

## ORE DEPOSIT GENESIS IN THE CHILEAN IRON BELT (ATACAMA AREA, CHILE).

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### Abstract.

The Chilean Iron Belt appears in andesitic lavas of an island-arc, Neocomian in age. The iron ore comes from latter pyroxene-bearing dioritic rocks which suffered a high temperature leaching, accompanied by a sodic alteration. The concentration of Fe, then Ca-Mg cations, is located in volcanic fractured hornfelses.

Key words: island-arc, calc-alkaline magmatism, pyroxene diorites, metasomatism, sodic alteration.

### Introduction.

The Chilean Iron Belt constitutes the first important mineralization episode of the Andean orogeny. It is made up of more than 40 deposits of economic interest, aligned along the axis of the Peruvian-Chilean Trench, in the Eastern part of the Coastal Cordillera in the Atacama Desert, between 25° 30' S and 31° S latitudes (Ruiz, 1965).

The iron mineralization is located in volcanic rocks mainly basaltic-andesites, more rarely andesites s.s. (Dostal et al., 1977), erupted during the Neocomian in an island-arc and lately metamorphised into hornfelses by plutons emplaced at the end of Lower Cretaceous. The major deposits are mainly composed of magnetite, locally associated with tremolite and apatite, and rare sulphides (pyrite-chalcopyrite). The first porphyry coppers of the Andean orogeny appear simultaneously about 30 to 50 km to the East (Munizaga et al., 1985).

Petrological and geochemical studies show that the plutonic rocks, at the latitude of Vallenar (28° 40' S), constitute a single calc-alkaline evolutionary trend, with mid-K characters, from gabbros to granodiorites-granites without significant major element content differences with island-arc porphyry copper suites (Ménard, 1989).

A single mineralization is associated with each rock type. In order of emplacement, the more abundant cpx-opx-bearing diorite plutons cause iron mineralization lenses through thermal aureoles; a sulphide copper mineralization in lodes is locally legated with hornblende quartz-monzonite; then hornblende-biotite granodioritic and granitic plutons are crossed by scarce quartz gold-bearing veinlets; the more recent gabbroic rocks are barren.

### Petrographic and geochemical evolution of pyroxene-bearing dioritic rocks.

The chemical compositions (Table 1) indicate that the pyroxene diorites have suffered metasomatic processes through 4 retromorphic facies (Ménard, 1986).

	facies 1	facies 2	facies 3	facies 4	facies 5
SiO <sub>2</sub>	52.56 (0.99)	53.89 (1.11)	58.46 (2.69)	67.00 (2.16)	73.45 (1.52)
TiO <sub>2</sub>	0.85 (0.13)	0.86 (0.25)	0.91 (0.28)	0.81 (0.07)	0.35 (0.03)
Al <sub>2</sub> O <sub>3</sub>	18.75 (0.55)	17.68 (1.47)	17.15 (0.92)	16.75 (0.96)	15.78 (1.26)
FeO <sub>t</sub>	7.86 (0.47)	5.00 (2.83)	3.97 (1.47)	2.03 (1.67)	0.64 (0.51)
MnO	0.15 (0.04)	0.18 (0.07)	0.12 (0.04)	0.07 (0.04)	0.13 (0.04)
MgO	4.72 (0.35)	4.53 (1.12)	3.31 (1.29)	0.95 (0.71)	0.13 (0.12)
CaO	8.26 (0.93)	10.11 (1.69)	9.27 (1.57)	5.07 (1.59)	0.88 (1.23)
Na <sub>2</sub> O	3.22 (0.25)	4.38 (0.68)	4.65 (0.49)	4.85 (0.68)	5.57 (0.90)
K <sub>2</sub> O	1.09 (0.26)	0.77 (0.37)	0.62 (0.28)	0.60 (0.41)	0.96 (0.54)
P <sub>2</sub> O <sub>5</sub>	0.16 (0.03)	0.12 (0.08)	0.10 (0.26)	0.07 (0.07)	0.03 (0.03)
n	2	11	16	10	8

FeO<sub>t</sub> = total iron; ( ) = standard error; n = number of analyses.

