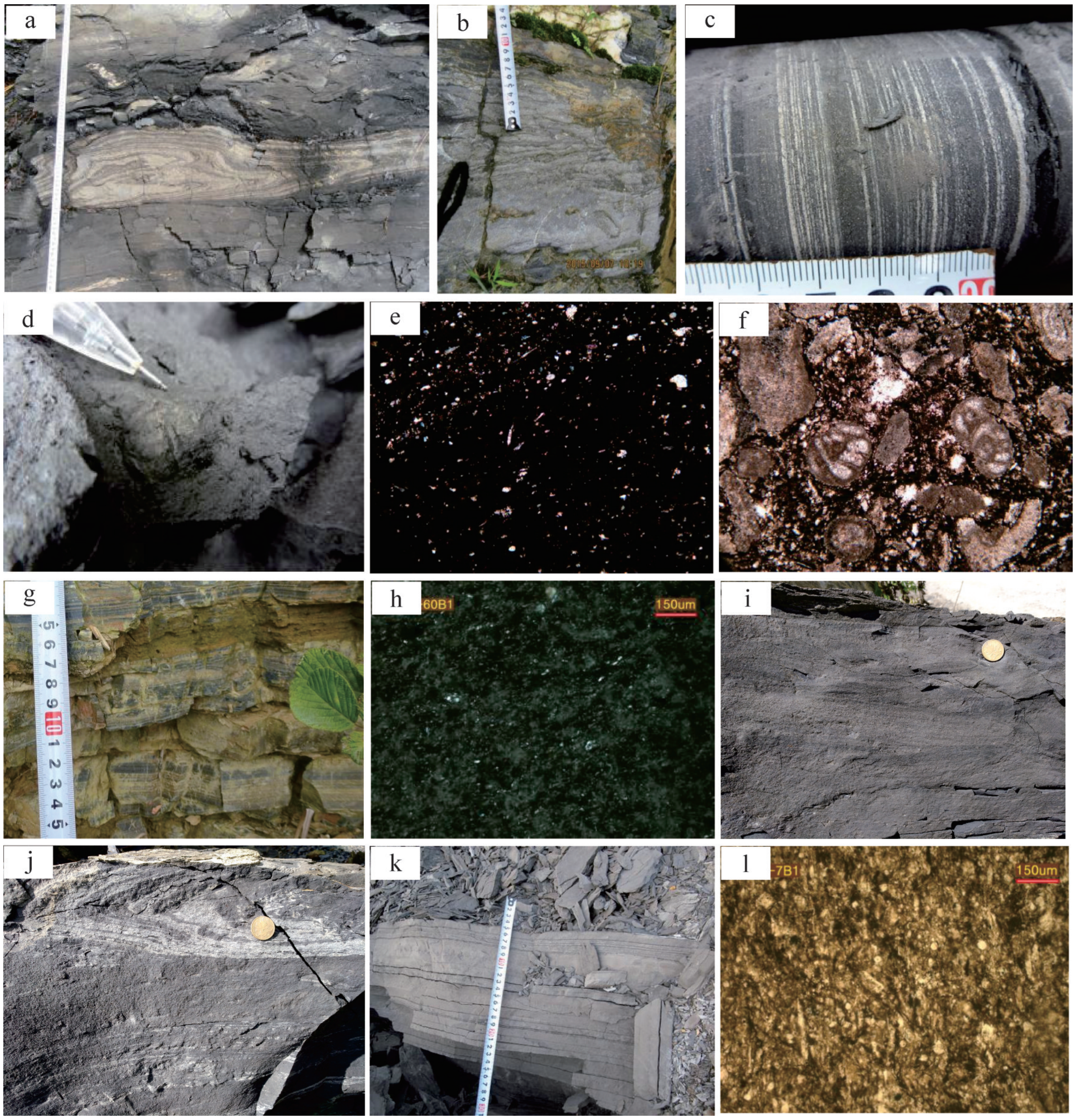

图4　贵州下石炭统不同沉积区沉积构造及镜下矿物组合特征照片

(a)紫云县罗岗发育包卷层理;(b)紫云县罗岗打屋坝组发育液化流;(c)长顺县代化打屋坝组发育水平纹层;(d)长顺县代化打屋坝组含腕足类化石;(e)代化打屋坝组泥岩镜下特征(正交偏光 物镜10× 目镜10×);(f)长顺县代化打屋坝组灰岩镜下特征(单偏光 物镜10× 目镜10×);(g)紫云县四大寨打屋坝组发育水平纹层;(h)紫云县四大寨打屋坝组页岩镜下特征(正交偏光 目镜10× 物镜10×);(i)盘县珠东打屋坝组滑移变形构造;(j)盘县珠东打屋坝组发育小型交错层理;(k)水城县双水钙质页岩外观;(l)双水打屋坝组泥岩镜下特征(单偏光 目镜10× 物镜10×)

Fig.4　Photos of sedimentary structures and microscopic mineral assemblages in different sedimentary areas of Lower Carboniferous in Guizhou

平行裂陷槽,在紫云、威宁地区下石炭统打屋坝组/旧司组地层厚度最大,紫云地区最厚可达365 m,威宁地区最厚可达700余米。而在紫云与威宁之间的水城—六枝地区打屋坝组地层厚度明显变薄,厚度仅为60余米,存在一个沉积高地,将紫云和威宁沉积区之间分隔开来,导致威宁地区为潮坪—潟湖相沉积,而六枝地区为相对隆起海水较浅的沉积环境。

