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内蒙古大石寨地区二叠系碎屑锆石年龄及其构造意义

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提要:本文收集大量锆石U−Pb年代学数据,通过制作年龄−频数图谱,简略探讨了西伯利亚克拉通、华北克拉通、东北地区微地块以及内蒙古大石寨地区的演化史,并对大石寨二叠系与其周边块体的锆石年龄作比较分析,进而探讨了大石寨地区二叠系的物源问题。碎屑锆石年龄−频数图表明,大石寨地区二叠系碎屑锆石年龄可以划分出古生代年龄段(500~250 Ma),中—新元古代年龄段(1.6~0.8 Ga),新太古—古元古代年龄段(2.6~1.7 Ga)。华北克拉通北缘与西伯利亚克拉通南缘基底年龄均 > 1.6 Ga,其二者都不能反映大石寨地区二叠系物源年龄信息,而大石寨地区二叠系碎屑锆石年龄峰值与东北地区地块年龄峰具有很好一致性,说明二者锆石年龄峰值反映的构造岩浆事件一致,表明大石寨地区二叠系物源应来源于东北地块而不是华北克拉通和西伯利亚克拉通。同时,东北地区大量古老基底锆石年龄数据的存在,暗示东北地块可能独立于上述两大板块而存在,并响应中亚造山带内存在古老微大陆的观点;东北地块由诸多微小块体拼贴而成,并分别与西伯利亚克拉通和华北克拉通碰撞拼接,缝合线分别是贺根山—黑河缝合带与西拉木伦缝合带。

关 键 词:东北地块;大石寨;锆石U−Pb年龄对比;克拉通
中图分类号:P597^{+}.3 **文献标志码**:A **文章编号**:1000−3657(2014)04−1143−16

内蒙古东部地区位于西伯利亚克拉通和华北克拉通之间,属于中亚造山带东段。该区中生代前受西伯利亚板块、华北板块和古亚洲洋板块之间相互作用的影响,经历了古亚洲洋的闭合和板块间的相互拼合过程[1-3];中生代及之后受太平洋板块向欧亚大陆之下俯冲作用的影响,经历了后期构造活动的强烈改造与叠加,由此形成了一个特殊的复合造山带。

古亚洲洋始于新元古代,曾是西伯利亚克拉通和华北克拉通间的巨大洋盆,晚古生代中期或末期闭合并形成宽阔的造山带。对于该洋盆最终闭合的时间及位置,目前主要有2种观点:一是认为贺根山缝合带为两大板块的最终拼合线[4-15],闭合时间为泥盆纪至石炭纪[6,7,10,16-21],或者晚二叠世[4,8,13-14,25];而有的学者[26-33]则持索伦山—西拉木伦河缝合线是西伯利亚板块和华北板块的缝合线的观点,并提出两大板块在晚志留世−晚泥盆世法门期之前闭合[26-27]或者晚二叠世完成最终拼合[28-32]。另外,东北地区微陆块研究的兴起[28](但目前尚未确定区内是否存在古老微大陆),使得这一地区的构造研究更趋复杂,

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因此，东北地区是否存在独立于上述两大板块的古老微大陆，抑或其只是两大板块碰撞造山的产物，这一问题一直悬而未决。故而对夹持于东北地区贺根山缝合带与西拉木伦缝合带之间的中亚造山带东部构造带的物源信息（来自华北克拉通？西伯利亚克拉通？东北地块？）及该区域的构造演化史的研究一直是一个瓶颈。

单颗锆石同位素年龄记录着区域地质事件发生的时间，地层里不同来源的大量锆石年龄反映着物源区演化史，其与周边构造单元进行锆石年龄对比可以用来判别物源[12]。为此，在野外调研基础上，笔者从同位素年代学的角度，以内蒙古大石寨地区地层碎屑锆石年龄为切入点，并搜集周边地块、华北克拉通北缘、西伯利亚克拉通南缘的大量碎屑锆石年龄，制作年龄-频数图，对整个区域做年代学对比研究，探讨本区地层物源，揭示本区构造演化史。

1 区域地质背景

内蒙古大石寨地区是华北和西伯利亚板块之间的古亚洲洋闭合过程中形成的增生造山带的一部分。区内地层从古生代到新生代都有发育（图1），最古老地层为古生界二叠系，分别是寿山沟组（P_1ss）、大石寨组（P_1ds）、吴家屯组（P_1w）、哲斯组（P_2zs）和林西组（P_2l）；中生代地层包括：哈达陶勒盖组（T_1hd）、万宝组（J_2wb）、满克头鄂博组（J_3mk）、玛尼吐组（J_3mn）、白音高老组（J_3b）以及梅勒图组（K_1m）。寿山沟组（P_1ss）分布在研究区南部，主要为一套碎屑岩夹灰岩，夹有火山岩，岩石组合特征表明，寿山沟组可能为一套在活动背景下快速沉积的产物，可能为快速拉张构造背景的产物；大石寨组（P_1d）逆冲于吴家屯组之上，俯冲于其南侧的寿山沟组之下，其上被中二叠统哲斯组和晚侏罗世满克头鄂博组不整合覆盖，岩性主要为中-基性熔岩、少量酸性熔岩、凝灰岩夹板岩、砂岩；吴家屯组（P_1w）为一套浅海相粗碎屑岩沉积，其间夹有代表古洋壳残片的超基性岩岩块、铬铁矿透镜体及片理化辉长岩；哲斯组（P_2z）角度不整合于吴家屯组、寿山沟组、大石寨组之上，与上覆地层林西组、满克头鄂博组呈不整合接触，岩石组合为一套浅海相砂岩、板岩夹灰岩透镜体，部分地区发育火山碎屑岩和硅质岩，富含化石，为浅海-滨海相沉积；林西组（P_2l）下部为灰黑色板岩、灰绿色粉砂岩夹灰绿色变质中细粒砂岩及酸性火山岩，上部为黄绿色变质砂砾岩、杂砂岩、变质粉砂岩互层，颗粒粗，颜色浅。区内中生界出露广泛，地层活动强烈，具多旋回火山活动，各组地层均以火山碎屑岩、凝灰岩为主。区内侵入岩主要发育三条带，分别是中二叠世呼和马场—哈达—马家窝铺花岗岩带、晚二叠世白音浩特—西马拉吐花岗岩带及中—晚三叠世和解家屯—大石寨—查干花岗岩带。研究区褶皱构造发育，主要为NE-NNE向的开阔-紧闭的线型背斜和向斜，总体形成以吴家屯组（ P_1w）、大石寨组（P_1d）、寿山沟组（P_1ss）为核部，中上二叠统哲斯组（P_2z）和林西组（P_2l）为翼部的轴向为北东的线型褶皱。

