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# Passive kimberlite intrusion into actively dilating dyke–fracture arrays: evidence from fibrous calcite veins and extensional fracture cleavage

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**Abstract**

Calcite veins are invariably associated with en-echelon kimberlite dyke–fracture arrays. A detailed microstructural study of veining indicates four vein types. Type I stretched or ataxial veins are defined by high aspect ratio calcite fibers that are crystallographically continuous with calcite of the kimberlite matrix wall rock, by elongated phenocrystic phlogopite with sharp crystal terminations centered on contacts between adjacent calcite fibers and by phenocrystic phlogopite that grows or extends across these veins. Type I vein mineralogy indicates syn-dilational crystallization of vein minerals in local tensional areas within the kimberlite. Vein Types II (stretched to syntaxial elongate-blocky) and III (antitaxial) indicate late crystallization vein mineral growth during subsequent or repeated dilation. Calcite fibers in Type I to Type III veins are orthogonal to the contacts of their host dykes regardless of the orientation of vein margins. Type IV calcite veins, with blocky or mosaic/polycrystalline textures, are attributed to minor post-intrusion extension, which was potentially accompanied by repeated kimberlite intrusion within a given dyke array. Syn-crystallization/syn-intrusion Type I veins and an ubiquitous dyke-parallel fracture cleavage, in a zone up to 4 m on either side of dyke contacts, suggest that en-echelon kimberlite dyke–fracture arrays occupied the approximate center of zones of active dilation within the brittle carapace of the upper crust. Type II and III veins indicate that extension or dilation continued, independently of an occupying kimberlite fluid phase, after initial intrusion. Arrested mobile hydrofracturing, under low differential stress within the upper brittle or seismic carapace of the continental crust, followed by repeated dilation of the dyke–fracture system, is proposed as a mechanism for producing the features observed in this study. The conditions constrained in this study indicate passive dyke intrusion into dilating fracture arrays during crustal extension.


*Keywords:* Kimberlite; Group II; Dyke–fracture; Microstructures; Fibrous veins; Intrusion mechanisms

## 1. Introduction

Three textural-genetic facies of kimberlite are currently recognized, each attributable to a specific style of magmatism. Hypabyssal facies dykes and root zones typically underlie the diatreme facies, which is in turn overlain by the crater facies (Hawthorne, 1975; Clement, 1982; Mitchell, 1986; Field and Scott-Smith, 1999). Current and past research mainly focuses on kimberlite diatremes, which consist predominantly of tuffisitic kimberlite and/or tuffisitic kimberlite breccia, due to their economic importance and volumes (Field

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