

doi: 10.12029/gc20200317

张德军, 张健, 郑月娟, 陈树旺, 苏飞, 黄欣, 张海华, 甄甄. 2020. 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[J]. 中国地质, 47(3): 798-809.

Zhang Dejun, Zhang Jian, Zheng Yuejuan, Su Fei, Chen Shuwang, Huang Xin, Zhang Haihua, Zhen Zhen. 2020. 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[J]. Geology in China, 47(3):798-809(in Chinese with English abstract).

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)

摘要: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牯牛海凹陷 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*, *Piceapollenites opimus*, *P. sp.*, *Voltziaceasporites 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, 具有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

中图分类号: Q913.84; P534.46; P618.13 文献标志码: A 文章编号: 1000-3657(2020)03-0798-12

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)

收稿日期: 2017-12-26; 改回日期: 2019-08-18

基金项目: 中国地质调查局项目(DD20190097)和国家自然科学基金项目(31670215, 41702032)联合资助。

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*, *Piceapollenites 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 stratigraphy; 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.

Fund support: Supported by the Program of China Geological Survey (No. DD20190097) and National Natural Science Foundation of China (No. 31670215, No. 41702032).

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 *Palaeanoontad 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 *Palaeanoontad*—*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;南部为牯牛海凹陷,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—牯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牯牛海西侧约9 km处,为牯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,煤田地质研究将牯牛海矿区地表产动、植物化石的含煤层砂砾岩组合定义到早—中侏罗世^{①②};前人依据采到的 *Equisetum laterale*, *Raphalia 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

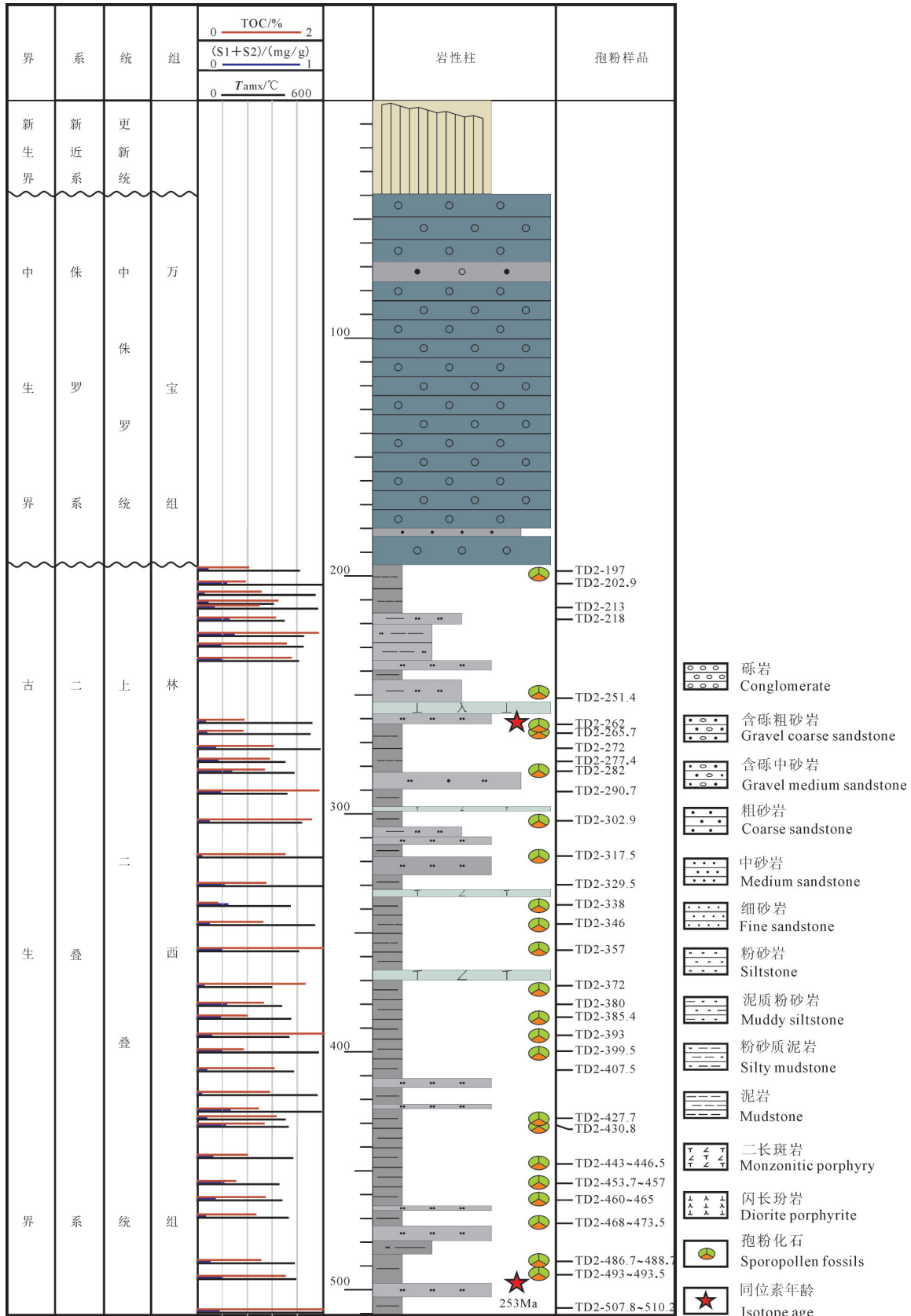


图2 内蒙古突泉县突地2(TD2)井综合柱状图
Fig. 2 Stratigraphic column of TD2 borehole in Tuquan County, Inner Mongolia

