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Geochronology and Geochemistry of the Permian Volcanic Rocks in the Heifengshan Fe-(Cu) Ore District, Eastern Tianshan, NW China

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1 Introduction

The Eastern Tianshan is characterized by prolonged and complex crustal accretionary and collisional processes with intense crustal-mantle interaction during the Late Paleozoic period (Xiao et al., 2003; Windley et al., 2007), which is a key area for understanding the Paleozoic evolution of the Central Asian Orogenic Belt (CAOB). However, various models have been proposed to explain the complex geodynamic evolution of the eastern Tianshan during this period (Windley et al., 2007; Mao et al., 2008).

The north of the Eastern Tianshan consists of four main tectonic units separated by east-west-trending faults including Dananhu-Tousuquan arc belt, the Kanggurtag belt, the Aqishan-Yamansu belt and the Central Tianshan belt. The Aqishan-Yamansu is an important polymetallic belt in China and host numerous Fe (-Cu) deposits or occurrences (eg., Yamansu, Shaquanzi, Shungfengshan and Heifengshan, etc). Recently, late Paleozoic basalt and rhyolite are recognized within Heifengshan Fe (-Cu) ore district in the Aqishan-Yamansu belt, which provides an opportunity to reconstruct the tectonic evolution of the Eastern Tianshan belt.

This paper presents the LA-ICP-MS zircon U-Pb age of rhyolite and major and trace element data of basalt and rhyolite cropped out in Heifengshan Fe (-Cu) ore district. These new data will help to understand the geodynamic background of this critical late Paleozoic period in the history of the CAOB.

2 Geological Setting and Petrography

Heifengshan Fe (-Cu) deposit is located about 200 km

southeast of Hami city, east of Xinjiang, NW China. In the mining area, the exposed strata include the Early Carboniferous Dikan'er Formation (Fm.), the Early Permian Aqikebulak Fm., and Cenozoic rocks. The Dikan'er Fm. are composed of intermediate-felsic volcanic rocks, pyroclastic rocks intercalated with carbonate rocks. The Aqikebulak Fm. consists of clastic sedimentary rocks, carbonate rocks intercalated with minor volcanic rocks including basalt, rhyolite and intermediate-felsic tuff. The main intrusive rocks in the mining area are diorite and granite dating at 274.4 Ma (inner data). The iron deposit occurs in the tuff of the Dikan'er Fm. and the contact belt between the Early Permian diorite-granodiorite and volcanic rocks of the Dikan'er Fm.

The rhyolite in the Aqikebulak Fm. has a porphyritic texture with K-feldspar (8%) and quartz (5-7%) phenocrysts distributed in the groundmass. The accessory minerals include zircon and titanite. The basalt is generally black-green in color, and shows porphyritic texture, with the phenocrysts being dominated by clinopyroxene (12%), olivine (8%) and plagioclase (20%).

3 Zircon U-Pb Geochronology

Zircon grains were separated from one rhyolite sample. These grains contain $18.5-90.9 \times 10^{-6}$ U and $20.8-224 \times 10^{-6}$ Th, with Th/U ratios of 0.63-2.47. A total of 19 spot analyses yielded a weighted mean $^{206}\text{Pb}/^{238}\text{U}$ age of 285.3 ± 2.6 Ma (MSWD = 0.15). This age is interpreted as the eruption age of the rhyolite.

4 Geochemistry

The basalt samples have a narrow range of SiO₂ (47.8-

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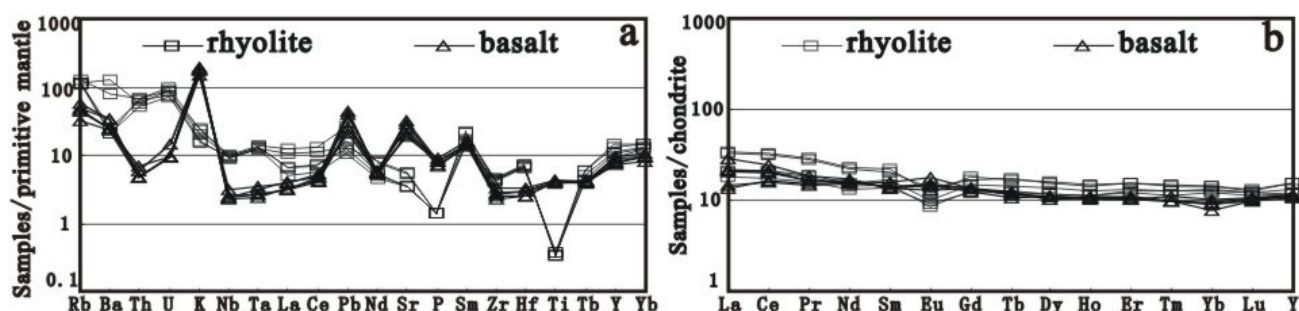