2 主要构造单元年代学研究

2.1 西伯利亚克拉通南缘年代学研究

西伯利亚克拉通主要由五个地块拼合而成，其基底年龄主要集中于太古宙[34]。这些地块中包含有现今地球上最古老的的陆壳残块，其年龄范围为3.4~3.6 Ga[34]。在Sharizhalgay隆起区，报道主要为3.4~3.2 Ga，3.3~3.0 Ga的英云闪长岩-奥长花岗岩以及花岗闪长岩组合[35-38]。在Anabar地盾区，Bibikova et al.[39]报道过锆石U-Pb年龄约3.3 Ga的片麻岩。西伯利亚克拉通内3.00~2.75 Ga的变质火山岩、角闪片麻岩、花岗岩主要出露在Aldan地盾和Stanovoy地块。其中又以2.7~2.5 Ga年龄段为主，并且2.4 Ga只零星分布于Aldan地盾[40]。

Rosen et al.[33]提出：西伯利亚克拉通的拼合引起的主要变质事件和岩浆事件发生在2.1~1.8 Ga。Zhao et al.[41]也指出，这个宽泛的时间段可能与全球的造山事件广泛一致。还有学者提出，它可能与古元古Nuna超大陆汇聚有关[42-43]。Columbia超大陆拼合也发生在大致相同的时间[44-45]。西伯利亚南缘后碰撞花岗岩的大量侵位主要集中在1.88~1.84 Ga[46]。

克拉通内，大部分太古宙和元古宙地块被早古生代中期至晚古生代早期及其他显生宙沉积岩覆盖，基底只在几个区域有出露。西伯利亚克拉通经历拼合后进入稳定期（1.9~1.8 Ga），随后进入伸展阶段，在1.73~1.68 Ga，形成数个克拉通内裂谷带[46]。位于西伯利亚克拉通东南缘的俄罗斯Riphean地区，沉积地层厚度1~4 km，但靠近克拉通边缘，

