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The pre-Caledonian Large Igneous Province and the North Atlantic Wilson Cycle

Christian Tegner (1), Torgeir B. Andersen (2), Fernando Corfu (2), Sverre Planke (2), Hans Jørgen Kjøll (2), and Trond H. Torsvik (2)

(1) Aarhus University, Centre of Earth System Petrology, Dept. Geoscience, Aarhus, Denmark (christian.tegner@geo.au.dk), (2) University of Oslo, Centre for Earth Evolution and Dynamics, Department of Geosciences, Oslo, Norway

Magmatism of the first known rifting phase of the North Atlantic Wilson Cycle is surprisingly well preserved in the Caledonian nappes of central Scandinavia. The Särv and Seve Nappes are characterised by spectacular dyke complexes originally emplaced into continental sediments along the rifted margin of Iapetus. The intensity and structure of the pre-Caledonian Dyke Complex is comparable to that of the present passive margins of the North Atlantic large igneous province (NALIP) and U-Pb ages of 610-590 Ma suggest magmatism was short-lived. It can be described as a pre-Caledonian large igneous province (CLIP).

To constrain the origin of CLIP magmatism we: (1) re-visited the dyke complexes of the Sarek, Kebnekaise and Tornetrask mountains of North Sweden; (2) compiled new and published geochemical data for the more than 950 km long, magma-rich segment of the Scandinavian Caledonides; and (3) extended reconstructions of the paleo-position of Baltica back to 600 Ma. Although the appearance of the dykes ranges from garnet amphibolite gneiss to pristine magmatic intrusions, all bulk rock compositions largely reflect the original magmatic rock. The compiled dataset includes 584 analyses that essentially forms a coherent suite of tholeiitic ferrobasalt (2-12 wt% MgO, 45-54 wt% SiO_2; 6-16 wt% FeOtot; 0.7-4.0 wt% TiO_2) akin to LIP basalts such as those of NALIP (61-54 Ma). A few samples (<20) are significantly contaminated with crust, but most are largely uncontaminated. The delta Nb value is a proxy for geochemical enrichment based on Nb-Zr-Y systematics and was defined for the present-day North Atlantic system to distinguish enriched Iceland basalts (positive delta Nb) from normal MORB basalts (negative delta Nb). The CLIP dykes are dominantly enriched with positive delta Nb (-0.07 to +0.9) in the central and southern portion, but stretching to more negative values (-0.6 to +0.5) in the northern portion (Sarek, Kebnekaise, Tornetrask). The few available rare earth element data support this distribution of geochemical enrichment.

We conclude that the compositions of the pre-Caledonian dykes are similar to LIP basalts dominated by asthenospheric mantle melts in general, and strikingly similar to basalts that erupted at 61-54 Ma (NALIP) in the subsequent rift-phase of the North Atlantic Wilson Cycle. It is also interesting that the paleo-positions of CLIP and NALIP appear to overly the margins of the large low shear-wave velocity provinces mapped today at the core-mantle boundary below the Pacific (CLIP) and below Africa (NALIP), respectively, and interpreted as plume generation zones. Is this a coincidence?