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Lithospheric Structure Beneath Southern Africa: Implications for the Formation and Evolution of Cratons

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The southern Africa seismic experiment, a collaboration involving Carnegie Institution, MIT, southern African academic institutions and industry collaborators, has provided detailed information on the tectospheric structure of the southern Africa cratons, and, by inference, on processes of early continental formation.

A buoyant and geochemically distinct tectospheric mantle keel beneath the Kaapvaal and Zimbabwe cratons of southern Africa is known from the study of mantle xenoliths to extend to at least 200 km (the maximum depth for xenoliths). P-wave and S-wave tomographic results from the southern Africa array are remarkably consistent with xenolith results and show irregularly shaped high velocity roots extending locally to depths of at least 250-300 km beneath undisturbed parts of the Kalahari craton. Roots are thinner beneath the 2.1 Ga Bushveld terrane and adjacent Proterozoic provinces and are notably less distinct beneath the Proterozoic fold and thrust belt that overlies the Archean of the western Kaapvaal. The Limpopo Belt, an Archean collision zone between the Kaapvaal and Zimbabwe cratons, is characterized by a root structure indistinguishable from that of undisturbed craton. Mantle contacts between Archean terranes and adjacent younger provinces are typically vertical.

Crustal thickness in southern Africa is uncorrelated or anticorrelated with elevation. Regions of high elevation within the undisturbed Kalahari craton tend to be characterized by thin crust (35-40 km), whereas the crustal thicknesses beneath the Proterozoic provinces, the Bushveld, and the Limpopo Belt are typically around 45 km. The absence of a correlation between crustal thickness and Bouguer gravity anomaly indicates isostatic balance is achieved by lateral density contrast in the upper mantle and/or in the crust. In regions of undisturbed craton, the Moho is sharp with a clear velocity contrast, whereas it is much more poorly defined in off-craton and disturbed craton regions. The character of the Moho beneath the craton suggests that the process of crustal formation: (1) was highly efficient at separating crust from mantle; and (2) produced a horizontally planar first-order Moho. Such simple Moho structure is typical of cratons, but far less common in younger continental crust. Intermediate crustal discontinuities are rarely observed in the Kalahari craton, indicating little or no layered differentiation of the crust.

Models for cratonic formation and processes of cratonic disruption are considered in light of the seismic results obtained from the experiment to date.

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