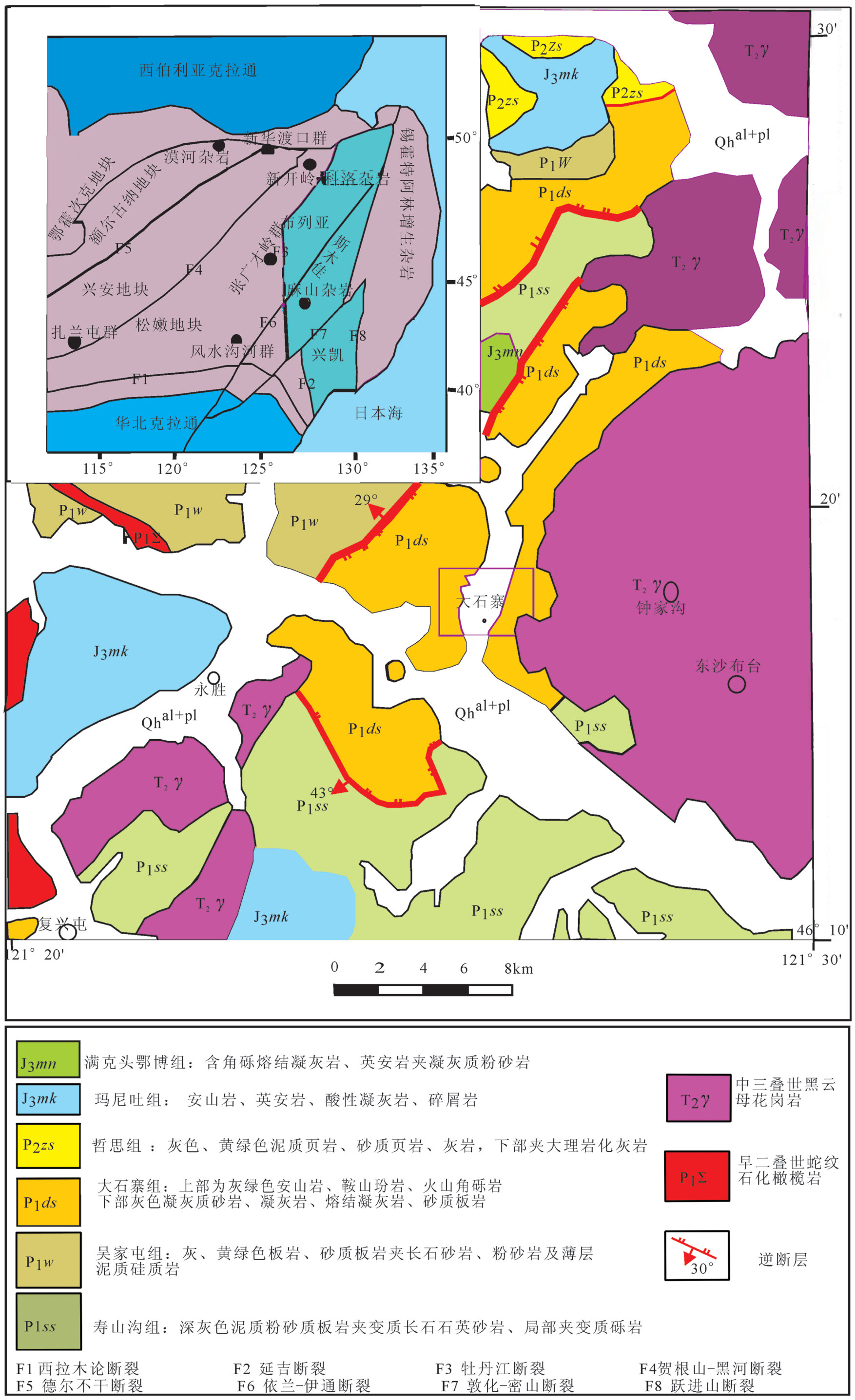

图1 大石寨地区区域地质简图[33]
Fig.1 Simplified geological map of the Dashizzhai region[33]

厚度增加至10~14 km，沉积时间始于1.6 Ga[46]。但对解译中亚造山带东部的碎屑锆石、结晶锆石记录尤为重要的一点是，西伯利亚克拉通内并未发现格林威尔期（Grenville-age）岩浆或造山事件的地质记录[46]，目前并无精确的定年手段证明西伯利亚克拉通南缘存在中元古代到新元古代早期的基性岩浆作用事件[24]。但在西伯利亚克拉通西南缘存在零星800~700 Ma基性岩墙群报道[24]，这应该反映古亚洲

洋的打开[47]。

西伯利亚克拉通内岩浆锆石和变质锆石年龄分布图(图2)显示，主峰值为1860 Ma左右，次峰值出现在约1720 Ma，2000 Ma以及2400~3500 Ma。很值得注意的是，几乎在1700 Ma之后，西伯利亚克拉通东南缘未出现变质岩浆事件[47]。

2.2 华北克拉通北缘年代学研究

华北克拉通是亚洲主要构造单元之一，其基底被划分为太古宙至早元古代的东部、中部和西部地块[48]。众多结晶基底被元古宙末期至显生宙沉积单元覆盖。2.9~2.7 Ga为陆壳的主要生长期，2.6~2.5 Ga和1.9~1.7 Ga发生了2期重要的构造-变质事件[49]，翟明国等[50]分别称为25亿年地质事件和18亿年地质事件，前寒武纪岩石均有这2期地质事件的变质作用和年代学记录。据前人研究，经过吕梁运动，华北古大陆最终形成较为稳定、统一的克拉通，成为全球Columbia超大陆的一部分[44-45,51]。但随后在中元古代初又发生了克拉通的伸展-裂解事件，在华北地块北缘及其内部形成白云鄂博—渣尔泰拗拉谷、泛河拗拉谷以及板内的燕辽拗拉谷或裂陷槽[52-53]。从1.65 Ga到中生代中期，华北陆块处于一个稳定期，称之为华北地台或华北准地台。

华北克拉通是否经历格林威尔期岩浆构造事件仍未知[50]。目前普遍认为，从中元古代到新元古代，华北克拉通与其他块体相分离，并隔洋相望，直到早古生代洋壳俯冲削减造山，中亚造山带形成，才与相邻板块汇聚拼贴[8,54]。Darby and Gehrels[55]对鄂尔多斯变质基底进行年代学研究，年龄分布于1.72~2.97 Ga，特征峰值集中在1.85~2.1 Ga，2.35~2.4 Ga，2.6~2.8 Ga，并未出现小于1.72 Ga的年龄，这证明了华北克拉通北缘基底缺乏格林威尔期岩石。从前人研究的华北克拉通内1791颗锆石U-Pb年龄分布图(图3，未包含中—新生代年龄数据)可看出，主峰为约2.5 Ga和1.8 Ga，次峰出现在2.15 Ga和3.3Ga左右，反映了华北克拉通生长-拼合-裂陷发展演化的全过程。

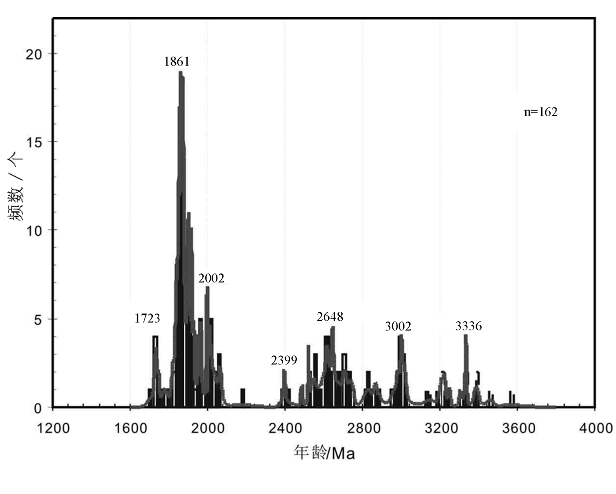

图2 西伯利亚克拉通南缘岩浆、变质锆石年龄频数图[47]
Fig.2 Relative probability plot of igneous and metamorphic zircons from the southern Siberian craton[47]

2.3 东北地区微地块年代学研究

东北地区在构造域上位于华北克拉通和西伯利亚克拉通之间，属于中亚造山带的最东段，即兴蒙造山带的东段。20世纪80年代以来地质工作者们开始用板块构造的观点诠释整个东北地区的大地构造属性[28,57-60]，并相继划分出了众多微陆块及多条缝合线(图1)。近年来对兴蒙造山带研究发现，其是位于两大板块之间的中-小块体群组成的构造拼贴带[7,61]。

