华南地区中生代主要金属矿床时空分布规律和成矿环境

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摘要：以广泛地质调查和放射性同位素年龄精测数据为基础，总结提出了华南地区中生代主要金属矿床成矿出现于三个阶段，即晚三叠世（230~210 Ma）、中晚侏罗世（170~150 Ma）和早中白垩世（134~80 Ma）。晚三叠世矿化组合为钨锡铌钽；中晚侏罗世的矿化组合进一步分为170~160 Ma斑岩–矽卡岩铜矿和160~150 Ma与花岗岩有关的钨锡多金属矿床；白垩纪矿化虽然持续了54 Ma，但主要峰期在100~90 Ma，主要矿化组合为浅成低温热液型铜金银矿床和花岗岩有关的钨锡铜多金属矿床。晚三叠世钨锡铌钽矿化成因上与过铝质二云母花岗岩有关，是华北、华南和印支三大板块后碰撞过程的成岩成矿响应。在180 Ma左右Izanagi板块向欧亚大陆俯冲，于170~160 Ma期间可能由于俯冲板片局部多处撕裂而形成Ⅰ型或埃达克质岩石和有关的的斑岩铜矿，紧接着在南岭地区于160~150 Ma期间俯冲板块开天窗，软流圈物质直接涌入上地壳，形成了一种壳幔混合型高分异花岗质岩石及其钨锡多金属矿床。在135 Ma左右由于俯冲板块改变了运动方向，由斜向俯冲调整到几乎平行大陆边缘沿NE方向走滑，造成大陆岩石圈大面积伸展而形成了大量白垩纪断陷盆地和变质核杂岩，并伴随大规模的火山活动和花岗质岩浆侵位及其浅成低温热液铜金银矿化系统、与花岗岩有关的钨锡多金属矿化系统和热液型铀矿的形成。

关键词：钨锡多金属矿；斑岩铜矿；浅成低温热液矿床；多阶段成矿；中生代；构造演化与成矿；华南

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Spatial-Temporal Distribution of Mesozoic Ore Deposits in South China and Their Metallogenic Settings

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Abstract: Based on extensive field investigation and precise geochronological data we proposed Mesozoic metallic mineralization in South China can be grouped into three pulses, i.e. Late Triassic (230~210 Ma), Mid-Late Jurassic (170~150 Ma), and Early-Middle Cretaceous (134~80Ma). The mineralization elements in these three pulses are different. The Triassic mineralization is Peraluminous granite-related W-Sn-Nb-Ta. The Mid-late Jurassic mineralization can be further divided into 170~160 Ma porphyry and skarn Cu and I-type granite-related Pb-Zn-Ag, and 160~150 Ma paraluminous granite-related polymetallic W-Sn. Although the Cretaceous mineralization lasted about 54 Ma, its peak ranged from 100 Ma to 90 Ma. The major types of the mineralization are epithermal Au-Ag-Cu and granite-related polymetallic tin (tungsten). The Triassic peraluminous granite-related W-Sn-Nb-Ta is a response to the post-collisional process of the South China plate with the North China plate. The Izanagi plate started to subduct beneath the Eurasian continent at ca. 180 Ma and then the porphyry copper deposits and vein type Pb-Zn-Ag deposits and their related I-type granitoids or aidakitic rocks formed when the subducted plate was torn up in several locations at 170~160 Ma.

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After then a big window occurred in the Nanling area, triggering the asthenospheric substance got into the upper crust so that developed large-scale high fractionation paraluminous granite and related polymetallic W-Sn mineralization. It was a relatively quiet period of 150~135 Ma in South China except for the Middle-Lower Yangtze River Valley area located in the northeastern margin of the South China plate. Because starting to change motion-direction to northeast the subucted plate was teared up along the Middle-Lower Yangtze River Valley which used to be a foreland basin of the Triassic Dabie-Sulu orogenic belt. A group of skarn-porphyry Cu-Mo-Au-Fe ore system and related I-type or aidakitic granites developed along the cross of the Middle-Lower Yangtze River Valley with the NE-trending faults at an age range of 145~135 Ma. From 135 Ma the subducted plate moved along several groups of regional-scale NE-striking fault zones comprising the Tan-Lu fault zone, which trigged the Eurasian continent to extensive extension. At the setting developed a lot of linear NE-trending Cretaceous faulting basins and metamorphic cores accompanied with volcanic rock eruption as well as epithermal Cu-Au-Ag ore system, granite-related polymetallic Sn (W) deposits and hydrothermal uranium deposits at age of 120~80 Ma with a peak of 100~90 Ma.

Key words: granite-related polymetallic tin and tungsten; porphyry copper; epithermal gold; multiple mineralization; Mesozoic tectonic evolution and metallogeny; South China

1 引言

华南地区是我国乃至全球大密度成矿区，成矿时代主要集中在中生代，是我国东部中生代“大规模成矿”或“大爆发成矿”（华仁民等，1999；毛景文等，1999）最具代表性的区带。由于近些年以来，在这样一个高密度矿化富集区找矿不断取得新突破，不仅在已知矿床的外围和深部探明新矿体，还发现不少新矿产地，因此，对于华南地区矿产资源研究又出现了新一轮高潮，不仅连续报道找矿勘查的新发现和新进展，而且还运用高精度放射性同位素测年技术精确厘定成岩成矿时代。基于最近几年毛景文等（2004a，2007）、华仁民等（2005a，b）、胡瑞忠等（2007）、彭建堂等（2008）、马东升（2008）对华南地区成矿环境的初步探讨，结合2007~2008年间大量精确年龄数据和新近的野外调查成果，本文进一步总结华南地区中生代主要金属矿床的成矿规律和成矿环境。

2 中生代三期矿化时空分布特点

最近几年获得的大量精确放射性同位素测年资料(主要包括辉钼矿的Re–Os方法和含钾矿物的$^{40}Ar/^{39}Ar$方法及其有关岩石的锆石U–Pb方法和云母类的$^{40}Ar/^{39}Ar$方法）清楚地表明，华南地区中生代成矿作用在空间分布上呈现出非均一性，在南岭地区表现为NE向成带和EW向成行的特点（图1和图2），在其它地区主要呈现为矿集区形式或成团出现；在时间上并非连续成矿，而是有三个比较清楚的成矿阶段（图3），即三叠纪（230~210 Ma），侏罗纪（170~150 Ma）和白垩纪（134~80 Ma），类似于脉冲式成矿。后者尽管矿化时间持续了54 Ma，但成矿峰期集中在100~90 Ma。

2.1 三叠纪Sn–W–Nb–Ta矿床

华南地区三叠纪成矿事件以前很少受到关注，仅仅是根据相关花岗岩体的不同方法测年而初步确定广西栗木Nb–Ta–W–Sn矿床成矿发生于晚三叠纪至早中侏罗世（史明魁等，1981；陈毓川等，1989；章锦统，1989；甘晓春等，1991）。最近，杨峰①等（2008）获得栗木矿田矿石的云母$^{40}Ar/^{39}Ar$年龄为214.1 ± 1.9 Ma，蔡明海（2006a）报道湘南与王仙岭花岗岩有关的荷花坪锡矿床的Re–Os等时线年龄为224 ± 1.9 Ma。在湘东地区新发现的锡田锡矿尽管被认为是侏罗纪成矿的产物，但是野外观察主体矽卡岩型锡矿体均位于印支期粗粒花岗岩体的外接触带，呈连续分布。马铁球等（2005）获得锡田矿区内粗粒花岗岩的SHRIMP锆石U–Pb年龄为228.5 ± 2.5 Ma，切穿主岩体的中细粒黑云母花岗岩的SHRIMP锆石U–Pb年龄为155.5 ± 1.7 Ma。后者与云英岩型锡矿有关，云英岩型矿化是一种非主要工业性矿化类型，局部叠加在矽卡岩型矿体之上，其年龄为157.2 ± 1.4~155.6 ± 1.3 Ma（马丽艳等，2008）。通过对湘东钨矿（以

① 杨峰, 李晓峰, 冯佐海, 等. 2008. 栗木锡矿云英岩化花岗岩白云母$^{40}Ar/^{39}Ar$年龄及其地质意义[J]. 桂林工学院学报 (待刊).

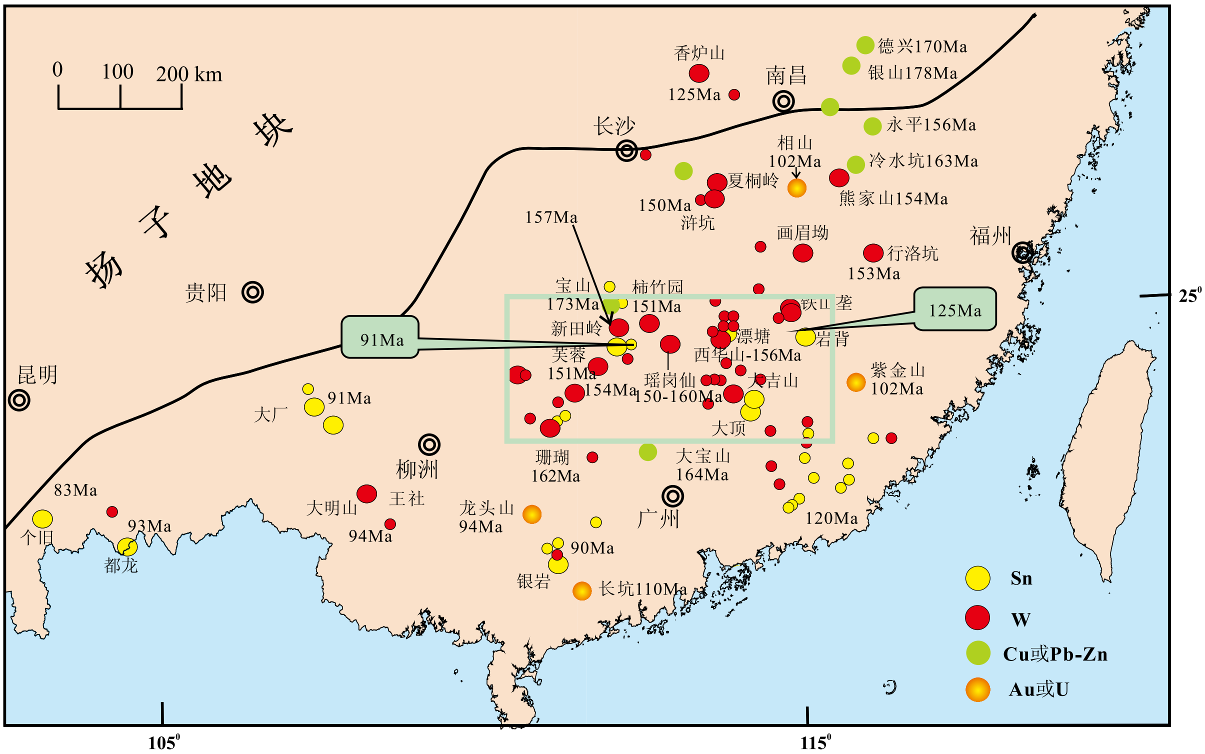


图1 华夏地块及邻区晚中生代主要金属矿床时空分布图

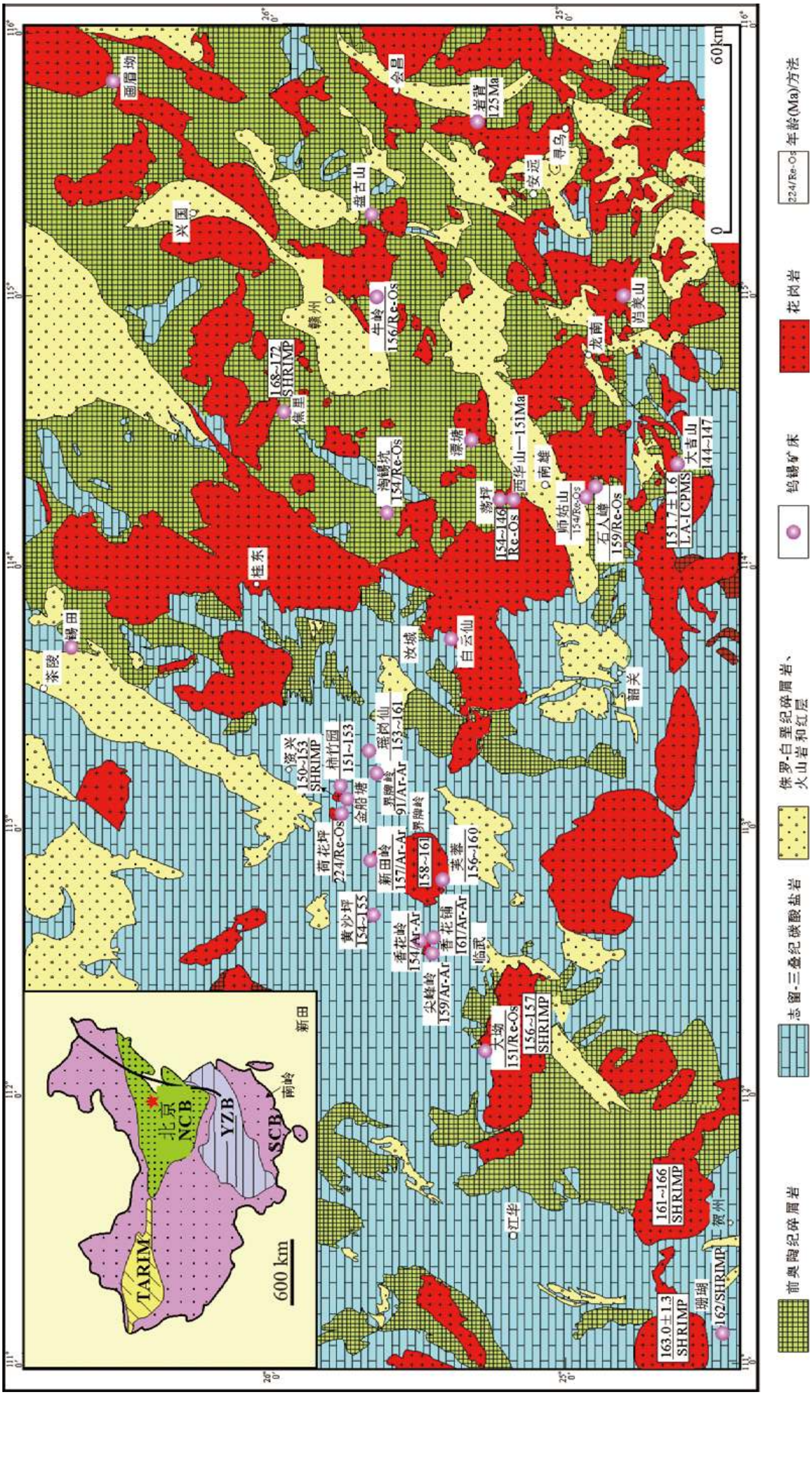
Fig. 1 Spatial-temporal distribution of Mesozoic ore deposits in Cathaysian block and adjoined areas

