Amphibole chemistry in alkaline igneous rocks of the Pikes Peak batholith, southern Front Range, Colorado

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The Pikes Peak batholith is one of many enigmatic alkaline granitic intrusions for which a satisfactory petrogenetic model has yet to be postulated. Barker et al. (1975, 1976) presented the only in-depth discussions of a possible model for the genesis and evolution of the Pikes Peak batholith and its associated sodic intrusions (see Noblett et al this volume for details), a model which requires a single parental magma for the varied rock types of the several sodic intrusions.

Compositional trends of amphiboles in alkaline rocks are well documented and can be related to trends in bulk rock composition (eg., Giret et al., 1980; Mitchell, 1990). Many reasearchers have found amphibole compositional trends to be a useful petrogenetic discriminant (eg., Platt and Woolley, 1986; Bedard, 1988), yet Barker et al. (1975) present the only previously published chemical analyses of Pikes Peak amphiboles, major element chemistry of amphiboles from just two rocks of the sodic intrusions.

Major element chemistry of amphiboles in 12 samples from three of the sodic intrusions (figure 1) was determined using a scanning electron microscope with an energy dispersive spectrometer. The general amphibole formula $A_{(0-1)}B_2C^{vi}_5T^{iv}_8O_{22}(F,Cl,OH)_2$ was filled by calculating on the basis of 23 O anhydrous. The ratio Fe^{2+}/Fe^{3+} was calculated on the basis of Σcations-(Ca+Na+K)=13 except where noted. Names were assigned following the recommendations of the International Mineralogical Association (Leake, 1978). Using neutron activation, amphibole separates from two of the samples were analyzed for trace element contents.

Based upon Ca+Al^{iv} and Si+Na+K content (after Giret et al., 1980) the amphiboles in these rocks can be divided into two groups, which are separated by a significant compositional gap (figure 1). The first group, (Ca+Al^{iv})-rich, (Si+Na+K)-poor amphiboles, consists of ferro-edenitic amphiboles and includes the amphiboles of the West Creek intrusive center and the Mount Rosa area fayalite granite. The second group, (Ca+Al^{iv})-poor, (Si+Na+K)-rich amphiboles, consists mainly of ferro-richteritic and arfvedsonitic amphibole, and includes the amphiboles of the Sugarloaf and Mount Rosa intrusive centers. Amphibole in one ferro-richterite-bearing sample shows solid solution toward ferro-winchite. Riebeckitic amphibole occurs in two samples: as a distinct phase in a ferro-richterite-bearing sample and as a solid solution component in an arfvedsonite-bearing sample. The twelfth sample contains gruneritic amphibole (endmember formula $Fe_7Si_8O_{22}(OH)_2$), which cannot be classified by this system. Gruneritic amphibole also occurs in trace amounts in one of the samples containing ferro-edenitic amphibole. In both samples in which it occurs, grunerite is probably a subsolidus phase, and it will not be considered further here.

The compositional trend shown in figure 1 is probably largely due to the substitution $CaAl^{iv}$ -> Na_BSi. This substitution is operative in both groups of amphiboles (figure 2), but the compositional gap between the two groups leaves the relationship between them ambiguous. Giret et al. (1980) suggested that in a fractional crystallization sequence (Ca+Al^{iv})-rich amphiboles break down when the agpaitic ratio ($(Na_2O+K_2O)/Al_2O_3$) of the host rock rises from <0.9 to >0.9, so that in rocks whose agpaitic coefficient is less than 0.9 amphiboles with a Ca+Al^{iv} content greater than 2.5 and a Si+Na+K content less than or equal to 8 occur, and in rocks whose agpaitic coefficient is greater than 0.9 amphiboles with a Ca+Al^{iv} content less than 2.5 and a Si+Na+K content generally greater than 8 occur (Giret et al., 1980). This distinction is found in the Pikes Peak amphiboles. The ferro-edenitic amphiboles have Ca+Al^{iv} contents greater than 2.5 and Si+Na+K contents less than 8 while the ferro-richteritic and arfvedsonitic amphiboles more than meet the second set of criteria. Compared to similar trends in other alkaline igneous complexes (eg., Giret et al., 1980; Platt and Woolley, 1986), the compositional gap between the two groups appears to be a little larger than might be expected. While Giret et al. (1980) and Platt and Woolley (1986) documented trends of (Ca+Al^{iv})-poor amphiboles extending from barroisite and katophorite through arfvedsonite and riebeckite, the Pikes Peak (Ca+Al^{iv})-poor amphiboles analyzed for this study extend only from ferro-richterite to arfvedsonite.

