

西藏马攸木金矿床的矿床类型讨论^{*}

江思宏 聂凤军 刘翼飞

(中国地质科学院矿产资源研究所, 北京 100037)

摘 要 位于青藏高原西段的马攸木金矿床,是由西藏地热队于 2001 年新发现的岩金矿床。通过对马攸木金矿床开展的野外实地调查和初步的室内研究,结果表明:①马攸木金矿床产于绿片岩相以上的变质地体;②其成矿年龄约为 (59.34 ± 0.62) Ma,反映成矿作用发生于青藏高原碰撞造山的高峰期;③金矿体呈脉状产于超地壳断裂带附近的韧性剪切带内;④矿石类型主要为构造蚀变岩型和石英脉型,含金石英脉呈较为致密的块状,并未见在低温石英脉中常见的皮壳状、条带状等结构构造以及玉髓等低温矿物;⑤初步的石英流体包裹体研究表明,成矿流体主要为富 CO_2 的低盐度 $\text{NaCl-H}_2\text{O}$ 流体,成矿温度介于 $240 \sim 280^\circ\text{C}$ 间,峰值为 270°C ;⑥初步的氢氧同位素资料表明,成矿流体主要为变质流体与天水的混合产物。上述这些特征总体符合造山型金矿床的基本特征,因此认为马攸木金矿床可能属于造山型金矿床,而不是曾被认为的热泉型金矿床。

关键词 地质学 矿床类型 造山型金矿床 马攸木 西藏

中图分类号: P618.51

文献标识码: A

Discussion on genetic type of Mayum gold deposit in Tibet

JIANG SiHong, NIE FengJun and LIU YiFei

(Institute of Mineral Resources, CAGS, Beijing 100037, China)

Abstract

The Mayum gold deposit in western Tibet plateau was discovered in 2001 by the Tibet Geothermal and Geological Party of Tibet Bureau of Geology and Mineral Exploration and Development. It was once considered to be of the hot spring type. The authors' study, however, reveals that the Mayum deposit should belong to the orogenic gold deposit. This conclusion is based on the following evidence: ① ore bodies are hosted by greenschist of the metamorphic terrain; ② the ore-forming age is about (59.34 ± 0.62) Ma, suggesting that mineralization took place at the culmination period of the Indo-Asian collision.; ③ ore bodies occur along the ductile zones near the supra-crustal fault belt; ④ ores are mainly of quartz vein and altered rock types, and auriferous quartz veins are massive, with no low-temperature crustose and banded structures and chalcedony observed among ores; ⑤ preliminary fluid inclusion studies show that the ore fluid is mainly of low salinity and CO_2 -rich $\text{NaCl-H}_2\text{O}$ type, and ore-forming temperatures are between 240 and 280°C , with the mode being 270°C ; ⑥ oxygen and hydrogen isotope geochemistry indicates that the ore fluid seems to be a mixture of metamorphic fluid and meteoric water.

Key words: geology, ore deposit type, orogenic gold deposit, Mayum, Tibet

^{*} 本文受国家重点基础研究发展规划项目(973) 2002CB412606、国家自然科学基金(40772064)和国土资源部百人计划联合资助
第一作者简介 江思宏,男,1968年生,博士,研究员,主要从事金矿床矿床地球化学研究。E-mail: jiangsihong1@163.com
收稿日期 2007-12-13; 改回日期 2008-01-13。张绮玲编辑。

造山型金矿床是目前国际矿床学界的研究热点,由于其规模一般较大,品位较高,蕴藏的经济价值巨大,因此被认为是世界上最重要的金矿床类型(Goldfarb et al., 2001)。自从 20 世纪 80 年代以来,不少学者对那些产于变质地体里的石英脉型金矿床的成矿模式(Bohlke, 1982; Colvine et al., 1984; Berger, 1986; Groves et al., 1991; Nesbit, 1991; Hodgson, 1993; Robert, 1996)及其形成的构造背景(Wyman et al., 1988; Barley et al., 1989; Hodgson et al., 1989; Kerrich et al., 1990; 1994; Kerrich, 1993; Goldfarb et al., 1998)进行了深入细致的研究与探讨。尽管 Bohlke(1982)早在 1982 年就提出“造山型”金矿床这个概念,但是矿床学家们仍然习惯于将这些金矿床归为“中温热液型”矿床。由于这类矿床形成的深度和温度范围均比传统的“中温热液型”矿床(Lindgren, 1933)要大,因此 Groves 等(1998)建议用“造山型”这个名称来代替这些所谓的“中温热液型”矿床(Lindgren, 1933),并特别强调了这些金矿床形成的构造背景和成矿时代。至此,造山型金矿床这个术语才被广泛运用。国外的许多古老克拉通以及显生宙的造山带都有造山型金矿床的大量产出,如美国的 Mother Lode、澳大利亚的 Kalgoorlie、加拿大的 Val d'Or、加纳的 Ashanti 等等(Goldfarb et al., 2001; Groves et al., 1998)。据估计,全球造山型金矿床提供的金资源量达 15 亿盎司之多(Goldfarb et al., 2001),其重要性可见一斑。

既然造山型金矿床如此重要,而中国又是一个造山带非常发育的国家,尤其是青藏高原,作为世界上最为年轻的陆-陆碰撞造山带,是否产有造山型金矿床就成为国内外学者广泛关注的一个焦点。位于青藏高原西段的马攸木金矿床,是由西藏地热队于 2001 年新发现的一处岩金矿床(温春齐, 2003)。一些学者认为它属于热泉型金矿床(温春齐等, 2004; 2006a, 2006b; 霍艳等, 2004, 2005; 郭建慈等, 2006),但是笔者的工作表明,马攸木金矿床具有造山型金矿床的一些典型特征。本文试图对该金矿床的矿床类型做一简要探讨。

1 矿床地质特征

马攸木金矿床位于北喜马拉雅构造带的西段,拉昂错-柴曲背斜的中部,紧靠雅鲁藏布江缝合带南部。容矿围岩是一套震旦纪—寒武纪浅变质碎屑

岩,主要由灰绿色的钙质绢云母-绿泥石石英片岩、黄褐色钙质片岩和结晶灰岩组成(图 1)。地层向南倾斜,倾角 $35^{\circ} \sim 50^{\circ}$ 。在矿区南部还出露有奥陶纪碳酸盐岩和三叠纪火山岩。

矿区内的主要逆断层走向近 EW 或 NEE,向南倾斜,几乎与地层产状一致,是主要的控矿构造,金矿体的产出明显受其控制。这些逆断层长达几千米至数十千米,并构成不同岩层的边界。它们又被近南北向或 NNE 向断层所切割。这些 EW 向、NEE 向和 NNE 向断层以及拉昂错-柴曲背斜可能是同一期构造作用的产物。与雅鲁藏布江缝合带平行产出的拉昂错-柴曲背斜,推测形成于印度与欧亚大陆碰撞期间。

呈岩株状产出于矿区西北端的花岗闪长斑岩,侵入于震旦纪—寒武纪浅变质碎屑岩,黑云母的 $^{40}\text{Ar}/^{39}\text{Ar}$ 坪年龄为 $(17.68 \pm 0.15) \text{ Ma}$, 初始 $^{40}\text{Ar}/^{36}\text{Ar}$ 值为 (294 ± 13) (江思宏等, 2006), 锆石 SHRIMP 年龄是 $(18.4 \pm 1.3) \text{ Ma}$ (胡朋等, 2006), 这说明斑岩体是在中新世侵位的。并且,花岗闪长斑岩的化学成分具有埃达克岩的特征,被认为可能是下地壳与富集地幔(EM II)物质混合熔融的产物(江思宏等, 2006)。

