Importance of fluid immiscibility in the H$_2$O-NaCl-CO$_2$ system and selective CO$_2$ entrapment in granulites: experimental phase diagram at 5-7 kbar, 900°C and wetting textures

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Abstract: New experimental data on fluid immiscibility in the H$_2$O-NaCl-CO$_2$ system at 900°C and 5-7 kbar have been obtained using the synthetic fluid-inclusion technique. The main result is a significant enlargement of the immiscibility field as pressure decreases from 7 to 5 kbar. Combined with previous data, our experiments show that immiscibility is probably a widespread phenomenon in low-pressure granulite-facies rocks. Because CO$_2$-rich fluids and NaCl-rich aqueous fluids have very contrasting wetting behaviour, fluid unmixing could result in a selective entrapment of the CO$_2$-rich component in granulites (Watson & Brenan, 1987). To check this hypothesis, we performed an experiment in which polycrystalline quartz was heat-treated in the presence of small volume percentages of the two immiscible fluids. The observed pore geometry is characterized by a combination of large, isolated CO$_2$-rich bubbles, and an interconnected network of NaCl-H$_2$O-filled channels along quartz edges. A model combining unmixing and the subsequent escape of the aqueous fluid by porous flow could therefore explain the CO$_2$-rich fluid inclusions in low-pressure granulites.

Key-words: immiscibility, H$_2$O-CO$_2$-NaCl system, synthetic fluid inclusion, wetting texture, granulite facies.

1. Introduction

During the last twenty years fluid-inclusion studies have demonstrated the importance of aqueous fluids containing dissolved electrolytes (mainly NaCl) and CHON gases (CO$_2$, ± CH$_4$, ± N$_2$) in crustal igneous, metamorphic or sedimentary processes. Mineral dissolution, mass transport and ore deposition are greatly influenced by the volatile composition of these fluids (Walther & Schott, 1988; Dandurand & Schott, 1992; Gibert et al., 1992). CO$_2$ is the dominant volatile in most medium- to high-grade metamorphic rocks; it is ubiquitous in high-T, low-P granulite-facies rocks, where CO$_2$-rich fluid inclusions are widely found (Touret, 1985). The origin of these CO$_2$-rich fluids is much debated. These fluids are generally interpreted in terms of CO$_2$ infiltration from a deep-seated source (see discussion in Newton, 1992), and deep crustal faults seem to play an essential role in this process (Pili et al., 1997). This model is, however, inconsistent with detailed petrological studies suggesting that granulite-facies rocks with CO$_2$-rich inclusions have parageneses typical of a low PCO$_2$ (Valley et al., 1990). For these authors, partial melting or intrusion of an H$_2$O-undersaturated magma may explain the large occurrences of CO$_2$-rich fluid inclusions in the Adirondacks granulite-facies rocks. Another hypothesis involves immiscibility (Sisson et al., 1981; Johnson, 1991), conditions under which a single-phase fluid becomes unstable and unmixes to give an assemblage of two coexisting immiscible fluid phases of different compositions. An increasing number of analytical data obtained from fluid-inclusion studies shows that immiscibility is a rather common