往称为邓阜仙钨矿）的野外考察，也可以看到该钨矿与印支期岩体具有明显的时空和成因关系。赣南崇（崇义）犹（上犹）余（大余）矿集区内的鹅仙塘锡钨石英脉型矿床的白云母$^{40}Ar/^{39}Ar$年龄为231.4 ± 2.4 Ma（刘善宝等，2008）。赵蕾等（2006）运用LA-ICP-MS方法测得与Sn-U矿床有关的闽西红山含黄玉花岗岩的锆石U-Pb年龄为226 Ma。除此之外，在华南地区鉴定出一系列印支期花岗岩，其成岩时代在220~239 Ma之间（孙涛等，2003；徐夕生等，2003；邓希光等，2004；周新民等，2007）。虽然这些岩体的大多数并非与成矿有直接关系，但是被认为是一种铀源体，在白垩纪花岗岩活动时，铀被淋滤出并富集成矿（陈培荣等，2004）。总的来讲，三叠纪矿化强度与后面即将叙述的侏罗纪和白垩纪两次大规模成矿差之甚远，但随着进一步工作可能有更多三叠纪矿产被鉴别出，也是华南地区进一步找矿的新方向。

2.2　中晚侏罗世铜矿和钨锡多金属矿床

侏罗纪是华南地区最重要的一次成矿事件，矿化有两种不同类型，其一是与花岗岩类有关的钨锡多金属矿床，主要矿床类型为矽卡岩型和石英脉型及少量的云英岩型；其二是斑岩-矽卡岩型铜矿或铜（钼、金）矿床和一些铅锌矿。

侏罗纪的钨锡多金属成矿事件主要发育于南岭地区及其邻区，其中最引人瞩目的是沿十杭带（杭州—十万大山）或杭钦带（杭州—钦州）（图2），在该带有一系列（超）大型矿床发育，包括湘南的柿竹园钨锡钼铋多金属矿床、金船塘锡铋矿、芙蓉锡矿、新田岭钨矿、香花岭锡矿、瑶岗仙钨矿、白云仙钨矿、黄沙坪铅锌锡钼矿，其成矿时代为161~150 Ma（李红艳等，1996；毛景文等，2004a，2007；Peng et al，2006；彭建堂等，2007；马丽艳等，2007；姚军明等，2007；Yuan et al，2008），付建明等（2007）测得湘南九嶷山地区新发现的大坳锡矿的辉钼矿Re-Os等时线年龄为151.4 ± 2.4 Ma。该带向西南延伸到桂东北的富贺钟地区，尽管该区内锡多金属矿仍然缺少精确的成矿年龄，但是与之有关的姑婆山和里松花岗岩的SHRIMP锆石U-Pb年龄为165.0~160.8 Ma（顾晟彦等，2006）。该带向北东方向延伸到湘东的锡田锡矿，如前所述，第2期云英岩型矿化的年龄为157.2 ± 1.4~155.6 ± 1.3 Ma（马丽艳等，



沿杭十带大型–超大型矿床密集分布

Many ore deposits comprising several large or supper-large tin-tungsten deposits are densely distributed along the regional Hangzhou-Shiwandanshan fault zone

图2 南岭地区晚中生代主要金属矿床分布图（据毛景文等，2007）

Fig. 2 Spatial-temporal distribution of major ore deposits in the Nanling area (after Mao et al, 2007)

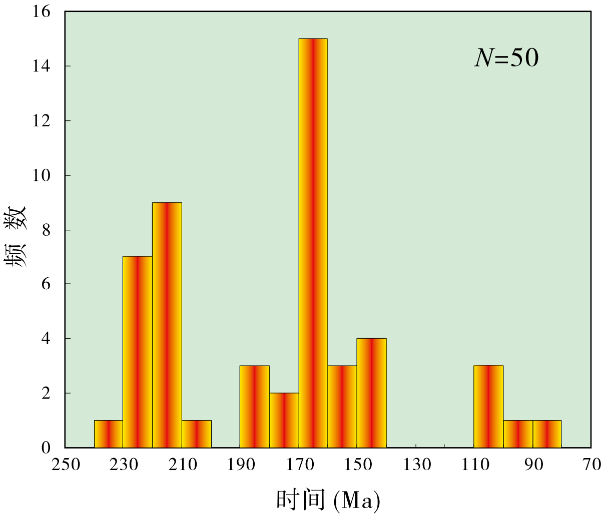


图3 华南地区中生代金属矿床在地质历史期间成矿频数分布图
Fig. 3 Histogram of the Mesozoic ore deposits in South China, reflecting three mineralization pulses

2008），再向北东方向到赣西浒坑石英脉钨钼矿和赣中的金溪熊家山钼矿（图1），浒坑和金溪的辉钼矿Re-Os年龄分别为150.2±2.2 Ma（刘珺等，2008b）和151.7±1.8~161.6±2.0 Ma（孟祥金等，2007）。从闽西行洛坑、赣南西华山到粤北始兴地区是与十杭带相平行的另一条NE向矿带（图1和图2），其中行洛坑钨钼矿的辉钼矿Re-Os等时线年龄为156.3±4.8 Ma（张家菁等，2008a），赣南崇犹余地区淘锡坑钨矿的辉钼矿Re-Os年龄为154.4±3.4 Ma（陈郑辉等，2006），漂塘和柯树岭钨矿的白云母$^{40}Ar/^{39}Ar$年龄分别为155.0±2.4~158.9±1.4 Ma和158.8±1.2 Ma（张文兰等，2007；刘善宝等，2008），大吉山钨矿的白云母$^{40}Ar/^{39}Ar$年龄为144.4±0.5~147.2±0.6 Ma（张文兰等，2006），粤北石人嶂钨矿和师姑山钨铋矿的辉钼矿Re-Os年龄分别为154.2±2.7~154.0±2.0 Ma和159.1±2.2 Ma（付建明等，2008）。从这些测年数据可以看出，南岭及其相邻地区的钨锡多金属矿成矿时代爆发式地出现在150~160 Ma期间，唯有大吉山钨矿在144~147 Ma之间，但蒋国豪等（2004）对大吉山矿区白云母的K-Ar测年数据为158.2±2.8~152.6±2.4 Ma。这些精确成矿时代与其有关的花岗质岩石的锆石SHRIMP和LA-ICP-MS U-Pb测年及云母$^{40}Ar/^{39}Ar$测年获得的数据完全吻合，时间范围为152~165 Ma（刘义茂等，1997，2002；朱金初等，2003，2006；张敏等，2003；付建明等，2004a，b，毛景文等，2004a，c；Li et al，2004；姚军明等，2005；李金东等，2005；江西根等，2006；赵葵东等，2006；李华芹等，2006；马铁球等，2005；顾晟彦等，2006；张文兰等，2006；郭春丽等，2007；丰成友等，2007a，b；刘善宝等，2008；刘珺等，2008a，b），表明了成岩成矿存在密切的相关性。在空间上侏罗纪钨锡多金属矿产及其相关花岗岩主要沿NE向大断裂分布，尤其是在与EW向古深大断裂的交汇部位，形成大型矿集区（图4）。与之有关的花岗岩主要为黑云母花岗岩，在矿化附近的岩体可以见到二云母花岗岩，甚至白云母花岗岩。

与钨锡多金属矿及有关的花岗岩仅分布于南岭及其邻区的特点不同，斑岩-矽卡岩铜矿分布在华南大陆边缘靠近板内一侧，主要包括赣东北德兴、永平、东乡、湘东七宝山、湘南水口山、宝山和铜山岭以及粤北大宝山。从图1可以看出，粤北大宝山可能位于行洛坑—西华山—始兴钨锡成矿带，其余位于十杭带，这种分布特征可能暗示出两种类型矿床的某些成因联系。斑岩铜矿的精确测年数据比较少，仅有德兴斑岩铜矿辉钼矿Re-Os年龄170.4±1.8 Ma（Lu，2005）和大宝山辉钼矿Re-Os年龄164.7±3 Ma（毛景文等，2004c）。但是，对于矿化有关的花岗闪长斑岩体进行了比较系统的高精度测年，其中德兴花岗闪长斑岩的SHRIMP锆石U-Pb年龄为171±3 Ma（王强，2004），宝山、铜山岭和水口山花岗闪长斑岩的锆石U-Pb年龄分别为173.3±1.9，172.3±1.6和178.9±1.7 Ma（王岳军等，2001），永平花岗闪长岩的LA-ICP-MS年龄为160±2.3 Ma（丁昕等，2005）。这组数据表明与斑岩-矽卡岩铜矿有关的岩浆岩侵位主要发生于160~179 Ma，有关矿化略晚于成岩作用，为160~170 Ma，只有永平矽卡岩铜矿有关岩体明显晚于其它岩体。总体来讲，斑岩铜矿及其岩浆系统成岩成矿发生在中晚侏罗世，略早于钨锡矿床及有关的花岗岩，两者似乎沿相同的NE向断裂侵位和成矿。

2.3 白垩纪锡钨铜铅锌金银铀矿床

白垩纪矿化在华南地区的分布特点是面积广泛，呈不连续的矿集区形式出现，成矿作用明显受断陷盆地或断陷隆起和变质核杂岩的控制。铜

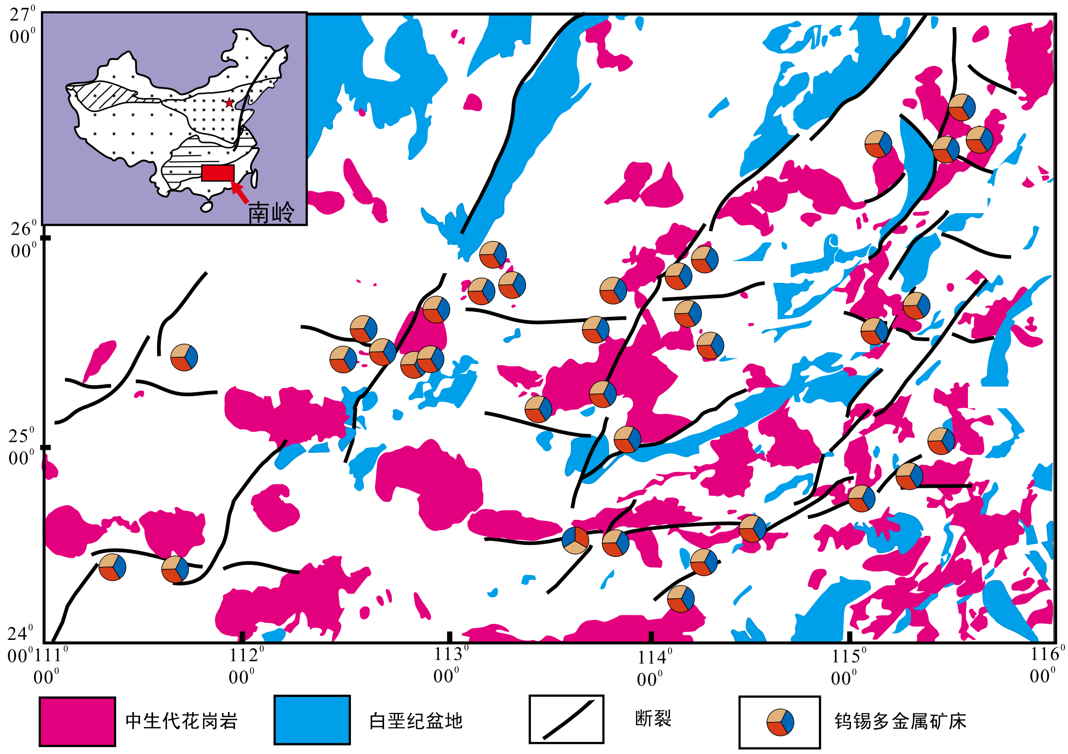


图4　南岭地区主要大型矿集区沿NE向与EW向断裂交汇部位分布图
Fig. 4 Late Jurassic ore deposits are located along the cross of the NE-trending Mesozoic faults with the EW-trending previous faults

金银矿化主要分布在大陆边缘及其内侧，锡钨多金属相对在大陆内部（图1）。在闽西上杭白垩纪断陷盆地发育一组斑岩–浅成低温热液型Cu–Au–Ag矿床，张德全（2003）和刘晓东等（2005）对中寮、五子骑龙、紫金山和碧田矿床进行$^{40}Ar/^{39}Ar$和Rb–Sr年龄测定，分别为104.5 ± 1.7，102.5 ± 1.5，101.9 ± 1.3~100 ± 3和94.7 ± 2.3~91.5 ± 0.4 Ma，这组数据也与区内罗卜岭花岗闪长岩SHRIMP锆石U–Pb年龄105 ± 7.2 Ma（毛建仁等，2004）相吻合。位于粤西三水白垩纪盆地边缘的长坑金矿和富湾银矿构成了另一个浅成低温热液矿集区，孙晓明等（2003）运用$^{40}Ar/^{39}Ar$方法测得成矿时代为109.9 ± 1.4~110.1 ± 1.3 Ma。另外，龙头山浅成低温热液型金矿位于桂东大瑶山断隆或变质核杂岩中，与成矿有关的流纹斑岩和花岗斑岩的SHRIMP锆石U–Pb年龄为103.3 ± 2.4 Ma和100.3 ± 1.4 Ma（陈富文等，2008）。

