

THE NOMENCLATURE AND ORIGIN OF THE NONCUMULATE ULTRAMAFIC
ROCKS AND THE SYSTEMATIC POSITION OF KIMBERLITES

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In most discussions of the systematics of igneous rocks, the kimberlites are omitted, or considered in a perfunctory manner. This is mainly because they are rare and their geochemical and petrographic characteristics set them apart from the more common igneous rocks. It is convenient to visualise igneous rocks as occupying a discrete field within multidimensional compositional space; and just as the Hertzprung-Russell diagram portrays the various types of stars and defines the stellar "main sequence", so in a similar manner the Total Alkali Silica (TAS) diagram portrays the broad spectrum of diverse igneous rocks and specifies the common rocks of the igneous main sequence. The compositions of the rocks that belong to the igneous main sequence range from the picobasalts and basalts through to the rhyolites, trachytes and phonolites. Most of the terms and concepts used in igneous petrology were developed in order to describe and account for the origin and evolution of the rocks of the main sequence. The trends in magmatic differentiation that characterise the rocks of the main sequence, together with the criteria conventionally used to define these trends, are often inapplicable to rocks outside the main sequence. A close examination of the low-silica igneous rocks reveals that, when compared to the rocks of the main sequence, they are in many ways dissimilar to normal volcanic or plutonic rocks.

An investigation of the concept of the plutonic and volcanic associations reveals that the rocks of the volcanic association are products of volcanic activity at, or very near, the surface of a planet; whereas the rocks of the plutonic association (Kennedy & Anderson 1938:25) usually "comprise the great, subadjacent stocks and batholiths" and typically comprise the granites and granodiorites of the continental crust. The peridotites of the upper mantle are dissimilar to crustal plutonic rocks as they evolved over long eons of time in a high temperature essentially static environment where annealing generated granular rocks in which the minerals have a high degree of inter-facial stability. It is proposed that the mantle rocks as a group belong to an ultraplutonic association. Included in this new association are rocks such as dunite, that are essentially solid residues left after partial melting, and a variety of peridotites. The latter have experienced one or more periods of partial melting, and periods of incompatible element enrichment caused by deep-mantle degassing and/or the reflux of previously subducted lithospheric materials. Another proposal is that the root name peridotite, should only be used to describe plutonic or ultraplutonic rocks: because, whereas it is proper to use this term to name rocks of these associations, it is contrary to conventional petrographic practice to use it to describe volcanic or quasi-volcanic rocks of similar composition. It would also be consistent with the foregoing discussion to accept the nomenclature introduced by Bogatikov et al. (1981:30), and give all the volcanic and quasi-volcanic rocks that contain between 25 and 41% SiO_2 , and less than 4.0% ($\text{Na}_2\text{O} + \text{K}_2\text{O}$) the root, or family name picrite. Irrespective of whether or not one recalculates their major element compositions on a H_2O^+ and CO_2 free basis, most kimberlites plot within the compositional field proposed for the picrite family on the TAS diagram.

In the preceding discussion the term quasi-volcanic was used to characterize rocks that have volcanic affinities but belong to the diatremic association (Harris et al. 1981:30). Such rocks usually occur in minor intrusions, dykes or pipes, and their structures and textures often indicate that they were injected as pipe-surge, or fluidized, systems. During emplacement these systems are characteristically composed of magmaclasts (i.e. fragments of partly or completely congealed magma), xenoclasts (i.e. xenoliths and xenocrysts) and a propellant phase. Before congealment part of the propellant phase may escape; however in many diatremic rocks part of it is trapped in carbonates and late-stage magmatic and/or secondary hydrous silicate minerals. The H_2O^+ and/or CO_2 contents of the diatremic rocks are normally

