

东北地区晚古生代区域构造演化

刘永江¹ 张兴洲¹ 金 巍¹ 迟效国¹ 王成文¹
马志红¹ 韩国卿¹ 温泉波¹ 赵英利¹ 王文弟² 赵喜峰³

(1. 吉林大学地球科学学院, 吉林 长春 130061; 2. 中国石油青海油田分公司勘探开发研究院, 甘肃 敦煌 8932753;
3. 吉林省核工业地质局, 吉林 长春 130062)

摘要:东北地区主要由东部佳木斯地块、中部兴安—松嫩地块和西部额尔古纳地块构成,各地块之间主要构造带拼合时代的研究表明,晚古生代之前各地块之间已经完成拼合,形成了统一的佳—蒙地块。晚古生代开始东北地区进入统一的盖层演化阶段,在佳—蒙地块南缘发育了晚古生代具有大陆边缘沉积特征的盖层建造。

晚古生代早期佳—蒙地块南缘为活动陆缘,在~320 Ma 向北的俯冲过程中古亚洲洋板块发生断离,形成火山弧,同时导致其北侧“贺根山”弧后洋的拉开,持续的向北俯冲导致弧—陆碰撞,并于~280 Ma 贺根山洋已经完全闭合。佳—蒙地块南缘开始由活动陆缘向被动陆缘环境转化,最后在晚二叠世末期古亚洲洋完全闭合转入内陆环境。

关键词:晚古生代;古亚洲洋;西拉木伦河缝合带;佳—蒙地块;东北

中图分类号:P534.4 **文献标志码:**A **文章编号:**1000-3657(2010)04-0943-09

东北地区位于北部西伯利亚板块、南部华北板块和东部太平洋板块之间围限的区域内(图 1),构造部位处于中亚造山带东端。前中生代时期主要受古亚洲洋构造体系控制,中生代以来又受到太平洋板块活动的强烈改造,构成环太平洋构造带的重要组成部分,这一地区是解决东北乃至东亚大陆构造演化的关键地区^[1]。

关于兴蒙造山带及邻区构造格局和演化历程的认识长期以来一直争议较大,20 世纪 80 年代前,对该区的构造演化的认识基本上依据多旋回槽台理论^[2-4]提出的,本区作为巨大的东亚华力西地槽褶皱区的一部分,主体分为内蒙—大兴安岭和吉黑两个多旋回地槽褶皱系,其中包含若干兴凯期固结的古老地块,最东部为那丹哈达优地槽褶皱带。

20 世纪 80 年代以来,尤其是 90 年代随着板块构造理论的引入,一些研究者确定了一系列反映板块构造作用证据的蛇绿岩、蓝片岩及与板块俯冲、碰撞有关的火山—深成岩带^[5-7]。越来越多的地质事实

表明,兴蒙造山带并非简单的西伯利亚板块与华北板块之间的缝合带,而是由位于两大板块之间的中、小块体群组成的构造拼合带^[8-10]。

1 东北及其邻区大地构造单元划分

依据板块构造观点,目前东北及其邻区通常被划分为(由西向东)额尔古纳地块、兴安地块、松嫩地块、布列亚—佳木斯地块和最东部的侏罗纪以来的陆缘增生带,以及各个地块之间的主要构造拼合带(图 1)。额尔古纳地块的主体在西部俄罗斯和蒙古境内,向南与中蒙古地块相连,向北与俄罗斯的岗仁地块相连^[10,11],以德尔布干构造带为界与东侧的兴安地块相邻。兴安地块在现今的地理位置上相当于大兴安岭,其基底主要由兴华渡口群变质岩组成,与东侧松嫩地块之间以传统的贺根山构造带为界。松嫩地块包括其西南部的锡林浩特地块,其北部与俄罗斯境内的马门地块相连,与东侧的布列亚—佳木斯地块以牡丹江构造带为界。佳木斯地块是东北区结

收稿日期:2010-07-19;改回日期:2010-07-28

基金项目:国家自然科学基金重点项目(40739905)、博士点基金项目(No. 200801830041)、中国石油化工股份有限公司科技开发项目(G0800-06-ZS-327)及国家留学基金建设高水平大学公派研究生项目(2008617114)联合资助。

