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Evolution of Northeast Atlantic magmatic continental margins

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One of the major problems interpreting the evolution of magmatic continental margins such as those which dominate the Irish, UK and Norwegian margins of the NE Atlantic is that the structure which should record the pre-magmatic evolution of the rift and which potentially influences the character of the rifting process is partially or completely obscured by thick basalt lava flows and sills. A limited number of deep reflection seismic profiles acquired with tuned seismic sources have penetrated the basalts and provide an image of the pre-magmatic structure, otherwise the principle data are lower resolution wide-angle/refraction profiles and potential field models which have greater uncertainties associated with them.

In order to sidestep the imaging contraints we have examined the Ethiopian ñ Afar rift system to try to understand the rifting process. This magmatic rift system provides, along its length, a series of ësnapshotsí into the possible tectonic evolution of a magmatic continental margin which are associated with different amounts of extension. The Main Ethiopian rift contains an embryonic magmatic passive margin dominated by faulting at the margins of the rift and en-echlon magmatic zones at the centre. Further north toward Afar the rift becomes infilled with extensive lava flows fed from fissure systems in the widening rift zone.

Deep seismic profiles crossing the NE Atlantic margins reveal ocean dipping reflector sequences (ODRS) of basaltic lavas overlying extended crust and lower crustal sill complexes of intruded igneous rock, often referred to as underplate, which extend back beneath the continental margin. The ODRS show a variety of morphologies and settings but frequently occur in fault bounded rift structures along the margins. We suggest, by analogy to the observations that can be made in the Ethiopia Afar rift that these fault bounded basins largely form at the embryonic rift stage and are then partially or completely filled with lavas fed from fissures which are now observed as the ODRS. The oceanward dip on the ODRS is predominantly the result of post-eruption differential subsidence, as opposed to syn-eruption extension. The timing of intrusion of the lower crustal sill complexes remains unclear but they are most likely to have been emplaced as the supply of magma increased, which implies they are a late stage addition. The structure of the Main Ethiopian rift appears to have been influenced by the pre-existing basement structure at an early stage in the rift process, defining the geometry of the rift and providing a control on the later magmatic phase and modification of the crust. This early influence of existing structure is less clear on the NE Atlantic margins and in the UK and Irish sectors it is difficult to link substantial along strike variations in the properties of the margin to variations in basement structures which can be traced across the continental shelf. It is possible that such variations are completely overprinted by magmatic additions to the crust to the point at which they no longer influence the break-up mechanism.