The (Ca+Al^{iv})-rich and (Ca+Al^{iv})-poor amphiboles are also distinguishable by their Ti versus Si and Mn versus Si trends (figures 3 and 4). The ferro-edenitic amphiboles show Mn increasing with increasing Si content, while the ferro-richteritic and arfvedsonitic amphiboles show Mn decreasing with increasing Si content. In the ferro-edenitic amphiboles as Si increases Ti sharply decreases. Ti also decreases with increasing Si content in the ferro-richteritic and arfvedsonitic amphiboles, but Ti content in the least siliceous ferro-richteritic and arfvedsonitic amphiboles is greater than in the most siliceous ferro-edenitic amphiboles.

Despite the compositional gap between the ferro-edenitic amphiboles and the ferro-richteritic and arfvedsonitic amphiboles, the trend seen in figures 1 and 2 is not inconsistent with a petrogenetic model in which the sodic intrusions evolved from a single parental magma. The compositional gap does, however, leave room for interpretation, and the Ti and Mn trends of the amphiboles suggest that processes more complex than pure fractional crystallization may have been involved in the chemical evolution of the sodic intrusions of the Pikes Peak batholith.

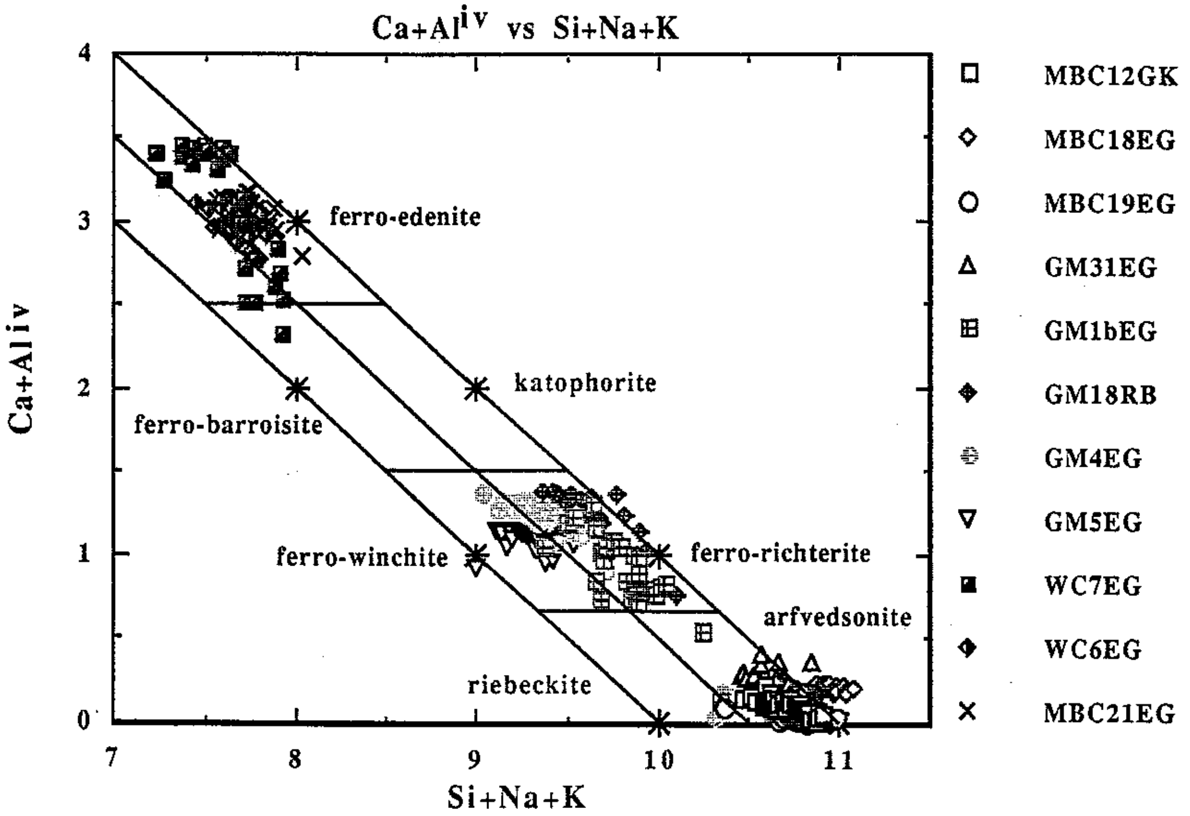

Figure 1. Mount Rosa intrusive center: MBC12GK fine-grained arfvedsonite granite (trace element analysis conducted), MBC18EG coarse-grained arfvedsonite granite (Fe^{2+}/Fe^{3+} calculated on the basis of Si+Al=8), MBC19EG fine-grained arfvedsonite to riebeckite granitic dike; Sugarloaf intrusive center: GM31EG fine-grained arfvedsonite granitic dike, GM1bEG coarse-grained biotite ferro-richterite to arfvedsonite granite, GM18RB coarse-grained ferro-richterite syenite (trace element analysis conducted), GM4EG coarse-grained ferro-richterite syenite, GM5EG fine-grained ferro-richterite to ferro-winchite syenite; West Creek intrusive center: WC7EG medium-grained biotite ferro-edenite quartz-syenite, WC6EG coarse-grained fayalite ferro-edenitic hornblende to ferro-edenite quartz syenite; MBC21EG Mount Rosa area fayalite biotite ferro-edenitic hornblende granite. (After Giret et al., 1980).

