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The case for a thermal origin of magmatism on the North Atlantic continental margin

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The cause of the magmatism on 'volcanic' continental margins is still disputed, specifically as to whether it is due to increased mantle temperatures. New seismic profiles across the Faroe and Hatton Bank volcanic margins in the NE Atlantic enabled us to constrain the seismic velocities and volumes of both the extruded and intruded melt. Near the Faroe Islands, for every 1 km along strike, 360–400 km^3 of basalt was extruded, while 540–600 km^3 was intruded into the continent-ocean transition (COT). Lower-crustal intrusions are focussed mainly into a narrow zone $\sim$50 km wide on the COT, whereas extruded basalts flow $>$100 km from the rift. Deep-penetration seismic profiles show that melt is intruded into the lower crust as sills which cross-cut the continental fabric, rather than as 'underplate' of 100% melt as has previously often been assumed. This means that measured lower-crustal velocities represent a mixture of continental crust and new igneous rock. Tomographic inversion of wide-angle traveltimes from 85 ocean bottom seismometers constrain average lower-crustal seismic velocities as 6.9–7.3 km/s under the COT, intermediate between the velocities of the continental crust and fully igneous oceanic crust on either side. By comparison with theoretical curves of igneous thickness versus seismic velocity (H–Vp), our observations are consistent with the dominant control on the melt production being elevated mantle temperatures, with no requirement for either significant active small-scale mantle convection under the rift or of the presence of fertile mantle at the time of continental breakup as suggested for the North Atlantic by other authors. The mantle temperature anomaly was c. 130–150 ˚C above normal at the time of continental breakup, decreasing steadily by about 75˚C over the first 10 Ma of seafloor spreading.