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Arc petrogenesis in southern Ireland and the Isle of Man: Implications for Ordovician accretionary history and constraints from Late Caledonian plutonism

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Peri-Laurentian and peri-Gondwanan magmatic arcs and microcontinents, and their attendant sedimentary basins were assembled during the Caledonian Orogeny (c. 490 - 400 Ma) to form the Irish and British lithosphere. Accretion of these terranes to Laurentia and subsequent closure of the Iapetus Ocean initiated the generation of widespread Late Caledonian plutons (c. 425 - 400 Ma). Petrogenetic investigation of Ordovician arc-related rocks aims to test possible terrane affinities, using geochemical data from the arcs and related rocks as well as isotopic signatures preserved within Late Caledonian granites.

SIMS zircon U-Pb geochronology has provided middle to early Ordovician ages for volcanic rocks with arc affinities from Avoca (Ireland, c. 463 Ma) and a newly discovered volcanic sequence from Port-e-Vullen (Isle of Man, c. 473 Ma). Granitic rocks from Leinster (Ireland), interpreted as arc plutons, yielded late to middle Ordovician ages of c. 457 - 454 Ma (Croghan Kinshelagh) and c. 462 - 459 Ma (Graiguenamanagh), similar to the c. 457 Ma age of the Dhoon Granite (Isle of Man).

Oxygen isotopic compositions of zircons from the Ordovician volcanic and plutonic rocks are close to or slightly heavier than mantle values (δ^{18}O generally < 7 ‰). Lu-Hf zircon compositions suggest different terrane affinities: relatively juvenile εHf_T values (c. +8.5 - +5.3) for the Avoca volcanics are similar to those of the older unit of the Croghan Kinshelagh Granite, whereas the Port-e-Vullen volcanics and the Graiguenamanagh Granite have less radiogenic εHf_T values (c. +4.4 - +1.3). The present-day geographic distribution of these rocks and petrogenetic inferences from their North American correlatives invite comparison with the Avalonian and the Ganderian microcontinent, respectively[1]. These constraints are supported by inherited zircons and corresponding isotopic analyses.

εHf_T values (c. +11.5 - +1.5) from magmatic zircons of the Dhoon Granite and the younger unit of the Croghan Kinshelagh Granite span the range defined by the two arc terranes, suggesting that these younger rocks formed after terrane amalgamation. This is in accordance with structural constraints: volcanic rocks from Avoca and Port-e-Vullen, as well as those from the Graiguenamanagh Granite, are strongly foliated, whereas the Dhoon and Croghan Kinshelagh granites show little or no deformation. This suggests a major accretion event in the early part of the Upper Ordovician.

Petrogenetic investigations of the Late Caledonian plutons reveal major differences in their inferred source compositions. Granites in the centre and to the south of the Iapetus Suture Zone (ISZ) faithfully preserve Ordovician arc isotopic signatures and are interpreted to have formed almost exclusively by reprocessing peri-Gondwanan arc-related rocks. In contrast, granites to the north of the ISZ suggest the amalgamation of peri-Laurentian continental arc-rocks with relatively unradiogenic Palaeoproterozoic Laurentian basement. Granites located in the Irish Sea are distinct due to the significant involvement of sedimentary protoliths, consistent with a mixed signature from both peri-Gondwanan arcs and Laurentian detritus. This threefold distinction is also supported by age and isotopic constraints from inherited zircons in the Late Caledonian plutons.

[1] van Staal et al. (2009, and references therein): J. Geol. Soc. London 327, 271-316.