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湖南省成矿地质事件纲要

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提要:【研究目的】湖南省矿产资源丰富,矿种及成因类型繁多,但对各类矿产形成的时代和构造背景尚缺乏系统归纳和总结。**【研究方法】**本文在既有区域矿产资料基础上,结合近些年区域构造演化、成岩成矿年龄、矿床成因机制等研究成果,对湖南省成矿地质事件及各期成矿事件的构造背景、矿床成因、矿产发育和分布特征等进行了系统探讨和总结。**【研究结果】**湖南省自早至晚发生过22期主要成矿地质事件,具体包括:雪峰期(板溪期)马底驿期沉积型锰矿,早南华世富禄期沉积型铁矿(叠加后期改造),中南华世大塘坡期沉积型锰矿,早震旦世陡山沱期磷矿,早寒武世牛蹄塘期钒多金属矿、重晶石矿、石煤矿,中—晚奥陶世沉积型锰矿,震旦纪—奥陶纪灰岩矿、白云岩矿、玉石矿等非金属矿产,志留纪内生热液矿床,中泥盆世棋梓桥期沉积型(叠加后期改造)锰矿,晚泥盆世宁乡式铁矿,早石炭世测水期煤矿,早石炭世梓门桥期膏盐矿,中二叠世梁山期煤矿,中二叠世孤峰期(茅口晚期)沉积型锰矿,晚二叠世龙潭期煤矿,泥盆纪—早三叠世灰岩、白云岩、砂岩、黏土等非金属矿,晚三叠世—早侏罗世煤矿,晚三叠世内生热液矿床,晚侏罗世—早白垩世早期内生热液及岩浆矿床,晚白垩世沉积-改造型铜矿,古近纪膏盐矿,第四纪黏土矿、稀土矿、砂锡矿、独居石多金属矿、金刚石矿。**【结论】**志留纪(加里东期)内生热液成矿、晚三叠世(印支晚期)内生热液成矿、晚侏罗世—早白垩世早期(中晚燕山期)内生热液及岩浆成矿等3期主要内生成矿事件的矿床分布明显受同期构造格局控制;南华纪铁锰沉积成矿、震旦纪—早奥陶世多矿种沉积成矿、泥盆纪—早三叠世多矿种沉积成矿、晚三叠世—早侏罗世煤层沉积成矿、白垩纪—古近纪铜和膏盐沉积成矿等外生成矿事件的矿床分布受同期构造古地理控制。本文以成矿地质事件为线索,较全面反映了湖南省矿产资源的时空分布特征和成矿地质规律,对区域地质找矿具有重要的参考价值。

关 键 词:成矿事件;时代背景;内生成矿;外生成矿;构造格局;构造古地理;矿产勘查工程;湖南

创 新 点:厘定了湖南省22期主要成矿地质事件,分析总结了各期成矿事件的构造背景、矿床成因、矿产发育和分布特征等。

中图分类号:P612 **文献标志码:**A **文章编号:**1000−3657(2022)01−0151−30

Summary of main mineralization events in Hunan Province

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Abstract:This paper is the result of mineral exploration engineering.

[Objective]Hunan Province is rich in mineral resources with various types of minerals and genetic types of deposits, but there is still a lack of systematic introduction and summary of the ages and tectonic settings of the various minerals.[**Methods]**Based on the existing regional mineral data, combined with the achievements on regional tectonic evolution, geochorology of igneous rocks and deposits and metallogenesis in recent years, this paper systematically discusses and summarizes the mineralization events and the tectonic settings, metallogenesis, mineral development and distribution characteristics of the mineralizations.[**Results]**There have been 22 major mineralization events in Hunan Province, which includes from early to late: Sedimentary manganese ore of Xuefeng period (Banxi period) Madiyi stage; sedimentary iron ore of Early Nanhua Fulu period (superimposed later transformation); sedimentary manganese ore of Middle Nanhua Datangpo period; phosphate ore of Early Sinian Doushantuo period; vanadium polymetallic ore, barite ore and stone coal mine of Early Cambrian Niutitang period; sedimentary manganese ore of Middle−Late Ordovician; non− metallic minerals such as limestone ore, dolomite ore and jade ore of Sinian− Ordovician; endogenetic hydrothermal deposits of Silurian; sedimentary manganese ore of Middle Devonian Qiziqiao period (superimposed later transformation); Ningxiang−type iron ore of Late Devonian; coal mine of Early Carboniferous Ceshui period; gypsum mine of Early Carboniferous Zimenqiao period; coal mine of Middle Permian Liangshan period; sedimentary manganese ore of Middle Permian Gufeng period (late Maokou period); coal mine of Late Permian Longtan period; non−metallic ore such as limestone, dolomite, sandstone and clay of Devonian−Early Triassic; coal mine of Late Triassic−Early Jurassic; endogenetic hydrothermal deposits of Late Triassic; endogenetic hydrothermal deposits and magmatic deposits of Late Jurassic−Early Cretaceous, sedimentary reformed copper mine of Late Cretaceous; gypsum mine of Paleogene; clay Ore, rare earth ore, alluvial tin ore, monazite polymetallic ore and diamond ore of Quaternary. **[Conclusions]**The distributions of deposits of the three major endogenetic events such as Silurian (Caledonian) endogenetic hydrothermal mineralization, Late Triassic (late Indosinian) endogenetic hydrothermal mineralization and Late Jurassic−Early Cretaceous (middle and late Yanshanian) endogenetic hydrothermal and magmatic mineralization are obviously controlled by the contemporaneous tectonic frameworks; The distributions of exgogenetic deposits such as sedimentary iron−manganese ore of Nanhua, multiple sedimentary deposits of Sinian−Early Ordovician, multiple sedimentary deposits of Devonian−Early Triassic, coal mine of Late Triassic−Early Jurassic, and sedimentary copper and gypsum mine of Cretaceous−Paleogene are controlled by contemporaneous tectonic paleogeography. Taking metallogenic events as clues, this paper comprehensively elaborated the temporal−spatial distribution characteristics of mineral resources and metallogenic regularities in Hunan Province, which has important reference value for regional prospecting.

Key words: mineralization events; metallogenic age and metallogenic background; endogenous mineralization; exogenous mineralization; tectonic framework; tectonic paleogeography;mineral exploration engineering; Hunan Province

Highlights: The 22 main metallogenic geological events in Hunan Province are determined, and the tectonic settings, deposit genesis, mineral development and distribution characteristics of each metallogenic event are analyzed and summarized.

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1 引 言

湖南省矿产资源丰富,矿种及成因类型繁多。自新元古代以来经历了多阶段构造演化历史,期间发生了二十余起重要成矿地质事件(贾宝华等,2019)。前人以成矿作用和成矿系列为线索,对湖南省矿产资源的发育和分布情况进行了全面阐述(唐分配等,2015),但对各类矿产形成的时代和构造背景缺乏系统归纳和总结。本文将在既有区域矿产资料基础上,结合近些年区域构造演化、成岩成矿年龄、矿床成因机制等研究成果,对湖南省主要成矿地质事件进行系统梳理,对各期成矿事件的

构造背景、矿床成因、矿产发育和分布特征，以及主要内生成矿事件的构造格局控制和主要外生成矿事件的构造古地理控制等进行总结、探讨，以全面反映全省矿产资源的时空分布特征和成矿地质规律，为区域地质找矿提供重要参考。

2　区域地质背景及矿产资源概况

湖南省整体属羌塘—扬子—华南板块一级构造单元（Ⅳ），并以川口—双牌一线（基底隐伏断裂）为界分为扬子陆块（Ⅳ-4）和华夏板块（Ⅳ-5）等2个二级构造单元。其中扬子陆块进一步划分为湘北断褶带（Ⅳ-4-5）、雪峰构造带（Ⅳ-4-9）、邵醴坳-隆带（Ⅳ-4-8）以及洞庭盆地（Ⅳ-4-14）等4个三级构造单元，华夏板块进一步分为粤湘赣早古生代沉陷带（Ⅳ-5-3）和云开晚古生代沉陷带（Ⅳ-5-4）2个三级构造单元。根据不同时期隆-坳构造格局或构造变形分带并结合构造-岩浆活动特征，在三级构造单元基础上可进一步划分四级构造单元（湖南省地质调查院，2017）（图1）。省境自早至晚经历了武陵期（冷家溪群沉积期）活动大陆边缘盆地、雪峰期（板溪群沉积期）—南华纪陆内裂谷盆地、震旦纪—早奥陶世被动陆缘盆地、中奥陶世—志留纪前陆盆地、泥盆纪—中三叠世陆表海盆地、晚三叠世—第四纪陆相盆地及山体抬升等6个大的构造阶段；相应可分为武陵、扬子—加里东、华力西—印支、早燕山、晚燕山—喜马拉雅等5个构造旋回，其中扬子—加里东旋回进一步分为雪峰亚旋回和扬子—加里东亚旋回，晚燕山—喜马拉雅旋回进一步分为晚燕山亚旋回和喜马拉雅亚旋回（湖南省地质调查院，2017）（表1）。

地表出露新元古代冷家溪群、板溪群（同期异相的高涧群）、南华系—震旦系、下古生界、上古生界—中三叠统、上三叠统—中侏罗统、白垩系—古近系和第四系等多时代地层。其中冷家溪群为活动陆缘火山-碎屑沉积，板溪群—南华系为裂谷盆地火山-碎屑沉积，震旦系—下奥陶统为被动大陆边缘盆地的碳酸盐岩和碎屑岩沉积（自北西往南东由碳酸盐岩为主渐变为以碎屑岩为主），中奥陶统—志留系为前陆盆地砂、泥质和少量碳酸盐沉积，泥盆系—下三叠统为陆表海碳酸盐、陆源碎屑夹硅质沉积，上三叠统—中侏罗统为陆相挤压类前陆盆地或伸展盆地碎屑沉积，白垩系—古近系为陆相断陷盆地红色碎屑沉积（湖南省地质调查院，2017）。

岩浆岩以中性—酸性侵入岩即花岗岩类为主，局部发育基性—超基性侵入岩、火山岩，规模很小的各类岩脉也有广泛发育。其中花岗岩可分为武陵期（岛弧—后碰撞环境（王孝磊等，2003，2006；马铁球等，2009；柏道远等，2010；段政等，2019；Deng et al.，2019））、加里东期（后碰撞环境（Wang et al.，2007a；Wan et al.，2010；Chu et al.，2012；Zhang et al.，2012；关义立等，2013；柏道远等，2015a））、印支期（后碰撞环境（柏道远等，2007a；Wang et al.，2007b；Mao et al.，2011；Zhao et al.，2013；刘凯等，2014；曾认宇等，2016））、早燕山期（后碰撞—后造山环境（李献华等，1999；陈培荣等，2002；柏道远等，2005a；李鹏春等，2005；王连训等，2008））和晚燕山期（后造山或裂谷环境（柏道远等，2005a；李鹏春等，2005；王连训等，2008；许德如等，2017））等5个阶段，分布于华容—溆浦—靖州一线以东地区。基性—超基性侵入岩分为新元古代、中—晚三叠世、中—晚侏罗世等多个时代，分布于古丈—中方—通道一带及湘东醴陵板杉铺等地（贾大成等，2002）。火山岩包括武陵期、南华纪、白垩纪等多个时代，岩性有凝灰岩、玄武岩等。

省境经历了武陵（晋宁）、加里东、印支、早燕山等几次具挤压造山性质的主要构造运动，分别造成板溪群与冷家溪群、上古生界与前泥盆系、上三叠统（或侏罗系）与上古生界、白垩系与侏罗系（或前白垩系）之间的角度不整合，形成了复杂的褶皱、断裂构造体系和隆-凹构造格局（柏道远等，2005b，2006a，2006b，2008，2009a，2009b，2012a，2012b，2013a，2013b，2013c，2014a，2014b，2015b，2015c，2015d，2018a，2018b），从而控制了几期主要的内生成矿作用。

长期的构造演化过程形成了沉积型和热液型（岩浆热液型、构造热液型）为主，岩浆型和变质改造型等为辅的大量金属、非金属和能源矿床（图1，表1）。矿种包括钨、锡、钼、铋、铅、锌、铜、金、银、锑、汞、铌、钽、铍、铷、砷、钒、镍、稀土、稀散、铁、锰等金属矿产，金刚石、独居石、高岭土、砖瓦黏土、砂石矿、硫铁矿、石膏、碳酸盐岩、重晶石、芒硝、石盐、