向大陆内部出现江西会昌中生代盆地内部的岩背锡矿、淘锡坝锡矿和红山斑岩铜矿，寻乌县铜坑嶂斑岩钼矿，粤北银岩斑岩锡矿，湘南界牌岭锡矿，赣北曾家垄锡矿、香炉山钨矿和张十八铅锌矿。其中赣南红山铜矿与闽西紫金山铜金矿位于同一NW向断裂带中，成矿作用发生在花岗斑岩、花岗闪长斑岩及隐爆角砾岩中，矿体总体分布在隐爆角砾岩筒的顶部和两侧及外接触带，其中隐爆角砾岩K–Ar法年龄为109~101 Ma，花岗斑岩K–Ar 法年龄为106~92 Ma，含矿石英脉K–Ar 法年龄为97~80 Ma（周济元等，2000）。会昌盆地中的锡矿缺少精确测年资料，王德滋等（1994）获得与成矿有关的黄玉花岗岩和黄玉花岗斑岩的的Rb–Sr等时线年龄为114.1 ± 0.6 Ma。与会昌盆地同位于武夷山西侧断陷带中的铜坑嶂斑岩钼矿的辉钼矿Re–Os同位素年龄为134.3 ± 1.6~133.4 ± 1.8 Ma（许建祥等，2007）。湘南界牌岭锡矿与成矿有关的黑云母$^{40}Ar/^{39}Ar$年龄为91.1 ± 1.1 Ma（毛景文等，2007），与粤北银岩斑岩锡矿有关花岗斑岩的Rb–Sr等时线年龄86.9 ± 6 Ma（胡祥昭，1989）相接近。张家菁等（2008b）获得香炉山矽卡岩型钨矿的石英Rb–Sr等时线年龄128 ± 3 Ma，与相关花岗岩体的年龄126.2 ± 2.6 Ma相吻合。位于彭山隆起的曾家垄和尖峰坡锡矿尚缺少最新的测年数据，曹汉生（1982）曾报道与成矿有关花岗岩的

K-Ar年龄为104 Ma。

滇东南—桂西是华南地区另一个锡钨集中成矿区，包括个旧、大厂和都龙等一批世界级锡矿。这一地区位于华南地区最西端，过去对于其成矿属于滨太平洋域还是特提斯域不十分清楚，最近的野外调查认为应该属于滨太平洋域的一部分（毛景文等，2008）。近年来同位素精确测年表明这些矿床均形成于中晚白垩世，而且在一个很窄的年龄范围内，其中个旧锡矿田的辉钼矿Re-Os等时线年龄为83.4 ± 2.1 Ma（杨宗喜等，2008），与成矿有关的等粒花岗岩的锆石（LA-ICP-MS）U-Pb年龄为85 ± 0.85 Ma（程彦博等，2008），碱性岩为77.6 ± 3.6 Ma和煌斑岩为77.2 ± 2.4 Ma（程彦博等，2008①）。刘玉平等（2000）曾获得滇东南都龙曼家寨矿段矿石单矿物Rb-Sr等时线年龄为76.7 ± 3.3 Ma。锡石TIMS法表明都龙锡锌矿床的成矿等时线年龄为82.0 ± 9.6 Ma，隐伏花岗岩和花岗斑岩的锆石SHRIMP法$^{206}Pb/^{238}U$年龄加权平均值分别为92.9 ± 1.9 Ma和86.9 ± 1.4 Ma（刘玉平，2007）。与滇东南白牛厂银铅锌矿有关的薄竹山花岗岩的Rb-Sr和U-Pb年龄为115~79 Ma（张世涛等，1997）。王登红等（2004）获得大厂西矿带铜坑-长坡矿床91号层状矿体石英$^{40}Ar/^{39}Ar$坪年龄94.52 ± 0.33 Ma，龙头山100号块状矿体石英$^{40}Ar/^{39}Ar$坪年龄94.56 ± 0.45 Ma。蔡明海等（2005）获得东矿带亢马脉状矿体石英Rb-Sr等时线年龄94.1 ± 2.7 Ma。蔡明海等（2006b）还获得了矿田内龙箱盖岩体主体黑云母花岗岩的SHRIMP锆石U-Pb年龄为93 ± 1 Ma，斑状黑云母花岗岩的SHRIMP锆石U-Pb年龄为91 ± 1 Ma。李水如等（2008）和蔺志永等（2008）运用辉钼矿Re-Os等时线方法测得大明山矿田内大明山钨矿和王社铜钨矿年龄分别为95.40 ± 0.97 Ma和93.8 ± 4.6 Ma。

如前所述，三叠纪过铝花岗岩是一种富含可活化铀的岩石（陈培荣等，2004），在中白垩世岩石圈伸展时受热而活化以至于形成广泛的热液型铀矿床。其时代为下庄铀矿81~115 Ma（邓平等，2003；范洪海等，2003）。

除了以上在华夏地块及邻区的三个成矿期次以外，在华南板块北缘还发育有长江中下游成矿带，该带是华南与华北的连接地带，成矿作用有斑岩-矽卡岩型铜铁金钼多金属矿和玢岩铁矿两个类型，前者及其相关的高钾钙碱性花岗岩类形成于144~130 Ma（毛景文等，2004b；Mao et al，2006；Xie et al，2007；Li et al， 2008；周涛发等，2008；张乐俊等，2008），后者及其相关的高钠碱性中酸性侵入-火山岩组合形成于127~123 Ma（余金杰等，2002；张旗等，2003；Mao et al，2006；谢桂青等，2006；范裕等，2008）。斑岩-矽卡岩型铜铁金钼多金属矿床在空间分布上纵贯全区，成近东西向等距性展布，从西向东有鄂东、九瑞、月山—贵池、铜陵和宁镇5个矿集区；而玢岩铁矿仅分布在宁芜和庐枞两个白垩纪火山盆地中。长江中下游成矿带虽然位于华南板块的北缘，但是其成矿时间分布与华北板块中生代成矿具有同时性（毛景文等，2003，2005），与华夏地块及邻区有明显的差异。

3 三期成矿事件的地质环境

矿床是在地质历史演化期间某些特定地质环境的产物，不同矿产资源组合明显受到不同地质环境的约束。

3.1 三叠纪成矿环境

包括南岭在内的华南板块在印支期地处华北地块与印支地块之间，三大板块于240~220 Ma碰撞对接连成一体。在华南板内出现一系列三叠纪强过铝质花岗岩，呈近东西向展布，面积约1.4万km^2，成岩年龄为252~205 Ma（Zhou et al，2006），Wang等（2001）将三叠纪花岗岩与华北与华南板块碰撞联系在一起，Zhou等（2006）进一步提出早中三叠世花岗岩为同碰撞花岗岩，中晚三叠世花岗岩为后碰撞花岗岩；华南三叠纪W-Sn-Nb-Ta成矿事件的时限为239~214 Ma，与后碰撞花岗岩有密切关系。与成矿有关的花岗质岩石主要表现为过铝质花岗岩，以二云母花岗岩为代表，为加厚地壳重熔的产物。

3.2 侏罗纪成矿环境

侏罗纪是东亚大陆边缘一个重要时期，由

① 程彦博, 毛景文, 陈懋弘, 等. 2008b. 云南个旧锡矿田碱性岩和煌斑岩的LA-ICP-MS锆石U-Pb测年及其地质意义[J]. 中国地质（待刊）.

于伊泽奈奇（Izanagi）板块向大陆斜向俯冲，导致整体从特提斯构造域向太平洋构造域的转换。早侏罗世（205~180 Ma）在东亚大陆曾经历过一个比较宁静时期，很少有火山活动和岩浆侵位（Zhou et al，2006）。在湘南宁远—新田、湘东南宜章、赣南龙南—寻坞和闽西南永定发现了一条约长500 km的中侏罗世火山岩带（许美辉等，1992；赵振华等，1998；陶奎元等，1998；陈培荣等，1999，2002；Li et al，2003；Wang et al，2003；Zhou et al，2006），岩性包括碱性玄武岩和拉斑玄武岩，在赣南和闽西南伴生有流纹岩和少量安山岩，总体上显示为双峰式火山岩，反映出一个中侏罗世早期的裂谷带。虽然这一双峰式火山岩带大致平行于大别—苏鲁和松马三叠纪缝合带，但鉴于与主碰撞的时间存在明显的时间差，徐夕生等（2005）和谢昕等（2005）将其描述为中国东南部特提斯构造域向太平洋构造域转换期及晚中生代大规模火山活动的序幕。Maruyama and Seno（1986），Moore（1989）及万天丰（1993，2002）指出进入侏罗纪以来，作用最强的是伊泽奈奇板块朝NW方向运移，俯冲到东亚大陆之下，初生的太平洋板块则在南半球微弱向NW方向俯冲，致使中国大陆及邻区受到较强的总体向北西挤压和缩短作用。正是这种朝NW方向的挤压、俯冲作用，导致中国大陆块体发生了逆时针20~30°的重要转变，各块体同时向北移动了一点。但至于究竟什么时间伊泽奈奇板块开始向大陆俯冲，一直是一个颇受关注且尚未解决的科学问题。董树文等（2007）根据构造观察和测年数据，提出165 ± 5 Ma以来东亚多板块拼贴运动发生重大调整，构造体制发生重大转换。毛景文等（2007）根据华南金属矿产形成最早时间及其动力学特点，推测伊泽奈奇板块于180 Ma左右从南东方向向北西俯冲，导致大陆加厚。自180 Ma左右，中国东部大陆边缘由于受伊泽奈奇板块向北西俯冲逐渐成为活动大陆边缘，在俯冲过程中由板片重熔形成埃达克质岩浆或钙碱质岩浆，这种岩浆高侵位于浅地表形成了花岗闪长（斑）岩和相关的斑岩–矽卡岩铜矿，其成岩成矿时间在170~160 Ma之间（图5a）。随着持续俯冲造山，大陆地壳不断加厚，在弧后地区出现一系列NE向岩石圈伸展带和深大断裂，在160~150 Ma期间大规模岩浆侵位爆发式出现在南岭及其邻区，主要沿着大断裂展布，尤其是在NE向深大断裂与EW向古老深大断裂交汇部位是岩浆活动的中心。这一套岩石由于其高硅富铝，贫镁铁质组分，而且锶初始值（I_{Sr}）较高，一般大于0.7100，磁化率大约为0.07 $\times 10^{-3}$ SI，通常被认为是S型或改造型花岗岩。近年来，李献华等（2007）认为这套岩石缺少S型花岗岩所特有的标志性矿物如堇青石、石榴石和红柱石等，而且其岩石化学成分不是过铝质，而是准铝质—弱过铝质以及SiO_2–P_2O_5均呈明显的负相关关系，因而建议命名为高分异型I型花岗岩。由于这套岩石相对其它花岗岩类比较富集碱质组分，有些学者建议命名为A型花岗岩（柏道远等，2005；付建明等，2004b）。总体来看，南岭晚侏罗世花岗岩很难与国外已知的典型花岗岩类进行比较，具有高度分异的特殊性。Gilder等（1996）提出从杭州经江西、湖南至十万大山存在一个低t_{DM}和高 ε_{Nd}的花岗岩带（即十杭带），形成于拉张环境。Hong 等（1998）和Chen等（1998）进一步总结提出在华南地块除了十杭带外，还存在其它几条NE向的低t_{DM}和高 ε_{Nd}带，这种低t_{DM}和高 ε_{Nd}带同样反映出几个深大断裂和岩石圈伸展带，这些异常带与南岭地区的钨锡矿的分布具有很好的耦合性。朱金初等（2005）指出牛庙岩体中广泛分布的微细粒暗色包体是共存的更偏基性的岩浆与寄主岩浆不完全混合的残留，李兆丽等（2006）通过对芙蓉矿田中矿石硫化物包裹体的$^3He/^4He$同位素的研究，提出有幔源流体参与成矿作用，所有这些研究一致证明十杭带是一个侏罗纪的岩石圈伸展带，软流圈地幔上涌，早期形成了双峰式火山岩盆地和少量的基性岩瘤，晚期玄武质岩浆底侵诱发隆起区的地壳重熔和混合形成了大量中晚侏罗世花岗岩。由此可以推测在伊泽奈奇板块俯冲过程中，南岭地区可能发生板片大面积撕裂或开天窗，导致地幔物质直接上涌到上地壳，并同熔地壳物质形成花岗岩浆（图5a）。部分岩浆经过高度分异演化后逐步成为富钨锡多金属的含矿岩浆，并经过多级分异演化成矿。可能正是由于南岭地区的俯冲板块在晚侏罗世开天窗或撕裂，导致出现大规模的岩浆活动和钨锡多金属的