作者简介:刘永江,男,1964 年生,博士,教授,主要从事构造地质学、造山带演化、构造年代学研究;E-mail: yongjiang@jlu.edu.cn。

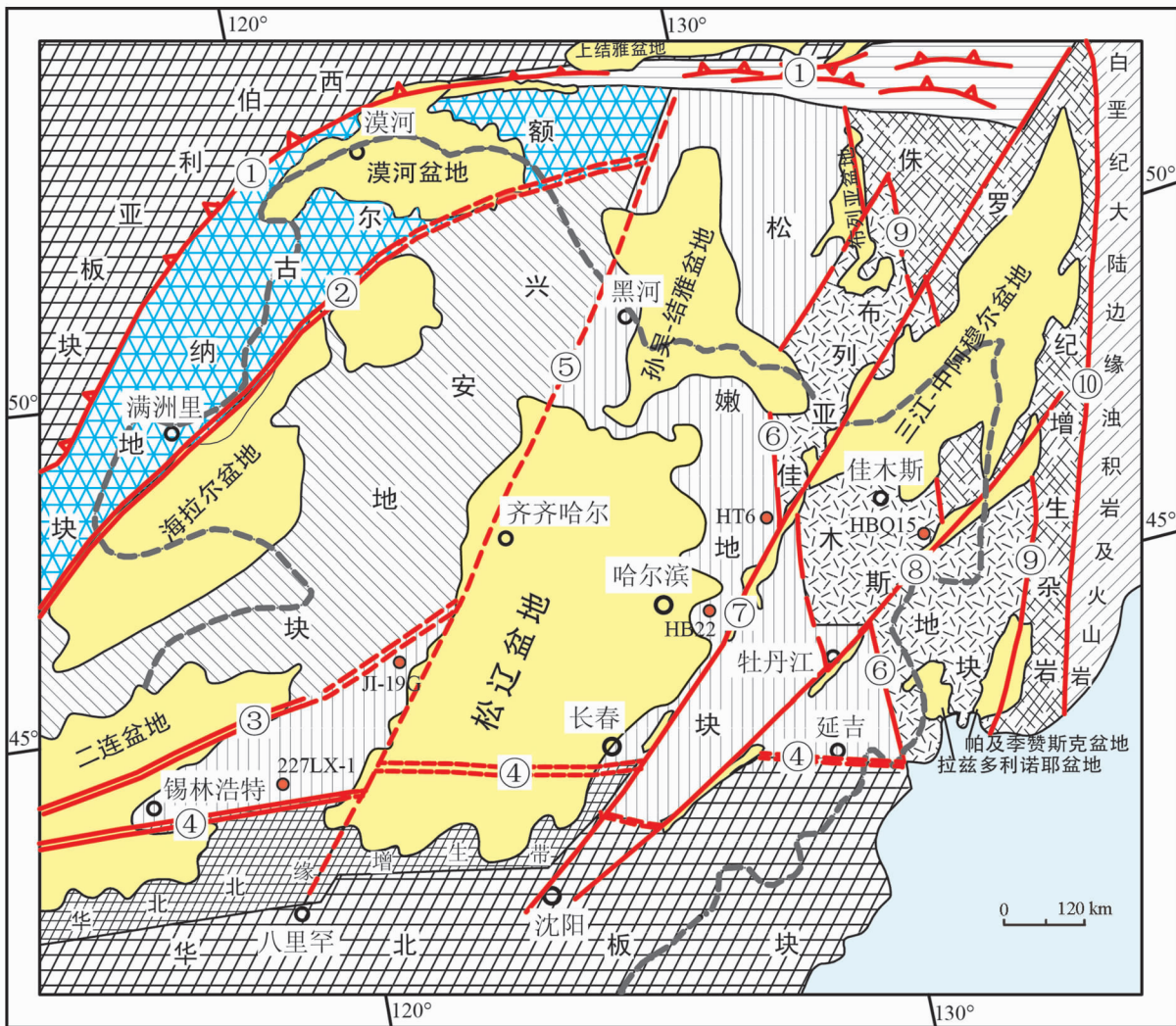


图1 东北地区构造单元图(据张兴洲等^[2]修改)

红圆点为样品采集点。①—鄂霍茨克缝合带;②—得尔布干构造带;③—贺根山缝合带;④—西拉木伦河缝合带;
 ⑤—嫩江—八里罕走滑断裂带;⑥—牡丹江断裂带;⑦—伊通—依兰走滑断裂带;⑧—敦—密走滑断裂带;⑨—锡霍特—阿林构造带

Fig.1 Tectonic divisions of Northeast China (modified after Zhang et al.^[2])

Sample locations are marked by red solid circle.

①—Okhotsk suture zone;②—Deerbugan tectonic zone;③—Hegenshan suture zone;④—Xar Moron River suture belt;
 ⑤—Neijiang—Balihan strike-slip fault;⑥—Mudanjiang fault belt;⑦—Yitong—Yilan strike-slip fault belt;⑧—Dunhua—Mishan strike-slip
 fault belt;⑨—Xihot—Alin tectonic zone

晶基底出露面积最大的古老地块,主体由高级变质的麻山群和黑龙江构造混杂岩组成,该地块北部与俄罗斯境内的布列亚地块相连,构成布列亚—佳木斯地块。

2 各地块间的拼合

长期以来,槽台学说将东北地区划归东亚海底地槽褶皱带的一部分,近些年来许多学者提出东北

亚地区造山带中诸多微板块(佳木斯地块、松嫩地块、兴安地块、额尔古纳地块等)的拼贴模式,有关这些地块的拼贴时间和方式等科学问题一直存在非常大的争议。

2.1 佳木斯地块与松嫩地块拼接时代

一般认为佳木斯地块与兴安—松嫩地块沿牡丹江断裂(图1)于早古生代拼接^[12,13],最近相继报道的黑龙江杂岩的同位素年龄显示该构造带记录有三

叠纪—侏罗纪的构造事件^[14,15]。但是,佳木斯地块东缘和松嫩地块哈尔滨东部黑龙江宫和依兰东北汤原地区早—中泥盆世沉积砂岩的碎屑锆石 U-Pb 年龄都发育有相同的 400~568 Ma 主峰值年龄(图 2)^[16],这组年龄与佳木斯地块基底麻山群的同位素年龄非常类似,说明晚古生代时期佳木斯地块与松嫩地块已经拼接,并成为滨东地区的物源区。因此,佳木斯地块与松嫩地块在泥盆纪之前就完成了拼合,两者之间的黑龙江杂岩的中生代同位素年龄很可能代表后期裂解和再闭合的热事件。

2.2 额尔古纳地块与兴安地块拼接时代

额尔古纳地块与兴安地块之间的拼合带传统上一般认为是德尔布干断裂带,认为其时代为早古生代^[17]。中亚蒙古地块与兴安地块的拼合界线为克鲁伦—赛音山达—德尔布干一线,其蛇绿岩的锆同位素年龄为 600 Ma^[18]。李春昱等^[19]报道了与该构造带拼合作用有关的钙碱系列中酸性岩浆岩的同位素年龄为 443~567 Ma。

葛文春^[20]对产于大兴安岭北部的额尔古纳地块上的塔河岩体研究表明,该岩体为后造山花岗岩组合,锆石 U-Pb 年龄为 494~480 Ma。标志着额尔古纳与南侧兴安地块间的碰撞拼合在古生代早期即已完成。同时结合新林蛇绿岩、伊敏河的头道桥和额尔古纳右旗东南的蓝片岩^[13,17]的报道,认为额尔古纳地块的东界应该位于新林—喜桂图旗一线。

2.3 兴安地块与松嫩地块

传统上通常认为兴安地块与松嫩地块沿贺根山—嫩江—黑河构造带拼接。近年来笔者对传统的贺根山—黑河构造带进行了详细的野外地质调查,研究表明,除了贺根山地区以外,该构造带的中、北段(扎兰屯—嫩江—黑河)没有发现残留洋壳的地质证据,而且该构造带西南段贺根山蛇绿岩向东延至松辽盆地西缘后,被中生代嫩江—八里罕走滑断裂所截^[21]。李锦轶等^[10]认为仰冲到东乌旗一带的具有被动陆缘特点的泥盆纪堆积物之上的贺根山蛇绿岩,很可能向东沿白城—吉林—延吉一带延伸,所以南戈壁—扎兰屯地块属于布列亚—佳木斯古板块的西延部分。