2.3.1 额尔古纳地块

额尔古纳地块位于兴蒙造山带西北部，南邻兴安地块，北接西伯利亚克拉通南缘，区内古生代花岗岩分布广泛，前寒武变质基底出露零星，代表性变质基底岩石为漠河杂岩[62]，分布于北极村、漠河村及红旗一带。黑龙江省地质矿产局[63]、王友琴[64]报道为一套新太古代至古元古代变质岩，但据周建波等[65]的最新研究，漠河杂岩变质成因锆石边部年龄约为500 Ma，碎屑锆石核心年龄介于608~1373 Ma，揭示其物源区为中—新元古代基底，608 Ma为沉积下限，表明其形成时代可能不是前人认为的新太古—早元古代。额尔古纳地块及其邻近的中蒙古、图瓦等块体上都存在480~520 Ma的早古生代后造山花岗岩[66-68]，武广等[67]根据额尔古纳地块北缘早古生代后碰撞花岗岩(结晶年龄517~504 Ma)，认为额尔古纳地块与西伯利亚克拉通南缘拼合，拼合时间在500 Ma左右，并完成其二者之间古亚洲洋北洋的演化。这暗示漠河杂岩的变质事件与额尔古纳地块和西伯利亚克拉通南缘拼合有关。

2.3.2 兴安地块

兴安地块变质基底以兴华渡口群为代表[63,69,70-71]，

过去多被认为其时代为新太古-早元古代[63]。已有资料显示，兴华渡口群变火成岩形成年龄为506~547 Ma，变碎屑岩中碎屑锆石年龄谱中出现大量1.0~1.2Ga、1.6~1.8Ga和2.5~2.6 Ga的年龄，表明兴华渡口群形成于寒武纪或新元古代，为寒武纪或新元古代活动大陆边缘的火山-沉积建造[72-73]。周建波等[65]研究显示，兴华渡口群变质时间为500 Ma左右，沉积时代为600~500 Ma，还存在较多（1496±23）~（2791±18）Ma岩浆成因锆石年龄，很好地反映了基底年龄信息。葛文春等[66]研究额尔古纳地块上的塔河岩体（480~490 Ma）为后造山构造背景，得出额尔古纳地块与兴安地块在480 Ma以前开始发生拼合的结论。

2.3.3 松嫩地块

松嫩地块中，松辽盆地变质基底一直存在争议，多数学者倾向于存在前寒武变质基底，王颖等[74]获得松辽盆地南部钻井岩心中约1.8 Ga的变质闪长岩侵位年龄；裴福萍等[75]也在松辽盆地南部基底变辉长岩和变花岗岩(角砾)中获得（1808±21）Ma和（1873±13）Ma的锆石结晶年龄；章凤奇等[76]对松辽盆地南北两地早白垩世火山岩的研究中也均获得了形成于前寒武纪的捕获锆石，这些研究表明松辽盆地存在前寒武纪结晶基底。另一观点认为松嫩地块并不存在大规模的前寒武纪结晶基底[77]，松辽盆地基底主要由花岗质岩石组成，但不具备大规模前寒武纪结晶基底。近来周建波等[65]对松辽盆地北部铁力变质砂岩进行年代学研究，显示松辽盆地基底至少存在3期主要的构造-岩浆事件：即503~596 Ma泛非期构造事件；808~951 Ma新元古代Rodinia期构造岩浆事件；1857~2442 Ma中—新太古代变质基底的构造岩浆事件。兴安地块与松嫩地块大致在古生代晚期或印支期沿贺根山—嫩江—黑河缝合带拼合[12-13,21-23,78-79]。

2.3.4 东北地块年代学研究

以上分析表明，东北地区可能存在古老的微陆块，并与西伯利亚板块和华北板块相分隔。笔者收集646个东北地区微地块内的碎屑锆石、岩浆及变质锆石年龄数据，并绘制年龄频数图(图4)。数据主要来源于额尔古纳地块—兴安地块—松嫩地块—佳木斯地块代表性杂岩群：漠河杂岩、兴华渡口群、扎兰屯群、张广才岭群、科洛杂岩、麻山群、松辽盆地基底岩石以及红水泉组等，包括各种成因锆石，其年龄范围广，基本涵盖东北地区主要构造-岩浆事件，能够反映东北地区各地块的演化信息。以上数据未包含大石寨地区二叠纪地层的碎屑锆石年龄数据，这主要为排除这些数据对东北地块年龄-频数图制图的影响，从而便于对东北地块与大石寨地区二叠系碎屑锆石年龄作对比研究，并揭示前者与后者是否有物源关系。从图中可看出，其出现168 Ma、222 Ma、300 Ma、501 Ma、864 Ma、1850 Ma、2592 Ma、2796 Ma八个峰值，最大峰为501 Ma，次峰为168 Ma、222 Ma、300 Ma、864 Ma、1850 Ma，而2592 Ma和2796 Ma为较小峰，说明东北地区太古宙时期古老锆石颗粒出现频率极低，而早元古古代以来尤其早古生代的年轻锆石颗粒出现频率很高，可能暗示其大规模结晶基底年龄比西伯利亚克拉通及华北克拉通普遍较新，同时也反映东北地区微地块为新生地块，这与区内岩体Hf、Nd同位素研究获得的结论一致[66,69]。500 Ma可能反映东北地区泛非期构造事件[65]或者额尔古纳地块与西伯利亚克拉通的拼合[80]。Wilde et al[81]、Zhou et al[82]、任留东等[83]报道了虎头地区约520 Ma侵位年龄和约510 Ma的变质年龄。而漠河花岗岩体[84]、塔河辉长岩体[69]、多宝山岩体以及松辽地块东缘小兴安岭—张广才岭地区的集岭、东风山和汤旺河岩体[85]的年龄集中于500~460 Ma。165~180 Ma反映佳木斯地块

