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Geochemical Fingerprinting of Granites Revisited

Pearce, J.A.
[1]School of Earth and Ocean Sciences, Cardiff University, Cardiff CF10 3AT, UK (PearceJA@cf.ac.uk)

The aim of this presentation is to update methodologies for granite fingerprinting published by myself and co-workers in 1984 and 1996 [1-2] and still in common use for evaluating past tectonic settings of granite genesis. It also follows by nearly two decades a detailed and independent assessment by Förster et al. in 1997 [3]. They used data from 250 localities to endorse the proposed optimal fingerprinting projection of Rb v (Nb+Y) and its discriminant boundaries and to highlight three precautions in its application: 1) that the greatest fingerprinting challenge is in complex or polyphase orogenies, which are common in continental arc and collision settings and sometimes closely associated in space and time with extensional regimes; 2) that differentiation can produce compositional trends which cross field boundaries and can be minimized by using less felsic, non-cumulate members of co-genetic series; and 3) that the diagram should not be used alone but in conjunction with other parameters such as dating and geology;. Note that Förster et al. [3] were able to greatly extend the database of acidic compositions of known tectonic settings by also including evolved volcanic rocks. Given that, usually, only volcanic rocks have clear tectonic settings, this was an important enhancement. A caveat is that some processes relevant to granites (such as cumulation and filter-pressing, and melt-restite mixing trends) may not be represented by erupted liquids; in addition, some intracrustal granite magmas never reach the surface. Thus, volcanic rocks cannot be used alone for fingerprinting granites.

The question of complex arc and collision settings (item 1 of Förster et al.) remains the major issue in 2016, although magma genesis in arc and collision zones are much better understood. Volcanic arcs can be viewed, for example, in terms of 'life cycles' from birth to death, including various 'mid-life crises' of hot and flat subduction and of roll-back. Collision zones also evolve from a syn-colliison setting of continental subduction, through a post-orogenic phase of slab rollback and detachment coupled with lithospheric detachment and then a post-orogenic phase of continental escape and lithospheric extension which may culminate in intraplate magmatism. Although this might seem to generate an impossible complexity, the aim of this presentation is to demonstrate that it provides opportunities to better interpret past arcs and collision zones when empirical and modelled petrogentic pathways on discrimination diagrams are combined with dating and geology. Here, I examine a number of volcanic terranes where granite geochemistry might be expected to vary significantly in space and time, including: flat subduction (Central Andes); triple-junction migration (Mexico); continent-oceanic arc collision (Banda arc); and continent-continent collision (Eastern Anatolia). In each case, compositions of evolved volcanic rocks evolve systematically in space and time and form distinct petrogenetic pathways on the Rb-(Y+Nb), and other, discrimination diagrams. Particularly interesting is the way in which post-collision magmas are dependent on the pre-collision geometries of the collision zone in question: lithosphere above pre-existing subducting slabs delivers arc-like magma into the base of the crust for eventual contribution to granite chemistry, while other lithosphere, and asthenosphere, typically deliver intraplate-like magma. The results also have implications for the original tectonic settings of I, A, and S-type granites, often used to evaluate granite settings despite the fact that the settings and genetic pathways of their type localities are not themselves understood!

References:

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[3] Forster, H.-J., Tischendorf, G. and Trumbull, R.B. Lithos 40: 269-293