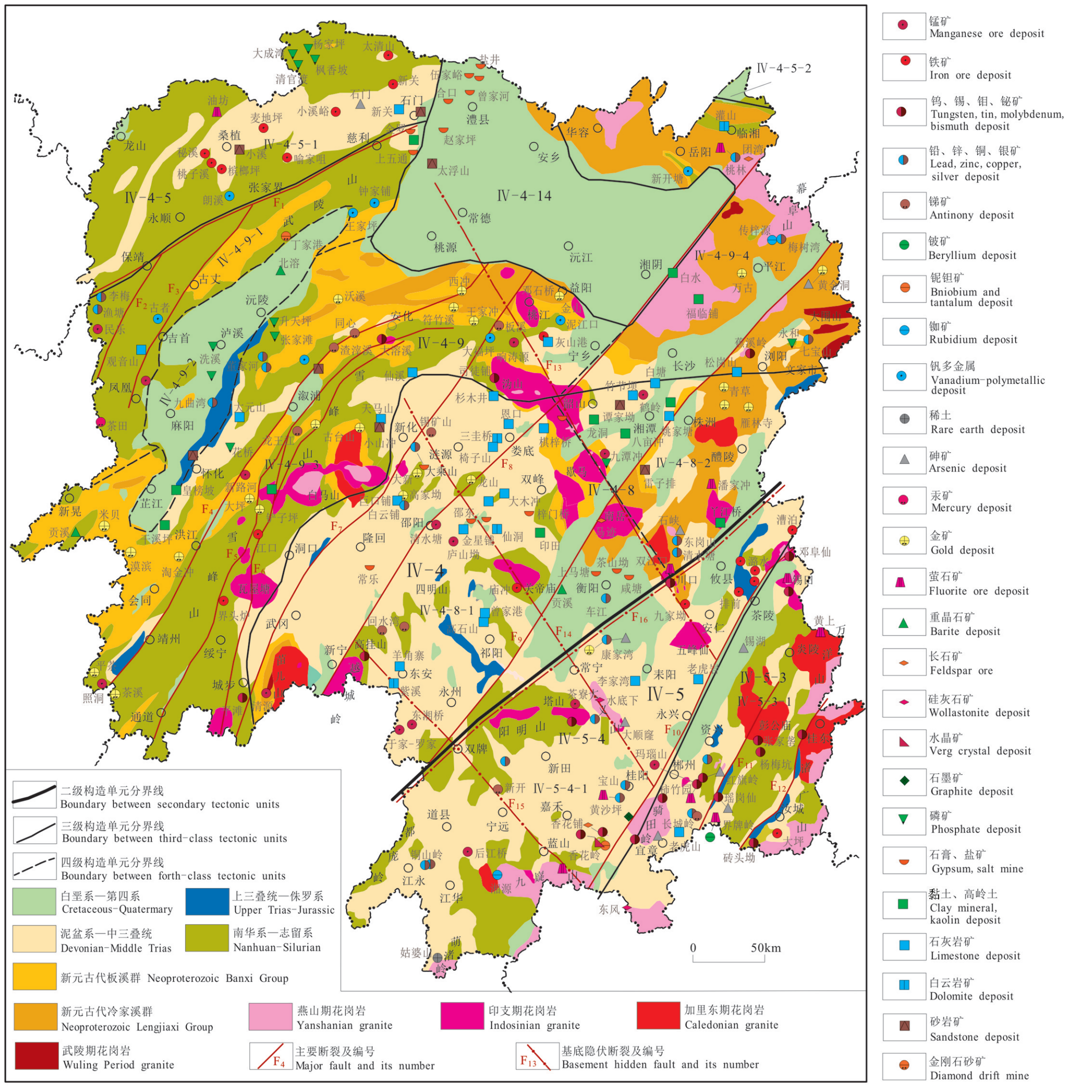

图1 构造单元划分及主要矿产地分布略图

图中未表达煤和石煤产地，构造单元划分据《中国区域地质志·湖南志》(湖南省地质调查院，2017)；构造单元划分及名称：Ⅳ—羌塘—扬子—华南板块；Ⅳ-4—扬子陆块：Ⅳ-4-5—湘北断褶带(八面山陆缘盆地)，Ⅳ-4-5-1—石门—桑植复向斜，Ⅳ-4-5-2—沅潭褶冲带；Ⅳ-4-9—雪峰构造带(江南新元古代造山带)，Ⅳ-4-9-1—武陵断弯褶皱带，Ⅳ-4-9-2—沅麻盆地，Ⅳ-4-9-3—雪峰冲断带，Ⅳ-4-9-4—湘东北断隆带；Ⅳ-4-8—邵醴坳-隆带(桂湘早古生代陆缘沉降带)，Ⅳ-4-8-1—邵阳坳褶带，Ⅳ-4-8-2—醴陵断隆带；Ⅳ-4-14—洞庭盆地；Ⅳ-5—华夏板块：Ⅳ-5-3—粤湘赣早古生代沉陷带，Ⅳ-5-3-1—炎陵-汝城冲断褶隆带；Ⅳ-5-4—云开晚古生代沉陷带，Ⅳ-5-4-1—宁远—桂阳坳褶带；主要断裂名称：F_1—慈利—保靖断裂(江南断裂)；F_2—保靖—铜仁断裂；F_3—古丈—吉首断裂；F_4—溆浦-靖州断裂；F_5—通道—江口断裂；F_6—城步—江口断裂；F_7—城步—新化断裂；F_8—公田—灰汤—新宁断裂；F_9—连云山—衡阳—零陵断裂；F_{10}—茶陵—郴州断裂；F_{11}—瑶岗仙断裂；F_{12}—桂东—汝城断裂；F_{13}—常德—安仁断裂；F_{14}—郴州—邵阳断裂；F_{15}—蓝山—新宁断裂；F_{16}—川口—双牌断裂

Fig.1 Subdivision of tectonic units in Hunan Province and distribution of main deposits

The origin of coal and stone coal are not shown. Subdivision of tectonic units after "The regional geology of China, Hunan Province Chapter" (Hunan Institute of Geological Survey, 2017). Subdivision and names of tectonic units: Ⅳ-Qiangtang-Yangtze-South China plate. Ⅳ-4-Yangtze block: Ⅳ-4-5-North Hunan fault-fold zone (Bamianshan epicontinental Basin), Ⅳ-4-5-1-Shimen-Sangzhi synclinore, Ⅳ-4-5-2-Yuangtan fold-thrust fault zone; Ⅳ-4-9-Xuefeng tectonic belt (Jiangnan Neoproterozoic orogenic belt), Ⅳ-4-9-1-Wuling fault-bend fold zone, Ⅳ-4-9-2-Yuanling-Mayang basin, Ⅳ-4-9-3-Xuefeng thrust-fault zone, Ⅳ-4-9-4-Northeastern Hunan faulted uplift zone; Ⅳ-4-8-Shaoyang-Liling depression-uplift zone (Guangxi-Hunan Early Paleozoic epicontinental depression zone), Ⅳ-4-8-1-Shaoyang depression-fold zone, Ⅳ-4-8-2-Liling faulted uplift zone; Ⅳ-4-14-Dongting Basin. Ⅳ-5-Cathaysia block: Ⅳ-5-3-Guangdong-Hunan-Jiangxi Early Paleozoic depression zone, Ⅳ-5-3-1-Yanling-Rucheng thrust-fold uplift zone; Ⅳ-5-4-Yunkai Late Paleozoic depression zone, Ⅳ-5-4-1-Ningyuan-Guiyang depression-fold zone. F_1-Cili-Baojing fault (Jiangnan fault); F_2-Baojing-Tongren fault; F_3—Guzhong-Jishou fault; F_4-Xupu-Jingzhou fault; F_5—Tongdao- Jiangkou fault; F_6- Chengbu- Jiangkou fault; F_7- Chengbu- Xinhua fault; F_8—Gongtian- Huitang- Xinning fault; F_9-Lianyunshan-Hengyang-Lingling fault; F_{10}-Chaling-Chenzhou fault; F_{11}-Yaogangxian fault; F_{12}-Guidong-Rucheng fault; F_{13}-Changde-Anren fault; F_{14}-Chenzhou-Shaoyang fault; F_{15}-Lanshan-Xinning fault; F_{16}-Chuankou-Shuangpai fault

表1 湖南省构造演化阶段及构造旋回划分

Table 1 Division of tectonic evolution and structural cycles of Hunan Province

年龄/Ma	地质时代	构造阶段	构造旋回		构造运动 湘北	构造运动 湘中湘南	形成矿产	
2.6	Q	陆相盆地及山体抬升阶段	晚燕山—喜马拉雅旋回	喜马拉雅亚旋回	喜马拉雅运动Ⅱ		黏土矿、稀土矿、砂锡矿、金刚石矿等	
23.0	N				喜马拉雅运动Ⅰ			
65.5	E			晚燕山亚旋回			沉积型石膏矿、盐矿	
99.6	K_2						沉积−改造型铜矿	
145.5	K_1				早燕山运动		有色金属、萤石等热液矿床及长石等岩浆矿床	
175.6	J_{2-3}		早燕山旋回					
199.6	J_1							
228.7	T_3				印支运动		煤矿 有色金属、萤石等热液矿床及长石等岩浆矿床	
245.9	T_2	陆表海盆地阶段	华力西—印支旋回					灰岩矿、白云岩矿、砂岩矿、黏土矿等
251.0	T_1							
260.4	P_3				东吴上升		龙潭组煤矿	
270.6	P_2				黔桂上升		孤峰组沉积型锰矿 梁山组煤矿	
299.0	P_1							
318.1	C_2				淮南上升			
359.2	C_1				柳江上升		测水组煤矿、梓门桥组石膏矿	
385.3	D_3						岳麓山组、欧家冲组、黄家磴组沉积型铁矿	
397.5	D_2						棋梓桥组沉积型锰矿	
416.0	D_1				加里东运动(晚幕)			
443.7	S	前陆盆地阶段	扬子—加里东旋回	扬子—加里东亚旋回	加里东运动(早幕)(宜昌上升)		热液型金、锑、铅锌矿	
488.3	O	被动陆缘盆地阶段					烟溪组、天马山组锰矿	玉石矿等 灰岩矿、白云岩矿、
542.0	∈				桐湾上升		牛蹄塘组中钒多金属矿及重晶石矿、石煤矿	
635.0	Z						陡山沱组沉积型磷矿	
720.0	Nh	陆内裂谷盆地阶段			雪峰运动		大塘坡组沉积型锰矿 富禄组江口式铁矿	
800.0	Qb*B*			雪峰亚旋回	武陵运动		马底驿组沉积型锰矿	
	Qb*L*	活动陆缘盆地阶段	武陵旋回					
	?							

石膏、磷、萤石、长石、硅灰石等非金属矿产,以及石煤、煤、铀等能源矿产(贾宝华等,2019)。

3 成矿地质事件

在上述新元古代以来的长期构造演化历史中,伴随构造活动及相关的沉积作用、岩浆活动、变质作用等地质过程发生了22期主要成矿地质事件(表1,表2)。自早至晚就各期成矿事件简介如下。

3.1 雪峰期(板溪群沉积期)马底驿组沉积期沉积型锰矿

新元古代雪峰期省境处于陆内裂谷环境,其中马底驿组沉积期沿伸展断裂产生火山喷发而形成凝灰岩,局部海底喷流带来大量锰质,在适当条件下锰质沉淀而形成碳酸锰矿床。本期代表性矿床有中方新路河锰矿、城步清源锰矿等(石少华等,2016)。

3.2 早南华世富禄期沉积型铁矿(叠加后期改造)

早南华世富禄期处于强伸展的陆内裂谷环境并为温暖的间冰期。因伸展断裂活动产生海底火山喷发,并在通道—绥宁—洞口、越城岭—关帝庙等地带形成断槽。在海进初期,来源于海底火山物质和扬子古陆风化剥蚀含铁碎屑的铁质呈胶体溶液运移至温暖浅海半封闭环境而沉淀,形成主要分布于断槽的铁矿初始矿源层。铁矿初始矿源层沉积后,经成岩阶段改造以及后期构造变质和岩浆热变质改造,形成富禄组中"江口式"铁矿(王廷江等,2006)。代表性矿床有洞口江口铁锰矿、绥宁界头炉铁矿、祁东庙冲—对家冲铁矿、王家老屋铁矿等。

3.3 中南华世大塘坡期沉积型锰矿

中南华世大塘坡期在陆内裂谷环境下形成不同级次的堑-垒构造格局,锰质于Ⅳ级断陷(地堑)盆地中沉积形成"大塘坡式"锰矿床(周琦等,2016)。前人对其成因进行了大量研究,提出了生物成因、火山喷发沉积成因、热水沉积成因、碳酸盐岩帽沉积成因以及天然气渗漏成因等认识(谢小峰等,2015),反映出成矿受多种因素控制。本期锰矿主要分布于花垣、靖县、湘潭等地,代表性矿床有花垣民乐锰矿、靖县照洞锰矿、湘潭鹤岭锰矿和九潭冲锰矿、宁乡棠甘山锰矿等(图1)。

3.4 早震旦世陡山沱期磷矿

继南华纪陆内裂谷之后,早震旦世陡山沱期构造环境转为被动大陆边缘,加之气候变暖而发生海侵,将冰期和同期源于地表风化的海洋中含磷物质通过上升洋流输入浅水区(密文天等,2010)而沉积成矿。含磷岩系的具体沉积环境为半局限性滞流洼地、潮坪浅滩等,构造抬升背景下滩相环境的波浪作用可使磷矿进一步富集(张成信等,2014)。省境本次成矿主要发生于怀化—桃源一线以西的湘西北地区以及湘东浏阳永和地区,代表性矿床有石门东山峰磷矿区、古丈天平界磷硫矿、泸溪洗溪磷矿和浦溪磷矿、中方花桥磷矿、浏阳永和磷矿等(图1)。

