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滇西兰坪—思茅盆地构造转换机制及成矿响应

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1 研究背景

三江腹心昌都—兰坪—思茅盆地, 吸收由印度板块挤入亚洲板块引起的变形, 处于印亚大陆北东向碰撞挤压的前沿地带和深部物质逃逸地带。完好记录了超级大陆从裂解→增生→碰撞的演化史和大陆动力学过程, 是中国大陆构造演化的缩影, 在全球构造演化中占举足轻重的地位。三江地区的特殊地质过程, 造就了丰富的金属矿产资源和油气资源。在中国紧缺的 Cu、Co、Pb、Cr、Zn 等矿种中, 西南地区的探明储量分别占全国同类矿种储量的 40%、55.7%、29.8%、80%和 30.8%, Au、PGE 和 REE 的储量在全国也占据“半壁江山”, 是中国最重要的多金属矿集区之一。

总结该区前人研究成果, 2005 年以前, 以单个矿床或单一成矿带成因研究为主。2005 年以后, 逐步过渡到关注成矿作用与超大陆的裂解、增生、碰撞、陆内演化及其动力学过程的耦合-互馈关系研究, 显示了矿床学研究理论深度不断深化提高。但无论是以碰撞成矿为理论基础的构造控矿作用研究还是复合造山的叠加成矿规律总结, 重点围绕了陆-陆汇聚造成板块堆叠逆冲构造、板块边界走滑对矿床的控制方面, 而忽略了板块内部变形作用以及板块壳-幔结构变化对成矿制约作用。典型矿床研究则重点围绕金顶超大型铅锌矿床以及金满、白秧坪铜多金属矿床的成矿作用和过程, 忽略了盆地内广泛发育的非金属成矿作用及其与金属成矿的关系, 以及矿床形成与大地构造应力转换响应机制问题。

2 选题依据

本文以“滇西兰坪—思茅盆地构造转换机制及其成矿响应”为题, 在三江特提斯中新生代演化框架之下, 围绕印亚大陆碰撞对兰坪—思茅板块内部构造变形转换过程及其成矿作用关键问题, 聚焦晚三叠世伸展裂谷成矿作用研究、新生代盆地挤压向伸展转换背景下兰坪盆地陆内壳幔结构的变化及其对应的成矿事件研究内容。在大量野外地质调查、室内测试研究基础上, 融合多学科综合研究手段, 取得了如下系列认识。

3 主要成果

(1)厘定了中生代以来兰坪—思茅盆地构造演化序列及其可能的动力学背景: 中生代以来, 伴随特提斯洋的演化, 兰坪—思茅盆地经历了三次重要构造应力转换时期。一是晚三叠世古特提斯洋闭合到新特提斯洋打开, 本区构造应力由挤压转换为伸展, 深层次动力学背景可能为全球超大陆裂裂解的地幔柱活动事件, 而不是简单的陆-陆碰撞后的伸展作用应力作用(T_3-K_3); 二是古新世以来, 受印亚大陆碰撞造成剧烈地壳缩短产生的水平推覆构造作用, 兰坪—思茅盆地由区域伸展向挤压应力转换(70—30 Ma); 三是渐新世时期挤压应力向走滑拉分应力转换(30 Ma—至今), 深层次动力学背景为印-亚陆-陆碰撞转变为东印度洋向东南亚的洋-陆俯冲造成的弧后扩张, 也不是传统意义上印度-大陆碰撞后伸展引起的。

三次大的构造转换分别对应了古特提斯洋闭合-PANGIA 大陆形成的汇聚应力到新特斯提洋打开-PANGIA 大陆解体过程全球伸展应力, 继而进入到印-亚大陆碰撞新特斯洋闭合消失的全球挤压应力阶段, 现今为印亚陆-陆碰撞转换为洋-陆(印度洋-东南亚)碰撞阶段, 挤压应力向走滑应力转换。兰坪—思茅盆地(三江地区)正是在这全球性的陆块多次汇聚离散的应力转换作用下造就了现今地质地貌, 成就特色不同的各种矿床。