金矿体沿震旦纪—寒武纪片岩内的近东西向层间破碎带产出(图 1),矿化断续延伸达 4 km 长,已在地表圈定 16 个金矿体,长 50~712 m,宽 0.9~8.0 m,延深 250~300 m。金的品位变化于 2.23~69.56 g/t,平均 31.84 g/t(温春齐等, 2006)。金矿体走向 NE75~80°,倾向南,倾角 40~60°,呈透镜状产出。

金矿化主要有两种形式:在破碎带中部以含金石英脉形式产出或在含金石英脉周围以含金蚀变岩形式产出。金矿石中的主要金属矿物是黄铁矿、方铅矿、辉锑矿和少量黄铜矿,所占体积不足 3%,并主要呈集合体形式产出;脉石矿物主要是石英和方解石。褐铁矿、铜蓝和黄钾铁矾见于靠近地表的氧化带中。

金主要富集在石英和硫化物中。初步研究表明,金主要呈银金矿和自然金的形式产出,并且自然金的成色在 950 以上。

围绕矿体的热液蚀变非常发育,主要产在破碎带附近。通常是蚀变越强,金的品位越高。除了与金矿化直接相关的硫化物化外,其他蚀变主要有绢云母化、硅化、碳酸盐化和泥化。在矿体周围未见明显的蚀变分带。

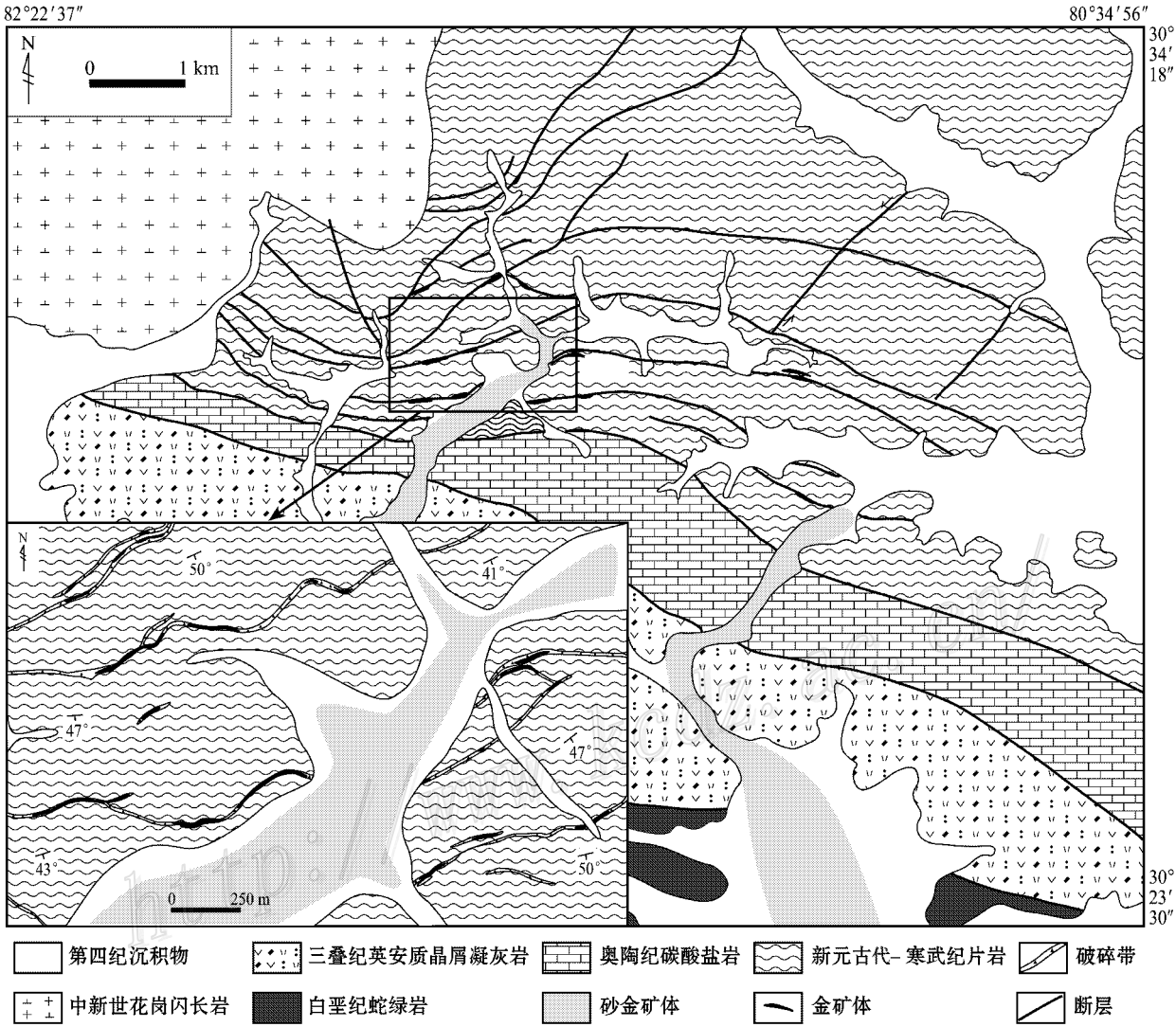


图 1 马攸木金矿床地质简图(据西藏地热队 2003^①修改)

Fig. 1 Simplified geological map of the Mayum ore district (modified from Tibet Geothermal and Geological Party, 2003, internal report)

马攸木金矿床的形成可以分为 3 个阶段:第一阶段形成石英和磁铁矿,第二阶段形成石英、硫化物(包括黄铁矿、方铅矿和辉锑矿)和金,这是金的主要成矿阶段;第三阶段形成石英和碳酸盐。

金矿体形成后的构造隆升作用使得金矿体遭受风化和剥蚀作用,并在其附近形成了砂金矿。

2 讨 论

2.1 造山型金矿床的主要特征与形成机理

自从 Groves 等(1998)明确提出“造山型”金矿床

以来,在国内外矿床学界掀起了一股造山型金矿床的研究热潮,有关这方面的论文俯首皆是(Craw et al., 2006; Evans et al., 2006; Klein et al., 2006; 武广等, 2006; 伊有昌等, 2006; McNaughton et al., 2005; Salier et al., 2005; Beaudoin et al., 2005; Kreuzer, 2005; Petrie et al., 2005; Kolb et al., 2004, 2005; 李晶等, 2004; 陈华勇等, 2004; 李碧乐等, 2004; 王志良等, 2004; Vielreicher et al., 2003; Haeberlin et al., 2003, 2004; 陈衍景等, 2003; 张德全等, 2001; 2005; 丰成友等, 2003; 2004a; 2004b; Christie et al., 2003; Jia et al., 2003; Bierlein et al.,

① 西藏自治区地质矿产勘查开发局地热地质大队. 2003. 西藏自治区普兰县马攸木岩金矿普查报告(内部资料).

