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# Geochemistry of Adakitic Rocks and Cu-Au Mineralization in the Tianzishan Region, West Qinling orogenic belt

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## 1 Geological Setting

West Qinling orogenic belt is located in the abdomen of China, developing the Indosinian granite, and the Au deposit enriched. Tianzishan area located in Liziyuan village, Beidao district of Tianshui, Gansu province, is situated in West Qinling orogenic belt. Tianzishan rocks is located in the splicing turning parts between North Qinling Caledonian orogenic belt and Middle Qinling Hercynian fault fold belt, under the control of Shujiaba deep fracture, which is intruded into the lower Neoproterozoic Muqitan Formation and Paleozoic Taiyangsi Formation. The wall rock shows different degrees of alteration, such as angle alteration, silicification and sericitization. Tianzishan rocks are mainly consists of monzogranite, whose mineralization is controlled by NW trending ductile shear zone.

## 2 Geochemistry

The collected samples of Tianzishan monzogranite are with high $SiO_2$ content ranging from 68.14%~69.92%. The $K_2O$ and $Na_2O$ have little difference, with an average $Na_2O/K_2O$ of 1.01, slightly enriched in Na. The $Al_2O_3$ contents are high, ranging from 15.08%~15.36% (Xin et al., 2013), indicating that Tianzishan monzogranite belongs to alkali metaluminous rocks.

In the trace element composition, samples from Tianzishan monzogranite show enrichments of La, Th, K and other large-ion lithophile elements (LILEs). High field strength elements (HFSEs), such as P, Ti, Nb, Ta, shows significantly negative anomalies.

The Tianzishan monzogranite is characterized by depleted in HREE, enriched in Sr contents (579~1120ppm), Ba contents (2350~2470ppm), Sr/Y value (64.10~132.32), and La/Yb value (56.33~ 75.19), and low Y (7.86~10.2ppm), Yb contents (0.72~0.98ppm), with geochemical characteristics of adakites.

## 3 Petrogenesis

The Mg#-$SiO_2$ and Sr/Y-$(La/Yb)_N$ diagrams (Fig. 1), show that Tianzishan rocks belong to C-type adakitic rock, illustrating the formation related to the melting of the thickened lower crust. According to the $SiO_2$ content and $TiO_2$, $P_2O_5$ content related diagrams. Tianzishan adakite is formed in the high temperature of 800~900℃. Tianzishan

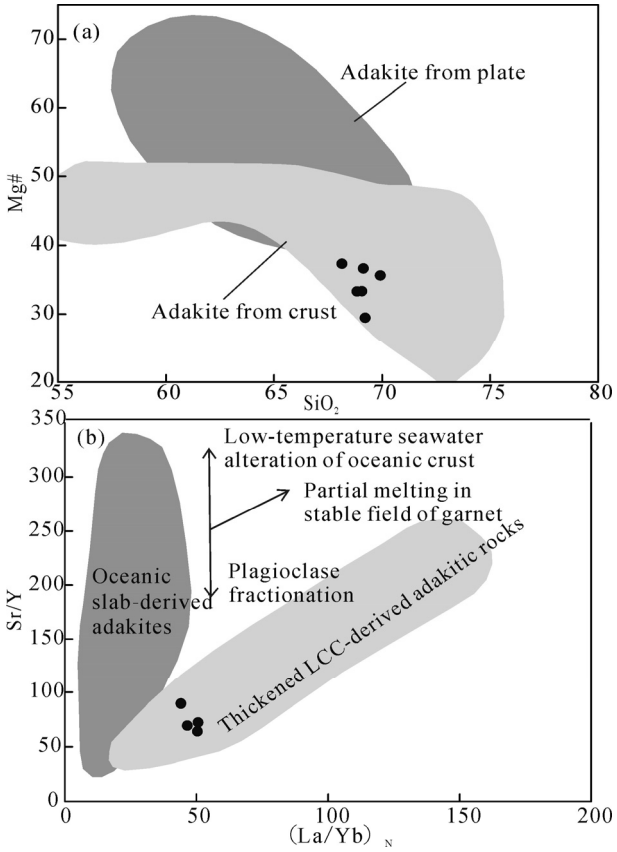


Fig. 1. a) $SiO_2$ vs. Mg# diagram of Tianzishan adakitic rocks; b) Sr/Y vs. $(La/Yb)_N$ diagram for Tianzishan adakitic rocks.