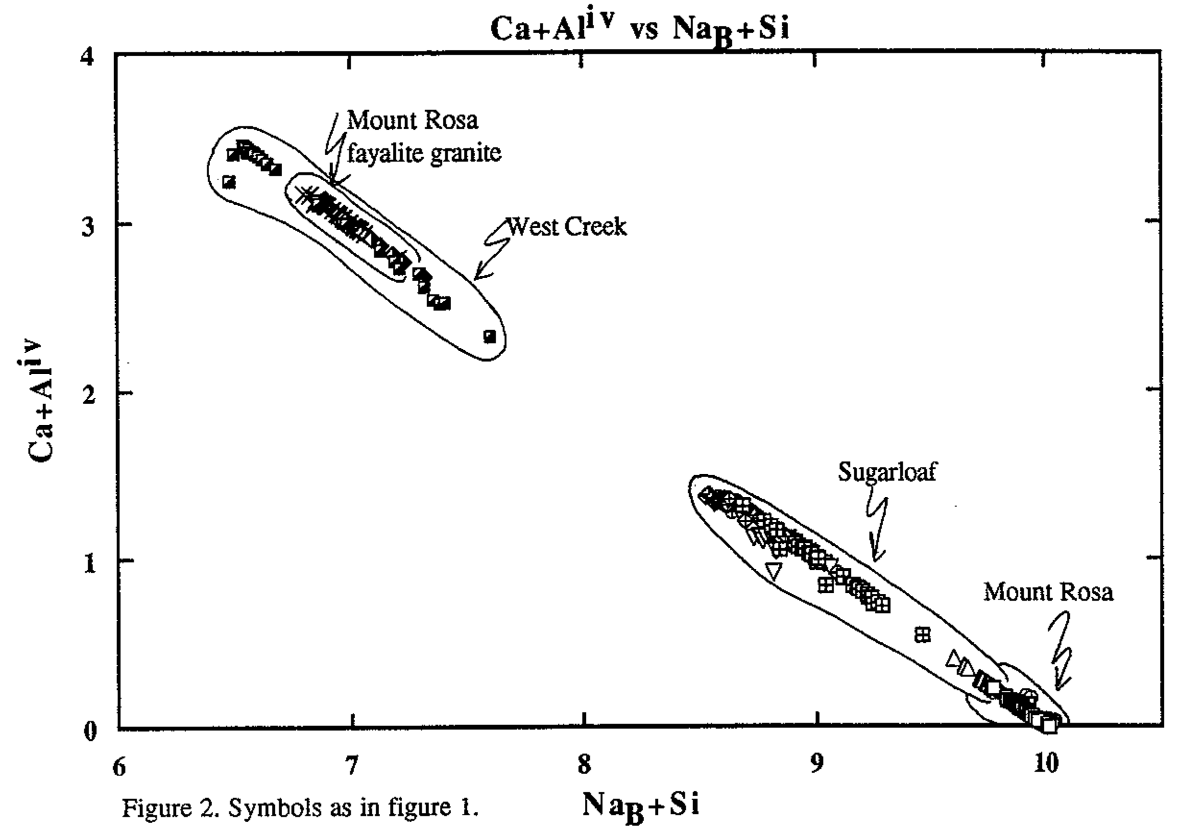

Figure 2. Symbols as in figure 1.