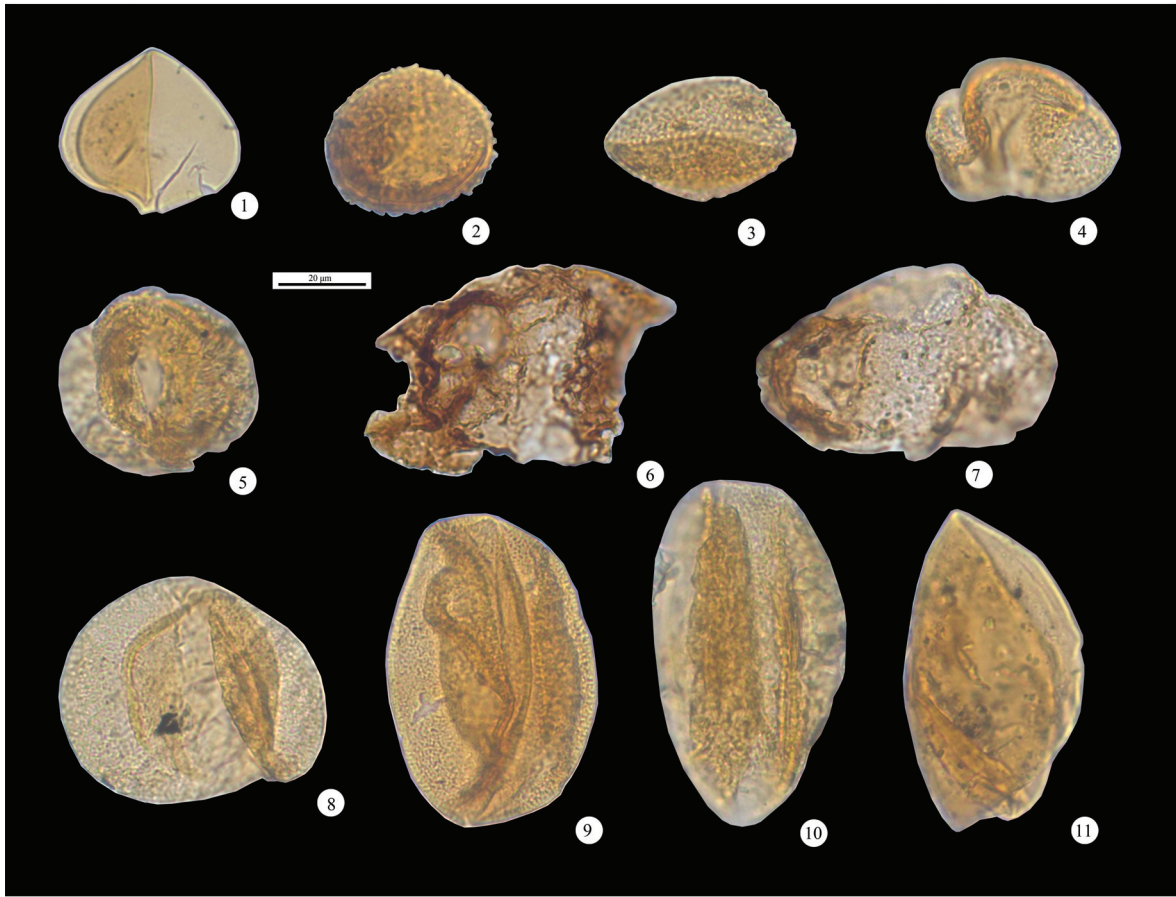


图3 内蒙古突泉县牻牛海地区突地2井(TD2)上二叠统林西组孢粉化石

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—粗糙锥囊粉; 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—*Piceapollenites* 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. stenoholcus*, *A. sp.?*, *Klausipollenites schaubergeri*, *Sulcatisporites dalongkouensis*, *S. ovatus*, *S. sp.?*, *Piceapollenites opimus*, *P. sp.*, *Voltziaceasporites 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)。*Voltziaceasporites 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)乐平统一下三叠统底部,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 Pereira 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)、安徽祁山(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(Loiñaze 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 *Palaeonodonta-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。

致谢: 本文写作过程中,吉林大学古生物学与地层学研究中心的孙跃武教授和张淑芹研究员给予了悉心指导和大力帮助;野外及样品采集过程中得到长江大学邓超伟的协助;文献收集方面得到了长江大学的董曼老师、沈阳师范大学梁飞老师、吉林大学郎嘉彬老师、李宁老师、那玉玲博士、李云峰博士、黄薇博士和李想等的帮助,在此一并致谢。

注释

① 内蒙古自治区 115 地质队, 1985. 内蒙古自治区突泉县—科尔沁右翼中旗牦牛海煤田 3 区初步勘探(最终)地质报告[J].