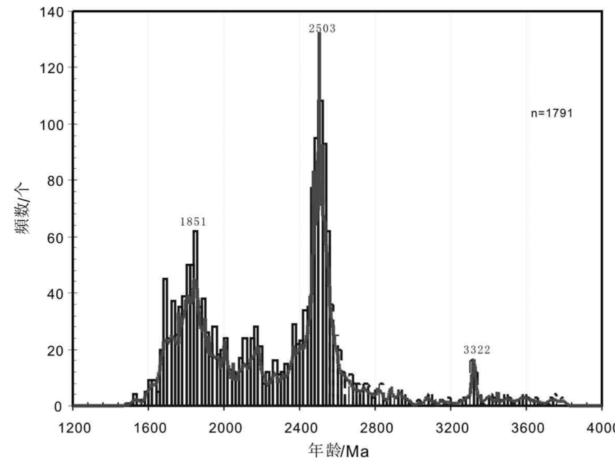

图3 华北克拉通北缘岩浆、变质锆石年龄频数图[8,21,44-45,47,49,51,53-54,56]
Fig.3 Relative probability plot of igneous and metamorphic zircons from the North China craton[8,21,44-45,47-49,51,53-54,56]

与松嫩地块的拼合[86]；216 Ma反映印支期地块碰撞事件[23]；222 Ma可能反映华北克拉通与西伯利亚克拉通缝合后的构造伸展事件；864 Ma可能代表Rodinia期构造岩浆事件，并可能反映中亚造山带晚元古早期的岩浆活动；1850 Ma、2592 Ma可能反映新太古代—早元古代变质基底的构造岩浆事件[65]。王颖等[74]在松辽盆地南部钻井岩心中获得约1.8 Ga的变质闪长岩侵位年龄；裴福萍等[75]也在松辽盆地南部基底变辉长岩和变花岗岩中获得(1808±21)Ma和(1873±13)Ma的锆石结晶年龄；周建波等[65]报道松辽盆地北部基底铁力变质砂岩9颗岩浆成因锆石的 $^{207}Pb/^{206}Pb$ 谐和年龄(1857±24)Ma~(2442±21)Ma，揭示盆地基底年龄信息，但这一年龄段尚未发现对应的基岩露头，主要为碎屑锆石年龄[87]。

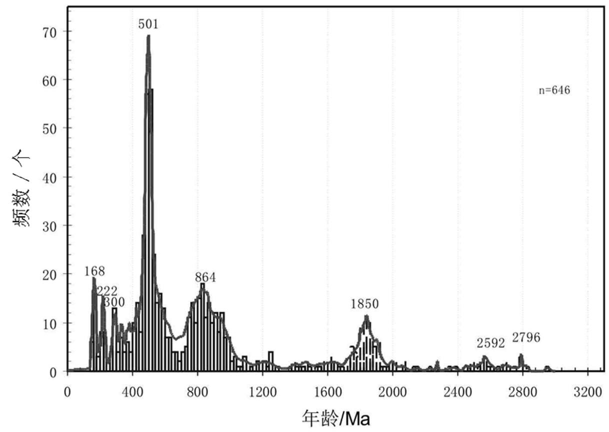

图4 东北地块碎屑、岩浆、变质锆石年龄频数图[19,23,33,47,65,72-76,88-90]
Fig. 4 Relative probability plot of detrital, igneous,and metamorphic zircons from NE block in China[19,23,33,47,65,72-76,88-90]

3 大石寨地区二叠纪地层年代学研究

3.1 寿山沟组年代学研究

美国学者Scott[91]及其学生曾到本区工作，在大石寨地区的寿山沟组中采集了2件碎屑岩样品进行碎屑锆石U-Pb定年。经统计分析认为，该组地层的形成时间晚于269 Ma(图5)；郑月娟等[89]对西乌旗地区寿山沟组砂岩中碎屑锆石进行年代学研究，得出其沉积时代应晚于289 Ma(图6)。从碎屑锆石的年龄分布(图5～6)可以看出，大石寨地区和西乌旗地区寿山沟组地层中碎屑锆石年龄峰值分布非常相似。根据锆石年代学数据，寿山沟组的地层时代可定为早二叠世。

寿山沟组剖面的岩石组合为泥质粉砂质板岩夹变质粗砂岩和变质细砾岩，夹数层片理化中酸性火山岩；大石寨剖面的岩石组合主要是一套泥、粉砂质板岩；老任大砬子剖面该组的岩石组合为下部以泥质板岩为主，上部为粗砂岩。总体地层层序为：下部为灰色变质长石石英砂岩夹变质英安岩及少量粉砂质片岩，中部为灰黑色泥质板岩，上部为变质长石石英砂岩，局部夹变质细砾岩，整体为一套在活动背景下快速沉积的产物，其中夹有火山

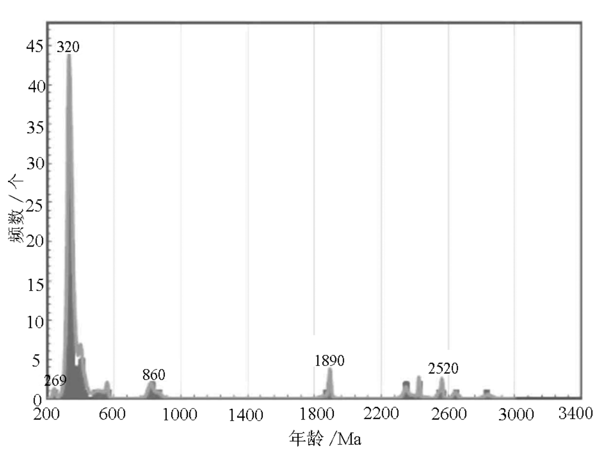

图5 大石寨地区寿山沟组碎屑锆石年龄频数图[91]
Fig.5 Relative probability plot of detrital zircons from Shoushangou Formation in dashizhai area[91]