采用V/(V+Ni)、Ni/Co和V/Cr比值对比分析裂陷槽内不同位置打屋坝组/旧司组沉积环境的变化差异(图8,9),可以看出,水城双水地区V/Cr分布在常氧环境,Ni/Co比值反映弱还原环境,而V/(V+Ni)比值基本分布在缺氧环境,说明该地区属于弱还原环境。紫云罗岗与水城双水特征非常相似,为浅海弱还原环境沉积。普安地区V/Cr比值均分布在贫氧环境,Ni/Co比值相对更加偏向还原环境,而V/(V+Ni)比值分布在缺氧环境,对比水城双水和紫云罗岗地

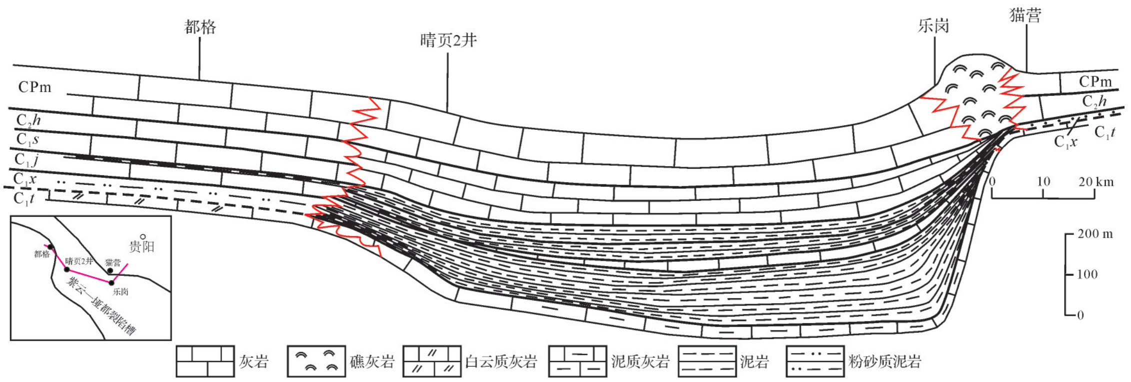

图5　裂陷槽切面打屋坝组/旧司组地层格架图

Fig.5　Stratigraphic framework of the Dawuba Formation (Jiusi Formation) at the section across the rift trough

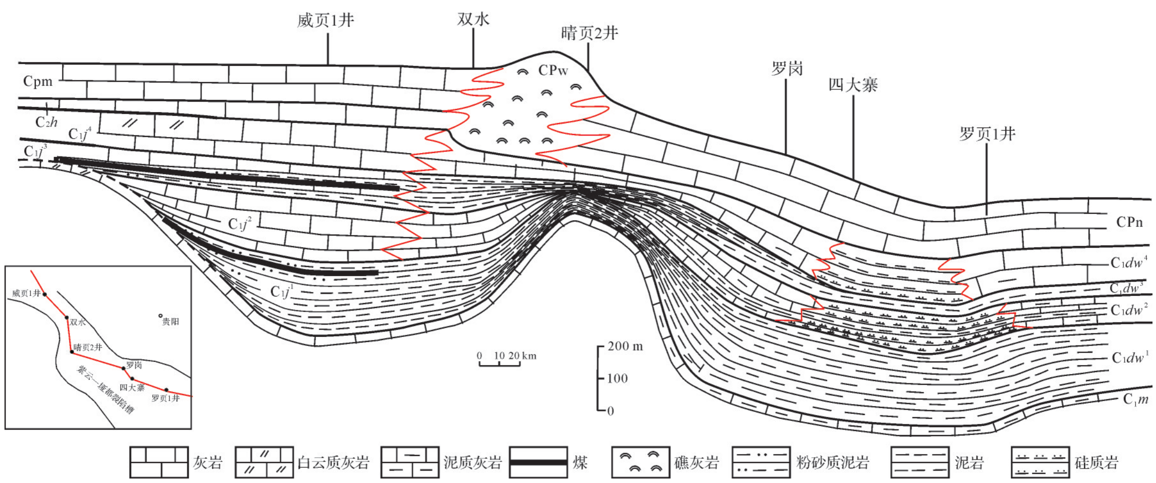

图6　平行裂陷槽打屋坝组/旧司组地层格架图

Fig.6　Stratigraphic framework of the Dawuba Formation (Jiusi Formation) parallel to the rift trough

区,还原环境特征更加明显。紫云四大寨有着更高的Ni/Co、V/Cr比值,滞留还原环境更加明显,显示了更深水的沉积。

2.2　沉积相

根据打屋坝组(旧司组)沉积构造、沉积环境及地层格架分析,将其沉积相划分为裂陷槽两侧边缘斜坡相,往裂陷槽内过渡浅海—半深海相,裂陷槽内槽盆相,水城地区隆起浅海相,威宁地区潮坪—潟湖相沉积(图10)。值得一提的是,贵州石炭系页岩地层分布范围在水城—紫云裂陷槽不同地区大小不一致,表现为在紫云—惠水—长顺、兴仁—贞丰一带沉积范围变窄,沉积相变快速而复杂。在盘县—安顺、望谟—长顺可能发育有垂直于水城—紫云裂陷槽的次级同生沉积断裂,形成垂直于裂陷槽局部沉积范围扩大的特征。不同的沉积相地层特征表现如下:

