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Two-, three- and four-feldspar assemblages with hyalophane and celsian: implications for phase equilibria in $BaAl_2Si_2O_8$–$CaAl_2Si_2O_8$–$NaAlSi_3O_8$–$KAlSi_3O_8$*

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Abstract: The occurrences of natural coexisting feldspars including hyalophane and also celsian delineate two-, three- and possibly four-phase fields in the system $BaAl_2Si_2O_8$–$CaAl_2Si_2O_8$–$NaAlSi_3O_8$–$KAlSi_3O_8$. Hyalophane occurs with albite and microcline in a very low grade (anchizonal to epizonal) metasedimentary association from the Uppony Mountains, Hungary, and in Grenville marbles from Ontario. Analyses show very little Ba in albite and only limited Na in hyalophane. One marble from the garnet zone has albite ($Ab_{95\text{-}98}$), oligoclase ($An_{17}Sl_3Ab_{80}$), hyalophane ($Cn_{65}Sl_3An_2Ab_9Or_{24}$) and celsian ($Cn_{92}Sl_3An_1Ab_2Or_2$). The albite and oligoclase are complexly intergrown and may indicate unmixing during cooling. A marble in the sillimanite zone contains albite ($Ab_{95\text{-}98}Or_{2\text{-}3}$), oligoclase ($An_{17}An_2Sl_3Ab_{33}Or_{24}$), hyalophane ($Cn_{65}Sl_3An_2Ab_9Or_{24}$), and an inclusion of celsian ($Cn_{67}An_1Sl_2Ab_2Or_{91}$) in an albite. Sanidine from the Peshtigo monzonite in Wisconsin unmixed to a symplectic perthite with barian microcline ($Cn_{8\text{-}11}An_2Ab_{8\text{-}13}Or_{75\text{-}80}$) and oligoclase ($Cn1An_{18}Ab_{79}Or_2$). The former compositions of the ternary igneous feldspars ($Cn_3An_9Ab_{46}Or_{42}$, $Cn_1An_{18}Ab_{69}Or_{12}$) were obtained by reintegration.

The Na content of hyalophane equilibrated with albite is correlated with metamorphic grade. Hyalophane has 5 ± 2 mol % Ab in very low-grade associations, 10 ± 3 mol % Ab in the greenschist facies, 16 ± 2 mol % Ab in the low to middle amphibolite facies, and 30 mol % Ab in the upper amphibolite to granulite facies even when not buffered with albite. The limited Na content of celsian equilibrated with albite in the greenschist facies is in striking disagreement with the narrow solvi obtained from unreversed experiments on the join $BaAl_2Si_2O_{86}$–$NaAlSi_3O_8$.

Up to 8 four-feldspar and 24 three-feldspar assemblages may be stable in the system $BaAl_2Si_2O_8$–$CaAl_2Si_2O_8$–$NaAlSi_3O_8$–$KAlSi_3O_8$. In contrast, the repeatedly observed and variably located discontinuities within zoned hyalophane grains may represent changes in the environment during mineral growth rather than internal miscibility gaps. Given its miscibility gaps with microcline and celsian, the name hyalophane is justified for intermediate feldspars near the Cn-Or join.

Key-words: hyalophane, celsian, solvus, three feldspars, four feldspars, $BaAl_2Si_2O_8$–$NaAlSi_3O_8$–$KAlSi_3O_8$, $BaAl_2Si_2O_8$–$CaAl_2Si_2O_8$–$NaAlSi_3O_8$–$KAlSi_3O_8$

Introduction

Most natural feldspars are well represented compositionally in $CaAl_2Si_2O_8$–$NaAlSi_3O_8$–$KAlSi_3O_8$ (An–Ab–Or). However, barian feldspars occur sporadically in diverse settings ranging from diagenetically altered sediments and hydrothermal veins, to marbles and other metasediments, to granites, pegmatites and felsic volcanic rocks. Celsian (Cn, $BaAl_2Si_2O_8$) has a structure similar to that of anorthite but with significant Al and Si disorder (Griffen & Ribbe, 1976). It has a polymorph, paracelsian, with a different space group, isostructural with danburite ($CaB_2Si_2O_8$) (Chiari *et al.*, 1985), slawsonite (Sl, $SrAl_2Si_2O_8$) (Griffen *et al.*, 1977), also meleevite ($BaB_2Si_2O_8$) and pekovite ($SrB_2Si_2O_8$) (Pautov *et al.*, 2004). Lin & Foster (1968) reacted paracelsian to celsian at T ≥ 500°C and 1 kbar and concluded that paracelsian is metastable. A stability field for paracelsian cannot however be ruled out altogether at

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