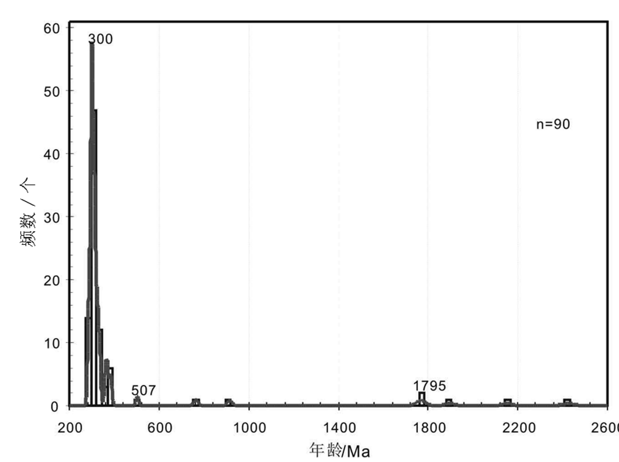

图6 西乌旗地区寿山沟组碎屑锆石U-Pb年龄频数图[88]
Fig. 6 Relative probability plot of detrital zircons from Shoushangou Formation in Xi Ujimqin Banner area[88]

岩,可能为快速拉张构造背景的产物,可能代表弧后盆地沉积。

3.2 大石寨组碎屑锆石年龄研究

大石寨组火山岩形成于与古亚洲洋俯冲有关的大陆边缘弧或岛弧环境或弧后盆地背景[31,88,92-98]。西部索伦山、满都拉地区的大石寨组火山岩单颗粒锆石U-Pb年龄为(285±11)Ma 、(280.4±1.1)Ma[96];苏尼特左旗东北达尔罕敖包地区大石寨组中的安山岩Rb-Sr等时线年龄为281 Ma[93];林西地区大石寨组钙碱性火山岩Rb-Sr年龄为270 Ma[99], 310 Ma[100];区域大石寨组火山岩的同位素年龄显示其时代为早二叠世。另外,鲍庆中等[101]对侵入早二叠世寿山沟组的二长花岗岩进行SHRIMP锆石U-Pb定年,其年龄为(280.8±3.6)Ma,与大石寨组火山岩时代同期。杨现力[102]报道林西组岩屑砂岩中岩浆成因锆石最年轻年龄为271~280 Ma,也表明晚古生代岩浆事件发生在早二叠世。

3.3 吴家屯组碎屑锆石年龄研究

在研究区的吴家屯组,周志广❶在豆荚状铬铁矿中选取了少量的锆石,并作锆石U-Pb测年,由于选取的锆石较少且较小,经锆石U-Pb测年得到的数据很分散,去掉一个明显不谐和年龄,得到U-Pb谐和年龄296 Ma的结果,所以,吴家屯组的时代应为早二叠世。值得注意的是,样品中含有2个2.4 Ga的数据、3个1.8 Ga左右的数据、2个400~470 Ma的数据,这些数据与东北地区构造岩浆事件基本一致,可能指示其源岩物质主要来源于由松嫩地块、兴安地块、额尔古纳地块等拼贴而成的东北地块。

3.4 哲斯组碎屑锆石年龄

韩国卿等[80]对西拉木伦河缝合带北侧克旗地区哲斯组地层进行了碎屑锆石LA-ICP-MS U-Pb年代学研究,年龄频数图见图7,地层沉积年龄为249 Ma左右。分析研究表明250 Ma左右可能代表华北板块与西伯利亚克拉通复合块体的最终闭合事件;520~250 Ma可能是古亚洲洋的消减时间,819 Ma、1163 Ma、1545 Ma、1830 Ma为岩浆成因锆石年龄,可能反映古老地块前寒武结晶基底的存在。韩国卿等[80]研究认为哲思组和林西组处于兴安—中蒙古地块的前弧地区,物源具有火山弧的特征。江小燕等[103]通过地球化学研究揭示哲思组物源区为大陆岛弧环境。二叠纪正是西伯利亚板块和华北板块相互碰撞闭合的时期,结合研究区所在的兴蒙造山带的地理位置,哲斯组位于兴蒙造山带偏西伯利亚板块一侧。说明中二叠世大石寨期火山岩后,西伯利亚复合块体俯冲到华北板块之下,火山活动停止,地壳仍继续抬升,哲斯组过渡为滨海-浅海相沉积,其所在地区同时接受了来自造山带的沉积物和来自岛弧的沉积物。

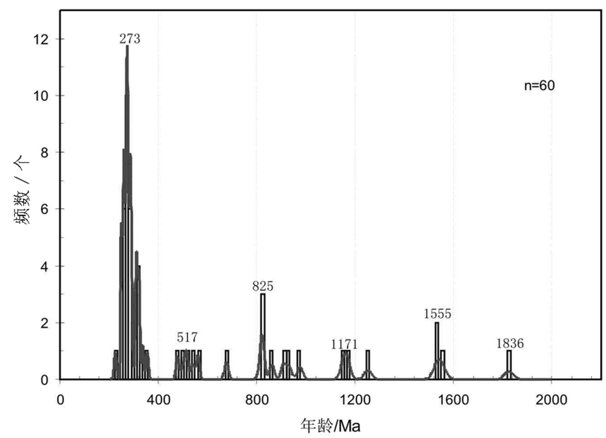

图7 哲斯组碎屑锆石年龄频数图[80]
Fig.7 Relative probability plot of detrital zircons from the Zhesi Formaton[80]

3.5 林西组碎屑锆石年龄

林西组为淡水湖盆相沉积,含植物化石,早期水体广泛,沉积环境平静,岩石以颜色深、碎屑粒度细、层理发育为特征。晚期由于地壳抬升,水体缩小,在碎屑物补给充分和快速堆积的环境中,形成厚层状的粗碎屑岩建造,以颜色较浅、碎屑粒度粗、未见动物化石,仅见植物化石且属种单调,岩层层理不发育等为特征。地层沉积年龄为256 Ma左右[104],近来一些地质工作者[80,104]对林西地区林西组地层进行了碎屑锆石LA-ICP-MS U-Pb年代学研究,年龄频数图见图8。276 Ma可能与西伯利亚克拉通复合块体和华北克拉通拼合相关,445~520 Ma可能代表古亚洲洋消减时间,小峰0.8~1.4 Ga、1.9 Ga及2.5 Ga为岩浆成因锆石年龄,可能代表古老结晶基底锆石年龄。

❶周志广.乌兰浩特地区地质调研报告[R]. 北京,2011.

