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内蒙古自治区兴安盟突泉盆地TD−2井晚二叠世孢粉的发现及其油气地质意义

张德军,张健,郑月娟,陈树旺,苏飞,黄欣,张海华,甄甄

(中国地质调查局沈阳地质调查中心,辽宁 沈阳 110034)

提要:松辽盆地西缘的突泉盆地是在古生界之上形成的中生代盆地,近年因在侏罗系发现轻质原油而备受关注。然而,对于该盆地古生代下伏地层及其油气资源前景的研究,过去并未系统开展过。本次运用岩石地层、微体化石和烃源岩样品测试分析等方法对突泉盆地南部牤牛海凹陷TD−2井的岩心开展系统分析,TD−2井在中侏罗世万宝组砂砾岩之下发育一套以暗色泥岩、粉砂质泥岩为主的沉积,产孢粉化石19属26种,包括:*Leiotriletes adnatus, Punctatisporites debilis, Cyclogranisporites* sp., *Alisporites auritus, Al. communis, Al. stenoholcus, Al.* sp.?, *Klausipollenites schaubergeri, Pityosporites evolutus, Sulcatisporites dalongkouensis, S. ovatus, S.* sp.?, *Hamiapollenites indistinctus, Lunatisporites tersus, Piceaepollenites opimus, P.* sp., *Voltziaceaesporites xinjiangensis, Crucisaccites variosulcatus, Divarisaccus cinctus, Plicatipollenites* cf. *densus, Parcisporites scabratus, Platysaccus* sp., *P. papilionis, Cycadopites caperatus, Samoilovitchisaccites chordens*,孢粉指示的地质时代为晚二叠世;烃源岩分析结果显示,这套暗色泥岩、粉砂质泥岩的烃源岩指标较好,具良好的油气资源前景。岩石地层和生物地层综合对比研究表明,TD−2井下部发育的这套以暗色泥岩、粉砂质泥岩为主的细碎屑沉积为晚二叠世林西组,且其具有良好的生烃基础。该发现为研究松辽盆地西缘晚古生代地层序列奠定了基础,对探讨松辽及周边盆地上古生界油气资源具有重要意义。

关 键 词:上二叠统;林西组;孢粉;地质调查工程;油气勘查工程;突泉盆地;内蒙古

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Discovery of Late Permian pollen and spores in TD−2 borehole in Tuquan Basin of Hinggan League of Inner Mongolia and their oil and gas geological implications

ZHANG Dejun, ZHANG Jian, ZHENG Yuejuan,
SU Fei, CHEN Shuwang, HUANG Xin, ZHANG Haihua, ZHEN Zhen

(*Shenyang Center of Geological Survey, CGS, Shenyang* 110034*, Liaoning, China*)

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作者简介:张德军,男,1987年生,硕士,工程师,主要从事古生物学与地层学研究;E−mail: 532413639@qq.com。

通讯作者:张健,男,1980年生,硕士,高级工程师,从事沉积学研究;E−mail: 48487885@qq.com。

Abstract: Tuquan Basin near the west boundary of the Songliao Basin is a Mesozoic sedimentary basin formed above the Paleozoic strata, which has aroused much attention from geologists due to the discovery of light crude oil from the Jurassic strata in recent years. In the past, systematic research on the oil and gas resources from the Paleozoic was very insufficient. In this paper, the methods such as stratigraphic (lithostratic) and sporopollen analysis and source rock test were conducted so as to analyze synthetically the core samples collected from TD-2 well in the Mangniuhai depression of Tuquan Basin. A stratigraphic unit composed of grayish black mudstone and siltstone beneath the Middle Jurassic conglomerate was discovered in TD-2 well, and some spores and pollen were extracted from the unit, which consist of 26 species and 19 genera, including *Leiotriletes adnatus*, *Punctatisporites debilis*, *Alisporites auritus*, *A. communis, A. stenoholcus, Klausipollenites schaubergeri, Pityosporites evolutus, Sulcatisporites dalongkouensis, Hamiapollenites indistinctus, Piceaepollenites opimus* etc. indicating Late Permian. Combined with the research results such as the stratigraphy (lithostratic) and source rock test, it is reasonably assigned to Late Permian Linxi Formation, and some high-quality source rocks are discovered in this unit. This discovery is significant for confirming the existence of Permian strata in the Tuquan Basin and also for exploring the late Paleozoic oil and gas resources in the Songliao Basin and adjacent regions.

