Alkaline Rock Lineages in the Warrumbungle Shield Volcano, Eastern Australia

THIS communication is to report the presence in the Warrumbungle Shield Volcano, eastern Australia, of three alkaline rock lineages representing lines of magmatic evolution similar to the well established Hawaiian and Hebridean alkali basalt-hawaiite-mugearite-benmoreite-trachyte series¹⁻⁴ and the potassic Gough Island-Tristan da Cunha trachybasalt-trachyandesite-tristanite-trachyte series⁴⁻⁶.

Within the Middle Miocene^{7,8} continental alkaline Warrumbungle Shield Volcano, which occupies an almost circular area greater than 1,200 km² in central western New South Wales (Fig. 1), several fractionation lineages have been recognized. (The age of the Warrumbungle Volcano has been established as between 13 and 17 m.y. by K/Ar dating.) The recognition of contrasting differentiates, quartz-bearing, olivine-bearing and nepheline-bearing trachytes in close field association with hypersthene and nepheline normative basaltic rocks indicates that the chemical characteristics, and therefore the normative characteristics, of the trachytes are directly related to the nature of the parental magmas and the conditions prevailing during the differentiation process. At the low pressures present during the eruption of the Warrumbungle Volcano the critical plane of silica undersaturation² acted as a thermal ridge separating the hypersthene normative basaltic rocks from the nepheline normative variants. As the Warrumbungle basaltic rocks occur just on either side of the thermal ridge they are extremely susceptible to any circumstances that may initiate differentiation towards increasing alkalinity and undersaturation with silica, or towards a combination progressively more felsic and containing more silica-rich trachytes.

Lineages within the Warrumbungle Shield have been recognized using the degree of undersaturation, the ratios of Na₂O to K₂O in conjunction with the bulk normative feldspar ratios (*ab* : *or* : *an*) recalculated to 100% as the latter ratio reflects more precisely the actual proportion of plagioclase to alkali feldspar found in the mode, and the ratios of Fe to Mg.

The three alkaline rock lineages recognized in the Warrumbungle Shield are, first, a sodic undersaturated alkali basalt-hawaiite-mugearite-trachyte lineage; second, a mildly potassic hypersthene normative trachybasalt-trachyandesite-tristanite-trachyte lineage; and, third, a mildly potassic undersaturated trachyandesite-high iron trachyandesite-nepheline bearing trachyte-phonolitic trachyte lineage.

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Thin Layers of Water in Vermiculites and Montmorillonites—Modification of Water Diffusion

WE have measured the self diffusion coefficient of water in thin layers between the aluminosilicate sheets of vermiculite and montmorillonite clay minerals. The measurements, by neutron scattering spectroscopy^{1,2}, are necessarily confined to diffusive motions over very small distances, that is, less than or of the order of the layer thickness. The data show the extent of dynamic ordering imposed by the surface; the short diffusion paths avoid the tortuosity factors needed to discuss macroscopic diffusion in the same systems³.

By careful swelling of lithium vermiculite (Young River) and sodium and lithium montmorillonite (API No. 26) we obtained reproducible water layer thicknesses of between one monolayer and 50 Å. The clay was prepared by the method of Posner and Quirk⁴ and dialysed against distilled water to remove excess salt. We evaporated dilute suspensions of the clay slowly to form uniform films which were then equilibrated, either at fixed humidities over saturated salt solutions or by adding the amount of water calculated to produce spacings below or above two water layers respectively. The samples were enclosed in specially designed, sealed aluminium containers for the neutron scattering experiments and were weighed before and after each experiment to check against water loss.

After the neutron experiment we used low angle X-ray diffraction to measure the basal spacing⁵ and obtained the water layer thickness by subtracting 9.5 Å, the clay sheet thickness⁶.

In neutron scattering spectroscopy, the relative motion of a diffusing molecule and the neutron during the scattering event broadens the energy spectrum of the incident beam by the Doppler effect¹. The observation time of the experiment is thus very short (typically $\sim 10^{-11}$ s) so the most microscopic aspects of the diffusion process are observed. For small angles of scattering ($< 60^\circ$) and for incident neutrons with mean wavelength greater than 4 Å the broadening increases with the angle of scattering, θ , and is related to the molecular self diffusion coefficient, D , by

$$\Delta E = 2\hbar D \cdot \left(\frac{4\pi}{\lambda} \cdot \sin \theta/2 \right)^2$$

where λ is the mean incident neutron wavelength and ΔE is the energy width in ergs.

Fig. 1 Location of the Warrumbungle Shield in eastern Australia.