2001a, 2001b, 2003, 2004, 2005, 2006a, 2006b; Groves et al., 2003; Qiu et al., 2002; Seccombe 2002; Miao et al., 2002; 毛景文等, 2002; Cassidy et al., 2001; 毛景文, 2001; Goldfarb et al., 2001; Voicu et al., 2000; Miller et al., 1998), 大大深化了人们对造山型金矿床成矿机理的认识和理解。

根据 Groves 等(1998)的研究总结, 造山型金矿床具有如下特点: ①造山型金矿床最一致的特征是这些矿床与各个不同时代的变形变质地体相伴生, 金矿床与绿片岩之间有着非常密切的关系; ②矿床形成于聚合板块边缘增生和碰撞造山带由挤压到扭压变形过程期间; ③矿(化)体严格受构造控制, 位于大型挤压构造(常切穿地壳)的二级或三级构造里, 其中断裂系统的扩容结和马尾状发散带是有利的矿体定位空间(Cox et al., 2001); ④在以石英为主的矿脉系统中, 硫化物含量 3%~5%, 碳酸盐矿物 5%~15%, 钠长石、白云母或绿云母、绿泥石、白钨矿和电气石都是矿脉中常见的脉石矿物; ⑤矿脉垂向上延续可达 1~2 km, 矿石中的 Au/Ag 比值从 10(常见)到 1(少见)不等; ⑥矿床热液蚀变包括碳酸盐化、硫化物化、碱质交代作用和绿泥石化等; ⑦成矿流体以 $H_2O-CO_2 \pm CH_4$ 为特征, 富含 CO_2 , $x(CO_2)$ 通常 $\geq 5\%$, 盐度 $\alpha(NaCl_{eq})$ 3%~10%, 金在流体中以还原的硫络合物的形式迁移; ⑧矿床形成温度从 200~700℃, 矿体就位深度 2~20 km。根据造山型金矿床的形成深度, 它们又被划分为浅成(<6 km)、中成(6~12 km)和深成(>12 km)三类(Groves et al., 1998)。

Goldfarb 等(2001)对该类型矿床在全球的时空分布特点进行了较为系统的总结, 并认为这些造山型金矿床主要集中在 3.1 Ga、2.7~2.5 Ga、2.1~1.8 Ga 和 0.6~0.05 Ga 等时间段产出。关于该类型矿床的成矿机理, 目前比较一致的看法是, 在增生造山过程中, 含水的海相沉积物和火山岩在数十百万年到 100 Ma 的碰撞中被加积到大陆边缘, 与俯冲有关的热事件, 不断地提高含水增生岩层的地热梯度, 导致和驱使热液流体做远距离的运移, 结果含金石英脉就位于热液矿床中的一个独特的深度范围(从 15~20 km 深度至近地表)(Groves et al., 1998)。尽管造山型金矿床的研究取得了很大的进展, 但是由于多期的矿化叠加, 因此在研究这些造山型金矿床时, 如何获得准确的矿化时间、判定成矿物质来源、恢复流体的运移轨迹以及理解金的迁移与

沉淀机理等方面仍然存在很多亟待解决的科学问题(Groves et al., 2003), 而这些问题的解决, 必将极大地提升造山型金矿床的理论研究与认识水平。

2.2 马攸木金矿床的矿床类型

马攸木金矿床曾被一些学者认为属于热泉型金矿床(温春齐等, 2004; 2006a; 2006b; 霍艳等, 2004; 2005; 郭建慈等, 2006), 其主要依据是: ①流体包裹体均一温度为 140~311℃; ②计算的捕获压力为 16.0~31.5 MPa, 成矿深度相当于 0.58~1.15 km; ③石英包裹体的氢-氧同位素特征显示成矿流体既不是典型的岩浆水, 也并非大气降水, 而可能是大气降水与围岩同位素交换的产物; ④马攸木地区泉华普遍含 Au, 最高达 18.72×10^{-6} , 故认为马攸木金矿床可能是与热泉在空间上和成因上有密切联系的浅成中低温热液矿床。但是, 基于前人已有的成果和笔者目前的工作, 将马攸木金矿床划归热泉型金矿床还存在有不少问题: ①正如霍艳等(2005)在其文章中提到的, 实际上流体包裹体测温多数集中在 225~235℃, 与笔者(Jiang et al., 2008)及侯增谦等(2006a)的结果(240~280℃)比较接近, 主要属于中温范畴(图 2); ②笔者计算的捕获压力为 140~480 MPa, 并主要集中在 150~240 MPa(Jiang et al., 2008)与温春齐等(2006b)和霍艳等(2005)的结果相差较大, 到底是什么原因, 还有待于进一步验证。由于造山型金矿床的形成深度可以从 15~20 km 深度至近地表(Groves et al., 1998), 因此成矿深度并不是一个判别造山型金矿床的主要指标; ③温春齐等(2006b)和霍艳等(2005)的石英包裹体的氢-氧同位素特征其实反映的正是造山型金矿床中成矿流体特征, 即成矿流体多来源, 具有变质水与大气降水的混合特征(Goldfarb et al., 2001); ④马攸木地区现代热泉活动确实比较强烈, 但是这些热泉与后碰撞期的地壳伸展环境(25~0 Ma)下发育的南北向裂谷有关, 其活动时代不早于 18 Ma(李振清等, 2005), 晚于马攸木金矿床的形成时代, 因此马攸木金矿床的形成应与热泉无关。这些热泉中较高的金含量, 可能是由于本区金的背景值较高, 或者热泉就产在矿区附近的缘故; ⑤一般说来, 浅成低温热液型金矿通常产于岛弧或陆缘弧环境, 多数分布于钙碱性火山岩分布区(White et al., 1995; Hedenquist et al., 2000), 而青藏高原碰撞造山带不论在主碰撞期还是后碰撞期, 均不具有岛弧或陆缘弧环境。总之, 将马攸木金矿床划归热泉型或浅成低温热液型金矿床难

以令人信服。

对马攸木金矿床开展的野外实地调查和初步的室内研究结果表明,马攸木金矿床具有造山型金矿床的一些典型特征,主要表现在:①马攸木金矿床产于绿片岩相以上的变质地体(即仲巴地块)内,反映其形成于中深部地壳环境;②其成矿年龄约为 (59.34 ± 0.62) Ma(坪年龄, ^{40}Ar - ^{39}Ar 法,蚀变绢云母)(Jiang et al., 2008)(图3),反映成矿作用发生于青藏高原碰撞造山的高峰期(55 ± 10) Ma(许志琴等 2006)或主碰撞期(侯增谦等, 2006a);③强烈的金矿化与超地壳规模的断裂带——被构造破坏和改造的雅鲁藏布江缝合带存在一定关系,金矿体呈脉状产于超地壳断裂带附近的韧性剪切带内(Jiang et al., 2008);④矿石类型主要为构造蚀变岩型和石英脉型,含金石英脉呈较为致密的块状,并未见在低温石英脉中常见的皮壳状、条带状等结构构造以及玉髓等低温矿物;⑤初步的石英流体包裹体研究表明,成矿流体主要为富 CO_2 的低盐度 $\text{NaCl-H}_2\text{O}$ 流体,成矿温度介于 $240 \sim 280^\circ\text{C}$ 间(图2),峰值为 270°C (侯增谦等 2006a);⑥初步的氢氧同位素资料表明,成矿流体主要为变质流体与天水的混合产物(霍艳等 2004; Jiang et al., 2008);⑦硫同位素研究表明,矿石硫同位素组成变化范围大,18件硫化物的 $\delta^{34}\text{S}$ 值为 $-0.2\text{‰} \sim +16.8\text{‰}$ (图4)。总之,马攸木金矿床的这些特征总体上与造山型金矿床的基本特征相吻合(Groves et al., 1998; Kerrich et al., 2000; Goldfarb et al., 2001)。

