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## Petrology and geochemistry of the Belhelvie and Arnage-Haddo House gabbro intrusions and their contact aureoles - Aberdeenshire, Scotland

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The Belhelvie and Arnage - Haddo House gabbro intrusions, situated within the Buchan Block of the Scottish Grampian Highlands, are part of a suite intruded at around 470 Ma, coincident with peak regional metamorphism and just predating the regional D3 deformation event. At the time of intrusion the host Dalradian metasediments had reached regional sillimanite migmatite gneiss grade, facilitating extensive partial melting in some places adjacent to the gabbro intrusions. This study uses different petrological, geochemical, and geochronological techniques to investigate the petrogenesis of the contact aureole of the Belhelvie gabbro and the highly anatectic melt contaminated marginal zones of the Arnage – Haddo House gabbro. The Belhelvie gabbro body is a layered intrusion, for which a tholeiitic differentiation trend can be defined. It is composed of varieties of gabbros and norites, together with troctolites and serpentinised peridotites. There is no obvious petrological evidence of contamination by silicious melts generated from the adjacent Dalradian metasediments. In contrast the marginal facies of the Arnage – Haddo House gabbro is heavily contaminated, consisting of a variety of hornblende and biotite bearing quartz norites and cordierite-norites, as well as containing a large number of partly melted garnet – spinel - cordierite xenolith restites derived from the adjacent Dalradian. The metamorphic aureole of the Belhelvie gabbro can be divided into three zones. An outer zone, at least 300 m wide, consisting of garnet – biotite ± cordierite hornfels, and an inner contact zone, some 30 m wide, which was affected by partial melting. This contact zone can be further divided into two subzones. The inner part, immediately adjacent to the gabbro, is characterised by assemblages containing orthopyroxene but no sillimanite, while assemblages in the outer part contain sillimanite and no orthopyroxene. Some silicious poor restite portions of the contact zone contain corundum. Phase modelling has been used to estimate the pressure-temperature conditions across these three zones, which range from 650 to 850°C and 0.33 to 0.41 GPa. Petrographic textures and changes in mineral assemblages have been used to determine the sequence of prograde and retrograde reactions that occurred as the contact aureole overprinted regional metamorphism. In-place U-Pb age dating of zircons from thin sections of a marginal intrusive sample of the Belhelvie gabbro and an aureole hornfels sample show that they both contain identical suites of zircons, indicating there was in fact some contamination of the margin of the gabbro. There are two major groups of concordant zircons, the younger at around 1007 Ma corresponding to a Grenvillian provenance while the older at around 1.6 Ga was probably derived from the core of Laurentia. A clearly defined discordia line has a lower intercept around 470 Ma, indicating lead loss during a significant thermal event, which is interpreted to correspond to the intrusion of the Belhelvie gabbro itself.

**Session:** *Pangeo workshop: Earth's Spheres (Crust, Mantle & Core)*

**Keywords:** *Contact metamorphism, Intrusion, contact aureole, age dating*