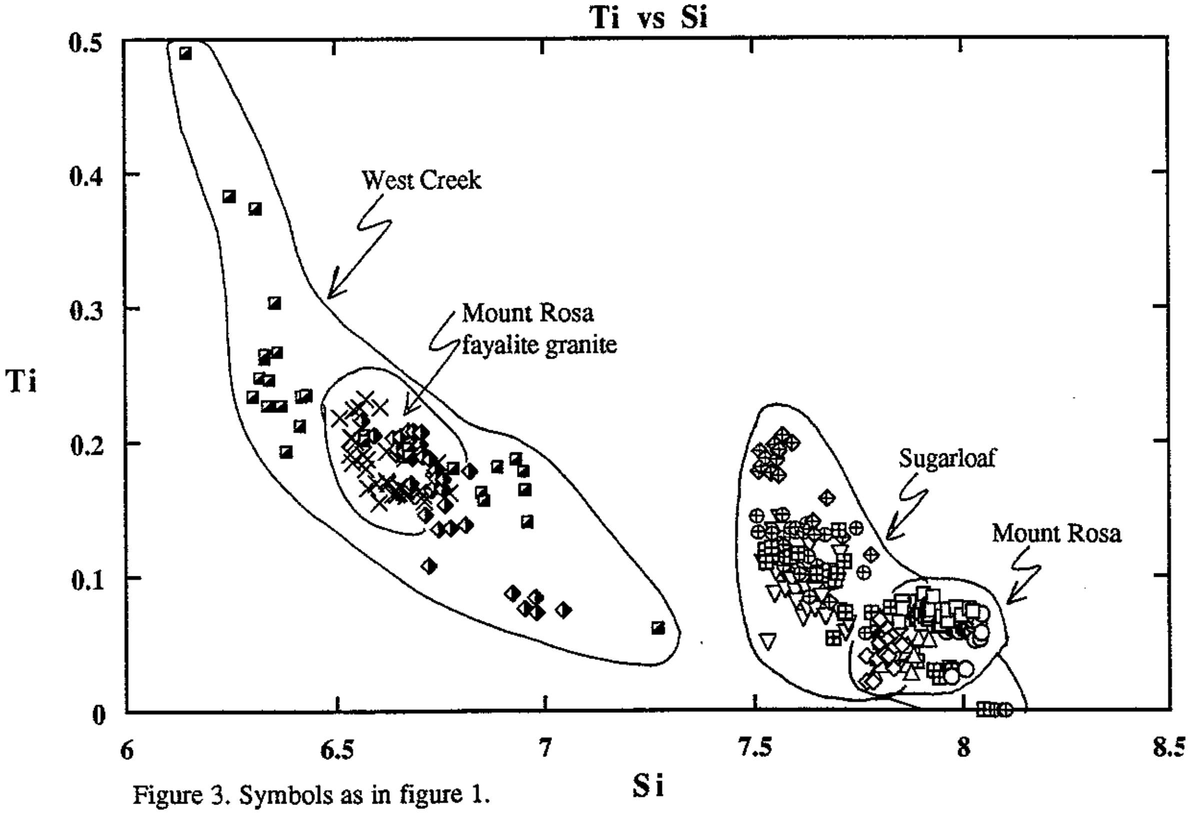

Figure 3. Symbols as in figure 1.

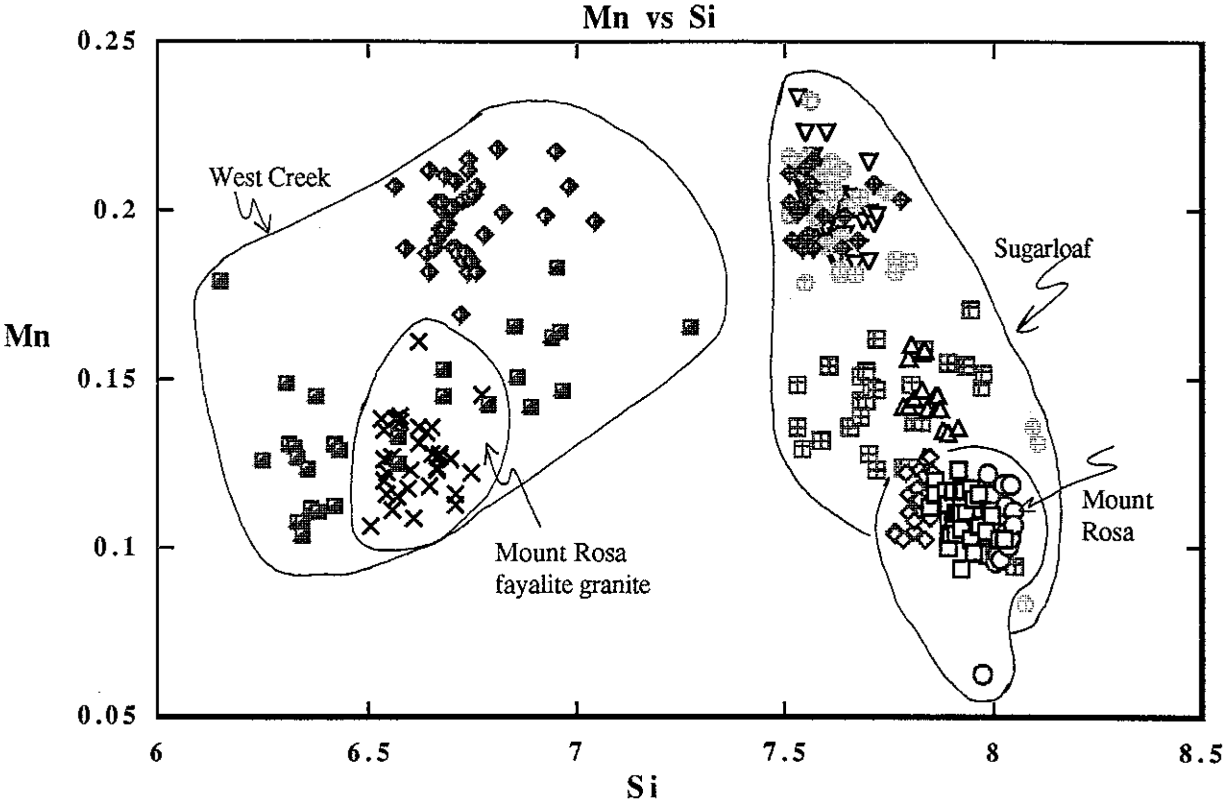

Figure 4. Symbols as in figure 1

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