Paragenesis of titanite in metagreywackes of the Franz Josef-Fox Glacier area, Southern Alps, New Zealand

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Abstract: Titanite occurs as an accessory mineral in schistose metagreywackes of the chlorite and biotite-albite zones in the Franz Josef-Fox Glacier area, Southern Alps of New Zealand. Two different types of titanite are recognized; detrital and authigenic, (i.e. as a replacement phase of detrital titanite and ilmenite, and as single grains in the matrix). Detrital titanite persists into the higher grade part of the biotite-albite zone and is characterized by low Al₂O₃, high TiO₂ and significant Fe₂O₃ in addition to containing Mn, Ce, La and Nb. With respect to authigenic matrix titanite, titanite that replaces detrital titanite and ilmenite has low Al₂O₃ and high TiO₂ reflecting the host mineral compositions. Nb is present but Ce and La are below detection limit. Authigenic matrix titanite becomes depleted in Al, Fe and F and enriched in Ti with increasing metamorphic grade indicating the coupled substitution [Al, Fe]³⁺ + [F, OH] ⇌ Ti⁴⁺ + O²⁻. Decreasing Fe³⁺ can probably be related to decreasing bulk rock oxidation ratio; decreasing Al to preferential uptake by coexisting epidote and decreasing F is associated with progressive F-enrichment of apatite with increasing metamorphic grade.

At temperatures between 300-400°C at pressures of 3-4kbar the titanite + CO₂ ⇌ calcite + rutile + quartz buffer reaction indicates that XCO₂ in the fluid phase was below 0.02 in rocks of the chlorite and biotite-albite zones where calcite is only present as veins. In the biotite-albite-oligoclase zone, calcite + ankerite occur as matrix minerals and XCO₂ may have been ~ 0.05 and coinciding with the disappearance of titanite and the incoming of oligoclase (An₂₀) and authigenic ilmenite.

Because the [Al, Fe]³⁺ + [F + OH] ⇌ Ti⁴⁺ + O²⁻ substitution in titanite is expected to increase with increasing pressure and/or increasing temperature in rocks of essentially the same bulk composition, the early generation of Al-Fe-F-rich titanite in the metagreywackes may be the product of a higher P/T metamorphism than the later generation of Al-Fe-F-poor replacement titanite.

Key-words: titanite, metagreywacke, Southern Alps, New Zealand.

Introduction

Titanite (previously known as "sphene", CaTiSiO₅) occurs as an accessory mineral in a large variety of rock types of igneous, hydrothermal and metamorphic origin (e.g. Deer et al., 1982). Studies of titanite-bearing metamorphic rock assemblages (e.g. Karpov, 1966; Ghent & DeVries, 1972; Zen, 1974; Coombs et al., 1976; Itaya & Banno, 1980; Kawachi et al., 1983) and experimental determination of titanite stability relations by Karpov (1966), Schuiling & Vink (1967) and Hunt & Kerrick (1977) indicate that titanite is a useful indicator of P-T-XCO₂ conditions of metamorphism. The titanite structure can accommodate significant amounts of Al,