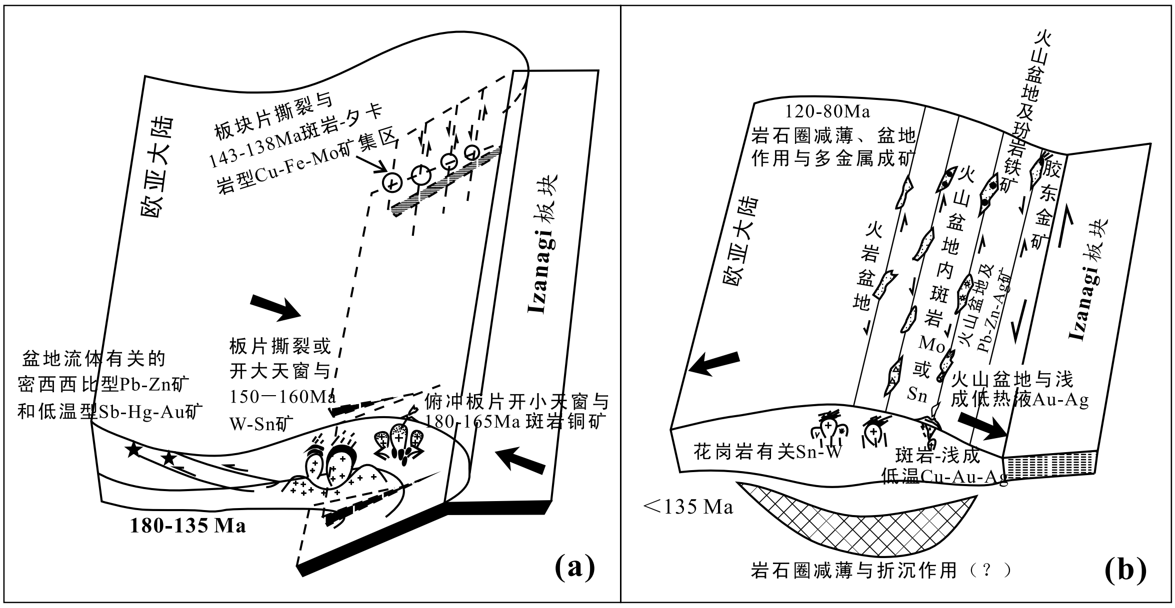
成矿事件，而且巨大的能量引发流体向外流动以及区域受热而产生一系列对流循环系统和低温成矿事件，在南岭西北及北部地区均出现Sb-Hg-Au矿化，例如，锡矿山锑矿和沃溪锑金矿的成矿时代为155.1±1.1~156.3 Ma（Hu et al，1996；Peng et al，2003）和144.8±11.7 Ma（史明魁，1993）。

3.3 白垩纪成矿环境

由于伊泽奈奇板块斜向俯冲，在大陆边缘出现以郯庐为代表的几条相互平行的走滑大断裂（Hilde，1976；戚建中等，2000），Wang（2005）运用SHRIMP锆石U-Pb和云母$^{40}Ar/^{39}Ar$测年获得郯庐大断裂最早形成于165~160 Ma。孙卫东等（2008）认为用洋中脊俯冲可以更好地解释长江中下游地区早白垩世岩浆岩的成分和空间分布特点，提出约125 Ma之前，太平洋板块向西南俯冲，而伊泽奈奇板块向NNW方向快速俯冲，推测洋中脊在145~125 Ma期间指向长江中下游地区，并且可能形成板片窗，是形成长江中下游成矿带及其相关岩体的主要原因。然而，李晓峰等（2008）推测该洋中脊或洋岭可能俯冲到南岭地区导致形成大规模花岗质岩石和有关的铜钼钨锡矿产。根据过去十年对于北美和南美斑岩铜矿研究的新进展，斑岩铜矿及贵金属矿主要与俯冲大洋板片的部分熔融或撕裂及开天窗（James and Sacks，1999；Kerrich et al，2000；Silitioe and Hedenquist，2003；Groves and Bierlein，2007）密切相关，因此，可以推测在145~135 Ma之间由于板块的俯冲并同时沿走向滑移，以至于在长江中下游地区这种曾经历过前陆盆地和山前盆地的薄弱地带发生撕裂或等距性开天窗（图5a），并引发大规模成岩成矿作用。Mao等（2008a，b）对比研究胶东、东秦岭、长江中下游和华夏及邻区的晚中生代花岗岩的精确测年龄数据，提出在中国东部以135 Ma为界线，曾发生过两次大规模的花岗岩侵位事件，胶东、东秦岭、长江中下游的峰期为165~135 Ma和125~115 Ma，华夏及邻区的峰期为165~150 Ma和120~80 Ma。从晚侏罗世到早白垩世华北与华南两大板块运动的不协调性可能也暗示出沿长江中下游地区在144~130 Ma之间曾经历过俯冲板片的撕裂过程。

以往已经有一些研究表明在东亚大陆东部边缘135 Ma是一个重要的地球动力学转折时刻，Hilde（1976）提出了俯冲-转换构造动力学模式。王岳军等（2002）对北淮阳晚中生代火山岩的野外调查和测年结果表明，该区曾发生过两期火山喷发作用：一是主要分布于金寨、鲜花岭和毛坦厂地区的原毛坦厂组火山岩，形成于149~138 Ma；二是主要分布于舒城一带的原晓天组火山岩，年龄为132~116 Ma，两者之间为含灰色片麻岩、榴辉岩和火山岩砾石的火山沉积砾岩层，砾岩层内火山砾石的地球化学特征与毛坦厂组火山岩一致，而有别于晓天组火山岩，这一发现说明早白垩世135 Ma左右有一次重要的地质事件发生。牛宝贵等（2003）报道燕山褶皱带中白垩纪盆地底部火山岩的 SHRIMP锆石U-Pb年龄为135.8±3.5 Ma。周涛发等（2008）对长江中下游地区枞阳盆地火山岩进行了系统锆石U-Pb年龄测定，发现火山岩的年龄为135~124 Ma，并不存在前人推测的侏罗纪火山岩，这套火山杂岩和玢岩铁矿覆盖在三叠纪地层及斑岩-矽卡岩Cu-Mo-Au-Fe矿床和有关花岗岩之上。通过最近几年的精确测年后，在华夏地块及其邻区很少见到有关135 Ma的岩浆活动和成矿作用。Wang等（2007）、贾军涛等（2008）和李理等（2008）分别在松辽盆地和鲁西盆地开展古地磁极移曲线分析和构造应力分析，不约而同地指出在135~110 Ma盆地迅速向北移动，并伴随有大规模的双峰式火山活动。以上这些资料比较一致地指示135 Ma是中国东部从挤压向伸展的转变时期，引起这一事件的重要原因是太平洋板块沿NNE走滑断裂带向北大规模走滑。尽管华南与长江中下游地区以北有一定差别，但整体上也是侏罗纪表现为挤压，白垩纪为岩石圈伸展。在东南沿海地区有大量火山岩，分布广泛的白垩纪石帽组火山岩的锆石LA-ICP-MS年龄为103.0~101.9 Ma（谢昕，2005，转引自邢光福等，2008），而南园组火山岩主体为162.3±3.7~149.8±4.5 Ma，其顶部流纹岩的年龄为130.1±3.6 Ma（邢光福等，2008），在采样处的下部出现不整合界面，可能表明流纹岩代表了另一次火山活动，也指示出135 Ma是岩石圈伸展的开始。

在华南地区，150~130 Ma是一个岩浆活动和成矿作用相对较弱的时期，在南岭地区的150~130



a. 在180~135 Ma期间，Izanagi板块向欧亚大陆俯冲，在大陆边缘及弧后伸展带成矿，170~160 Ma的斑岩铜矿系统及有关岩浆形成可能与俯冲板片局部撕裂或重熔有关，160~150 Ma期间在南岭地区可能由于俯冲板片开天窗，软流圈直接上侵到上地壳，形成一种高分异的富碱质花岗岩和钨锡多金属矿产组合，而由于软流圈底侵及岩浆活动而引发的浅表大规模流体对流循环及远距离运移和成矿形成了密西西比型铅锌矿和低温型Sb+Lg–Au矿床。长江中下游地区可能是在145~135 Ma期间由于经历过前陆盆地和山前盆地这样的薄弱地带发生撕裂或等距性开天窗，进而引发大规模成岩成矿作用；b. 135 Ma以后，俯冲板片沿NE方向快速走滑，导致大陆全面伸展，形成一系列断陷盆地和变质核杂岩及铜金银浅成低温热液矿床、花岗岩有关的钨锡多金属矿床和热液型铀矿

a. The porphyry copper deposits and vein type Pb-Zn-Ag deposits and their related I-type granitoids or aidakitic rocks formed when the Izanagi subducted plate was teared up in several locations at 170~160 Ma. After then a big window occurred in the Nanling area, triggering the asthenospheric substance got into the upper crust so that developed large-scale high fractionation paraluminous granites and related polymetallic W-Sn mineralization. Because starting to change motion-direction to northeast the subucted plate was teared up along the Middle-Lower Yangtze River Valley which used to be a foreland basin of the Triassic Dabie-Sulu orogenic belt. A group of skarn-porphyry Cu-Mo-Au-Fe ore system and related I-type or aidakitic granite developed along the cross of the Middle-Lower Yangtze River Valley with the NE-trending faults at an age range of 145~135 Ma. b. From 135 Ma the subducted plate moved along several groups of regional-scale NE-striking fault zones comprising the Tan-Lu fault zone, which trigged the Eurasian continent to extensive extension. At the setting developed a lot of linear NE-trending Cretaceous faulting basins and metamorphic cores accompanied with volcanic rock eruption as well as epithermal Cu-Au-Ag ore system, granite-related polymetallic Sn (W) deposits and hydrothermal uranium deposits at age of 120~80 Ma with a peak of 100~90 Ma. Izanagi plate started to subduct beneath the Eurasian continent at ca. 180 Ma, During 180~135 Ma

图5 华南地区侏罗—白垩纪地球的动力学演化与成矿的模式图

Fig. 5 Jurassic-Cretaceous mineralization in the South China and their corresponding tectonic regimes

Ma期间较少形成金属矿床。在135 Ma之后进入了一个新的构造成矿旋回，以90~100 Ma为成矿的高峰期。成矿的特点是在大陆边缘以浅成低温热液型铜金银矿床为主，大陆内部主要为与花岗岩小岩体有关的锡钨多金属矿床。所有控矿构造特点明显表现为伸展构造（图5b），即断陷盆地（例如上杭盆地和会昌盆地）和变质核杂岩的拆离断层（龙头山金矿和老君山岩体周围都龙锡矿及南秧坪钨矿等），即使像大厂、个旧锡矿田和大明山钨矿田，虽然没有明显的断陷盆地和变质核杂岩控矿，但是在矿田内抑或发育双峰式的岩浆侵位，抑或有大量岩墙产出，这些都显示出岩石圈伸展环境。在这些矿田广泛出现的沿层交代的Manto型矿体在一定程度反映出与断陷盆有关的层间破碎带控矿，有关岩体出露面积较小则可能反映出所在地区剥蚀较浅。这些控矿构造的基本特点比较一致地指向该时期成岩成矿作用与岩石圈伸展的密切关系，Xie等（2006）研究提出在武夷山以东与以西的白垩纪基性岩墙性质有所不同，分别反映出活动大陆边缘和板内环境。至于东南沿海大陆边缘盆地及其火山岩是由于俯冲板块运移方向改变还是另一次板块俯冲所引起，这一问题有待进一步查明。

References:

Bai Daoyuan, Chen Jianchao, Ma Tieqiu, et al. 2005. Geochemical characteristics and tectonic setting of Qitianling A-type granitic pluton in southeast Hunan [J]. Acta Petrologica et Mineralogica, 24 (4): 255–272. (in Chinese with English abstract)

Cai Minghai, Chen Kaixu, Qu Wenjun, et al. 2006. Geological characteristics and Re–Os dating of molybdenites in Hehuaping tin-polymetallic deposit, southern Hunan Province [J]. Mineral Deposits, 25 (3): 263–268. (in Chinese with English abstract)

Cai Minghai, He Longqing, Liu Guoqing, et al. 2006. SHRIMP zircon U–Pb dating of the intrusive rocks in the Dachang tin-polymetallic ore field, Guangxi and their geological significance [J]. Geological Review, 52 (3): 409–414. (in Chinese with English abstract)

Cai Minghai, Liang Ting, Wu Decheng. 2005. Geological characteristics and ore-forming time of the Kangma deposit in the Dachang tin-polymetallic ore field, Guangxi [J]. Acta Geologica Sinica, 79 (2): 262–268. (in Chinese with English abstract)

Cao Hansheng. 1982. Geological feature and ore-controlling factors of the Zengjialong tin deposit [J]. Geology and Prospecting, 1–6. (in Chinese)

Chen Fuwen, Li Huaqin, Mei Yuping. 2008. Zircon SHRIMP U–Pb chronology of diagenetic mineralization of the Longtoushan porphyry gold orefield, Gui County, Guangxi [J]. Acta Geologica Sinica, 82 (7): 921–926. (in Chinese with English abstract)

Chen J F, Jahn B M. 1998. Crustal evolution of southeastern China: Nd and Sr isotopic evidence [J]. Tectonophysics, 284: 101–133.

Chen Peirong, Hua Renmin, Zhang Bangtong, et al. 2002. Early Yanshanian post-orogenic granitoids in the Nanling region petrological constraints and geodynamic settings [J]. Science in China (Series D), 32 (4): 279–289. (in Chinese)

Chen Peirong, Kong Xinggong, Wang Yinxi, et al. 1999. Rb–Sr isotopic dating and significance of early Yanshanian bimodal volcanic-intrusive complex from south Jiangxi Province [J]. Geological Jounral of China Universities, 5 (4): 378–383. (in Chinese with English abstract)

Chen Peirong. 2004. Geodynamic setting of Mesozoic magmatism and its relationship to uranium metallogenesis in southeastern China [J]. Uranium Geology, 20 (5): 266–270. (in Chinese with English abstract)

Chen Yuchuan, Pei Rongfu, Zhang Hongliang, et al. 1989. The Geology of Non-Ferrous and Rare Metal Deposits Related to Mesozoic Granitoids in Nanling Region [M]. Beijing: Geological Publishing House, 1–506. (in Chinese)

Chen Zhenghui, Wang Denghong, Qu Wenjun, et al. 2006. Geological characterisrics and mineralization age of the Taoxikeng tungsten deposit in Chongyi County, southern Jiangxi Province, China [J]. Geological Bulletin of China, 25 (4): 495–501. (in Chinese with English abstract)

Cheng Yanbo, Mao Jingwen, Xie Guiqing, et al. 2008. Preliminary study of the Petrogenesis of Laochang–Kafang granite in the Gejiu area, Yunnan Province: Constraints from geochemistry and zircon U–Pb dating [J]. Acta Geologica Sinica, 82 (11): 1480–1495. (in Chinese with English abstract)

Deng Ping, Shen Weizhou, Ling Hongfei, et al. 2003. Uranium mineralization related to mantle fluid: A case of study of the Xianshi deposit in the Xiazhuang uranium ore field [J]. Geochimica, 32 (6): 520–528 (in Chinese) .

