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Defining a magma-rich rifted margin fossil analogue in the Scandinavian Caledonides

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The Iapetus Ocean opened ca 610 Ma ago possibly due to the interaction with a mantle plume at the base of the lithosphere. Stretching of the conjoined crystalline crust started prior to break-up and provided accommodation for continental and shallow marine syn-rift sediments. An early non-magmatic phase with discrete and localized deformation was followed by pervasive mafic magmatism where dyke-emplacement accounted for the bulk of the stretching. During the Caledonian orogeny, the Iapetan margin was thrusted onto Baltica as the Iapetus closed. Today, vestiges of the magma-rich margin reside within nappes from central Sweden to northern Norway. Although overprinted by Caledonian deformation fabrics and metamorphism, there are localities where pre-Caledonian magmatic and sedimentary structures are well-preserved, thereby allowing for detailed studies of deep to intermediate processes at magma-rich rifted margins. Three field seasons have yielded observations on the outcrop and microscopic scale that provide information about relative timing and development of the margin, both the early non-magmatic stage and the subsequent magmatic stage. In particular, dyke geometries and morphologies have been assessed from photogrammetric 3D models to constrain the active mechanisms during dyke emplacement. Jadeite in clinopyroxene geobarometry constrain the crystallization pressure of clinopyroxenes of the different intrusion levels and coupled with U/Pb geochronology constrain the timing of intrusion. Furthermore, dense sampling of mafic intrusions for geochemistry reveals a similar lateral geochemical signature as observed across the Iceland plume. Based on these new observations we argue that the well-preserved parts of the margin comprise: 1) Parts of an early lower crustal magmatic complex consisting of coronitic gabbros and granites; 2) Strongly stretched and attenuated crystalline basement intruded by mafic dykes; 3) Highly intruded pre- to syn-rift sediments, locally forming sheeted dyke complexes and 4) Extrusive mafic lavas, including pillow basalts, interlayered with metasediments. Such a complete fossil magma-rich rifted margin analogue has never been recognized in the field before and provides unique opportunities to study processes occurring at deep levels in the crust even at the microscopic scales and may thus reform our understanding of the architecture, evolution, and processes at magma-rich rifted margins.