



HAL
open science

Iron-oxide mineralogy of banded iron formations in the Takab region, North Western Iran

Beate Orberger, Serge Miska, Alina Tudryn, Christiane Wagner, Michel Fialin, Omar Boudouma, Colette Derré, Ghasem Nabatian, Maryam Honarmand, Iman Monsef, et al.

► **To cite this version:**

Beate Orberger, Serge Miska, Alina Tudryn, Christiane Wagner, Michel Fialin, et al.. Iron-oxide mineralogy of banded iron formations in the Takab region, North Western Iran. SGA Biennial Meeting, 2017, Aug 2017, Quebec, Canada. hal-03894595

HAL Id: hal-03894595

<https://hal.science/hal-03894595>

Submitted on 12 Dec 2022

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Iron-oxide mineralogy of banded iron formations in the Takab region, North Western Iran

Beate Orberger, Serge Miska, Alina Tudryn

GEOPS, Université Paris Saclay, Université Paris Sud, Bât 504, 91405 Orsay Cedex, France

Christiane Wagner, Michel Fialin, Omar Boudouma, Colette Derré

ISTeP and Centre Camparis, Sorbonne Université, UPMC Univ Paris 06, 4 Place Jussieu, 75005 Paris, France

Ghasem Nabatian

University of Zanjan, Zanjan, Iran

Maryam Honarmand, Iman Monsef, Abdolreza Ghods

Institut of Advanced Studies of Basic Sciences, Zanjan, Iran

Abstract. Siliceous banded and nodular iron ores intercalated in mica schists and marbles of Precambrian age, were studied from the NW part of Iran (Takab region). The iron ore is composed of magnetite, which was partly transformed into maghemite and hematite along fractures and cleavages during a major oxidizing deformation event. Quartz shows undulose extinction. Both quartz and iron oxides partly form 120° triple junctions, but essentially grain boundary migrations. In the nodular ore, grain boundary migration is more pronounced leading also to grain isolation quartz is partially annealed. Iron oxides are agglomerated, elongated and disrupted. These findings indicate a longer recrystallization episode in the nodular ore. The iron oxide grains contain inclusions of euhedral, zoned and corroded zircons and euhedral monazite. Magnetite contains traces of Al. Hematite and goethite show higher Al, Si and Ca contents. Later hydrothermal solutions precipitated goethite surrounding the magnetite-hematite-maghemite grains and replacing hematite. Barite and uraninite occur in fractures of iron oxides, Mn-Ba-Pb oxi-hydroxides and scheelite occur interstitial to iron oxides.

Key words: Banded iron formation, Precambrian, Iran, magnetite, maghemite, hematite, goethite

1 Introduction

Iran is the 10th largest iron ore producer and the 9th iron ore exporter in the world. According to forecasts, iron production will triple until 2025 up to 66.2 Mt of iron ore (Hastorun et al. 2016). Most of the iron deposits are located in the northeast and central part of Iran, while iron ore deposits of the northwest part are still little studied. We carried out a preliminary mineralogical study on different iron ore samples from the Takab region in north western Iran (Fig. 1) in order to define iron oxide minerals in their structural and fluid context.

2 Geological setting

The Takab iron ore deposits belong structurally to the Sanandaj-Sirjan Zone (Fig. 1). The study area comprises Precambrian-Early Paleozoic metamorphic rocks, Miocene

sedimentary rocks and Quaternary deposits. The Precambrian rocks have been thrust over the Cenozoic sedimentary units. The iron ore deposits of this area are classified being of volcano sedimentary origin. Their formation might be related to the back arc extension due to the Prototethys subduction beneath the Cadomian magmatic arc (Ghorbani, 2013; Nabatian et al., 2015). The most important iron deposits, known at present, occur in schists and marbles.