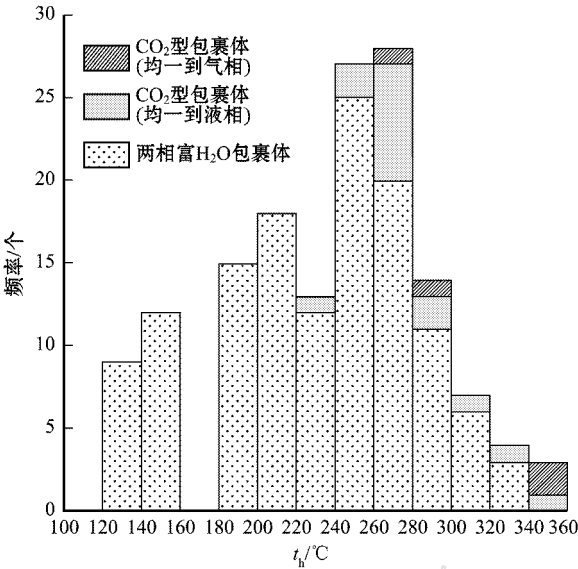


图2 马攸木金矿两相富水包裹体与三相 CO_2 型包裹体均一温度直方图(引自Jiang et al., 2008)

Fig. 2 Histogram showing homogenization temperatures (t_h) of two-phase H_2O -type inclusions and three-phase CO_2 -type inclusions (after Jiang et al., 2008)

目前国际矿床学界对大陆碰撞造山带,特别是年轻的陆-陆碰撞造山带的金矿尚缺乏系统研究,对这些碰撞造山带能否产出大型的造山型金矿床尚有不同认识。造山型金矿床的倡导者(如Groves et al., 1998; Kerrich et al., 2000)认为,造山型金矿床主要产生于增生造山过程的增生体内,而像阿尔卑斯-喜马拉雅这样的碰撞造山带并不利于形成大型

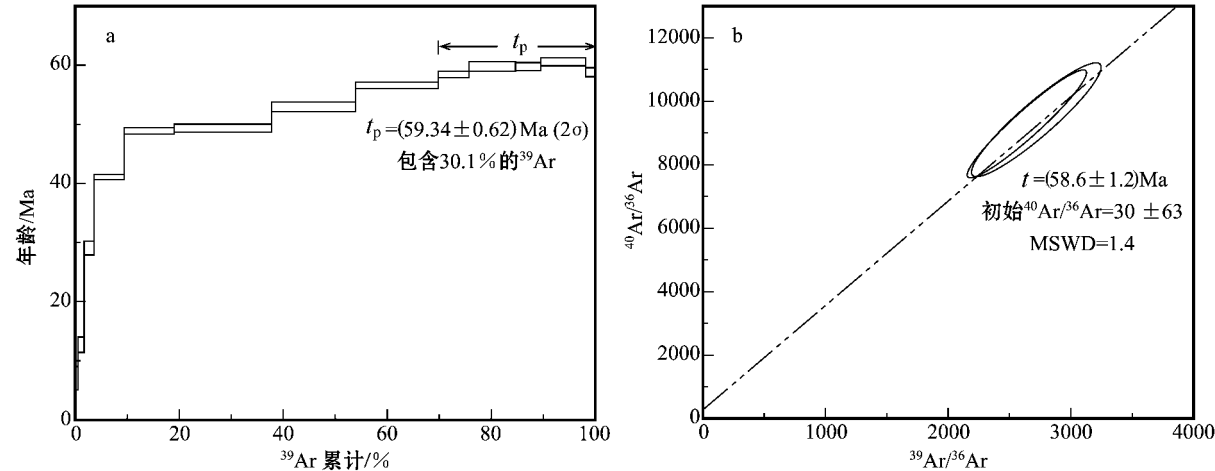


图3 马攸木金矿床绢云母的 $^{40}\text{Ar}/^{39}\text{Ar}$ 阶段升温年龄谱图(a)与 $^{40}\text{Ar}/^{36}\text{Ar}$ - $^{39}\text{Ar}/^{36}\text{Ar}$ 等时线图(b)(引自Jiang et al., 2008)
Fig. 3 $^{40}\text{Ar}/^{39}\text{Ar}$ stepwise heating age spectra (a) and $^{40}\text{Ar}/^{36}\text{Ar}$ versus $^{39}\text{Ar}/^{36}\text{Ar}$ isochron (b) of sericite from the Mayum gold deposit (after Jiang et al., 2008)

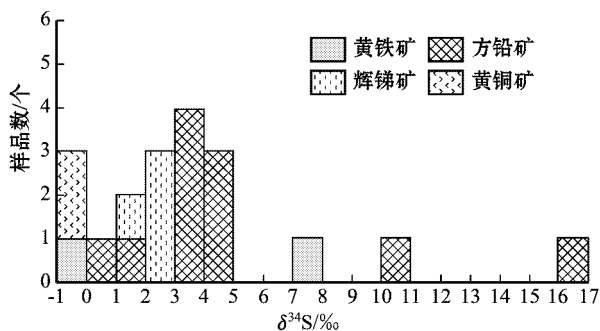


图 4 马攸木金矿床的硫同位素组成直方图(引自 Jiang et al., 2008)

Fig. 4 Histogram showing sulfur isotopic composition of the Mayum gold deposit (after Jiang et al., 2008)

造山型金矿床,他们认为喜马拉雅碰撞造山带垂直断裂系统规模小,深度浅,构造网络连通性差。但是,侯增谦等(2006a)研究认为,青藏高原碰撞造山带具有长期活动、规模大、切割深的复杂断裂系统,因此构造网络连通性好,具有发育造山型金矿床的优越环境。

据侯增谦等(2006a, 2006b)研究,青藏高原碰撞造山带相继经历了主碰撞(65~41 Ma)、晚碰撞(40~26 Ma)和后碰撞过程(25~0 Ma),现在仍处于后碰撞期的活动状态。尽管目前在西藏马攸木金矿床获得了3组年龄数据,从59 Ma到22 Ma不等(温春齐等,2004;范小平等,2005;Jiang et al., 2008),但温春齐等(2004)和范小平等(2005)获得的 ^{40}Ar - ^{39}Ar 坪年龄谱线均呈马鞍形,显示过剩氩的存在,而且范小平等(2005)用计算坪年龄的数据点难以获得等时线年龄,说明数据之间相关性很差,由此可见这些 ^{40}Ar - ^{39}Ar 年龄数据不太可靠。相对来说,笔者获得的年龄数据较为可信,反映了马攸木金矿床形成于印度-亚洲大陆的主碰撞期(65~41 Ma)。

马攸木金矿床是目前在青藏高原西部发现的唯一一处规模较大的独立岩金矿床。沿雅鲁藏布江流域,在雅鲁藏布江缝合带两侧已发现众多金矿点和矿化点,并伴有大量砂金矿床和矿点,初步分析表明,这些矿点和矿化点的矿化特征在许多方面与马攸木金矿床具有类似性,预示着一一条沿雅鲁藏布江缝合带——超壳断裂带分布的金矿化带的存在。因此,加强对马攸木金矿床的研究,建立其成矿模型和勘查模型,将会有效地指导该类型金矿床的勘查与评价,因而具有重要的现实意义。