3.5 早寒武世牛蹄塘期钒多金属矿、重晶石矿、石煤矿

早寒武世牛蹄塘期,省境处于被动大陆边缘伸展环境,相应的基底沉降与海侵造成水体加深和强还原环境,同时伸展断裂活动引发海底热泉并在局部形成断陷盆地。还原环境及细菌、藻类等低等水生生物的繁盛形成了大量的黑色页岩(石煤)(杨平等,2012;赵明胜等,2013)。在天柱—新晃—玉屏断陷盆地,盆地中因硫酸盐型低温热水发生大规模同生沉积成岩成矿作用而形成超大型重晶石矿(方维萱等,2002)。在怀化—安化—长沙一线以北,海底热泉或喷泉沉积形成了牛蹄塘组下部黑色岩系中的钒、铬、镍、钼等多金属矿(邓义楠等,2015;谢再波等,2016)。本期代表性石煤矿有安化杨林石煤矿、常德太阳山石煤矿等,代表性重晶石矿有新晃贡溪重晶石矿,代表性钒矿有吉首古者钒矿、溆浦110钒矿、永顺朗溪钒矿、桃源钟家铺钒矿和王家坪钒石煤矿、宁乡温冲钒石煤矿、岳阳新开塘钒石煤矿等(图1)。

3.6 中—晚奥陶世沉积型锰矿

继早奥陶世被动大陆边缘盆地之后,中—晚奥陶世区域构造环境转为挤压前陆盆地。岩石圈弯曲导致部分地区盆地基底下沉、构造掀斜与海平面上升,在相对缺氧、滞流的安静环境下形成碳酸锰或氧化锰矿(付胜云等,2014;石少华等,2016)。锰矿赋存于烟溪组和天马山组中,前者代表性矿床有桃江县响涛源锰矿和安化枚子洞锰矿,后者代表性矿床有常宁茶寮锰矿(图1)。

3.7 震旦纪—奥陶纪灰岩矿、白云岩矿、玉石矿等非金属矿产

震旦纪—早奥陶世省境属被动大陆边缘环境,湘西北—湘北地区台地相为主的沉积环境下形成

表2 主要成矿地质事件一览

Table 2 Main mineralization events in Hunan Province

序号	时代(层位)	形成矿产	成因类型	成矿构造环境及成矿机制	备注
22	Q	黏土矿、稀土矿、砂锡矿、金刚石矿等风化、沉积矿产	风化残余型；冲积型	构造抬升为主，局部沉降；风化、淋滤、离子吸附、冲积等作用形成矿床	
21	E	石膏矿、盐矿	沉积型	断陷盆地转为坳陷盆地，相对封闭的条件下形成湖相膏盐沉积	
20	K_2	铜矿	沉积-改造型	区域伸展构造背景下形成盆-岭构造格局，碎屑成矿物质于盆地中沉积后经地下热卤水溶离、运移再沉淀	
19	J_3(—K_1)	有色金属、萤石等热液矿床及长石等岩浆矿床	热液交代型、热液充填型、接触变质型、伟晶岩型等	后造山构造环境下的大规模花岗质岩浆活动，导致热液成矿和岩浆成矿作用	以J_3成矿为主，K_1成矿较少
18	T_3	有色金属、萤石等热液矿床	热液交代型、热液充填型	后碰撞构造环境下的大规模花岗质岩浆活动，导致热液成矿	
17	T_3—J_1	煤矿	沉积型	区域SN向挤压下发育陆相盆地，在滨湖沼泽环境下形成含煤沉积	
16	D—T_1	灰岩矿、白云岩矿、砂岩矿、黏土矿等	沉积型	总体伸展的陆表海盆地中，不同沉积相带的碳酸盐岩和碎屑岩沉积	
15	P_3l	龙潭组中煤矿	沉积型	陆表海盆地，构造抬升与海退条件下于沼泽环境下形成含煤沉积	
14	P_2g	孤峰组中锰矿	沉积型	陆表海拉张环境，与峨嵋地幔柱演化中晚期有关的热水沉积	叠加后期风化淋滤
13	P_2l	梁山组中煤矿	沉积型	陆表海盆地，构造沉降和海侵条件下于滨海沼泽形成含煤碎屑沉积	
12	C_1z	梓门桥组石膏矿	沉积型	陆表海盆地，构造沉降和海侵条件下于潮坪潟湖中形成石膏	
11	C_1c	测水组中煤矿	沉积型	陆表海盆地，基底抬升与海退背景，于滨海等环境中形成含煤碎屑沉积	
10	D_3yl、D_3hj	岳麓山组、欧家冲组、黄家磴组和写经寺组宁乡式铁矿	沉积型	加里东运动及沉积期伸展形成的盆地与海湾中，于构造沉降相关的海侵序列中沉积成矿	部分具后生热液活动叠加成矿
9	D_2q	棋梓桥组锰矿	沉积-热液叠加再造	伸展的陆表海盆地，于海湾中形成胚胎矿，后期热液叠加富集	叠加后期热液活动成矿
8	S	钨、金、锑、铅锌等	岩浆热液型、构造热液型	加里东运动相关的岩浆热液、构造热液活动	
7	Z—O	灰岩矿、白云岩矿、玉石矿等	沉积型	被动大陆边缘盆地中不同沉积相带的化学沉积	玉石矿叠加后期变质
6	$O_{2\text{-}3}$	烟溪组、天马山组锰矿	沉积型	前陆盆地环境，构造沉降、掀斜与海平面上升条件下，于相对滞流环境下形成碳酸锰或氧化锰沉积	
5	$\in_1n$	牛蹄塘组中钒多金属矿、重晶石矿、石煤矿	沉积型	被动陆缘构造环境下，断裂活动相关的海底热水沉积和微生物成矿形成钒多金属矿，硫酸盐型海底低温热水沉积形成重晶石矿，热水影响及还原条件下形成黑色页岩(石煤)	
4	Z_1d	陡山沱组中磷矿	沉积型	被动陆缘环境下磷酸盐随洋流上升至浅水区沉积，构造抬升背景下滩相波浪作用使矿质进一步富集	
3	Nh_2d	大塘坡组中碳酸锰矿	沉积型	裂谷环境下形成堑-垒构造格局，在火山喷发、热水活动、古天然气泄漏等因素控制下锰质于地堑内沉淀	
2	Nh_1f	富禄组中(“江口式”)铁矿	沉积-改造型	裂谷环境下，源于古陆剥蚀和盆内火山的铁质于断槽内沉淀，成岩期再次转移、富集，并叠加后期改造	叠加后期变质改造
1	Qb^2m	马底驿组和黄狮洞组碳酸锰矿	沉积型	裂谷环境下火山喷发或海底喷流带来的锰质沉淀而形成碳酸锰矿床	叠加后期热液活动成矿

了灰岩矿和白云岩矿,代表性矿床有石门杨坪灰岩矿、临湘灌山白云岩矿等;湘东南地区震旦系埃歧岭和丁腰河组硅泥质沉积岩经构造活动和岩浆活动相关的变质作用而形成七彩石玉石矿。

3.8 志留纪内生热液成矿

志留纪晚期加里东运动主幕(北流运动)发动,慈利—保靖断裂以南地区发生陆内造山,强烈的褶皱、断裂变形之后又发生了大规模的后碰撞花岗质岩浆活动,由此产生了与构造和岩浆活动相关的热液成矿作用。本期代表性矿床有炎陵黄上萤石矿、城步落家冲钨矿(杜云等,2017)和平滩钨矿、靖县平茶金矿(彭建堂和戴塔根,1998)、会同漠滨金矿(王秀璋等,1999)和肖家金矿(彭建堂和戴塔根,1998)、沅陵沃溪金锑矿(彭建堂等,2003)、平江万古金矿(韩凤彬等,2010)和黄金洞金矿(韩凤彬等,2010;Xu et al.,2017)、花垣李梅铅锌矿(段其发等,2014)等(图1);沃溪、万古、黄金洞等矿床叠加有后期成矿作用。

3.9 中泥盆世棋梓桥期沉积型(叠加后期改造)锰矿

由于加里东运动在部分地区形成隆、凹相间地貌,中泥盆世海侵时形成较为复杂的沉积古地理格局,在海湾等相对封闭环境下锰、铁、铅、锌等金属元素得以在棋梓桥组白云岩中沉淀而形成锰多金属"胚胎矿",其经后期构造活动、岩浆热液作用等进一步富集而形成规模矿床(谢俊福,1984;李祥能,2002)。本期代表性矿床有道县后江桥锰多金属矿和郴州玛瑙山锰铁多金属矿(图1)。

3.10 晚泥盆世宁乡式铁矿

晚泥盆世因构造沉降而发生海侵,在湿热气候条件下于较封闭或半封闭的古海盆、古海湾或潮坪中的浅海—滨海等古地理环境中铁质沉淀而形成宁乡式铁矿(黄德仁,1992;赵一鸣和毕承思,2000),一般在构造沉降相对强烈的盆地中心矿床规模更大(周家云等,2009)。除正常沉积成矿作用外,部分矿床尚见有后生热液活动叠加成矿(祝新友等,2015)。宁乡式铁矿主要发育于湘西北黄家磴组和写经寺组以及湘中—湘东岳麓山组中,前者代表性矿床有石门新关铁矿和太清山铁矿、慈利小溪峪铁矿、桑植麦地坪铁矿、永顺桃子溪铁矿等,后者代表性矿床有宁乡陶家湾铁矿、攸县凉江铁矿和漕泊铁矿、茶陵潞水铁矿和清水铁矿、汝城大坪铁矿等(图1)。

3.11 早石炭世测水期煤矿

早石炭世测水期因基底构造抬升而发生海退,平江—安化—溆浦—绥宁一线以北暴露剥蚀,该线以南沉积环境以河流-三角洲、滨海、潟湖、沼泽等为主,在泥炭沼泽、潮坪中形成含煤碎屑沉积(何红生,2009;扈金刚等,2014;朱林英等,2015)。本期煤矿主要分布于涟源凹陷,邵阳凹陷、零陵凹陷及郴耒地区含煤性较差。代表性煤矿有冷水江煤矿、渣渡煤矿、金竹山煤矿、武冈龙江煤矿等。

3.12 早石炭世梓门桥期膏盐矿

早石炭世晚期即梓门桥期发生构造沉降和海侵,湘中南广大地区多为碳酸盐陆棚、局限台地型潮坪潟湖环境,在涟邵盆地多个潮坪潟湖中形成了大量石膏沉积。本期代表性矿床有涟源良相桥石膏矿、双峰梓门桥凤形山石膏矿、邵阳常乐石膏矿等(刘剑峰和陆红,2010)(图1)。

3.13 中二叠世梁山期煤矿

继早二叠世末黔桂上升之后,中二叠世早期发生构造沉降和海侵,雪峰古陆北侧于滨海沼泽环境下形成梁山组陆源碎屑含煤沉积。本期代表性矿床有澧县羊耳山煤矿、石门平塌煤矿和龙阳湾煤矿、慈利向家溪煤矿、桑植新街煤矿、龙山洛塔煤矿、溆浦椒板溪煤矿等(贾宝华等,2019)。

3.14 中二叠世孤峰期(茅口晚期)沉积型锰矿

在区域拉张构造环境下,中二叠世中晚期发生构造沉降,海水加深,湘中南在半深水陆棚环境下形成硅泥质和碳酸锰沉积。本期锰矿沉积属可能与峨嵋地幔柱演化中晚期有关的热水沉积(刘平等,2008)。代表性锰矿有芝山东湘桥锰矿和于家—罗家锰矿、邵阳清水塘锰矿、邵东芦山坳锰矿等(图1)。

3.15 晚二叠世龙潭期煤矿

中二叠世末—晚二叠世早期构造抬升(东吴上升)而发生海退,省境主要沉积环境转为水下三角洲、三角洲平原、远岸潮坪等,形成龙潭组含煤沉积。煤层主要形成于潮坪沼泽、分流河道之间沼泽等环境(扈金刚等,2014;朱林英等,2015)。本期煤矿主要分布于涟源凹陷、邵阳凹陷北部以及宁乡—常宁—嘉禾一线以东地区,靖州上古生界残留区有少量发育;代表性矿床有涟源晏家铺煤矿、桥头河煤矿、斗笠山煤矿、隆回箍脚底煤矿、双峰朝阳煤矿、嘉祥江煤矿、邵东牛马司煤矿、邵阳短陂桥煤