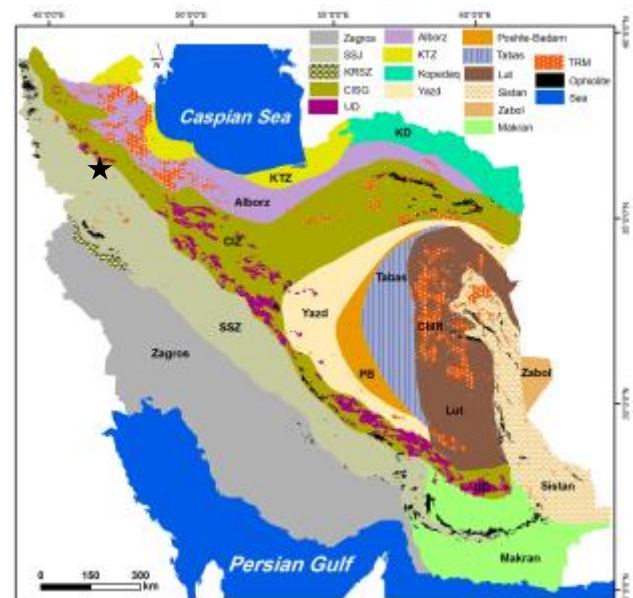


Figure 1. Tectonic and structural map of Iran (modified after Alavi 1991; Aghanabati 1998, 2005). The location of the study area is shown by the black star. Abbreviations are as following: Zagros, Zagros ranges: KRSZ, Kermanshah Radiolarites subzone; SSZ, Sanandaj-Sirjan magmatic-metamorphic zone; UD: Urumieh-Dokhtar magmatic arc; CIM, Central Iranian microcontinent (includes the Yazd, Posht-e-Badam (PB), Tabas, and Lut blocks); Alborz, Alborz ranges, western Alborz-Azərbayjan, KTZ Khazar-Talesh-Ziveh structural zone; CIZ, Central Iranian zone; Sistan, East Iran ranges; Makran, Makran zone; KD, Kopeh-Dagh ranges; Zabol, Zabol area; and TMR, Cenozoic magmatic rocks.

The mineralization forms thin layers and lenses

interlayered with quartzite (Nabatian et al. 2015; Fig. 2A). The iron oxide mineralogy is essentially described as hematite, goethite, with barite as accessory mineral (Ghorbani et al., 2013).

This is the first detailed petrological mineralogical study on banded and nodular iron ores from the Takab region reflecting its complex geological history.

2 Analytical Methods

Optical microscopy on polished thin sections was performed in transmitted and reflected light mode, SEM and electron microprobe analyses at the Centre Camparis, Sorbonne Université, UPMC Univ Paris 06, Paris, France. XRD and Curie Balance analyses were carried out at the GEOPS, Université Paris Saclay, Université Paris Sud, Orsay, France.

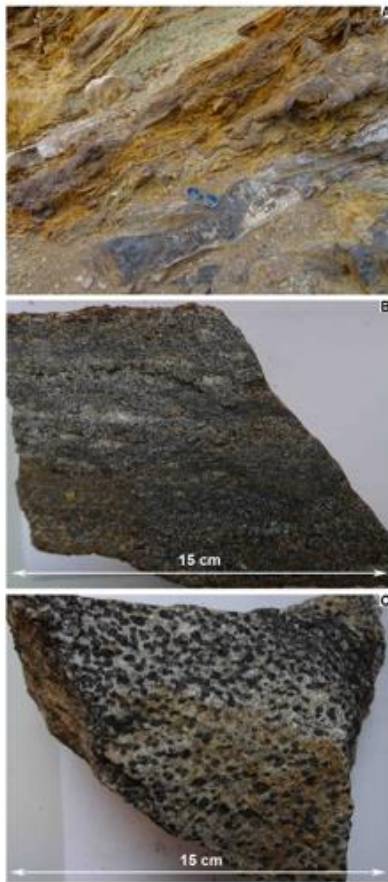


Figure 2. A. Iron ore layer (mainly magnetite) in mica schist. B. fine banded iron ore; C. nodular iron ore (Takab region, NW of Zanjan).

The studied samples are banded and nodular iron ores. Both massive banded and nodular ore occur as decimetric layers within deformed (folded) mica schist (Fig. 2A). The banded iron ore shows coarse and discontinuous banding with interstitial quartz (Fig. 3A). The nodular ore is composed of mm-sized iron oxide agglomerates, partly elongated and disrupted (Fig. 3B).