② 内蒙古自治区 115 地质队, 1985. 内蒙古自治区突泉县牦牛海煤田 4 区 1 井田北延初步勘探(最终)地质报告[J].

References

Chen Shuwang, Ding Qihong, Zheng Yuejuan, Li Yongfei, Wang Jie, Zhang Jian, Su Fei, Gao Xiaoyong, Li Xiaohai, Zhang Yongsheng,

Fang Hui, Zhang Minghua, Zhong Qing. 2010. Early Jurassic-Late Paleozoic hydrocarbon potential analysis in the periphery of Songliao Basin [J]. *Mineral Deposits*, 29(Supp.):1037-1038 (in Chinese).

Chen Shuwang, Zhang Haihua, Zheng Yuejuan, Bian Xiongfei, Zhang Jian, Su Fei, Gong Fanhao, Huang Xin, Zhen Zhen. 2015. Detrital zircon LA-ICP-MS U-Pb age of the Late Permian Linxi Formation in Horqin Right Wing Middle Banner-Tuquan area of Inner Mongolia and its geological significance[J]. *Geological Bulletin of China*, 34(10):1869-1877 (in Chinese with English abstract).

Crippa G, Angiolini L, Van W I, Crow M J, Hasibuan F, Stephenson M H, Ueno K. 2014. Brachiopods, fusulines and palynomorphs of the Mengkarang Formation (Early Permian, Sumatra) and their palaeobiogeographical significance [J]. *Journal of Asian Earth Sciences*, 79: 206-223.

Du Fengjun, Lu Shuwei, Gao Lianda, Zhang Yanqi, Jia Gong-xiang. 2006. Characteristics and significance of the Late Permian sporopollen assemblage in the Gongjiubu area, Ngamring, southern Tibet, China [J]. *Geological Bulletin of China*, 25 (1/2) :168-172 (in Chinese with English abstract).

Diéguez Carmen, Barrón Eduardo. 2005. Late Permian flora and vegetation changes near the Permian-Triassic boundary in the Landete section of the Alcotas Formation (SE Iberian Ranges, Spain) [J]. *Palaeogeography, Palaeoclimatology, Palaeoecology*, 229(1/2): 54-68.

Dimitrova Tatiana K H, Cleal Christopher J, Thomas Barry A. 2005. Palynology of late Westphalian - early Stephanian coal-bearing deposits in the eastern South Wales Coalfield[J]. *Geological Magazine*, 142(6): 809-821.

Falcon Rosemary S. 1975. Palyno-stratigraphy of the lower Karroo sequence in the central Sebungwe District, Mid-Zambezi Basin, Rhodesia [J]. *Palaeont. Afr.*, 18: 1-29.

Foster C B, Afonin S A. 2005. Abnormal pollen grains: an outcome of deteriorating atmospheric conditions around the Permian-Triassic boundary[J]. *Journal of the Geological Society*, 162(4): 653-659.

Gao Lianda, Shen Zhida, Qin Dianxi. 1989. Discovery of early Permian sporopollen assemblages from Kaili County, Guizhou and stratigraphic significance[J]. *Guizhou Geology*, 6(2): 97-109 (in Chinese with English abstract).

Huang Benhong. 1983. On Late Paleozoic Palaeophytogeographic Regions of Eastern Tianshan-Hingan Foldbelt and Its Geological Significance [C]// Tang Kedong (ed.). *Contributions for the Project of Plate Tectonics in Northern China*, No. 1. Beijing: Geological Publishing House, 135-155 (in Chinese).

Huang Benhong. 1983. Plant fossils of the Taohaiyingzi Formation in the eastern Inner Mongolia [J]. *Plant Journal*, 26(6): 580-583 (in Chinese with English abstract).