(2)初步提出兰坪—思茅盆地“中轴构造带”可能是正在发育的大陆裂谷系统的新认识。根据横跨全区 23 条大地电磁剖面解释分析, 结合区域地质、

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地球化学、反射深部地球物理结构、布格重力异常、地热分布、地震分布特征。提出滇西兰坪思茅盆地中轴构造带是西南“三江”地区继陆-陆碰撞、走滑、隆升后正在发育的大陆裂谷系统。中轴断裂和垂向断裂，均具很深的透入性，在下地壳和上地幔形成显著热窿。兰坪—思茅盆地正在发育大陆裂谷样式是渐新世以来三江地区构造应力转换的响应。控制了兰坪—思茅盆地新生代以来大规模的成矿作用。这一特征与区域地质、地球化学、反射深部地球物理结构、布格重力异常、地热分布、地震分布特征吻合较好。这对于揭示兰坪盆地构造演化、区内碱性岩的形成、扬子西缘与碱性岩有关大型金矿和金顶超大型铅锌矿的形成及空间分布规律具有重要意义。中轴构造带正在形成的大陆裂谷样式是三江地区构造应力由挤压向拉伸转换的地壳结构响应，其深层次的动力学背景可能是陆-陆碰撞到洋-陆俯冲的转换。即印-亚陆-陆碰撞转变为东印度洋向东南亚的洋-陆俯冲造成的弧后扩张所致。

(3)厘定了兰坪盆地含盐层位时空分布。通过野外实测剖面和大量室内岩矿工作，指出兰坪盆地上三叠统至少存在 2 套含盐层位，上含盐层位于三合洞组上段(T_3s^2)，盐类物质以石膏、天青石为主，下含盐层位于三合洞组下段(T_3s^1)，以天青石为主。天青石和石膏均呈中厚层层状产出，与顶底板地层产状一致，不同地区含盐层岩石组合及序列不同，横向上不具有可对比性，暗示其并非广域水域沉积的产物。从兰坪盆地构造演化环境、含盐建造和盐类物质组成特征看，兰坪盆地北部上三叠统盐类物质成因有别于正常蒸发沉积作用，推断与热水沉积作用关系更为密切。含盐地层是盆地内铅锌矿重要的赋矿层位，因此上三叠统含盐建造层序的厘定对深化认识区域铅锌矿床成矿机制、指导盐类矿床和铅锌矿找矿具有重要意义。

(4)建立了兰坪盆地大型锶矿成矿模型。根据矿床地质特征、矿石结构及组份特征、与金属矿化关系、流体包裹体特征和地球化学证据，指出兰坪盆地上三叠统锶矿床可能不是正常蒸发沉积作用形成的，也不是在海相潮坪环境沉积形成，其可能的成矿模式可能为晚三叠世中期(诺利期)短暂的裂谷环境形成半深海环境，海水下渗循环流经下覆中三叠组火山岩加热形成富锶流体，经热水沉积作用形成于盆地次级拗陷地区，是本区喷流沉积的铅锌矿远离喷口的硫酸盐沉积系列。河西-大三界盐类矿床与南侧莱籽地铅锌矿、北侧庆福菱镁矿构成硫化物-硫酸盐-碳酸盐演化系列，与经典喷流沉积侧向元素分布模型非常相似，三者同属于热水成矿系统。锶盐的特殊成因反映了本区的特殊构造环境，是对晚三叠兰坪—思茅裂谷沉积盆地的矿床物质响应。

(5)识别并厘定了兰坪盆地喷流沉积矿床空间分布规律，完善了成因模型。通过对兰坪盆地北侧莱籽地、青甸湾等铅锌矿床研究，开展了矿床地质特征、铅锌元素空间富集规律、矿床地球化学等研究工作，综合证据显示，此类矿床为一套晚三叠世喷流沉积矿床。喷流沉积成矿作用的识别，印证了该期大地构造环境为裂谷盆地甚至可能为早期洋盆阶段。该矿床是兰坪—思茅盆地晚三叠陆内的裂谷的产物，是古特提斯洋闭合到新特提斯拉张，滇西地区由挤压到伸展构造应力转换的成矿响应。该类型矿床的确定，为在兰坪盆地寻找铅锌矿床提供了新的思路，研究认为隐伏的晚三叠裂谷沉积建造是寻找新金属资源的方向。同时，该类型矿床的厘定增加兰坪盆地矿床成因类型，提供了新的研究方向。