3 结 论

鉴于目前的研究成果与认识,马攸木金矿床具有造山型金矿床的一些典型特征:①金矿床产于绿片岩相以上的变质地体;②成矿年龄为(59.34 ± 0.62) Ma,反映成矿作用发生于青藏高原碰撞造山的高峰期;③金矿体呈脉状产于超地壳断裂带附近的韧性剪切带内;④成矿流体主要为富 CO_2 的低盐度 $\text{NaCl-H}_2\text{O}$ 流体,成矿温度介于240~280℃间;⑤初步的氢氧同位素资料表明,成矿流体主要为变质流体与天水的混合产物,因此认为该矿床属于造山型金矿床。

References

- Barley M E and Groves D I. 1992. Supercontinental cycles and the distribution of metal deposits through time[J]. *Geology*, 20: 291~294.
- Barley M E, Eisenlohr B N, Groves D I, Perring C S and Vearncombe J R. 1989. Late Archean convergent margin tectonics and gold mineralization: A new look at the Norseman-Wiluna belt, Western Australia[J]. *Geology*, 17: 826~829.
- Beaudoin G and Pitre D. 2005. Stable isotope geochemistry of the Archean Val-d'Or (Canada) orogenic gold vein field[J]. *Mineralium Deposita*, 40(1): 59~75.
- Berger B R. 1986. Descriptive model of low-sulphide Au-quartz veins [A]. In: Cox D P, Singer D A, eds. *Mineral Deposit Models*[C]. U.S. Geol. Surv. Bull. 1693: 183~186.
- Bierlein F P, Christie A B and Smith P K. 2004. A comparison of orogenic gold mineralisation in central Victoria (AUS), western South Island (NZ) and Nova Scotia (CAN): Implications for variations in the endowment of Palaeozoic metamorphic terrains[J]. *Ore Geology Reviews*, 25(1-2): 125~168.
- Bierlein F P, Groves D, Goldfarb R J and Dubé B. 2006a. Lithospheric controls on the formation of provinces hosting giant orogenic gold deposits[J]. *Mineralium Deposita*, 40(8): 874~886.
- Bierlein F P and Maher S. 2001a. Orogenic disseminated gold in Phanerozoic fold belts—examples from Victoria, Australia and elsewhere[J]. *Ore Geology Reviews*, 18: 113~148.
- Bierlein F P, Arne D C, Foster D A and Reynolds P. 2001b. A geochronological framework for orogenic gold mineralisation in central Victoria, Australia[J]. *Mineralium Deposita*, 36(8): 741~767.
- Bierlein F P and Smith P K. 2003. The Touquoy zone deposit: An example of "unusual" orogenic gold mineralisation in the Meguma Terrane, Nova Scotia, Canada[J]. *Canadian Journal of Earth Sciences*, 40(3): 447~466.
- Bierlein F P, Foster D A, Gray D R and Davidson G J. 2005. Timing of

- orogenic gold mineralisation in northeastern Tasmania : Implications for the tectonic and metallogenetic evolution of Palaeozoic SE Australia[J]. *Mineralium Deposita* , 39(8) : 890 ~ 903.
- Bierlein F P , Murphy F C , Weinberg R F and Lees T. 2006b. Distribution of orogenic gold deposits in relation to fault zones and gravity gradients : Targeting tools applied to the Eastern Goldfields , Yilgarn Craton , Western Australia[J]. *Mineralium Deposita* , 41 : 107 ~ 126.
- Bohlke J K. 1982. Orogenic (metamorphic-hosted) gold-quartz veins [A]. U. S. Geol. Surv. Open-File Rep. 79[C]. 70 ~ 76.
- Cassidy K F and Hagemann S G. 2001. " World class " Archean orogenic gold deposits , eastern Yilgarn Craton ; diversity in timing , structural controls and mineralization styles[A]. In : Cassidy K F , Dunphy J M , van Kranendonk M J , eds. Fourth international Archaean symposium ; extended abstracts[C]. AGSO - Australian Geological Survey Organisation , Canberra , Australia. 382 ~ 384.
- Chen H Y , Chen Y J , Ni P and Zhang Z J. 2004. Fluid inclusion study of the Sawyardun Au deposit in southern Tian Shan , China : Implication for ore genesis and exploration[J]. *J. Mineral. Petrol.* , 24 (3) : 46 ~ 54 (in Chinese with English abstract).
- Chen Y J , Sui Y H and Pirajno F. 2003. Exclusive evidences for CMF model and a case of orogenic silver deposits : Isotope geochemistry of the Tieluping silver deposit , east Qinling orogen[J]. *Acta Petrologica Sinica* , 19(3) : 551 ~ 568 (in Chinese with English abstract).
- Christie A B and Brathwaite R L. 2003. Hydrothermal alteration in metasedimentary rock-hosted orogenic gold deposits , Reefton Goldfield , South Island , New Zealand[J]. *Mineralium Deposita* , 38(1) : 87 ~ 107.
- Colvine A C , Andrews A J , Cherry M E , Durocher M E , Fyon J A , Lavigne M J , Macdonald A J , Marmont S , Poulsen K H , Springer J S and Troop D G. 1984. An integrated model for the origin of Archean lode-gold deposits[A]. *Ont. Geol. Surv. Open-File Rep* [C]. 5524 : 1 ~ 98.
- Cox S F , Knackstedt M A and Braun J. 2001. Principles of structural control on permeability and fluid flow in hydrothermal system[J]. *SEG Reviews* , 14 : 1 ~ 24.
- Craw D , Begbie M and MacKenzie D. 2006. Structural controls on Tertiary orogenic gold mineralization during initiation of a mountain belt , New Zealand[J]. *Mineralium Deposita* , 41 : 645 ~ 659.
- Evans K A , Phillips G N and Powell R. 2006. Rock-buffering of auriferous fluids in altered rocks associated with the Golden Mile-style mineralization , Kalgoorlie gold field , Western Australia[J]. *Econ. Geol.* , 101 : 805 ~ 817.
- Fan X P , Duo J , Wen C Q , Guo J C , Hu A C , Chen H Q and Li X W. 2005. $^{40}\text{Ar}/^{39}\text{Ar}$ fast-neutron activation dating and geological significance of quartz from the gold-bearing quartz veins in the Mayum gold deposit , Xizang. *Sedimentary Geology and Tethyan Geology* , 25 (4) : 33 ~ 36 (in Chinese with English abstract).
- Feng C Y , Zhang D Q , Li D X and She H Q. 2003. Sulfur and lead isotope geochemistry of the orogenic gold deposits in east Kunlun area , Qinghai province[J]. *Acta Geoscientica Sinica* , 24(6) : 593 ~ 598 (in Chinese with English abstract).
- Feng C Y , Zhang D Q , Wang F C , Li D X and She H Q. 2004a. Geochemical characteristics of ore-forming fluids from the orogenic Au (and Sb) deposits in the eastern Kuulun area , Qinghai Province[J]. *Acta Petrologica Sinica* , 20(4) : 949 ~ 960 (in Chinese with English abstract).
- Feng C Y , Zhang D Q , Wang F C , She H Q , Li D X and Wang Y. 2004b. Multiple orogenic processes and geological characteristics of the major orogenic gold deposits in east Kunlun area , Qinghai Province[J]. *Acta Geoscientica Sinica* , 25(4) : 415 ~ 422 (in Chinese with English abstract).
- Goldfarb R J , Groves D I and Gardoll S. 2001. Orogenic gold and geologic time : A global synthesis[J]. *Ore Geology Reviews* , 18 : 1 ~ 75.
- Goldfarb R J , Phillips G. N and Nokleberg W J. 1998. Tectonic setting of synorogenic gold deposits of the Pacific Rim[J]. *Ore Geology Reviews* , 13 : 185 ~ 218.
- Groves D I , Goldfarb R J , Gebre-Mariam H , Hagemann S G and Robert F. 1998. Orogenic gold deposits-a proposed classification in the context of their crustal distribution and relationship to other gold deposit types[J]. *Ore Geology Reviews* , 13 : 7 ~ 27.
- Groves D I , Goldfarb R J , Robert F and Hart C J R. 2003. Gold deposits in metamorphic belts : Overview of current understanding , outstanding problems , future research , and exploration significance [J]. *Econ. Geol.* , 98 : 1 ~ 29.
- Groves D I and Foster R P. 1991. Archean lode-gold deposits[A]. In : Foster R P , ed. *Gold Metallogeny and Exploration* [C]. Glasgow , Blackie and Son. 63 ~ 103.
- Groves D I. 1993. The crustal continuum model for late-Archaean lode-gold deposits of the Yilgarn Block , Western Australia[J]. *Mineralium Deposita* , 28 : 366 ~ 374.
- Guo J C , Duo J , Wen C Q , Chen H Q , Fan X P and Li X W. 2006. Mineralization background and stages of the Mayum gold deposit , Xizang[J]. *Sedimentary Geology and Tethyan Geology* , 26(1) : 60 ~ 66 (in Chinese with English abstract).
- Haerberlin Y , Moritz R , Fontbote L and Cosca M. 2004. Carboniferous orogenic gold deposits at Patash , Eastern Andean Cordillera , Peru ; geological and structural framework , paragenesis , alteration , and $^{40}\text{Ar}/^{39}\text{Ar}$ geochronology[J]. *Econ. Geol.* , 99(1) : 73 ~ 112.
- Haerberlin Y , Moritz R and Fontbote L. 2003. Paleozoic orogenic gold deposits in the eastern Central Andes and its foreland , South America [J]. *Ore Geology Reviews* , 22(1-2) : 41 ~ 59.
- Hagemann S G and Cassidy K F. 2000. Archean orogenic lode gold deposits[J]. *SEG Reviews* , 13 : 9 ~ 68.
- Hedenquist J W , Arribas R A and Gonzalez U E. 2000. Exploration for epithermal gold deposits[J]. *Reviews in Economic Geology* , 13 : 245 ~ 277.
- Hodgson C J and Hamilton J V. 1989. Gold mineralization in the Abitibi greenstone belt : End stage result of Archaean collisional tectonics [A]? In : Keays R R , Ramsay W R H , Groves D I , eds. *The geology of gold deposits : The perspective in 1988* [C]. *Econ. Geol.* ,

