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Geochemistry of pyroxene inclusions from the Warrumbungle Volcano, New South Wales, Australia

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ABSTRACT

Pyroxenes provide an elegant key to understanding the tangled petrogenesis of the diverse midalkaline rocks of the Warrumbungle Volcano. These rocks evolved from two primary magmas, and the pyroxenes record the various stages in their origin and evolution. Trace-element abundance patterns for chromian diopside crystals from a spinel-lherzolite xenolith provide evidence of an early mantle-depletion event. Depleted spinel-lherzolite is an appropriate mantle source for the ITEP (incompatible-trace-element-poor) series of rocks. Subcalcic augite megacrysts are common in the basic rocks of this series. They crystallized in a high-pressure, intratelluric environment where they controlled the initial magmatic differentiation of the ITEP series. Aluminian augite occurs as megacrysts and also in gabbronorite xenoliths found in one of the more differentiated rocks of the ITEP series. This pyroxene crystallized in a lower-crustal magma chamber where its host magma was peraluminous and intermediate in composition. A few clinopyroxene (Cpx) megacrysts are Fe-rich and exceptionally enriched in rare-earth elements (REE). They crystallized from a moderately differentiated magma, locally contaminated by crustal material, or were later subjected to a metasomatic event. One of the nepheline-normative basic rocks of the ITER (incompatible-trace-element-rich) series contains small inclusions of K-rich omphacite. This phase contains one of the highest K contents (0.6–2.3 wt%) ever reported in a Cpx, and crystallized from a K-rich liquid at a greater depth than any of the other pyroxenes, probably deep within the upper mantle. Orthopyroxene (Opx) megacrysts are rare and belong to at least three geochemically distinct types: in association with chromian diopside, with subcalcic augite, and with aluminian augite megacrysts. Each type of Opx crystallized in a separate chemical and physical environment.