矿、宁乡煤炭坝煤矿、湘潭谭家山煤矿和坪塘煤矿、醴陵大障煤矿、攸县兰村洋滨—咸弦煤矿、常宁盐湖煤矿、衡南斗岭煤矿、耒阳白沙煤矿、永兴湘永煤矿和马田煤矿、临武梅田煤矿、嘉禾袁家煤矿、靖县煤矿等(贾宝华等,2019)。

3.16 泥盆纪—早三叠世灰岩、白云岩、砂岩、黏土等非金属矿

泥盆纪—早三叠世总体属陆表海伸展构造环境,巨量的沉积物以碳酸盐岩和碎屑岩为主,由此形成了分布广泛、层位众多的灰岩、白云岩、石英砂岩、黏土等非金属矿产。代表性灰岩矿有石门新关灰岩矿和贺家山灰岩矿、辰溪大元山灰岩矿、新化拓木岭灰岩矿和天马山电石用灰岩矿、涟源椅子山水泥用灰岩矿、娄底恩口熔剂用灰岩矿、邵东金星铺熔剂用灰岩矿、湘潭竹节坝熔剂用灰岩矿和姚家塘灰岩矿、攸县东院熔剂用灰岩矿、祁阳曾家港灰岩矿和高石山灰岩矿、东安羊角寨熔剂用灰岩矿、耒阳李家湾水泥用灰岩矿、安仁老虎水泥用岩灰岩矿、宜章老虎山水泥用灰岩矿等,多为泥盆系灰岩;代表性白云岩矿有娄底三圭桥冶金用白云岩矿、涟源仙洞冶金用白云岩矿、东安县紫溪冶金用白云岩矿等,多为泥盆系和石炭系;代表性砂岩矿有桑植小溪冶金用和玻璃用砂岩矿、临澧县太浮山玻璃用砂岩矿、溆浦谭家湾玻璃用砂岩矿、湘潭谭家坳玻璃用砂岩矿和雷子排砂岩矿等,多为中泥盆世跳马涧组砂岩;代表性黏土矿有双峰印田黏土矿、湘乡龙洞海泡石黏土矿、湘潭八亩冲海泡石黏土矿、芷江皇榜坡耐火黏土矿、洪江干溪坪耐火黏土矿等(图1),均为泥岩风化产物(魏均启等,2014)。

3.17 晚三叠世—早侏罗世煤矿

继中三叠世印支运动之后,晚三叠世—早侏罗世在区域SN向挤压下部分地区发育陆相盆地,在滨湖沼泽环境下形成含煤沉积。本期煤矿主要分布于沅麻盆地、永州盆地、湘东南资兴—攸县盆地;洞口、株洲—湘潭等地的残留盆地也有发育。代表性矿床有辰溪五一煤矿、中方泸阳板栗坪煤矿、祁东七一煤矿、冷水滩东风煤矿、祁阳三口塘煤矿、宜章杨梅山煤矿、资兴三都煤矿、醴陵南桥煤矿、洞口石下江煤矿、株洲华石煤矿等(贾宝华等,2019)。

3.18 晚三叠世内生热液矿床

继中三叠世晚期印支运动主幕之后,省境晚三叠世进入挤压减弱、应力松弛的后碰撞构造环境,经先期加厚、增温的下地壳发生重熔而发生大规模花岗质岩浆活动,由此发生热液成矿作用。相对晚侏罗世而言,本期成矿规模总体不大。根据相关岩体年龄和成矿年龄,可以确定的代表性矿床有安化大溶溪钨矿(大神山岩体)(张龙升等,2014)、邵东石桥铺铅锌矿和衡南双溪荧石矿(关帝庙岩体)、醴陵潘家冲萤石多金属矿(丫江桥岩体)、衡南双江口萤石铅矿(将军庙岩体)、衡南杨林坳钨矿和三角潭钨矿(川口岩体)(彭能立等,2017)、锡田合江口锡钨矿(邓湘伟等,2015)、郴州荷花坪锡矿(王仙岭岩体)(蔡明海等,2006),以及雪峰构造带内的渣滓溪钨锑矿(王永磊等,2012)、铲子坪金矿和大坪金矿(李华芹等,2008)、古台山金矿(Li et al.,2018)、符竹溪金矿(姚振凯和朱蓉斌,1993)、板溪金锑矿(彭建堂和胡瑞忠,2001)、雁林寺金矿(黄诚等,2012)、团山背金矿(韩风彬等,2010)等(图1)。

3.19 晚侏罗世—早白垩世早期内生热液及岩浆矿床

继中侏罗世早燕山陆内造山运动之后,晚侏罗世—早白垩世初华容—安化—靖州一线以东进入后造山或后碰撞伸展构造环境,岩石圈拆沉、软流圈上隆、陆内碰撞后期增温减压、俯冲板块崩塌等深部构造作用引发大规模花岗质岩浆活动和岩浆热液成矿作用,形成一大批大型—超大型金属矿床。省境大部分内生矿床形成于本期成矿事件(成矿及相关岩体的年龄数据很多,有关文献从略)。代表性矿床有汝城砖头坳钨多金属矿、白云仙钨多金属矿,宜章瑶岗仙钨多金属矿、界牌岭铍多金属矿、东风硅灰石矿,郴州柿竹园钨多金属矿、红旗岭锡多金属矿、新田岭钨多金属矿,临武香花岭锡多金属矿、鸡脚山水晶矿、香花铺钽多金属矿、香花铺长石矿,桂阳宝山铅多金属矿、黄沙坪萤石铅锌多金属矿,常宁康家湾金多金属矿、水底下硅灰石矿,茶陵邓阜仙钽多金属矿、锡田钨锡多金属矿,衡山马迹长石矿,道县湘源铷多金属矿,江永铜山岭银多金属矿,冷水江锡矿山锑矿,新邵潭溪钨银铁矿,临湘桃林萤石多金属矿、团湾长石矿,浏阳七宝山硫铁铜多金属矿,平江传梓源铷多金属矿等(图1)。此外,雁林寺金矿、黄金洞金矿、万古金矿、沃溪金锑矿、龙山锑金矿等也存在本期的成矿作用或

矿质进一步富集(史明魁等,1993;董国军等,2008;黄诚等,2012;付山岭等,2016;Deng et al.,2017;Zhang et al.,2019,2020)。

3.20 晚白垩世沉积–改造型铜矿

晚白垩世在区域伸展构造背景下形成盆–岭构造格局。古陆区或山地暴露区的碎屑含矿物质搬运至盆地内沉积,尔后经地下热卤水溶离、运移至有利的岩性–构造部位沉淀成矿(曾乔松和刘石年,1997;黄满湘,1999;杨兵,2018)。代表性矿床有麻阳九曲湾铜矿、衡南车江铜银矿(图1),均为小型矿床。

3.21 古近纪膏盐矿

白垩纪开始的断陷盆地在古近纪中晚期转为坳陷盆地,洞庭盆地澧县凹陷、衡阳盆地、邵阳盆地等在地形高差不大、构造稳定且相对封闭的条件下形成大量湖相膏盐沉积。代表性矿床有澧县盐井盐矿、曾家河芒硝矿和金罗石膏矿、石门歇驾山石膏矿、临澧合口石膏矿和赵家坪石膏矿、邵东石膏矿、衡阳上马塘芒硝矿石盐矿、茶山坳石盐芒硝矿、七里井芒硝矿、衡南县咸塘石膏芒硝矿等(陈强春,1998)(图1)。

3.22 第四纪黏土矿、稀土矿、砂锡矿、独居石多金属矿、金刚石矿等

除洞庭盆地沉降外,第四纪省境地壳活动以抬升为主。风化、淋滤、离子吸附、冲积等作用形成了黏土矿、稀土矿、砂锡矿、独居石多金属矿、金刚石矿等。代表性矿床有益阳白水高岭土矿、长沙福临铺高岭土矿、浏阳永和海泡石黏土矿、湘潭八亩冲海泡石黏土矿、江华县姑婆山稀土多金属矿、常宁白沙锡矿和西岭锡钨矿等(砂矿)、新墙河流域独居石多金属砂矿、临湘詹家桥独居石多金属砂矿、湘阴望湘独居石多金属砂矿、丁家港金刚石砂矿、桃源金刚石砂矿等(薄昊楠等,2019)(图1)。

4 主要内生成矿事件的构造格局控制

如前文所述,省境存在志留纪(加里东期)内生热液成矿、晚三叠世(印支晚期)内生热液成矿、晚侏罗世—早白垩世早期(中晚燕山期)内生热液及岩浆成矿等3期主要内生成矿事件。已有研究表明,各期内生成矿事件明显受构造格局控制(柏道远等,2020),具体简介如下。

4.1 志留纪(加里东期)内生热液成矿的构造格局控制

受加里东运动自南东向北西扩展以及深部岩石圈结构差异控制,本成矿期省境自南东至北西分为湘中—湘东南构造岩浆带(Ⅰ)、雪峰构造带(Ⅱ)、湘西北构造抬升带(Ⅲ)等3个构造带,其中雪峰构造带根据构造样式和变形强度差异可进一步分为雪峰冲断带($Ⅱ_1$)和武陵低缓褶皱带($Ⅱ_2$)等2个次级构造带(图2)。

湘中—湘东南构造岩浆带(Ⅰ)发生后碰撞花岗质岩浆活动,于局部产生与岩浆活动相关的钨、萤石等成矿作用,如彭公庙岩体加里东期细晶岩脉中发育岩浆成因的白钨矿、岩体南缘发育张家垄钨矿(张文兰等,2011;郭爱民等,2017),苗儿山岩体北西缘发育加里东期落家冲钨矿(杜云等,2017),万洋山岩体(陈迪等,2016)发育黄上萤石矿等(图2)。矿床类型主要为构造蚀变岩型和石英脉型,含矿构造主要为岩体侵位相关的断裂或裂隙,如落家冲钨矿和张家垄钨矿(杜云等,2017;郭爱民等,2017)。

雪峰构造带(Ⅱ)东部的雪峰冲断带($Ⅱ_1$)受强烈构造变形与构造抬升控制,形成了产于板溪群和冷家溪群中的造山型(或类造山型)金矿和锑金矿(董国军等,2008)(图2),具有加里东期成矿年龄数据的有平茶金矿(彭建堂和戴塔根,1998)、漠滨金矿(王秀璋等,1999)、肖家金矿(彭建堂和戴塔根,1998)、沃溪金锑矿(彭建堂等,2003)、万古金矿和黄金洞金矿(韩凤彬等,2010)、字溪金矿(Wang et al.,2019)等(沃溪、万古、黄金洞等矿床叠加有中生代成矿作用);矿床类型有石英脉型、构造蚀变岩型和蚀变围岩型等,含矿构造以武陵运动或加里东运动中形成的层间剪切断裂及其派生的次级裂隙为主,如漠滨金矿(鲍振襄等,1998)、沃溪金锑矿(鲍振襄等,2002)、万古金矿(顾江年等,2012)和黄金洞金矿(黄强太等,2010)等。雪峰构造带(Ⅱ)西部的武陵低缓褶皱带($Ⅱ_2$)及湘西北构造抬升带(Ⅲ)内形成了与加里东运动后伸展活动和相应的热液活动有关的汞铅锌矿(部分与先期寒武纪同沉积断裂活动有关),如李梅铅锌矿、渔塘铅锌矿(段其发等,2014)、茶田汞铅锌矿和打狗洞铅锌矿(杜国民等,2012;周云等,2014)、江家垭铅锌矿(周云等,2015)、唐家寨铅锌矿(周云等,2014;王云峰等,2018)等;矿体多为似层状,含矿构造主要为加里东期背斜相关的层间断裂和层内裂隙系统,次为切层断层(杨绍祥和劳可通,2007)。