significantly higher than those of the rocks of the main sequence. In brief, it is argued that volatile components are a part of the very nature of the diatremic rocks, and it is thus inappropriate to recalculate the major element compositions of these rocks on a H_2O and CO_2 free basis. The lamprophyres are pre-eminent among the rocks of the diatremic association. In orthodox classifications of igneous rocks they occupy an extensive range that embraces many families and even clans of rocks. The ordinary lamprophyres are part of the main sequence of rocks and they are essentially shoshonites; the alkaline lamprophyres are essentially potassic tephrites; whereas the melilitic lamprophyres occur well outside the main sequence and are essentially picrites and foidites. It is proposed that the rocks of the diatremic association and the lamprophyres are synonymous; and as the lamproites and kimberlites are members of the diatremic association, they are thus also members of the lamprophyric association.

In the preceding discussion it was stated that the range of the melilitic lamprophyres extended from the picritic field into the foiditic field. On the extended TAS diagram the foidite domain is expanded into the low-silica field, and the new boundary lines are placed at 35% SiO_2 and 4% total alkali. In order to understand the nature of the low-silica rocks and the relationship between the picrites and foidites one has to take cognisance of the fact that these rocks contain less SiO_2 than both the normal upper mantle rocks, and the common igneous rock-forming silicate minerals of the crust. A high content of non-silicate minerals is found in the picritic rocks that grade into the non-silicate clan of rocks.

Most of the rocks of the lamprophyric association are usually regarded as being potassic, however it is difficult to apply this term in a systematic way to an association of rocks that ranges in composition from picrites to shoshonites. Zanettin (1984:20) has recently proposed that volcanic rocks are sodic when $Na_2O - 1.5 > K_2O$, and potassic when $Na_2O - 1.5 < K_2O$. These criteria are absurd, as they imply that all volcanic rocks that contain less than 1.5% Na_2O , and most that contain less than 1.8 Na_2O , are potassic, even if Na_2O is strongly enriched relative to K_2O . This absurdity explains why Le Maitre (1984:250) classified 83% of the picrobasalts as potassic rocks, yet the mean Na_2O and K_2O values of these rocks were 1.44% and 0.51% respectively. There is clearly a need for precisely defined terms to describe the alkaline character of the rocks that plot within the picrobasalt, tephrite, picrite and foidite fields of the extended TAS diagram. It is proposed that the general term potassium-dominant should be used to describe all igneous rocks in which K_2O exceeds Na_2O ; and the term perpotassic should be used to describe igneous rocks that contain significant amounts of potassium relative to Na_2O or another oxide such as MgO . There is no simple way of defining perpotassic using a K_2O/Na_2O ratio because this ratio tends to change with magmatic differentiation. If one wishes to use the K_2O/Na_2O ratio to define the term perpotassic one has to change the limits set on the ratio as one proceeds from one domain to the next on the TAS diagram. One might choose a limiting ratio as low as 1.2 in the picrobasalt field, but increase it to 2.5 in the phonotephrite field as it contains many leucite-bearing rocks. It is proposed that the use of the term perpotassic should normally be restricted to the rocks on the low-silica side of the main sequence, and it should be defined by using a K_2O versus MgO diagram (cf. Figure 1). In this diagram the lamproites are observed to be perpotassic (i.e. above line AB); whereas the kimberlites, and most of the lamprophyres, plot between the lamproites and the normal hyperalkalic rocks of the main sequence.

An elegant method of illustrating the alkaline character of igneous rocks is to plot their Al, Na and K abundances on a triangular diagram (cf. Figure 2). This diagram enables one to explore changes in the Na/Al, K/Al and K/Na ratios, and in the peralkaline tendency, of the rocks being studied. The kimberlites and lamproites occupy discrete fields on the Al-Na-K diagram; with the lamproites being quite unique in that they are normally peralkaline with remarkably high K/Al ratios. It is proposed that, either the K_2O versus MgO , or the Al-Na-K diagrams, should be used to separate the lamproites from the kimberlites.

When one studies the origin of a suite of main sequence igneous rocks one is able to use one of a number of standard variation diagrams: they enable one to

