赣南盘古山钨铋矿床发现扇状成矿现象

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内容提要:在扇状成矿规律指导下,资源几近枯竭的赣南盘古山钨铋矿床取得新的找矿成果。在矿区南部揭露了两组倾向北的钨铋矿化石英细脉,总脉数达102条,与矿区北部倾向南的已知矿脉相向倾斜,横剖面呈扇状。这一成果对广大钨铋矿找矿工作者具有重要的借鉴意义。

关键词:扇状成矿;盘古山矿床;钨矿;铋矿;找矿成果

钨是中国、美国、英国、欧盟等国家的战略性关键矿产(毛景文等,2019;王登红,2019;侯增谦等,2020),由于其熔点高、硬度高、密度高、导电性和导热性良好、膨胀系数较小等特性而被广泛应用到硬质合金、电子、化工等领域。钨也是制造枪炮管、火箭喷嘴、穿甲弹、电磁炮等国防器械的必须元素,历史上几次战争期间钨的需求和价格都有大幅提升,因而也被誉为"战争金属之王"。一个多世纪以来钨一直是我国的优势矿产,2020年我国钨矿储量190万吨,年产量6.9万吨,均居世界首位,分别占世界总储量和年产量的56%和82%(USGS,2021),近年来还发现了朱溪、大湖塘等世界级超大型钨矿床(毛景文等,2020)。

石英脉型钨矿通常产于花岗岩类岩体与地层的内外接触带,矿体主要呈独立的含矿石英脉产出,成组成带出现。钨矿工作者相继提出了"五层楼"(古菊云,1979)、"五层楼+地下室"(许建祥等,2008;王登红等,2010;Wang Denghong et al.,2019)、"上脉下体"(华仁民等,2015)等找矿模型,有效指导了钨矿的深部找矿勘查。然而,一大批曾为我国革命和经济建设作出突出贡献的著名石英脉型钨矿床,如盘古山、西华山、岿美山、大吉山、漂塘、黄沙等,因长期开采,资源形势极为严峻,部分矿山甚至已经闭坑,迫切需要寻找外围新的钨矿资源。

著名的盘古山钨铋矿床位于江西于都县盘古山镇,与西华山钨矿、大吉山钨矿、岿美山钨矿等齐名,至今已有百余年开采历史,是我国革命和经济建设的"功勋老矿"。百余年来,该矿床主要开采北组、中组和南组三组矿脉,三组矿脉均倾向近南,由北组至南组依次变陡,总体向浅部发散,向深部收敛(Fang Guicong et al.,2018)。本课题组通过广泛调研钨矿床实例,发现尽管江西盘古山、西华山、大吉山、坑尾窝、牛岭、徐山,广西珊瑚,广东瑶岭等绝大多数石英脉型钨矿床的矿脉呈相同或相近的倾向产出,但江西茅坪、东坪、淘锡坑,广西社垌,广东梅子窝等石英脉型钨矿床具有扇状成矿的规律,即在花岗岩体顶部围岩中形成相向倾斜、近于对称的矿脉群,横剖面呈扇状,于是提出在已知矿脉组外围寻找与之相向倾斜的另一矿脉组的找矿新思路(方贵聪等,2021)。在此规律和思路的指导下,2018年至2019年间,课题组对盘古山矿区开展了详细的野外地质调查,在地表发现了两组矿化标志带QV1和QV2(图1),均倾向近北。

QV1出露于矿区已知南组工业矿脉以南约300 m的公路切坡上,12号勘探线南侧,横向宽度约5 m,发育8条细脉,含脉密度0~3条/m,单脉厚度0.2~0.6 cm,总体产状12°∠75°,脉体风化较为严重,残余矿物组合主要为石英和褐铁矿,石英呈晶簇状

