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Crustal melting during the initiation of continental breakup – examples from the North Atlantic Igneous Province

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Continental breakup is often associated with the formation of Large Igneous Provinces (LIPs) as e.g. the North Atlantic Igneous Province (NAIP) in the Northeast Atlantic. Though volumetrically minor, silicic magmatic rocks are an integral part of many LIPs worldwide (e.g. NAIP, Karoo, Parana-Etendeka, Deccan). Early-erupting silica-rich melts bear valuable information on the initial phase of continental breakup and LIP formation.

We study silicic volcanics from the Palaeogene Vøring Plateau, an early formed part of the NAIP at the Norwegian margin, which was drilled during ODP Leg 104 at Hole 642E. The recovered volcanic succession can clearly be subdivided into the texturally, mineralogically and chemically distinct “Upper Series” (US) and “Lower Series” (LS), separated by a small estuarine sedimentary sequence. The US comprises mainly subaerially erupted transitional MORB.

The LS, which is the focus of our study, comprises the lower 130 m of the core and is made up of glassy dacitic lavas and some minor basaltic andesitic lava flows with an interbedded rhyolitic ignimbrite. These calc-alkaline dacitic lavas have perlitic to variolitic textures and are of high-K-type (K_2O = 2.5–3.3 wt%), peraluminous magmas. The trace element geochemistry and isotopic composition (e.g. $^{87}Sr/^{86}Sr > 0.711$) characterize the dacites of the LS at the Vøring Plateau as partial melts of upper crustal metasedimentary rocks (S-type granodioritic melts).

The mineral chemistry of the phenocrysts assemblage and the composition of glassy mesostasis was studied in detail using electron microprobe (EPMA). Estimations of the melt temperatures point out to high degrees of overheating (c. 900˚C) of the magma. The finding of magmatic cordierite within the dacitic lavas indicates alumina-rich source rocks for these anatectic products such as shales and are often found in silicic volcanic and intrusive rocks associated with subduction zones. Relatively high Fe-, Ti- and Ca-contents at relatively low Si- and alkali-contents in the glasses may point out to some degrees of mixing of the minimum crustal melts with mantle derived melts. Bimodal plagioclase distributions in andesitic rocks within the section substantiate the mixing assumption.

We propose that the Vøring margin LS dacites represent partial melts of crustal remnants of the Caledonian subduction zone, thus inducing continental breakup at the location of former continental amalgamation.

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