- Monogr. , 6 : 86~100.
- Hodgson C J. 1993. Mesothermal lode-gold deposits[A]. In : Kirkham R V , Sinclair W D , Thorpe R I , Duke J M , eds. Mineral deposit modeling[C]. Geol. Assoc. Can. , Spec. Pap. , 40 , 635~678.
- Hou Z Q , Yang Z S , Xu W Y , Mo X X , Ding L , Gao Y F , Dong F L , Li G M , Qu X M , Li G M , Zhao Z D , Jiang S H , Meng X J , Li Z Q , Qin K Z and Yang Z M. 2006a. Metallogenesis in Tibetan collisional orogenic belt : I . Mineralization in main collisional orogenic setting[J]. Mineral Deposits , 25(4) : 337~358(in Chinese with English abstract).
- Hou Z Q , Pan G T , Wang A J , Mo X X , Tian S H , Sun X M , Ding L , Wang E Q , Gao Y F , Xie Y L , Zeng P S , Qin K Z , Xu J F , Qu X M , Yang Z M , Yang Z S , Fei H C , Meng X J and Li Z Q. 2006b. Metallogenesis in Tibetan collisional orogenic belt : II . Mineralization in late-collisional transformation setting[J]. Mineral Deposits , 25(5) : 521~543(in Chinese with English abstract).
- Hu P , Nie F J , Jiang S H , Liu Y and Zhang W Y. 2006. Zircon SHRIMP U-Pb age of the Songtuoga intrusion in Mayum gold deposit district , Xizang(Tibet) and its geological significances[J]. Geological Review , 52(2) : 276~282(in Chinese with English abstract).
- Huo Y , Wen C Q , Li B H and Sun Y. 2005. Preliminary study on the fluid physicochemical conditions of Mayum gold deposit in Tibet[J]. Contributions To Geology and Mineral Resources Research , 20(3) : 156~160(in Chinese with English abstract).
- Huo Y , Wen C Q , Li B H and Sun Y. 2004. Preliminary study on geochemical characteristics of fluid inclusion of Mayoumu gold deposit in Tibet[J]. Contributions To Geology and Mineral Resources Research , 19(2) : 100~104 , 113(in Chinese with English abstract).
- Jia Y F , Kerrich R and Goldfarb R J. 2003. Metamorphic origin of ore-forming fluids for orogenic gold-bearing quartz vein systems in the North American Cordillera : Constraints from a reconnaissance study of $\delta^{15}\text{N}$, δD , and $\delta^{18}\text{O}$ [J]. Econ. Geol. , 98(1) : 109~123.
- Jiang S H , Nie F J , Hu P and Liu Y. 2006. ^{40}Ar - ^{39}Ar age and geochemical features of the Mayum adakitic porphyry in Tibet[J]. Acta Petrologica Sinica , 22(3) : 603~611(in Chinese with English abstract).
- Jiang S H , Nie F J , Hu P and Lai X R. 2008. Mayum : An orogenic gold deposit in Tibet , China[J]. Ore Geology Reviews , (in review).
- Kerrick R and Wyman D A. 1990. The geodynamic setting of mesothermal gold deposits : An association with accretionary tectonic regimes[J]. Geology , 18 : 882~885.
- Kerrick R. 1993. Perspectives on genetic models for lode gold deposits[J]. Mineralium Deposita , 28 : 362~365.
- Kerrick R and Cassidy K F. 1994. Temporal relationships of lode gold mineralization to accretion , magmatism , metamorphism and deformation , Archean to present : A review[J]. Ore Geol. Rev. , 9 : 263~310.
- Kerrick R , Goldfarb R , Groves D , Garwin S and Jia Y F. 2000. The characteristics , origins , and geodynamics of supergiant gold metallogenic provinces[J]. Science in China(Series D) , 43(Supp.) : 1~68.
- Klein E L , Harris C Renac C , Giret A , Moura C A V and Fuzikawa K. 2006. Fluid inclusion and stable isotope (O , H , C , and S) constraints on the genesis of the Serrinha gold deposit , Gurupi Belt , northern Brazil[J]. Mineralium Deposita , 41 : 160~178.
- Kolb J , Sindern S , Kisters A F M , Meyer F M , Hoernes S and Schneider J. 2005. Timing of Uralian orogenic gold mineralization at Kochkar in the evolution of the East Uralian granite-gneiss terrane[J]. Mineralium Deposita , 40(5) : 473~491.
- Kolb J , Hellmann A , Rogers A , Sindern S , Vennemann T , Boettcher M E and Meyer F M. 2004. The role of a transcrustal shear zone in orogenic gold mineralization at the Ajjanahalli Mine , Dharwar Craton , south India[J]. Econ. Geol. , 99(4) : 743~759.
- Kreuzer O P. 2005. Intrusion-Hosted Mineralization in the Charters Towers Goldfield , North Queensland : New isotopic and fluid inclusion constraints on the timing and origin of the Auriferous Veins[J]. Econ. Geol. , 100 : 1583~1603.
- Li B L , Chen G J , Song Z W. 2004. Discussion on minerogenetic epoch of the gold deposit in Jiapi gou of Jilin Province[J]. Global Geology , 23(4) : 354~359(in Chinese with English abstract).
- Li J , Chen Y J and Liu Y X. 2004. Typomorphic characteristics of pyrite from the lode gold deposits in north China craton : Implications for fluid mineralization[J]. J. Mineral. Petrol. , 24(3) : 93~102(in Chinese with English abstract).
- Li Z Q , Hou Z Q , Nie F J and Meng X J. 2005. Characteristic and distribution of the partial melting layers in the upper crust : Evidence from active hydrothermal fluid in the south Tibe[J]. Acta Geologica Sinica , 79(1) : 68~77(in Chinese with English abstract).
- Lindgren W. 1933. Mineral Deposits[M]. 4th ed. New York and London : McGraw Hill. 930p.
- Mao J W. 2001. Geology , distribution and classification of gold deposits in the western Qinling belt , central China[J]. Bulletin of Mineralogy , Petrology and Geochemistry , 20(1) : 11~13(in Chinese with English abstract).
- Mao J W , Zhang Z H , Wang Y T , Jia Yefei and Kerrich R. 2002. The nitrogen isotope and nitrogen contents of the Mesozoic orogenic gold deposits occurring along the margin of the north China craton[J]. Science in China(Series D) , 32(9) : 705~716(in Chinese).
- McNaughton N J , Muller A G and Groves D I. 2005. The age of the Giant Golden Mile deposit , Kalgoorlie , Western Australia : ion-microprobe zircon and monazite U-Pb geochronology of a synmineralization lamprophyre dike[J]. Econ. Geol. , 100 : 1427~1440.
- Miao L C , Qiu Y M , McNaughton N , Luo Z K , Groves D , Zha Y S , Fan W M , Zhai M G and Guan K. 2002. SHRIMP U-Pb zircon geochronology of granitoids from Dongping area , Hebei Province , China : Constraints on tectonic evolution and geodynamic setting for gold metallogeny[J]. Ore Geology Reviews , 19 : 187~204.
- Miller L D , Goldfarb R J , Nie F J , Hart C J R , Miller M L , Yang Y Q and Liu Y Q. 1998. North China Gold-A product of multiple orogens[J]. SEG Newsletter , 33 : 1~12.

