permeability and adsorption-swelling on high-rank coal reservoirs, this paper has analyzed the tertiary seepage characteristics of high-rank coal reservoirs, discussed the coupling effect of effective stress and coal matrix shrinkage on permeability of high-rank coal reservoirs, revealed the "bottle-neck" phenomenon that the productivity of coalbed methane(CBM)is high in the initial stages and attenuates rapidly after a few months in the course of development using the water drainage and pressure reduction methods, and found out the radical reason that leads to the reduction of methane recovery in high—rank coal reservoirs. Techniques and measures are suggested for developing CBM in high-rank coal reservoirs aiming at the particularity of physical properties of high-rank coal reservoirs.

Key words: high-rank coal reservoir; coalbed methane; effective stress; coal matrix shrinkage; "bottle-neck" problem; Qinshui basin

内蒙古东部与夕卡岩型矿床有关的花岗岩氧同位素特征——以浩布高矿床为例

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浩布高—白音诺铅锌铜锡矿床位于大兴安岭山脉的中南段和黄岗—甘珠尔庙锡铅锌成矿带的北东端(Chu, 2002)，属夕卡岩型矿床。已经发表的论文中提出浩布高—白音诺地区与 Cu-Zn-Pb(-Sn) 成矿有关的碱性花岗岩有非常特殊的、可低到－8‰～＋1‰的原始 $\delta^{18}O_{V\text{-}SMOW}$(‰)值，因此认为该区域岩浆具有不正常的原始氧同位素组分(张德全等，1993；牟保磊等，1997)，即该区深部存在低氧的岩浆源。国外也有类似的报道(Muehlenbaches et al., 1974; Auweral et al., 1991; Cartwright et al., 1991; Taylor et al., 1997)。为此，笔者对浩布高矿床与成矿有关的花岗岩体、矿体夕卡岩的全岩和从中分离出来的石英单矿物的氧同位素进行了进一步的分析研究。

1　地质背景

浩布高矿床位于内蒙古东部巴林左旗境内的一个中生代火山断陷盆地中的局部基底隆起区，矿区呈北东向长条状，矿区中部为下二叠统，南部出露上侏罗统，东部及西北部为早白垩世花岗岩体所占据。

矿区东部是乌兰坝花岗岩体，乌兰坝岩体中尚包裹有小罕山岩体。小罕山岩体具中等含量的 SiO_2、富碱，属碱性花岗岩系列。矿床中所有的 Pb、Zn、Cu 矿体都产于该岩体的外接触带，小罕山碱性花岗岩体与浩布高矿床 Pb、Zn、Cu 成矿有关(张德全等，1993)。

乌兰坝岩体系燕山晚期侵入体，主要岩性为黑云母花岗岩，岩石为富硅、碱，贫镁铁钙，富含 F、Cl，含大量的粗粒石英，与含锡花岗岩可以类比。矿区东北部 I 矿段部分夕卡岩及 Sn 矿体产于钾长花岗岩体与大理岩接触带上，该黑云母花岗岩体与锡成矿有关(张德全等，1993)。

2　氧同位素分析

对浩布高矿床小罕山碱性花岗岩、乌兰坝黑云母花岗岩、夕卡岩及其中石英单矿物进行了氧同位素分析。小罕山花岗岩体以长石矿物为主，由于长石是极易蚀变的矿物，不能充分真实反映氧的初始来源。因此本次工作中我们从大量的岩石样品中挑选出对蚀变作用有强抵御能力的石英单矿物进行分析。分析结果见表1。

表 1　氧同位素分析结果

Table 1　The $\delta^{18}O_{V\text{-}SMOW}$(‰) compositions

样品号	岩体(或矿体)	岩性	$\delta^{18}O_{V\text{-}SMOW}$(全岩，‰)	$\delta^{18}O_{V\text{-}SMOW}$(石英，‰)
W2418-12	矿体	夕卡岩矿体	－0.29	
W2418-19	矿体	夕卡岩矿体	－6.09	
W2420-1	乌兰坝岩体	黑云母花岗岩	4.78	7.06
W2418-25	乌兰坝岩体	黑云母花岗岩	1.38	8.51
W2418-31	矿体内	夕卡岩	－3.5	
W2419-5	矿体内	夕卡岩	－1.75	－0.09
W2419-18	矿体	夕卡岩矿体	－2	
W2419-40		岩脉	－0.33	
W2420-5	小罕山岩体	碱性花岗岩	－1.75	9.89
W2420-6	小罕山岩体	碱性花岗岩	0.91	9.22
W2420-7	小罕山岩体	碱性花岗岩	－8.61	4.09
W2420-8	小罕山岩体	碱性花岗岩	－6.75	5.31
W2418-24	小罕山岩体	碱性花岗岩	－8.81	