边缘斜坡相,发育有沉积斜坡,沉积水体较浅,还原环境相对较弱,页岩钙质含量高,并夹有大量灰岩、泥灰岩,钙质含量高,长石丰富,发育有丰富的斜坡相沉积构造,见少量腕足、腹足类化石。

过渡浅海—半深海相:在边缘斜坡相继续往裂陷槽内,表现为水体逐渐变深,还原环境增强,但仍然夹有灰岩、泥灰岩夹层,页岩普遍含钙质,但钙质含量降低,长石含量减少。

槽盆相:在裂陷槽核部地带,为深水相沉积,滞留还原环境进一步增强,受陆相及浅海沉积影响较小,灰岩夹层也明显变少,硅质岩逐渐增多的特征,并在裂陷槽南部逐步向右江盆地相过渡。

浅海相:在水城—六枝隆起区,表现为黑色页岩依然较为发育,但地层厚度变薄,碳酸盐岩夹层变多,页岩内钙质含量高,白云石丰富,蒸发作用强,处于弱还原环境。

潮坪—潟湖相:可能源于物源较为丰富的原因,地层厚度较大,发育有丰富的粉砂岩、细砂岩、灰岩,夹有煤层,灰岩内白云石丰富,黑色页岩厚度并没有

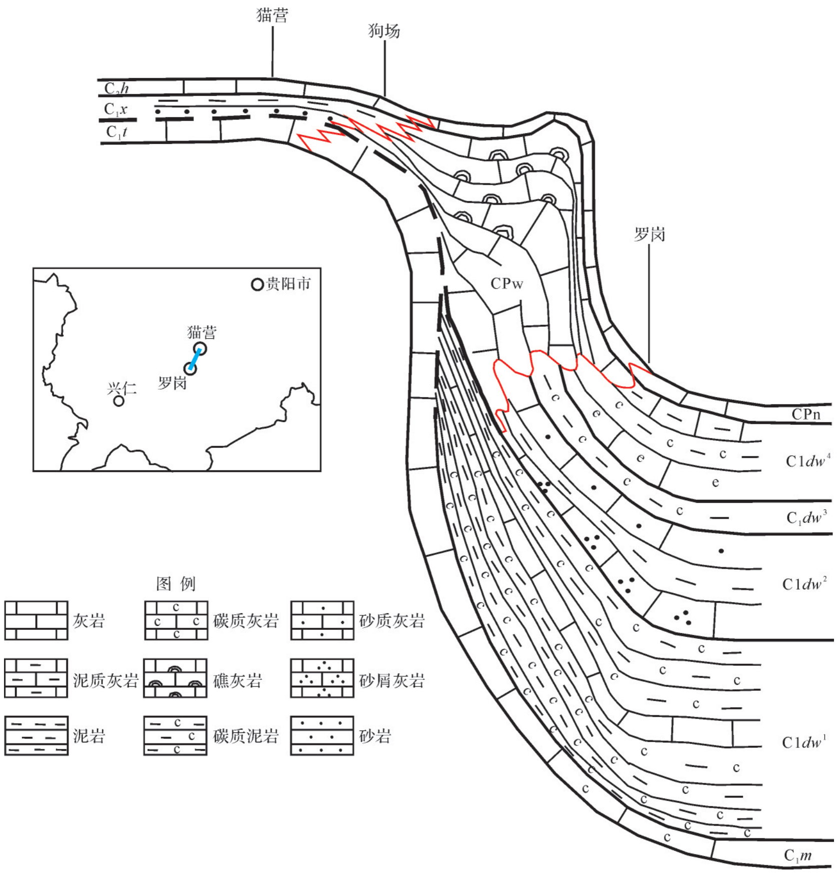

图7 紫云地区石炭系打屋坝组/旧司组地层格架图

Fig.7 Stratigraphic framework of the Dawuba Formation (Jiusi Formation) in the Ziyun area