- Nesbitt B E. 1991. Phanerozoic gold deposits in tectonically active continental margins[A]. In : Foster R P , ed. Gold Metallogeny and Exploration[C]. Glasgow : Blackie and Son. 104~132.
- Petrie B S , Craw D and Ryan C G. 2005. Geological controls on refractory ore in an orogenic gold deposit , Macraes mine , New Zealand [J]. Mineralium Deposita , 40(1) : 45~58.
- Qiu Y M , Groves D I , McNaughton N J , Wang L G and Zhou T H. 2002. Nature , age , and tectonic setting of granitoid-hosted , orogenic gold deposits of the Jiaodong Peninsula , eastern North China Craton , China[J]. Mineralium Deposita , 37(3-4) : 283~305.
- Robert F. 1996. Quartz-carbonate vein gold[A]. In : Eckstrand O R , Sinclair W D , Thorpe R I , eds. Geology of Canadian Mineral Deposit Types[C]. The Geology of North America , vol. P-1. Geol. Soc. Am. , 350~366.
- Salier B P , Groves D I , McNaughton N J and Fletcher I R. 2005. Geochronological and Stable Isotope Evidence for Widespread Orogenic Gold Mineralization from a Deep-Seated Fluid Source at ca 2.65 Ga in the Laverton Gold Province , Western Australia[J]. Econ. Geol. , 100(7) : 1363~1388.
- Secombe P K. 2002. Orogenic gold deposits ; structural controls and the timing of mineralization[J]. SEG Newsletter. 50 : 33~34.
- Vielreicher N M , Groves D I , Fletcher I R , McNaughton N J and Rasmussen B. 2003. Hydrothermal monazite and xenotime geochronology : A new direction for precise dating of orogenic gold mineralization [J]. SEG Newsletter , 53 : 1 , 10~16.
- Voicu G , Bardoux M , Stevenson R and Jebrak M. 2000. Nd and Sr isotope study of hydrothermal scheelite and host rocks at Omai , Guiana Shield : Implications for ore fluid source and flow path during the formation of orogenic gold deposits[J]. Mineralium Deposita , 35(4) : 302~314.
- Wang Z L , Mao J W , Wu G G , Yang J M , Han C M , Ma T L and Zhang Z H. 2004. C , O and H isotopic evidences for mantle fluids involved in the late ore-forming stage of the Kanggur gold deposit in eastern Tianshan mountain[J]. Acta Geologica Sinica , 78(2) : 195~202 in Chinese with English abstract).
- Wen C Q. 2003. The discovery of the Mayum gold deposit and its significance[J]. J. Chengdu University of Technology (Science & Technology Edition) , 30(3) : 253(in Chinese with English abstract).
- Wen C Q , Duo J , Sun Y , Fan X P , Xu L , Huo Y , Duoqing Gesang and Luo X J. 2004. ^{40}Ar - ^{39}Ar dating of quartz from gold-bearing quartz veins in the Mayum gold deposit , Burang , Tibet , and its geological significance[J]. Geological Bulletin of China , 23(7) : 686~688(in Chinese with English abstract).
- Wen C Q , Duo J , Fan X P , Chen H Q , Hu X C , Li X W , Zhang S X , Liu W Z , Sun Y and Li B H. 2006a. Geological characteristics and genetic analysis of the Mayoumu gold deposit , Tibet , China[J]. J. Chengdu University of Technology (Science & Technology Edition) , 33(2) : 122~133(in Chinese with English abstract).
- Wen C Q , Duo J , Fan X P , Hu X C , Li B H , Sun Y , Liu W Z , Huo Y , Wen Q and Ren W J. 2006b. Characteristics of ore fluids of the Mayum gold deposit , western Tibet , China[J]. Geological Bulletin of China , 25(1~2) : 261~266(in Chinese with English abstract).
- White N C and Hedenquist J W. 1995. Epithermal gold deposits : Styles , characteristics and exploration[J]. SEG Newsletter , 23 : 9~13.
- Wu G , Sun F Y , Zhu Q , Li Z T , Ding Q F , Li G Y , Pang Q B and Wang H B. 2006. Geological characteristics and genesis of gold deposits in upper Heilongjiang basin[J]. Mineral deposits , 25(3) : 215~230(in Chinese with English abstract).
- Wyman D and Kerrich R. 1988. Alkaline magmatism , major structures , and gold deposits : Implications for greenstone belt gold metallogeny [J]. Econ. Geol. , 83 : 451~458.
- Xu Z Q , Yang J S , Qi X X , Cui J W , Li H B and Chen F Y. 2006. India-Asia collision : A further discussion of N-S- and E-W-trending detachments and the orogenic mechanism of the modern Himalayas [J]. Geological Bulletin of China , 25(1-2) : 1~14(in Chinese with English abstract).
- Yi Y C , Chen S Y and Wen X F. 2006. Geological characteristics and metallogeny of the Songshunagou orogenic deposit in Northern Qilianshan Qinghai[J]. Gold , 27(10) : 16~19(in Chinese with English abstract).
- Zhang D Q , Feng C Y , Li D X , Xu W Y , Yan S H , She H Q , Dong Y J and Cui Y H. 2001. Orogenic gold deposits in the north Qaidam and east Kunlun orogen , West China[J]. Mineral Deposits , 20(2) : 137~146(in Chinese with English abstract).
- Zhang D Q , Dang X Y , She H Q , Li D X , Feng C Y and Li J W. 2005. Ar-Ar dating of orogenic gold deposits in northern margin of Qaidam and East Kunlun Mountains and its geological significance [J]. Mineral Deposits , 24(2) : 87~98(in Chinese with English abstract).