Deng Xiguang, Chen Zhigang, Li Xianhua, et al. 2004. SHRIMP U–Pb zircon dating of the Darongshan–Shiwandashan granitoid belt in southeastern Guangxi, China [J]. Geological Review, 50 (4): 426–432. (in Chinese with English abstract)

Ding Xin, Jiang Shaoyong, Ni Pei, et al. 2005. Zircon SIMS U–Pb geochronology of host granitoids in Wushan and Yongping copper deposits, Jiangxi Province [J]. Geological Jounral of China Universities, 11 (3): 383–389. (in Chinese with English abstract)

Dong Shuwen, Zhang Yueqiao, Long Changxing, et al. 2007. Jurassic tectonic revolution in China and new interpretation of the Yanshan movement [J]. Acta Geologica Sinica, 81 (11): 1449–1461. (in Chinese with English abstract)

Fan Honghai, Ling Hongfei, Wang Dezi, et al. 2003. Study on metallogenic mechanism of Xiangshan uranium ore-field [J]. Uranium Deposits, 19: 208–213.

Fan Yu, Zhou Taofa, Yuan Feng, et al. 2008. LA–ICP–MS zircon ages of the A-type granites in the Luzong (Lujiang–Zongyang) area and their geological significances [J]. Acta Petrologica Sinica, 24: 1715–1524. (in Chinese with English abstract)

Feng Chengyou, Feng Yaodong, Xu Jianxiang, et al. 2007b. Isotope chronological evidence for upper Jurassic petrogenesis and mineralization of altered granite-type tungsten deposits in the Zhangtiantang area, southern Jiangxi [J]. Geology in China, 34 (4): 642–650. (in Chinese with English abstract)

Feng Chengyou, Xu Jianxiang, Zeng Zailin, et al. 2007a. Zircon SHRIMP U–Pb and molybdenite Re–Os dating in Tianmenshan–Hongtaoling tungsten-tin orefield, southern Jiangxi Province, China, and its geological implication [J]. Acta Geologica Sinica, 81 (7): 925–963. (in Chinese with English abstract)

Fu Jianming, Li Huaqin, Qu Wenjun, et al. 2007. Re–Os isotope dating of the Da'ao tungsten-tin deposit in the Jiuyi Mountains, southern Hunan Province [J]. Geology in China, 34 (4): 651–656. (in Chinese with English abstract)

Fu Jianming, Li Huaqin, Qun Wenjun, et al. 2008. Determination of mineralization epoch of quartz-vein type tungsten deposits in Shixing region, northern Guangdong and its geological significance [J]. Geotectonica et Metallogenia, 32 (1): 57–62. (in Chinese with English abstract)

Fu Jianming, Ma Changqian, Xie Caifu, et al. 2004a. Zircon SHRIMP dating of the Cailing granite on the eastern margin of the Qitianling granite, Hunan, South China, and its significance [J]. Geology in China, 31 (1): 96–100. (in Chinese with English abstract)

Fu Jianming, Ma Changqian, Xie Caifu, et al. 2004b. SHRIMP U–Pb zircon dating of the Jiuyishan composite granite in Hunan and its geological significance [J]. Geotectonica et Metallogenia, 28 (4): 370–378. (in Chinese with English abstract)

Gan Xiaochun, Shen Weizhou and Zhu Jinchu. 1991. A study of isotopic geology of Shuiximiao deposit Limu district, Guangxi Zhuang Autonomous Region. Journal of Nanjing University (Earth sciences), 3 (1): 48–55. (in Chinese with English abstract)

Gilder S A, Gill J, COE R S, et al. 1996. Isotopic and paleomagmatic constraints on the Mesozoic tectonic evolution of South China. Journal of Geophysics Research, 101 (B7): 13137–16154.

Groves D I, and Bierlein F. 2007. Geodynamic settings of mineral deposit system [J]. Jour. Geol. Soc. London, 164: 19–30.

Gu Shengyan, Hua Renmin, Qi Huawen, et al. 2007. Study on zircon LA–ICP–MS U–Pb dating and Sr–Nd isotope of the Guposhan granite in Guangxi [J]. Acta Geologica Sinica, 80 (4): 543–553. (in Chinese with English abstract)

Guo Chunli, Wang Denghong, Chen Yuchuan, et al. 2007. Precise zircon SHRIMP U–Pb and quartz vein Rb–Sr dating of Mesozoic Taoxikeng tungsten polymetallic deposit in southern Jianxi [J].

Mineral Deposits, 26 (4): 432–442. (in Chinese with English abstract)

Hilde T W C. 1976. Tectonic history of the western Pacific [M] // Drake CL. Geodynamics. In: Progress and Prospects, American Geophysical Union.

Hong D W, Xie X L, Zhang J S. 1998. Isotope geochemistry of granitoids in South China and their metallogeny [J]. Resource Geology, 48: 251–264.

Hu Ruizhong, Bi Xianwu, Peng Jiantang, et al. 2007. Some problems concerning relationship between Mesozoic–Cenozoic lithospheric extension and uranium metallogenesis in South China [J]. Mineral Deposits, 26 (2): 139–152. (in Chinese with English abstract)

Hu Xiangzhao. 1989. The origin and petrology of the Yinyan tin-bearing granite porphyry [J]. Geochimica, 18 (3) :251–263. (in Chinese with English abstract)

Hu XW, Pei R F, Zhou S. 1996. Sm–Nd dating for antimony mineralization in the Xikuangshan deposit, Hunan, China [J]. Resource Geology, 46: 277–231.

Hua Renmin, Chen Peirong, Zhang Wenlan, et al. 2005a. Three major metallogenic events in Mesozoic in South China [J]. Mineral Deposits, 24 (2), 99–107. (in Chinese with English abstract)

Hua Renmin, Chen Peirong, Zhang Wenlan, et al. 2005b. Metallogeneses and their geodynamic setting related to Mesozoic granitiods in the Nanling range [J]. Geological Journal of China Universities, 11 (3): 291–304. (in Chinese with English abstract)

Hua Renmin and Mao Jingwen. 1999. A preliminary discussion on the Mesozoic metallogenic explosion in east China [J]. Mineral Deposits, 18 (4): 300–308. (in Chinese with English abstract)

James D E and Sacks I S. 1999. Cenozoic formation of the Central Andes: A geophysical perspective [M]. // Skinner B J. Geology and Ore Deposits of the Central Andes. Soc. Econ. Geol. Special Pub., 7: 1–26.

Jia Juntao, Wang Pujun, Wan Xiaoqiao. 2008. Chronostratigraphy of the Yingcheng Formation in the Songliao Basin, Cretaceous, NE China [J]. Geological Review, 54 (4): 439–448.

Jiang Guohao, Hu Ruizhong, Xie Guiqing, et al. 2004. K-Ar ages of plutonism and mineralization at the Dajishan tungsten deposit, Jiangxi Province, China [J]. Acta Mineralogica Sinica, 24 (3): 253–256. (in Chinese with English abstract)

Jiang Xigen, Bai Daoyuan, Chen Jianchao, et al. 2006. Geochemical characteristics and tectonic setting of Baofengxian early Yanshanian granites, southeastern Hunan [J]. Geotectonica et Metallogenia, 30 (2): 206–219. (in Chinese with English abstract)

Kerrich R, Goldfarb R, Groves D I, et al. 2000. The geodynamics of world-class gold deposits: Characteristics, space-time distribution, and origin [J]. Rev. Econ. Geol., 13: 501–551.

Li Hongyan, Mao Jingwen, Sun Yali, et al. 1996. Re–Os isotopic chronology of molybdenites in the Shizhuyuan polymetallic tungsten deposit, southern Hunan [J]. Geological Review, 42 (3): 261–267. (in Chinese with English abstract)

Li Huaqin, Lu Yuanfa, Wang Denghong, et al. 2006. Dating of the rock-forming and ore-forming ages and their geological significances in the Furong ore-field, Qitianling Mountain, Hunan [J]. Geological Review, 52 (1): 113–121. (in Chinese with English abstract)

Li J W, Zhao X F, Zhou M F, et al. 2008. Origin of the Tongshankou porphyry-skarn Cu-Mo deposit, eastern Yangtze craton, Eastern China: Geochronological, geochemical and Sr–Nd–Hf isotopic constraints [J]. Mineralium Deposita, 43: 315–336.

Li Jindong, Bai Daoyuan, Wu Guangying, et al. 2005. Zircon SHRIMP dating of the Qitianling granite, Chenzhou, southern Hunan, and its geological significance [J]. Geological Bulletin of China, 24 (5): 411–414. (in Chinese with Egnlish abstract)

Li Li, Zhong Dalai, Shi Xiupeng, et al. 2008. Late Mesozoic extensional structure and its constraints on mineralization in western Shandong [J]. Geological Review, 54 (4): 449–458. (in Chinese with English abstract)

Li Shuiru, Wang Denghong, Liang Ting, et al. 2008. Metallogenic epochs of the Damingshan tungsten deposit in Guangxi and its prospecting potential [J]. Acta Geologica Sinica, 82 (7): 873–879. (in Chinese with Egnlish abstract)

Li X H, Chen Z G, Liu D Y, et al. 2003. Jurassic grabbro-syenite suites from southern Jiangxi province, SE China: Age, origin, and tectonic significance [J]. International Geology Review, 45: 898–921

Li X H, Liu D Y, Sun M, et al. 2004. Precise Sm-Nd and U-Pb isotopic dating of the supper-giant Shizhuyuan polymetallic deposit and its host granites, SE China [J]. Geological Magazine, 141: 225–231.

Li Xianhua, Li Wuxian, Li Zhengxiang. 2007. On the genetic classification and tectonic implications of the early Yanshanian granitiods in the Nanling range, South China [J]. Chinese Science Bulletin, 52 (9): 981–991. (in Chinese)

Li Xiaofeng, Watanabe Yasushi, Hua Renmin, et al. 2008. Mesozoic Cu-(Mo)-W-Sn mineralization and ridge/triple subduction in south China [J]. Acta Geologica Sinica, 82 (5): 625–640. (in Chinese with Egnlish abstract)

Li Zhaoli, Hu Ruizhong, Peng Jiantang, et al. 2006. Helium isotope composition of fluid inclusions and the origin of ore-forming fluids of Furong tin orefield in Hunan Province, China [J]. Earth Science—Journal of China University of Geosciences, 31 (1):129–135. (in Chinese with Egnlish abstract)

Lin Zhiyong, Wang Denghong, Li Shuiru. 2008. Re-Os isotopic age of molybdenite from the Wangshe copper-tungsten deposit in Guangxi Province and their implications [J]. Acta Geologica Sinica, 82 (11): 1569–1575. (in Chinese with Egnlish abstract)

Liu Jun, Mao Jingwen, Ye Huishou, et al. 2008a. Zircon LA-ICP-MS U–Pb dating of the Hukeng granite in Wugongshan area, Jiangxi Province and its geochemical characteristics [J]. Acta Petrologica Sinica, 24: 1813–1822. (in Chinese with English abstract)

Liu Jun, Mao Jingwen, Ye Huishou, et al. 2008b. Re–Os dating of molybdenite from the Hukeng tungsten deposit in the Wugongshan area, Jiangxi Province, and its geological implications [J]. Acta Geologica Sinica, 82 (11): 1576–1584. (in Chinese with Egnlish abstract)

Liu Shanbao, Wang Denghong, Chen Yuchuan, et al. 2008. $^{40}Ar/^{39}Ar$ ages of muscovite from different types tungsten-bearing quartz veins in the Chong–Yu–You concentrated mineral area in Gannan region and its geological significance [J]. Acta Geologica Sinica, 82 (7): 932–940. (in Chinese with Egnlish abstract)

Liu Xiaodong and Huan Renmin. 2005. $^{40}Ar/^{39}Ar$ dating of adularia from the Bitian gold-silver-copper deposit, Fujian Province [J]. Geological Review, 51 (2):151–155. (in Chinese with Egnlish abstract)

Liu Yimao, Dai Tongmo, Lu Huanzhang, et al. 1997. Isotopic date of $^{40}Ar/^{39}Ar$ and Sm-Nd for diagenesis-metallogenesis of the Qianlishan granite [J]. Science in China (Series D), 27 (5): 425–430. (in Chinese)

Liu Yimao, Xu Jifeng, Dai Tongmo, et al. 2002. $^{40}Ar/^{39}Ar$ isotopic ages of Qitianling granite and their geologic implications [J]. Science in China (Series D), 32 (Supp): 40–48. (in Chinese)

Liu Yuping, Li Chaoyang, Gu Tuan, et al. 2000. Isotopic constraints on the source of ore-forming materials of Dulong Sn-Zn polymetallic deposit, Yunnan [J]. Geology–Geochemistry, 28 (4): 75–82. (in Chinese with Egnlish abstract)

Liu Yuping, Li Zhengxiang, Li Huimin, et al. 2007. U-Pb geochronology of cassiterite and zircon from the Dulong Sn–Zn deposit: Evidence for Cretaceous large-scale granitic magmatism and mineralization events in southeastern Yunnan Province, China [J]. Acta Petrologica Sinica, 23 (5): 967–976. (in Chinese with Egnlish abstract)

Lu J J, Hua R M, Yao C L. 2005. Re–Os age for molybdenite from the Dexing porphyry Cu-Au deposit in Jiangxi province, China [J]. Geochim. Cosmochim. Acta, 69 (Suppl. A), 882.

