USE OF OLIVINE AND PLAGIOCLASE SATURATION SURFACES FOR THE PETROGENETIC MODELING OF RECRYSTALLIZED BASIC PLUTONIC SYSTEMS

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During petrogenetic studies of basic plutonic rocks, there are at least three major questions to be considered: (1) what were the relative proportions of cumulate crystals and intercumulus melt in a given sample? (2) what is the composition and variation in composition of the melts within the pluton? and (3) what is the original composition of the liquids, their source and evolution prior to the time of emplacement? These questions are difficult to attempt to answer in unaltered bodies. They are even more difficult to answer in bodies which have undergone recrystallization and metamorphism as have most Archean basic plutons. In extreme cases one may not even be be sure a unit represents a metamorphosed basic pluton. Use of the olivine and plagioclase saturation surfaces can help to answer some of these questions in recrystallized bodies.

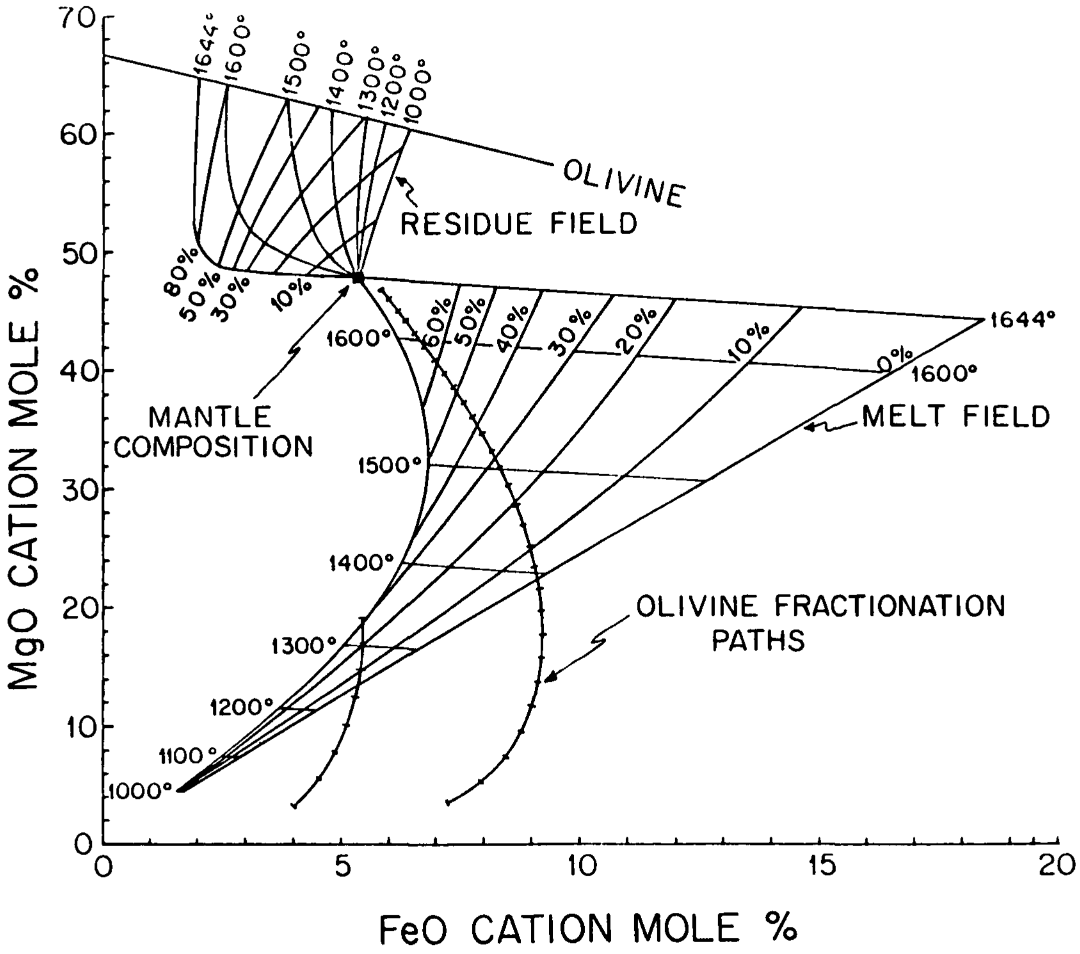

Figure 1.

Use of the olivine saturation surface diagram of Roeder and Emslie (1) on which possible melts and residues of mantle melting can be plotted and contoured for extents of melting and temperature of melting (one atmosphere) for a given mantle compositon (Fig. 1 from Hanson and Langmuir, 2) permits distinquishing whether a sequence of ultramafic rocks represents cumulates or residual mantle. A sequence of samples of residual mantle should plot close to the residue field in Fig. 1. The exact position of any sample will be dependent on the composition of the mantle, the extent and conditions of melting, and the fraction of melt retained with the residue.

