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Contemporaneous MORB-type and extremely enriched volcanic rocks in the central Scandinavian Caledonides: the effect of slab break-off after arc-continent collision and/or subduction initiation after polarity flip?

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Oceanic arc development above an eastward subduction zone, followed by arc-continent collision, ophiolite obduction and subsequent subduction polarity flip, are common elements in tectonic models for the Laurentian margin during the first closing stages of Iapetus in the Ordovician. In the central Scandinavian Caledonides, such models have been based on the presence of obducted Late Cambrian to Early Ordovician (ca. 488-479 Ma) supra-subduction-zone ophiolites, which are intruded by continental-arc-related rocks during the Middle Ordovician (from ca. 469 Ma onwards). Obduction and inferred east to west subduction polarity flip must have happened during the ∼10 m.y. between the youngest ophiolite-related rocks and the oldest continental-arc-related rocks, but no rock record from this crucial period has been described in detail so far.

Recent field studies combined with geochemistry and geochronology have identified a >120 km long (along-strike) volcanic and sedimentary marine basin which covers the time interval between ophiolite obduction and continental arc establishment in the central Scandinavian Caledonides. This basin contains a peculiar association of volcanic rocks. An up to 5 km thick sequence of N- to predominantly E-MORB basalts, devoid of any subduction zone signatures, coexist with mafic to felsic submarine pyroclastic deposits, lava and subvolcanic intrusions extremely enriched in, e.g., Th, U, Zr, LREE and Be. High-field-strength element ratios indicate several different parental melts for the enriched magmas, some of which are remarkably similar to Mediterranean lamproites. The volcanic rocks are under- and overlain by thick turbiditic successions, with sediment petrology and detrital zircon spectra indicating derivation from both the obducted ophiolite and the underlying continental substratum.

The peculiar and very contrastive association of MORB-type and extremely enriched magmas requires access to at least two completely different magma sources in the time interval between ophiolite obduction and continental arc establishment. Preliminary ideas for the geodynamic setting of these rocks include the following elements: (1) Arc-continent collision led to slab steepening and eventually slab break-off, allowing mantle upwelling to produce MORB-type basalts. (2) The enriched magmas might have formed by small degrees of partial melting of metasomatosed mantle above the sinking slab due to input of heat from the slab window, implying that they formed prior to initiation of new westward subduction and active continental margin magmatism. An alternative model envisages the formation of the enriched melts above the newly sinking slab after the polarity flip, as the first, volatile-rich subduction-related melts; but this model apparently requires very complex time-space relations between slab break-off and new subduction initiation and is considered less likely. Initial basin subsidence, providing space for the thick turbidite-volcanite successions, is tentatively interpreted as being facilitated by pull from the sinking slab prior to slab break-off and/or the onset of new subduction. We would like to discuss these ideas and potential modern analogues with the “subduction zone community” in order to develop a realistic geodynamic model for the Ordovician development of the Laurentian continental margin during narrowing of the Iapetus Ocean.