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Recognition of two types of SDR: straddling the continental thinning to seafloor spreading stage of continental breakup

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The presence or absence of SDRs is one of the key characteristics used in the division into the traditional volcanic and non-volcanic passive margin classes. Despite their importance, only recently has seismic data of sufficient quality been available to see their relationships with the underlying basement and hence better determine their role during breakup. In many models SDRs are envisaged as a late-stage form of subaerial seafloor spreading, whereas others suggest they can form much earlier during continental thinning. Here we combine an analysis of commercial pre- and post-stack seismic reflection and magnetic anomaly data from offshore South America to gain new insights into the structure of the SDRs and hence pattern of magmatism during continental breakup.

We observe two types of SDRs. The most landward packages show high velocity anomaly "bulls-eyes" of up to 1 km s-1. These highs occur where the stacked section shows them to thicken at the down-dip end of individual packages that are bounded by faults. All lines show 5-6 velocity highs spaced approximately 10 km apart. We interpret the velocity bulls-eyes as depleted mafic or ultramafic bodies that fed the sub-aerial tholeiitic lava flows during continental stretching. Similar relationships have been observed in outcrop onshore but have not been previously demonstrated in seismic data.

The bulls-eye packages pass laterally into reflector packages that show no velocity highs. These SDRs are not associated with faulting and become more extensive going north towards the impact point of the Tristan da Cunha hotspot. This second type of SDR coincides with linear magnetic anomalies, which implies it is new magmatic crust that has a close affinity to oceanic crust. We interpret these SDRs as the products of sub-aerial oceanic spreading similar to those seen on Iceland and described in the classic "Hinz model" of marine geophysical literature. Our work demonstrates that these SDRs are preceded by ones generated during an earlier phase of mechanical thinning of the continental crust. The origin of the distinctive SDR tilt is therefore primarily the result of faulting in the landward type and magmatic loading in the seaward type. The volume of the volcanism during the first phase is more-or-less uniform along the entire margin whereas that of the second phase increases dramatically towards the ancestral hotspot. The controls on melting may therefore be more complex than asthenospheric temperature alone.