



湘南地区芙蓉锡矿床中硼矿化的发现及意义^{*}

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摘 要 硼矿是中国重要的紧缺矿产, 长期依赖进口, 找寻新的硼矿资源迫在眉睫。笔者在湘南地区芙蓉锡矿床新发现了矽卡岩型硼矿化, 硼矿物包括硼镁铁矿、透安石和氟硼镁石, 1 件典型样品的 X 射线粉晶衍射分析结果表明硼矿物总含量达到 47.4%, 换算成 $w(\text{B})$ (以 B_2O_3 计) 约为 9.5%, 高于 5% 的硼矿最低工业品位。该发现预示着湘南地区, 乃至华南与高分异花岗岩有关的钨锡多金属矿集区有良好的硼成矿潜力, 在今后的找矿过程中, 需加强与钨锡多金属共伴生的硼矿化评价工作。

关键词 地质学; 硼矿化; 矽卡岩; 高分异花岗岩; 湘南地区; 芙蓉锡矿床

New discovery and significance of boron mineralization in Furong tin ore deposit, southern Hunan area

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Abstract

Boron ore is important but in short supply in China, and thus is of significance to find new boron resources. This paper discovers skarn boron mineralization in the Furong tin deposit of southern Hunan area, with ore minerals including ludwigite, suanite and fluoborite. A typical sample conducted by X-ray powder diffraction analysis shows that the boron mineral reached 47.4% in volume, with B_2O_3 content about 9.5% when converted into mass fraction, which is higher than the industrial ore grade. This discovery indicates that there is a good potential for boron mineralization in tungsten-tin polymetallic skarn deposits associated with highly fractionated granite in southern Hunan area and extends to south China. The evaluation of boron mineralization associated with highly fractionated granite is necessary for future prospecting processes.

Key words: geology, boron mineralization, skarn, highly fractionated granite, southern Hunan area, Furong tin ore deposit

硼在自然界只以化合物形式存在, 被广泛应用于建材、机械、电器、化工、轻工、医药、农业、冶金、核工业等领域, 在中国国民经济和国防事业中发挥着极为重要的作用(王莹等, 2014; 袁建国等, 2018)。

中国硼矿有沉积变质型、盐湖沉积型、矽卡岩型、地下卤水型、热液型、海相沉积型、火山沉积型等 7 种类型, 但具工业意义的仅有沉积变质型、盐湖沉积型、矽卡岩型 3 种(陈毓川等, 2010)。沉积变质型硼

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矿是中国最重要的硼矿类型,主要分布在辽东地区,其中后仙峪硼镁矿和翁泉沟硼镁铁矿已经开采利用,但仍然供不应求。盐湖沉积型硼矿主要分布在青藏高原,由于伴生元素多、加工技术水平较低等原因,导致该类型硼矿利用程度有限。长期以来,中国硼矿依赖进口,对外依存度居高不下,因此,找寻新的硼矿资源迫在眉睫(袁建国等,2018)。

近期,笔者在前人研究的基础上,通过对湘南地区钨锡多金属矿床成矿特征的认识,认为该地区具备矽卡岩型硼矿的成矿条件。进而,对该地区一些矿床进行了野外调查和室内岩矿鉴定工作,发现芙蓉锡矿床屋场坪矿区存在硼镁铁矿、遂安石、氟硼镁石等硼矿物,确认了屋场坪矽卡岩型硼矿化的存在。这为拓展中国工业硼矿的找矿空间提供了重要依据,同时,对于区域成矿规律的深化研究与找矿工作部署具有重要意义。

1 芙蓉锡矿床中矽卡岩型硼矿化的发现

芙蓉锡矿床地处华夏地块中北缘(图1a),位于骑田岭岩体南部(图1b),是湘南地区具代表性的大型锡矿床之一,矿化类型有云英岩型、矽卡岩型、构造蚀变带型、蚀变岩型等(许以明等,2000)。以往对该矿床只注重于锡矿的找矿和研究,未关注到硼矿化。笔者在芙蓉锡矿床屋场坪采坑19号锡矿体(矽卡岩型锡矿石)中发现了大量富硼矿物,用于本次研究的锡硼矿石即采自该矿体。