Key words: Upper Permian; Linxi Formation; spores and pollen; geological survey engineering; oil and gas exploration engineering; Tuquan Basin; Inner Mongolia

About the first author: ZHANG Dejun, male, born in 1987, engineer, mainly engages in the study of paleontology and sratigraphy; E-mail: 532413639@qq.com.

About the corresponding author: ZHANG Jian, male, born in 1980, senior engineer, mainly engages in the study of sedimentology; E-mail: 48487885@qq.com.

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1　引　言

2014年中国地质调查局在松辽盆地外围的内蒙古自治区兴安盟突泉盆地侏罗系中钻获轻质原油(李世臻等,2015;张德军等,2019),打开了"大庆外围找大庆,大庆深部找大庆"的油气勘探新思路。然而,侏罗系油气的重大发现,使得系列基础地质问题呈现出来,如盆地的性质及面积、地层发育特征、基底性质、原油和烃源岩的层位等等,亟待深入研究解决。

晚古生代中后期,中国东北及邻区存在一个由额尔古纳—兴安、松嫩、布列亚—佳木斯等微板块拼合而成的联合地块,称东北地块群或佳蒙板块(王成文等,2008;王五力等,2014),其与南部的华北板块和北部的西伯利亚板块之间分别被古亚洲洋(南支)和古太平洋隔离,西伯利亚板块、佳蒙板块和华北板块之间古纬度差距大、发育的地层迥异、生长的植物不同(姚兆奇,1991)。近几十年来,三大构造单元的碰撞拼合,中亚造山带的形成与演化一直是地质学者们关注的焦点,目前,佳蒙板块和西伯利亚板块东段在晚侏罗—早白垩世最终沿蒙古—鄂霍次克缝合带拼合的观点已基本达成共识(赵越等,1994;张梅生等,1998;Van der Voo et al., 1999;邱士龙等,2018);然而,对于佳蒙板块自身演化以及佳蒙板块和华北板块最终碰撞拼合却历来备受争议。晚古生代以来东北及邻区是否普遍发育相同或相似的地层系列(李文国等,1996;王成文等,2009);古生代地层是否作为盆地基底伏于中、新生带沉积-火山岩之下;晚二叠世林西组沉积时期佳蒙和华北两大板块之间是否还存在深海大洋等一系列问题(黄本宏,1983;李福来等,2009;张永生等,2013;梁天意等,2019),需要进一步深入研究和探讨。

林西组起源于1924年法国人Teilhard Chardin在内蒙古自治区林西县创建的林西系黑色砂板岩,1965年经内蒙古区测一队改称林西组,1978年辽宁省地层编写组根据地层中所含的瓣鳃类*Palaeanoeontad ubia, Palaeomutela soronensis*, *P. khingartenis, Nuculites* sp.和植物*Paracalamites* sp., *Noeggratiopsis* cf. *derzavinii, Pecopteris* sp., 将其地质时代厘定为晚二叠世。李文国等(1996)将普遍出露于大兴安岭地区和松辽盆地以南西拉木伦河以北地区(内蒙古草原—吉林磐石地区)的这一套含*Palaeanodonta*- *Palaeomutela*动物群和*Callipteris*-*Comia*-*Iniopteris*植物组合的潟湖、湖相

黑灰色砂泥岩(砂板岩)沉积统称为林西组,厚度可达3000 m以上。目前前针对林西组露头区的报道虽已不少,不少地点更是发现了植物大化石,但孢粉化石报道却甚少,仅郑月娟等(2013)、杨兵等(2014)分别在扎鲁特旗和林西官地一带发现了少量孢粉化石。另外,近年林西组因广泛发育巨厚的暗色泥岩及良好的烃源岩指标而备受石油地质工作者们的关注(康玉柱,2009;任收麦等,2011;甄甄等,2018;康晓倩等,2019),然而对于松辽及周边盆地之下是否存在该组地层,其石油地球化学指标如何却一直缺乏有力证据。