另外,吴福元等^[22,23]和张兴洲等^[2]对东北地区各地块所开展的 Nd 模式年龄研究表明,兴安地块和松嫩地块具有一致的 Nd 同位素模式年龄(1200~500 Ma)(图 3),但是明显与额尔古纳和佳木斯地块

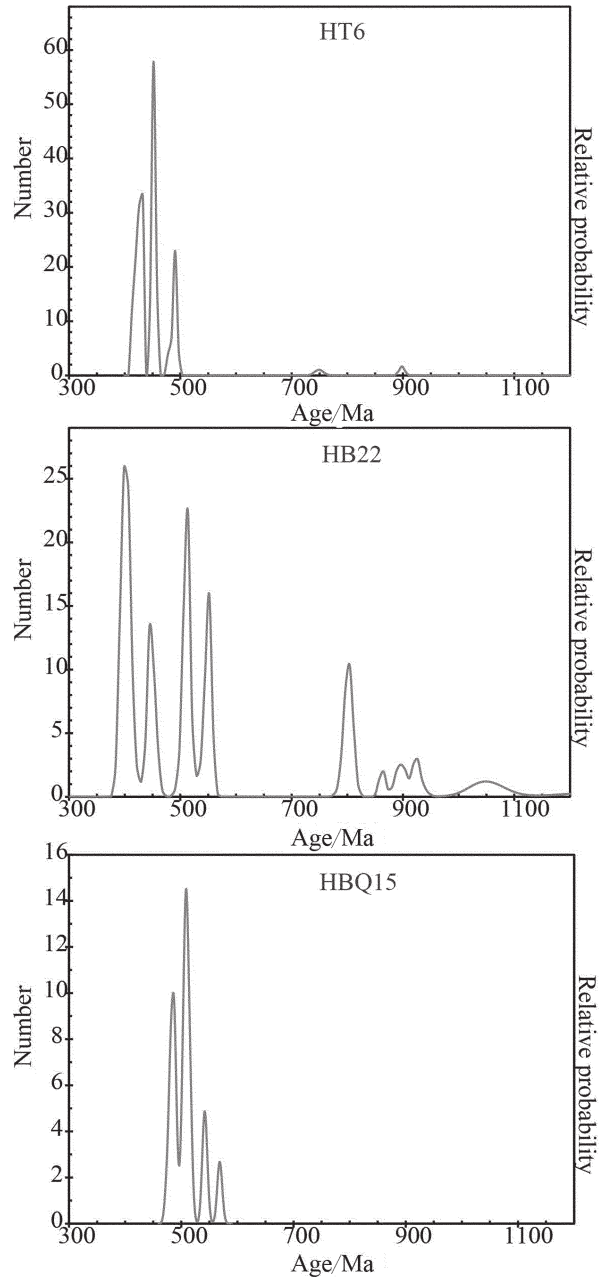


图 2 东北地区东部早中泥盆世砂岩碎屑锆石年龄频率分布图^[16](样品位置见图 1)

Fig.2 Frequency diagram of zircon ages for Early-Middle Devonian sandstones in eastern Northeast China^[16] (for sample locations see Fig. 1)