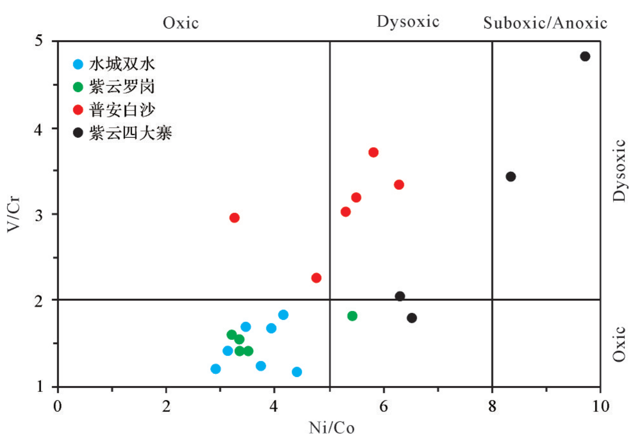

图8 V/Cr与Ni/Co散点图

Fig. 8 Scatter diagram of V/Cr and Ni/Co

因为地层厚度增加而增大，反映处于弱还原环境，受陆相物源影响很大。

3 沉积模式

水城—紫云裂陷槽与右江盆地之间通道较为局限，导致裂陷槽的沉积水体较为封闭，处于海水滞留的蒸发环境。裂陷槽北东盘高，为滨浅海相，氧化沉积环境，以陆源沉积物质组成为主；而在裂陷槽南西盘相对北东盘低，发育潮坪相沉积，发育丰富的碳酸盐矿物，夹少量灰黑色页岩。在裂陷槽边缘形成斜坡相沉积，发育滑移变形构造，陆源有机质、碎屑丰富，为弱的还原沉积环境，发育有腹足、腕足等化石，有利于碳酸盐矿物的沉积形成。由于裂陷槽南西盘低、北东盘高，因此裂陷槽南西部的裂谷边缘滑移变

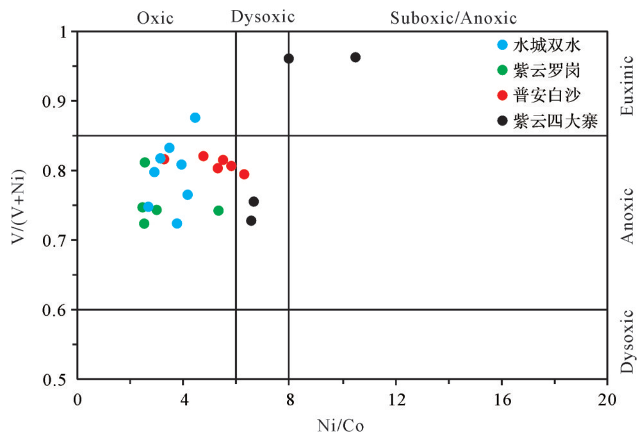

图9 V/(V+Ni)与Ni/Co散点图

Fig.9 Scatter diagram of V/(V+Ni) and Ni/Co

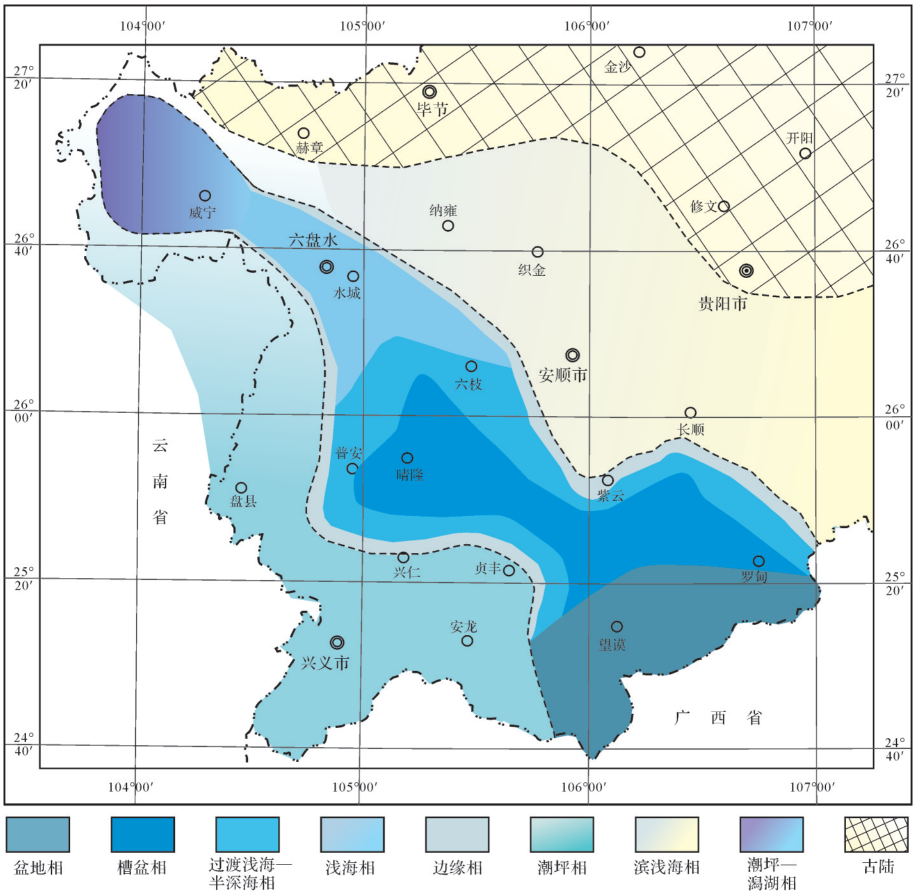

图10　研究区早石炭世晚期沉积相图

Fig.10　Sedimentary facies map of the late Early Carboniferous in the study area

形构造远不如北东缘发育。从斜坡相继续往裂陷槽内,进入相对稳定的滞留浅海—半深海相沉积环境,受陆源碎屑的影响逐渐减弱,还原环境增强,有利于黑色页岩沉积富集,碳酸盐矿物减少,黄铁矿富集,发育骨针类化石。在裂陷槽核部为滞留槽盆相沉积,发育骨针类、藻类等浮游生物化石,受陆源碎屑及有机质的影响更弱,有利于黑色页岩沉积富集,不利于碳酸盐矿物的富集,变为硅质岩和硅质页岩的发育富集为主,黄铁矿也较为发育。因此,贵州石炭系页岩地层具有裂谷边缘—槽盆滞留沉积模式(图11)。