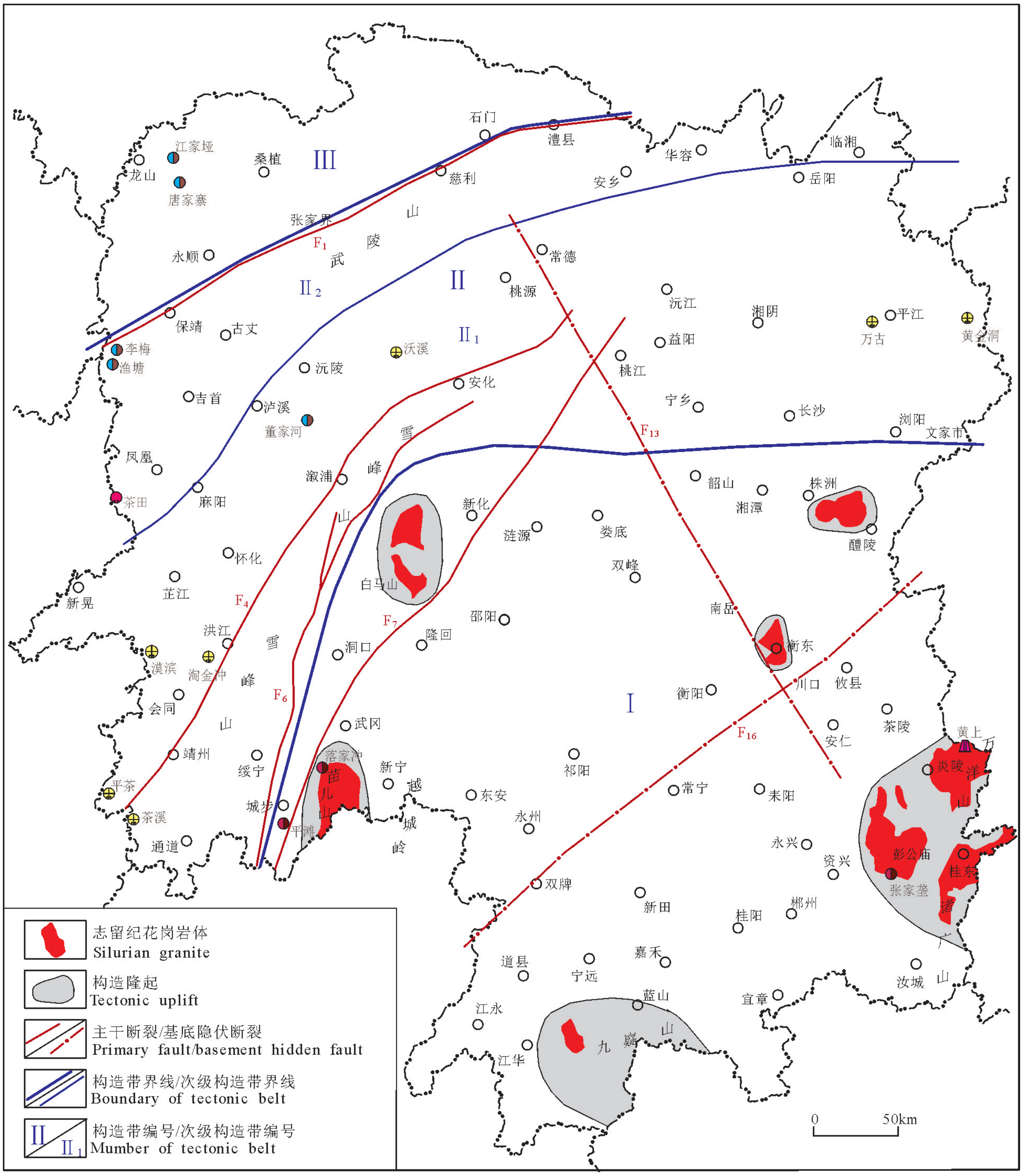

图2 志留纪后期内生热液成矿期构造格局(据柏道远等,2020;断裂名称及矿床类型同图1)

Ⅰ—湘中—湘东南构造岩浆带;Ⅱ—雪峰构造带:Ⅱ$_1$—雪峰冲断带,Ⅱ$_2$—武陵低缓褶皱带;Ⅲ—湘西北构造抬升带

Fig.2 Tectonic framwork of late Silurian endogenous hydrothermal mineralization (after Bai Daoyuan et al., 2020;Names of faults and types of deposits same as fig.1)

Ⅰ−Central−Southeastern Hunan tectonomagmatic belt; Ⅱ−Xuefeng tectonic belt: Ⅱ$_1$−Xuefeng thrust−fault zone; Ⅱ$_2$−Wuling gentle fold zone; Ⅲ−Northwestern Hunan tectonic uplifting belt

4.2 晚三叠世(印支晚期)内生热液成矿

继中三叠世晚期印支运动主幕之后,晚三叠世省境进入挤压减弱、应力松弛的后碰撞构造环境而于湘中—湘东南地区发生大规模花岗质岩浆活动,并由此发生较强的热液成矿作用。受深部岩石圈结构差异控制,本成矿期省境自南东至北西分为湘中—湘东南构造岩浆带(Ⅰ)、雪峰构造带(Ⅱ)、湘西北褶皱带(Ⅲ)等3个构造带,其中湘中—湘东南构造岩浆带(Ⅰ)据隆-凹构造格局可进一步分为炎陵—汝城隆起带($Ⅰ_1$)、湘中凹陷带($Ⅰ_2$)和雪峰东南缘构造岩浆隆起带($Ⅰ_3$)等3个次级构造带(图3)。

湘中—湘东南构造岩浆带(Ⅰ)东南部的炎陵—汝城隆起带($Ⅰ_1$)内,王仙岭岩体和锡田岩体分别形成了荷花坪锡矿(蔡明海等,2006)和合江口锡钨多金属矿(邓湘伟等,2015);含矿构造有侵入接触构造、印支运动形成的层间断裂及切层的断裂和节理裂隙等(邓湘伟等,2015)。中部湘中凹陷带($Ⅰ_2$)越城岭岩体(程顺波等,2018)北面形成了赵家岭等多个小型钨矿、关帝庙岩体形成了石桥铺铅锌矿(史国伟等,2015)和双溪萤石矿;含矿构造主要为岩体侵位相关的断裂或裂隙。西北部雪峰东南缘构造岩浆隆起带($Ⅰ_3$)成矿作用较强,不同规模矿床较多,主要矿种有Au、Sb、W、萤石等,如铲子坪大型金矿和大坪金矿(李华芹等,2008;李国亮等,2014;李建华等,2014)、古台山金矿(Li et al.,2018)、同心中型锑矿和渣滓溪大型金钨锑矿(王永磊等,2012)、大溶溪大型钨矿(张龙升等,2014)、司徒铺中型钨矿(丁兴等,2005)、团山背小型金矿(韩凤彬等,2010)、潘家冲大型萤石多金属矿(丫江桥岩体)(马铁球等,2013)、双江口大型萤石矿(将军庙岩体)(刘昌福,2007)、杨林坳和三角潭大型钨矿(川口岩体)(彭能立等,2017)等(图1)。含矿构造有印支运动形成的切层断裂,如铲子坪金矿(骆学全,1996)、古台山金矿(余建国,1998)、渣滓溪金钨锑矿(王朝飞等,2015)等;岩体同侵位断裂,如双江口萤石矿(刘昌福,2007)和三角潭钨矿(彭能立等,2017);前印支期断裂,如大溶溪钨矿产于南华系层间剪切断裂中(张龙升等,2014),从区域构造演化历史来看,该层间断裂形成于加里东运动的可能性更大。

雪峰构造带(Ⅱ)就目前已有年龄数据来看,未见有内生热液矿床发育。

湘西北褶皱带(Ⅲ)发育五伦、卡西湖等小型脉型铅锌矿,含矿构造为印支运动形成的切层断裂(曾广乾等,2018)。

4.3 晚侏罗世—早白垩世(中晚燕山期)内生热液及岩浆成矿

本成矿期省境自南东往北西分为湘中—湘东构造岩浆带(Ⅰ)、雪峰西部构造带(Ⅱ)、湘西北褶皱带(Ⅲ)等3个构造带,其中湘中—湘东构造岩浆带(Ⅰ)根据区域隆-凹构造格局可进一步划分为炎陵—汝城冲断褶隆带($Ⅰ_1$)、宁远—桂阳坳褶带($Ⅰ_2$)、邵阳坳褶带($Ⅰ_3$)和雪峰东南部构造岩浆隆起带($Ⅰ_4$)等4个次级构造带,雪峰西部构造带(Ⅱ)进一步分为怀化—桃源冲断带($Ⅱ_1$)和武陵断弯褶皱带($Ⅱ_2$)等2个次级构造带(图4)。

湘中—湘东构造岩浆带(Ⅰ)受岩石圈拆沉、软流圈上隆、陆内碰撞后期增温减压、俯冲板块崩塌等深部构造作用控制而发生大规模花岗质岩浆活动,形成了大量的有色金属矿床和金矿床(罗凡等,2019;张永谦等,2019)。其中炎陵—汝城冲断褶隆带($Ⅰ_1$)和宁远—桂阳坳褶带($Ⅰ_2$)成矿以有色金属为主(成元素包括W、Sn、Mo、Bi、Cu、Pb、Zn、Sb、Ag、Au、As、Li、Rb、Be、Cs、Nb、Ta、Cd等)、其它矿种为辅(萤石矿、长石矿、水晶矿、硅灰石矿等),包括锡田、瑶岗仙、界牌岭、柿竹园、红旗岭、新田岭、香花岭、香花铺、宝山、黄沙坪、水口山、铜山岭等一大批大型、超大型矿床(贾宝华等,2019)(图4);炎陵—汝城冲断褶隆带以中高温的钨锡多金属为主、中低温的铅锌多金属为次,宁远—桂阳坳褶带则以中低温的铅锌多金属为主、中高温的钨锡多金属为次(柏道远等,2007b)。邵阳坳褶带($Ⅰ_3$)总体成矿强度较低,主要于北部新化—双峰一带发育锑、金矿床,包括锡矿山锑矿(Hu et al.,1996;彭建堂等,2002)、大新金锑矿、高家坳金矿、龙山锑金矿(史明魁等,1993;付山岭等,2016)等(图4);南部高挂山隆起内发育回水湾中型锑银矿、龙口里中型锑金矿、线江冲小型锑矿等,推测形成于燕山期。雪峰东南部构造岩浆隆起带($Ⅰ_4$)内矿床主要分布于东部花岗岩发育区,矿种包括W、Pb、Zn、Cu、Au、Rb、Nb、Ta、As、长石等,自北而南代表性矿床有桃林铅锌矿(Yu et al.,2020)、团湾长石矿、传梓源铷多金属矿、梅树湾铅锌矿、万古金矿(Deng et al.,2017)、黄金洞

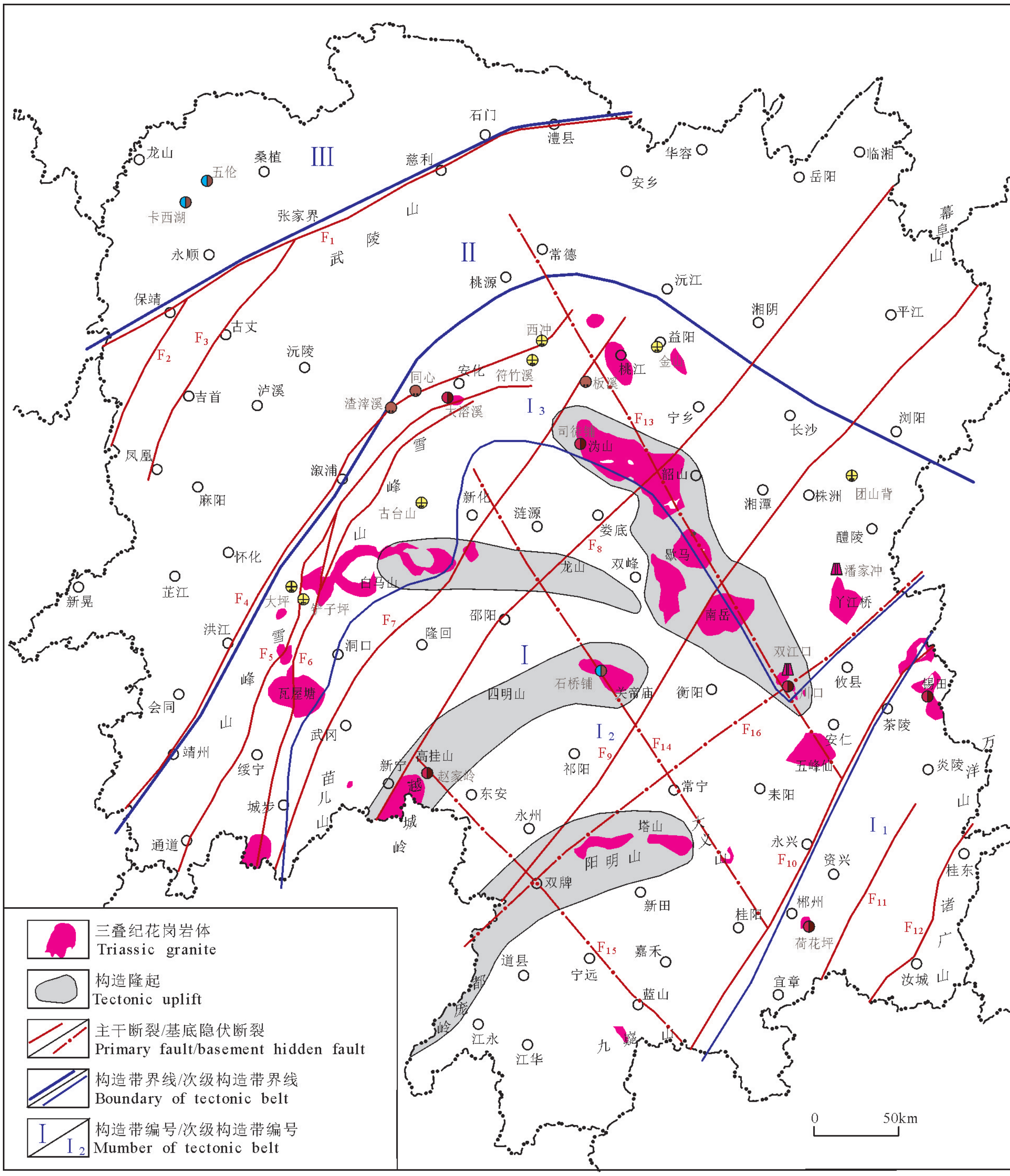

图3 晚三叠世内生热液成矿期构造格局(据柏道远等,2020;断裂名称及矿床类型同图1)