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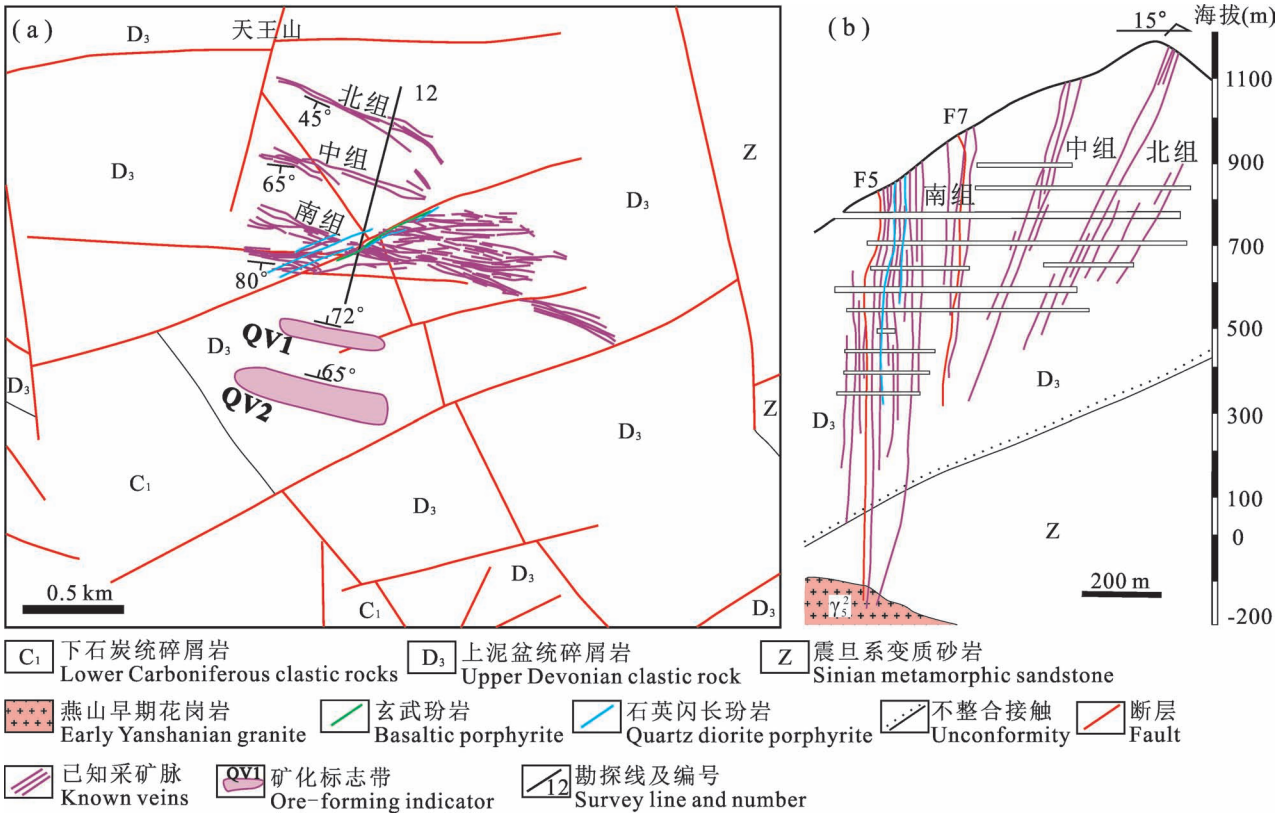
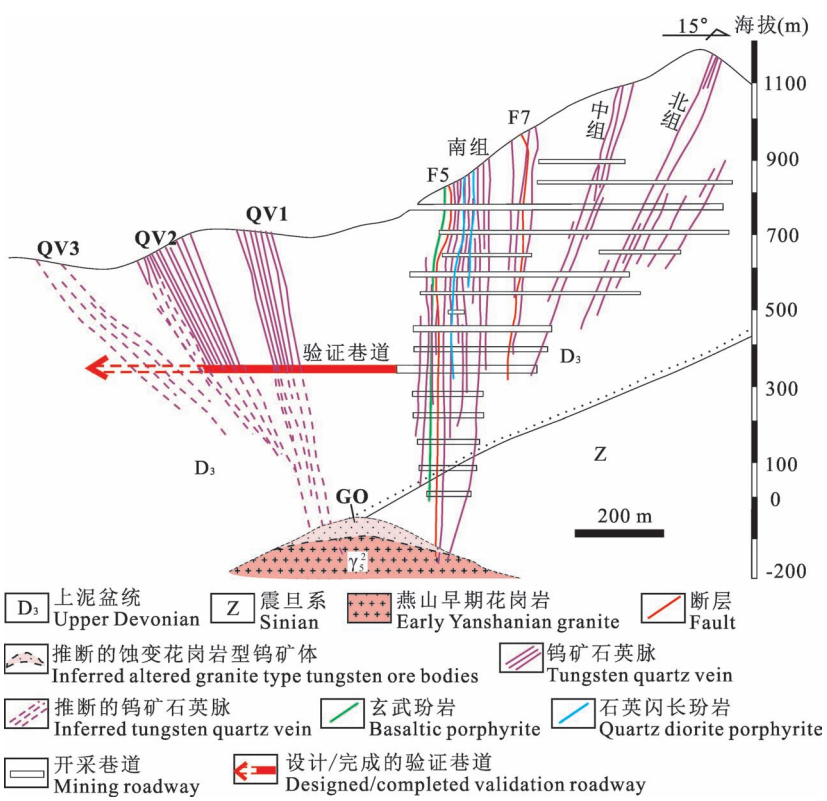


