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Magmatic Enclaves in Granitic Rocks: Paragons or Parasites?

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Granitic rocks form the fundamental building blocks of Earth's continents and provide us with a wide range of resources, so their formation is worth trying to understand. Fine-grained, igneous-textured microgranular enclaves of tonalitic to monzogranitic composition (ME) are common in granitic rocks and their origins have been hotly debated, with some workers suggesting that ME are not igneous. These ME have been studied intensively enough that we are now certain that they are of igneous origin – globules of mingled and quenched magma. Although a mantle connection is evident in many cases, their ultimate origin (including where in the lithosphere they originate) is still debated. This contribution explores the systematics of chemical variation in ME and their host granites, with the aim of uncovering any systematics in their behaviour and modelling the processes that have led to the variations that we measure, comparing host-rock series to their respective ME series. As always, the hope is that the study of ME may lead to improved understanding and modelling of the processes that are responsible for the formation of the host granitic magmas.

Using variations between the molecular quantities Ti and M (Fe+Mn+Mg), we demonstrate that the petrogenetic processes that operated within a diverse group of S- and I-type granitic host magmas and their ME suites are dissimilar. Variations within the granitic series result from a variety of what might be called 'orderly' processes, resulting in linear or curvilinear trends in chemical variation diagrams. In contrast, processes that affected the ME series commonly resulted in scattered, chaotic variations. Even in cases in which an ME series displays more orderly variation, it can be shown that the hypothesis of simple mixing between a parent enclave magma and its host granitic magma, to produce the overall variations, cannot be supported. ME magmas had vastly smaller volumes compared with their host granitic magmas. Thus, they have commonly undergone hybridisation through mixing with deep crustal melts and both chemical and mechanical interactions with wall rocks and their host granitic magmas. As a result of this complex and chaotic set of processes, it remains extremely difficult to unravel the precise mechanisms that produced a given suite of ME magmas. Due to the similarities between the studied granites and their ME with occurrences worldwide, we suggest that our findings are likely to be generally applicable.