水城—紫云裂陷槽内的沉积地貌对地层发育影响很大,沉积凹陷之间受隆起带的阻隔形成不同的沉积环境,对黑色页岩的发育造成影响。在裂陷槽南东部受右江盆地影响,总体为明显的海相滞留还原沉积环境。在裂陷槽北西威宁沉积凹陷内,受水城—六枝隆起的影响,正常海相沉积影响变弱,陆源碎屑丰富,蒸发作用强,为潟湖相沉积环境,发育煤层。在潟湖深水沉积区内富集黑色页岩(图8),但厚度明显较裂陷槽内海相沉积区薄。

4　页岩富集规律

纵观整个水城—紫云裂陷槽沉积变化,往北东、北西、南西各有不同,相变特征复杂,该特征与水城—紫云裂陷槽的构造沉积格局有关。

沿水城—紫云裂陷槽内紫云、威宁2个沉积中心打屋坝组/旧司组地层厚度较大,其中威宁地区最厚可超过700 m,从两个沉积中心往外,地层厚度变薄,可降低至数十米(图12),反映了沿裂陷槽坳隆相间的沉积地貌控制了地层的厚度发育。根据裂陷槽内不同位置黑色页岩厚度分布图(图13),显示打屋坝组/旧司组黑色页岩厚度一般为50~200 m,受裂陷槽和裂陷槽内坳隆相间的沉积地貌控制明显。在研究区南部望谟—兴仁、北部长顺—安顺裂陷槽边缘部位厚度小于50 m,而往裂陷槽内逐渐增厚,存在一个高值区,位于紫云附近,与紫云沉积中心吻合,表现为该地区黑色页岩随地层厚度增大而变厚。但在威宁地区表现不明显,黑色页岩并没有随整个地层厚度的增大而增厚,源于该地区沉积环境发生改变,受

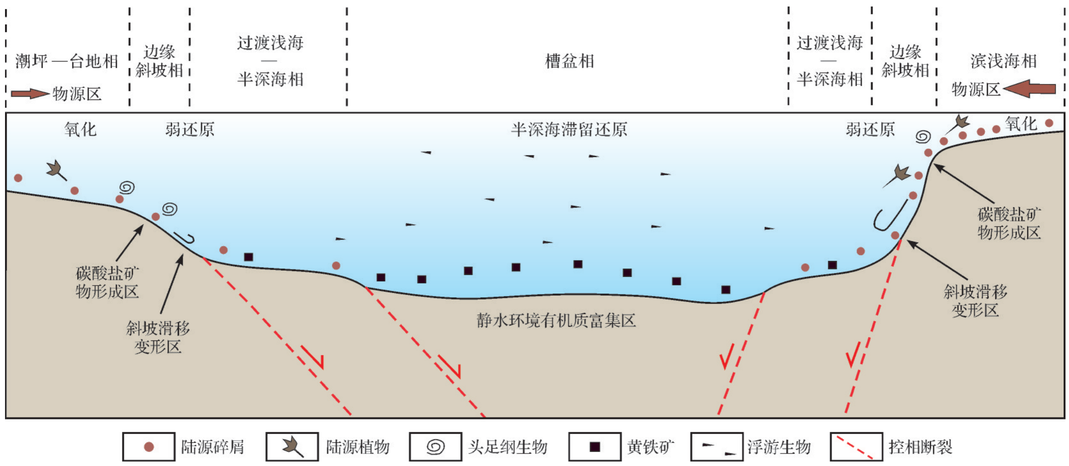

图11 打屋坝组/旧司组沉积模式示意图

Fig.11 Sedimentary model of the Dawuba Formation (Jiusi Formation)