The banded iron ore is characterized by micro quartz showing 120° triple junctions or slight grain boundary migration of lobate crystal surfaces. Some quartz grains show also 120° triple junctions with iron oxide grains. Quartz grains show undulose extinctions. In iron oxide rich bands, poikilotopic textures of iron oxides or quartz grain are characteristic. Iron oxide veins formed perpendicular to the iron oxide bands (Fig. 4A). Pyrite relicts are observed in goethite. Barite, interstitial to quartz, is rarely present.

The nodular iron ore shows bimodal iron oxide and quartz grain sizes: 1) some tenths of micron and 2) some hundreds of microns. Both quartz types show undulose extinction (Fig. 4B). The large quartz grains occur mainly in the vicinity of iron oxide agglomerates of a few hundreds of microns. They are composed of individual small oriented quartz crystals. Small iron oxide grains show sometimes 120° triple junctions with quartz grains. Grain boundary migration also led to grain isolation (Fig. 4B).

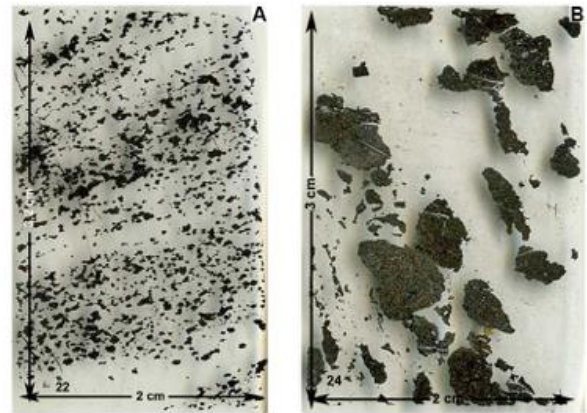


Figure 3. Polished thin section scans. A. Banded iron ore composed of alternating quartz and iron oxide bands; B. Nodular iron ore in quartz matrix.

X-ray diffraction on 3 banded and 1 nodular ore samples indicate that all samples contain similar major mineralogy quartz, magnetite, hematite, maghemite, goethite in different proportions. Small peaks are attributed to witherite (BaCO_3).

The iron oxi-hydroxide mineralogy is complex. Euhedral magnetite is transformed into maghemite and hematite (Fig. 4C, D, 5A, B).

3 Results

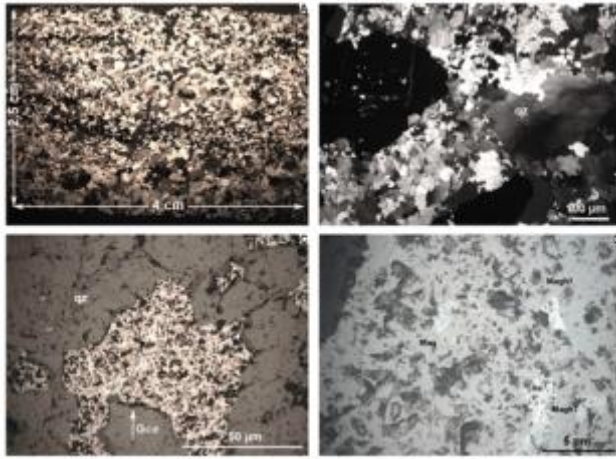


Figure 4. A+B: Optical Microscopy (transmitted light). A. Micro quartz hosting iron oxide bands and an iron oxide vein perpendicular to banding. Quartz grains show grain boundary migrations and rarely 120° triple junctions; B. Iron oxide nodules and large quartz grains showing undulose extinction at large grain scale. The large quartz grains are composed of individual small elongated quartz grains. C+D: Reflected light microscopy. C. Iron oxide grain in quartz matrix showing hematite (he, bright) in magnetite (mag). Goethite occurs between the iron oxide grain and the quartz grains; D. Close up of an iron oxide grain showing magnetite (Mag, grey), hematite (He, bright) and probably maghemite (Magh, light grey).

Trellis structures, which are characteristic for martite, are also observed (Fig. 5E). Chemical zoned goethite occurs interstitial to the magnetite-hematite-maghemite grains (Fig. 5C). Goethite may also host neoformed hematite inclusions (Fig. 5B). Euhedral, zoned and corroded zircon, as well as euhedral monazite are observed as inclusions in magnetite (Fig. 5D, E). In the matrix, a few hundreds of micron large oxi-hydroxides composed of Mn-Ba-Pb occur (Fig. 5F). Scheelite (CaWO_4) was also observed. Secondary barite and uraninite occur in fractures of the iron oxides together with goethite.