Ma Dongsheng. 2008. Metallogenetic characteristics of the important deposits in South China [J]. Bulletin of Mineralogy, Petrology and Geochemistry, 27 (3): 209–217. (in Chinese with Egnlish abstract)

Ma Liyan, Fu Jianmin, Wu Shichong, et al. 2008. $^{40}Ar/^{39}Ar$ isotopic dating of the Longshang tin-polymetallic deposit, Xitian orefield, eastern Hunan [J]. Geology in China, 35 (4): 706–713. (in Chinese with Egnlish abstract)

Ma Liyan, Lu Yuanfa, Qu Wenjun, et al. 2007. Re–Os isotopic chronology of molybdenites in Huangshaping lead-zinc deposit, southeast Hunan, and its geological implications [J]. Mineral Deposits, 26 (4): 425–431. (in Chinese with Egnlish abstract)

Ma Tieqiu, Bai Daoyuan, Kuang Jun, et al. 2005. Zircon SHRIMP dating of the Xitian granite pluton, Chaling, southeastern Hunan, and its geological significance. Geological Bulletin of China, 24 (5): 415–419. (in Chinese with Egnlish abstract)

Mao J W, Wang Y T, Lehmann B, et al. 2006. Molybdenite Re–Os and albite $^{40}Ar/^{39}Ar$ dating of Cu-Au-Mo and magnetite porphyry systems in the Yangtze River valley and metallogenic implications [J]. Ore Geol. Rev., 29: 307–324.

Mao J W, Xie G Q, Bierlein F, et al. 2008a. Tectonic implications from Re-Os dating of Mesozoic molybdenum deposits in the East Qinling–Dabie orogenic belt [J]. Geochim. Cosmochim. Acta, 72：4607–4626

Mao J W, Xie G Q, Pirajno F, et al. 2008b. Late Jurassic–Cretaceous granitoids in the Eastern Qinling, Central-eastern China: SHRIMP zircon U-Pb ages and tectonic implications [J]. Australia Journal of Earth Sciences, (in press).

Mao Jianren, Xu Naizheng, Hu Qing, et al. 2004. The Mesozoic rock-forming and ore-forming processes and tectonic environment evolution in Shanghang–Datian region, Fujian [J]. Acta Petrologica Sinica, 20 (2): 285–296. (in Chinese with Egnlish abstract)

Mao Jingwen, Chen Yanbo, Guo Chunli, et al. 2008. Gejiu tin polymetallic ore-field: Deposit model and discussion for several points concerned [J]. Acta Geologica Sinica, 82 (11): 1455–1467. (in Chinese with Egnlish abstract)

Mao Jingwen, Hua Renmin, Li Xiaobo. 1999. A preliminary study of large–scale metallogenesis and large clusters of mineral deposits [J]. Mineral Deposits, 18 (4): 291–299. (in Chinese with Egnlish abstract)

Mao Jingwen, Li Xiaofeng, Bernd Lehmann, et al. 2004b. $^{40}Ar–^{39}Ar$ dating of tin ores and related granite in Furong tin orefield, Hunan Province, and its geodynamic significance [J]. Mineral Deposits, 23 (2): 164–174. (in Chinese with Egnlish abstract)

Mao Jingwen, Stein H, Du Andao. 2004c. Re–Os dating of Cu, Au(Mo) deposit and its implications for mineralization in Middle-Lower Reacher of Yangtz River [J]. Acta Geologica Sinica, 78 (1):121–131. (in Chinese with Egnlish abstract)

Mao Jingwen, Xie Guiqing, Guo Chunli, et al. Large-scale tungsten-tin mineralization in the Nanling region, South China: Metallogenic ages and corresponding geodynamic processes [J]. Acta Petrologica Sinica, 23 (10): 2329–2338. (in Chinese with Egnlish abstract)

Mao Jingwen, Xie Guiqing, Li Xiaofeng, et al. 2004a. Mesozoic large scale mineralization and multiple lithospheric extensions from South China [J]. Earth Science Frontiers, 11 (1): 45–56. (in Chinese with Egnlish abstract)

Mao Jingwen, Xie Guiqing, Zhang Zuoheng, et al. 2005. Mesozoic large-scale metallogenic pulses in North China and corresponding geodynamic settings. Acta Geologica Sinica, 21 (1): 169–188. (in Chinese with Egnlish abstract)

Mao Jingwen, Zhang Zuoheng, Yu Jinjie, et al. 2003. Geodynamic setting of Mesozoic large-scale mineralization in the North China and adjacent area: Implication from the highly precise and accurate ages of metal deposits [J]. Science in China (Series D), 33 (4): 289–300. (in Chinese)

Maruyama S and Seno T. 1986. Orogeny and relative plate motion: Example of the Japanese Islands [J]. Tectonophysics, 127: 305–329.

Meng Xiangjin, Hou Zengqian, Dong Guangyu, et al. 2007. The geological characteristics and Re–Os isotope age of molybdenite of the Xiongjiashan molybdenum deposit, Jiangxi Province [J]. Acta Geologica Sinica, 81 (7): 946–951. (in Chinese with Egnlish abstract)

Moore G W. 1989. Mesozoic and Cenozoic paleographic development of the Pacific region. Abstract, 28th IGC (2), Washington DC, USA: GAS Press, 455–456.

Niu Baogui, He Zhengjun, Song Biao, et al. 2003. SHRIMP dating of the Zhangjiakou volcanic series and its significance [J]. Geological Bulletin of China, 22 (2): 140–141.(in Chinese)

Peng J T, Hu R Z, Burnard P G. 2003. Samarium-neodymium isotope systematics of hydrothermal calcites from the Xikuangshan antimony deposit (Hunan, China): The potential of calcite as a geochronometer [J]. Chemical Geology, 200: 129–136.

Peng J T, Zhou M F, Hu R Z, et al. 2006. Precise molybdenite Re–Os and mica Ar–Ar dating of the Mesozoic Yaogangxian tungsten deposit, central Nanling district, South China [J]. Mineralium Deposita, 41: 661–669.

Peng Jiantang, Hu Ruizhong, Bi Xianwu, et al. 2007. $^{40}Ar–^{39}Ar$ isotopic dating of tin mineralization in Furong deposit of Hunan Province and its geological significance [J]. Mineral Deposits, 26 (3): 237–248. (in Chinese with Egnlish abstract)

Peng Jiantang, Hu Ruizhong, Yuan Shunda, et al.2008. The time ranges of granitiod emplacement and related nonferrous metallic mineralization in southern Hunan [J]. Geological Review, 54 (5): 617–625. (in Chinese with Egnlish abstract)

Qi Jianzhong, Liu Hongying, Jiang Yaohui. 2000. Yanshanian subduction and strike–strike-sliping regime of East China, and its control of ore localization [J]. Volcanology & Mineral Resources, 21 (4): 244–265. (in Chinese with Egnlish abstract)

Shi Mingkui and Sun Gong'an. 1981. Petrological and geochemical characteristics of rare-metal granites in Limu, Guangxi [J]. Yichang

Inst Geol Bull., 3: 96–107. (in Chinese)

Shi Mingkui, Fu Biqin, Jin Xixiang. 1993. Xiangzhong Sb deposits [M]. Changsha: Hunan Sci. Pub. House.1–110. (in Chinese)

Sillitoe R H and Hedenquist J W. 2003. Linkages between volcanotectonic settings, ore-fluid compositions, and epithermal precious metal deposits [J]. Society of Econ Geol Spec Publication, 10: 315–343.

Sun Tao, Zhou Xinmin, Chen Peirong, et al. 2003. Mesozoic strongly peraluminous granites from eastern Nanling range, southern China: Petrogenesis and implications for tectonics [J]. Sciences in China (Series D), 33 (12):1209–1218. (in Chinese)

Sun Weidong, Ling Mingxing, Wang Fangyue, et al. 2008. Pacific plate subduction and Mesozoic geological event in eastern China [J]. Bulletin of Mineralogy, Petrology and Geochemistry, 27 (3): 218–225. (in Chinese with Egnlish abstract)

Sun Xiaoming, Chen Wen, Wang Min, et al. 2003. Dating of sediment-hosted disseminated-type gold deposit by using $^{40}Ar/^{39}Ar$ laser probe: A case study of Changkeng large-scale gold deposit, China [J]. Chinese Science Bulletin, 48 (12): 1355–1358. (in Chinese)

Tao Kuiyuan, Mao Jianren, Yang Zhuliang, et al. 1998. Mesozoic petro-tectonic associations and records of the geodynamic processes in southeast China [J]. Earth Science Frontiers, 5 (4): 183–191. (in Chinese with Egnlish abstract)

Wan Tianfeng and Zhu Hong. 2002. Tectonics and environment change of Meso-Cenozoic in China continent and its adjacent areas [J]. Geoscience, 16 (2): 107–120. (in Chinese with Egnlish abstract)

Wan Tianfeng. 1993. Studies on intraplate deformation and structural stress field during the Mesozoic-Cenozoic era in eastern China and its application [M]. Beijing: Geological Publ House, 1–103. (in Chinese).

Wang D Z, Shu L S, Fure M, et al. 2001. Mesozoic magmatism and granitic dome in the Wugongshan Massif, Jiangxi province and their genetical relationship to the tectonic events in southeast China [J]. Tectonophysics, 339: 259–277.

Wang Denghong, Chen Yuchuan, Chen Wen, et al. 2004. Dating the Dachang gaint tin-polymetallic deposit in Nandan, Guangxi [J]. Acta Geologica Sinica, 78 (1): 132–138. (in Chinese with Egnlish abstract)

Wang Dezi, Shen Weizhou, Liu Changshi, et al. 1994. Geochemical features and origin of volcanic-intrusive complex in Yanbei, Jiangxi [J]. Science in China (Series B), 24 (5): 531–538. (in Chinese)

Wang P J, Xie X A, Frank M, et al. 2005. The Cretaceous Songliao basin: Volcanic succession, sedimentary sequence and tectonic evolution, NE China [J]. Acta Geologica Sinica, 81: 1002–1011.

Wang Qiang, Zhao Zhenhua, Jian Ping, et al. 2004. SHRIMP zircon geochronology and Nd–Sr isotopic geochemistry of the Dexing granodiorite porphyries [J]. Acta Petrologica Sinica, 20 (2): 315–320. (in Chinese with Egnlish abstract)

Wang Y J, Fan W M, Guo F, et al. 2003. Geochemistry of Mesozoic mafic rocks adjacent to the Chenzhou–Linwu fault, South China: Implication for the lithosphere boundary between the Yangtze and Cathysia blocks [J]. International Geological Review, 45: 263–286.

Wang Y. 2005. The onset of the Tan–Lu fault movement in eastern China: Constraints from zircon (SHRIMP) and $^{40}Ar/^{39}Ar$ dating [J]. Terra Nova, 18: 423–431.

Wang Yuejun, Fan Weiming, Guo Feng, et al. 2001. U–Pb dating of early Mesozoic granodioritic intrusions in southeastern Hunan Province, South China and its petrogenetic implications [J]. Science in China (Series D), 31 (9): 745–751. (in Chinese)

Wang Yuejun, Fan Weiming, Guo Feng. 2002. K–Ar dating of late Mesozoic volcanism and geochemistry of volcanic gravels in the North Huaiyang belt, Dabie orogen: Constraints on the stratigraphic framework and exhumation of the northern Dabie orthogenesis complex [J]. Chinese Science Bulletin, 47 (20): 1528–1534. (in Chinese)

Xie G Q, Hu R Z, Mao J W, et al. 2006. K–Ar dating, geochemical, and Sr–Nd–Pb isotopic systematics of late Mesozoic mafic daykes, southern Jiangxi province, Southeastern China: Petrogenesis and tectonic implication [J]. International Geological Reviews, 48: 1023–1051.

Xie G Q, Mao J W, Li R L, et al. 2007. Re–Os molybdenite and Ar–Ar phlogopite dating of Cu-Fe-Au-Mo (W) deposits in southeastern Hubei, China [J]. Mineral. Petrol., 90: 249–270.

Xie Guiqing, Mao Jingwen, Li Ruiling, et al. 2006. SHRIMP zircon U–Pb dating for volcanic rocks of the Dasi Formation in southeast Hubei Province, middle-lower reaches of the Yangtze River and its implications [J]. Chinese Science Bulletin, 51 (19): 2283–2291. (in Chinese)

Xie Xin, Xu Xisheng, Zou Haibo, et al. 2005. The prelude of Mesozoic large magmatic processes in southeast China: Early J2 basalt [J]. Science in China (Series D), 35 (7): 587–605. (in Chinese)

Xing Guangfu, Lu Qingdi, Chen Rong, et al. 2008. Study on the ending time of late Mesozoic tectonic regime transition in South China—Comparing to the Yanshan area in North China [J]. Acta Geologica Sinica, 82 (4): 451–463. (in Chinese with Egnlish abstract)

Xu Jianxiang, Zeng Zailin, Li Xueqin, et al. 2007. Geological characteristics and mineralization age of the Tongkengzhang molybdenum deposit in Xunwu County, south Jiangxi Province, China [J]. Acta Geologica Sinica, 81 (7): 924–928. (in Chinese with Egnlish abstract)

Xu Meihui. 1992. Early Jurassic bimodal volcanic rocks and their structure environment in Yongding County, Fujian Province [J]. Geology of Fujian, 11 (2): 115–125. (in Chinese with Egnlish abstract)

Xu Xisheng and Xie Xin. 2005. Late Mesozoic–Cenozoic basaltic rocks and crust-mantle interaction, SE China [J]. Geological Jounral of China Universities, 11 (3): 318–334. (in Chinese with Egnlish abstract)

Xu Xisheng, Deng Ping, S.Y. O'Reilly, et al. 2003. Single zircon LA–ICPMS U–Pb dating of the Guidong complex (SE China) and its petrogenetic significance [J]. Chinese Science Bulletin, 48 (12): 1328–1334. (in Chinese)

Yang Zongxi, Mao Jingwen, Chen Maohong, et al. 2008. Re–Os dating of molybdenites from the Kafeng skarn-type copper (tin) deposit in the Gejiu tin polymetallic ore distritct and its geological significance [J]. Acta Petrologica Sinica, 24: 1937–1944. (in Chinese with English abstract)

Yao Junming, Hua Renmin, Lin Jinfu. 2005. Zircon LA–ICPMS U–Pb dating and geochemical characteristics of Huangshaping granite in southeast Hunan Province, China [J]. Acta Petrologica Sinica, 21 (3): 688–696. (in Chinese with English abstract)

Yao Junming, Hua Renmin, Qu Wenjun, et al. 2007. Re–Os isotope dating of molybdenites in the Huangshaping Pb-Zn-W-Mo polymetallic deposit, Hunan Province, South China and its geological significance [J]. Science in China (Series D), 37 (4):

471–477. (in Chinese)

Yu Jinjie and Mao Jingwen. 2002. Albite $^{40}Ar-^{39}Ar$ dating and its significance of the Ningwu porphyrite Fe deposit [J]. Progress in Natural Science, 12 (10): 1059–1063. (in Chinese)

Yuan S D, Peng J T, Hu R Z, et al. 2008. A precise U–Pb age on cassiterite from the Xianghualing tin-polymetallic deposit (Hunan, South China) [J]. Mineralium Deposita, 43: 385–372.

