Magnetite formed in different environments commonly has distinct trace element compositions that can potentially be used as an indicator of ore genesis (Dupuis et al., 2011; Hu et al., 2014; Nadoll et al., 2014). In this study petrographic and geochemical data of magnetite from the Tieshan deposit are presented in an attempt to better understand the genesis of the deposit, which has been considered to have formed via hydrothermal metasomatism, or alternatively from an iron melt (Zhai et al., 1992).

The Tieshan Fe-Cu skarn deposit is located in the Daye Fe-Cu metallogenic district, western Middle-Lower Yangtze River metallogenic belt, along the NE margin of the Yangtze Craton. The deposit is related to the early Cretaceous Tieshan intrusive complex that intruded marine carbonate rocks of the lower Triassic Daye Formation. The Tieshan complex consists of (in temporal order): syenodiorite; diopside diorite; monzodiorite; granodiorite; and quartz diorite or monzodiorite. The two main mineralization episodes are related to the diopside diorite and quartz diorite. The deposit consists of six main ore bodies, with numerous smaller ones, making up a discontinuous, 4.9 km-long mineralizing belt along the intrusive contact. Orebodies are overprinted by an episode of syn-ore brittle deformation.

Seven samples were collected from a 20 m-wide vein-type ore body in the carbonate rocks proximal to the quartz diorite. This magnetite-dominated vein has a sharp contact with the carbonate rocks with little or no hydrothermal alteration on both sides of the vein. Six samples were collected from an ore body spatially related to the diopside diorite. This ore body is characterized by particularly clear expression of both prograde and retrograde skarn assemblages. One sample was taken from the least-altered diopside diorite, ~160 m below the surface.

A combination of SEM-EDS characterization and electron microprobe analysis (the following wt.% values are for element) has revealed five types of magnetite from the vein-type and skarn ores. Types 1 and 2 are identified in the vein-type ores. Type 1 magnetite is coarse-grained (~100 μm) euhedral to subhedral grains, which are variably replaced by fine-grained (~50 μm) anhedral domains (type 2) associated with ankerite, calcite and siderite. Type 1 magnetite contains high Fe (70.11–71.32 wt.%) and low Si (0.03–0.06 wt.%). In contrast, the type 2 magnetite is marked by low Fe (67.65–69.14 wt.%) and high Si (0.78–1.29 wt.%). Both type 1 and 2 magnetite are enriched in Mg (0.84–1.28 wt.%). Both type 1 and 2 magnetite are enriched in Mg (0.84–1.28 wt.%), have moderate to low concentrations of Al (0.12–0.27 wt.%), Mn (0.04–0.21 wt.%), Zn (0.09–0.20 wt.%), Ti (0.02–0.07 wt.%), Ni (0.01–0.06 wt.%), V (0.01–0.06 wt.%), and Co (0.10–0.15 wt.%).

Magnetite from the skarn ores related to the diopside diorite occurs as euhedral to subhedral grains (50–200 μm) associated with pyrite, chalcopyrite, pyrrhotite, diopside, phlogopite and garnet. Two types of magnetite, hereafter termed as types 3 and 4, have been identified based on the texture and chemical composition. Type 3 magnetite contains low Fe (66.14–69.41 wt.%) and high to moderate Si (0.64–1.50 wt.%), Al (0.49–0.95 wt.%), Mg (0.40–0.96 wt.%), Mn (0.04–0.11 wt.%), Ni (0.01–0.06 wt.%), V (0.01–0.06 wt.%), and Co (0.10–0.15 wt.%). Magnetite from the skarn ores related to the diopside diorite occurs as euhedral to subhedral grains (50–200 μm) associated with pyrite, chalcopyrite, pyrrhotite, diopside, phlogopite and garnet. Two types of magnetite, hereafter termed as types 3 and 4, have been identified based on the texture and chemical composition.

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has high contents of Ti (0.07~0.54 wt.%), V (0.25~0.36 wt.%), with minor Co (0.11~0.13 wt.%), Ni (0.03~0.06 wt.%), Si (0.06~0.07 wt.%), Al (0.02~0.20 wt.%), Mg (0.02~0.08 wt.%), Zn (0.06~0.17 wt.) and Mn (0.02~0.27 wt.%).

The geological, textural and compositional data indicate that the type 1 magnetite from the vein-type ores and type 3 from the skarn ores were formed via the interaction between the magmatic-hydrothermal fluids and the wall rocks. This view is confirmed by the fact that Mg-rich magnetite from both ore types is proximal to the Triassic dolomitic limestone. Type 1 magnetite from the vein-type ores contains much higher Mg and lower Si than type 3 variety, indicating formation under higher fluid/rock ratios. The similar compositions of type 2 and type 3 magnetite indicates that they likely crystallized from fluids with similar compositions, as partially confirmed by field observation indicating two distinct episodes of mineralization related to the quartz diorite and diopside diorite.

Magnetite from the skarn ores have striking textural features consisting of two types of magnetite (3 and 4) with distinctly texture and chemical composition represent the different generations in the same episode. Type 3 magnetite displays oscillatory zoning and is replaced by the type 4 variety along microfractures and/or grain margins. This textural feature is interpreted as the result of dissolution-reprecipitation process (DRP) in magnetite. The DRP has led to significant decrease in Si, Al and Mg and an increase of Fe (68.36 to 71.28 wt.% on average), and therefore is considered as an important mechanism forming high-grade and high-quality iron ores in the Tieshan deposit.

Magnetic magnetite from the ore-related intrusion contains significantly higher Ti and V due to the abundance of Ti and V in the magma and the higher partition coefficients of these elements in magnetite crystallized from the magma. Lack of Ti and V in the hydrothermal magnetite consists with the low activity of these elements in magmatic-derived fluids, as Ti and V are considered to be much less mobile in magmatic hydrothermal fluids.

Minor and trace element compositions of magnetite have been used as a genetic indicator of this mineral and associated ore deposits (Dupuis et al., 2011). In the (Ti+V) vs. (Al+Mn) diagram (Fig.1), most analyses of magnetite from the vein and skarn ores fall in the skarn field, whereas the variety form the diopside diorite plot into the Kiruna field. This confirms that both types of iron ores formed by hydrothermal metasomatism rather than via crystallization from iron melts as previously thought.

**Acknowledgements**

This research is supported by the National Basic Research Program of China (2012CB416802).

**References**


