

Micromineralogy of the Aegirine-type ore of the East Orebody of the supergiant Bayan Obo REE-Nb-Fe deposit, China

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INTRODUCTION

The Bayan Obo deposit is located in Baotou City, Inner Mongolia Autonomous Region of China. It is the Earth's largest known deposit of Rare Earths (REE), the second one of niobium and also, a large iron deposit. The whole mining district covers an area of ca. 328.64 km², which extends along the northern margin of the North China Craton. Adjacent to the Central Asian Orogenic Belt it is primarily governed by the nearly east-west-oriented Wulanbaolige Deep Fault and the Kuangou Fault (Xiao et al., 2003). The ore-bearing layer is hosted by a dolomite Jiashan Formation which extends nearly 20 km in an east-west direction, with a central thickness of about 100-500 m, tapering to around 50-100 m at both ends. Three orebodies are distinguished within this formation: the main, the eastern and the western bodies.

The eastern orebody is conformably oriented with stratification trending NNE (70°) and southward dipping 60-70°. It shows little change in thickness at depth and a gentle decline in its orientation (Zhao, 2014). Its main host rock is a dolomitic volcanic rock with a micro-porphyritic texture (Wang et al., 2010) and contains different types of REE-rich ores: riebeckite type, aegirine type, massive type and banded type (Wang et al., 2023). The REE-rich aegirine-type ore mainly contains aegirine, magnetite, hematite, rare earth minerals, fluorite, barite, apatite, amphibole, dolomite and calcite. Iron-rich minerals are magnetite, hematite and pyrite, while the REE minerals are predominantly bastnäsite-(Ce), monazite, parisite-(Ce) and huanghoite-(Ce). In addition, aeschynite and pyrochlore are the main niobium minerals. The REE minerals typically occur as small particles and often exhibit an impregnated microtexture. The mineral assemblages of this deposit are complex and diverse. To explore the complex mineral assemblages, this study employs a combination of a polarized light microscope and a scanning electron microscope for backscattered electron imaging analysis of thin sections, along with an energy-dispersive spectrometer for micro-area compositional analysis of the samples. This approach deepens our understanding of the mineral coexistence relationships within the Bayan Obo deposit.

RESULTS AND DISCUSSIONS

The studied samples come from a magnetite-rich layer located within the dolomitic mineralization zone of the East ore body; the sampled ore is classified as REE-rich aegirine type. In hand-specimen, this ore type consists of interlayered purple fluorite and aegirine bands, meanwhile under the polarized light microscope, a complex mineral assemblage is revealed made up of aegirine, quartz and minor muscovite, Fe-Ti oxides (magnetite and minor ilmenite and rutile), phosphates (apatite and some monazite), along with the REE minerals bastnäsite [(Ce,La)(CO₃)F] and huanghoite-(Ce) [BaCe(CO₃)₂F], as well as barite and fluorite. Aegirine forms subidiomorphic elongated prisms or irregular grains 40 to 200 µm in size often enclosing magnetite with bastnäsite. The latter fluor carbonate hosting frequent inclusions of thorite is the most abundant REE mineral in the sample being found as irregularly-shaped aggregates (approximately 10-50 µm) embedded (occasionally intergrowth) in the ground mass of aegirine and quartz, often intergrown with parisite [Ca(Ce,La)₂(CO₃)₃F₂] and aeschynite-(Ce) [(Ce,Ca,Fe)(Ti,Nb)₂(O,OH)₆]. Often these aggregates are replaced by huanghoite-(Ce) during the crystallization of barite. These mutual textural relationships suggest that huanghoite-(Ce) may have formed by the metasomatic alteration of bastnäsite by a Ba-

rich fluid that also promoted the crystallization of barite (Jin et al., 2020). Fluorite becomes concentrated in discrete bands but also occurs in aegirine-, quartz-, bastnäsite- and magnetite-rich bands serving as the matrix for all these other minerals (Fig. 1). Subidiomorphic and idiomorphic crystals of magnetite (<90 µm) are also found interstitially in aegirine as well as inclusions in fluorite, bastnäsite, and huanghoite-(Ce). Ilmenite ~20 µm in size, coexist closely intergrown with rutile, forming scattered aggregates in fluorite. Apatite forms rounded granular aggregates (approximately 10-50 µm) enclosed by fluorite and shows signs of having encapsulated magnetite crystals. Monazite is found as very fine subautomorphic grains (around 20 µm) in close relationship with apatite, in fluorite.

The crystallization sequence of minerals can be divided into four stages: (1) Silicate-oxide stage that formed the primary banded assemblage dominated by the crystallization of aegirine, quartz and muscovite, and the almost contemporaneous crystallization of magnetite, rutile and ilmenite found as inclusions and intergranular to these silicates. (2) Phosphate stage including the crystallization of apatite and monazite and partly overlapping the crystallization of Fe-Ti oxides. (3) REE carbonates stage where crystallization of thorite-bearing bastnäsite along with parisite $[\text{Ca}(\text{Ce},\text{La})_2(\text{CO}_3)_3\text{F}_2]$ and eschynite-(Ce) $[(\text{Ce},\text{Ca},\text{Fe})(\text{Ti},\text{Nb})_2(\text{O},\text{OH})_6]$ prevailed by replacing the previously formed silicate-oxide assemblage. During this stage, some grains of bastnäsite reacted with Ba- and sulfate-rich fluids, becoming partly replaced by huanghoite-(Ce) coevally with the crystallization of barite. (4) Fluorite stage characterized by extreme dissolution of previous assemblages and extensive crystallization of fluorite due to high fluid intergranular flow, leaving behind remnants of the partially dissolved silicates, oxides, phosphates and REE carbonates.

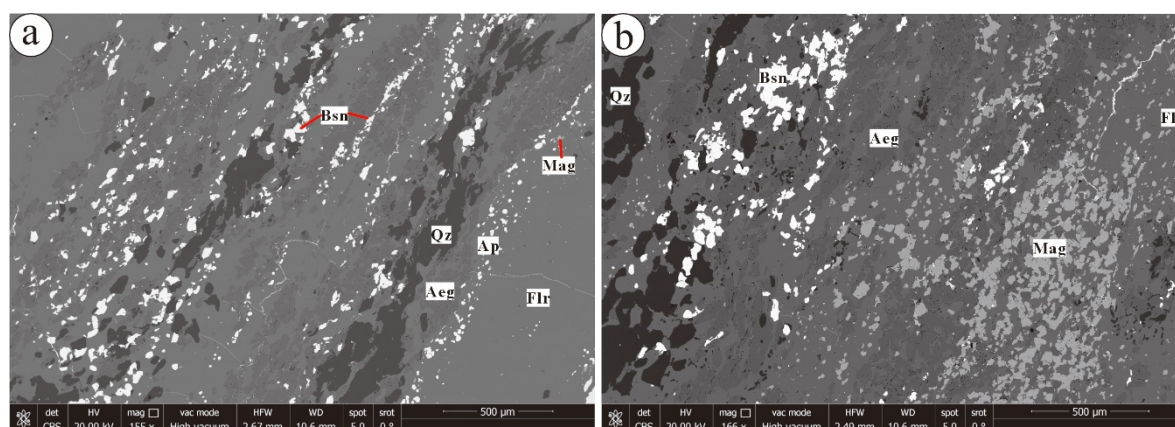


Fig. 1. Back-Scattered Electron Images of a the studied, banded Aegirine-Type Ore. Aeg: aegirine; Q: quartz; Mag: magnetite; Ap: apatite; Bas: bastnäsite; Fl: fluorite.

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