图 1 赣南盘古山钨铋矿地质平面图(a)及 12 号勘探线剖面图(b)

Fig. 1 Geological map of the Pangushan W—Bi deposit in southern Jiangxi (a) and geological section of its 12# exploration line (b)



或梳状,由脉壁向脉中心生长,褐铁矿呈蜂窝状或骨架状。QV2 位于 QV1 以南约 300 m 的公路切坡上,横向宽度约 80 m,总脉数超过 160 条,含脉密度一般 2~10 条/m,最大可达 35 条/m,单脉厚度一般为 0.2~0.8 cm,少数达 2.5 cm,倾向 14°~20°,倾角 60°~70°,大部分脉体已风化成松散土状,个别较厚的脉体保存较完整,主要矿物组合为石英,局部可见少量黑钨矿、辉钼矿和白云母(方贵聪等, 2019)。

课题组对两组矿化标志带开展

图 2 赣南盘古山钨铋矿床 12 号勘探线巷道施工位置剖面示意图

Fig. 2 Diagrammatic cross-section of tunnel driving in 12 # exploration line, Pangushan W—Bi deposit, southern Jiangxi

细致研究后,结合扇状成矿的规律(方贵聪等, 2021; Fang Guicong et al., 2021)及“五层楼+地下室”找矿模型(王登红等, 2010; 陈郑辉等, 2013),预测矿区南部极可能发育另外三组倾向北的矿脉(图 2 的 QV1、QV2、QV3),与已知三组矿脉相向倾斜,且三组南倾矿脉与三组北倾矿脉之间的燕山早期花岗岩突(岩体年龄为 161.7 Ma,方贵聪等, 2014)还可能形成面状的蚀变花岗岩型钨矿体(图 2 的 GO)。经多次交流和研讨后,江西盘古山钨业有限公司最终选择了巷道掘进的方式进行验证,即于 12 号勘探线的 335 中段,由已有穿脉继续向南以 195°方位掘进 650 m(图 2)。

截至投稿,验证巷道已掘进 436 m,目前揭露矿化细脉共计 102 条,脉宽 0.3~1cm,富含白钨矿和黑钨矿(图 3),除个别外均倾向北,与已知矿脉相向倾斜(李平, 2021)。矿化石英细脉主要集中在进尺 210~300 m 和 410~436 m 两个区间内,其中前者细脉数 34 条,脉密度最大可达 4 条/m,总体产状 15°∠69°;后者细脉数达 68 条,脉密度最大可达 7 条/m,产状 5°∠64°。经空间几何分析,这两组矿化石英细脉分别对应地表的两个脉组 QV1 和 QV2。总体来看,矿床横剖面已显示出较明显的扇状成矿特征,验证巷道继续掘进有望再揭露第三个脉组 QV3(图 2)。

根据石英脉型钨矿的垂向矿化分带规律,这些细脉向深部极可能变为经济价值显著的钨矿脉,相信随着验证工作的逐步开展,矿山有望取得更大找矿突破。

石英脉型钨矿床是我国开采历史最久、数量最多的钨矿床类型,这一找矿成果不仅为我国广大钨矿工作者提供了很好的借鉴,也表明了石英脉型钨矿床扇状成矿的规律对于找矿预测及钻孔、巷道工程部署均具有重要指导意义。扇状成矿可能是花岗岩浆主动上侵动力、区域水平构造应力、岩层自身重力等联合作用造成的(方贵聪等, 2021),课题组将继续对扇状成矿现象开展详细的矿田构造解析及典型矿床研究,更好地服务钨矿勘查。