不同,这说明兴安地块和松嫩地块具有相同时代的基底,两者很可能为统一的兴安—松嫩地块,其现今的不同构造演化的差异主要是由于中生代以来构造演化造成的。

综上所述,可以推测传统上划分的兴安地块和

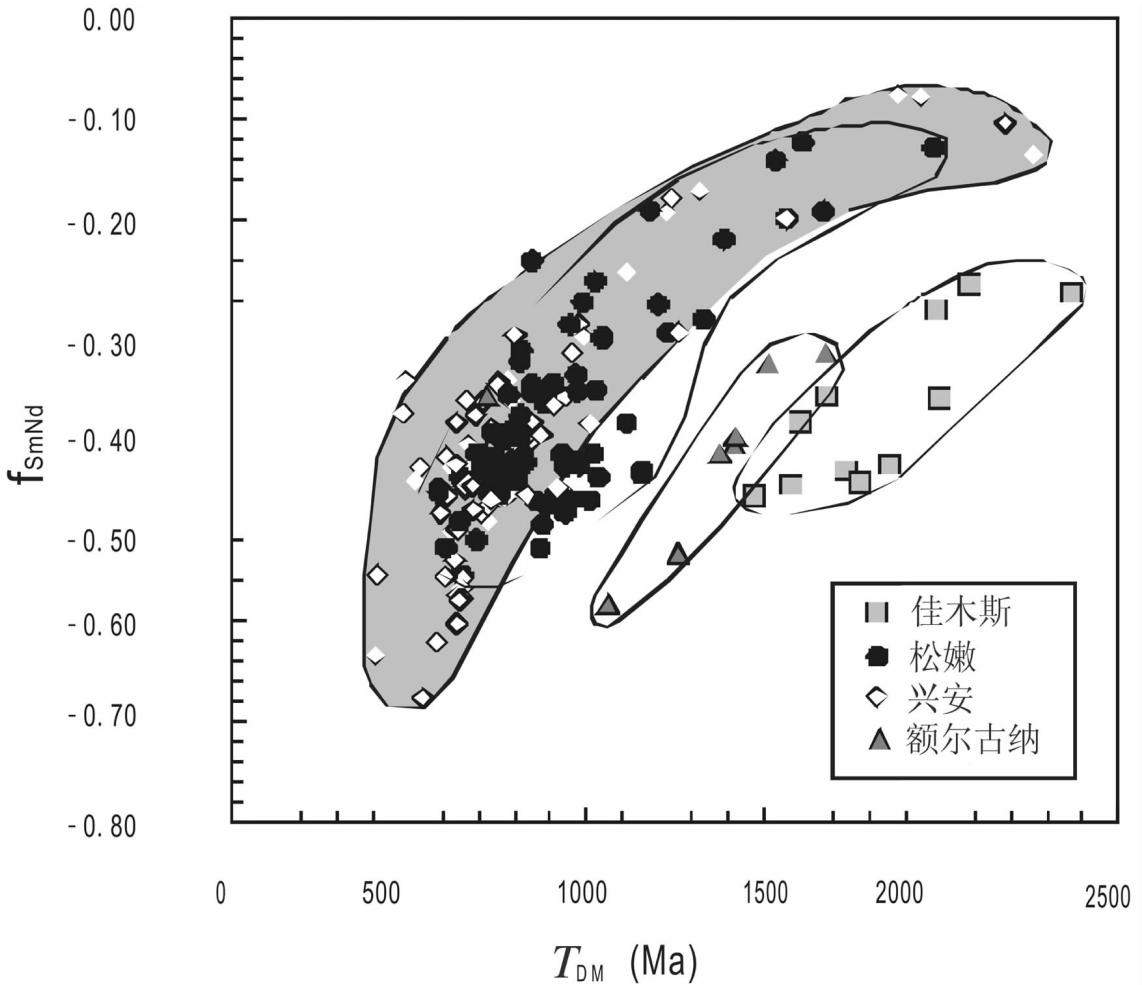


图3 东北地区不同地块壳源岩石的Nd同位素模式年龄特征^[2]

Fig.3 Nd isotopic model age features of crust-derived rocks from different blocks^[2]

松嫩地块具有统一基底，其间发育的晚古生代火山岩和花岗岩带^[1,24]应该是兴安—松嫩地块区域拉伸构造背景下的产物。

2.4 统一“佳—蒙地块”的形成

李双林等^[24]提出在西伯利亚与华北板块之间存在的诸多微陆块在早、中海西期就完成拼合，形成统一的黑龙江板块，并认为晚海西期—早印支期黑龙江板块与华北板块碰撞拼贴。

近年来王成文等^[25]对东北地区早泥盆世、石炭纪和二叠纪的沉积地层和化石分布的研究表明，在蒙古—鄂霍茨克缝合带以南和索伦—西拉木伦河缝合带以北发育有南、北两套大陆边缘沉积，空间上呈东西向在不同的地块上连续分布，而且没有发生区域变质，由此提出，东北及其邻区至少在晚古生代已

经存在一个统一的地块——“佳—蒙地块”。其分布范围北至鄂霍茨克缝合带，南至西拉木伦河缝合带，东至中锡霍特—阿林构造带。

佳木斯地块与兴安—松嫩地块至少在泥盆纪沉积前完成了拼合，额尔古纳地块与兴安—松嫩地块在早古生代完成了拼合统一，所以，晚古生代之前东北地区各地块已经完成拼合，从晚古生代开始就进入了统一的盖层演化阶段。

3 佳—蒙地块与华北板块的拼贴

西伯利亚和华北板块之间的最终闭合位置和时间一直存在较大的争议。其闭合位置有西拉木伦河缝合带和贺根山缝合带之争，闭合时间有石炭纪和二叠纪末之争。目前看来西伯利亚与华北板块的拼

合实际上就是佳—蒙地块与华北板块的拼合,近年来的研究显示佳—蒙地块和华北板块之间古亚洲洋的消亡一般认为在二叠纪末沿西拉木伦河构造带闭合^[26-29],这些研究结果主要依据对西拉木伦河构造

