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Magmatic-Subsolidus and Oxidation Trends in Composition of
Amphiboles from Silica-Saturated Peralkaline Igneous Rocks

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Summary

Sub-calcic alkali amphiboles from silica-saturated peralkaline rocks exhibit two main patterns of compositional variation, which we term the magmatic-subsolidus and oxidation trends. The first is a continuous change from magmatic to subsolidus amphibole from barroisite through richterite to arfvedsonite, involving substitutions under reducing conditions, mainly of the type $\text{Al}^{IV} \text{Ca} \rightarrow \text{Si(Na, K)}$. The second trend is towards riebeckite, under the influence of oxidizing hydrothermal fluids, according to a reaction such as $\text{Fe}^{2+} \text{Si} \rightarrow \text{Fe}^{3+}\text{Al}^{III}$ or $(\text{K, Na})\text{AFe}^{2+} \rightarrow \text{Fe}^{3+}$. Textural evidence suggests that fluid characteristics are as important as host-rock compositions in controlling the chemical characteristics of amphiboles in peralkaline intrusive and volcanic rocks.

Zusammenfassung

Alkali-Amphibole aus Si-gesättigten peralkalinen Gesteinen zeigen zwei definierte Trends chemischer Variation, die hier als „magmatisch-subsolidus“ und „Oxydations“-Trend bezeichnet werden. Der erstere stellt einen kontinuierlichen Übergang von magmatischen zu subsolidus Amphibolen dar, und zwar von Barroisit über Richterit bis zu Arfvedsonit, wobei Substitutionen unter reduzierenden Bedingungen, hauptsächlich des Typs $\text{Al}^{IV} \text{Ca} \rightarrow \text{Si(Na, K)}$, zu beobachten sind. Der zweite Trend zeigt, unter dem Einfluß oxydierender hydrothermaler Lösungen, eine Tendenz auf Riebeckit hin, entsprechend einer Reaktion wie z.B. $\text{Fe}^{2+} \text{Si} \rightarrow \text{Fe}^{3+}\text{Al}^{III}$ oder $(\text{K, Na})\text{AFe}^{2+} \rightarrow \text{Fe}^{3+}$. Mikroskopische Befunde weisen darauf hin, daß die Eigenschaften dieser Lösungen genauso wichtig für die chemische Zusammensetzung der Amphibole in peralkalinen Intrusiv-Gesteinen und Vulkaniten sind, wie die Zusammensetzung der Wirtsgesteine.
Introduction

Sub-calcic alkali amphiboles are distinctive features of peralkaline\(^1\) igneous rocks, whether saturated or undersaturated with respect to silica (Sorensen, 1974). Giret et al. (1980) have made the following observations concerning amphibole compositions in such rocks.

1. The Ca + Al\(^{IV}\) content of the amphiboles is less than 3.5, reflected in the presence of solid-solution series from barroisite to winchite (with CaAl\(^{IV}\) ⇔ NaSi substitution), or from barroisite to kataphorite, richterite, and then arfvedsonite with balanced substitutions (⇌ Fe\(^{3+}\) ⇔ NaFe\(^{2+}\) and CaAl\(^{IV}\) ⇔ NaSi).

2. The absence of (Ca + Al\(^{IV}\))-rich amphiboles in agpaitic rocks and an observed compositional break between (Ca + Al\(^{IV}\))-rich amphiboles and (Ca + Al\(^{IV}\))-poor amphiboles suggest that (Ca + Al\(^{IV}\))-rich amphibole stability is controlled by magma alkalinity.

We have done a detailed petrographic and electron microprobe study of amphiboles from silica-saturated peralkaline rocks in the Topsails and St. Lawrence plutonic/volcanic complexes of Newfoundland which generally supports their conclusions regarding chemical trends and substitutions, and extends the range of textural observations to allow some refinement of their interpretation. In particular, we suggest that magma chemistry is less important than fluid chemistry in controlling late stage amphibole compositions in peralkaline rocks.

The Topsails Igneous Complex

Geological Setting. The Topsails igneous complex of western Newfoundland is a large (> 6000 km\(^2\)) intrusive complex of two contrasting geochemical suites, a non-peralkaline and a peralkaline, and at least four distinct granitoid facies: (i) a fine- to medium-grained biotite-bearing slightly peraluminous biotite-hastingsite granite; (ii) a medium- to coarse-grained metaluminous biotite-hastingsite granite; (iii) fine- to medium-grained biotite-hornblende granite and syenite; and (iv) a coarse-grained peralkaline aegirine-arfvedsonite granite. Peralkaline microgranite dykes cut the other granitoid intrusions and country rocks (Taylor et al., 1980).

Peralkaline granites occur within the central parts of the complex, and the other granitoid phases are found in marginal areas. Volcanic roof pendants and porphyries are likewise divisible into peralkaline and non-peralkaline groups. The former are extrusive equivalents of the peralkaline granite, and the latter represent extrusive equivalents of the other intrusions of the complex. Contemporaneous basalt magmatism is indicated by dikes that cut the biotite granite and are in turn cut by the peralkaline granite. Radiometric dates which we have determined for the complex range from 425 to 390 Ma.

The peralkaline and non-peralkaline suites are chemically distinctive, with the peralkaline rocks all displaying agpaitic ratios greater than one, and enrichment in

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\(^1\) Those rocks in which the molecular ratio \((Na_2O + K_2O)/Al_2O_3\) is greater than 1.0.