Geophysical Research Abstracts, Vol. 7, 01356, 2005
SRef-ID: 1607-7962/gra/EGU05-A-01356

Chemical and Nd isotopic constraints on the composition of granitoid sources during the Caledonian orogeny in Scotland

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Chemical and Nd isotopic data, combined with new zircon ages, for granitoid samples from the Grampian Highlands in Scotland, show a systematic variation in composition in course of the Caledonian Orogeny during the time interval from ca. 486 to 403 Ma. 486 to 454 Ma old granitoids intruded during the collision of the Midland Valley island arc with the Grampian Highland terrane (s.l. the Grampian event) and show major element compositions with S-type affinity. Their trace element patterns lack Eu-anomalies, and show in some cases fractionated REE patterns as in greywackes that suggest chemically immature sources. ε_{Nd} values show a limited range of -14.3 to –11.7, equivalent to Nd model ages of 2.0 to 2.3 Ga and indicate old sources that we interpret as Dalradian metasediments. Granitoids emplaced from 427 to 403 Ma represents the final stages of Caledonian Orogeny and are generally associated with an Andean-type plate margin that developed after the arc-continent collision. Their major element data reveal a variety of rock compositions with I-type affinity from granodiorite to high-silica granite. The trace element patterns of these rocks show a variety of melting- and melt fractionation processes, and source compositions. REE of the granodioritic samples show moderately fractionated patterns, no Eu-anomalies, and flat HREE patterns suggesting sources outside the garnet-stability field. The associated granites display high overall REE abundances with little fractionated patterns and large negative Eu-anomalies. REE patterns of granitic dikes are highly fractionated giving evidence for interaction of hydrothermal fluids with residual melts. The initial ε_{Nd} values range from -2.1 to -6.9 (Nd model ages = 2.0 to 2.3 Ga) revealing

a distinctly more juvenile source as identified in the granites associated with the arc-continent collision. These data are consistent with a large proportion of mantle-derived material mixed with old basement rocks as can be found in subduction environments. Although there is a spectrum of lithologies, some that typically originate in subduction zones, such as the granodiorites, and high-silica granites resemble intraplate melting processes, we are not able to associate these lithologies with the specific tectonic stages proposed for the Grampian Highlands. Evidence for an origin of the granitoids in a subduction environment is the long-lasting granodioritic magmatism until the end of magmatism, the lack of a magmatic hiatus that may signal a transition to a slab-break off stage, and the Nd isotopic evidence for involvement of juvenile material.

We conclude that the geochronological and geochemical-isotopic evidence in granitoids of the Grampian Highland reveal two major events that changed the composition of the crust. Docking of the Midland Valley arc with Laurentia led to remobilization of older crust, whereas during the convergence of Avalonia with Laurentia distinctly more juvenile sources were melted, probably due to ongoing plate subduction.