Fig. 1. Plots of primitive mantle-normalized trace elements patterns (a) and chondrite-normalized REE patterns (b) of the volcanic rocks in the Heifengshan Fe-(Cu) ore district .

50%), CaO (9.3-10.2%) and relatively low TiO_2 (0.76-0.87%) contents. The Mg# values vary from 0.42 to 0.50. All samples display obvious negative Th, U, Nb, Ta and P anomalies, positive Ba, Sr and Pb anomalies. They are uniformly enriched in LREE relative to HREE with low $(\text{La}/\text{Yb})_n$ ratios (1.4-3.6) with weakly positive Eu anomalies ($\text{Eu}/\text{Eu}^*=0.96-1.23$) (Fig. 1).

The rhyolites have 74.0-75.0% SiO_2 , 13.1-13.3% Al_2O_3 and 1.62-2.11% CaO. They are characterized by negative Sr, P and Ti anomalies, positive Th, U, Nb, Ta and Pb anomalies. They exhibit LREE enrichment $((\text{La}/\text{Yb})_n = 1.5-2.4)$ and obvious negative Eu anomaly ($\text{Eu}/\text{Eu}^* = 0.62-0.73$) (Fig. 1).

5 Discussion and Conclusions

The basalts display significant enrichment in LILE and depletion in HFSE with negative Nb-Ta anomalies (with $(\text{Nb}/\text{La})_N$ of 0.58-0.78), suggesting affinities with subduction-related rocks or continental crustal rocks. The low Th concentrations, Nb/La (0.6-0.8) and La/Sm (1.0-1.3) ratios excludes the contamination by continental crusts. The Nb/Ta (8.5-17), Zr/Hf (39-54), Ce/Pb (1.2-2.2) as well as Nb/U (5.3-11) ratios suggest that the source have subducted fluid. The relatively low Th/Nb (0.22-0.31) and high Ba/Th (283-600) ratios suggest the addition of subducted sediments. The low Mg# values and the correlation between MgO and oxides indicate that olivine, clinopyroxene and apatite fractionated from the parental magma.

The rhyolites display enrichment in LREE, Zr and Hf, and depletion in Sr, Eu, Nb, Ta, P and Ti, which is different from the weakly negative P, Ti anomalies and positive Sr and Eu anomalies of basalts. The HFSE/HFSE ratios (e.g. Zr/Nb, Zr/Hf and Nb/Ta) change much between rhyolites and basalts. Therefore, the rhyolites are not the products of fractional crystallization of basaltic magmas and they should be derived from different parental magmas. The rhyolites have high value of $\varepsilon_{\text{Hf}}(t)$ (6.7-15.8) and young crustal model ages (377-669Ma), suggesting that they were generated by partial melting of

juvenile lower crust.

All rhyolite and basalt samples plot in the volcanic arc field in the classification diagrams of tectonic setting. In the FeO^T/MgO vs TiO_2 diagram, all basalts exclusively plot in the field of BABB. Combined the previously researches, we suggest that these volcanic rocks represent magmatism results of period of postcollisional extension. We considered that the delamination of lithosphere led to the upwelling of asthenospheric mantle and underplating during the Permian because of the tectonic transition from compression to extension. The heat released from asthenosphere mantle triggered melting of juvenile lower crust.

In conclusion, the rhyolite from Aqikebulak Fm. in Hefengshan region emplaced in the Early Permian (285.3 ± 2.6 Ma). The volcanic rocks of the Aqikebulak Fm. were results of magmatism in post-collision setting. The vertical crustal growth through mantle-derived magmas in post-collisional setting played a major role in the Eastern Tianshan in the late Paleozoic.

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