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Alteration of braunite ores from Eastern Liguria (Italy) during syntectonic veining processes: mineralogy and fluid inclusions

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Abstract: The manganese ores of the Northern Apennine ophiolites (Val Gravegila, Eastern Liguria, Italy) occur within chert sequences, mainly as stratiform layers (0.1–1 m thick) or massive lenses (5–20 m thick). The ores originated in the Ligurian-Piedmont oceanic basin (Middle Callovian) during turbiditic resedimentation of hydrothermally Mn-enriched submarine muds. During Upper Cretaceous-Lower Cenozoic orogenic events, the primary sedimentary oxide assemblages were completely recrystallized to braunite + quartz assemblages under prehnite-pumpellyte facies conditions (T = 275 ± 25 °C; P = 2.5 ± 0.5 kbar). This tectonic event induced mobilisation of Mn and Si, and thickening of the mineralised layers. A complex network of sigmoidal quartz veins formed at this stage. The interaction between the Mn mineralisation and the circulating fluids generated centimetric to decimetric reaction rims in the wall rock, where the braunite + quartz assemblage is replaced by Mn silicates (mainly bementite, johannsenite, parsettensite and rhodonite) and carbonates (mainly Mn-bearing calcite and rhodochrosite) with a zoned distribution. Mineral zoning points to an early interaction between the Mn mineralisation and H_2O-CO_2 fluids with high water activity. Two distinct types of fluids are present in syntectonic quartz veins, namely a low-salinity water-rich fluid, and a Mn-Ca-Na-Mg-Fe-bearing aqueous solution that in all probability represent a relict of an early fluid phase circulating during breakdown of braunite. The isochore distribution related to low-salinity fluids indicates that veining processes took place during the main tectono-metamorphic events, at peak P-T conditions.

Key-words: Liguria, manganese ore, braunite, fluid inclusions, metamorphic fluids.

Introduction

Braunite + quartz is the most common assemblage in metamorphosed, sedimentary-diagenetic, and hydrothermal manganese ores (Roy, 1980, 1981; Dasgupta & Manickavasagam, 1981; Ostwald, 1992). In metamorphic deposits, braunite + quartz has been reported as the stable assemblage over a wide range of metamorphic conditions, spanning from chlorite to sillimanite grade (Bhattacharyya *et al.*, 1984). However, in natural systems, many questions remain unanswered especially regarding their stability as a function of the variation of chemical factors.

In the northern Apennine Mn ores braunite + quartz represent the stable mineral assemblage during the entire tectono-metamorphic evolution, up to prehnite-pumpellyte-facies conditions (T = 275 ± 25 °C; P = 2.5 ± 0.5 kbar; Lucchetti *et al.*, 1990). During metamorphism, however, the development of syntectonic fracture systems provided preferential pathways for extensive fluid circulation within the manganese ores and triggered the breakdown of the braunite + quartz assemblage, as a consequence of the variation of the chemical conditions.

The aim of this study is to evaluate the mechanism and the physicochemical constraints of the

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