Slawsonite-celsian-hyalophane assemblage from a picrite sill (Prague Basin, Czech Republic)

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ABSTRACT

The first European occurrence of slawsonite is reported from a picrite sill within Upper Ordovician strata of the Prague Basin near the village of Rovina, Czech Republic. The rare slawsonite forms an interstitial phase in association with abundant celsian and hyalophane, replacing the original calcic plagioclase (bytownite). A study of this curious natural slawsonite-celsian-hyalophane assemblage provides a valuable insight into feldspar stability and petrogenesis. Whole-rock geochemical signatures of the picrite sill and underlying doleritic basalt intrusion show conspicuous enrichment in Sr and Ba superimposed on normal basaltic multielement patterns. These two elements were most likely introduced by intergranular fluids during diffusional seafloor metamatism (rodingitization and serpenitization) of the picrite. Strontian and barianfeldspars precipitated directly from BaO-SrO-H2O-bearing fluid, which caused decomposition of plagioclase to vaugnaitite, aqueous SiO2, and Al2O3 at T ≤ 350 °C. Subsequently, vaugnaitite decomposed to hydrogrossular and excess SiO2 was consumed by serpenitization of olivine. At the expense of aqueous Al2O3, serpentine reacted to chlorite closing the picrite alteration at 320–160 °C. Pressure did not exceed 0.5 GPa. In situ EDS analyses indicate that the chemical composition of the slawsonite is Sr10Ca10An18Ab17Or7Si0.5 (core) to Sr8Ca10An18Ab17Or7Si0.5 (rim), the celsians range from Cn36,6An35,6Ab35,6Or3,6 to Cn36,6An7,3Ab15,5Or16,5Si6,3, and the hyalophanes vary from Cu12,3An4,5Ab5,3Or5,3Si6,3 to Cn37,3An35,6Ab17,3Or16,3Si6,3.

Keywords: Slawsonite, celsian, hyalophane, strontium and barium feldspars, vaugnaitite, hydrogrossular, rodingitization, serpenitization, Prague Basin

INTRODUCTION

Feldspar can be assigned as a barian once its chemical analysis contains more than 2 wt% of BaO (Deer et al. 1992). Celsian (BaAl2Si2O8; Cn) is an end-member of an extensive solid solution with K-feldspar (KAlSi3O8), whereby the term hyalophane (Hy) is used for intermediate compositions [10–80 mol% of Cn: Deer et al. (2001) or 15–75 mol% of Cn: Essene et al. (2005)], with the remainder being dominated by Or prevailing over Ab. Furthermore, hyalophanes with >50 mol% Cn are referred to as barian, and those with <25 mol% Cn as potassian. Natural celsians and hyalophanes usually have a monoclinic symmetry. However, even triclinic polymorphs of hyalophane (with < Cn30) were found in nature (Gay and Roy 1968). Celsian structure resembles monoclinic body-centered Si-Al unit cells of anorthite, in which an addition of relatively small Ca2+ leads to distortion of framework and origin of triclinic symmetry. Nevertheless, celsians do not show strict regularity in alternation of Si and Al atoms like anorthite but significant Al and Si disorder (Griffin and Ribbe 1976). An acceptance of large radius ion Ba2+ into celsian framework keep the monoclinic symmetry and explain why hyalophanes with <Cn30, e.g., with prevalence of Ca2+, have triclinic symmetry. Experimental works confirmed the solid solution between celsian and albite (NaAlSi3O8) but with a miscibility gap (Viswanathan and Harneit 1989). These results were applied to the ternary system BaAl2Si2O8-NaAlSi3O8-KAlSi3O8 (Lagache and Catel 1992; Viswanathan 1992). According to the most recent summary (Essene et al. 2005), 8 four-feldspar and 24 three-feldspar assemblages may be stable in the system BaAl2Si2O8-CaAl2Si2O8-NaAlSi3O8-KAlSi3O8.

While the occurrence of Ba-bearing feldspars is relatively common, natural slawsonite (SrAl2Si2O8; Sl) is extremely rare. It is isostructural with paracelsian (BaAl2Si2O8) (Griffin et al. 1977; Matsubara 1985). Paracelsian is a metastable phase of the slawsonite-paracelsian series and reacts to celsian at 550 °C; however, its stability at a lower T remains a possibility (Lin and Foster 1968). Phase transition from the low-T triclinic to the moderate-T monoclinic structure of natural slawsonite at ambient pressure has been observed at 320 °C (Tagai et al. 1995). Monoclinic slawsonite is stable up to 500 °C (McCauley 2000) or 600 °C (Bambauer and Nager 1981), when it transforms into another monoclinic polymorph, Sr-celsian (melting T = 1650 °C), although the reaction has not yet been reversed. The Sr-celsian is isostructural with celsian but has no natural counterpart (McCauley 2000). Partial replacement of Sr by Ca has been reported in slawsonite from metamorphosed limestones in Wallowa County, Oregon (Griffin et al. 1977; Matsubara 1985), and from slawsonite veinlets cutting pectolite veins in metamorphosed xenoliths (glaucophane to pumpellyite-actinolite schist of the Ino Formation) in Rendai, Japan (Nakajima et al. 1978; Matsubara 1985). Barium substitution was detected in slawsonite veinlets from xenolith in an ultramafic rock exposed in weakly metamor-