Metallogenic Environment Changes During the Late Carboniferous to Early Permian for Iron and Copper Deposits in the Awulale Region, Western Tianshan, China

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The Central Asian orogenic belt, as the largest Phanerozoic accretionary terrane on Earth, has been endowed with abundant Fe and Cu deposits due to its complex tectonic and magmatic evolution during the Paleozoic. Recently, a series of large Fe and Cu deposits have been discovered in the Awulale region, western Tianshan, China, which is located along the southwestern margin of the Central Asian orogenic belt. The Fe and Cu deposits in the Awulale region tend to be formed in different geological epochs.

Sm-Nd isochrons of garnet intergrown with magnetite indicate that the Chagangnuoer Fe deposit possibly formed ca. 316.8 ± 6.7 Ma. At the Zhibo Fe deposit, LA-ICP-MS analyses of titanite from ore samples yield U-Pb ages of between 310 and 315 Ma. Dioritic intrusion closely associated with the Wuling Fe deposit gives a zircon U-Pb age of 307.7 Ma, which provides the bottom limit constraining the time of Fe mineralization. These geochronological results prove that Fe deposits in the East Awulale belt were probably formed in the late Carboniferous. Contrastingly, Cu deposits in the West Awulale belt are hosted in Early Permian igneous rocks and, specifically, the causative diabase for the Qunji Cu deposit is represented by a zircon LA-ICP-MS U-Pb age of 290 Ma, probably demonstrating that these Cu deposits were deposited in the Early Permian.

Recent research indicates that the Fe deposits and their volcanic hosts in the Awulale region were generated in a strike-slip extensional arc. A large number of whole-rock geochemical analyses of the late Carboniferous igneous rocks in western Tianshan show that they were chemically similar to those formed on a volcanic arc. The ophiolites on the northern margin of western Tianshan contain cumulate gabbro with a zircon SHRIMP U-Pb age of ~344 Ma, and Late Devonian to early Carboniferous radiolarian and conodont microfossils hosted in radiolarian cherts. The ophiolites were intruded by anorthosite with a zircon SHRIMP U-Pb age of ~325 Ma. Early Carboniferous (ca. 320 Ma) Nb-enriched basalts and basaltic andesites and late Carboniferous (ca. 306–310 Ma) calc-alkaline andesites, dacites, and rhyolites were reported from the northern margin of western Tianshan. Bimodal magmatism consisted of gabbro and granite and took place contemporaneously in the late Carboniferous only along the Awulale Mountain. In the West Awulale region, numerous chemical results show basalts have an affinity comparable with intracontinental extensional basalt, and alkaline volcanic rocks and intrusive rocks are widely developed. Permian bimodal volcanic rocks composed of alkaline basalt and rhyolite are localized in the district. Symmetrical N-S–oriented sedimentary sequences were exposed in the Awulale region, among which the sediments at center were deposited earlier than those on the edges.

Therefore, we propose a strike-slip extensional arc for the Carboniferous Fe deposits, but a shallow extension-deep delamination setting for the Permian Cu deposits in the Awulale region, respectively. The transformation from Carboniferous subduction to Permian postcollisional extension may have triggered the accumulation of huge Fe resources in the Awulale region which was superimposed by a later Cu mineralization event.