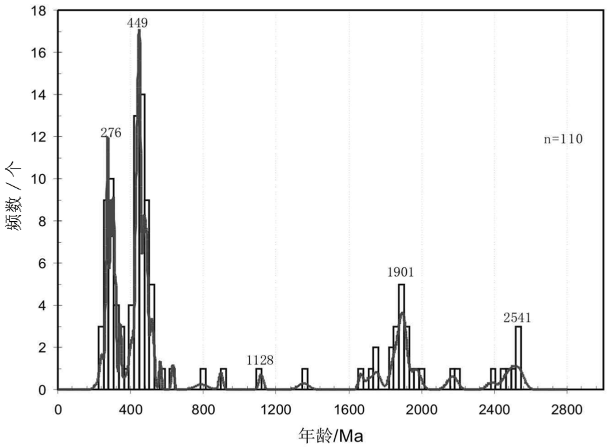

图8 林西组碎屑锆石年龄频数图[80,104]
Fig.8 Relative probability plot of detrital zircons from the Linxi Group[80,104]

根据岩性组合、化石组合分析，林西组为海陆交互相沉积。林西组地层形成时，处于地壳快速上升的构造背景，从早期的海陆交互相，由于地壳抬升转为陆缘湖泊相和潟湖相。通过Dickinson砂岩骨架成分分析指示其构造背景属切割岛弧[103]。

根据上述资料，在西伯利亚板块复合块体和华北板块闭合后，本区地壳继续上升，大规模的海退还在继续。林西组位于哲斯组的更北面，即西伯利亚板块南缘的切割岛弧，在这种环境下，林西组覆盖于哲斯组之上，形成了以切割岛弧为主要物源的海陆交互相碎屑岩沉积。

4 讨论与结论

4.1 大石寨地区二叠纪地层物源年代学证据

内蒙古大石寨地区二叠纪地层碎屑锆石年龄可以划分出古生代年龄段(500~250 Ma)，其中450~497 Ma年龄段对应于佳蒙地块的基底变质岩年龄[22,89]，357~450 Ma代表东北地块泥盆纪和志留纪的岩浆物源[104]，250~350 Ma对应于兴安地块与松嫩地块间洋壳俯冲消减和两地块拼合的构造岩浆事件；新太古—古元古年龄段(2.6~1.7 Ga)，中—新元古代年龄段(1.6~0.8 Ga)，以及古生代年龄段，在上文介绍的漠河杂岩(代表额尔古纳变质基底)[62]、兴华渡口群和扎兰屯群(代表兴安地块变质基底)[63,65,69-71,73]、松辽盆地南北部基底[65,74-77]、麻山群(代表佳木斯地块变质基底)[65]等老变质岩中均有报道，对比其与东北

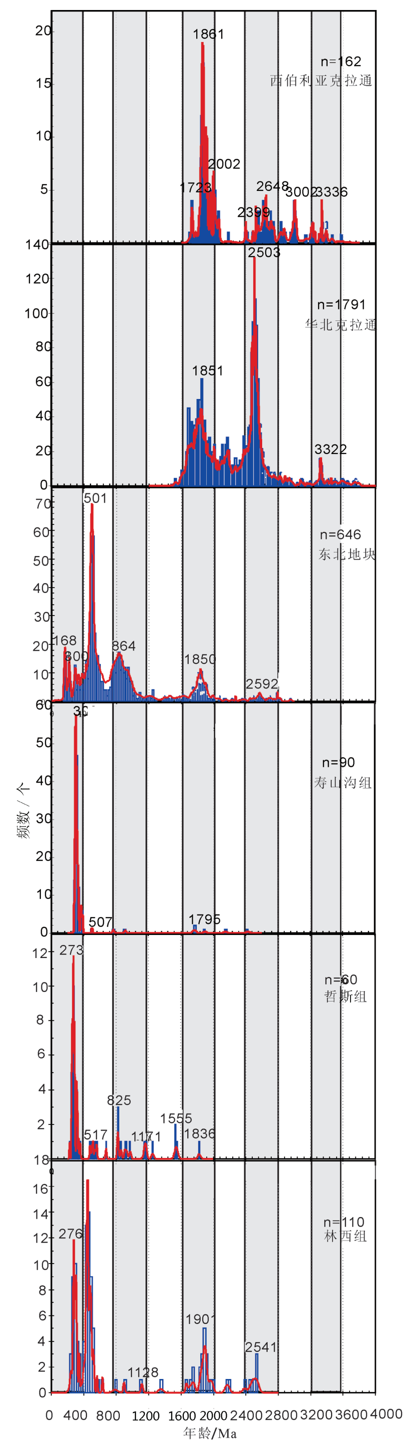

图9 大石寨地区二叠系与古老克拉通及东北地块的锆石年龄对比
Fig.9 The U–Pb ages of zircons of comparison of the Permian stratum in Dashizhai area with southern Siberia, North China craton and Northeast-micro block

