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Temporal constraints on crustal contamination: whole-rock and crystal-scale evidence from the Carlingford Igneous Centre, Ireland

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Magmatism at the Palaeogene Carlingford Igneous Centre is represented by a major gabbro laccolith and a micro-granite ring-dyke, both of which are crosscut by a series of aphyric to highly porphyritic basaltic cone-sheets with subordinate rhyolite, basaltic-andesite and trachy-andesite components. These lithologies, plus local crust, were analysed for major and trace elements and whole-rock Sr, Nd and Pb isotopes to assess petrogenetic processes throughout these three magmatic episodes. All samples (^{87}Sr/^{86}Sr = 0.7057-0.7201$_{(60Ma)}$) deviate markedly from mantle values towards local Silurian siltstones (^{87}Sr/^{86}Sr = 0.7144-0.7276$_{(60Ma)}$). The earlier microgranite ring-dyke (^{87}Sr/^{86}Sr = 0.7067-0.7127$_{(60Ma)}$) seems to have incorporated partial melts of the Silurian crust, rather than bulk material. In contrast, the majority of trends for mafic samples can be explained by bulk contamination. The highly evolved cone-sheet rhyolites (^{87}Sr/^{86}Sr = 0.7098-0.7100$_{(60Ma)}$) lie within the range of the basalt/basaltic-andesite, suggesting fractionation after initial contamination of basaltic parental magmas. Evidence from experimental petrology indicates that the meta-siltstones can be easily melted at basaltic temperatures ($\sim$1000 degrees C) and magma chamber pressures (3 KBar). Melting of the local country rock is therefore likely to have been commonplace where it came into contact with hot magmas. Localised K-rich trachy-andesites from cone-sheet intrusions (^{87}Sr/^{86}Sr = 0.7198-0.7201$_{(60Ma)}$) appear to be sedimentary derived, representing the (high-K) melt of hornfelsed xenoliths (*S-type basalts!*). The xenoliths represent the restite remaining after partial melt loss from the local Longford-Down meta-siltstone.

Plagioclase phenocrysts from porphyritic basalt cone-sheets show that An generally decreases with crystal growth (An_{91-24}), with resorption surfaces marking distinct compositional steps. Convection and re-equilibration in a heterogeneous magma chamber may therefore be an important process affecting these phenocrysts. This is consistent with groundmass values, which are also highly variable and range in ^{87}Sr/^{86}Sr from 0.7064 to 0.7092, with matrix feldspar values of An_{62-46}. Micro-drilled Sr isotope analyses of individual zones of large plagioclase phenocrysts show strong variation, with high-An cores yielding both high (0.7070-0.7077) and low (0.7063-0.7067) Sr ratios compared with low An rims. These variations are attributed to the presence of inherited xenocrystic cores from feldspars formed in the calc-silicate rocks of the contact aureole, as well as classical replenishment and magma mixing processes.

Despite the involvement of a single major crustal contaminant, our data imply petrogenetic evolution was not straightforward. Rather, we see a succession of variably overprinting processes that form a time sequence of contamination; from initial formation of microgranite by incorporation of crustal partial melts, to bulk contamination of gabbro and basalt as the system heats up, and subsequent melting of the remaining restites during late-stage cone-sheet emplacement to form a melt of trachy-andesite-type composition.