
**Data Repository**

**Figure DR1.** TIMA-X TESCAN integrated mineral analyzer images of iron skarn (A) and IOA ores (B).

**Figure DR2.** The paragenetic sequence of mineralization and alteration of the Wangbaoshan iron deposit.

**Figure DR3.** X-ray element distribution maps showing the texture of typical garnet in the iron skarn ore. The color scale bar in EMPA maps represents the intensity of collected X-ray counts.

**Figure DR4.** The plot of Na-Ca-Fe-K-Mg code bars on an alteration discrimination diagram from Montreuil et al. (2013). Chemical data from Mao et al. (2011) and references therein; Xie et al. (2012); Chen et al. (2014, 2016). Note: Most of the igneous rock in the Ningwu and Luzong district are plotted in the field of least alteration. This indicates that the high K contents of most igneous rocks related to IOA and iron skarn deposits reflect a metasomatized lithospheric mantle source for the magma rather than being caused by potassic alteration. Unlike the extensive albitization in the Wangbaoshan ore district, the volcanic rocks far away from the iron mine in this region are mostly fresh. The granitoid host rock surrounding the iron skarn often shows sodic alteration.

**Figure DR5.** Ternary diagrams of garnet and pyroxene end members from iron skarns and IOA ores. Gr—grossular, Pyr—pyralspite, Ad—andradite, Di—diopside, Hd—hedenbergite, Jo—johannsenite. The composition of garnets and pyroxenes from the Chengchao and Jinshandian iron deposits, and the Fe skarn deposits worldwide are adapted from Xie et al. (2015) and Meinert et al. (2005).

**Table DR1.** Electron microprobe analyses (wt%) of magnetite from iron skarn and iron oxide-apatite ores from the Wangbaoshan iron deposit, and the Meishan and Wangmujian prospects.

**Table DR2.** LA-ICP-MS trace element compositions of magnetite from iron skarn and iron oxide-apatite ores in the Wangbaoshan iron deposit.

**Table DR3.** Major and trace element compositions of iron skarn and iron oxide-apatite (IOA) ores from the Wangbaoshan iron deposit and typical IOA ores from the Meishan and Wangmujian prospects.

**Table DR4.** Electron microprobe analyses (wt%) of garnet and diopside from iron skarn and iron oxide-apatite ores from the Wangbaoshan iron deposit.
APPENDIX 1

Methods

Thin sections mapping

Typical iron skarn thin section (WBS14) and IOA ore thin section (15WBS1) were analyzed using the Tescan Integrated Mineral Analyzer (TIMA) mineralogy system at the Tescan Orsay Holding demo lab, Czech Republic. The TIMA operating system comprises a Tescan Mira Schottky field emission scanning electron microscope with four silicon drift energy dispersive (EDS) detectors. TIMA analyses were conducted at operating conditions of 25 keV using a spot size ~50 nm, a working distance of 15 mm and a field size set at 1500 μm. The BSE image is obtained and used to determine individual particles and to determine boundaries between distinct preliminary phases. The EDX collected for each pixel is summed together based on grain boundaries. The spectroscopic data is then matched to mineral definition files within the TIMA classification scheme, where a set of rules must be satisfied for a phase to be correctly matched. This systematic identification of each grain allows for mineral phases within the sample to be identified and mapped. The mineral definition files contain mineral properties that can be used to determine the elemental composition, elemental deportment and density of the sample.

Electron microprobe analysis of garnet and diopside

A typical iron skarn sample (WBS14) and an IOA ore sample (WBS10) were collected for electron microprobe analysis (EMPA) and X-ray mapping of garnet and diopside in two sessions. Session 1 major-element analysis were determined using a CAMECA SX100 electron microprobe (EMP) analyzer (Masaryk University, Brno) at an accelerating voltage of 15 kV, a beam current of 20 nA, and a beam diameter of 3 μm. The following standards were used for garnet and diopside: albite (Na), sanidine (Al and K), wollastonite (Si and Ca), pyroxene (Mg), anatase (Ti), chromite (Cr), almandine (Fe), and spessartine (Mn). Session 2 was performed at the Center for Material Research and Analysis, Wuhan University of Technology (WUT), using a JXA-8230 Superprobe. Standards and unknowns were analyzed with 1 μm beam diameter at 15 kV and 20 nA current. The peak counting time for all the elements were 20 s. The following standards were used: NaAlSi3O8 (Na), KAlSi3O8 (K), Mg₃Al₂Si₃O₁₂ (Mg, Al and Si), (Ca, Fe)SiO₃ (Ca), MnSiO₃ (Mn), FeTiO₃ (Fe, Ti) and FeCr₂O₄ (Cr).
REFERENCES CITED


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- **Main**
- **Minor**
- **Local occurring**
Iron-oxide apatite and iron skarn deposits related igneous rocks in Luzong and Ningwu districts

Volcanic rocks in Daye district

Granitiod host rock in iron skarn deposits

IOA and iron skarn ores in Wangbaoshan deposit
Iron skarn deposits worldwide

Pyr (20)
$(\text{Fe}^{2+}, \text{Mn}^{2+}, \text{Mg})_3\text{Al}_2\text{Si}_3\text{O}_{12}$

Jinshandian

Fe skarn deposits worldwide

Chengchao

CaMnSi$_2$O$_6$

Ca$_3$Al$_2$Si$_3$O$_{12}$

Ca$_2$Fe$_{2+}$Si$_2$O$_6$

Gr

Ad

Di

Hd

Pyr

Jo

OAl

Ca$_3$Fe$_2$Si$_3$O$_{12}$

10 30 50 70 90

0 10 20 30 40 50 60 70 80 90

Iron skarn

IOA

10 30 50 70 90

10 90