为了深入研究突泉盆地的基底性质以及其所含的微体化石组合和烃源岩特征,明确基底(地层)发育的生物群类型、时代特征,探讨其构造以及油气资源前景的指示意义。本文对TD-2井钻遇的地层开展了岩石地层、微体化石和烃源岩测试分析研究,通过与区域岩石组合特征的对比、微体化石(孢粉)典型属种分析以及烃源岩样品测试结果分析等方法,理清了突泉盆地南部TD-2井发育的地层系列,明确了该井下部暗色泥岩、粉砂质泥岩的时代、孢粉植物群面貌和烃源岩特征,这对探讨佳蒙与华北板块的构造演化,以及进一步开展松辽盆地及周边盆地晚二叠世林西组油气资源前景研究具有重要的意义。

2 地质概况

突泉盆地位于内蒙古自治区兴安盟南部,属于大兴安岭中段南部在晚古生代基底之上形成的中生代盆地,其东部与松辽盆地西缘接壤。盆地北部发育万宝—红旗断陷,充填早—中侏罗世含煤碎屑岩沉积;中部为小泡子凹陷,发育晚侏罗世—早白垩世火山及火山碎屑岩沉积;南部为牤牛海凹陷,发育中侏罗世和晚侏罗世—早白垩世地层。盆地大致以永安屯—中心屯—蒙古屯断裂为西部边界,以镇西—大泡子一带的低山丘陵区为东部边界,以满克头鄂博—孟恩陶勒盖—牤牛海断裂为南部边界(陈树旺等,2010;刘玲等,2013;李世臻等,2015)。

突泉盆地周边晚古生代地层发育,自下而上出露的地层有早二叠世寿山沟组、早二叠世大石寨组、中二叠世哲斯组。晚二叠世林西组,仅在盆地以东的突泉县九龙乡黑顶山、莲花山一带的低山丘陵区零星出露了一套含*Callipteris-Comia-Iniopteris*植物化石组合林西组暗色细碎屑沉积(曲永贵,1986;黄本宏,1993)。近年来,在盆地西部的科尔沁右翼中旗代钦塔拉双龙岗附近出露的一套砂岩,通过碎屑锆石研究确认为晚二叠世林西组(陈树旺等,2015)。但对于盆内是否发育有林西组地层一直缺乏有力的证据(陈树旺等,2010)。

本文拟通过分析内蒙古兴安盟突泉盆地南部边缘附近突地2井(简称TD-2)发现的孢粉化石,结合同位素年代学数据及其上覆地层的岩性、岩相分析,明确突泉盆地南部边缘,解决盆地地层发育、基底性质及埋深等关键地质问题,以建立松辽盆地西缘突泉盆地晚古生代以来的地层序列;同时,根据林西组地层烃源岩地球化学指标,探讨松辽及周边盆地上古生界油气资源前景,为深部二叠系油气资源调查奠定基础。

3 地 层

突地2井(简称TD2)钻孔位于突泉县东部的牤牛海西侧约9 km处,为牤牛海煤矿矿区的南部边缘带,地理坐标:45°13′18" N, 121°46′3" E(图1)。TD2全井深510.7 m,其中0~39.3 m为更新统表土,39.3~195 m井段为一套局部夹砂岩的巨厚砾岩层,195~510.7 m井段为一套以灰黑色泥岩、粉砂质泥岩夹粉细砂岩为主的沉积建造,砾岩与下伏暗色细碎屑岩之间为不整合接触(图2)。

20世纪70—80年代,煤田地质研究将牤牛海矿区地表产动、植物化石的含煤层砂砾岩组合定义到早—中侏罗世[1,2];前人依据采到的*Equisetum laterale, Raphaelia diamensis, Phoenicopsis angustifolia*, *P. speciosa*, *Czekanowskia rigida* 4属5种,将其归入中侏罗世万宝组(杨学林等,1985a, b)。通过地层对比,确定TD2井上部(39.3~195 m井段)的这套巨厚砂砾岩层为中侏罗世万宝组。而下部(195~510.7 m井段)的暗色细碎屑沉积发现了诸多晚二叠世常见或特征孢粉化石分子,且其砂岩、粉砂岩夹层(259.3 m、480~500 m处)LA-ICP-MS U-Pb同位素年代学均获得了253 Ma的最年轻峰值年龄(苏飞等,2017),说明地层的时代为晚二叠世无疑,在岩石特征上可以与林西官地、大板、巴林左旗碧流台(李文国等,1996)、扎鲁特旗陶海营子(黄本宏,1983;郑月娟等,2013)、科尔