锡硼矿石手标本呈灰黑色,条带状或块状构造(图2a),主要由粒硅镁石、硼镁铁矿、遂安石及少量的磁铁矿、氟硼镁石、绿泥石、菱镁矿、透辉石和锡石等矿物组成。矿石中浅色条带和暗色条带之间界线清晰(图2b),浅色条带由共生的粒硅镁石和绿泥石组成(图2c),暗色条带由共生的硼镁铁矿、磁铁矿、遂安石和锡石组成(图2d)。其中,硼镁铁矿呈自形-半自形板状,长约200 μm 、宽约100 μm ,遂安石长100~200 μm ,锡石多为针状,长多为5~15 μm ,生长于磁铁矿颗粒内或填充于硼镁铁矿和遂安石颗粒之间(图2e~h)。

笔者对其中1件矽卡岩型锡硼矿石(编号:WCP-12)进行X射线粉晶衍射分析,结果进一步明确该矿石主要由硼镁铁矿、遂安石、磁铁矿、菱镁矿、绿泥石、透辉石、粒硅镁石、氟硼镁石、锡石等9种矿物组成,矿物比例分别为22.0%、18.6%、9.3%、4.6%、

6.2%、4.6%、26.7%、6.8%、1.3%(图3)。可以看出,芙蓉锡矿床中屋场坪矿区含硼矿物共3种,按矿物比例由高到低分别为硼镁铁矿、遂安石、氟硼镁石,总比例达到47.4%,换算成 $w(\text{B})$ (以 B_2O_3 计)为9.5%。

本次研究结果显示,芙蓉锡矿床屋场坪矿区中的硼以独立矿物产出,主要有硼镁铁矿、遂安石和氟硼镁石3种,均为硼酸盐矿物,与磁铁矿、锡石密切共生。按化学组成,含硼矿物可分为硼硅酸盐矿物、硼铝硅酸盐矿物和硼酸盐矿物3种,但能够作为工业硼资源开发利用的主要是硼酸盐矿物,具体包括硼镁石、硼镁铁矿、天然硼砂、遂安石、钠硼解石、硬硼钙石、柱硼镁石等10余种(赵鸿,2007)。显然,芙蓉锡矿床屋场坪矿区中含硼矿物为工业可利用类型,其品位高于中国硼镁石型、硼镁铁矿型硼矿的最低工业品位(均为5%,以 B_2O_3 计),且略高于湖南常宁地区七里坪矽卡岩型硼矿的矿石品位(6.5%~8.8%)(赵鸿,2007)。因此,芙蓉锡矿床屋场坪矿区的硼完全可作为伴生矿产与锡矿一起开采利用。

2 地质意义

湘南地区燕山期花岗岩十分发育,并具有多挥发分和高分异等特点(毛景文等,2004)。在燕山期花岗岩体周围形成了众多与之相关的钨锡多金属矿床(图1b),矿床类型有矽卡岩型等多种。有的矿床钨锡均达工业利用价值,如香花岭 Sn-W-Pb-Zn 矿床和柿竹园 W-Sn-Mo-Bi-F 矿床;有的矿床钨达工业利用价值,如新田岭 W-Mo 矿床和瑶岗仙 W-Mo 矿床;有的则是锡达工业利用价值,如芙蓉 Sn 矿床和界牌岭 Sn-Cu-F 矿床(李厚民等,2021)。

在花岗质岩浆演化过程中,锡、硼等元素在残余熔体中不断富集(Yuan et al., 2018; 2019)。因此,高分异花岗岩中普遍富硼(Duke et al., 1992; Thomas et al., 2003)。国外与高分异花岗岩有关的、且有经济价值的矽卡岩型硼矿主要分布于俄罗斯塔约日诺耶-西伯利亚地区、韩国霍尔-科尔地区等(Dill, 2010)。该类硼矿在国内主要分布在湖南常宁地区、江苏六合地区等(孙浅等,2017)。矽卡岩型硼矿主要有遂安石、硼镁铁矿、硼镁石等硼酸盐矿物,其矿化伴随磁铁矿等铁矿物的沉淀而发生,主要发育在镁矽卡岩型外接触带最外带(Dill, 2010)。常宁地区大义山花岗岩体与中上石炭统壶天群富碳酸盐岩接触交代形成的矽卡岩外接触带附近,形成了受构