Table 1: Chemical compositions of dioritic rocks (facies 1) and metasomatised rocks (facies 2 to 5).

The primary magmatic assemblage (facies 1) is composed of titanomagnetite and rare ilmenite equilibrated at 1150°C, plagioclases (An 70-40) precipitated under P.H<sub>2</sub>O = 1.6 kb (4 km deep), hypersthene and augite-salite stable at 1120°C, scarce hornblende and biotite (Pichon, 1981).

At subsolidus stage (900-950°C), a supercritical fluid phase is exsolved from dioritic rocks. This would result in sequential leaching of different elements (mainly Fe, then Ca, Mg), under increasing oxygen fugacities and water pressures (Ménard, 1988).

The major mineralogical changes are:

- Oxidization of iron oxides with, in-situ, precipitation of rutile and titanite together with resorption of primary pyroxenes and crystallization of diopside (facies 2).
- Uralitization of diopside to zoned actinolite (facies 3).
- Resorption of actinolite (facies 4).
- Gradual resorption of primary plagioclases (complete in facies 4) and neo-crystallization of sodic plagioclases: An 40-05 (facies 2 to 5).
- Interstitial precipitation of quartz (facies 2 to 5) with large amounts of triphasic salted fluid inclusions with halite and hematitic crystals.

The later facies has an entirely secondary paragenesis with sodic plagioclases and quartz, without any iron oxides nor ferromagnesian minerals.

The facies 2 and 3 are largely represented in the bulk of dioritic rocks but the facies 4 and 5 are exclusively located in external zones near the iron-mineralized hornfelses (Montecinos, 1983).

#### Migration and concentration of the iron ore.

The origin of the iron of the ore deposits is to be found in the gradual leaching of this element from pyroxene-bearing dioritic rocks. From primary magmatic plutonic rocks, mass balance of metasomatic processes indicates that Fe, then Ca and Mg are successively lost; Na is gain; Si and Al seem to be the less mobile elements.

In the case of El Algarrobo iron deposits, the Fe lost from the plutonic material is very greater than the observed deposit mass (Ménard, 1986).

From mineralogical paragenesis as well as experimental results (f.e., Eugster, 1985), the metasomatic processes evolved during the end of the thermal history of dioritic rocks.

- From about 700°C, Fe begins to be extracted progressively from iron oxides, pyroxenes and actinolite (and possibly P from apatite).
- Then, between 600-500°C, Ca (from plagioclases, diopside and actinolite) and Mg (from diopside and actinolite) are mobilised together with Fe cations.

The metallic elements are carried out, in cationic form, associated with Cl-anions, toward the cooler wallrocks where they are concentrated under structural control (faulting).

The magnetite begins to precipitate at 550°C, tremolite and apatite at less than 500-450°C in volcanic wallrocks retromorphosed from hornblende hornfels facies to greenschist-amphibolite facies conditions.

## Conclusions.

The Chilean Iron Belt is located in an island-arc environment. The mineralization appears in andesitic rocks. However, the chemical elements (mainly Fe, Ca and Mg) must be thought to be extracted from minerals of metasomatic dioritic rocks, intruding the volcanic arc. A high temperature convective leaching (700-500°C) induces the migration and the deposition of iron ores in the thermal aureoles of dioritic plutons. All these processes happened in deep-seated rocks (4 km), which evolved under high oxygen fugacities, increasing water pressures with a sodic alteration.

The iron mineralization is thus fully different from porphyry coppers which are issued from shallower (1 km) differentiated hydrous (hornblende) magmas, and associated with low-temperature (250-400°C) reducing and potassic alteration processes (Titley and Beane, 1981).

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