Huang Benhong. 1993. Carboniferous and Permian Systems and Floras

- in the Da Hinggan Range[M]. Beijing: Geological Publishing House, 1–141 (in Chinese).
- Huang Pin, Zhu Huaicheng, Wang Ayun. 2002. Palynofloras of the Shanxi Formation from the Wangzhuang Coal Mine of Xuzhou, Jiangsu and their stratigraphical significance [J]. *Acta Micropala eontologica Sinica*, 19(3): 33–52 (in Chinese with English Abstract).
- Huang Xin, Zheng Yuejuan, Bao Qingzhong. 2015. New discovery of sporopollen fossils from Linxi Formation in Arun Qi, Inner Mongolia[C]// Chinese Society of Paleontology. Abstracts of Papers of the 28th Annual Meeting of Chinese Paleontology Society. Shenyang: Chinese Paleontology Society, 87 (in Chinese).
- Jan I U, Stephenson M H, Khan F R. 2009. Palynostratigraphic correlation of the Sardhai Formation (Permian) of Pakistan[J]. *Review of Palaeobotany and Palynology*, 158(1): 72–82.
- Jha Neerja, Aggarwal Neha. 2012. Permian–Triassic palynostratigraphy in Mailaram area, Godavari Graben, Andhra Pradesh, India[J]. *Journal of Earth System Science*, 121(5): 1257–1285.
- Kang Xiaoqian, Feng Xuan, Hou Hesheng, Sun Chengcheng, Liu Qian, Yu Hailong. 2019. Carboniferous– Permian stratigraphic thickness innorthern Songliao Basin: Evidence from deep reflection seismic data[J]. *Geology in China*, 46(5): 1116–1125 (in Chinese with English abstract).
- Kang Yuzhu. 2009. The Oil and Gas prospect of Paleozoic in several areas of the Northeast, North and the West China [J]. *Journal of Southwest Petroleum University (Science & Technology Edition)*, 31(3): 1–7 (in Chinese with English abstract).
- Kyle Rosemary A. 1977. Palynostratigraphy of the Victoria Group of South Victoria Land, Antarctica [J]. *New Zealand Journal of Geology and Geophysics*, 20(6): 1081–1102.
- Li Fulai, Qu Xiyu, Liu Li, Yang Deming, Wang Dehai, Zhao Guoxiang. 2009. Sedimentary environment of the Upper Permian Linxi Formation in Northeastern Inner Mongolia [J]. *Acta Sedimentologica Sinica*, 27(2): 265–272 (in Chinese with English abstract).
- Li Shizhen, Zhou Xingui, Wang Dandan, Lin Yanhua, Zhang Wenhao. 2015. Geochemical characteristics of crude oil and oil– source correlation of well Tucan 1, Tuquan Basin, Inner Mongolia[J]. *Geological Bulletin of China*, 34(10):1946–1951 (in Chinese with English abstract).
- Li Shoujun, Zhao Xiuli, Yin Tiantao, Yuan Liyuan, He Miao, Xu Fenglin, Chen Ru, Huang Pengpeng. 2013. The characteristics of Early to Middle Permian sporopollen assemblages in Pengzhuang, Shangong Province [J]. *Acta Geologica Sinica*, 87(2): 1819–1825 (in Chinese with English abstract).
- Liang Tianyi, Liu Jingdang, Zhang Yanfei, Wang Gang, Wang Yan, Ding Wei, Zhang Hailong. 2019. Marine facies oncolite found in Permian Linxi Formation in middle Da Higgan Mountains in Northeast China [J]. *Geology in China*, 46(1): 213– 214 (in Chinese).
- Li Wenguo, Li Qingfu, Jiang Wandu. 1996. Stratigraphy (Lithostratic) of Nei Mongol Autonomous Region[M]. Wuhan: China University of Geosciences Press , 1–344 (in Chinese).
- Lindstrom Sofie. 2003. Carboniferous palynology of the Loppa High, Barents Sea, Norway[J]. *Norsk Geologisk Tidsskrift*, 83(4):333–350.
- Liu Feng, Zhu Huaicheng, Ouyang Shu. 2015. Late Pennsylvanian to Wuchiapingian palynostratigraphy of the Baode section in the Ordos Basin, North China[J]. *Journal of Asian Earth Sciences*,111: 528–552.
- Liu Ling, Zhang Minghua, Tian Qianning, Shang Longping. 2013. The method of using gravity and magnetic data for Gravity field separating in Tuquan Basin and 3D inversion of rock [J]. *Geophysical & Geochemical Exploration*, 37(2): 242– 245 (in Chinese with English abstract).
- Liu Zhaosheng. 2000. The Permian–Triassic boundary on the Northern Margin of the Turpan– Hami basin of Xinjiang, NW China [J]. *Journal of Stratigraphy*, 24(4): 310–314 (in Chinese with English abstract).
- Loinaze VS Perez, Césari Silvia Nelida, Gamundi O López, Buatois L. 2010. Palynology of the Permian San Miguel Formation (Western Paraná Basin, Paraguay): Gondwanan biostratigraphic correlations[J]. *Geologica Acta*, 8(4): 483–493.
- Lu Yanban Yuan Xiurun. 1988. Sporopollen assemblage in Late Paleozoic Coal series of Dangshan, Anhui Province [J]. *Experimental Petroleum Geology*, 10(1): 44–52 (in Chinese with English abstract).
- Meyen S V. 1991. Paleozoic Floras and Phytogeography of Eurasia[M] // Yao Zhaoqi (ed.). Nanjing: Nanjing University Press, 1–177 (in Chinese).
- Murthy S, Kavali P S. 2015. Bernardes–de–Oliveira M. E. C. Latest Permian palynomorphs from Jharia Coalfield, Damodar Basin, India and their potential for biostratigraphic correlation [J]. *Revue de Micropaléontologie*,58(3): 167–184.
- Ouyang Shu. 1962. The microspore assemblage from the Lungtan Series of Changhsing, Chekiang [J]. *Acta Palaeontologica Sinica*, 10(1): 76–141 (in Chinese with English abstract).
- Ouyang Shu, John Utting. 1990. Palynology of Upper Permian and Lower Triassic rocks, Meishan, Changxing County, Zhejiang Province, China[J]. *Review of Palaeobotany and Palynology*, 66 (1): 65–103.
- Ouyang Shu, Wang Zhi, Zhan Jiazhen. 2003. Palynology of the Carboniferous and Permian Strata of Northern Xinjiang, Northwestern China[M]. Hefei: University of Science and Technology of China Press, 1–700 (in Chinese).
- Ouyang Shu, Zhu Huaicheng, Zhan Jiazhen, Wang Zhi. 2004. Comparison of Permian Palynofloras from the Junggar and Tarim Basins and its bearing on phytoprovincialism and stratigraphy[J]. *Journal of Stratigraphy*, 28(3): 194–207 (in Chinese with English