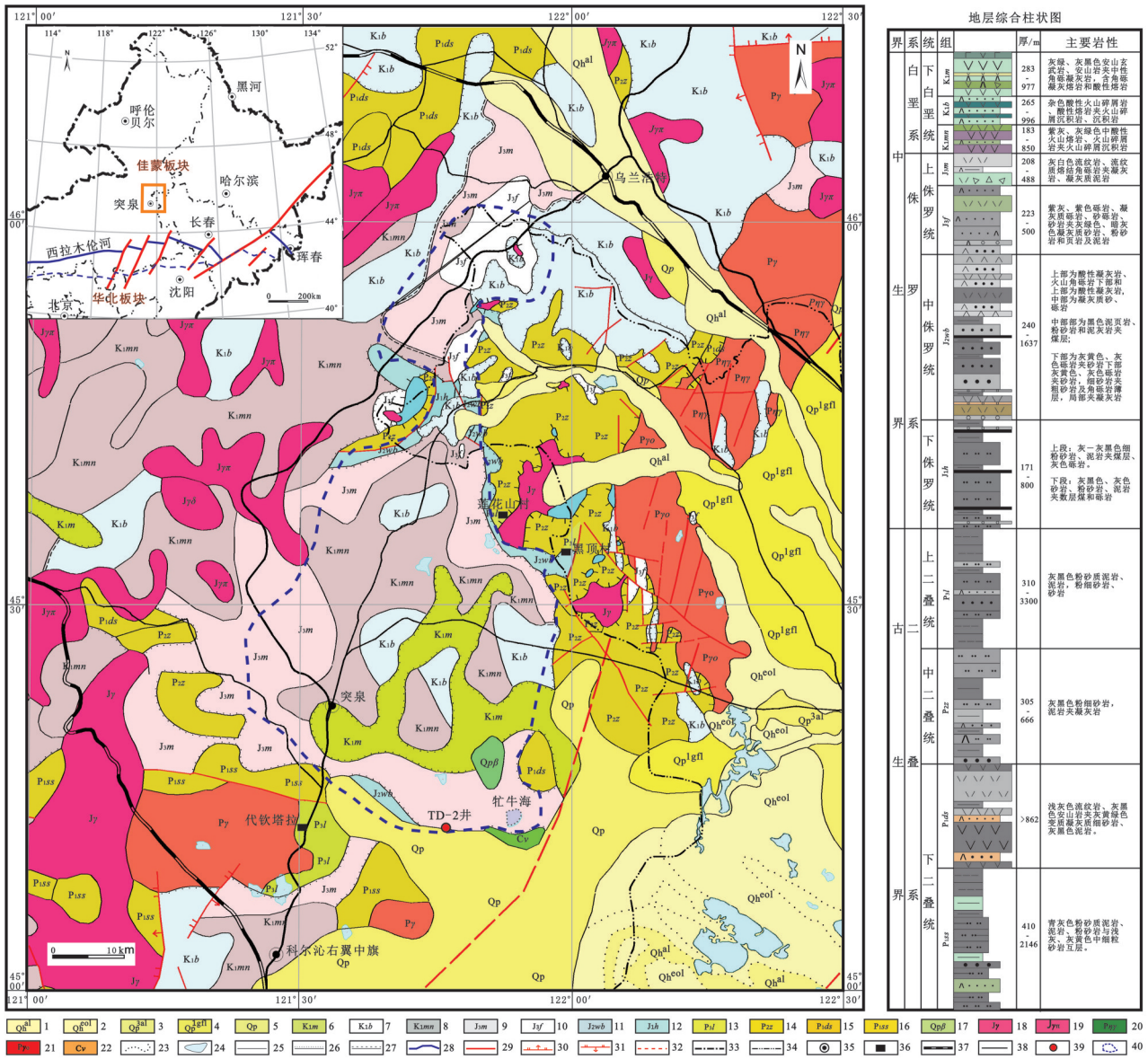

图1 内蒙古突泉县突地2(TD2)井位置图

1—全新统湖冲积物;2—全新统风积物;3—上更新统冲洪积物;4—下更新统冰水堆积物;5—更新统;6—梅勒图组;7—白音高老组;8—玛尼吐组;9—满克头鄂博组;10—付家洼子组;11—万宝组;12—红旗组;13—林西组;14—哲斯组;15—寿山沟组;16—大石寨组;17—更新统玄武岩;18—侏罗纪花岗岩;19—侏罗纪花岗斑岩;20—二叠纪二长斑岩;21—二叠纪斜长花岗岩;22—石炭纪辉长岩;23—风沙沉积;24—湖泊;25—整合;26—平行不整合;27—角度不整合;28—缝合线;29—断裂;30—正断层;31—逆断层;32—推测断层;33—中国东北大陆边界;34—省界;35—城镇;36—乡村;37—铁路;38—公路;39—TD-2井;40—推测突泉盆地边界

Fig.1 Location of TD2 borehole in Tuquan County, Inner Mongolia

1−Qh^{al};2−Qh^{col};3−Qp^{3al};4−Qp^{1gfl};5−Qp;6−K_1m;7−K_1b;8−K_1mn;9−J_3m;10−J_3f;11−J_2wb;12−J_1h;13−P_2l;14−P_2z;15−P_1ss;16−P_1ds;17−Qpβ;18−Jγ;19−Jγπ;20−Pηπ;21−Pγo;22−Cv;23−Aeolian landform;24−Lake;25−Conformity;26−Parallel unconformity;27−Angular unconformity;28−Suture;29−Fault structure;30−Normal fault;31−Reverse fault;32−Speculated fault;33−Land boundary of the northeast China;34−Provincial boundary;35−Town;36−Village;37−Railway;38−Highway;39−TD−2 well;40−Inferred boundary of the Tuquan Basin

沁右翼前旗索伦(Zhang et al., 2014),突泉九龙乡莲花山、黑顶山(曲永贵,1986;黄本宏,1993),科尔沁右翼中旗代钦塔拉(陈树旺等,2015)等地的林西组进行对比,因此,这套暗色细碎屑沉积应为晚二叠世林西组。TD−2井林西组烃源岩有机质丰度为中等—好(图2),具有较好的生烃基础;有机质类型为Ⅱ1型,有机质成熟度为过成熟,进入生气阶段(苏飞等,2017),展示了晚二叠世林西组具有良好的油气资源前景。

