Synthesis and chemical variability of Mg-staurolite in the system MgO-Al2O3-SiO2-H2O as a function of water pressure

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Abstract: Mg-staurolites were synthesized from a gel with the oxide ratio 4 MgO : 9 Al2O3 : 8 SiO2 at water pressures from 20 to 50 kbar and the constant temperature of 800°C. They form euhedral grains up to 10 μm in length. The chemical composition is strongly correlated with water pressure and, compared to the ideal formula of Mg3.4Al1.8Si2.8O10(OH)2.4, the magnesium content increases only slightly between pressures of 20 and 30 kbar, whereas a strong decrease in the aluminum content is accompanied by an increase in the amount of hydrogen. This suggests the following substitutions: 3 H+ ↔ Al3+ and Mg2+ ↔ H12. At higher pressures, a further increase in hydrogen is accompanied by a decrease in magnesium content related to the substitution 2 H+ ↔ Mg2+. The change in substitution mechanisms may reflect an increase in the amount of sixfold coordinated magnesium at high pressure. Surprisingly, the lattice parameters of Mg-staurolites are not measurably influenced by their chemical variability.

Key-words: MASH-system, Mg-staurolite, synthesis, chemical composition

Introduction

Staurolite, a common mineral of medium-grade pelitic schists, is a phase showing very wide chemical variability. In the last 30 years, several geoscientists have studied the crystal chemistry of this mineral and proposed various substitutions accounting for the observed differences from the formula (Fe,Mg)4Al16Si16O48(OH)12 proposed by Náray-Szabó & Sasvári (1958). Difficulties arise in the exact determination of the chemical composition of natural staurolites because of variable amounts of lithium, hydrogen and trivalent iron, which cannot be determined by routine analysis using the electron microprobe (Dutrow et al., 1986; Holdaway et al., 1986 a; Hawthorne et al., 1993 a). In recent years, attempts have been made to obtain more complete chemical data for natural staurolites using the ion microprobe technique (Holdaway et al., 1986 a,b; Dutrow et al., 1986). On the basis of these and other studies on natural specimens by Hawthorne et al. (1993 a,b,c) the crystal chemistry of staurolite has been elucidated. These authors found that "the chemical complexity of staurolite is resulting from the interaction between long-range and short-range charge-balance requirements" (Hawthorne et al., 1993 c). The staurolite structure typically contains more than 2 H and the resulting positive net charge is compensated by the substitution [M(4)]R2+ + 2 [T(2)] = [M(4)] R2+ + 2 [T(2)] (Hawthorne et al., 1993 c; site assignments after Hawthorne et al., 1993 a). The present study investigates the influence of