The timing of iron mineralization in the Awulale iron metallogenic belt, Western Tianshan, China: Constraints from Sm-Nd garnet and U-Pb titanite geochronology

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Western Tianshan (Xinjiang, NW China) has long been known as an important metallogenic province in the Central Asia Orogenic Belt (or Altaids). Several high-grade iron deposits have been recently discovered in this region, constituting the Awulale iron metallogenic belt (AIMB). The majority of these iron deposits are hosted by volcanic and volcaniclastic rocks of the Carboniferous Dahalajunshan Formation, and it has been suggested that the two are genetically linked. While many geochronological investigations have been carried out on the volcanic host rocks, the age of mineralization at AIMB has not been constrained unequivocally, in part due to the general lack of minerals suitable for radiometric dating. Here we present Sm-Nd isochron age on garnet and LA-ICP-MS U-Pb ages on titanite from the Chagangnuoer and Zhibo deposits at the AIMB. These results provide a robust constraint on the timing of iron mineralization and its temporal relationship to the volcanism in the AIMB.

Garnet separated from ores of Chagangnuoer yielded a Sm-Nd isochron age of 316.8 ± 6.7 Ma (MSWD=1.9, n=7) that is interpreted as the formation age of the deposit. In situ LA-ICP-MS U–Pb analyses of titanite from three ore samples of Zhibo yielded ages of 310.0 ± 2.1 Ma, 310.6 ± 2.6 Ma, and 315.2 ± 2.8 Ma. These ages of titanite are considered to record the main stage of iron mineralization because of its: (1) intergrowth with magnetite; (2) trace element characteristics of hydrothermal origin; and (3) relatively high closure temperature for the U-Pb system (600–700°C). The age of mineralization at Zhibo is constrained at 310-315 Ma, which is within error of the ~316 Ma Sm–Nd garnet age from the adjacent Chagangnuoer deposit. These results indicate that Zhibo and Chagangnuoer deposits have formed more-or-less coevally in a single metallogenic episode generated by magmatic-hydrothermal activity within the same volcano.

A prolonged volcanism event (330–321Ma) that occurred prior to mineralization in this region have been recognized by previous studies. The iron mineralization at the Zhibo and Chagangnuoer deposits formed very shortly after the eruption of the calc-alkaline volcanic rocks. The close spatial and temporal association between the majority of the deposits and widespread volcanic rocks in the AIMB suggests that this prolonged volcanism event may be fundamental to iron mineralization as it provided large amounts of metals and ore-forming fluids. In addition, oxygen isotope (δ18O) of magnetite (avg. 2.7‰, n=56) and sulfur isotope (δ34S) of pyrite (avg. 2.6‰, n=53) from Chagangnuoer and Zhibo deposits, confirm a primary magmatic origin for the metals and fluids at the AIMB. Iron mineralization at AIMB was ascribed to be volcanogenic, the significant iron enrichment being assumed to have been transported by Fe-rich fluid originating from the arc magma along the Western Tianshan.