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Seaward-Dipping Reflectors and the Mode of Extension: Implications for Magma-Influenced Continental Breakup

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ABSTRACT

Discoveries in the pre-salt offshore Brazil and the Kudu gas field offshore Namibia are driving hydrocarbon exploration into frontier magmatic basins on the South Atlantic volcanic margins. Volcanic margins are characterised by thick sub-aerial volcanic sequences along the continent-ocean transition zone (COTZ). Such sequences are identified on seismic data as high-amplitude diverging reflections, known as seaward-dipping reflectors (SDRs). SDRs form during the final stages of continental breakup, amid the transition from tectonic to magmatic extension. Thus, their geometry reflects the formation of the COTZ and, consequentially, has implications for both the construction and heat-flow of the early magmatic basins. Here, we use ~18,000 km of long-offset (10.2 km) 2D reflection data, recorded by ION, to document the SDR geometry offshore Argentina, Uruguay and Brazil. We constrain our geological interpretation using detailed velocity analysis of high-quality pre-stack seismic gathers, along three seismic profiles, and present novel insights into the formation of three distinct SDR sub-types. These three sub-types vary in style both across and along the margin and may record the transition between tectonic and magmatic extension. Type I SDRs are fault-bounded and associated with anomalously high-velocity bodies (6.5-7 km/s) both beneath and at the down-dip end of their diverging wedges. Type I SDRs are identified along the entire margin. Outboard of Type I, we observe another set of SDRs (Type II) which are not fault-bounded and are not associated with high-velocity anomalies. In the south, the Type II SDRs are short (IIa) with average lengths of 2 ± 2 km. Conversely, closer to the Paraná flood basalt province, Type II SDRs are longer (IIb) with average lengths of 27 ± 23 km. We interpret Type I SDRs as lava flows confined to continental rifts and sourced from point-source intrusive magmatic bodies while Type II SDRs are erupted from linear sub-aerial spreading centres. The difference in the average length of our Type II SDRs is likely due to variations in the elevation of the source along the margin. Where the southern Type IIa lavas flow into standing bodies of water and the northern Type IIb do not. Interpreting SDRs using our sub-types provides new insights into; (1) the architecture and construction of the COTZ, (2) the formation of magmatic basins and (3) provides possible constraints on relative sea-level during magma-influenced continental breakup.