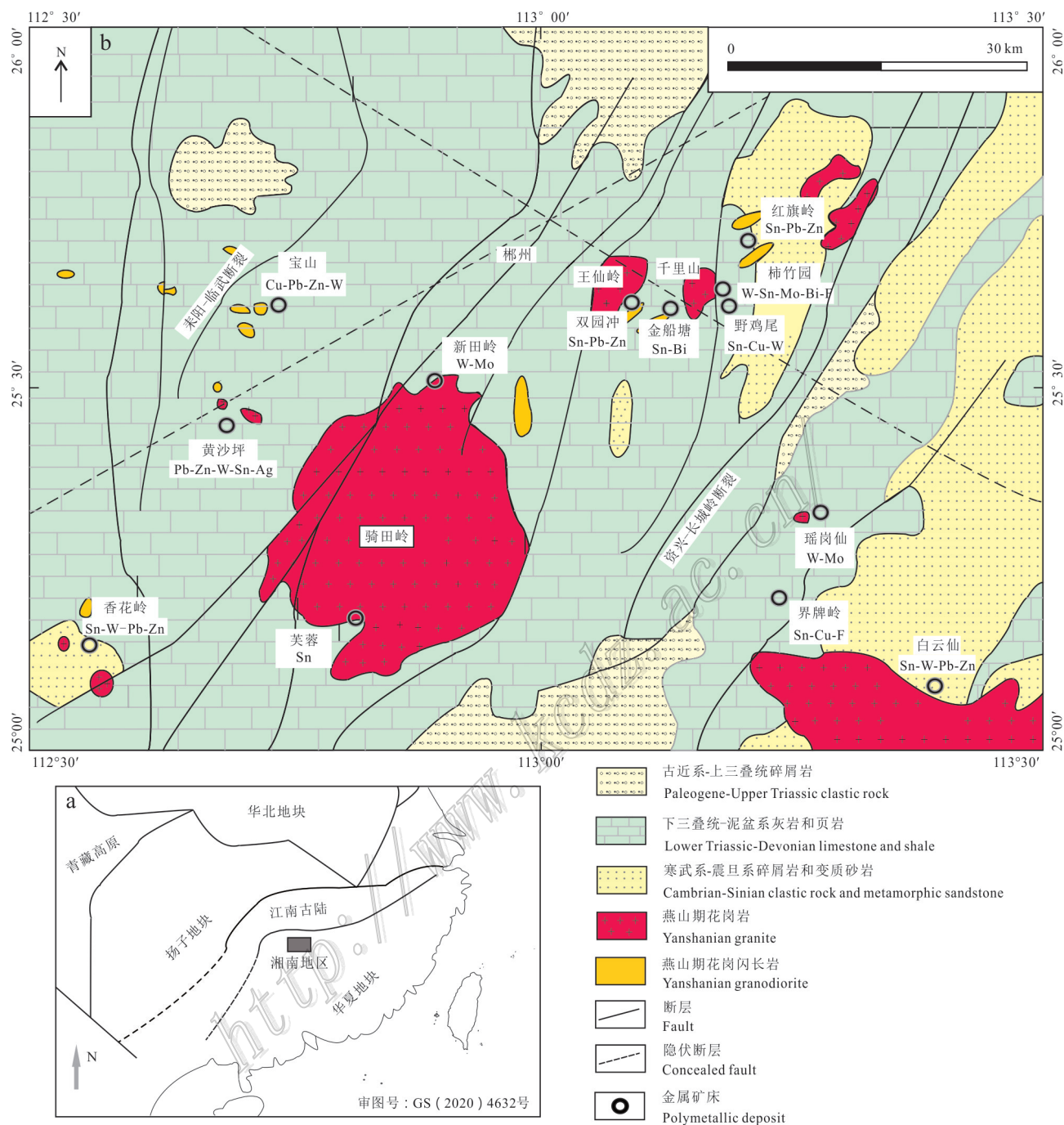


图1 湘南地区大地构造简图(a)与地质矿产简图(b,修改自Yuan et al., 2011)

Fig.1 Simplified tectonic map (a) and geological map of the southern Hunan area (b, modified after Yuan et al., 2011)

造带控制的七里坪和汤市铺硼矿(李昌元等,2015)。六合地区冶山花岗闪长岩体与上震旦系和下寒武统镁质碳酸盐岩的接触带及附近的构造裂隙中,形成了冶山硼矿(孙浅等,2017)。可见,中酸性富硼岩浆流体、镁质碳酸盐岩和断裂带是形成矽卡岩型硼矿非常重要的成矿要素。

湘南地区与中酸性高分异花岗岩相关的钨锡多金属矿床中很多都发育显生宙碳酸盐岩(袁顺达等,2012a;2012b;Yuan et al., 2015),具备形成矽卡岩型硼矿床的条件。本文芙蓉锡矿床屋场坪19号锡矿体中硼矿化的发现,预示着湘南地区,乃至华南地区有良好的硼成矿潜力,在今后的找矿过