- abstract).
- Qiu Shilong, Zhao Qingying, Li Shichao, Li Zihao, Tian Zilong, Li Shixian, Zheng Zeyu. 2018. The Late Jurassic I - type granite from Baohetun of Tuquan region in Eastern Inner Mongolia: Geochemistry, petrogenesis and geologic implication [J]. *Geology and Resources*, 27(2): 107–116(in Chinese with English abstract).
- Qu Yonggui. 1986. A new cognition on the Permian System in the Yiema Area, Western Jilin[J]. *Jilin Geology*, 1: 58–65 (in Chinese with English abstract).
- Ren Shoumai, Qiao Dewu, Zhang Xingzhou, Liu Yongjiang, Wang Nan, Sun Yuewu, Tang Zhenxing, Cui Yongqian. 2011. The present situation of oil & gas resources exploration and strategic selection of potential area in the Upper Paleozoic of Songliao Basin and surrounding area, NE China[J]. *Geological Bulletin of China*, 30(2/3): 197–204 (in Chinese with English abstract).
- Schneebeil Hermann Elke, Bucher Hugo. 2015. Palynostratigraphy at the Permian–Triassic boundary of the Amb section, Salt Range, Pakistan[J]. *Palynology*, 39(1): 1–18.
- Shi Xiao, Yu Jianxin, Chen Bin, Huang Cheng, Gu Songzhu, Li Hui, Chi Hongfei. 2004. Palynology of the Lower Permian Dazhuyuan and Liangshan Formations in Wuchuan–Zheng’an–Daozhen area, northern Guizhou Province [J]. *Journal of Palaeogeography*, 16(2): 217–226 (in Chinese with English abstract).
- Spina Amalia, Cirilli Simonetta, Utting John, Jansonius Jan. 2015. Palynology of the Permian and Triassic of the Tesero and Bulla sections (Western Dolomites, Italy) and consideration about the enigmatic species *Reduviasporonites chalastus*[J]. *Review of Palaeobotany and Palynology*, 218: 3–14.
- Spina A, Aria–Nasab M R, Cirilli S, Stephenson M H. 2015. Palynostratigraphy of the Permian Faraghan Formation in the Zagros Basin, Southern Iran: preliminary studies[J]. *Executive Notes*, (61): 1–22.
- Steiner M B, Eshet Y, Rampino M R, Schwindt D M. 2003. Fungal abundance spike and the Permian –Triassic boundary in the Karoo Supergroup (South Africa) [J]. *Palaeogeography, Palaeoclimatology, Palaeoecology*, 194(4): 405–414.
- Su Fei, Li Zhen, Zhang Jian, Tang Youjun, Zhang Haihua. 2017. Discovery of the source rock from Upper Permian Linxi Formation in Tuquan Basin, Inner Mongolia[J]. *Geology and Resources*, 26(3): 268–274(in Chinese with English abstract).
- Sun Chunlin, Li Tao, Wu Wenhao, Wang Lixia, Zhang Lijun. 2012. An aquatic fern leaf from the Late Triassic of Western Liaoning, China[J]. *Journal of the Geological Society of Japan*, 58: 227–228.
- Sun Yuewu, Zhang Shuqin, Wan Chuanbiao, Zhang Dejun, Li Mingsong. 2012. Lopingian palynomorphs in the Linxi Formation, Inner Mongolia, China[J]. *Journal of the Geological Society of Japan*, 58: 228.
- Upshaw Charles F, Creath Wilgus B. 1965. Pennsylvanian miospores from a cave deposit in Devonian limestone, Callaway County, Missouri[J]. *Micropaleontology*, 11(4): 431–448.
- Van der Voo R, Spakman W, Bijwaard H. 1999. Mesozoic subducted slabs under Siberia[J]. *Nature*, 397(6716):246–249.
- Wang Chengwen, Jin Wei, Zhang Xingzhou, Ma Zhihong, Chi Xiaoguo, Liu Yongjiang, Li Ning. 2008. New understanding of the Late Paleozoic tectonics in Northeastern China and adjacent areas[J]. *Journal of Stratigraphy*, 32(2): 119–136 (in Chinese with English abstract).
- Wang Chenwen, Sun Yuewu, Li Ning, Liu Huan, Zhao Guowei. 2009. On the distribution of Late Palaeozoic strata in Northeast China[J]. *Journal of Stratigraphy*, 33(1): 56–61 (in Chinese with English abstract).
- Wang Shixin, Hu Chang’an, Luo Guichang, Li Hui, Wang Ping, Gan Jijun, Yang Yan. 2011. Recognition of the Late Permian Strata in Shaerhu coalfield in Turpan–Hami Basin, Xinjiang [J]. *Xinjiang Geology*, 29(3): 275–283 (in Chinese with English abstract).
- Wang Wuli, Li Yongfei, Guo Shengzhe. 2014. The northeast China Block Group and Its tectonic evolution[J]. *Geology and Resources*, 23(1): 4–24(in Chinese with English abstract).
- Wilson Graeme J. 1976. Notes from the New Zealand geological survey—9: Permian palynomorphs from the Mangarewa Formation, Productus Creek, southland, New Zealand[J]. *New Zealand Journal of Geology and Geophysics*, 19(1): 136–140.
- Yanev Slavcho. 2009. Stratigraphy and sedimentology of the Stephanian and Permian in the Lozen Mts. and Vakarel Hills[J]. *Geological Institute, Bulgarian Academy of Sciences*,70(1/3): 73–89 (in Russian with English summary).
- Yang Bing, Zhang Xionghua, Ge Mengchun, Zhao Shengmin, Wei Yi, Huang Xing, Luan Tengfei, Wei Xinxiang, Yang Zhiyong. 2014. Late Permian–Early triassic palynological assemblages in Linxi, Inner Mongolia and discovery of Triassic strata [J].*Earth Science (Journal of China University of Geosciences)*, 39(7): 784–794 (in Chinese with English abstract).
- Yang Xuelin, Sun LiWen. 1985. Jurassic fossil plants from the Southern part of Dahingganling, China [J]. *Bull. Shenyang Inst. Geol. Min. Res., Chinese Acad. Geol. Sci.*, 12: 98–114(in Chinese with English abstract).
- Yang Xuelin, Sun LiWen. 1985. Strata of the Early and Middle Jurassic in the Southern part of Dahingganling, China [J]. *Journal of Stratigraphy*, 9(1): 56–61 (in Chinese).
- Yao Jianxin, Xiao Xuchang, Gao Lianda, Wang Naiwen, Ji Wenhua, Wang Shiyan, Wang Yong, Chi Zhenqing. 2007. Discovery of Permian sporopollen from Daftar, Taxkorgan, Xinjiang and their geological implications[J]. *Palaeogeography, Palaeoclimatology, Palaeoecology*, 252(1): 66–71.
- Yin Hongfu, Yang Fengqing, Yu Jianxin, Peng Yuanqiao, Wang Shangyan, Zhang Suxin. 2007. An accurately delineated Permian–Triassic Boundary in continental successions[J]. *Science in China (Series D: Earth Sciences)*, 50(9): 1281–1292.