Curie Balance analyses show that the material is highly magnetic and magnetite is the dominate phase. In two banded iron ore samples maghemite and /or goethite are indicated.

Electron microprobe analyses were performed on iron oxi-hydroxides from banded and nodular ores. A special program was designed to analyse oxygen in order to trace the iron oxide and hydroxide variabilities. The magnetite and hematite contain traces of Al (< 0.5 wt. %). Goethite hosts variable amounts of Al (up to 0.7 wt. %), Si (up to 1.7 wt. %) and Ca (up to 0.2 wt. %). Figure 6 shows the iron versus the oxygen contents of representative iron ox-hydroxides and the iron contents versus the total (wt. %). The conversion of Fe^{2+} into Fe^{3+} is accompanied by a decrease of the total iron content and a slight increase of oxygen. Goethite has lowest totals.

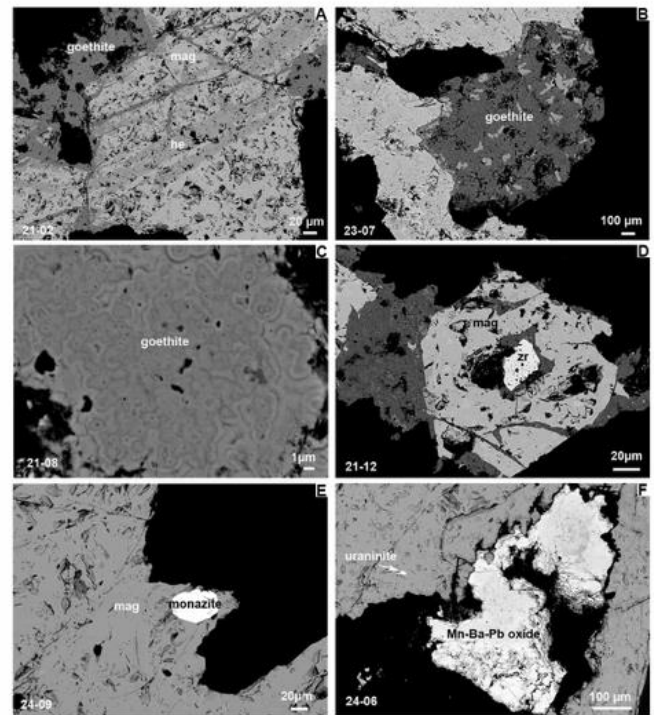
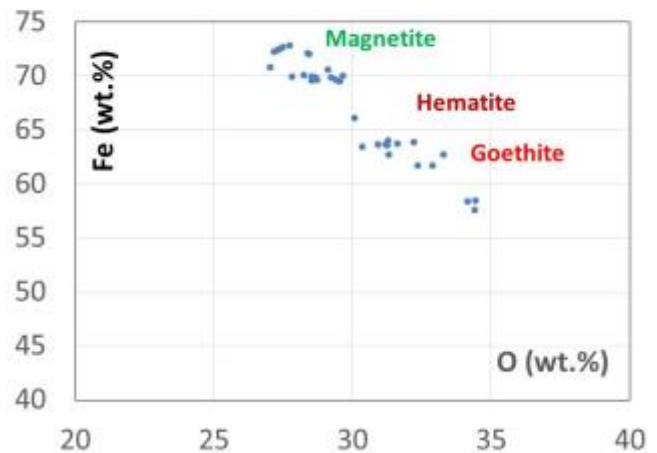


Fig. 5. Scanning electron microprobe images in back scattered mode. A. Euhedral magnetite partly transformed into hematite and surrounded by goethite; B. Goethite interstitial to magnetite with euhedral hematite inclusions. C. Goethite showing oscillatory zoning; D. Euhedral magnetite with corroded zircon (zr) inclusion; E. Magnetite showing trellis hosting euhedral monazite; F. Mn-Ba-Pb oxi-hydroxide interstitial to magnetite. Magnetite hosts uraninite inclusion.