Zhang Dequan, Feng Chengyou, Li Daxin, et al. 2003. $^{40}Ar-^{39}Ar$ dating of adularia from Bitian sericite-adularia type epithermal Ag-Au deposit in Fujian Province and its geological significance [J]. Mineral Deposits, 22 (4): 360–365. (in Chinese with Egnlish abstract)

Zhang Jiajing, Chen Zhenghui, Wang Denghong, et al. 2008a. Geological characteristics and metallogenic epoch of the Xingluokeng tungsten deposit, Fujian Province [J]. Geotectonica et Metallogenia, 2008a, 32 (1): 92–97. (in Chinese with Egnlish abstract)

Zhang Jiajing, Mei Yuping, Wang Denghong, et al. 2008b. Isochronology study on the Xianglushan scheelite deposit in north Jiangxi Province and its geological significance [J]. Acta Geologica Sinica, 82 (7): 927–922. (in Chinese with Egnlish abstract)

Zhang Lejun, Zhou Taofa, Fan Yu, et al. 2008. SHRIMP U–Pb zircon dating of the Yueshan intrusion in the Yueshan ore field, Anhui, and its significance [J]. Acta Petrologica Sinica, 24 (8): 1725–1732. (in Chinese with English abstract)

Zhang Min, Chen Peirong, Zhang Wenlan, et al. 2003. Geochemical characteristics and petrogenesis of Dadongshan granite pluton in mid Nanling range [J]. Geochimica, 32 (6): 529–539. (in Chinese with Egnlish abstract)

Zhang Qi, Jian Ping, Liu Dunyi, et al. 2003. SHRIMP dating of volcanic rocks from Ningwu area and its geological implications [J]. Science in China (Series D), 33 (4): 309–314. (in Chinese)

Zhang Shitao and Chen Guochang. 1997. The geological features and evolution of the Baozhu MT complex granite body in SE Yunnan [J]. Yunnan Geology, 16 (3): 222–232. (in Chinese with Egnlish abstract)

Zhang Tongjin. 1989. Limu Nb-Ta-W-Sn deposit [M]. // Chen Yuchuan, et al. Nonferrous Metal and Rare Metal Deposits Geology Related to Mesozoic Granites in Nanling Area. Beijing: Geol. Pub. House, 130–140. (in Chinese with English abstract)

Zhang Wenlan, Hua Renmin, Wang Rucheng, et al. 2006. New dating of the Dajishan granite and related tungsten mineralization in southern Jiangxi [J]. Acta Geologica Sinica, 80 (7): 956–962. (in Chinese with Egnlish abstract)

Zhang Wenlan, Hua Renmin, Wang Rucheng, et al. 2007. Study on the age of Piaotang granite and related tungsten mineralization in southern Jiangxi Province [J]. Acta Mineralogica Sinica, 27 (supp): 324–325. (in Chinese)

Zhao Kuidong, Jiang Shaoyong, Jiang Yaohui, et al. 2006. SHRIMP U–Pb dating of the Furong unit of Qitianling granite from southeast Hunan Province and their geological implications [J]. Acta Petrologica Sinica, 22 (10): 2611–2616. (in Chinese with Egnlish abstract)

Zhao Lei, Yu Haijin, Wang Lijuan, et al. 2006. Formation time of Hongshan topaz-bearing granite and its metallogenic potential prognosis [J]. Mineral Deposits, 25 (6): 672–682. (in Chinese with Egnlish abstract)

Zhao Zhenhua, Bao Zhiwei, Zhang Boyou. 1998. The geochemistry of Mesozoic basalts in south Hunan Province, South China [J]. Science in China (Series D), 28 (supp): 7–14. (in Chinese)

Zhou Jiyuan, Cui Bingfang, Chen Hongming. 2000. Metallogenic Regularities and Prognosis of Copper and Tin Deposits on the area of Hongshan–Xikengjing, South of Jiangxi Province [M]. Beijing: Geological Publishing House, 1–195. (in Chinese)

Zhou Taofa, Fan Yu, Yuan Feng. 2008. Advances on petrogensis and metallogeny study of the mineralization belts of the middle and lower Yangtze River area [J]. Acta Petrogologica Sinica, 24 (8): 1665–1678. (in Chinese with English abstract)

Zhou X M, Sun T, Shen W Z, et al. 2006. Petrogenesis of Mesozoic granitoids and volcanic rocks in South China: A response to tectonic evolution [J]. Episodes, 29: 26–33.

Zhou Xinmin, Chen Peirong, Xu Xisheng, et al. 2007. Petrogenisis of Late Mesozoic granite and dynamic evolution of lithosphere in Nanling region [M]. Beijing: Science Press, 1–691. (in Chinese)

Zhu Jinchu, Huang Gefei, Zhang Peihua, et al. 2003. On the emplacement age and material sources for the granites of Cailing superunit, Qitianling pluton, south Hunan Province [J]. Geological Review, 49 (3): 245–252. (in Chinese)

Zhu Jinchu, Zhang Hui, Xie Caifu, et al. 2005. Zircon SHRIMP U–Pb geochronology, petrology and geochemistry of the Zhujianshui granite, Qitianling pluton, southern Hunan Province [J]. Geological Jounral of China Universities, 11 (3): 335–342. (in Chinese with Egnlish abstract)

参考文献:

柏道远, 陈建超, 马铁球, 等. 2005. 湘南骑田岭岩体A型花岗岩的地球化学特征及其构造意义[J]. 岩石矿物学杂志, 24 (4): 255–272.

蔡明海, 陈凯旭, 屈文俊, 等. 2006a. 湘南荷花坪锡多金属矿床地质及辉钼矿Re–Os测年[J]. 矿床地质, 25 (3): 263–268.

蔡明海, 何龙清, 刘国庆, 等. 2006b. 广西大厂锡矿田侵入岩SHRIMP锆石U–Pb 年龄及其意义[J]. 地质论评, 52 (3): 409–414.

蔡明海, 梁婷, 吴德成. 2005. 广西大厂锡多金属矿田亢马锡矿床地质特征及成矿时代[J]. 地质学报, 79 (2): 262–268.

曹汉生. 1982. 曾家垅锡矿床地质特征及控矿因素[J]. 地质与勘探: 1–6.

陈富文, 李华芹, 梅玉萍. 2008. 广西龙头山斑岩型金矿成岩成矿锆石SHRIMP U–Pb年代学研究[J].地质学报, 82 (7): 921–926.

陈培荣, 华仁民, 章邦桐, 等. 2002. 南岭燕山早期后造山花岗岩类: 岩石学制约和地球动力学背景[J]. 中国科学 (D辑), 32 (4): 279–289.

陈培荣, 孔兴功, 王银喜, 等. 1999. 赣南燕山早期双峰式火山–侵入杂岩的Rb–Sr同位素定年及其意义[J]. 高校地质学报, 5 (4): 378–383.

陈培荣. 2004. 华南东部中生代岩浆作用的动力学背景及其与铀成矿关系[J]. 铀矿地质, 20 (5): 266–270.

陈毓川, 裴荣富, 张宏良, 等. 1989. 南岭地区与中生代花岗岩类有关的有色及稀有金属矿床地质[M]. 北京: 地质出版社, 1–506.

陈郑辉, 王登红, 屈文俊, 等. 2006. 赣南崇重义淘锡坑钨矿的地质特征与成矿时代[J]. 地质通报, 25 (4): 495–501.

程彦博, 毛景文, 谢桂青, 等. 2008a. 云南个旧老厂–卡房花岗岩体成因初探: 锆石U–Pb年代学和岩石地球化学约束[J]. 地质学报, 82 (11): 1480–1495.

邓平, 沈渭洲, 凌洪飞, 等. 2003. 地幔流体与铀矿成矿作用: 以下庄矿田仙石铀矿床为例[J]. 地球化学, 32 (6): 520–528.

邓希光, 陈志刚, 李献华, 等. 2004. 桂东南地区大容山—十万大山花岗岩带SHRIMP锆石U–Pb定年[J]. 地质论评, 50 (4): 426–432.

丁昕, 蒋少涌, 倪培, 等. 2005. 江西武山和永平铜矿含矿花岗质岩体锆石SIMS U–Pb年代学[J]. 高校地质学报, 11: 383–389.
董树文, 张岳桥, 龙长兴,等. 2007. 中国侏罗纪构造变革与燕山运动新诠释[J]. 地质学报, 81 (11): 1449–1461.
范洪海，凌洪飞，王德滋，等. 2003. 相山铀矿田成矿机理研究[J]. 铀矿地质, 19: 208–213.
范裕, 周涛发, 袁峰, 等. 2008. 安徽庐江枞阳地区A型花岗岩的LA–ICP–MS定年及其地质意义[J]. 岩石学报, 24: 1715–1524.
丰成友, 丰耀东, 许建祥, 等. 2007a. 赣南张天堂地区岩体型钨矿晚侏罗世成岩成矿的同位素证据[J]. 中国地质, 34 (4): 642–650.
丰成友, 许建祥, 曾载淋, 等. 2007b. 赣南天门山—红桃岭钨锡矿田成岩成矿时代精细测定及其地质意义[J]. 地质学报, 81 (7): 925–963.
付建明, 李华芹, 屈文俊, 等. 2007. 湘南九疑山大坳钨锡矿的Re–Os同位素定年研究[J]. 中国地质, 34 (4): 651–656.
付建明, 李华芹, 屈文俊, 等. 2008. 粤北始兴地区石英脉型钨矿成矿时代的确定及其地质意义[J]. 大地构造与成矿学, 32 (1): 57–62.
付建明, 马昌前, 谢才富, 等. 2004a. 湖南骑田岭岩体东缘菜岭岩体SHRIMP锆石定年及其意义[J]. 中国地质, 31 (1): 96–100.
付建明, 马昌前, 谢才富, 等. 2004b. 湖南九疑山复式花岗岩体SHRIMP锆石定年及其意义[J]. 大地构造与成矿学, 28 (4): 370–378.
甘晓春, 沈渭洲, 朱金初. 1991. 广西栗木水溪庙矿床同位素地质研究[J]. 南京大学学报 (地球科学), 3 (1): 48–55.
顾晟彦, 华仁民, 戚华文. 2006. 广西姑婆山花岗岩单颗粒锆石LA–ICP–MSU–Pb定年及其全岩Sm–Nd同位素研究[J]. 地质学报, 80 (4): 543–553.
郭春丽, 王登红, 陈毓川, 等. 2007. 赣南中生代淘锡坑钨矿区花岗岩锆石SHRIMP年龄及石英脉Rb–Sr年龄测定[J]. 矿床地质, 26 (4): 432–442.
胡瑞忠, 毕献武, 彭建堂, 等. 2007. 华南地区中生代以来岩石圈伸展及其与铀矿成矿关系研究的若干问题[J]. 矿床地质, 26 (2): 139–152.
胡祥昭. 1989. 银岩含锡花岗斑岩的岩石学特征及成因研究[J]. 地球化学, 18 (3): 251–263.
华仁民, 陈培荣, 张文兰, 等. 2005a. 论华南地区中生代3次大规模成矿作用[J]. 矿床地质, 24 (2), 99–107.
华仁民, 陈培荣, 张文兰, 等. 2005b. 南岭与中生代花岗岩类有关的成矿作用及其大地构造背景[J]. 高校地质学报, 11 (3): 291–304.
华仁民, 毛景文. 1999. 试论中国东部中生代成矿大爆发[J]. 矿床地质, 18 (4): 300–308.
贾军涛, 王璞君, 万晓樵. 2008. 松辽盆地断陷期白垩纪营城组的时代归属[J]. 地质论评, 54 (4): 439–448.
江西根, 柏道远, 陈建超, 等. 2006. 湘东南宝峰仙地区燕山早期花岗岩地球化学特征及其构造环境[J]. 大地构造与成矿学, 30 (2): 206–219.
蒋国豪, 胡瑞忠, 谢桂青, 等. 2004. 江西大吉山钨矿成矿年代学研究[J]. 矿物学报, 24 (3): 253–256.
李红艳, 毛景文, 孙亚利, 等. 1996. 柿竹园钨多金属矿床的Re–Os同位素等时线年龄研究[J]. 地质论评, 42 (3): 261–267.
李华芹, 路远发, 王登红,等. 2006. 湖南骑田岭芙蓉矿田成岩成矿时代的厘定及其地质意义[J]. 地质论评, 52 (1): 113–121.
李金东, 柏道远, 伍光英, 等. 2005. 湖南郴州地区骑田岭花岗岩锆石的SHRIMP定年及其地质意义[J]. 中国地质, 24 (5): 411–414.
李理, 钟大赉, 时秀朋, 等. 2008. 鲁西地区晚中生代以来伸展构造及其控矿作用[J]. 地质论评, 54 (4): 449–458.
李水如, 王登红, 梁婷, 等. 2008. 广西大明山钨矿床成矿时代及其找矿前景分析[J]. 地质学报, 82 (7): 873–879.
李献华, 李武显, 李正祥. 2007. 再论南岭燕山早期花岗岩的成因类型与构造意义[J]. 科学通报, 52 (9): 981–991.
李晓峰、Watanabe Y, 华仁民, 等. 2008. 华南地区中生代Cu–(Mo)–W–Sn矿床成矿作用与洋岭/转换断层俯冲[J]. 地质学报, 82 (5): 625–640.
李兆丽, 胡瑞忠, 彭建堂, 等. 2006. 湖南芙蓉锡矿流体包裹体的He同位素组成及成矿流体来源示踪[J]. 地球科学——中国地质大学学报, 31 (1):129–135.
蔺志永, 王登红, 李水如. 2008. 广西王社铜钨矿床的Re–Os同位素年龄及其地质意义[J]. 地质学报, 82 (11): 1569–1575.
刘珺, 毛景文, 叶会寿, 等. 2008a. 江西武功山地区浒坑花岗岩的锆石U–Pb定年及元素地球化学特征[J]. 岩石学报, 24 (8): 1813–1822.
刘珺, 毛景文, 叶会寿, 等. 2008b. 江西武功山地区浒坑钨矿床辉钼矿的Re–Os年龄及其地质意义[J]. 地质学报, 82 (11): 1576–1584.
刘善宝, 王登红, 陈毓川, 等. 2008. 赣南崇义—大余—上犹矿集区不同类型含矿石英中白云母$^{40}Ar/^{39}Ar$年龄及其地质意义[J]. 地质学报, 82 (7): 932–940.
刘晓东, 华仁民. 2005. 福建碧田金银铜矿床冰长石的$^{40}Ar–^{39}Ar$年龄[J]. 地质论评, 51 (2):151–155.
刘义茂, 戴橦谟, 卢焕章, 等. 1997. 千里山花岗岩成岩成矿的$^{40}Ar–^{39}Ar$和Sm–Nd同位素年龄[J]. 中国科学 (D辑), 27 (5): 425–430.
刘义茂, 许继峰, 戴橦谟, 等. 2002. 骑田岭花岗岩Ar/Ar同位素年龄及其地质意义[J]. 中国科学 (D辑), 32 (增刊): 40–48.
刘玉平, 李朝阳, 谷团, 等. 2000. 都龙锡锌多金属矿床成矿物质来源的同位素示踪[J]. 地质地球化学, 28 (4): 75–82.
刘玉平, 李正祥, 李惠民, 等. 2007. 都龙锡锌矿床锡石和锆石U–Pb年代学: 滇东南白垩纪大规模花岗岩成岩–成矿事件[J]. 岩石学报, 23 (5): 967–976.
马东升. 2008. 华南重要金属矿床的成矿规律——时代爆发性、空间分带性、基底继承性和热隆起成矿[J]. 矿物岩石地球化学通报, 27 (3): 209–217.
马丽艳, 付建明, 伍式崇, 等. 2008. 湘东锡田垄上锡多金属矿床的$^{40}Ar/^{39}Ar$同位素定年研究[J]. 中国地质, 35 (4): 706–713.
马丽艳, 路远发, 屈文俊, 等. 2007. 湖南黄沙坪铅锌矿床的Re–Os同位素等时线年龄及其地质意义[J]. 矿床地质, 26 (4): 425–431.
马铁球, 柏道远, 邝军, 等. 2005. 湘东南茶陵地区锡田岩体锆石SHRIMP定年及其地质意义[J]. 地质通报, 24 (5): 415–419.
毛建仁, 许乃政, 胡青, 等. 2004. 福建上杭—大田地区中生代成岩成矿作用与构造环境[J]. 岩石学报, 20 (2): 285–296.
毛景文, 程彦博, 郭春丽, 等. 2008. 云南个旧锡矿田: 矿床模型及若干问题讨论[J]. 地质学报, 82 (11): 1455–1467.
毛景文, 华仁民, 李晓波. 1999. 浅议大规模成矿作用与大型矿集区[J]. 矿床地质, 18 (4): 291–299.
毛景文, 李晓峰, Bernd Lehmann, 等. 2004a. 湖南芙蓉锡矿床锡矿石和有关花岗岩的$^{40}Ar–^{39}Ar$ 年龄及其地球动力学意义[J]. 矿床地质, 23 (2): 164–175.
毛景文, Stein H, 杜安道, 等. 2004b. 长江中下游地区铜金(钼)矿Re–Os年龄测定及其对成矿作用的指示[J]. 地质学报, 78 (1): 121–131.
毛景文, 谢桂青, 郭春丽, 等. 2007. 南岭地区大规模钨锡多金属成矿作用: 成矿时限及地球动力学背景[J]. 岩石学报, 23 (10): 2329–2338.
毛景文, 谢桂青, 李晓峰, 等. 2004c. 华南地区中生代大规模成矿作用与岩石圈多阶段伸展[J]. 地学前缘, 11 (1): 45–55.
毛景文, 谢桂青, 张作衡, 等. 2005. 中国北方中生代大规模成矿作用