带内发育的各种与碰撞有关的岩石研究和定年。

笔者最近通过对佳—蒙地块南缘索伦、林西地区二叠纪砂岩碎屑锆石的同位素定年和物源分析研究^①,探讨了佳—蒙地块南缘的大地构造属性和与华

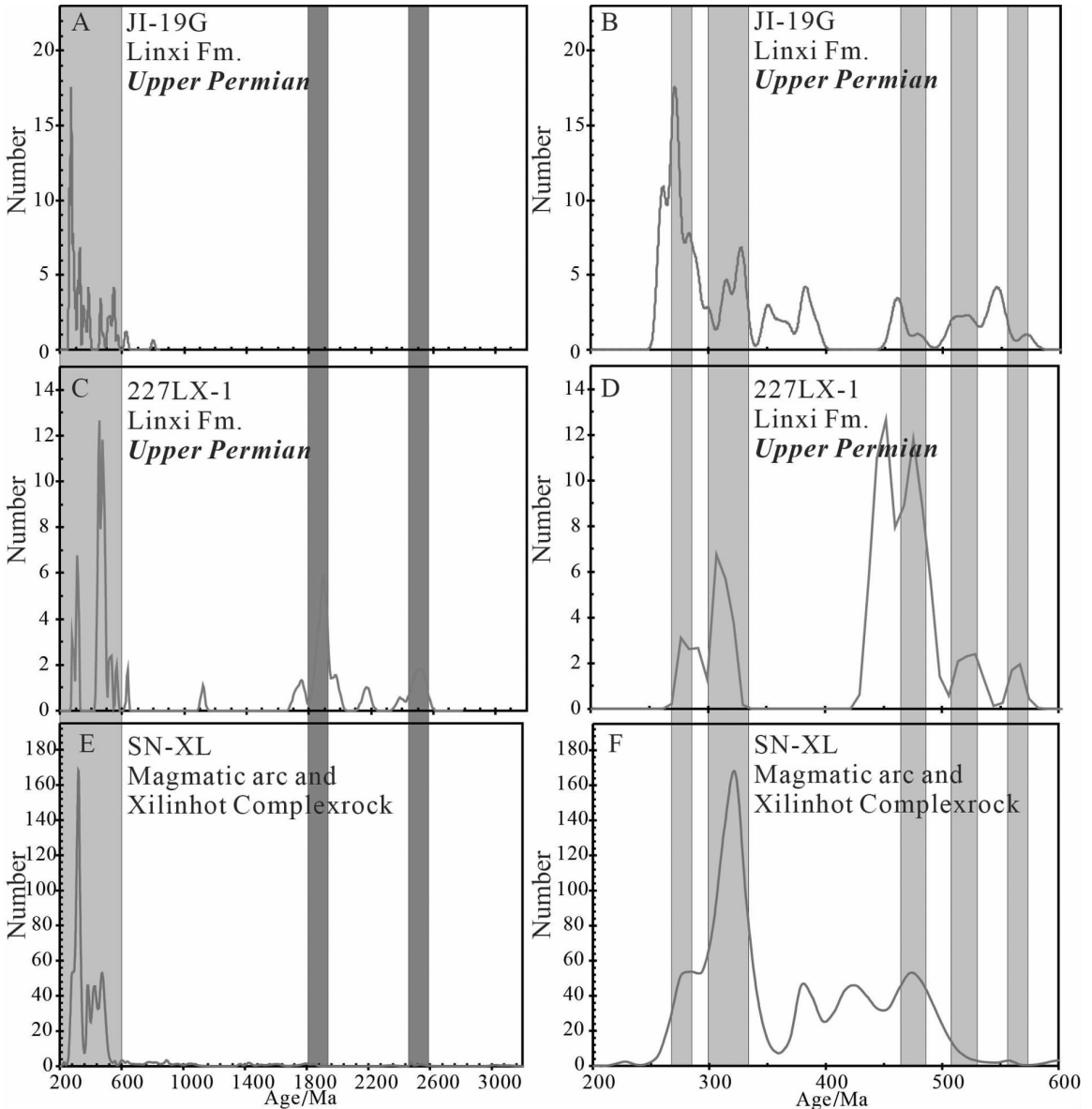


图 4 大兴安岭中南段二叠纪碎屑砂岩锆石年龄频率分布

(A, B 为索伦地区; C, D 为林西地区; E, F 为苏尼特左旗岩浆岩和锡林浩特杂岩, 数据来源于文献[30-39], 右图是左图的局部放大)
Fig.4 Frequency diagram of zircon ages for Permian sandstones in central and southern Da Hinggan Mountains (this study) and subduction-collision-related magmatic rocks in Sonidzuoqi and Xilinhot area (data from[30-39]).

(A, B from Suolun; C, D from Linxi; E, F from Sonidzuoqi and Xilinhot. Diagrams on the right are zooms of age populations with ages between 200 and 600 Ma from diagrams on the left)

① 韩国卿, 刘永江, 温泉波, 等. 西拉木伦河缝合带北侧二叠纪砂岩碎屑锆石 LA-ICP-MS U-Pb 年代学及其构造意义. 地球科学, 2010, 待发表。

北板块的拼合时间。研究区位于西拉木伦河缝合带北部林西地区(227LX-1)和索伦地区(JI-19G)(图 1),样品为晚二叠世林西组砂岩,碎屑锆石 U-Pb 年龄测试在西北大学大陆动力学国家重点实验室完成。

测试结果表明,两地区砂岩碎屑锆石均具有明显的~280 Ma 和~320 Ma 年龄峰值(图 4),该组年龄与研究区北侧苏尼特左旗—锡林浩特—西乌旗南岩浆弧的时代非常一致^[30-39],因此研究区晚二叠世砂岩沉积的主要物源应为北侧苏尼特左旗—锡林浩特—西乌旗南岩浆弧,是一套弧前沉积。

林西地区晚二叠世林西组出现~1800 Ma 和~2500 Ma 两组明显的锆石年龄峰值(图 4),这两组年龄是华北板块的标志性构造事件年龄,因此,林西地区林西组沉积时已经有来自其南侧华北板块北缘地区的物源供给,说明晚二叠世末东北地区的佳—蒙地块已经与华北板块非常接近或开始发生碰撞。这一认识进一步限定了西拉木伦河缝合带的闭合时间应为晚二叠世末。

晚古生代期间早二叠世火山活动强烈,早二叠世火山岩空间上具有南北成分极性,南部林西黄冈梁地区大石寨组火山岩为玄武岩、玄武安山岩组合,北部锡林浩特—西乌旗大石寨组火山岩以安山岩、流纹岩为主体,少量玄武岩。地球化学特征显示林西黄冈梁火山岩性质为岛弧低钾拉斑玄武岩,锡林浩特—西乌旗早二叠世玄武岩具有由岛弧玄武岩向弧后玄武岩和板内玄武岩过渡的特征。这种成分极性表明古亚洲洋板块向北俯冲到佳—蒙地块南缘之下^①。最近苗来成等^[29,40]对贺根山蛇绿岩的研究表明,贺根山洋是晚石炭世拉开的弧后盆地,与其南侧的苏尼特左旗—锡林浩特—西乌旗南岩浆弧一起构成了中蒙古地块(佳—蒙地块)南缘的活动大陆边缘。

4 晚古生代区域构造演化

晚古生代之前东北地区的佳木斯地块、兴安—松嫩地块和额尔古纳地块之间已经完成拼合,在北至鄂霍茨克构造带,南至西拉木伦河构造带,东至中锡霍特—阿林构造带的广大范围内形成了统一的佳—蒙地块。从晚古生代开始东北地区进入了统一的盖层演化阶段,在佳—蒙地块南缘发育了晚古生代具有大陆边缘沉积特征的盖层建造。

由于古亚洲洋壳向北侧佳—蒙地块南缘之下的俯冲,在~320 Ma 俯冲过程中古亚洲洋板块发生断裂,形成火山弧花岗岩^[30-32],同时导致其北侧“贺根山”洋的拉开^[29,40],向北俯冲作用持续导致弧—陆碰撞,并于~280 Ma 贺根山洋已经完全闭合,此时,苏尼特左旗地区以南至华北板块北缘地区仍存在残余的古亚洲洋^[29,40]。

晚石炭世—早二叠世佳—蒙地块南缘主要发育有一套活动大陆边缘沉积建造,属于苏尼特左旗—锡林浩特—西乌旗南岛弧的前弧沉积,中二叠世哲斯组主体为一套海相稳定的具有被动大陆边缘特征的沉积建造,说明佳—蒙地块南缘在中二叠世开始大地构造属性由活动陆缘转化为被动陆缘。晚二叠世由于古亚洲洋的消亡总体转为陆相环境,发育了以林西组为代表的一套陆相沉积建造,而且其物源具有南侧华北板块北缘和北侧苏尼特左旗—锡林浩特—西乌旗南火山弧的混源特征,说明晚二叠世末(250 Ma 左右)华北板块北缘沿西拉木伦河缝合线与北侧佳—蒙地块最终碰撞拼贴,转入陆内演化阶段。

参考文献(References):