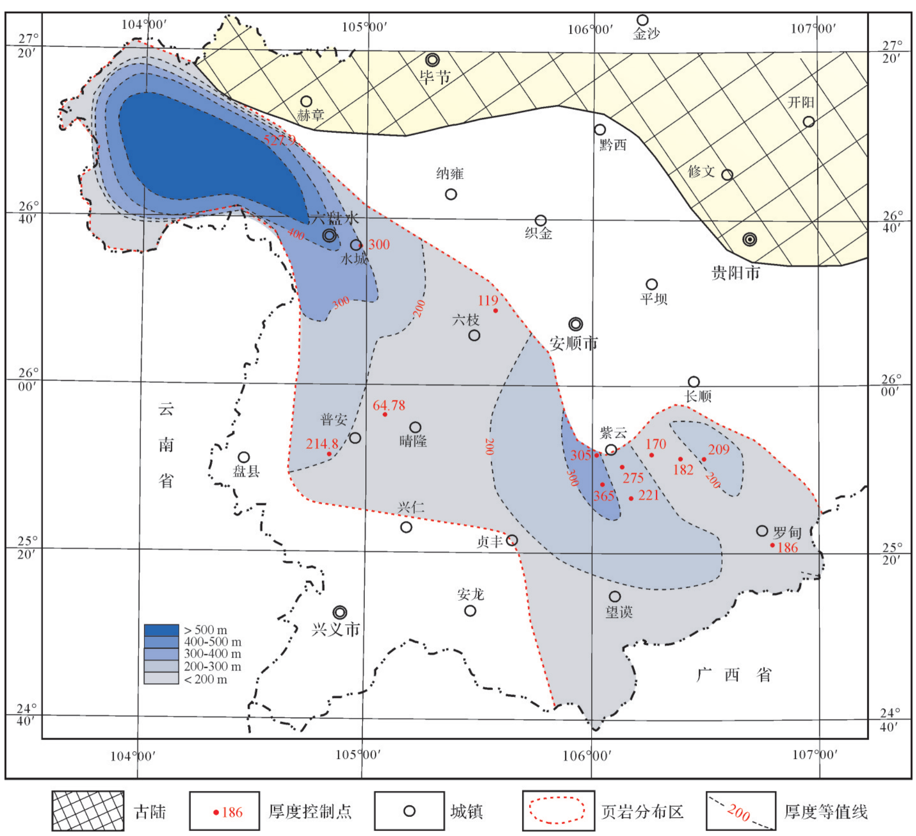

图12 打屋坝组/旧司组地层厚度等值线图

Fig.12 Thickness contour map of the Dawuba Formation (Jiusi Formation)

陆源沉积影响大，蒸发作用较强，沉积速率快，陆源碎屑补给丰富有关。总体黑色页岩在裂陷槽核部厚度较大，呈带状北西—南东向展布，裂陷槽中部黑色页岩厚度一般在100 m以上，是黑色页岩厚度较大的区域。

不同区域打屋坝组/旧司组黑色页岩TOC分析，显示以水城—紫云裂陷槽沉积中心为轴线，中部TOC较高，往两侧逐渐降低，并且从右江盆地往六盘水、威宁地区TOC也逐渐降低（图14）。处于右江盆地的罗甸地区是有机质含量最高的区域，TOC平均值可超过5%，其次是晴隆—紫云地区，TOC平均值一般为2%~4%，再次为水城—晴隆地区，TOC平均值一般为1%~3%。

总的来看，水城—紫云裂陷槽从北西往南东，

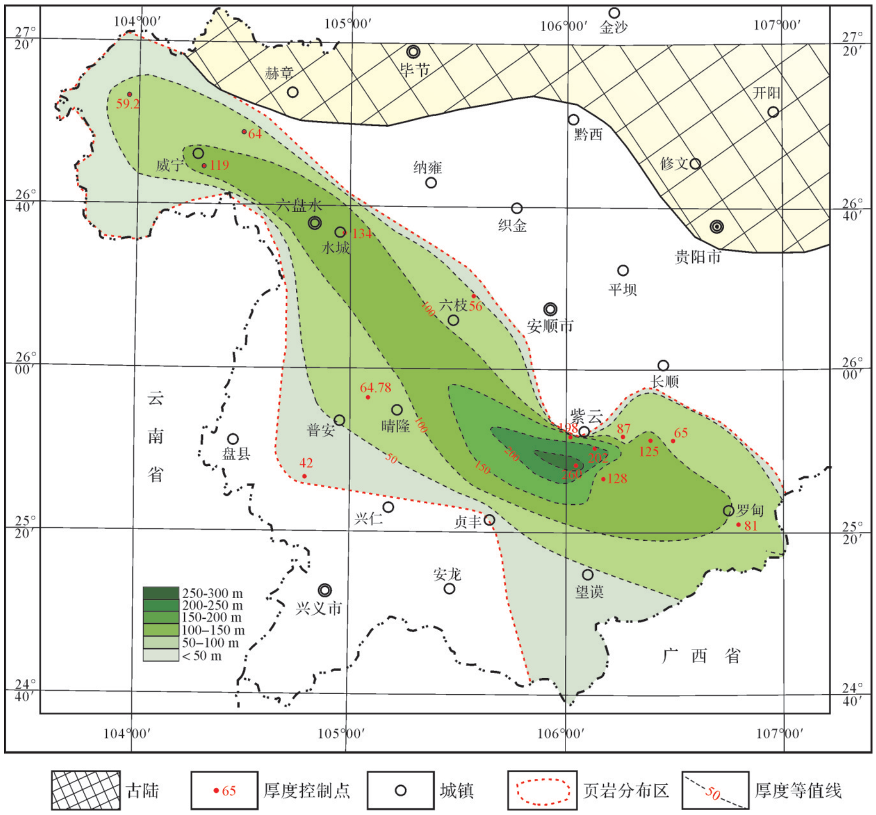

图 13　打屋坝组/旧司组黑色页岩厚度等值线图

Fig.13　Thickness contour map of black shale in the Dawuba Formation (Jiusi Formation)