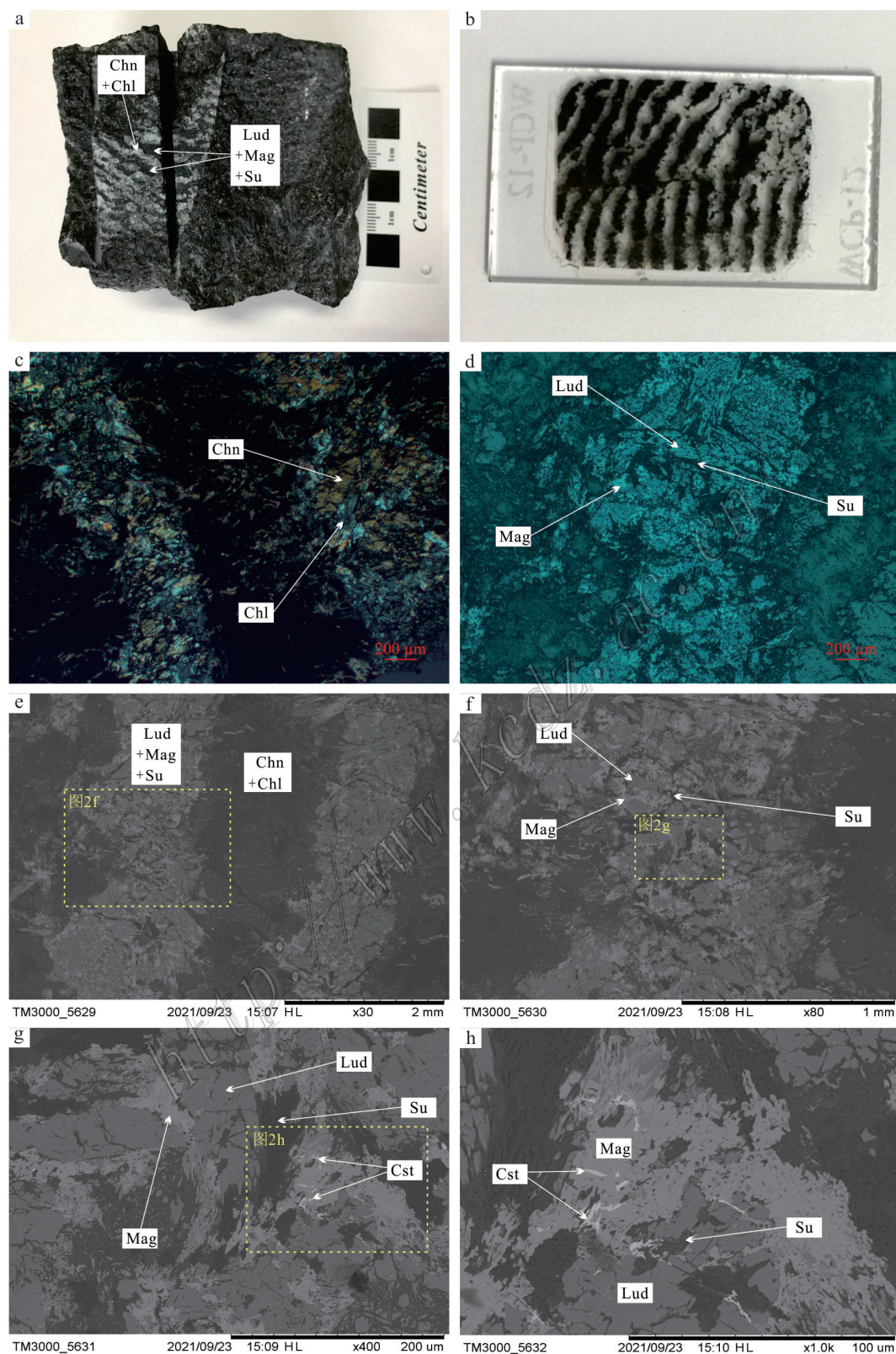


图2 芙蓉锡矿床屋场坪矿区硼矿化特征

a. 锡硼矿石标本; b. 锡硼矿石发育条带状构造; c. 粒硅镁石与绿泥石共生(正交偏光显微镜照片); d. 硼镁铁矿、遂安石、磁铁矿共生(反射光显微镜照片); e. 两组共生矿物组合界线清晰(背散射图像); f. 硼镁铁矿、遂安石、磁铁矿共生(背散射图像); g. 锡石呈浸染状与硼镁铁矿、磁铁矿等共生(背散射图像); h. 针状锡石与硼镁铁矿、磁铁矿共生(背散射图像)

