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Pyroxenitic xenoliths from southern Scotland and what they tell us.

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Late Carboniferous/early Permian mafic volcanic rocks occurring in Scotland carry a broad spectrum of peridotitic and pyroxenitic xenoliths. The latter provide evidence of magmatic processes in the lower crust and the lithospheric mantle. In this study we present textural and compositional data on twenty-eight pyroxenitic xenoliths from six localities from southern Scotland (Midland Valley and Southern Uplands Terranes).

Most are interpreted as adcumulates (varying in grain size from fine to coarse) although some others are mesocumulates. They include both clinopyroxenites and websterites with variable amounts of olivine; phlogopite is present in only one sample. Cores of greenish clinopyroxene in three of the olivine clinopyroxenites are enveloped by brownish clinopyroxene, while one composite xenolith comprising coarse-grained olivine clinopyroxenite in sharp contact with harzburgite. Five groups, based on textural and mineralogical features were distinguished. Representatives of more than one group can be present in a single locality.

Most of the samples from the same textural group share similar chemical composition. In general, the clinopyroxenes are Ti,Al-diopside/augite with Mg#=0.74-0.86; where clinopyroxenes are zoned the rims have lower Mg# and higher Al content. The orthopyroxene is an Al (±Cr)-enstatite with Mg#=0.78-0.89, olivine (Fo_{76-77}) is relatively NiO-rich (0.16-0.29 wt.%). In clinopyroxenites the pyroxenes are LREE-enriched (La_N/Lu_N=1.31-3.17) with convex-upward REE patterns (Sm_N/Lu_N=2.48-7.37).

The temperatures and pressures of clinopyroxene crystallization in most of the clinopyroxenites are 1220-1300°C and 1.08–1.30 GPa (Putirka, 2008), respectively. Only the composite xenolith and the coarse-grained clinopyroxenites recorded higher pressures (1.42 and 1.65-2.03 GPa, respectively). As the Moho beneath S Scotland is located at ~35 km (corresponding to ~1 GPa; Davis et al., 2012), most of the clinopyroxenites are considered to come from the uppermost portions of lithospheric mantle or lowermost continental crust; the coarse-grained clinopyroxenites and the composite xenolith sample lithospheric mantle.

Clinopyroxenites from the southern Scotland crystallized from alkaline basaltic magmas similar to those that entrained them. Whilst Downes et al. (2007, 2001) had previously suggested this for clinopyroxenites from Midland Valley localities, our studies show that crystallization of mafic melts was more widespread. Strong chemical and textural variations in the pyroxenites together with relatively constant PT conditions of crystallization suggest that they formed either from melts of slightly different composition, perhaps in response to magma chamber processes such as magma replenishment and/ or mixing. While, the presence of mafic cumulates points to possible crustal underplating beneath S Scotland, the presence of a high-pressure clinopyroxenites and composite clinopyroxenitic-peridotitic xenolith imply that some of the pyroxenites originated in the lithospheric mantle.

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