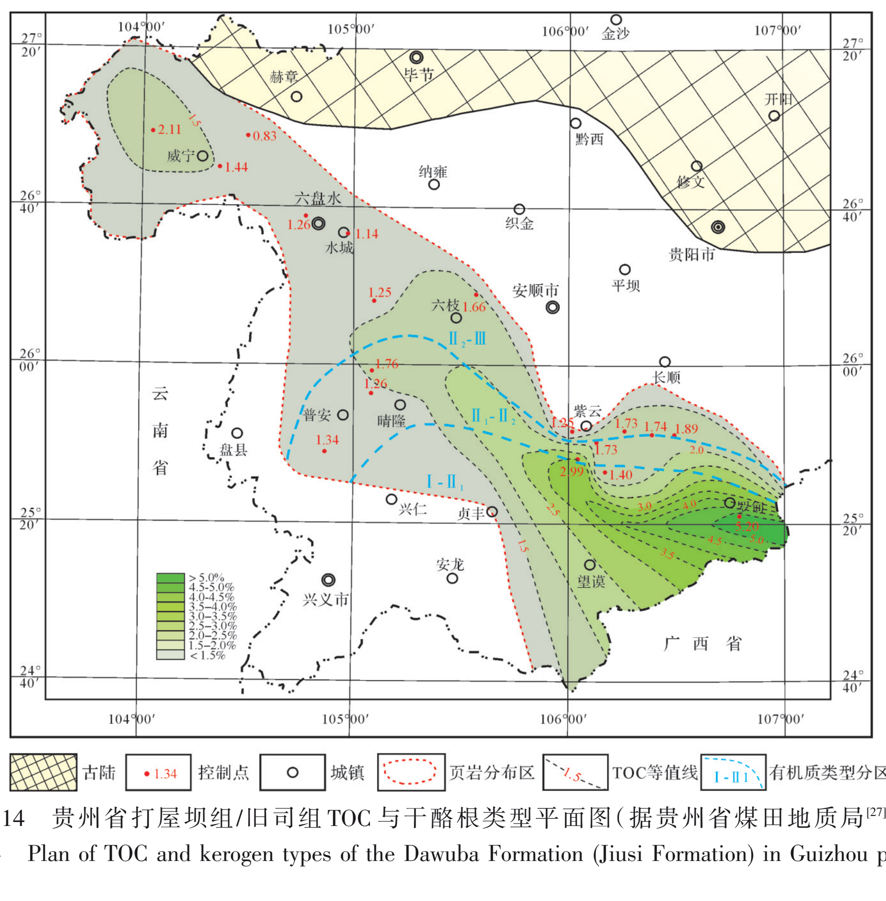

图 14　贵州省打屋坝组/旧司组TOC与干酪根类型平面图(据贵州省煤田地质局[27]改)

Fig.14　Plan of TOC and kerogen types of the Dawuba Formation (Jiusi Formation) in Guizhou province

贵州石炭系页岩地层从边缘相往槽盆相逐步变迁，受到陆源碎屑矿物及陆源有机质影响变弱，沉积还原环境增强，碳酸盐岩矿物含量变低，硅质矿物和有机质丰度增高，干酪根类型从Ⅲ型向Ⅰ型逐渐过渡，页岩储层条件变得更好，对页岩气的富集和开发更加有利。考虑到黑色页岩分布范围和，六枝—普安、长顺—望谟贵州石炭系黑色分布范围最大，是页岩气勘探首要关注的地区；而进一步从页岩厚度、有机质丰度及干酪根类型考虑，长顺—望谟地区对页岩气富集更为有利，勘探前景会更佳。值得一提的是六盘水地区尽管沉积水体变浅，有机质丰度不是很高，但演化程度低，局部裂缝非常发育，前人在该地区实施的钻井取得了较好的含气性显示。

根据以上打屋坝组/旧司组黑色页岩厚度、有机质丰度、干酪根类型的区域变化，贵州早石炭世水城—紫云裂陷槽内海侵方向为从南东右江盆地往北西向，主要的物源来自于北部黔中隆起区。受物源、海侵及裂陷槽内沉积地貌的影响，从南东往北西分别形成裂陷槽内槽盆相、过渡浅海—半深海相、隆起区浅海相和潟湖相、边缘浅海相沉积，而在裂陷槽外围形成滨岸—潮坪相沉积。其中裂陷槽内槽盆相、隆起区浅海相、过渡浅海—半深海相、潟湖湖盆相均有一定厚度黑色页岩发育，是贵州石炭系黑色页岩有利的发育区。而沉积水体较深的槽盆相黑色页岩有机质丰度高，硅质含量高，是优质硅质页岩发育富集有利区；而过渡浅海—半深海相、隆起区浅海相及泄湖湖盆相沉积中心区域有机质丰度有所降低，碳酸盐岩矿物含量高，为钙质页岩沉积富集最有利区域。靠近裂陷槽边缘沉积水浅，黑色页岩厚度变薄，有机质丰度低，陆源碎屑及碳酸盐岩矿物含量较高，不利于黑色页岩的沉积富集(图15)。

5　结论

(1) 水城—紫云裂陷槽为右江盆地北部次级断陷构造，控制了贵州石炭系打屋坝组/旧司组地层的沉积。从裂陷槽两侧向中部石炭系打屋坝组/旧司组发育有边缘斜坡相、过渡浅海—半深海相以及槽盆相、局部区域隆起形成浅海相，隆起区北西的威宁地区形成潮坪—潟湖相。

(2) 水城—紫云裂陷槽内石炭系打屋坝组/旧司组具有裂谷边缘—槽盆滞留沉积特征。裂陷槽边缘靠近陆源区，受陆源沉积影响大，往裂陷槽内海相沉积逐渐增强，陆源沉积影响减弱，复杂的沉积地貌控制其地层、岩石组合的快速变化。