注：氧同位素分析在中国科学院地质与地球物理研究所矿物资源研究重点实验室李铁罕完成。数据均为相对于国际标准 V-SMOW 之值。使用质谱型号：Finnigan MAT Delta S。分析精度：标准偏差为 0.1‰。

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The Mangshan Loess in Central China and Paleomonsoon Characteristic since the Last Interglacial Stage

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Abstract

The Mangshan Yuan is a loess platform on the southern bank of the Yellow River, which is located in northwestern Zhengzhou of Henan Province, China. The typical Zhaoxiayu section of the Mangshan Yuan preserves stratigraphical loess units above S_{10} with a total thickness of 172.1 m, which includes 15.7 m of the last interglacial paleosol S_1, 77.3 m of the last glacial loess L_1 that consist of 41.6 m of the late stade L_1LL_1, 13.2 m of the interstade L_1SS_1 and 22.5 m of the early stade L_1LL_2. Based on the age marking points by correlating magnetic susceptibility of the section with the SPECMAP curve, the timescale of the section was constructed, and the average accumulation rate and the resolution of each loess strata over the S_2 were subsequently calculated using the susceptibility age model. The results indicate that strata units developed in the glacial, interglacial stages, stadial and interstadial show substantial differences in grain size, average accumulation rate and time resolution in the Zhaoxiayu section. Specifically, the average accumulation rate of the loess L_1LL_1 is 3.45 mm/a, whereas that of paleosol S_1 is only 0.28 mm/a. Based on the high-resolution records of magnetic susceptibility and >45 μm fraction percentage of the loess-paleosol, the summer and winter monsoon variations as well as their interrelations since the last interglaciation have been discussed, which were correlated with the SPECMAP and the GRIP climate records.

Key words: loess; magnetic susceptibility; grain size; paleomonsoon; Mangshan, Henan Province

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从表1明显看出，浩布高矿床与 Pb、Zn、Cu 成矿有关的小罕山碱性花岗岩体的全岩 $\delta^{18}O_{V\text{-}SMOW}$(‰)值多为负值，最低为－8.81‰，小罕山岩体石英单矿物 $\delta^{18}O_{V\text{-}SMOW}$(‰)均为正值，最高为＋4.09‰～＋9.89‰。石英是最不易蚀变的矿物，石英的 $\delta^{18}O_{V\text{-}SMOW}$(‰)值相对能代表岩石形成初始的氧同位素的值。因此可以认为初始岩浆氧同位素值应是正常值，而非负值；矿体夕卡岩及夕卡岩中石英的 $\delta^{18}O_{V\text{-}SMOW}$(‰)值均为负值，表明夕卡岩矿体形成时成矿热液以天水为主；与锡成矿有关的乌兰坝黑云母花岗岩的 $\delta^{18}O_{V\text{-}SMOW}$(‰)为较低的正值(约＋1.38‰～＋4.78‰)，其中的石英单矿物为较高的正值(＞＋7‰)，也说明该岩体受到天水的影响而发生了蚀变反应，但该岩体含较丰富的不易蚀变的石英矿物，因此，全岩的 $\delta^{18}O_{V\text{-}SMOW}$(‰)值相对高于小罕山岩体。此外，我们进行的花岗岩全岩分析及薄片的镜下鉴定都反映了天水的蚀变作用。

3 结论

浩布高矿床小罕山及乌兰坝花岗岩体全岩及岩体中石英单矿物的氧同位素分析等研究均反映了浩布高矿床花岗岩经历了来自天水的强烈蚀变作用，改变了其氧同位素组成。该矿床中硅酸盐、碳酸盐等夕卡岩矿物成矿流体明显来自初始天水，因此可以认为在花岗岩体侵入时循环天水的蚀变作用引起了本区花岗岩体的氧同位素改变和夕卡岩矿床的形成。

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