Ⅰ—湘中—湘东南构造岩浆带: $Ⅰ_1$—炎陵—汝城隆起带, $Ⅰ_2$—湘中凹陷带, $Ⅰ_3$—雪峰东南缘构造岩浆隆起带;Ⅱ—雪峰构造带;Ⅲ—湘西北褶皱带

Fig.3 Tectonic framwork of Late Triassic endogenous hydrothermal mineralization (after Bai Daoyuan et al., 2020; Names of faults and types of deposits are the same as Fig.1)

Ⅰ−Central−southeastern Hunan tectonomagmatic belt: $Ⅰ_1$−Yanling−Rucheng uplift zone, $Ⅰ_2$−Central Hunan depression zone, $Ⅰ_3$—Southeastern Xuefeng tectonomagmatic uplift zone; Ⅱ−Xuefeng tectonic belt; Ⅲ−Northwestern Hunan fold belt

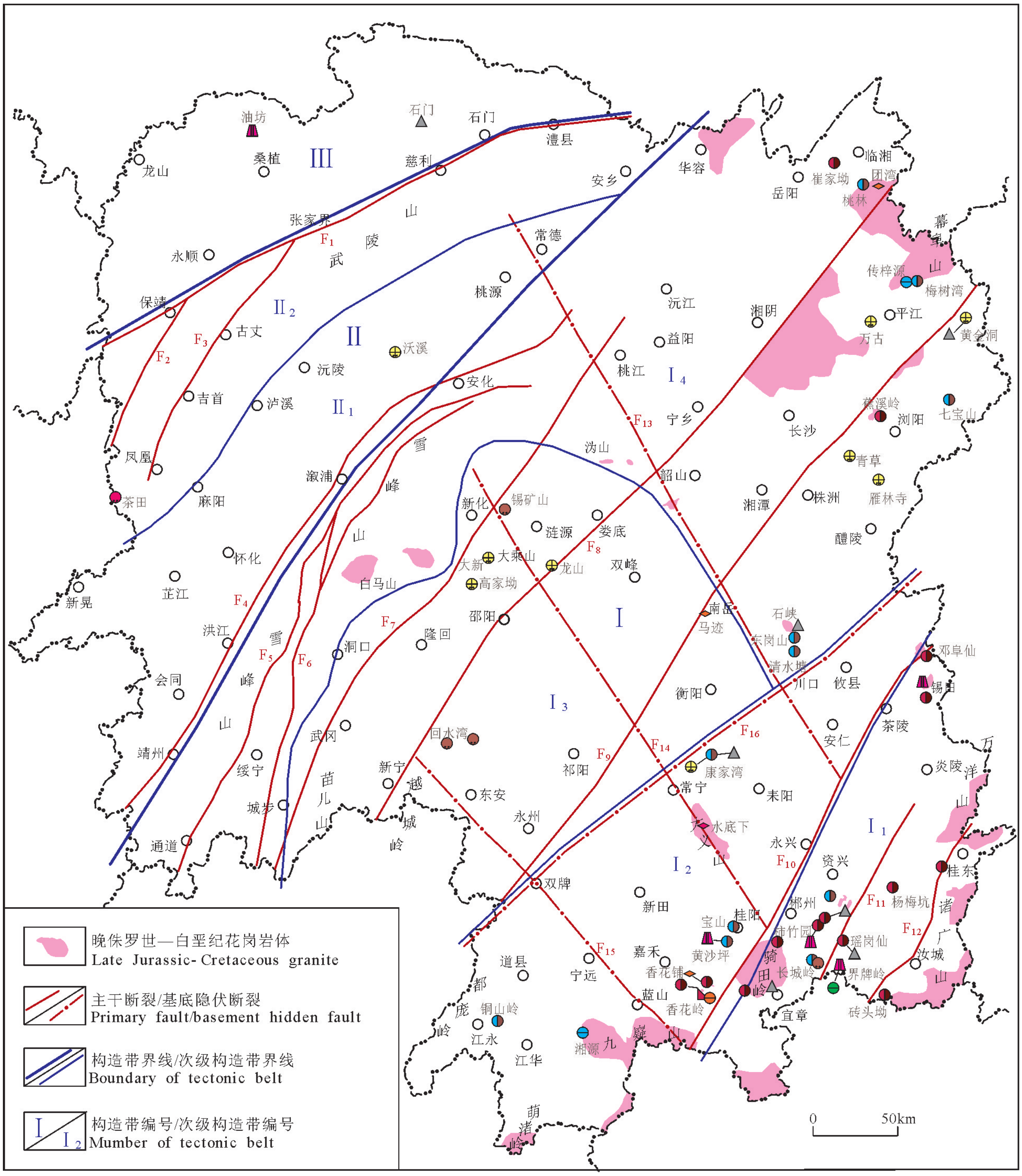

图4 晚侏罗世—早白垩世早期内生热液成矿期构造格局（据柏道远等，2020；断裂名称及矿床类型同图1）

Ⅰ—湘中—湘东构造岩浆带：$Ⅰ_1$—炎陵—汝城冲断褶隆带，$Ⅰ_2$—宁远-桂阳坳褶带，$Ⅰ_3$—邵阳坳褶带，$Ⅰ_4$—雪峰东南部构造岩浆隆起带；Ⅱ—雪峰西部构造带：$Ⅱ_1$—怀化—桃源冲断带，$Ⅱ_2$—武陵断弯褶皱带；Ⅲ—湘西北褶皱带

Fig.4 Tectonic framework of Late Jurassic-Early Cretaceous endogenous hydrothermal mineralization (after Bai Daoyuan et al., 2020; Names of faults and types of deposits are the same as Fig.1)

Ⅰ-Central-Southeastern Hunan tectonomagmatic belt: $Ⅰ_1$-Yanling-Rucheng thrust-fold uplift zone, $Ⅰ_2$-Ningyuan-Guiyang depression-fold zone; $Ⅰ_3$-Shaoyang depression-fold zone; $Ⅰ_4$-Southeastern Xuefeng tectonomagmatic uplift zone; Ⅱ-Western Xuefeng tectonic belt:; $Ⅱ_1$-Huaihua—Taoyuan thrust-fault zone; $Ⅱ_2$-Wuling fault-bend fold zone; Ⅲ-Northwestern Hunan fold belt

金矿和砷矿(董国军等,2008)、七宝山铅锌矿(胡俊良等,2017)、蕉溪岭钨铜矿、青草和雁林寺金矿(黄诚等,2012)、东岗山和清水塘铅锌矿、石峡砷矿等(图4),其中黄金洞金矿和万古金矿尚存在加里东期成矿作用(韩凤彬等,2010)。

湘中—湘东构造岩浆带(Ⅰ)内的含矿构造多样,主要有侵入接触构造,如水口山(张庆华,1999)、柿竹园(蔡新华等,2006)、香花岭(钟江临和李楚平,2006)、铜山岭(张果等,2019)、骑田岭白腊水(蒋中和等,2005)、七宝山(曹兴男,1987)等矿田的接触交代型矿床;背斜核部及两翼的层间滑动断裂及节理裂隙,如宝山(唐朝永,2005)、水口山(张庆华,1999)、锡矿山(刘光模和简厚明,1983)等矿田;切层断裂和节理、裂隙,如红旗岭锡多金属矿(苏咏梅,2007)、瑶岗仙钨矿(陈依壤,1981)等;岩体中同侵位断裂,如瑶岗仙钨矿花岗岩中矿脉(陈依壤,1981);断裂-复合侵入接触构造,如桃林铅锌矿(喻爱南等,1993)。侵入接触构造和岩体中同侵位断裂与岩浆活动同时;其他含矿断裂、裂隙部分可能与岩浆活动同期,但大多应形成于先期印支运动和早燕山运动的褶皱-断裂变形事件;湘东北地区的顺层剪切带脉型金矿具有本期成矿作用(文志林等,2016),但剪切断裂在武陵运动或加里东运动中即已形成(刘亮明等,1997)。

雪峰西部构造带(Ⅱ)本期成矿作用弱,发育矿床少,其东部怀化—桃源冲断带(Ⅱ$_1$)内的沃溪金矿可能存在本期成矿叠加(史明魁等,1993);西部武陵断弯褶皱带(Ⅱ$_2$)内凤凰茶田地区多个低温热液层控型汞(铅锌)矿床主要形成于本期(雷义均等,2012)。

湘西北褶皱带(Ⅲ)发育少量低温热液充填型矿床,以油坊中型萤石矿和石门大型砷矿(雄黄矿)为代表(图4),前者的含矿构造为NW向右行切层断裂(闫友谊,2014),后者的含矿构造为背斜倾伏端断裂相关的岩溶洞穴(曹承清,2013);相关断裂主要形成于印支运动。

5　主要外生成矿事件的构造古地理控制

5.1　南华纪铁、锰沉积成矿的构造古地理控制

受Rodinia超大陆解体的影响,南华纪省境处于陆内裂谷伸展环境(王剑等,2001;王剑和潘桂棠,2009),分属扬子陆缘盆地和华夏陆缘盆地,两盆地分界位于双牌—茶陵一线(图5,图6)。扬子陆缘盆地发育同沉积断裂和次级断陷盆地,导致了富禄组中铁矿和大塘坡组中锰矿的形成。

早南华世晚期即富禄组沉积期,扬子陆缘盆地自北西往南东依次为后滨沼泽-潟湖相区、冰岸带相区和陆棚-陆坡相区,同期湘东北为古陆;华夏陆缘盆地为边缘海槽盆相区。受同沉积伸展断裂控制,靖州—新化一带形成NE向、新宁—关帝庙一线形成NEE向断陷盆地(图5),盆内海底火山喷发带来大量铁质,与扬子古陆风化剥蚀含铁碎屑的铁质呈胶体溶液运移至温暖浅海半封闭环境而沉淀,形成主要分布于断槽的铁矿初始矿源层,为后期变质改造形成富禄组中"江口式"铁矿(王廷江等,2006)打下了物质基础。

中南华世晚期即大塘坡组沉积期,扬子陆缘盆

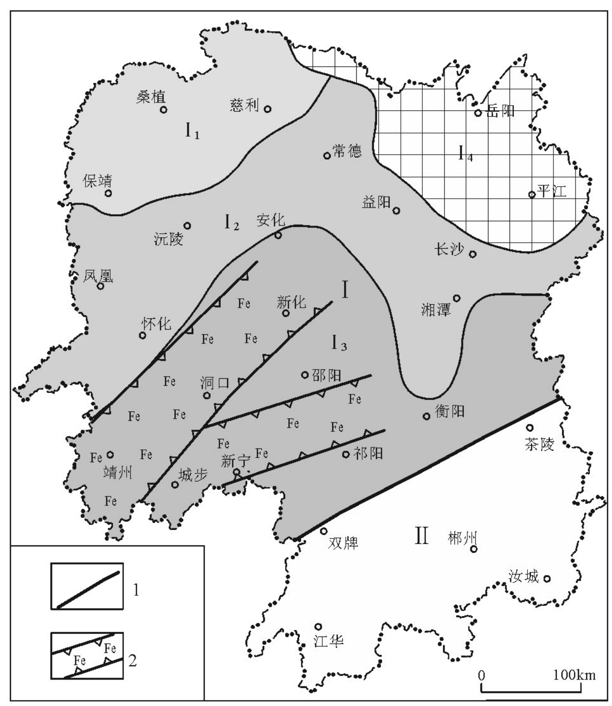

图5　早南华世富禄期构造古地理格局与成矿
1—扬子陆缘盆地与华夏陆缘盆地分界线;2—含铁断陷盆地;Ⅰ—扬子陆缘盆地:Ⅰ$_1$—后滨沼泽-潟湖相区;Ⅰ$_2$—滨岸相区;Ⅰ$_3$—陆棚-陆坡相区;Ⅰ$_4$—古陆;Ⅱ—华夏陆缘盆地,边缘海槽盆相区
Fig.5 Tectonic paleogeographic setting and mineralization in Fulu Stage of Early Nanhuan
1-Boundary between Yangtze margin basin and Cathaysia margin basin; 2-Fe-bearing faulted basin. Ⅰ-Yangtze margin basin; Ⅰ$_1$-Backshore swamp-lagoon; Ⅰ$_2$-Shore; Ⅰ$_3$-Shelf-continental slope; Ⅰ$_4$-Old land; Ⅱ-Marginal sea trough basin at Cathaysia margin basin