- Zélia Pereira, Paulo Fernandes, Gilda Lopes, João Marques, Lopo Vasconcelos. 2016. The Permian– Triassic transition in the Moatize– Minjova Basin, Karoo Supergroup, Mozambique: A palynological perspective[J]. *Review of Palaeobotany and Palynology*, 226:1–19.
- Zhang Dejun, Sun Yuewu, Ding Haisheng, Yang Zhenyuan, Tang Lijing. 2014. Lopingian mixed floras from Linxi Formation in Soron area, Inner Mongolia [J]. *Global Geology*, 17(2): 67–77.
- Zhang Dejun, Zhang Jian, Zheng Yuejuan, Chen Shuwang, Su Fei, Huang Xin, Zhang Haihua. 2019. Study on the Middle Jurassic flora in Southern Tuquan Basin, Inner Mongolia [J]. *Geology and Resources*, 28(1):7–12 (in Chinese with English abstract).
- Zhang Haihua, Zheng Yuejuan, Chen Shuwang, Zhan Jian, Gong Fanhao, Su Fei, Huang Xin. 2015. Age of Xingfuzhulu Formation and contact relationship between Permian and Triassic strata in southern Da Hinggan Mountains: Constraints from the tuff zircon U–Pb ages[J]. *Geology in China*, 42(6): 1754–1764 (in Chinese with English abstract).
- Zhang Meisheng, Peng Xiangdong, Sun Xiaomeng. 1998. The Paleozoic Tectonic Geographical Pattern of Northeast China [J]. *Liaoning Geology*, 1(2): 91–96 (in Chinese with English abstract).
- Zhang Yongsheng, Tian Shugang, Li Zishun, Gong Yuexuan, Xing Enyuan, Wang Zhuozhuo, Zhai Daxing, Cao Jie, Sui Kui, Wang Meng. 2013. Discovery of marine fossils in the upper part of the Permian Linxi Formation in Lopingian, Xingmeng area, China[J]. *Chinese Science Bulletin*, 58: 3429–3439 (in Chinese).
- Zhao Yue, Yang Zhenyu, Ma Xinghua. 1994. Geotectonic transition from PaleoAsian system and Paleo– Tethyan system to Paleopacific active continental margin in eastern Asia[J]. *Scientia Geologica Sinica*, 29(2):105–119 (in Chinese with English abstract).
- Zhen Zhen, Chen Shuwang, Zheng Yuejuan, Zhang Jian, Li Yongfei, Su Fei, Huang Xin, Gong Fanhao. 2018. Geochemical characteristics of Linxi Formation along Taohaiyingzi section in Ar Horqin Banner, Inner Mongolia, and the constraint on the provenances and the tectonic settings[J]. *Geology in China*, 45(5): 1011–1022 (in Chinese with English abstract).
