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How do your flood basalts grow? Constraining flood basalt development using detailed field studies and 3-D geological models.

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Outline

Flood basalts often form an integral part of volcanic rifted margins. Recent studies (e.g. Jerram et al, 1999; Mountney et al., 1999; Jerram et al., 2000) have focused on using detailed outcrops studies to constrain the internal and external architecture in flood basalt provinces and their associated sedimentary basins. This has fostered the first attempt at constructing 3D geological surface models of flood basalts (Jerram & Robbe 2001). At the same time advances have been made with new insights into facies relationships at different scales (e.g. Planke et al., 2000; Jerram, 2002). Ongoing research efforts are now working on building up detailed 3-D geological models incorporating rock property data as well as looking at the effects of the igneous rocks on the diagenetic history of the sediments they interact with. Here we report on some of the observation from field studies on flood basalts that we feel are pertinent to offshore exploration aims and problems.

Facies Relationships

On a large scale (m's-km's) the internal and external facies architecture of flood basalts provides information on how different lava packages stack both vertically and laterally. This is of paramount importance in gaining insite into the sub-basalt imaging problem, as well as providing constraints on the relative timing and spatial position of volcanic events. Examples from the Parana-Etendeka Igneous province (~133 MA), The Deccan Traps (~65 MA), The North Atlantic Igneous Province (~58 MA), and the Ethiopian Traps (~30 MA) are used to show examples of different facies preserved at different stages of continental flood basalt (CFB) evolution. Facies, and facies associations identified in CFBs include: Tabular-Classic flows, Compound Flows, Ponded flows, truncation-onlap volcanic disconformities, burial-onlap volcanic disconformities, prograding hyaloclastite facies, preserved shield volcanic features, and sill facies.

Influence of igneous rocks on diagenesis

On a small scale (cm's-m's) lava flows and intrusions can affect the sediments they are associated with. To address these issues we have identified a number of outcrop case studies within the Huab Basin in NW Namibia. In some cases igneous dykes have acted as flow barriers to pore fluids and have therefore altered the type and degree of cementation either side of the dyke. In examples where lava flows have erupted onto sediments sandstones are shown to be well-cemented in an indurated zone (visually 1-2m wide) beside the contact but less well-cemented with distance from it. Geochemical analysis of the cement can shed some light on the origin of the associated fluids and determine whether hot fluids have been triggered by the lava.

Normalised $\delta^{18}O$ values decrease steadily from values of 15.6 (±0.2)‰ at the contact to 14.4 (±0.2)‰ at a distance of 4m from it which quantifies the hot diagenetic contact. This ongoing work* will also use examples from the British Tertiary to compare and contrast diagenetic effects of igneous contacts with in different sedimentary facies.

3-D geological modelling

Following the first preliminary 3-D models from the Etendeka flood basalt province in NW Namibia (Jerram & Robbe, 2001) a programme of 3-D geological modelling was initiated. At present, studies which build on the first Namibian model are being complimented with detailed examples from the British Tertiary province, NW Scotland and offshore Faeroe-Shetland basin data. A detailed lava flow by lava flow model has been mapped out from the Isle of Skye. This highlights lava flow distribution patterns and fault structure patterns which break-up the lava pile. On the offshore study is providing a broad scale stratigraphic grid and surface model which is populated by onshore observations. This can be used to forward model the seismic response trough flood basalt cover.

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