1 Geological Characteristics of Ore Deposit

The deposit is located in the North of the Taihang Mountain orogenic belt. Wulonggou big fault runs through it. There is the Dahaituo-Zijingguan tectonic magmatic belt in the northeast, the Cathaysian fuping uplift in the southwest, the Laiyi anticlinorium in the east and it also situates in the waist of the Laiyuan complex. The main tectonic of the mining area are fold and the intrusive contact structures. They are the basic ore-controlling structure of skarn type magnetite ore deposits in this region.

The strata of Zhijiazhuang iron deposit include substrate and cover layer. The basement is mainly composed of Banyukou formation gneiss of Archean Wutai group (Arwtb). The cover include dolomite in Gaoyuzhuang Formation of Changcheng System (Chg) and Wumishan Formation of Jixian System (Jxw) in the Mesoproterozoic Group, and the eluvium, diluvium slope and alluvial-pluvial deposit in Quaternary Holocene (Chang et al., 1996). The dolomite of Gaoyuzhuang Formation form altered dolomite in eastern and southern due to the invasion of the granite type. The iron ore is exactly located in the contact area. Dolomite usually distribute in roof pendant shape. The average mass fraction of MgO is 22.76%, and CaO is 20.10%. The magnesium content of the dolomite is higher, therefore, when the rock intruded into, it is easy to produce contact metasomatism and form magnesium skarn.

The exposed magmatic rocks belong to the Laiyuan complex rock of Yanshan Period. According to the intrusive sequence of the rocks, there are three periods as follows. It appears firstly that the Cretaceous quartz monzonite of Early Yanshan Period which distribute in the southern area, with granular texture and massive structure. The rock have higher silicon (SiO$_2$ = 59.2%), richer alkali (K$_2$O + Na$_2$O = 7.85%), the Rittmann Index is 3.81 which belongs to the alkaline, A/ CNK is 4.45 strongly peraluminous. Secondly, it is the Cretaceous granite that distribute in the east and south of the mining area, with granite texture, block structure, and visible K-feldspar phenocrysts. The granite is also rich of silicon (SiO$_2$ = 70.65%) and alkali (K$_2$O + Na$_2$O = 8.53%), the Rittmann Index is 2.63, belonging to calc-alkaline rocks, A/ CNK = 2.82, which is aluminum. Thirdly, the Cretaceous porphyritic diorite in late Yanshanian epoch occurs. Phenocrysts are mainly plagioclase and hornblende, the dominant mineral in the matrix is plagioclase. In addition, there are a lot of dikes and magnetite with distribution (Chang et al., 1996).

Magnetite ore bodies are mainly controlled by the contact zones and anticline structure of the mining area. These bodies seem to be lenticular, vein, and banded and distribute in the contact zone. It includes north Zhijiazhuang ore section and Qiaomaidi ore section. The ores are mainly magnetite, followed by ludwigite, boric magnesium ore and a small amount of sulfide, such as pyrrhotite, pyrite, chalcopyrite, galena, and sphalerite. The gangue minerals are serpentine, forsterite, calcite, humite, phlogopite, diopside, chlorite, garnet, etc.

2 Mineralogical Analysis and Stable Isotope Geochemistry Study

2.1 Electron microprobe analysis of magnetite

Some conclusions can be reached by means of electron probe analysis. The TiO$_2$ value of the magnetite is 0.04%–0.24%, the average is 0.12%; the Al$_2$O$_3$ is 0.02%–1.38%, the average is 0.36%; the Fe$_2$O$_3$ is 67.51%–77.98%, the
average is 71.33%; the FeO is 7.14%–30.70%, the average is 22.89%; the MgO is 0.4%–15.28%, largely distributed in 2.28%–3.26%, the average is 4.09%; the MnO value is 0.07%–2.43%, the average is 0.63%; the CaO value is 0.03%–0.31%, the average is 0.07%; the NiO value is 0.04%–0.25%, the average value is 0.7%; the content of Cr2O3 and V2O3 is very little, below the limit of detection. According to the typomorphic characteristics table of the magnetite in different genetic types of iron ore (Xu et al., 1979), the chemical composition of magnetite in this mining area is very similar with the magnetite in the contact metasomatic skarn deposit. According to the typomorphic chemical components type of magnetite in different genetic types of magnetite deposit (Yang et al.,1987), the content of TiO2 and Al2O3 is lower but MgO and MnO is higher in magnetite of Zhijiazhuang iron deposit, these characteristics and chemical composition are consistent with contact metasomatic deposit.

2.2 H-O-C-S isotopic geochemical analysis

The measured value of the δD is low, which is significantly lower than the category of magmatic water. This may be implied the join of the rain in different mineralization stages. From the perspective of development trend, however, the value of δD was gradually increased from the ore-forming stage to late stage, and evolved to the direction of meteoric water. The value of δD ranges small, between 127.4 ‰ to 152.8 ‰ (Table 1). The value of δ18O in H2O is range from 5.59 to 9.05, which similar to the scope of the original magma water, reflecting the hydrothermal ore-forming solution comes from the deep. But with the gradual evolution of the ore-forming fluid, the numerical of δ18O decreases gradually and becomes negative, reflecting the added of meteoric water at late stage. In conclusion, the ore-forming hydrothermal is magmatic hydrothermal which was mixed with meteoric water at the same time, and the evolutionary trend is atmospheric precipitation.

The carbon isotope research of magnetite shows that the carbon values of the ore is generally low, δ13C = −27.8‰ to −29.9‰, this implies that it could have mixed with crustal organic carbon. As the contact metasomatism occurs between intrusion and carbonate rock, the magnetite produced and enriched, which may have been mixed with sedimentary organic carbon of the surrounding rock, resulting in the low δ13C value in magnetite. S-isotope data indicate that the δ34S in Zhijiazhuang iron deposit is in the range of −2.4‰ to −3.5‰,averages −3.08‰, range 1.1.The variation range is small, perhaps this is because the source of the sulfur is relatively single, which intensively distribute in the mantle source sulfur of the earth's deep (−3‰ to 3‰).

In a word, Zhijiazhuang iron deposit belongs to skarn iron deposit. Hydrogen and oxygen isotope research show that the ore-forming fluid came from the deep earth, which is the mixture of magmatic hydrothermal solution and meteoric water. Carbon isotope and sulfur isotope studies also show that the ore-forming materials come from the deep, showing the characteristics of magmatic sulfur or the sulfur of mantle source.

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References