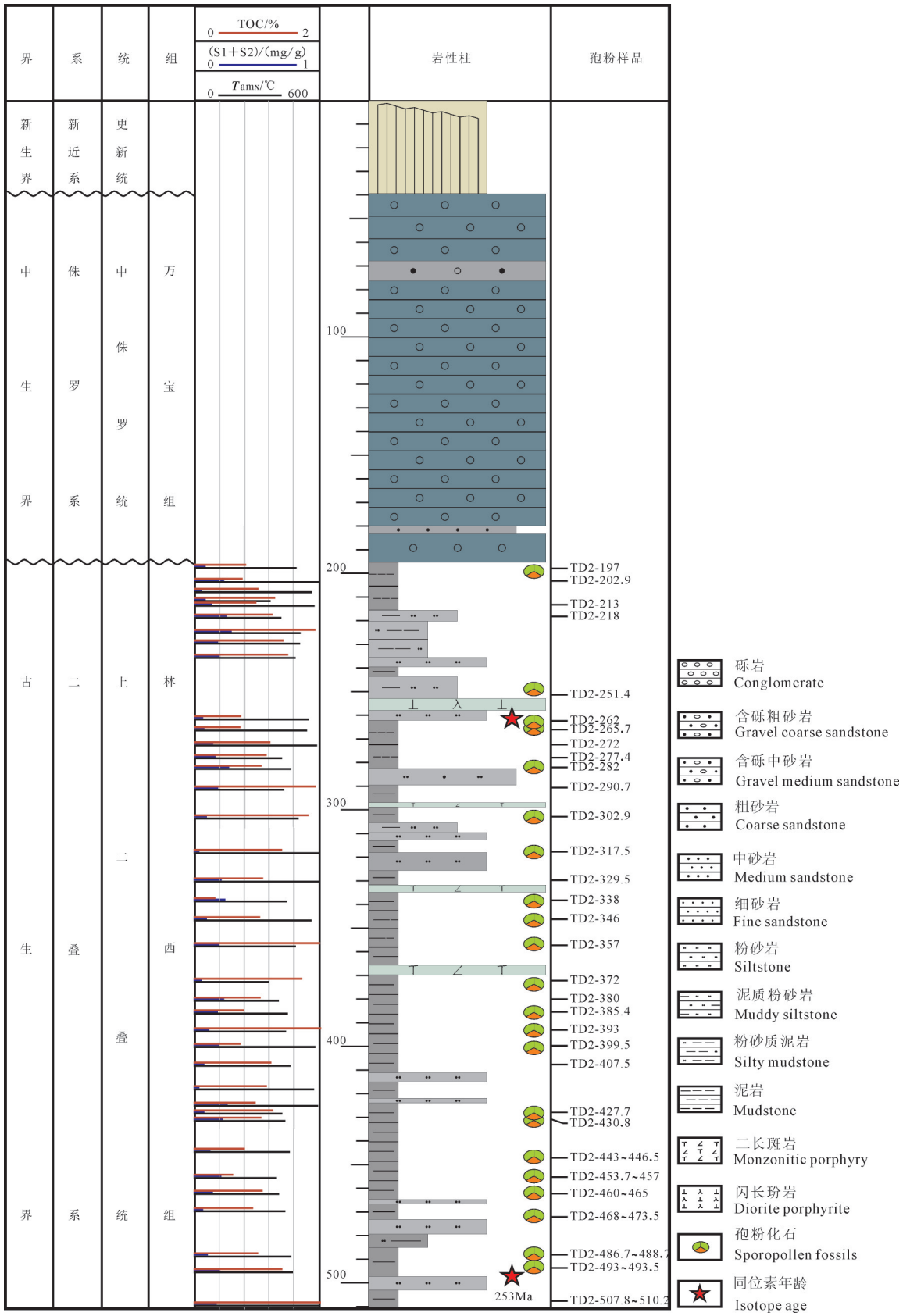

图2 内蒙古突泉县突地2(TD2)井综合柱状图

Fig. 2 Stratigraphic column of TD2 borehole in Tuquan County, Inner Mongolia

图3 内蒙古突泉县牤牛海地区突地2井(TD2)上二叠统林西组孢粉化石

1—弓形堤光面三缝孢;2, 3—圆形粒面孢(未定种);4—展开松型粉;5—粗糙雏囊粉;6—整洁四肋粉;7—复网残缝粉;8—拟云杉粉(未定种);9,10—大龙口具沟双囊粉;11—皱粒苏铁粉

Fig. 3 Spores and pollen from the Upper Permian Linxi Formation in TD2 borehole of Mangniuhai, Tuquan County, Inner Mongolia

1−Leiotriletes adnatus (Kosanke) Potonie et Kremp; 2, 3− Cyclogranisporites sp.; 4−Pityosporites evolutus Ouyang; 5−Parcisporites scabratus Ouyang; 6−Lunatisporites tersus Ouyang; 7−Vestigisporites complexus Ouyang; 8−Piceaepollenites sp.; 9,10−Sulcatisporites dalongkouensis Ouyang; 11− Cycadopites caperatus (Luber) Hart

4　材料和方法

本文研究的孢粉样品采自TD2井195~510.7 m井段暗色泥岩、粉砂质泥岩中,取样及分析方法如下:

4.1 样品采集

优选颜色较深、岩性较细的井段进行采样,每次取样前,清理干净取样工具,确保样品之间没有混染。每个样品取200 g左右,取完样品后,立即装入标有井号、采样深度、岩性特征及编号的样品袋内封好(样品信息见图2)。