- [1] Wu Fuyuan, Sun Deyou, Li Huimin, et al. A-type granites in northeastern China: age and geochemical constraints on their petrogenesis[J]. *Chemical Geology*, 2002, 187(1/2): 143-173.
- [2] 张兴洲, 杨宝俊, 吴福元, 等. 中国兴蒙—吉黑地区岩石圈结构基本特征[J]. *中国地质*, 2006, 33(4): 816-823.
Zhang Xingzhou, Yang Baojun, Wu Fuyuan, et al. The lithosphere structure in the Hingmong—Jihei (Hinggan—Mongolia—Jilin—Heilongjiang) region, northeastern China [J]. *Geology in China*, 2006, 33(4): 816-823(in Chinese with English abstract).
- [3] 黄汲清. 中国地质构造基本特征的初步总结 [J]. *地质学报*, 1960, 40(1): 1-31.
Huang Jiqing. Preliminary summary of China geological tectonic feature[J]. *Acta Geological Sinica*, 1960, 40(1): 1-31 (in Chinese with English abstract).
- [4] 黄汲清, 任纪舜, 姜春发, 等. 中国大地构造基本轮廓 [J]. *地质学报*, 1977, 51(2): 117-135.
Huang Jiqing, Ren Jishun, Jiang Chunfa, et al. An outline of the tectonic characteristics of China[J]. *Acta Geological Sinica*, 1977, 51(2): 117-135(in Chinese with English abstract).
- [5] 梁日暄. 内蒙古中段蛇绿岩特征及地质意义 [J]. *中国区域地质*, 1994, (1): 37-45.
Liang Rixuan. The features of ophiolites in the central sector of

①迟效国, 等. 东北地区火山岩与油气关系研究(中石化项目报告), 2010.

- inner Mongolia and its geological significance [J]. *Regional Geology of China*, 1994, (1):37-45(in Chinese with English abstract).
- [6] T.Robinson P, 白吉文, 杨经绥, 等. 内蒙古贺根山蛇绿岩岩石成因和地壳增生的地球化学制约[J]. *岩石学报*, 1995, 11:112-124.
T.Robinson P, Bai Jiwen, Yang Jingsui, et al. Geochemical constraints on petrogenesis and crustal accretion of the Hegenshan ophiolite, Northern China [J]. *Acta Petrologica Sinica*, 1995, 11: 112-124(in Chinese with English abstract).
- [7] 邵济安, 唐克东. 吉林省延边开山屯地区蛇绿混杂岩 [J]. *岩石学报*, 1995, 11:212-220.
Shao Ji'an, Tang Kedong. The ophiolite melange in Kaishantun, Jilin Province, China [J]. *Acta Petrologica Sinica*, 1995, 11: 212-220(in Chinese with English abstract).
- [8] 王荃, 刘雪压, 李锦轶. 中国内蒙古中部的古板块构造 [M]. *中国地质科学院院报*, 1991, 22:1-15.
Wang Quan, Liu Xueya, Li Jinyi. Plate tectonics between Cathaysia and Angaraland in China [M]. Beijing:Publishing House of Peking University, 1991:1-151(in Chinese).
- [9] Shao Ji'an, Mu Baolei, He Guoqi, et al., Geological effects in tectonic superposition of Paleo-Pacific domain and Paleo-Asian domain in northern part of north China[J]. *Science in China (Series D)*, 1997:40(6):634-640.
- [10] 李锦轶. 中国东北及邻区若干地质构造问题的新认识[J]. *地质论评*, 1998, 44(4):339-347.
Li Jinyi. Some new ideas on tectonics of NE China and its neighboring areas[J]. *Geological Review*, 1998, 44(4):339-347(in Chinese with English abstract).
- [11] 张梅生, 彭向东, 孙晓猛. 中国东北区古生代构造古地理格局[J]. *辽宁地质*, 1998(2):91-96.
Zhang Meisheng, Peng Xiangdong, Sun Xiaomeng. The Paleozoic tectonic geographical pattern of Northeast China [J]. *Liaoning Geology*, 1998, (2):91-96(in Chinese with English abstract).
- [12] 张兴洲. 黑龙江岩系-古佳木斯地块加里东缝合带的证据[J]. *长春地质学院学报*, 1992, 22:94-101.
Zhang Xingzhou. Heilongjiang melange: The evidence of Caledonian suture zone of the Jiamusi massif. *Journal of Changchun University of Earth Sciences*, 1992, 22:94-101 (in Chinese with English abstract).
- [13] 叶慧文, 张兴洲, 周裕文. 从蓝片岩及蛇绿岩特点看满洲里—绥芬河地学断面岩石圈结构与演化 [C]//M-GGT 地质课题组编. 中国满洲里—绥芬河地学断面域内岩石圈结构及其演化的地质研究. 北京:地震出版社, 1994:73-83.
Ye Huiwen, Zhang Xingzhou, Zhou Yuwen. The texture and evolution of Manzhouli-Suifenhe lithosphere—Study based on features of bluechist and ophiolites [C]//Geological studies of lithospheric structure and evolution of Manzhouli-Suifenhe geotranssect, China (M-SGT Geology Group Ed.). Beijing: Seismological Press, 1994:73-83 (in Chinese with English abstract).
- [14] Wu Fuyuan, Yang Jinhui, Lo Chinghua, et al. The Heilongjiang Group: A Jurassic accretionary complex in the Jiamusi Massif at the western Pacific margin of northeastern China [J]. *Island Arc*, 2007, 16(1):156-172.
- [15] Li Weimin, Akira Takasu, Liu Yongjiang, et al. ⁴⁰Ar/³⁹Ar ages of the high-P/T metamorphic rocks of the Heilongjiang Complex in the Jiamusi Massif, northeastern China [J]. *Journal of Mineralogical and Petrological Sciences*, 2009, 104:110-116.
- [16] Meng En, Xu Wenliang, Pei Fuping, et al. Detrital-zircon geochronology of Late Paleozoic sedimentary rocks in eastern Heilongjiang Province, NE China: Implications for the tectonic evolution of the eastern segment of the Central Asian Orogenic Belt[J]. *Tectonophysics*, 2010, 485(1/4):42-51.
- [17] 李瑞山. 新林蛇绿岩[J]. *黑龙江地质*, 1991, 2(1):19-31.
Li Ruishan. Xinlin ophiolite[J]. *Heilongjiang Geology*, 1991, 2(1): 19-31(in Chinese with English abstract).
- [18] Plyusnin, G S. Strontium isotopes in the rocks of the ophiolite complex in the Khan-Tayshiri Range (Western Mongolia) [J]. *International Geology Review*, 1980, 22(8):890-898.
- [19] 李春昱, 王荃, 刘雪亚. 亚洲大地构造图(1/800 万)说明书[M]. 北京:中国地图出版社, 1982:1-49.
Li Chunyu, Wang Quan, Liu Xueya, et al. Specification of Asian Tectonic Map (1:8 000 000)[M]. Beijing: Sino Maps Press, 1982: 1-49(in Chinese).
- [20] 葛文春, 吴福元, 周长勇, 等. 大兴安岭北部塔河花岗岩体的时代及对额尔古纳地块构造归属的制约 [J]. *科学通报*, 2005, 12: 1239-1247.
Ge Wenchun, Wu Fuyuan, Zhou Changyong, et al. Emplacement age of the Tahe granite and its constraints on the tectonic nature of the Ergun block in the northern part of the Da Hinggan Range[J]. *Chinese Science Bulletin*, 2005, 12:1239-1247(in Chinese).
- [21] 韩国卿, 刘永江, 温泉波, 等. 嫩江—八里罕断裂带岭下韧性剪切带变形特征[J]. *吉林大学学报(地球科学版)*, 2009, 39(3):397-405.
Han Guoqing, Liu Yongjiang, Wen Quanbo, et al. The characteristics of structural deformation for the Lingxia ductile shear zone of Nenjing-Balihan fault belt in northeastern China [J]. *Journal of Jilin University (Earth Science Edition)*, 2009, 39(3): 397-405(in Chinese with English abstract).
- [22] Wu Fuyuan, Yang Jinhui, Simon Wilde, et al. Geochronology, petrogenesis and tectonic implications of Jurassic granites in the Liaodong Peninsula, NE China [J]. *Chemical Geology*, 2005, 221 (1/2): 127-156.
- [23] Sun Deyou, Wu Fuyuan, Li Huimin, et al. Emplacement age of the post-orogenic A-type granites in northwestern Lesser Xing'an Ranges, and its relationship to the eastward extension of Suolunshan-Hegenshan-Zhalaithe collisional suture zone [J]. *Chinese Science Bulletin* 2001, 46, 427-432.
- [24] 李双林, 欧阳自远. 兴蒙造山带及邻区的构造格局与构造演化 [J]. *海洋地质与第四纪地质*, 1998, 18(3):45-54.
Li Shuanglin, Ouyang Ziyuan. Tectonic framework and evolution of Xing'anling-Mongolian orogenic belt (Xmob) and its adjacent region [J]. *Marine Geology & Quaternary Geology*, 1998, 18 (3):

