Wagnerite in a cordierite-gedrite gneiss: Witness of long-term fluid-rock interaction in the continental crust (Ile d’Yeu, Armorican Massif, France)

PAVEL PITRA,1,* PHILIPPE BOULVAIS,1 VLADIMIR ANTONOFF,1† AND HERVÉ DIOT2

1Géosciences Rennes, UMR CNRS 6118, Université Rennes 1, 35042 Rennes, France
2Pôle Sciences et Technologie, Université de La Rochelle, 17042 La Rochelle, France

ABSTRACT

We describe the first occurrence in the Variscan Belt of Western Europe of the relatively rare phosphate wagnerite, ideally Mg₂PO₄F. It occurs in albite-rich, cordierite-gedrite-bearing gneisses on the island of Ile d’Yeu, southern Armorican Massif, France. These gneisses are associated with a network of shear zones that crosscut granitoid orthogneisses of calc-alkaline affinity. Wagnerite is zoned and displays a rimward decrease of Fe/(Fe + Mg) from 0.16 to 0.08 and a concomitant increase in F. The F content ranges 0.46–1.05 apfu, but critically depends on the choice of the analytical standard. Based on phase diagrams calculated with THERMOCALC, we infer that the wagnerite-bearing orthoamphibole + cordierite + biotite + chlorite paragenesis equilibrated at ca. 550 °C, and pressures lower than 4 kbar. The presence of staurolite relics requires similar temperatures, but pressures higher than 4 kbar, implying an evolution dominated by decompression. On the basis of whole-rock chemistry and stable isotopes, we suggest that superimposed periods of metasomatic alteration throughout the metamorphic history led to the prograde stabilization of the cordierite-gedrite gneiss at the expense of the orthogneiss. This alteration involved aqueous fluids in isotopic equilibrium with local rocks and caused significant loss of Ca, K, and Si, and gain of Mg and Na. We argue that the Na-enrichment is the most significant difference between wagnerite-bearing and wagnerite-free Mg-rich, Ca-poor rocks on Ile d’Yeu. This emphasizes the possible importance of Na metasomatism for the formation of wagnerite. In light of comparisons with other wagnerite occurrences, we conclude that a long-term fluid-rock interaction, typically associated with shear-zones, may be the rule rather than the exception for the formation of wagnerite in metamorphic rocks unaffected by anatexis.

Keywords: Wagnerite, cordierite-gedrite gneiss, fluid-rock interaction, metamorphism, phase diagrams, P-T and P-X pseudosections

INTRODUCTION

Wagnerite, a relatively rare constituent of metamorphic and igneous rocks, is the Mg- and F-dominant member of the tripolite group, (Mg,Fe,Mn)₂(PO₄)(OH,F). It has been reported from pegmatites (e.g., Staněk 1965), anatectic veins in a ultrahigh-temperature complex (e.g., Grew 1981; Grew et al. 2006), low-temperature carbonate veins (Hegemann and Steinmetz 1927), and from a wide range of metamorphic conditions: diagenetic environments (Braithsch 1960a, 1960b), amphibolite-facies rocks (Sheridan et al. 1976; Irouschek-Zumthor and Armbruster 1985; Leroux and Ercit 1992), and very high-pressure rocks (Chopin and Sobolev 1995; Brunet et al. 1998), and low- to high-pressure granulites (Novák and Povondra 1984; Vry and Cartwright 1994; Simmat and Rickers 2000; Ouzegane et al. 2003; Ren et al. 2003). Thus, there appears to be no restriction on the P-T stability range of wagnerite. In contrast, the OH-analog of wagnerite (β-Mg₂PO₄·OH) has been synthesized only at pressures above ca. 8 kbar, suggesting that wagnerite is stabilized toward lower pressures by the incorporation of F (Brunet et al. 1998). The chemical composition of wagnerite could therefore be of geobarometric interest.

Most authors concur that wagnerite occurrences are limited to rocks that have high Mg and low Ca contents. The relatively rare cordierite + orthoamphibole-bearing gneisses, which typically result from metamorphism under low- to medium-pressure and moderate- to high-temperature conditions, display such uncommon bulk compositions (Ca- and K-poor, Mg- and Al-rich). These unusual chemical characteristics are ascribed either to particular protoliths (evaporitic sediments, products of pre-metamorphic weathering, or hydrothermal alteration) or to metasomatic alteration during metamorphism (e.g., Spear and Schumacher 1982). Many cordierite-orthoamphibole rocks are associated with massive sulfide deposits and are interpreted as volcanic rocks hydrothermally altered by seawater prior to metamorphism (e.g., Schumacher 1988; Smith et al. 1992; Pan and Fleet 1995; Witt 1999; Peck and Valley 2000; Roberts et al. 2003). In other, less common cases, cordierite + orthoamphibole formed at the expense of granulite-facies parageneses during fluid-assisted retrogression (Guiraud et al. 1996; Owen and Greenough 2000) that may be localized along shear zones (Dasgupta et al. 1999).

* E-mail: pavel.pitra@univ-rennes1.fr
† Present address: Institut National de la Recherche Scientifique, 490 rue de la Couronne, Québec G1K 9A9, Canada.