的期次及其地球动力学背景[J]. 岩石学报, 21 (1): 169–188.
毛景文, 张作衡, 余金杰, 等. 2003. 华北及邻区中生代大规模成矿的地球动力学背景: 从金属矿床年龄精测得到启示[J]. 中国科学(D辑), 33 (4): 289–300.
孟祥金, 侯增谦, 董光裕, 等. 2007. 江西金溪熊家山钼矿床地质特征及其Re–Os年龄[J]. 地质学报, 81 (7): 946–951.
牛宝贵, 和政军, 宋彪, 等. 2003. 张家口组火山岩SHRIMP定年及其重大意义[J]. 地质通报, 22 (2): 140–141.
彭建堂, 胡瑞忠, 毕献武, 等. 2007. 湖南芙蓉锡矿床$^{40}Ar/^{39}Ar$ 同位素年龄及地质意义. 矿床地质, 26 (3): 237–248.
彭建堂，胡瑞忠，袁顺达，等. 2008. 湘南中生代花岗质岩石成岩成矿时限[J]. 地质论评, 54 (5)：617–625.
戚建中, 刘红樱, 姜耀辉. 2000. 中国东部燕山期俯冲走滑体制及其对成矿定位的控制[J]. 火山地质与矿产, 21 (4): 244–265.
史明魁, 傅必勤, 靳西祥. 1993. 湘中锑矿[M]. 长沙: 湖南科学技术出版社, 1–110.
史明魁, 孙恭安. 1981. 广西栗木稀有金属花岗岩的岩石学和地球化学特征[J]. 宜昌地质矿产研究所所刊, 3: 96–107.
孙涛, 周新民, 陈培荣, 等. 2003. 南岭东段中生代强过铝花岗岩成因及大地构造意义[J]. 中国科学 (D辑), 33 (12): 1209–1218.
孙卫东, 凌明星, 汪方跃, 等. 2008. 太平洋板块俯冲与中国东部中生代地质事件[J]. 矿物岩石地球化学通报, 27 (3): 218–225.
孙晓明, 陈文, 王敏, 等. 2003. 微细粒浸染型金矿微区$^{40}Ar/^{39}Ar$ 等时线年龄测定: 以长坑大型金矿为例[J]. 科学通报, 48 (12): 1355–1358.
陶奎元, 毛建仁, 杨祝良, 等. 1998. 中国东南部中生代岩石构造组合和复合动力学过程的记录[J]. 地学前缘, 5 (4), 183–191.
万天丰, 朱鸿. 2002. 中国大陆及邻区中生代—新生代大地构造与环境变迁[J]. 现代地质, 16 (2): 107–120.
万天丰. 1993. 中国东部中、新生代板内变形, 构造应力场及其应用[M]. 北京: 地质出版社, 1–103.
王登红, 陈毓川, 陈文, 等. 2004. 广西南丹大厂超大型锡多金属矿床的成矿时代[J]. 地质学报, 78 (1): 132–138.
王德滋, 沈渭洲, 刘昌实, 等. 1994. 江西岩背火山侵入杂岩的地球化学特征和成因. 中国科学 (B辑), 24 (5): 531–538.
王强, 赵振华, 简平, 等. 2004. 德兴花岗闪长斑岩SHRIMP锆石U–Pb年代学和Nd–Sr同位素地球化学[J]. 岩石学报, 20 (2): 315–320.
王岳军, 范蔚茗, 郭锋, 等. 2001. 湘东南中生代花岗闪长岩锆石U–Pb法定年及其成因指示[J]. 中国科学 (D辑), 31 (9): 745–751.
王岳军, 范蔚茗, 郭锋. 2002. 北淮阳晚中生代火山岩定年及火山砾石地球化学对大别灰色片麻岩隆升和中生代地层格架的约束[J]. 科学通报, 47 (20): 1528–1534.
谢桂青, 毛景文, 李瑞玲, 等. 2006. 长江中下游鄂东南地区大寺组火山岩SHRIMP定年及其意义. 科学通报, 51 (19): 2283–2291.
谢昕, 徐夕生, 邹海波, 等. 2005. 中国东南部晚中生代大规模岩浆作用的序幕: J_2早期玄武岩[J]. 中国科学 (D辑), 35 (7): 587–605.
邢光福, 卢清地, 陈荣, 等. 2008. 华南晚中生代构造体制转折结束时限研究——兼与华北燕山地区对比[J]. 地质学报, 82 (4): 451–463.
许建祥, 曾载淋, 李雪琴, 等. 2007. 江西寻乌铜坑嶂钼矿床地质特征及其成矿时代[J]. 地质学报, 81 (7): 924–928.
许美辉. 1992. 福建永定地区早侏罗世双峰式火山岩及其构造环境[J]. 福建地质, 11 (2): 115–125.
徐夕生, 邓平, O'Reilly S Y, 等. 2003. 华南贵东杂岩体单颗粒锆石激光探针ICPMS U–Pb定年及其成岩意义[J]. 科学通报, 48 (12): 1328–1334.
徐夕生, 谢昕. 2005. 中国东南部晚中生代—新生代玄武岩与壳幔作用[J]. 高校地质学报, 11 (3): 318–334.
杨宗喜, 毛景文, 陈懋弘, 等. 2008. 云南个旧卡房夕卡岩型铜（锡）矿Re–Os年龄及其地质意义[J]. 岩石学报, 24 (8): 1937–1944.
姚军明, 华仁民, 林锦富. 2005. 湘东南黄沙坪花岗岩LA–ICP–MS锆石U–Pb定年及岩石地球化学特征[J]. 岩石学报, 21 (3): 688–696.
姚军明, 华仁民, 屈文俊, 等. 2007. 湘南黄沙坪铅锌钨钼多金属矿床辉钼矿的Re–Os同位素定年及其意义[J]. 中国科学 (D辑), 37 (4): 471–477.
余金杰, 毛景文. 2002. 宁芜玢岩铁矿钠长石$^{40}Ar–^{39}Ar$定年及意义[J]. 自然科学进展, 12 (10): 1059–1063.
张德全, 丰成友, 李大新, 等. 2003. 福建碧田矿床冰长石的$^{40}Ar–^{39}Ar$年龄及其地质意义[J]. 矿床地质, 22 (4): 360–365.
张家菁, 陈正辉, 王登红, 等. 2008a. 福建行洛坑大型钨矿的地质特征、成矿时代及其找矿意义[J]. 大地构造与成矿, 32 (1): 92–97.
张家菁, 梅玉萍, 王登红, 等. 2008b. 赣北香炉山白钨矿床的同位素年代学研究及其地质意义[J]. 地质学报, 82 (7): 927–922.
张乐俊, 周涛发, 范裕, 等. 2008. 安徽月山岩体的SHRIMP定年及其意义[J]. 岩石学报, 24 (8): 1725–1732.
张敏, 陈培荣, 张文兰, 等. 2003. 南岭中段大东山花岗岩体的地球化学特征和成因[J]. 地球化学, 32 (6): 529–539.
张旗, 简平, 刘敦一. 2003. 宁芜火山岩的锆石SHRIMP定年及其意义[J]. 中国科学 (D辑), 33 (4): 309–314.
张世涛, 陈国昌. 1997. 滇东南薄竹山复式岩体的地质特征及其演化规律[J]. 云南地质, 16 (3): 222–232.
张文兰, 华仁民, 王汝成, 等. 2006. 赣南大吉山花岗岩成岩成矿年龄的研究[J]. 地质学报, 80 (7): 956–962.
张文兰, 华仁民, 王汝成, 等. 2007. 赣南漂塘钨矿区花岗岩成岩与成矿年龄的研究[J]. 矿物学报, 27 (增刊): 324–325.
章锦统. 1989. 广西栗木铌、钽、钨、锡矿床 [M] // 陈毓川等. 南岭地区与中生代花岗岩有关的有色及稀有金属矿床地质. 北京: 地质出版社, 130–140.
赵葵东, 蒋少涌, 姜耀辉, 等. 2006. 湖南骑田岭岩体芙蓉超单元锆石SHRIMP U–Pb年龄及其地质意义[J]. 岩石学报, 22 (10): 2611–2616.
赵蕾, 于海津, 王丽娟, 等. 2006. 红山含黄玉花岗岩的形成时代及其成矿能力分析[J]. 矿床地质, 25 (6): 672–682.
赵振华, 包志伟, 张伯友. 1998. 湘南中生代玄武岩类地球化学特征[J]. 中国科学 (D辑), 28 (增刊): 7–14.
周济元, 崔炳芳, 陈宏明. 2000. 赣南红山—锡坑迳地区铜锡矿地质及预测[M]. 北京: 地质出版社, 1–195 .
周涛发, 范裕, 袁峰. 2008. 长江中下游成矿带成岩成矿作用研究进展[J]. 岩石学报, 24 (8): 1665–1678.
周新民, 陈培荣, 徐夕生, 等. 2007. 南岭地区晚中生代花岗岩成因与岩石圈动力学演化[M]. 北京: 科学出版社, 1–691.
朱金初, 黄革非, 张佩华, 等. 2003. 湖南骑田岭岩体菜岭超单元花岗岩侵位年龄和物质来源研究[J]. 地质论评, 49 (3): 245–252.
朱金初, 张辉, 谢才富, 等. 2005. 湖南骑田岭竹枧水花岗岩的锆石SHRIMP年代学和岩石学[J]. 高校地质学报, 11 (3): 335–342.