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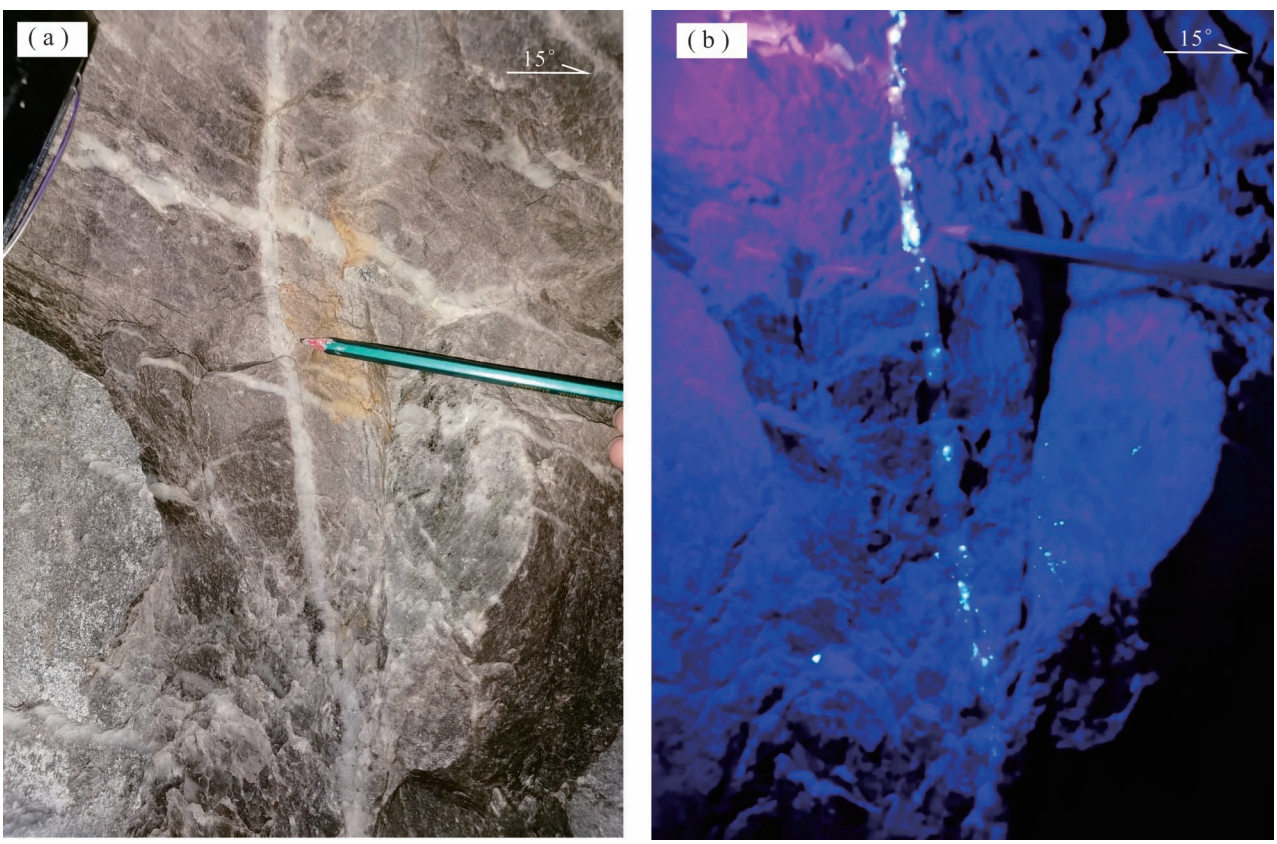

图 3 赣南盘古山钨铋矿验证巷道进尺 210 m 处白光(a)和紫外灯光(b)下的白钨矿化石英细脉

Fig. 3 Scheelite-bearing quartz veinlet under white light (a) and UV-light (b) at 210 m footage of the driving tunnel, Pangushan W—Bi deposit, southern Jiangxi

参 考 文 献 / References

(The literature whose publishing year followed by a "&" is in Chinese with English abstract; The literature whose publishing year followed by a "#" is in Chinese without English abstract)

陈郑辉, 王登红, 曾载淋, 赵斌, 陈毓川, 方贵聪. 2013. "五层楼+地下室"模式在南岭于都-赣县矿集区立体探测与深部成矿预测中的实践. 地质论评, 59(z1): 951~952.

