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Generation of granites and continental growth in eastern Australia: An analysis of compositional variation in the 'I-type' Siluro-Devonian Bega Batholith

JACK E STIRLING[1], ANTHONY KEMP[1], STEVEN DENYSZYN[2] AND MALCOLM MCCULLOCH[1]

[1]University of Western Australia

[2]Memorial University of Newfoundland

Presenting Author: jack.stirling@research.uwa.edu.au

Granite plutonism in subduction-related magmatic arcs is considered the principal driver of continental growth, and probing the magmatic history of these granites provides detailed insight into the magma plumbing system responsible for producing continental crust. Convergent margin settings, such as in the Lachlan Fold Belt (LFB) of south-eastern Australia, are considered the distilleries where mantle-derived melts are refined to produce intermediate, calc-alkaline igneous rocks which constitute the bulk of Earth's continental crust. Seminal studies of the LFB I-type granites suggest derivation from partial melting of infracrustal sources, yet these same granites show evidence of open-system behaviour consistent with two-component magma mixing between supracrustally-derived and juvenile-mantle melts. These opposing interpretations obfuscate the link between I-type granite petrogenesis and continental growth in south-eastern Australia. The potential to resolve these conflicting interpretations lies within the Siluro-Devonian I-type Bega Batholith, a classic 'Cordillera' style batholith that exhibits systematic lateral isotopic and geochemical asymmetry from east to west across the batholith. Here, an integrated U-Pb geochronology, zircon ε_{Hf}-$\delta^{18}O$, and bulk-rock Nd-Sr-O isotopic and geochemical approach was used to decipher the magmatic processes responsible for producing this compositional asymmetry. Secular compositional trends are identified where granites transition from crustal isotopic signatures in the west, towards relatively juvenile mantle-like compositions in the east. These systematic compositional shifts are consistent with differential mixing between mantle-derived and supracrustally-derived melts, where changes in crust-mantle mixing ratios are regulated by ongoing extension and lithospheric thinning within a developing continental back-arc environment. Additionally, isotopic and geochemical data has resolved two distinct mantle end-members within the batholith, leading to a redefined estimate of isotopic mixing ratios and crustal addition rates in eastern Australia. Isotopic mixing ratios estimate that up to 65% of the Bega Batholith by volume comprises juvenile-mantle additions, indicating a considerable net-gain in new crustal material along the eastern margin of Australia between ca. 420–385 Ma. Our results suggest that I-type granites of the LFB and wider Tasmanides potentially represent a large, poorly documented reservoir of continental growth, necessitating a re-evaluation of global crustal growth curves over the Phanerozoic.