

# Seismic structure of southern Africa: New constraints from surface waves

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## ABSTRACT

Continental-scale seismic tomography shows the lithospheric keels beneath the cratons of Africa as pronounced high-velocity anomalies, bottoming at depths of up to about 200 km. A pronounced sub-cratonic low-velocity zone is observed only in Tanzania, where it is neighbored by volcanic areas and may be showing hot material—possibly of mantle-plume origin—trapped or spreading beneath the thick cratonic lithosphere. Regional-scale, surface-wave array analysis in South Africa shows variations in lithospheric structure across the Kaapvaal Craton and the Limpopo Belt. A reduction in S-velocity at the bottom of the lithosphere (150-200 km depths) is required by the data both beneath the Kaapvaal Craton and the Limpopo Belt, being less pronounced beneath the latter.

**Key words:** South Africa, cratons, seismic tomography

## INTRODUCTION

Surface-wave observations can offer tight constraints on the shear-velocity structure of the lithosphere-asthenosphere system. Seismic properties of the rock at depth can, in turn, characterise the physical structure, composition and evolution of the lithosphere.

In this paper we combine the results of surface-wave measurements and inversions of two different types: large-scale, multimode-waveform tomography and regional-scale, array imaging. With the first approach, we sample the entire African continent and surroundings with seismic data. With the second approach, we aim to derive particularly accurate information where data is best and constrain robust S-velocity profiles and variations in structure beneath the Kaapvaal Craton in South Africa.

## METHOD

Our large-scale model of the entire Africa is computed in a global inversion of global-network data performed with the Automated Multimode Inversion (AMI) of surface and S-waveforms (Lebedev et al., 2005). The model of the upper-mantle (crust—660 km) has lateral resolution of a few hundred kilometres, varying with data sampling (Lebedev & van der Hilst, 2008).

Our regional, array analysis relies on broad-band measurements of surface wave dispersion performed using pairs of SASE array stations. The method is a combination of cross-correlation and multimode-waveform inversion (AMI) techniques (Meier et al., 2004; Lebedev et al., 2005) and produces robust, accurate phase-velocity curves in broad period ranges.

## RESULTS AND CONCLUSIONS

Our large-scale tomographic model shows the lithosphere beneath African cratons as pronounced high-velocity anomalies. The cratonic lithosphere bottoms at depths of up to about 200 km. A pronounced low-velocity zone beneath a craton is observed only in Tanzania, where it is neighbored by volcanic areas near cratonic boundaries and may be showing hot material—possibly of mantle-plume origin—trapped or spreading beneath the thick cratonic lithosphere (Figure 1).

Using regional dispersion measurements in southern Africa, we derive robust S-velocity profiles beneath different parts of the cratons. A reduction in S-velocity near the bottom of the lithosphere (150-200 km) is required by the data to occur both beneath the Kaapvaal Craton and the Limpopo Belt, although asthenospheric velocities are not required to be lower than global average values. Interestingly, the magnitude of sub-lithospheric reduction in S-velocity varies substantially between different parts of the craton (Figure 2).

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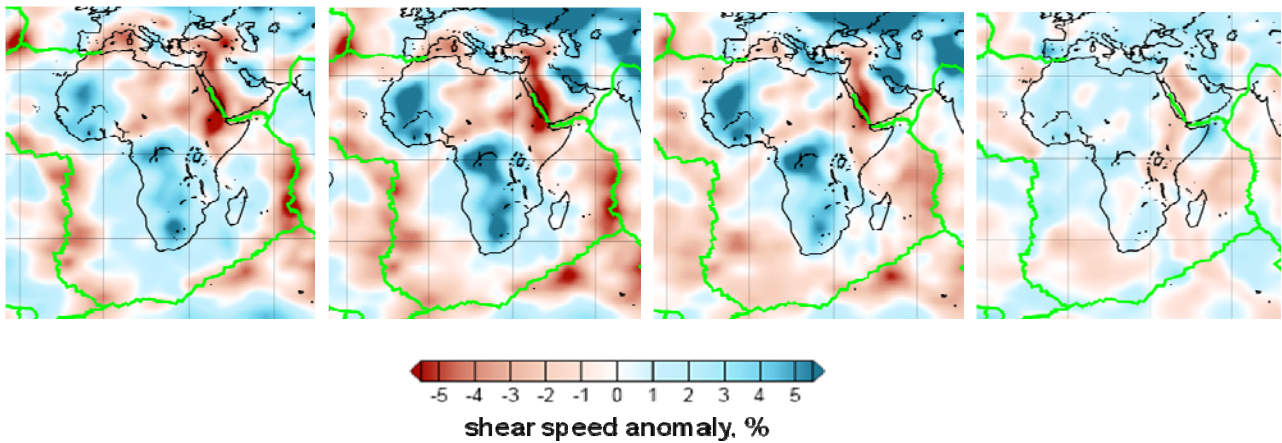
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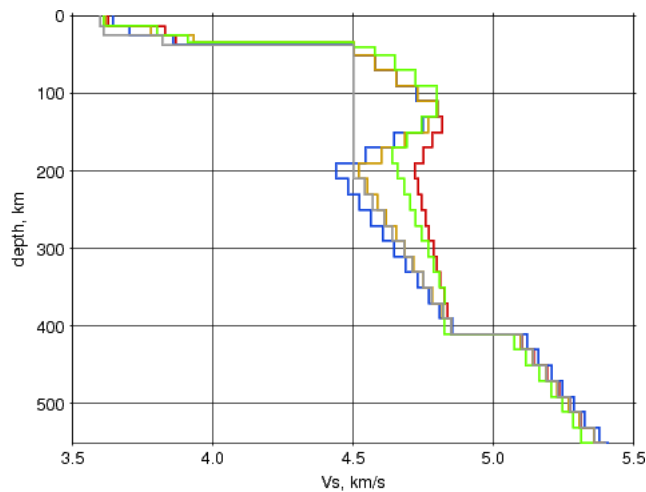
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**Figure 1. Shear-speed heterogeneity at (left to right) 80, 110, 150, and 260 km depths.**



**Figure 2. S-velocity profiles constrained by interstation measurements beneath different parts of South Africa.**