方贵聪, 陈毓川, 陈郑辉, 曾载淋, 张永忠, 童启荃, 孙杰, 黄鸿新, 郭娜欣. 2014. 赣南盘古山钨矿床锆石 U-Pb 和辉钼矿 Re-Os 年龄及其意义. 地球学报, 35(1): 76~84.

方贵聪, 陈毓川, 王登红, 童启荃, 吴家旭, 严翔. 2019. 江西盘古山钨矿发现新的矿化石英细脉带. 地质论评, 65(6): 1435~1438.

方贵聪, 王登红, 冯佐海, 付伟, 康志强, 吴家旭, 赵云彪, 童启荃, 杨明. 2021. 华南石英脉型钨矿床扇状成矿的规律及其找矿意义. 大地构造与成矿学, 45(3): 523~533.

古菊云. 1979. 矿化细脉(带)是寻找隐伏矿床的重要标志. 地质论评, 25(2): 47~52.

华仁民, 韦星林, 王定生, 郭家松, 黄小娥, 李光来. 2015. 试论南岭钨矿"上脉下体"成矿模式. 中国钨业, 30(1): 16~23.

李平. 2021. 江西盘古山钨矿找矿取得重要成果[N]. 中国矿业报, 2021-08-05, B3.

毛景文, 杨宗喜, 谢桂青, 袁顺达, 周振华. 2019. 关键矿产——国际动向与思考. 矿床地质, 38(4): 689~698.

毛景文, 吴胜华, 宋世伟, 戴盼, 谢桂青, 苏蔷薇, 刘鹏, 王先广, 余忠珍, 陈祥云, 唐维新. 2020. 江南世界级钨矿带:地质特征、成矿规律和矿床模型. 科学通报, 65(33): 3746~3762.

王登红, 唐菊兴, 应立娟, 陈郑辉, 许建祥, 张家菁, 李水如, 曾载淋. 2010. "五层楼+地下室"找矿模型的适用性及其对深部找矿的意义. 吉林大学学报(地球科学版), 40(4): 733~738.

王登红. 2019. 关键矿产的研究意义、矿种厘定、资源属性、找矿进展、存在问题及主攻方向. 地质学报, 93(6): 1189~1209.

许建祥, 曾载淋, 王登红, 陈郑辉, 刘善宝, 王成辉, 应立娟. 2008. 赣南钨矿新类型及"五层楼+ 地下室"找矿模型. 地质学报, 82(7): 880~887.

ChenZhenghui, Wang Denghong, Zeng Zailin, Zhao Bin, Chen Yuchuan, Fang Guicong. 2013 #. Practice of " five levels + basement" model in three-dimensional exploration and deep metallogenic prediction in Yudu—Ganxian ore concentration area, Nanling. Geological Review, 59(z1): 951~952.

FangGuicong, Zhao Zheng, Chen Yuchuan, Chen Zhenghui, Krapez Bryan and Mao Jingwen. 2018. Genetic relationship between granitic magmatism and W mineralization recorded in the Nanling Scientific Drilling (SP-NLSD-2) in the Pangushan W mining district, South China. Ore Geology Reviews, 101: 556~577.

FangGuicong, Chen Yuchuan, Chen Zhenghui, Zeng Zailin, Zhang Yongzhong, Tong Qiquan, Sun Jie, Huang Hongxin, Guo Naxin. 2014&. Zircon U-Pb and molybdenite Re-Os geochronology of the Pangushan tungsten teposit in South Jiangxi Province and its significance[J]. Acta Geoscientica Sinica, 35(1): 76~84.