A sequence of cumulates need not be restricted to the residue field in Fig. 1. If the composition of a cumulate plots close to the olivine composition, the range in compositions of the melt from which that cumulate precipitated must lie within the range of isopleths with the potential olivine compositions in the cumulate. For example in Fig. 2 for the cumulate plotted, the limits to the range of possible compositions for the cumulate olivine will be dependent on whether the rock represents an

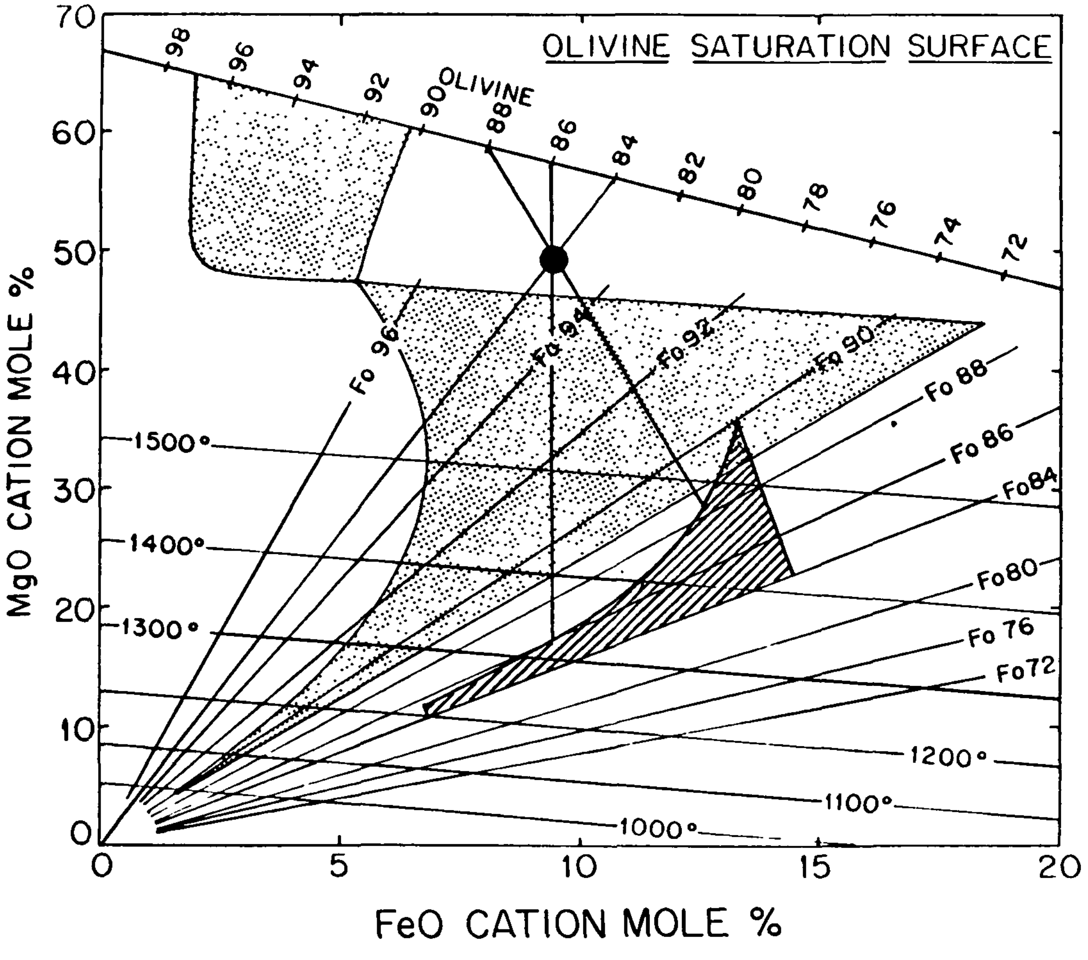

Figure 2.

orthocumulate or an adcumulate. For a metamorphosed rock this may not be apparent. If it is an adcumulate, because the pyroxenes generally have similar or higher Mg numbers than olivine, the maximum forsterite content of the olivine is given by a line from the origin through the sample intersecting the olivine composition, in this example Fo-84. If the sample represents an orthocumulate, the composition of potential melts is given by each line from the compositions of olivine with Fo greater than 84, through the sample to the appropriate isopleth. Two lines are shown as examples in Fig. 2. The field of possible intercumulus melts shown are below the primary melt field as might be expected for melts which have undergone olivine fractionation and is similar to the fields for mafic Archean volcanics.

The plagioclase saturation surface is shown in Fig. 3 from Langmuir (3) in which cation normative An and Ab are used to represent the plagioclase components in basic to dacitic melts. The composition and temperature of crystallization of liquidus plagioclase are shown on their respective contours. The recovered composition and temperature ar on average 3 mole % An and 12 degrees C respectively. Use of the olivine saturation surface in conjunction with the plagioclase saturation surface diagram allows consideration of whether a rock with a basaltic composition could have originally represented a melt. This is done by relating the composition of the rock to the possible melt field and olivine fractionation curves in Fig. 2 and comparing the liquidus temperatures for olivine and plagioclase on the respective saturation surfaces.