(6)建立了金顶超大型铅锌矿二元成矿模型。系统梳理了兰坪金顶铅锌矿床二元地质结构特征和多元矿床地球化学特征，分析指出金顶铅锌存在晚三叠纪和渐新世两套矿化类型。分别形成晚三叠纪伸展裂谷热水沉积成矿和渐新世走滑拉分底辟流体(热卤水)交代成矿作用。建立了金顶铅锌矿二元成矿模型。金顶矿床耦合盆地演化过程两次最佳应力转换期，构筑了最有利的成矿条件。这是超大型矿床形成的机制和根本原因。

关键词： 构造转换；大陆裂谷；成矿作用；兰坪—思茅盆地；青藏高原东缘；特提斯演化
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The Tectonic Transformation Mechanism and Metallogenic Response of the Lanping–Simao Basin

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1 Research Background

The Lanping–Simao basin in the center of Sanjiang (Three Rivers) region, located in the southeastern margin of the Tibetan Plateau, is tectonically in the transition zone between the Gondwana and Eurasia tectonic domains. It is also the frontier zone of northeastern extrusion of Indian plate towards the Eurasia plate as well as the escape zone for the deep material. Extensive metallogenesis occurred in the geology epochs due to the sophisticated geological process. Numerous ore deposits of diverse genetic types and metal speciation were formed in Cenozoic, making the Sanjiang one of the most productive and potential regions for metal resources in China. The Cu, Co, Pb, Cr, and Zn resource reserves accounts for 40%、55.7%、29.8%、80%and 30.8% of the total reserves, respectively. The Au, PGE and REE reserves were almost one half of that in China.

A large number of papers on the geology and ore deposits in the Sanjiang Tethys have been published since the 1960s. The single deposit or metallogenic belt have been extensively investigated before 2005, and the linkage between the tectonic, magmatic, and metallogenic aspects and the control of pre-Cenozoic lithosphere architecture on the Cenozoic evolution have been well studied in the past ten years. However, The crust deformation in the intraplate, and the control of crust-mantle architecture evolution on the metallogenic processes in the Lanping–Simao basin have not been well addressed. Although the metal deposits occurred in the basin were investigated by lot of researchers, nevertheless, the vast non-metal deposits always be neglected. The relationship between the metal and non-metal deposits mineralization not clear especially. A coherent picture for the tectonic transitional and metallogenic evolution of the Sanjiang region also need more research.

2 Topic Basis

Under the framework of the evolution of the Sanjiang Tethyan in the Mesozoic and Cenozoic, this paper focused on the plate tectonic deformation conversion process and the mineralization in the Lanping–Simao plate caused by the Indo-Asian continental collision. This paper discussed that the metallogenic events in the Late Triassic extensional rift, and the changes of continental crust mantle structure in the Lanping basin and its corresponding mineralization events under the transformation from compression to extension in the Cenozoic basin. Based on a lot of field geological survey and laboratory test, coupled with comprehensive research methods of multidisciplinary integration, the main results are as followed.

3 Main Achievements

(1)Since the Mesozoic, with the evolution of the Tethys ocean, Lanping–Simao basin experienced two important tectonic stress transition period. The first tectonic stress transition period is from the closure of the Paleo Tethys ocean to the opening of the Neo-Tethys ocean in the Late Triassic. The tectonic stress was from extrusion to extension in this area, and the deep dynamic background was maybe the mantle plume event causing the breakup of the supercontinent, rather than the extension of a simple continental collision. The second tectonic stress transition period is the compressional stress produced by strike slip pull stress transformation, which was caused by intense crustal shortening caused the Indo-Asian continental collision since the Paleocene. The deep dynamic background is the transition from the Indo-Asian continental collision to the back arc spreading caused by the ocean continent subduction of the eastern India Ocean to the southeast of Asian, which is not caused by the traditional extension following the India-Asian collision.