- Zheng Yuejuan, Zhang Jian, Chen Shuwang, Huang Xin, Zhang Lijun, Wang Wuli. 2013. New fossil discovery along the section of Linxi Formation at Taohaiyingzi in Ar Horqin Banner, Inner Mongolia [J]. *Geological Bulletin of China*, 32(8):1269–1276 (in Chinese with English abstract).
- Zhu Huaicheng, Ouyang Shu, Zhan Jiazhen, Wang Zhi. 2005. Comparison of Permian palynological assemblages from the Junggar and Tarim Basins and their phytoprovincial significance[J]. *Review of Palaeobotany and Palynology*, 136(3): 181–207.
- 张永生, 方慧, 张明华, 钟清. 2010. 松辽外围早侏罗世—晚古生代油气远景分析[J]. *矿床地质*, 29(Z1): 1037–1038.
- 陈树旺, 张海华, 郑月娟, 卞雄飞, 张健, 苏飞, 公繁浩, 黄欣, 甄甄. 2015. 内蒙古科右中旗—突泉地区晚二叠世林西组碎屑岩 LA–ICP–MS 锆石 U–Pb 年龄及其地质意义[J]. *地质通报*, 34(10): 1869–1877.
- 杜凤军, 卢书炜, 高联达, 张彦启, 贾共祥. 2006. 藏南昂仁县贡久布地区晚二叠世孢粉组合的特征及其意义[J]. *地质通报*, 25(1): 168–172.
- 高联达, 沈志达, 秦典燮. 1989. 贵州凯里地区早二叠世早期孢子花粉的发现及其地层意义[J]. *贵州地质*, 6(2): 97–109.
- 黄本宏. 1983. 天山—兴安褶皱区东部古生代末植物地理区系及其地质意义[C]//唐克东编. 中国北方板块构造文集(第一集). 沈阳: 中国地质科学院沈阳地质矿产研究所: 138–155.
- 黄本宏. 1983. 内蒙古东部陶海营子组植物化石[J]. *植物学报*, 25(6): 580–583.
- 黄本宏. 1993. 大兴安岭地区石炭、二叠系及植物群[M]. 北京: 地质出版社, 1–141.
- 黄焱, 朱怀诚, 王阿云. 2002. 徐州王庄煤矿山西组孢粉植物群及其地层意义[J]. *微体古生物学报*, 19(3): 33–52.
- 黄欣, 郑月娟, 张健, 鲍庆中. 2015. 内蒙古阿荣旗林西组孢粉化石新发现[C]//中国古生物学会. 中国古生物学会第28届学术年会论文摘要集. 沈阳: 中国古生物学会, 87.
- 康晓倩, 冯恒, 侯贺晟, 孙成城, 刘乾, 俞海龙. 2019. 松辽盆地北部石炭—二叠纪地层厚度: 来自深反射地震的证据[J]. *中国地质*, 46(5): 1116–1125.
- 康玉柱. 2009. 中国东北、华北、西部等地区古生界油气前景探讨[J]. *西南石油大学学报(自然科学版)*, 31(3): 1–7.
- 梁天意, 刘敬党, 张艳飞, 王刚, 汪岩, 丁伟, 张海龙. 2019. 中国大兴安岭中段二叠系林西组发现海相核形石[J]. *中国地质*, 46(01): 213–214.
- 李福来, 曲希玉, 刘立, 杨德明, 王德海, 赵国祥. 2009. 内蒙古东北上部二叠统林西组沉积环境[J]. *沉积学报*, 27(2): 265–272.
- 李世臻, 周新桂, 王丹丹, 林燕华, 张文浩. 2015. 内蒙古突泉盆地突参1井原油地球化学特征与油源分析[J]. *地质通报*, 34(10): 1946–1951.
- 李守军, 赵秀丽, 殷天涛, 原丽媛, 贺森, 徐凤琳, 陈茹, 黄彭彭. 2013. 山东彭庄早、中二叠世孢粉组合特征[J]. *地质学报*, 87(2): 1819–1825.
- 李文国, 姜万德, 王慧. 1996. 内蒙古自治区岩石地层[M]. 武汉: 中国地质大学出版社, 1–344.
- 刘玲, 张明华, 田黔宁, 尚龙平. 2013. 突泉盆地磁性体重力场剥离的方法技术及岩体三维显示[J]. *物探与化探*, 37(2): 242–245.
- 刘兆生. 2000. 吐哈盆地北缘二叠系与三叠系界线[J]. *地层学杂志*, 24(4): 310–314.
- 陆彦邦, 袁修润. 1988. 安徽砀山晚古生代煤系的孢粉组合[J]. *石油实验地质*, 10(1): 44–52.
- 梅因 C B, 姚兆奇编译. 1991. 欧亚大陆古生代植物群和植物地理学[M]. 南京: 南京大学出版社. 1–177.

