1 Introduction

The Yamansu iron deposit is a large open-pit iron ore mining area in the Eastern Tianshan Mountains. Previous studies had been focusing on geology, geochemistry and metallogenesis of the deposit. However, the study of the mechanism of skarn mineral formation and mineralization correlation are still lack. This study focuses on major skarn minerals and magnetite using electron microprobe to investigate the mechanism of skarn and the relationship between skarn and magnetite, in order to provide new information for further research and mineral exploration.

2 Deposit geology

The main outcropping strata are Upper Yamansu Formation of Lower Carboniferous. It is composed of shallow marine volcanic intercalated with clastic rocks. The orebody occurs in the second lithological alteration associated with andesitic tuff crystalline limestone formations. The skarn alternation near the wall rock is strong, mainly as garnet skarn and complex skarn. A total of 23 ore bodies is hosted in Yamansu iron deposit, which occurs as layered, stratoid or lenticular. The spatial distribution of the mineralization is controlled by fault structures. Orebody Fe1 is in larger scale which is 940m-long with an inclined extent is more than 540m; the average grade of the iron deposit is 51.43%.

The dominant ore mineral is magnetite with lesser amount of pyrite, hematite, sphalerite, chalcopyrite, etc. Gangue minerals are mainly skarn, including garnet, diopside, tremolite, epidote, actinolite, etc. The main textures of iron ore are subhedral-xenomorphic granular with metasomatic replacement. The ore occurs as aggregated and disseminated, locally banded.

Magnetite can be divided into two types. Most of the early magnetite are anhedral-subhedral and granulous. It is generally smaller and mostly densely aggregated, often associated with silicate minerals, such as garnet. Most of the later magnetite is coarse-grained and crystallined, in which often associated with epidote, chlorite, feldspar and actinolite.

Garnet is one of the more common gangue minerals in magnetite ore and can be classified into two types: Type one is densely aggregated fine-grained garnet, light brown-reddish brown, subhedral-euhedral grain, particle size about 0.14 to 1.16 mm. The second category is coarse-grained garnet, dark brown-dark red. The diameter varies from 0.15 to 2.15 mm, subhedral-euhedral granular, with pentagonal dodecahedron and corners octahedron structure. Most of them show concentric rings and twin crystals. The rims of some garnet were replaced by late hydrothermal fluids which gives bright edges.

3 Electron microprobe results

52 garnet samples were examined by electron microprobe analysis which shows the key garnet end-member component as andradite (And) varies from 45.68% to 100% (63.59% in average); subsequently as andradite, which ranges Gro = 0.67%–57.95% (34.11% in average); with a lower content of almandine (Alm) and spessartine (Sps). Garnet end-member component diagram shows that the end-member group was defined into andradite-grossular series. Garnet ring of Yamansu iron deposit was well developed. The content of Si and Ca has no significant change from the core to the edge. The substitution relationship between Fe and Al was not obvious and fluctuated in a small range. This reflects the
small changes in the formation of garnet in both physical and chemical environment. The 32 magnetite samples analyzed by electron microprobe showed that the main component of magnetite are FeO and Fe2O3 (FeO\textsuperscript{T}=79.07\%-94.77\%). FeO\textsuperscript{T} and Al\textsubscript{2}O\textsubscript{3}, CaO, MgO, SiO\textsubscript{2} showed a negative correlation in magnetite. The content of FeO\textsuperscript{T} in early magnetite is relatively higher than the later ones. The content of Al\textsubscript{2}O\textsubscript{3}, CaO, MgO and SiO\textsubscript{2} in late magnetite is relatively higher.

4 Discussion

The skarn near wall rock of Yamansu iron deposit is extensive. The main end-member component of garnet is in andradite-grossular series. The characteristic of garnet is comparable to the large-scale major skarn-type iron deposits in the world. It justified the replacement skarn in Yamansu iron deposit. In the figure illustrating Ca+Al+Mn vs Ti+V, most of the samples from Yamansu magnetite fall into the category of skarn type iron ore, which reflects a hydrothermal metasomatism process. It also indicates the contribution of skarn to mineralization. In the TiO\textsubscript{2}-Al\textsubscript{2}O\textsubscript{3}-MgO formation illustration, most of the early magnetite distributed in a mafic magma trend. This shows that the early magnetite may be a product of magmatism. Late magnetite is located in sedimentary metamorphic-contact metasomatic zone, which indicates the contribution of late hydrothermal metasomatic mineralization to the ore-forming processes. Yamansu iron orebody and skarn are not distributed along the contact zone. It has some differences with typical contact metasomatic skarn iron ore deposits but resembles the geological features of Mengku iron deposit in Altai area, Xinjiang (Yang et al., 2007) and Chagangnuoer iron skarn mineralization in the West Tianshan mountain (Hong et al., 2012). Both of them were produced in skarn zone, which is generally controlled by faults. The chemical composition of skarn minerals and some of the calcium skarn of metasomatic skarn deposits in the study (Zhao et al., 1990) is basically the same. Mafic, neutral and acidic volcanic rocks of the Yamansu group are all exposed in the mining area. It indicates that the magma underwent a complete fractional crystallization and possibly formed by magmatic fluids.

5 Conclusion

(1) The main component of garnet is in andradite-grossular series of skarn in the Yamansu iron deposit. It is indicated as calcium skarn in metasomatism.

(2) The magnetite can be divided into the early and the late stages in Yamansu iron deposit. Most of the early-stage magnetite has component features of magma type, whereas the late-stage magnetite has metasomatic genesis features. It is suggested that the formation of Yamansu iron deposit is related to magmatic hydrothermal metasomatism.

(3) Yamansu iron deposit is a metasomatic skarn deposit which was produced in a marine volcanic environment. The ore-forming hydrothermal fluids may be derived mainly from magma.

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References