Chn—粒硅镁石;Chl—绿泥石;Lud—硼镁铁矿;Mag—磁铁矿;Su—遂安石;Cst—锡石

Fig.2 Photographs showing boron mineralization of the Wuchangping mining district in the Furong tin deposit

a. Tin-boron ore; b. Thin-section of tin-boron ore with clear banded texture; c. Coexisting chondrodite and chlorite (cross-polarized light); d. Symbiosis of ludwigite, suanite and magnetite (reflected light); e. Dark bands (composed of ludwigite, suanite, magnetite and cassiterite) showing clear boundary with light bands (composed of chondrodite and chlorite) (BSE image); f. Coexisting ludwigite, suanite and magnetite (BSE image); g. Cassiterite coexisted with ludwigite and magnetite (BSE image); h. Needle-like cassiterite coexisted with ludwigite and magnetite (BSE image)

Chn—Chondrodite; Chl—Chlorite; Lud—Ludwigite; Mag—Magnetite; Su—Suanite; Cst—Cassiterite

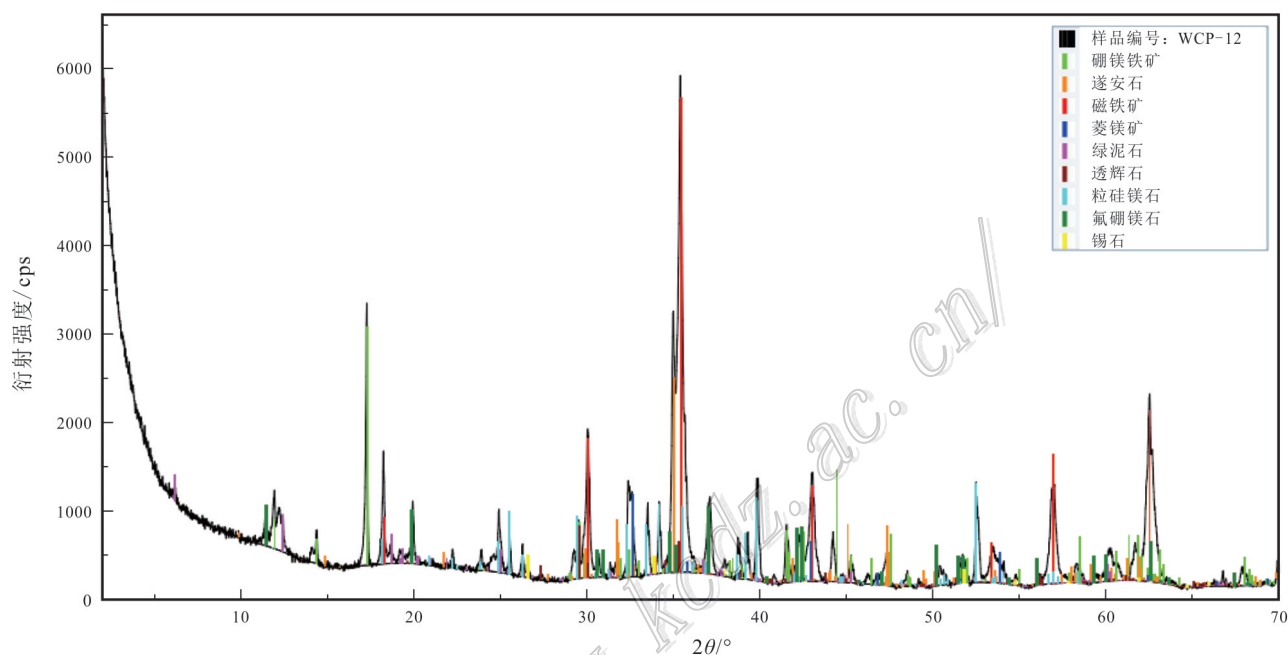


图3 芙蓉锡矿床屋场坪矿区锡硼矿石样品(编号:WCP-12)X射线粉晶衍射谱图

Fig.3 X-ray powder diffraction spectrum of the tin-boron ore sample (Number : WCP-12) in the Wuchangping mining district of the Furong tin deposit

程中,要特别关注该地区矽卡岩型钨锡多金属矿床中的硼矿化。

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