

# LOWER PALAEOZOIC HISTORY OF THE SCOTTISH MIDLAND VALLEY, A XENOLITH STUDY

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Lower crustal xenoliths of the Scottish Midland Valley, carried to the surface by Lower Carboniferous volcanic activity, provide a unique insight into the Lower Palaeozoic history of this region which is largely obscured by Upper Palaeozoic sediments. Three types of xenoliths, metadiorites, metatonalites and metasediments, were the subject of geothermobarometry and *in situ* U-Pb zircon isotopic analyses, accompanied by *in situ* Lu-Hf analyses in case of the magmatic samples. All these different lithologies were affected by the same Late Silurian to Middle Devonian two-phase metamorphism.

Metadiorite xenoliths are samples from unexposed Newer Granite plutons with a protolith age of c. 416 Ma and with  $\epsilon\text{Hf}_{t=416}$  zircon isotopic values ranging from -0.6 to +7.8, suggesting that the Newer Granite plutonism had a great impact on the Midland Valley crust. Metatonalite xenoliths have a protolith age of  $454 \pm 8$  Ma and possibly originated from a Late Ordovician magmatic arc, not exposed at the present-day surface of the Midland Valley. Zircon  $\epsilon\text{Hf}_{t=454}$  values of +7.4 to +9.0 for dated zircons suggest a juvenile origin for this arc. Inherited zircons of similar Late Ordovician age with  $\epsilon\text{Hf}_{t=454}$  values of +1.5 to +7.4 are occasionally present in the younger metadiorite xenoliths suggesting that the metadiorites intruded within and/or through the crustal domain represented by the metatonalites.

Metasedimentary xenoliths comprise two distinct detrital zircon age populations the older of which is interpreted to have a Laurentian provenance while the younger detrital zircons originated from the Late Ordovician Midland Valley arc. Hence, the xenolith protoliths are thought to have accumulated on the accreted margin of Laurentia after c. 450 Ma.

Metamorphic zircon domains are present in all three types of xenolith. Based on their U-Pb zircon ages, metatonalites and metasediments have experienced the same prolonged metamorphism interpreted as a two-stage event (c. 420-400 Ma and c. 400-385 Ma). The onset of metamorphism is likely due to tectonic burial of the southern margin of the Midland Valley (i.e., due to overthrusting of the Southern Uplands onto the Midland Valley), also marking the minimum depositional age for the metasediments. The early phase of metamorphism was possibly also enhanced by the thermal effect of the intruding "Newer Granite" plutons. The younger stage of metamorphism corresponds to the Acadian Orogeny. Metamorphic zircons from metadiorite xenoliths record only the a single metamorphic event at c. 395 Ma, also corresponds to the Acadian Orogeny.

Thermobarometric calculations yielded PT values of c. 5-11 kbar and c. 825-858 °C for the metadiorites and c. 5-7 kbar and c. 620-780 °C for the metasedimentary xenoliths. Connecting these PT values with the timing of the metamorphism was unsuccessful.