附中文参考文献

- 陈华勇 , 陈衍景 , 倪培 , 张增杰. 2004. 南天山萨瓦亚尔顿金矿流体包裹体研究 : 矿床成因和勘探意义[J]. 矿物岩石 , 24(3) : 46~54.
- 陈衍景 , 隋颖慧 , Pirajno F. 2003. CMF 模式的排他性依据和造山型银矿实例 : 东秦岭铁炉坪银矿同位素地球化学[J]. 岩石学报 , 19(3) : 551~568.
- 范小平 , 多吉 , 温春齐 , 郭建慈 , 胡先才 , 陈惠强 , 李小文. 2005. 西藏马攸木金矿床含金脉石英的 $^{40}\text{Ar}/^{39}\text{Ar}$ 快中子活化定年及其地质意义[J]. 沉积与特提斯地质 , 25(4) : 33~36.
- 丰成友 , 张德全 , 李大新 , 余宏全. 2003. 青海东昆仑造山型金矿硫、铅同位素地球化学[J]. 地球学报 , 24(6) : 593~598.
- 丰成友 , 张德全 , 王富春 , 李大新 , 余宏全. 2004a. 青海东昆仑造山型金(锑) 矿床成矿流体地球化学研究[J]. 岩石学报 , 20(4) : 949~960.
- 丰成友 , 张德全 , 王富春 , 余宏全 , 李大新 , 王彦. 2004b. 青海东昆仑复合造山过程及典型造山型金矿地质[J]. 地球学报 , 25(4) : 415~422.
- 郭建慈 , 多吉 , 温春齐 , 陈惠强 , 范小平 , 李小文. 2006. 西藏马攸木

- 金矿成矿背景与成矿阶段[J]. 沉积与特提斯地质, 26(1):60~66.
- 侯增谦, 杨竹森, 徐文艺, 莫宣学, 丁林, 高永丰, 董方浏, 李光明, 曲晓明, 李光明, 赵志丹, 江思宏, 孟祥金, 李振清, 秦克章, 杨志明. 2006a. 青藏高原碰撞造山带: I. 主碰撞造山成矿作用[J]. 矿床地质, 25(4):337~358.
- 侯增谦, 潘桂棠, 王安建, 莫宣学, 田世洪, 孙晓明, 丁林, 王二七, 高永丰, 谢玉玲, 曾普胜, 秦克章, 许继峰, 曲晓明, 杨志明, 杨竹森, 费红彩, 孟祥金, 李振清. 2006b. 青藏高原碰撞造山带: II. 晚碰撞转换成矿作用[J]. 矿床地质, 25(5):521~543.
- 胡朋, 聂凤军, 江思宏, 刘妍, 张万益. 2006. 西藏马攸木金矿松托嘎岩体锆石 SHRIMP 年龄及其地质意义[J]. 地质评论, 52(2):276~282.
- 霍艳, 温春齐, 李保华, 孙燕. 2004. 西藏马攸木金矿床流体包裹体特征初步研究[J]. 地质找矿论丛, 19(2):100~104, 113.
- 霍艳, 温春齐, 李保华, 孙燕. 2005. 西藏马攸木金矿床流体物理化学条件初步研究[J]. 地质找矿论丛, 20(3):156~160.
- 江思宏, 聂凤军, 胡朋, 刘妍. 2006. 西藏马攸木埃达克质斑岩的 ^{40}Ar - ^{39}Ar 年龄与地球化学特征[J]. 岩石学报, 22(3):603~611.
- 李碧乐, 陈广俊, 宋宗维. 2004. 论吉林夹皮沟金矿成矿时代[J]. 世界地质, 23(4):354~359.
- 李晶, 陈衍景, 刘迎新. 2004. 华北克拉通若干脉状金矿的黄铁矿标型特征与流体成矿过程[J]. 矿物岩石, 24(3):93~102.
- 李振清, 侯增谦, 聂凤军, 孟祥金. 2005. 藏南上地壳低速高层的性质与分布: 来自热水流体活动的证据[J]. 地质学报, 79(1):68~77.
- 毛景文. 2001. 西秦岭地区造山型与卡林型金矿床[J]. 矿物岩石地球化学通报, 20(1):11~13.
- 毛景文, 张作衡, 王义天, Jia Yefei, Kerrich R. 2002. 华北克拉通周缘中生代造山型金矿床的氮同位素和氮含量记录[J]. 中国科学(D 辑), 32(9):705~716.
- 王志良, 毛景文, 吴淦国, 杨建民, 韩春明, 马天林, 张作衡. 2004. 东天山康古尔金矿成矿晚阶段地幔流体参与成矿作用的碳氧同位素证据[J]. 地质学报, 78(2):195~202.
- 温春齐. 2003. 西藏马攸木金矿床的发现及其意义[J]. 成都理工大学学报(自然科学版), 30(3):253.
- 温春齐, 多吉, 孙燕, 范小平, 徐凌, 霍艳, 格桑多庆, 罗小军. 2004. 西藏普兰县马攸木金矿床石英的 $^{40}\text{Ar}/^{39}\text{Ar}$ 年龄及其地质意义[J]. 地质通报, 23(7):686~688.
- 温春齐, 多吉, 范小平, 陈惠强, 胡先才, 李小微, 张胜祥, 刘文周, 孙燕, 李保华. 2006a. 西藏马攸木金矿床地质特征及成因初探[J]. 成都理工大学学报(自然科学版), 33(2):122~133.
- 温春齐, 多吉, 范小平, 胡先才, 李保华, 孙燕, 刘文周, 霍艳, 温泉, 任文静. 2006b. 西藏西部马攸木金矿床成矿流体的特征[J]. 地质通报, 25(1~2):261~266.
- 武广, 孙丰月, 朱群, 李之彤, 丁清峰, 李广远, 庞庆帮, 王宏博. 2006. 上黑龙江盆地金矿床地质特征及成因探讨[J]. 矿床地质, 25(3):215~230.
- 许志琴, 杨经绥, 戚学祥, 崔军文, 李海兵, 陈方远. 2006. 印度/亚洲碰撞—南北向和东西向拆离构造与现代喜马拉雅造山机制再讨论[J]. 地质通报, 25(1~2):1~14.
- 伊有昌, 陈树云, 文雪峰. 2006. 青海北祁连松树南沟造山型金矿床地质特征及矿床成因[J]. 黄金, 27(10):16~19.
- 张德全, 丰成友, 李大新, 徐文艺, 阎升好, 余宏全, 董英君, 崔艳合. 2001. 柴北缘-东昆仑地区的造山型金矿床[J]. 矿床地质, 20(2):137~146.
- 张德全, 党兴彦, 余宏全, 李大新, 丰成友, 李进文. 2005. 柴北缘-东昆仑地区造山型金矿床的 Ar-Ar 测年及其地质意义[J]. 矿床地质, 24(2):87~98.