4.2 样品处理

碎样后,过筛,确保岩样均匀、粒度可取。将样品装入烧杯中,加入稀盐酸。蒸馏水洗涤3~4次,每次洗涤自然沉淀4 h左右。吸出剩余水分,加入碱溶液,洗涤2~3次。将碱处理后的样品洗到pH = 7(中性),吸去样品中的水溶液,倒入离心管中,离心10 min,将水倒掉,加入重液,充分搅拌均匀,离心10~15 min,把下部的重液部分慢慢倒入或用小吸管吸入原来的烧杯中,用重液进行第二次浮选。加水稀释,静止沉淀4 h以上,让孢粉及有机物部分下沉到杯底,将稀释液吸出。将杯底沉淀物倒入离心管中离心,直到样品完全分离,用水洗到pH = 7再加入几滴甘油,即可在镜下观察孢粉含量情况。

4.3 分析鉴定

将每个样品用筛选法集中在试管中的孢粉化石,制作2个固定片在Olympus BX51生物显微镜下分析

鉴定(固定片编号与样品号一致,详见图2;固定片现保存于吉林大学古生物学与地层学研究中心),用配套的扫描成像系统(CS5)进行拍照。

5 孢粉组成及时代

TD2井195~510.7 m多个井段中共计发现孢粉化石19属26种,蕨类植物孢子(3属3种): *Leiotriletes adnatus, Punctatisporites debilis, Cyclogranisporites* sp.;裸子植物花粉(16属23种):无肋双囊花粉有 *Plicatipollenites* cf. *densus, Alisporites auritus, A. communis , A.* sp.?, *Klausipollenites schaubergeri, Sulcatisporites dalongkouensis, S. ovatus, S.* sp.?, *Piceaepollenites opimus, P.* sp., *Voltziaceaesporites xinjiangensis, Pityosporites evolutus, Platysaccus papilionis, P.* sp. *Parcisporites scabratus*;具肋双囊花粉有 *Hamiapollenites indistinctus, Lunatisporites tersus*;单囊花粉有 *Crucisaccites variosulcatus, Divarisaccus cinctus, Samoilovitchisaccites chordens*;单沟花粉有 *Cycadopites caperatus*(图3)。

孢粉化石中,*Alisporites stenoholcus*、*Sulcatisporites dalongkouensis*、*Hamiapollenites indistinctus*、*Samoilovitchisaccites chordens* 仅发现于新疆上二叠统(欧阳舒等,2003;王世新等,2011)。*Voltziaceaesporites xinjiangensis* 见于准东中二叠世平地泉组,*Parcisporites scabratus* 产于准西下二叠统(欧阳舒等,2003)。*Pityosporites evolutus* 曾报道于新疆晚二叠世锅底坑组(欧阳舒等,2003),该种亦见于贵州北部早二叠世地层(史骁等,2014);*Lunatisporites tersus* 发现于天山—兴蒙构造带二叠—三叠系过渡层(欧阳舒等,2003;郑月娟等,2013);*Alisporites communis* 见于新疆(Zhu et al., 2005),内蒙古阿鲁科尔沁旗(郑月娟等,2013)、巴林右旗(张海华等,2015)、林西(Sun Yuewu et al., 2012),贵州威宁(Yin et al., 2007)乐平统—下三叠统底部,以及辽宁西部地区上三叠统之中(Sun Chunlin et al., 2012);*Klausipollenites schaubergeri* 作为晚二叠世的特征分子(史骁等,2014),广泛分布于欧亚大陆及南非,如:中国新疆吐哈(刘兆生,2000;王世新等,2011)、准噶尔及塔里木盆地(欧阳舒等,2004),内蒙林西(杨兵等,2014),浙江长兴(Ouyang et al., 1990),意大利白云石山脉西部(Spina et al., 2015), 俄罗斯沃洛格达(Foster et al., 2005),巴基斯坦岩岭(Schneebeli et al., 2015),印度安德拉邦(Jha Neerja et al., 2012)、达莫德尔盆地(Murthy et al., 2015),非洲莫桑比克太特(Zélia Pereiraa et al., 2016),南非卡罗盆地(Steiner et al., 2003)等地晚二叠世地层之中;*Sulcatisporites ovatus* 广泛分布于中国新疆(欧阳舒等,2003;Yao et al., 2007)、藏南(杜凤军等,2006)、内蒙古东部(黄欣等,2015)、贵州凯里(高联达等,1989)、安徽砀山(陆彦邦等,1988),伊朗(Spina et al., 2015),巴基斯坦Salt和Khisor地区(Jan et al., 2009),印尼苏门答腊岛(Crippa et al., 2014),西班牙伊比利亚南东(Diéguez et al., 2005),新西兰(Wilson et al., 1976),南非罗德西亚(Falcon Rosemary S, 1975),南极洲维多利亚(Kyle Rosemary A, 1977)等地二叠系之中。