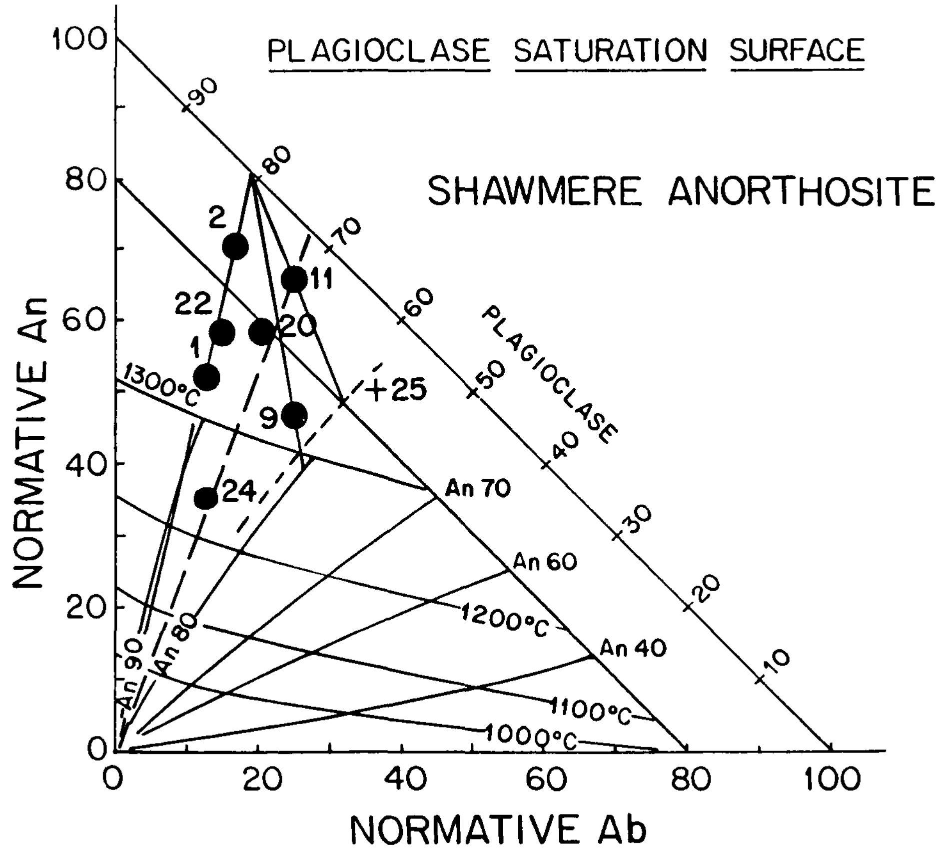

Figure 3.

The plagioclase saturation surface can also be used to place limits on the relative proportions and compositions of intercumulus melt and cumulate minerals in potential cumulate rocks (4). For example, cumulate samples from the Shawmere Anorthosite Complex are plotted in Fig. 3 as well as an anorthositic gabbro dike (Sample 25) from Simmons, Hanson and Lumbers (5). The cumulate minerals other than plagioclase plot near the origin of this diagram. Thus, any given rock must lie within the field defined by the origin, the cumulate plagioclase composition and the intercumulus melt composition. If samples 1, 2, and 22 are considered to be adcumulates, the cumulate plagioclase has a composition of An-81, which is the composition of recrystallized plagioclase from the core of a remnant megacryst in sample 2. If they contain significant intercumulus melt, the cumulate plagioclase has a higher An content. Thus the melt lies on an isopleth with an An content equal to or greater than An-81.

Assuming that sample 11 may have been derived from a melt similar to that from which sample 2 crystallized, we may use it to help place constraints on the normative plagioclase composition and abundance of the intercumulus melt. Sample 11 has a REE pattern and abundances compatible with significant cumulate plagioclase as does sample 2. Sample 11, however, has 2.3 to 4.0 times the abundance of REE for lights to heavies respectively compared to sample 2. This suggests that sample 11 is a mesocumulate or orthocumulate. Thus, the cumulate plagioclase is more anorthitic than An-73 the composition of cumulate plagioclase if sample 11 were an adcumulate. If for example, the cumulate plagiocase had an An content of An-81, the intercumulus melt must lie along the An-81 isopleth and to the right of a line drawn between the compositons of An-81 plagioclase and sample 11. Sample 25, the anorthositic gabbro dike, has a composition similar on this diagram to such a potential intercumulus melt. For a given composition melt and cumulate plagioclase it is possible to calculate the proportions of melt, plagioclase and total other cumulate phases using the lever rule.

Use of both saturation surfaces can place strong limits on the compositions of potential cumulate phases and intercumulus melts. Consideration of appropriate trace elements can indicate whether a sample is an orthocumulate, adcumulate or mesocumulate. Thus, when trace element and petrographic data are considered together with the saturation surfaces, it should be possible to begin to answer the three major questions given above, even for strongly recrystallized basic plutons.

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