(3) 研究区石炭系打屋坝组/旧司组受水城—紫云裂陷槽沉积的控制明显，其黑色页岩在裂陷槽沉积中心厚度较大，一般在100 m以上，呈带状沿北西—南东向展布，往裂陷槽边缘逐渐变薄至50 m左右；在裂陷槽中心区晴隆—紫云—罗甸一带是TOC的高值区，一般在1%和5%之间向两侧逐渐降低，

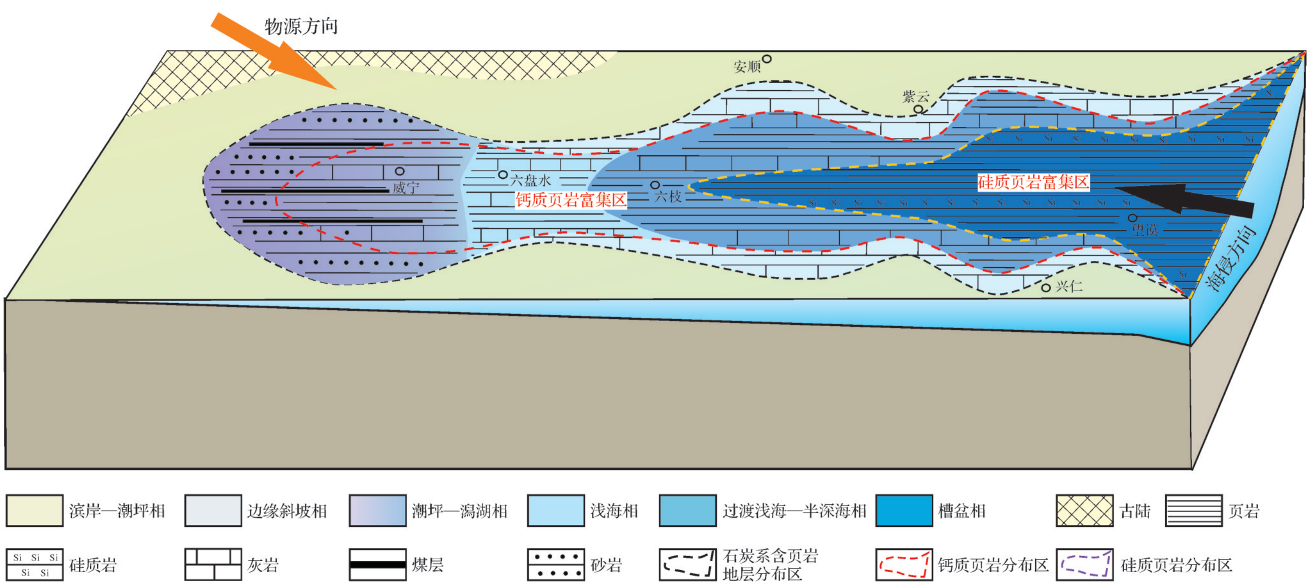

图15　水城—紫云裂陷槽沉积模式下打屋坝组/旧司组页岩沉积富集图

Fig.15　Sedimentary enrichment of shale in the Dawuba Formation (Jiusi Formation) under the sedimentary mode of the Shuicheng Ziyun rift trough

干酪根类型在水城—紫云裂陷槽北缘往南至槽盆内,具有从Ⅲ型向Ⅰ型过渡的趋势,受黔中隆起区影响较大。浅海相、过渡浅海—半深海相和槽盆相是打屋坝组黑色页岩发育的有利富集相带,其中槽盆相以硅质页岩沉积富集为主,浅海相为钙质页岩沉积富集区。

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Sedimentary Characteristics and Distribution of the Carboniferous Black Shale in Guizhou Province

LU ShuFan[1], CHEN Yi[2], LUO XiangJian[1], HE Ben[1], FU HongBin[1]

1. Guizhou Geological Survey ,Guiyang 550081,China

2. Guizhou Research Institute of Petroleum Exploration & Development, Guiyang 550004, China

Abstract: With the strengthening of shale gas exploration in recent years, breakthroughs have been made in some areas, and a certain scale of production capacity has been built. However, the resource support capacity is still insufficient. It is necessary to further study the sedimentary environment and shale enrichment law of newly discovered shale strata in recent years to further expand the exploration horizon and scope of shale gas. As a newly discovered shale gas target layer, the Carboniferous black shale in Guizhou has good shale gas exploration prospects. However, due to the control of the Shuicheng-Ziyun rift, the sedimentary phase transition is complex. Therefore, the study of the sedimentary facies and sedimentary model of the shale and the summary of the characteristics of shale enrichment and deposition are conducive to the promotion of shale gas exploration. The study reveals that the Carboniferous shale strata in Guizhou Province can be divided into the two sides of the rifting trough, slope facies, transitional shallow to semi deep sea facies in the trough, trough basin facies in the rifting trough, uplifted shallow sea facies in the Shuicheng area, and tidal flat lagoon facies deposition in the Weining area. The model of the rifting margin trough basin retention sedimentation is summarized. Formation thickness, development of black shale, total organic carbon content (TOC), and kerogen type are greatly influenced by the provenance supply area of the sedimentary model, while shallow marine, shallow semi deep marine, trough basin, and lagoon basin are favorable areas for the deposition and enrichment of the black shale.

Key words: Carboniferous; shale gas; sedimentary facies; sedimentary model; shale enrichment