地自北西往南东依次为潮坪潟湖相区、陆棚浅海区和陆坡相区；华夏陆缘盆地仍为边缘海槽盆相区(图6)。受同沉积伸展断裂控制，湘西民乐、凤凰形成NEE向，湘西南城步和洞口以西、靖州以东形成NNE向，湘中湘潭—安化一带形成NW向断陷盆地。这些规模较大的断陷盆地中往往形成更次级的断陷盆地(周琦等，2016)。断裂拉张引发的海底火山喷发和天然气渗漏带来大量锰质，在生物活动、热水作用和温暖海湾等合适沉积环境下(谢小峰等，2015)，这些深部锰质与源于古陆风化的锰质一道于上述断陷盆地尤其是其内部的次级断陷盆地中沉积，形成“大塘坡式”锰矿床。

值得指出的是，富禄组沉积期与大塘坡组沉积期的成矿特征及其差异，是全球背景下区域古气候、古构造活动以及古海洋化学演化多重因素共同

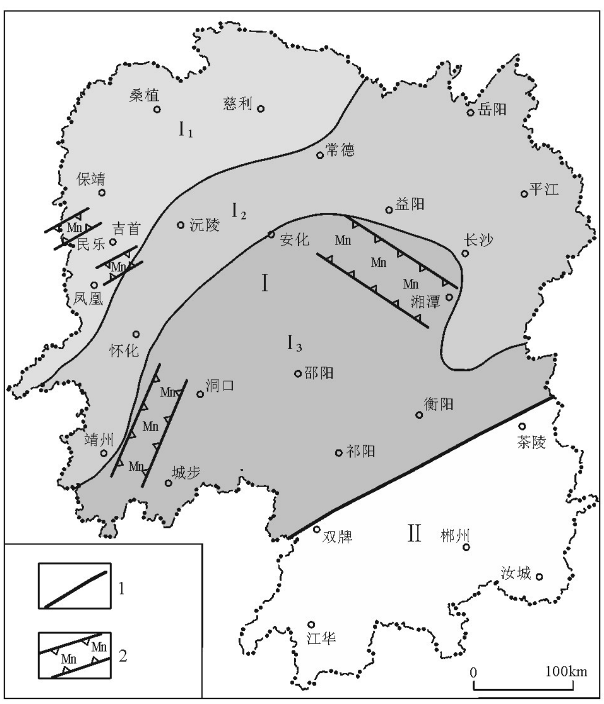

图6 早南华世大塘坡期构造古地理格局与成矿
1—扬子陆缘盆地与华夏陆缘盆地分界线；2—含锰断裂盆地；Ⅰ—扬子陆缘盆地：$Ⅰ_1$—潮坪潟湖相区；$Ⅰ_2$—陆棚浅海区；$Ⅰ_3$—陆坡相区；Ⅱ—华夏陆缘盆地，边缘海槽盆相区

Fig.6 Tectonic paleogeographic setting and mineralization in Datangpo Stage of Early Nanhuan

1−Boundary between Yangtze continental margin basin and Cathaysia continental margin basin; 2−Mn−bearing faulted basin. Ⅰ−Yangtze margin basin; $Ⅰ_1$−Tidal flat−lagoon; $Ⅰ_2$−Shelf shallow sea; $Ⅰ_3$−Continental slope; Ⅱ−Marginal sea trough basin at Cathaysia margin basin

作用的结果(周琦等，2016)。裂谷盆地发育早期主要受正断裂及断块的差异升降控制，隆起与断陷的分异或高差较大，沉积水域较小、水体较浅；中晚期仍有正断裂活动，但盆地主要受基底的整体沉降控制，水域进一步扩张，沉积水体较深。这一构造发展过程导致富禄组沉积期与大塘坡组沉积期的构造古地理存在一定差异(图5，图6)，同时也是前者铁质成矿而后者锰质成矿的成因机制之一。

5.2 震旦纪—早奥陶世沉积成矿的构造古地理控制

震旦纪—早奥陶世省境处于被动大陆边缘伸展环境，仍分属扬子陆缘盆地和华夏陆缘盆地，且两盆地边界自早至晚由南东往北西迁移(图7，图8，图9)。本阶段古地理格局总体为北西高、南东低。受地壳伸展、断裂活动、被动大陆边缘盆地总体沉降背景下的脉动式升降过程及相关古地理格局的控制，本阶段形成了早震旦世陡山沱期磷矿，早寒武世牛蹄塘期钒多金属矿、重晶石矿、石煤矿，以及其他分属不同时代的灰岩矿、白云岩矿、玉石矿等非金属矿产。

早震旦世即陡山沱组沉积期，扬子与华夏陆缘盆地的界线位于双牌—茶陵一线，其中扬子陆缘盆地自北西往南东依次为碳酸盐台地相区、台缘斜坡−陆棚相区、陆坡相区，华夏陆缘盆地为边缘海槽盆相区(图7)。因地壳整体沉降和气候变暖而发生海侵，冰期和同期源于地表风化的海洋中含磷物质通过上升洋流进入浅水区(密文天等，2010)，于扬子陆缘盆地的碳酸盐台地相区和台缘斜坡−陆棚相区沉积而形成磷矿，其中台地相区的磷矿因滩相环境的波浪簸选作用而具有更高的品位(张成信等，2014)。此外，同期及之后的晚震旦世，华夏陆缘盆地边缘海槽盆相区的汝城—资兴一带形成硅泥质沉积(图7)，经后期热液变质作用后形成远景可观的玉石(七彩石)矿。

寒武纪早期即牛蹄塘组沉积期，扬子与华夏陆缘盆地的界线位于祁阳—衡阳一线，其中扬子陆缘盆地自北西往南东依次为陆棚相区、陆坡相区，两区之间为凤凰—常德—岳阳同沉积断裂；华夏陆缘盆地仍为边缘海槽盆相区(图8)。因基底沉降、海侵及强还原环境而形成大量的黑色页岩(石煤)。在怀化—安化—长沙一线以北，同沉积断裂活动产生的海底热泉或喷泉沉积形成了牛蹄塘组下部黑

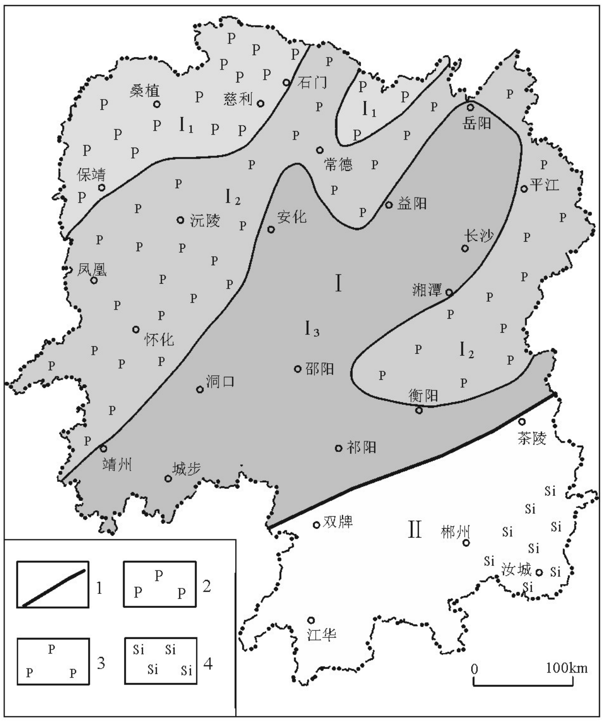

图7 早震旦世构造古地理格局与成矿

1—扬子陆缘盆地与华夏陆缘盆地分界线;2—高品位磷矿产区;3—低品位磷矿产区;4—硅泥质(玉石原岩)沉积区;Ⅰ—扬子陆缘盆地:Ⅰ$_1$—碳酸盐台地相区;Ⅰ$_2$—台缘斜坡-陆棚相区;Ⅰ$_3$—陆坡相区;Ⅱ—华夏陆缘盆地,边缘海槽盆相区

Fig.7 Tectonic paleogeographic setting and mineralization in Early Sinian

1-Boundary between Yangtze continental margin basin and Cathaysia continental margin basin; 2-High quality phosphate rock area; 3-Low grade phosphate rock area; 4-Siliceous and muddy (protolith of jade ore) sedimentary area; Ⅰ-Yangtze margin basin: Ⅰ$_1$-Carbonate platform; Ⅰ$_2$-Platform marginal slope-shelf; Ⅰ$_3$-Continental slope; Ⅱ-Marginal sea trough basin at Cathaysia margin basin

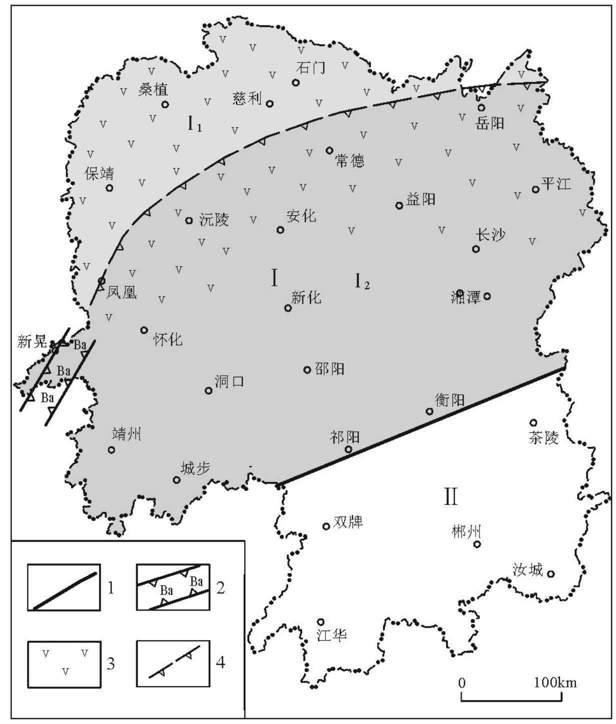

图8 寒武纪早期构造古地理格局与成矿

1—扬子陆缘盆地与华夏陆缘盆地分界线;2—含重晶石断陷盆地;3—钒多金属矿产区;4—同沉积断裂;Ⅰ—扬子陆缘盆地:Ⅰ$_1$—陆棚相区;Ⅰ$_2$—陆坡相区;Ⅱ—华夏陆缘盆地,边缘海槽盆相区

Fig.8 Tectonic paleogeographic setting and mineralization in Early Cambrian

1-Boundary between Yangtze continental margin basin and Cathaysia continental margin basin; 2-Barite-bearing faulted basin; 3-Vanadium polymetallic deposits area; 4-Syndepositional fault; Ⅰ-Yangtze margin basin: Ⅰ$_1$-Shelf, Ⅰ$_2$-Continental slope; Ⅱ-Marginal sea trough basin at Cathaysia margin basin

色岩系中的钒、铬、镍、钼等多金属矿(邓义楠等,2015;谢再波等,2016)。在湘西新晃一带形成NE向断陷盆地,盆内断裂相关的硫酸盐型低温热水活动形成超大型沉积型重晶石矿(方维萱等,2002)。

寒武纪晚期—早奥陶世,扬子与华夏陆缘盆地的界线位于城步—衡阳一线,其中扬子陆缘盆地自北西往南东依次为局限台地和台缘边缘浅滩相区、陆棚前缘斜坡相区、陆坡上部相区、陆坡下部相区;华夏陆缘盆地仍为边缘海槽盆相区(图9)。湘西北的局限台地和台缘边缘浅滩相区形成了灰岩矿和白云岩矿。值得指出的是,上述古地理格局与地壳伸展和同沉积正断裂的活动有关,如扬子陆缘盆地陆棚前缘斜坡相区与陆坡上部相区之间即为凤凰—岳阳同沉积断裂(图9)。

5.3 泥盆纪—早三叠世沉积成矿的构造古地理控制

泥盆纪—早三叠世省境处于陆表海伸展构造环境,总体古地理面貌表现为两盆一陆,即雪峰古陆和南、北两侧的湘中—湘东南盆地、湘西北盆地,只是受地壳差异升降运动和同沉积断裂活动影响,不同时期陆、海边界和范围变化很大。沉积环境包括河流、河口湾、三角洲、水下三角洲、三角洲平原、滨岸和远岸潮坪、潟湖、沼泽、滨海、浅海陆棚(砂泥质陆棚、碳酸盐陆棚、混积陆棚)、深水陆棚、陆棚盆地、开阔台地、局限台地、台间盆地等,形成以碳酸盐和砂泥质为主,其他组分(砾质、炭质、硅质、锰质、铁质等)为辅的沉积,由此形成了石炭系测水组、二叠系梁山组和龙潭组中的煤矿,上泥盆统岳麓山组、欧家冲组、黄家磴组中的沉积型铁矿,中泥