地区微地块的年龄峰值具有很好的一致性(图9),说明大石寨地区二叠系地层碎屑锆石年龄反映的构造事件与东北地区微地块一致。而华北克拉通北缘与西伯利亚克拉通南缘基底年龄均大于1.6 Ga,均主要存在1.85 Ga和2.5 Ga两个峰值,而缺失中—晚元古代年龄数据,故与大石寨地区二叠系锆石年龄相比,它们的锆石年龄峰值不能对应(图9),说明二者锆石年龄反映的构造岩浆事件不一致,其所代表的的块体演化史也不一样。这暗示,大石寨地区二叠系物源来源于东北微地块,而与上述两大古老克拉通无关。另外,何国琦等[26]、唐克东[27]、李春昱[28]、王鸿祯[29]、王玉净等[30]、Li[31]、孙德有等[32]、陈志广等[33]都支持索伦山—西拉木伦河缝合线存在的观点,且近来研究其缝合时间大多支持倾向于晚二叠世[28-33,80,104]。说明晚二叠世之前,松嫩地块与华北克拉通北缘之间是海盆[95],大石寨地区位于缝合线北侧,即海沟北侧,紧邻松嫩地块,故华北克拉通北缘不是大石寨地区地层的物源区。而大石寨地区所在的松嫩地块地理位置偏南,毗邻华北克拉通北缘,与西伯利亚克拉通南缘之间又相隔额尔古纳地块和兴安地块,所以大石寨地区二叠纪地层的物源应来源于东北地区微地块而不是华北克拉通北缘或西伯利亚克拉通南缘。

4.2 大石寨地区二叠纪地层构造演化

从南到北,寿山沟组地层逆冲于大石寨组地层之上,大石寨组地层逆冲于吴家屯组地层之上,且吴家屯组-大石寨组-寿山沟组为同时代沉积。寿山沟组地层为浅海相沉积地层,从岩石组合分析,可能属弧后盆地构造背景;吴家屯组地层是一套夹有洋壳残余的深海相沉积,发育有硅质岩,可能属海沟构造背景。夹于两者之间的大石寨地层岩性主要为一套中酸性火山岩,火山岩岩石组合为玄武岩-玄武安山岩-安山岩-英安岩-流纹岩,属钙碱性系列,通过对大石寨火山岩的主量元素、微量元素和稀土元素等岩石地球化学数据进行分析,都证明大石寨组火山岩产出于大陆边缘岛弧构造环境[95]。吴家屯组-大石寨组-寿山沟组可能为同时期不同构造背景下代表沟-弧-盆沉积体系的沉积产物(具体构造背景有待进一步深入研究)。从年代学研究发现,东北地区,额尔古纳地块与西伯利亚克拉通南缘于大约500 Ma发生缝合[67];480 Ma左右,额尔古纳地块与兴安地块开始拼合[66];330 Ma左右,兴安地块与松嫩地块之间的洋壳开始向松嫩地块之下俯冲消减[86];洋壳消减过程中诱发314~270 Ma[84,93,95-96,99-100]的大石寨期火山活动,形成岛弧(可能类似于现今的日本岛弧),同时伴随海沟沉积和弧后盆地沉积;之后两地块于古生代晚期或印支期沿贺根山—嫩江—黑河缝合带拼合形成西伯利亚克拉通复合块体[13,21-23,78-79]。中二叠世大石寨期火山岩后,西伯利亚复合块体俯冲到华北板块之下,火山活动停止,地壳仍继续上升,哲斯组所在地区同时接受了来自造山带的沉积物和来自岛弧的沉积物[103]。256 Ma,西伯利亚克拉通复合块体与华北克拉通基本完成拼合,地壳整体抬升,整个东北地区残余部分洋壳,林西组所在地区接受海陆交互相沉积[103]。

4.3 古老微陆块是否存在的探讨

据上述大量代表古老基底的锆石年代学数据说明,东北地区可能存在独立的古老微陆块,现今东北地块是由众多微小陆块拼贴而成。进一步可推断,贺根山—黑河缝合带和西拉木伦河缝合带可能分别是东北地块拼贴成整体之后,与西伯利亚克拉通和华北克拉通碰撞拼接的两条缝合线。据此,则可解决西伯利亚克拉通与华北克拉通最终拼合线的争议问题,我们认为,东北地块分别与西伯利亚克拉通和华北克拉通发生碰撞,缝合线分别是贺根山—黑河缝合带与西拉木伦缝合带。

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Ages of detrital zircons from the Permian strata in Dashizhai area of Inner Mongolia and their tectonic implications

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Abstrac: The authors collected a large number of data about U−Pb ages of zircons through compling the relative probability plot of detrital zircons, briefly discussed the evolution history of the Siberia craton, North China craton, Northeast China micro−block and Dashizhai area of Inner Mongolia. The comparative analysis of ages for the Permian strata in Dashizhai area of Inner Mongolia and the neighboring old blocks can help to study the problem of the source of Permian strata in Dashizhai area of Inner Mongolia. Based on the ages of detrital zircons from the South Siberia craton, North China craton, Northeast China micro−block and the Permian strata in Dashizai area in comparison with zircon ages of blocks in neighboring areas, the authors discussed the provenance and made research on zircons U−Pb chronology. The source of the Permian strata in Dashizhai area of Inner Mongolia was reasonably determined. The study of the ages of detrital zircons shows that detrital zircon ages of Permian strata in Dashizai area of Inner Mongolia can be divided into the Paleozoic age group (500−250 Ma), the central and late Proterozoic age group (1.6−0.8 Ga) and the late Archean age group (2.6−1.7 Ga), whereas on the northern margin of North China craton and on the southern margin of Siberian craton, zircon U−Pb ages are earlier than 1.6Ga. Both of them fail to reflect the reasonable age information of the Permian strata source in Dashizhai area of Inner Mongolia. The age peaks of the Northeast China micro−block in China are consistent with the age peaks of the Permian strata from Dashizai area, which indicates that the provenance of the Permian strata came from the Northeast China block rather than the northern margin of North China craton and the southern margin of Siberian craton. Large quantities of ages of zircons from old basements indicate the existence of ancient micro-continents in Northeast China that may be independent of Siberia craton and North China craton, which is consistent with the view that there existed an ancient micro−continent in the central Asian orogenic belt. Northeast China block might have consisted of many small blocks after collision, and it then collided with the Siberia craton and the North China craton, with the collision taking place respectively along the Hegenshan−Heihe suture zone and Silas Mulun suture zone.

Key words: Northeast China block; Dashizai; zircon U−Pb age comparison; craton

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