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# Microstructure, texture and seismic anisotropy of the lithospheric mantle above a mantle plume: Insights from the Labait volcano xenoliths (Tanzania)

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**Abstract**

The impact of a mantle plume at the base of the Tanzania craton has modified the composition and seismic velocity of the lithospheric mantle. Lavas erupted by the Labait volcano have sampled the perturbed mantle from the lithosphere–asthenosphere boundary (>140 km) to the spinel-peridotite domain (<70 km). We have studied the microstructure, texture and seismic anisotropy of a set of xenoliths spanning these depths to investigate the effects of plume activity on the fabric and seismic properties of the lithospheric mantle. The microstructure changes with depth: first the grain-size increases significantly, and then nucleation recrystallization occurs. The deepest samples display a recrystallized equidimensional matrix embedding relicts of deformed paleoclasts. The crystallographic preferred orientation (CPO) of olivine remains clear and even tends to increase with depth. In most samples, the observed CPO is consistent with dominant activation of the (010)[100] slip system. Samples from the base of the lithosphere display more unusual CPO, suggesting increasing activity on the (010)[001] slip system. Nucleation recrystallization does not appear to modify the pre-existing CPO, since neoblasts have a crystallographic orientation close to the parent grain orientation. Seismic properties remain similar over the whole section. In particular, no weakening of the seismic anisotropy is observed with depth, either for the P azimuthal or for the S polarization anisotropies. These results are consistent with previous seismological observations suggesting a coherent seismic anisotropy over the entire thickness of the Tanzania cratonic lithosphere. Our data thus provide new constraints for interpreting shear wave splitting measurements in East Africa, and support a model of perturbed lithosphere characterized by seismic signatures transitional between the "normal" lithosphere (for seismic anisotropy) and asthenosphere (for seismic velocities).
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*Keywords:* cratonic lithosphere; mantle plume; xenoliths; microstructure; crystallographic preferred orientation; seismic anisotropy; Tanzania; Labait volcano

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## 1. Introduction

Data from seismology (e.g., [1–3]), geochemistry (e.g., [4,5]) and numerical modeling (e.g., [6,7]) consistently suggest that cratonic lithosphere may remain stable over long periods of time. However, processes such as rifting or impingement of an upwelling mantle plume may trigger destabilization of the cratonic lithosphere. Beneath continental rifts or above a mantle plume, asthenosphere and lithosphere deeply interact. The lowermost lithosphere might be eroded through reheating (upward migration of the isotherms by thermal conduction) and through the thermo-mechanical action of small-scale convection cells (e.g., [8]). Moreover, magmas resulting from decompression melting of upwelling asthenosphere may percolate through the lithosphere, advecting heat and modifying its microstructure. As a consequence, seismic velocities of the mantle lithosphere are significantly reduced and its apparent thickness diminished, since the boundary between the asthenosphere and the seismic lithosphere can be equated with the transition between the seismically "fast" lithospheric domain and the abnormally "slow" underlying domain. However, relatively little is known about how the microstructure, texture and resulting seismic anisotropy of the thermally and chemically modified mantle lithosphere are affected by these processes. This is an important issue since: (1) determining lithospheric thickness based only on seismic velocity may lead to underestimates [9], and (2) the contribution of the lithospheric mantle to measured seismic anisotropy is a function of both the bulk anisotropy (which depends mostly on the crystallographic fabric of olivine) and the thickness of the lithospheric lid. An improved understanding of lithosphere–asthenosphere interactions and their effects on seismic properties will therefore aid in the interpretation of seismic anisotropy.

Mantle xenoliths brought to the surface by the Labait volcano (Fig. 1) provide a unique opportunity to study the interaction between an active rift and a cratonic lithosphere. The Labait area is the only area in East Africa where evidence of modification of the Tanzania craton by the eastern branch of the East African Rift is observed in both body wave (e.g., [10,11]) and surface wave data [3]. Recent geochemical [12,26] and seismological (e.g., [10]) studies

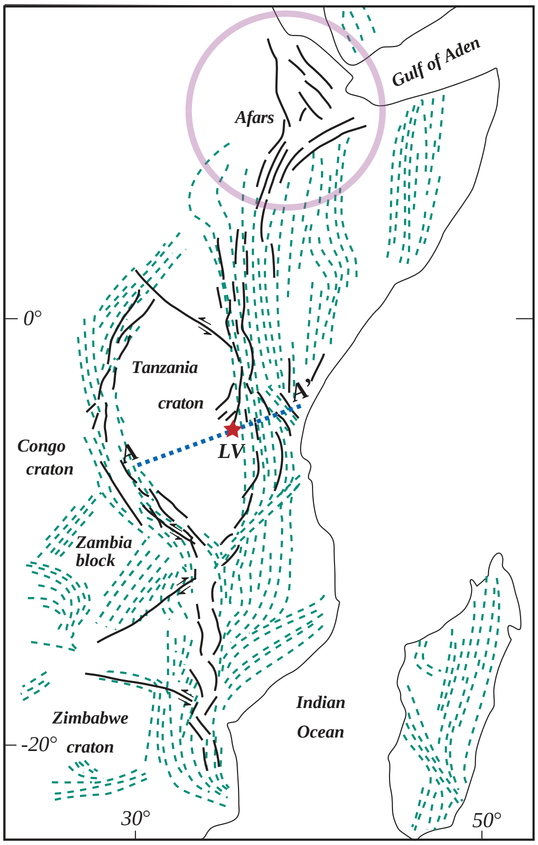


Fig. 1. Sketch map of East Africa showing location of the main cratonic blocks, the mobile belts surrounding the cratons (grey, stippled lines), the main faults related to the East African Rift (black, continuous lines) and the possible zones of impact of the plumes at the base of the lithosphere (gray circles). The star labelled LV marks the location of the Labait volcano. Line labelled AA′ marks the location of the vertical cross-section shown on Fig. 2.

in Northern Tanzania suggest that the base of the lithosphere has been modified by the plume, and that the asthenosphere–lithosphere transition is gradational (Fig. 2). A similar progressive modification of the continental lithosphere (asthenospherization) by the action of heat, partial melting and percolating fluids was proposed by Vauchez and Garrido [9] based on a combined geochemical and petrophysical study of peridotites across a melting front fossilized in the Ronda massif (Spain). In this paper, we describe the microstructures and textures of the Labait peridotite xenoliths and compute their seismic properties. These xenoliths equilibrated at depths ranging from <70 km (spinel peridotites facies) to ~140 km and at temperatures of <1000 °C to >1400 °C (Fig. 2). Although it

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