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adakitic magmas in crustal temperature range, has not enough heat to melt the mantle completely, and verifying that the Tianzishan adakite should be formed by partial melting of the thickened lower crust.

The characteristics such as depletion of HREE, low Y and Yb content, Y/Yb ratio ranging from 10.41~10.92, show that garnet and amphibole should exist in the residual phase. Because of the loss of Nb, Ta and Ti, the magma source may have rutile residue, indicating the melting pressure higher than 1.5GPa (Ernst and Liu, 1998), equivalent to more than 50km. High Sr and Ca content and no Eu anomalous show the its source should have little or no plagioclase residue, and there has no fractional crystallization of plagioclase. Furthermore, the alkali metaluminous feature shows that the source rocks should be composed of basaltic rocks. Thus, the original rock of Tianzishan rocks may be the high pressure eclogite basaltic rock composed of garnet, pyroxene and rutile (no plagioclase), and the formation process should be like that the crust thickened resulted from the mantle derived magma underplating in late collision stage of orogeny, and the geothermal gradient increased, leading to partial melting of new underplating basaltic rock.

Zircons of Tianzishan monzogranite U-Pb dating yields an age of 256.1±3.7~260.0±2.1Ma, which the value of zircon epsilon Hf(t) is -5.1～-14.1, with the average second stage of zircon Hf model age of 1551±86Ma (Yang et al., 2012), suggesting that the magmas of the Tianzishan monzogranite were derived from partial melting of crustal sources under the regional extrusion background.

## 4 Tectonic and Metallogenic

Most gold and adakite have correlation in temporal and spatial distribution of gold deposit in West Qinling orogenic belt, and many wall rocks of gold ore are adakite, breeding in generality similar temperature-pressure conditions, such as Dashui gold deposit and Shuangwang gold deposit of Shanxi. The reason of adakitic magmas in favor of Au and Cu mineralization maybe like that the adakitic magmas are characterized by high water content, oxygen fugacity and sulfur enrichment, and the source of rocks are abundant of Cu and Au, also the formation needs high temperature and pressure, so that the amphibole dehydration melting brings a large amount of fluid to the extraction of ore-forming elements. The close relationship between most Cu-Au deposits and the C-type adakite suggests that the Cu and Au should be mainly derived from basalt instead of the mantle, as the average content of Cu and Au in the basalt is higher than that in the mantle. The data of Tianzishan adakite indicates that it is formed in Indosinian period. In that period, the collision between north China plate and southern China plate leads to the thickened crust of Qinling orogenic belt, ductile shearing and metamorphism. Tianzishan adakitic magma occurred at depths more than 50km, a large amount of water released from the decomposition of amphibole, with volatile matter (such as $CO_2$) and silicon released from the rock, composed the metamorphic fluid, which forms the mineralization fluid in the process of migration activation, migration and enrichment of ore elements (Au, Ag, Cu) .As the ore fluid migration to the ductile shear zone, the pressure fluctuation caused the immiscibility of ore-forming fluid, so that the gold and sulfide are precipitated to form the Cu-Au deposit. The fault structure of Tianzishan monzogranite is intense, which leads to the ore beared hydrothermal easily accumulated in rock, and the wall rocks mineralized along the fissures. So far, six epithermal gold deposits, one medium and small gold deposit and four occurrences have been found and explored surrounding Tianzishan monzogranite (Yin and Yin, 2009). All above shows that the gold deposits in this area has great potential.

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