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An overview of geophysical experiments across the continental margins of Southern Africa

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ABSTRACT

In the framework of the multi-disciplinary Inkaba yeAfrica initiative a number of geophysical experiments have been carried out across the continental margins of Southern Africa. Across the southern margin the so-called Agulhas-Karoo Geoscience Transect extends from the offshore Agulhas Plateau, across Southern Africa's sheared margin, across the Cape Fold Belt and into the Karoo Basin. Across the western margin, a classic volcanic rifted margin, the Springbok profile was conducted across the offshore Orange Basin, extending to the onshore exposure of the Gariep Belt. Goals of the experiments included broadening our understanding of the features crossed by the transects, especially in the framework of formation of Southern Africa's margins and the break-up of Gondwana.

INTRODUCTION

Southern Africa and its continental margins offer an unrivalled region, where continental accretion and related processes over more than 3.5 billion years can be studied. With this in mind, geoscientific transects were carried out across the completely different southern and western margins. The southern margin is a transform margin, developed through the relative motion of Africa and South America along the Agulhas-Falkland Transform Zone (AFFZ). The western margin formed with the break-up of Western Gondwana and shows classic features of a volcanic rifted margin.

METHODS

Geophysical experiments, which have been carried out are shown on Fig. 1. Across the southern, sheared, margin, two offshore, multichannel, near vertical reflection and wide angle refraction seismic profiles have been conducted. While both of them crossed the AFFZ, the eastern one started on the Agulhas Plateau (Parsiegla et al, 2008), the other targeted the Outeniqua Basin and the transition to the Cape Fold Belt (Parsiegla et al, 2007). Extensions of both these profiles have been carried out onshore, with two wide angle refraction profiles starting at the coast, and crossing the Cape Fold Belt on the way to the Karoo Basin, as well as the BMA and SCCB (Stankiewicz et al, 2007). A near vertical reflection profile partially coincident with the Western Profile has been carried from the northern edge of the Cape Fold Belt, across the BMA and into the Karoo Basin (Bräuer et al, 2007). Logistical constraints made it impossible for such a profile to be carried out across the mountains. A similar experiment further east has been carried out the Council for Geoscience, but has not previously been fully analysed, and has been incorporated into the Inakba yeAfrica initiative.

Across the rifted western margin, the geophysical data sets include several thousand kilometres of multi-channel seismic, magnetic and gravity data acquired during cruises by BGR along the continental margins off Namibia and South Africa (Mamba Profile, Bauer et al., 2000), as well as results from wide-angle seismic and magnetic traverses across the margin conducted by BGR, AWI and GFZ in cooperation with the Namibian and South African geological surveys (Springbok Profile, Hirsch et al, 2009).

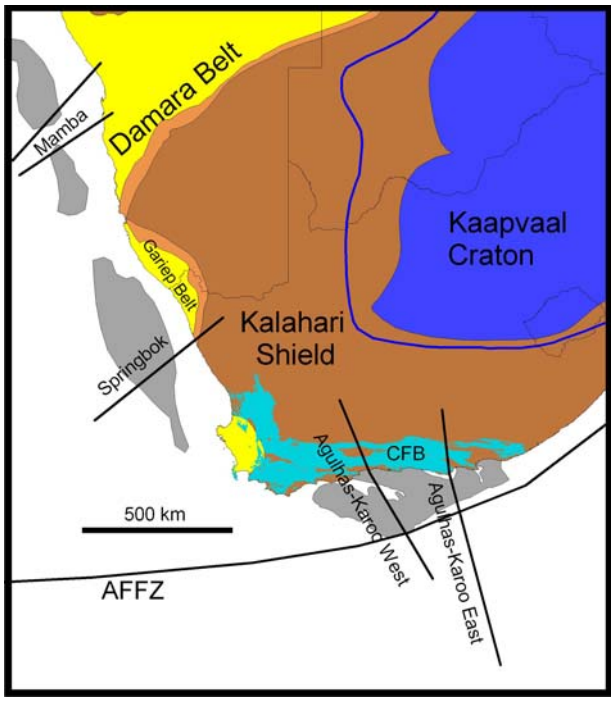

Fig. 1: Geophysical Transects across Southern Africa's margins. CFB= Cape Fold Belt, Oceans basins in grey.

CONCLUSIONS

The Agulhas-Karoo transect showed abrupt thinning of the crust begins inland from the present day coast (Stankiewicz et al., 2008). A zone of high-velocity material is observed in the lower-most crust in the vicinity of the thinning. This either represents metabasic lithologies of the Mesoproterozoic Namaqua-Natal Metamorphic Complex, or intrusions of gabbroic material added to the base of the crust by younger magmatism. As no such metabasic lithologies have been observed anywhere in the NNMC, we suggest the latter explanation, with the Karoo magmatism as the most likely source.

Analysis of crustal stretching factors suggested the thinning at the Outeniqua Basin is the result of crustal extension attributed to the rift stage of the basin, possibly initiated by stresses related to the separation of Africa and Antarctica (Parsiegla et al., 2009). To explain high stretching factors south of the Outeniqua Basin, a second stretching episode is necessary, possibly related to shear motion along the Agulhas Falkland transform system.

Seismic modelling across the Springbok profile identified typical oceanic crust followed eastwards by transitional crust. Here typical volcanic margin features were found encompassing seaward dipping reflectors (SWRs), as well as a high-velocity, high density keel-like body in the lower crust.

The results of studies along the western margin outline important North-South differences in the volumes and composition of mantle-derived magmas (Trumbull et al., 2007). The presence of picritic primary magmas in the northern segment and their absence in the south supports the inference of a plume-enhanced melting scenario for the high-flux margin in NW Namibia and a passive rift scenario for the southern segment. The volumes of magma exposed on land and the volumes inferred to intrude the lower crust at the Continent-Ocean Transition decrease from north to south, but the width and thickness of SDR sequences along the margin are nearly constant. Identification of magnetic seafloor-spreading anomalies indicates that the south Atlantic opening proceeded from south to north. We believe that rifting began independent of plume influence in the south, and magma generation occurred by decompression melting of the upper mantle. In the northern segment, the propagating rift encountered a region influenced by a mantle plume which added heat and mass flux to the system. The magma supply was much larger in the north, but mechanical limits on accumulated lava thickness imposed by the amount of subsidence and magma pressure dictated that the Seaward Dipping Reflectors in the north are no thicker than in the south, just that lavas spread well beyond the initial rift valley to cover the Parana Basin and much of what is now coastal Namibia.

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