- 45-54 (in Chinese with English abstract).
- [25] 王成文, 金巍, 张兴洲, 等. 东北及邻区晚古生代大地构造属性新认识[J]. 地层学杂志, 2008, 32(2):119-136.
Wang Chengwen, Jin Wei, Zhang Xingzhou, et al. New conception of the Late Paleozoic tectonics in the Northeastern China and adjacent areas [J]. Journal of Stratigraphy, 2008, 32 (2): 119-136(in Chinese with English abstract).
- [26] 王玉净, 樊志勇. 内蒙古西拉木伦河北部蛇绿岩带中二叠纪放射虫的发现及其地质意义[J]. 古生物学报, 1997, 36(1):58-69.
Wang Yujing, Fan Zhiyong. Discovery of Permian radiolarians in ophiolite belt on northern side of Xar Moron River, Inner Mongolia and its geological significance [J]. Acta Paleontologica Sinica, 1997, 36(1):58-69(in Chinese with English abstract).
- [27] 邓胜徽, 万传彪, 杨建国. 黑龙江阿城晚二叠世安加拉—华夏混生植物群——兼述古亚洲洋的关闭问题 [J]. 中国科学 (D 辑), 2009, 39(12):1744-1752.
Deng Shenghui, Wan Chuanbiao, Yang Jianguo. Discovery of a Late Permian Angara-Cathaysia mixed flora from Acheng of Heilongjiang, China, with discussions on the closure of the Paleasian Ocean [J]. Science in China (Series D), 2009, 39(12): 1744-1752(in Chinese with English abstract).
- [28] 孙德有, 吴福元, 张艳斌, 等. 西拉木伦河—长春—延吉板块缝合带的最后闭合时间——来自吉林大玉山花岗岩体的证据[J]. 吉林大学学报(地球科学版), 2004, 34(2):174-181.
Sun Deyou, Wu Fuyuan, Zhang Yanbin, et al. The final closing time of the west Lamulun River-Changchun-Yanji palte suture zone: evidence from the Dayushan granitic pluton, Jilin Province [J]. Journal of Jilin University (Earth Science Edition), 2004, 34, 174-181(in Chinese with English abstract).
- [29] Miao Laicheng, Fan Weiming, Liu Dunyi, et al. Geochronology and geochemistry of the Hegenshan ophiolitic complex: Implications for late-stage tectonic evolution of the Inner Mongolia-Daxinganling Orogenic Belt, China [J]. Journal of Asian Earth Sciences, 2008, 32(5/6): 348-370.
- [30] Chen Bin, Jahn Borming, Wilde Simon A, et al. Two contrasting paleozoic magmatic belts in northern Inner Mongolia, China: petrogenesis and tectonic implications [J]. Tectonophysics, 2000, 328(1/2): 157-182.
- [31] 陈斌, 赵国春, Wilde Simon A. 内蒙古苏尼特左旗南两类花岗岩同位素年代学及其构造意义[J]. 地质论评, 2001, 47(4): 361-367.
Chen Bin, Zhao Guochun, Wilde Simon A. Subduction - and collision-related granitoids from southern Sonidzuqi, Inner Mongolia, isotopic ages and tectonic implications [J]. Geological Review, 2001, 47(4):361-367(in Chinese with English abstract).
- [32] 石玉若, 刘敦一, 简平, 等. 内蒙古中部苏尼特左旗富钾花岗岩锆石 SHRIMP U-Pb 年龄[J]. 地质通报, 2005, 24(5):424-428.
Shi Yuruo, Liu Dunyi, Jian Ping, et al. Zircon SHRIMP dating of K-rich granites in Sonidzuqi, central Inner Mongolia [J]. Geological Bulletin of China, 2005, 24 (5):424-428 (in Chinese with English abstract).
- [33] 石玉若, 刘敦一, 张旗, 等. 内蒙古苏左旗地区闪长-花岗岩类 SHRIMP 年代学[J]. 地质学报, 2004, 78(6):789-799.
Shi Yuruo, Liu Dunyi, Zhang Qi, et al. SHRIMP dating of diorites and granites in southern Sonidzuqi, Inner Mongolia [J]. Acta Geologica Sinica, 2004, 78(6):789-799(in Chinese with English abstract).
- [34] 石玉若, 刘敦一, 张旗, 等. 内蒙古中部苏尼特左旗地区三叠纪 A 型花岗岩锆石 SHRIMP U-Pb 年龄及其区域构造意义[J]. 地质通报, 2007, 26(2):183-189.
Shi Yuruo, Liu Dunyi, Zhang Qi, et al. SHRIMP U-Pb zircon dating of Triassic A-type granites in Sonid Zuoqi, central Inner Mongolia, China and its tectonic implications [J]. Geological Bulletin of China, 2007, 26(2):183-189(in Chinese with English abstract).
- [35] Chen Bin, Jahn Borming, Tian Wei. Evolution of the Solonker suture zone: Constraints from zircon U-Pb ages, Hf isotopic ratios and whole-rock Nd-Sr isotope compositions of subduction- and collision-related magmas and forearc sediments [J]. Journal of Asian Earth Sciences, 2009, 34(3): 245-257.
- [36] Shi Guanghai, Liu Dunyi, Zhang Fuqin, et al. SHRIMP U-Pb zircon geochronology and its implications on the Xilin Gol Complex, Inner Mongolia, China [J]. Chinese Science Bulletin, 2003, 48(24): 2742-2748.
- [37] 鲍庆中, 张长捷, 吴之理, 等. 内蒙古白音高勒地区石炭纪石英闪长岩 SHRIMP 锆石 U-Pb 年代学及其意义[J]. 吉林大学学报(地球科学版), 2007, 37(1):15-23.
Bao Qingzhong, Zhang Changjie, Wu Zhili, et al. SHRIMP U-Pb zircon geochronology and its implications of Carboniferous Period quartz-diorite in Baiyingaole area, Inner Mongolia [J]. Journal of Jilin University (Earth Science Edition), 2007, 37(1):15-23 (in Chinese with English abstract).
- [38] 鲍庆中, 张长捷, 吴之理, 等. 内蒙古东南部晚古生代裂谷区花岗质岩石锆石 SHRIMP U-Pb 定年及其地质意义 [J]. 中国地质, 2007, 34(5):790-798.
Bao Qingzhong, Zhang Changjie, Wu Zhili, et al. Zircon SHRIMP U-Pb dating of granitoids in a Late Paleozoic rift area, southeastern Inner Mongolia, and its implications [J]. Geology in China, 2007, 34(5):790-798(in Chinese with English abstract).
- [39] 刘建峰, 迟效国, 张兴洲, 等. 内蒙古西乌旗南部石炭纪石英闪长岩地球化学特征及其构造意义 [J]. 地质学报, 2009, 83(3): 365-376.
Liu Jianfeng, Chi Xiaoguo, Zhang Xingzhou, et al. Geochemical characteristic of Carboniferous quartz-diorite in the southern Xiwuqi area, Inner Mongolia and its tectonic significance [J]. Acta Geologica Sinica, 2009, 83(3): 365-376(in Chinese with English abstract).
- [40] Miao Laicheng, Zhang Fuqin, Fan Weiming, et al. Phanerozoic evolution of the Inner Mongolia-Daxinganling orogenic belt in North China: constraints from geochronology of ophiolites and associated formations [J]. Geological Society Special Publications, 2007, 280: 223-237.