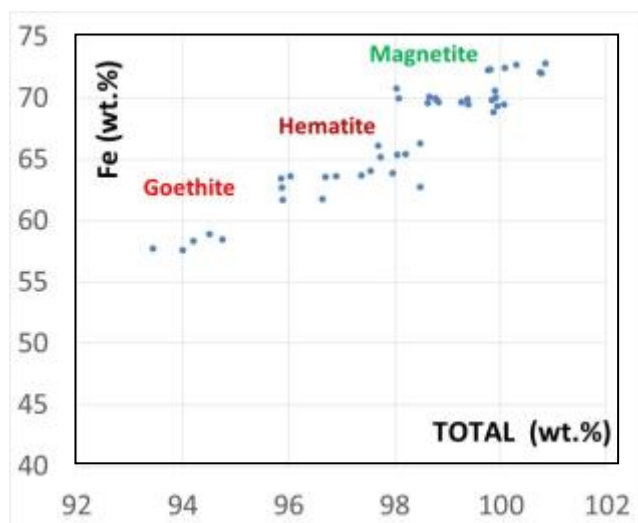


Figure 6. Electron microprobe analyses of iron oxides and iron hydroxides of some iron ores from the Takab region. Upper diagram: Fe versus O (wt. %), lower diagram: Fe versus Total (wt. %). Centre Camparis, Sorbonne Université, UPMC, Univ Paris 06, France).

Discussion and Conclusions

This study highlights the complex history of this iron ore and gives useful hints for future research, which will contribute to elucidate the origin of the ore forming elements iron and silica, but also the accessory elements (Mn, Ba, Pb, U, W...). Based on the present results, it can be suggested that: (1) The primary iron ore is banded and crystallized statically from an iron and silica rich solution. Zircon and monazite were included during this step in the initial iron oxide, magnetite; (2) Regional deformation led to recrystallization of the iron oxides through grain boundary migration and quartz grain isolation. The micro quartz grains form neoblasts and annealed to the larger quartz grains. The nodular ore represents most likely a highly deformed banded iron ore, where iron oxide bands were disrupted and recrystallized. Sulfides were present at that state. Oxidizing fluids accompanied this step and transformed the magnetite into maghemite and hematite. (3) Aqueous solutions carrying Mn, Ba, Pb, Ca, W, U, S, CO₂ led to the formation of goethite and Mn-Ba-Pb oxihydroxides and associated scheelite, barite and uraninite. This episode is most likely contemporaneous to the W mineralisation in this region (Ghorbani, 2013).

References

- Aghanabati A. 1998. Major sedimentary and structural units of Iran (map). *Geosciences*, 7, 29-30.
- Aghanabati A. 2005. *Geology of Iran*. Geological Survey of Iran (Persian book), Tehran, Iran, 538 pp.
- Alavi M. 1991. Sedimentary and structural characteristics of the Paleo-Tethys remnants in northeastern Iran. *Geological Society of America Bulletin*, 103, 983-992.

Hastorun S, Renaud KM, Lederer GW (2016) Recent trends in the nonfuel minerals industry of Iran: U.S. Geological Survey Circular 1421, 18, <http://dx.doi.org/10.3133/cir1421>.

Ghorbani M. (2013) *The Economic Geology of Iran: Mineral Deposits and natural Ressources*. Springer Dordrecht Heidelberg New York, 567. ISBN 978-94-007-5624-3 ISBN 978-94-007-5625-0 (eBook), DOI 10.1007/978-94-007-5625-0.

Nabatian G, Rastad F, Neubauer F, Ghaderi, M (2015) Iron and Fe-Mn mineralisation in Iran: implications for Tethyan metallogeny. *Australian Journal of Earth Sciences*, 62:2, 211-241, DOI: [10.1080/08120099.2015.1002001](https://doi.org/10.1080/08120099.2015.1002001)

Acknowledgements

We thank the Institute of Advanced Sciences of Basic Science and University of Zanjan, Zanjan for logistic support during fieldwork and the stay of BO in Zanjan. Campus France and the French embassy are thanked for financing the stay of BO at IASBS, Zanjan. The UMR7193 IStEP, UPMC is thanked for financial support of the analyses.