附中文参考文献:

陈树旺, 丁秋红, 郑月娟, 李永飞, 王杰, 张健, 苏飞, 郜晓勇, 李晓海,

- 欧阳舒. 1962. 浙江长兴龙潭组孢子花粉组合[J]. 古生物学报, 10(1): 76-141.
- 欧阳舒, 王智, 詹家桢. 2003. 新疆北部石炭纪—二叠纪孢子花粉研究[M]. 合肥: 中国科学技术大学出版社: 1-700.
- 欧阳舒, 朱怀诚, 詹家桢, 王智. 2004. 新疆准噶尔盆地和塔里木盆地二叠纪孢粉组合的比较及其植物区系和地层意义[J]. 地层学杂志, 28(3): 193-207.
- 邱士龙, 赵庆英, 李世超, 李子昊, 田子龙, 李湜先, 郑泽宇. 2018. 内蒙古东部突泉地区宝合屯晚侏罗世 I 型花岗岩——地球化学特征、岩石成因及地质意义[J]. 地质与资源, 27(2): 107-116, 136.
- 曲永贵. 1986. 吉林省西部野马地区二迭系的新认识[J]. 吉林地质, 1: 58-65.
- 任收麦, 乔德武, 张兴洲, 刘永江, 王楠, 孙跃武, 唐振兴. 2011. 松辽盆地及外围上古生界油气资源战略选区研究进展[J]. 地质通报, 30(2/3): 197-204.
- 史骁, 喻建新, 陈斌, 黄程, 顾松竹, 李慧. 2014. 黔北务川—正安一道真地区下二叠统大竹园组和梁山组孢粉学研究[J]. 古地理学报, 16(2): 217-226.
- 苏飞, 李臻, 张健, 唐友军, 张海华. 2017. 内蒙古突泉盆地突D2井上二叠统林西组烃源岩新发现[J]. 地质与资源, 26(03): 268-274.
- 王成文, 金巍, 张兴洲, 马志红, 迟效国, 刘永江, 李宁. 2008. 东北及邻区晚古生代大地构造属性新认识[J]. 地层学杂志, 32(2): 119-136.
- 王成文, 孙跃武, 李宁, 刘欢, 赵国伟. 2009. 东北地区晚古生代地层分布规律[J]. 地层学杂志, 33(1): 56-61.
- 王世新, 胡长安, 罗桂昌, 李慧, 王平, 甘继军, 杨艳. 2011. 吐哈盆地沙尔湖煤田晚二叠世地层再认识[J]. 新疆地质, 29(3): 275-283.
- 王五力, 李永飞, 郭胜哲. 2014. 中国东北地块群及其构造演化[J]. 地质与资源, 23(1): 4-24.
- 杨兵, 张雄华, 葛梦春, 赵省民, 韦一, 黄兴, 栾腾飞, 魏信祥, 杨志勇. 2014. 内蒙古林西地区晚二叠世—早三叠世孢粉组合及三叠系的发现[J]. 地球科学(中国地质大学学报), 39(7): 784-794.
- 杨学林, 孙礼文. 1985. 大兴安岭南部侏罗纪植物化石[J]. 中国地质科学院沈阳地质矿产研究所刊, 12: 98-114.
- 杨学林, 孙礼文. 1985. 大兴安岭南部早、中侏罗世地层[J]. 地层学杂志, 9(1): 10-20.
- 张德军, 张健, 郑月娟, 陈树旺, 苏飞, 黄欣, 张海华. 2019. 内蒙古突泉盆地南部中侏罗世植物群初探[J]. 地质与资源, 28(1): 7-12.
- 张海华, 郑月娟, 陈树旺, 张健, 公繁浩, 苏飞, 黄欣. 2015. 大兴安岭南部幸福之路组的时代及二叠—三叠系界线研究——来自凝灰岩 LA-ICP-MS 锆石 U-Pb 年龄的证据[J]. 中国地质, 42(6): 1754-1764.
- 张梅生, 彭向东, 孙晓猛. 1998. 中国东北区古生代构造古地理格局[J]. 辽宁地质, 1(2): 91-96.
- 张永生, 田树刚, 李子舜, 官月莹, 邢恩袁, 王卓卓, 翟大兴, 曹洁, 苏奎, 王猛. 2013. 兴蒙地区二叠系乐平统林西组上部发现海相化石[J]. 科学通报, 58(33): 3429-3439.
- 赵越, 杨振宇, 马醒华. 1994. 东亚大地构造发展的重要转折[J]. 地质科学, 29(2): 105-119.
- 甄甄, 陈树旺, 郑月娟, 张健, 李永飞, 苏飞, 黄欣, 公繁浩. 2018. 内蒙古阿鲁科尔沁旗陶海营子剖面林西组地球化学特征及其对物源—构造背景的制约[J]. 中国地质, 45(5): 1011-1022.
- 郑月娟, 张健, 陈树旺, 黄欣, 张立君, 王五力. 2013. 内蒙古阿鲁科尔沁旗陶海营子剖面林西组化石新发现[J]. 地质通报, 32(8): 1269-1276.