Late Paleozoic tectonic evolution in Northeast China

LIU Yong-jiang¹, ZHANG Xing-Zhou¹, JIN Wei¹, CHI Xiao-guo¹,
WANG Cheng-wen¹, MA Zhi-hong¹, HAN Guo-qing¹, WEN Quan-bo¹,
LI Wei¹, WANG Wen-di², ZHAO Xi-feng³

(1. College of Earth Sciences, Jilin University, Changchun 130061, Jilin, China; 2. Research Institute of Exploration and Development, Qinghai Oilfield Company, PetroChina, Dunhuang 8932753, Gansu, China; 3. Jilin Bureau of Geology for Nuclear Industry, Changchun 130062, Jilin, China)

Abstract: Northeast China area consists of several micro-continental blocks, such as Jiamusi Block in the southeast, Xing'an-Songliao Block in the middle, and Erguna blocks in the northwest. Studies of the suture zones between the blocks indicate that the amalgamation of these blocks ended before Late Paleozoic and formed a big continental block, i.e., Jia-Meng Block. From Late Paleozoic the cover sequences started to develop and formed a Late Paleozoic continental margin cover sequence.

The tectonic setting of the southern margin of the Jia-Meng Block was an active continental margin during early Paleozoic. The Paleo-Asian ocean plate broke down during the northward subduction around 320 Ma, and formed a volcanic arc. Meanwhile the Hegenshan back-arc basin ocean was opened. The continuous northward subduction resulted in the arc-continent collision, and the Hegenshan Ocean was closed at 280 Ma. The tectonic setting changed from active margin to passive margin. Finally the Paleo-Asian ocean was closed at the end of Late Permian, and the whole area became an intracontinental terrestrial setting.

Key words: Late Proterozoic; Paleo-Asian Ocean; Xar Moron River suture zone; Jia-Meng Block, Northeast China

About the first author: LIU Yong-jiang, male, born in 1964, doctor, professor, engages in the study of structural geology, orogenic belt evolution and tectono-chronology; E-mail: Yongjiang@jlu.edu.cn.