其他属种多广泛分布于欧亚大陆、北美、非洲、南美洲及拉丁美洲等地晚古生代—早中生代地层中,如:*Leiotriletes adnatus* 分布于中国新疆、山东、山西、河南、江苏、浙江、内蒙古鄂尔多斯等地莫斯科阶-吴家坪阶(欧阳舒,1962;黄嫔等,2002;欧阳舒等,2003;Zhu et al., 2005;李守军等,2013;Liu et al., 2015),意大利白云石山脉西部二叠—三叠系之交(Spina Amalia et al., 2015),挪威巴伦支海谢尔普霍夫阶—莫斯科阶下部(Lindstrom Sofie, 2003),保加利亚索非亚上石炭统上部—二叠系(Yanev Slavcho, 2009),英国威尔士煤田莫斯科阶—卡西莫夫介(Dimitrova Tatiana et al., 2005),美国密苏里州卡拉威泥盆纪(Upshaw Charles et al., 1965),南美洲巴拉圭巴拉那盆地西部二叠系(Loinaze et al., 2010)等等。

以上分子,与内蒙古阿鲁科尔沁旗陶海营子剖面和林西地区晚二叠世孢粉有较大的相似和可比性,呈现裸子植物花粉占优势或主导的一种状态,且裸子植物花粉中以无肋双囊花粉占优势(康玉柱,2009;杨兵等,2014),总体上展现了晚二叠世孢粉植物群面貌,特征分子 *Klausipollenites schaubergeri* 的出现更加说明了当前孢粉组合时代属于晚二叠世。值得一提的是,*K. schaubergeri* 如今亦报道于早三叠世初期地层之中(Jha Neerja et al., 2012;Spina Amalia et al., 2015)。

6 结 论

(1)突地2井(TD-2)孢粉化石与大兴安岭地区当前已报道的阿鲁科尔沁旗和林西地区晚二叠世孢粉有较大的相似和可对比性,呈现裸子植物花粉占优势或主导地位,且裸子植物花粉中又以无肋双囊花粉占优势的状态,展现了晚二叠世孢粉植物群面貌。

(2)林西组孢粉化石、淡水 *Palaeanodonta-Palaeomutela* 动物群、近原地埋藏的 *Callipteris-Comia-Iniopteris* 植物组合以及关于林西组沉积环境的有关报道和发现,说明林西组是一套以潟湖-陆相湖泊为主的沉积地层,指示晚二叠世时期,分隔佳蒙和华北两大地块的古亚洲洋南支已经消亡,这为探讨佳蒙与华北板块的构造演化提供了有力支撑。

(3)TD-2井中侏罗世万宝组边缘相巨厚砂砾岩层直接不整合覆于晚古生代林西组地层之上,一方面说明钻孔位置处于盆地边缘附近;同时验证了突泉盆地及其周边地区中、新生带沉积-火山岩之下确实存在晚二叠世林西组地层,为建立突泉盆地乃至松辽盆地内地层系列提供了可靠的新材料;另外,盆内林西组暗色泥岩及优质烃源岩的发现,对下一步开展松辽及周边盆地晚二叠世林西组乃至上古生界油气资源前景研究具有重要的意义。

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注释

❶内蒙古自治区115地质队, 1985.内蒙古自治区突泉县—科尔沁右翼中旗牤牛海煤田3区初步勘探(最终)地质报告[J].

❷ 内蒙古自治区115地质队. 1985. 内蒙古自治区突泉县牤牛海煤田4区1井田北延初步勘探(最终)地质报告[J].

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