(2)According to 23 magnetotelluric (MT) sounding sections across the study area, we purposed the central tectonic belt of the Lanping–Simao basin is a developing continental rift system in the “Sanjiang” area, Southwest China following the continental collision, tectonic slip and uplift. The axial fracture and vertical fracture have deep penetration, forming a significant doming in the deep crust and the upper mantle, which are in good agreement with the regional geological, geochemical, reflection deep geophysical structure, the Bouguer gravity anomaly, geothermal distribution as well as the characteristics of earthquake distribution. The developing continental rift of the Lanping–Simao basin is the response of tectonic stress transformation in the “Sanjiang” area since the Oligocene, which controlled the large-scale mineralization in the Lanping–Simao basin since Cenozoic.

(3)Based on the measured sections in field and a large number of indoor work, we purposed that there are at least 2 sets of salt beds in the Upper Triassic in the Lanping basin for the first time. The upper salt bed is located in the upper section of the Sanhedong Formation (T_3s^2), and the containing salt minerals are mainly gypsum and celestite. The lower salt bed is located in the lower section of the Sanhedong Formation (T_3s^1), and the containing salt minerals are mainly celestite. Celestite and gypsum occurred as the middle-thick layer, and is consistent with the roof and floor of stratum in occurrence. The containing salt rock and sequence are different in the different regions, and does not comparable in the horizontal direction, which suggest that the deposit was not formed by the normal evaporation deposition and probably formed by the hydrothermal sedimentation in the late Triassic rift basin. The containing salt formation is the important ore bearing strata for the lead-zinc deposit. Therefore, the determination of the upper Triassic salt sequence plays an important role in the understanding of regional metallogenic mechanism, the prospecting of the salt deposits and lead-zinc deposits.

(4)The metallogenic model of the large strontium deposit in Lanping basin was established for the first time. The Hexi large strontium deposit was not formed by normal evaporation and deposition, also not formed in the marine tidal flat deposition. Then, this deposit probably formed in the bathyal environment which is formed in the short rift environment (Norian) in the Late Triassic. The seawater infiltration cycle is heated by the underlying Middle Triassic volcanic rocks, and the rich-Sr fluid was formed, which was stored in the deep. During Himalayan period, the Lanping basin experienced strong extrusion, and the formations were compressed in the EW direction. Then, the fluid in the deep migrated to the foreland basin, and formed rich-brine salt and gypsum resource in the appropriate space (strata tectonic belt, fault fracture zone), which formed the deposit by the sedimentary mineralization.

(5)The spatial distribution of the exhalative sedimentary deposits (SEDEX) in the Lanping basin has been identified and determined, and the genetic model has been improved. The identification of the Late Triassic SEDEX deposits in the middle Sanjiang area confirms the geotectonic setting of rift basin, even probably the early stages of oceanic basin. The deposit is the product of the Late Triassic intracontinental rift in the Lanping–Simao basin, the metallogenic response of the tectonic conversion from the Paleo Tethys ocean closure to the extension of the Neo Tethys and the tectonic stress conversion from the compression to extension in the west of Yunnan province. The identification of these deposits provides a new way to search for lead-zinc deposits in the Lanping basin. The studies suggest that The Late Triassic superimposed rift sedimentary formation is the direction for the new metal resources. At the same time, the identification of the deposit increases the deposit types in the Lanping basin, providing a new research direction;

(6)The metallogenic bimodal of the Jinding super-large lead-zinc was purposed for the first time. There are two types of mineralization in the Jinding lead-zinc deposits, i.e. Late Triassic mineralization and Oligocene mineralization. The former formed the hydrothermal sedimentary deposit of the extensional rift in the Late Triassic, while the latter formed the metasomatic deposit of diapirism fluid (hot brine) in the strike slip tectonic in the Oligocene. There are two best stress transition period during the coupled basin evolution in the Jinding basin, when the most favorable metallogenic conditions were fomed. This is the fundamental reason and mechanism of the formation of the super-large deposits.

Key words: tectonic transformation; continent rift; metallogenic; Lanping–Simao basin; eastern Tibetan Plateau; tethys evolution

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