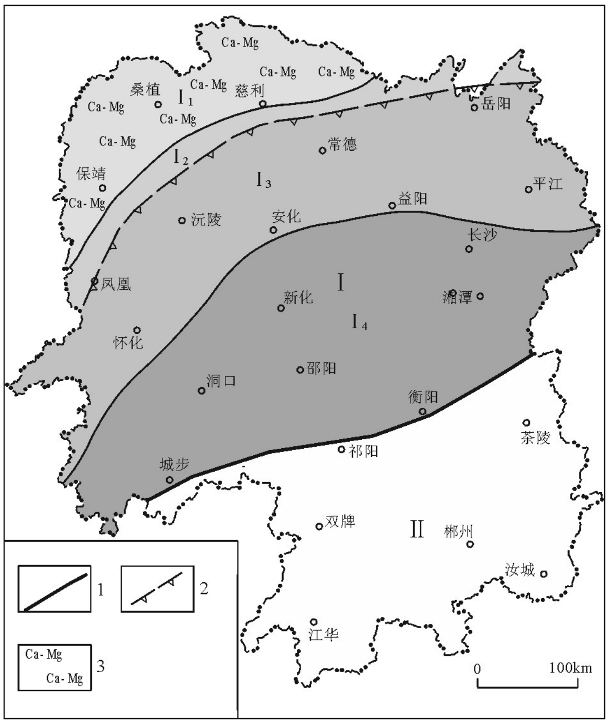

图9 寒武纪晚期—早奥陶世构造古地理格局与成矿

1—扬子陆缘盆地与华夏陆缘盆地分界线；2—同沉积断裂；3—灰岩、白云岩相区；Ⅰ—扬子陆缘盆地：$Ⅰ_1$—局限台地和台地边缘浅滩相区；$Ⅰ_2$—陆棚前缘斜坡相区；$Ⅰ_3$—陆坡上部相区；$Ⅰ_4$—陆坡下部相区；Ⅱ—华夏陆缘盆地，边缘海槽盆相区

Fig.9 Tectonic paleogeographic setting and mineralization during Late Cambrian−Early Ordovician

1−Boundary between Yangtze continental margin basin and Cathaysia continental margin basin; 2−Syndepositional fault; 3−Limestone and dolomite facies.; Ⅰ−Yangtze margin basin: $Ⅰ_1$−Restricted platform and platform margin shoal; $Ⅰ_2$−Shelf front slope; $Ⅰ_3$−Upper continental slope; $Ⅰ_4$−Lower continental slope; Ⅱ−Marginal sea trough basin at Cathaysia margin basin

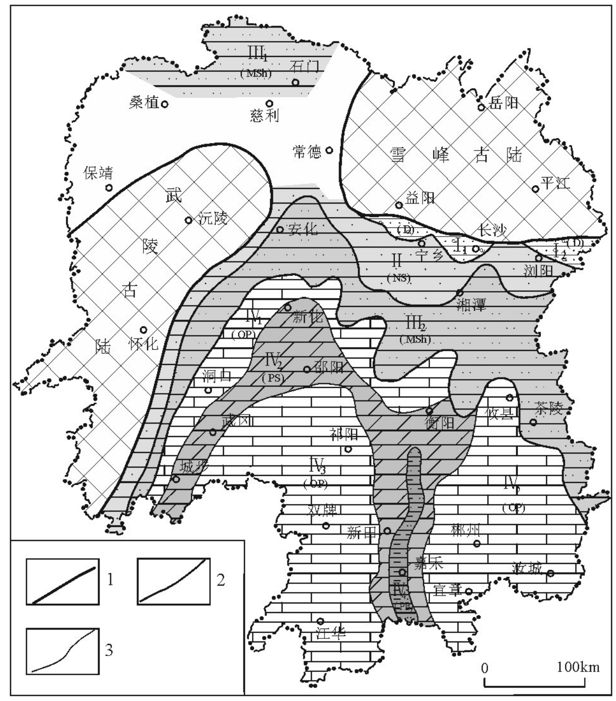

图10 晚泥盆世锡矿山期构造古地理格局

1—矿海陆界线；2—相区界线；3—相界线；$Ⅰ_1$—桃江三角洲；$Ⅰ_2$—永和三角洲；Ⅱ—宁乡—浏阳滨浅海；$Ⅲ_1$—石门混积陆棚；$Ⅲ_2$—安化—茶陵混积陆棚；$Ⅳ_1$—洞口—衡阳开阔台地；$Ⅳ_2$—武冈—新田台棚；$Ⅳ_3$—邵阳—江华开阔台地；$Ⅳ_4$—常宁—嘉禾台盆；$Ⅳ_5$—攸县—宜章开阔台地。沉积相：D—三角洲；FS—前滨带；NS—近滨；MSh—混积陆棚；OP—开阔台地；PS—阔台棚；PB—台盆

Fig.10 Tectonic paleogeographic setting and mineralization in Xikuangshan Stage of Late Devonian

1−Sea−land demarcation line; 2−Boundary of facies areas; 3−Boundary of facies. $Ⅰ_1$−Taojiang delta; $Ⅰ_2$−Yonghe delta; Ⅱ−Ningxiang−Liuyang offshore area; $Ⅲ_1$−Shimen mixed shelf; $Ⅲ_2$−Anhua−Chaling mixed shelf; $Ⅳ_1$−Dongkou−Hengyang open platform; $Ⅳ_2$−Wugang−Xintian platform−shelf; $Ⅳ_3$−Shaoyang−Jianghua open platform; $Ⅳ_4$−Changning−Jiahe platform−basin; $Ⅳ_5$−Youxian−Yizhang open platform; D−Delta; FS−Foreshore; NS−Nearshore; MSh−Mixed shelf; OP−Open platform; PS−Platform−shelf; PB−Platform−basin

盆统棋梓桥组、中二叠统孤峰组中的沉积锰矿（前者叠加后期改造），上石炭统梓门桥中的膏盐矿，以及广布于泥盆系—下三叠统不同层位的灰岩、白云岩、砂岩、黏土等非金属矿。

由于泥盆纪—早三叠世的沉积岩相古地理变迁频繁且横向分异大，以下仅以晚泥盆世锡矿山期为例，说明构造古地理格局对成矿的控制。

晚泥盆世锡矿山期，省境西部和东北部为构造隆起即武陵古陆和雪峰古陆，湘北和湘中—湘东南为沉降盆地，两盆地之间有海峡相通。湘北盆地主要为混积陆棚环境；湘中—湘东南盆地自古陆向盆地中心依次为三角州、滨浅海、混积陆棚和开阔台地，台地内部发育有水体更深的马蹄形的武冈—新田台棚和常宁—嘉禾台盆（图10）。受此古地理格局控制，在湿热气候条件下，铁质于较封闭或半封闭的古海湾、潮坪或滨-浅海等环境中沉淀，从而形成了汝城—攸县一带的欧家冲组、茶陵—宁乡一带的岳麓山组以及石门—桑植一带的黄家磴组中的鲕状赤铁矿即宁乡式铁矿。

值得指出的是，省境泥盆纪—早三叠世沉积成矿相关的地壳升降运动及岩相古地理格局，受控于古特提斯洋演化背景下的中国南方陆块间离散—聚合的不同构造运动体制，期间湘中—湘东南盆地

经历了扬子陆块南缘裂谷到台内坳陷再到裂谷的演化过程,湘西北盆地则经历了扬子陆块内部台内拗陷—裂谷的演化过程(李凤杰等,2009)。

5.4 晚三叠世—早侏罗世煤层沉积成矿的构造古地理控制

中三叠世晚期印支运动使省境整体抬升并遭受剥蚀,从此脱离海相沉积环境。晚三叠世早期(卡尼期)仍处于暴露剥蚀状态,晚三叠世中期(诺尼期)—早侏罗世在区域SN向挤压下形成多个陆相盆地,盆内充填陆源碎屑为主的沉积,多数盆地于滨湖沼泽环境下形成含煤沉积(部分盆地中侏罗世也有沉积,但无煤层发育)。由于后期断裂、褶皱改造及抬升、剥蚀影响,盆地沉积仅剩少部分在局部呈点状、带状保存,原型盆地规模和范围难以准确厘定。根据残留沉积物质记录,结合构造变形特征和相关的历史隆-凹构造格局分析,初步确定晚三叠世—早侏罗世古地理特征如图11所示。大部分地区为抬升剥蚀区,发育石门、沅麻(沅陵—麻阳)、靖州、洞口、娄底、邵阳、湘潭、永和(浏阳北东面)、永州—汝城、宁远—江华等陆相盆地。除石门、娄底、邵阳、永和等盆地外,其他盆地为含煤盆地。除永州—汝城盆地东部具拉张性质外(柏道远等,2006c),其他盆地一般为挤压类前陆盆地。

5.5 白垩纪—古近纪铜和膏盐沉积成矿的构造古地理控制

经中侏罗世后期早燕山运动抬升后,省境晚三叠世—早白垩世早期整体处于暴露剥蚀状态。早白垩世中期—始新世,在区域伸展构造体制(末期转为挤压)下形成大量规模不等的陆相断陷盆地,盆地之间则为隆起山地,从而形成盆-岭构造格局。尽管经后期剥蚀,但本阶段盆地沉积物保留范围大多与沉积期接近,图1中白垩系—古近系分布区基本反映出沉积期的盆地构造格局。晚白垩世期间,沅麻盆地东部、衡阳盆地中部的局部地区,受沉降幅度、沉积岩相、物源成分(含铜)、地下热水活动等地质条件的异常控制,形成了小型沉积型铜矿。古近纪中晚期,盆地性质由断陷转为坳陷,洞庭盆地澧县凹陷、衡阳盆地、邵阳盆地等在地形高差不大、构造稳定且相对封闭的条件下形成湖相膏盐沉积(湖南省地质调查院,2017)。

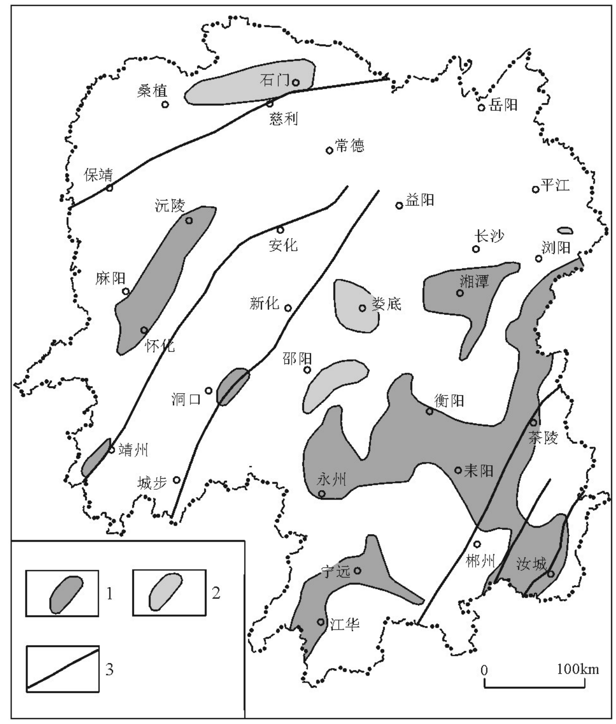

图11 晚三叠世—早侏罗世构造古地理格局与成矿
1—陆相含煤盆地;2—陆相非含煤盆地;3—同沉积期断裂
Fig.11 Tectonic paleogeographic setting and mineralization during Late Triassic−Early Jurassic
1−Continental coal basin; 2−Cordially,ontinental non−coal basin; 3−Syndepositional fault

6 结 论

(1)湖南省丰富的矿产资源形成于新元古代以来的22期主要成矿地质事件,自早至晚依次为雪峰期(板溪期)马底驿期沉积型锰矿,早南华世富禄期沉积型铁矿(叠加后期改造),中南华世大塘坡期沉积型锰矿,早震旦世陡山沱期磷矿,早寒武世牛蹄塘期钒多金属矿、重晶石矿、石煤矿,中—晚奥陶世沉积型锰矿,震旦纪—奥陶纪灰岩矿、白云岩矿、玉石矿等非金属矿产,志留纪内生热液矿床,中泥盆世棋梓桥期沉积型(叠加后期改造)锰矿,晚泥盆世宁乡式铁矿,早石炭世测水期煤矿,早石炭世梓门桥期膏盐矿,中二叠世梁山期煤矿,中二叠世孤峰期(茅口晚期)沉积型锰矿,晚二叠世龙潭期煤矿,泥盆纪—早三叠世灰岩、白云岩、砂岩、黏土等非金属矿,晚三叠世—早侏罗世煤矿,晚三叠世内生热液矿床,晚侏罗世—早白垩世早期内生热液及岩浆矿床,晚白垩世沉积-改造型铜矿,古近纪膏盐矿,

第四纪黏土矿、稀土矿、砂锡矿、独居石多金属矿、金刚石矿。

(2)志留纪(加里东期)内生热液成矿、晚三叠世(印支晚期)内生热液成矿、晚侏罗世—早白垩世早期(中晚燕山期)内生热液及岩浆成矿等3期主要内生成矿事件的矿床分布明显受同期构造格局控制;南华纪铁锰沉积成矿、震旦纪—早奥陶世多矿种沉积成矿、泥盆纪—早三叠世多矿种沉积成矿、晚三叠世—早侏罗世煤层沉积成矿、白垩纪—古近纪铜和膏盐沉积成矿等外生成矿事件的矿床分布受同期构造古地理控制。

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