FangGuicong, Chen Yuchuan, Wang Denghong, Tong Qiquan, Wu Jiaxu, Yan Xiang. 2019&. Discovery of a new quartz veinlets zone in Pangushan tungsten deposit, Jiangxi Province. Geological Review, 65(6): 1435~1438.

FangGuicong, Wang Denghong, Feng Zuohai, Fu Wei, Kang Zhiqiang, Wu Jiaxu, Zhao Yunbiao, Tong Qiquan, Yang Ming. 2021&. The fan-like distribution of ore veins in the quartz-vein type tungsten deposits in South China and its prospecting significance. Geotectonica et Metallogenia, 45(3): 523~533.

FangGuicong, Xu Cheng, Feng Zuohai, Wu Jiaxu, Zhao Yunbiao, Tong Qiquan, Yang Ming. 2021. Genesis of quartz veinlets in the Pangushan W—Bi deposit, South China: Implications for exploration of wolframite quartz vein-type mineralization. Ore Geology Reviews, 138: 104413.

Gu Juyun. 1979 #. Veilets (zone) of mineralization are important indicators for searching blind deposit. Geological Review, 25(2): 47~52.

Hua Renmin, Wei Xinglin, Wang Dingsheng, Guo Jiasong, Huang Xiaoe, Li Guanglai. 2015&. A new metalloginetic model for tungsten deposit in South China´s Nanling area: Up veins + underneath mineralized granite. China Tungsten Industry, 30(1): 16~23.

Li Ping. 2021#. Important achievements have been made in prospecting for the Pangushan tungsten deposit in Jiangxi Province[N]. China Mining News, 2021-08-05, B3.

MaoJingwen, Yang Zongxi, Xie Guiqing, Yuan Shunda, Zhou Zhenhua. 2019&. Critical minerals: International trends and thinking. Mineral Deposits, 38(4): 689~698.

MaoJingwen, Wu Shenghua, Song Shiwei, Dai Pan, Xie Guiqing, Su Qiangwei, Liu Peng, Wang Xianguang, Yu Zhongzhen, Chen Xiangyun, Tang Weixin. 2020&. The world-class Jiangnan tungsten belt: Geological characteristics, metallogeny, and ore deposit model. China Science Bulletin, 65(33): 3746~3762.

USGS (U. S. Geological Survey). 2021. Mineral Commodity Summaries 2021[OL]. U. S. Geological Survey, 2021, 200 p.; https://doi.org/10.3133/mcs2021.

WangDenghong, Tang Juxing, Ying Lijuan, Chen Zhenghui, Xu Jiangxiang, Zhang Jiajing, Li Rushui, Zeng Zailin. 2010&. Application of "five levels + basement" model for prospecting deposits into depth. Journal of Jilin University (Earth Science Edition), 40(4): 733~738.

WangDenghong. 2019&. Study on critical mineral resources: significance of research, determination of types, attributes of resources, progress of prospecting, problems of utilization, and direction of exploitation. Acta Geologica Sinica, 93(6): 1189~1209.

WangDenghong, Huang Fan, Wang Yan, He Hanhan, Li Xiaomei, Liu Xinxing, Sheng Jifu, Liang Ting. 2020. Regional metallogeny of Tungsten—tin—polymetallic deposits in Nanling region, South China. Ore Geology Reviews, 120: 103305.

Xu Jianxiang, Zeng Zailin, Wang Denghong, Chen Zhenghui, Liu Shanbao, Wang Chenghui, Ying Lijuan. 2008&. A new type of tungsten deposit in southern Jiangxi and the new model of "five floors + basement" for prospecting. Acta geologica Sinica, 82(7): 880~887.

Discovery of fan-liked mineralization in Pangushan tungsten—bismuth deposit, southern Jiangxi

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Abstract: Based on fan-liked mineralization regularity, new prospecting results have been obtained in Pangushan tungsten—bismuth deposit in southern Jiangxi province, whose resources are nearly exhausted. In the southern part of the mining area, two groups of tungsten bearing quartz veins (a total of 102 veins) with a dip to the north are revealed, which are inclined to the known ore veins with a dip to the south in the north of the mining area, and their cross section are generally fan-liked. This achievement has important reference significance to tungsten ore exploration.

Keywords: Fan-liked mineralization; Pangushan deposit; tungsten deposit; bismuth deposit; prospecting achievement

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