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From mantle to crust: Tomographic image of a mid-ocean ridge volcano

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Volcanoes are an integral part of mid-ocean ridges. At ultraslow spreading ridges, volcanic centres receive more melt than is produced locally and hence are centres of very efficient magmatism. The cause of melt focussing and the structure of the underlying magma plumbing systems at these volcanic centres are still enigmatic. We present microearthquake data and local earthquake tomography results, based on a one-year deployment of ocean bottom seismometers from 2012 to 2013 on a volcanic centre at the ultraslow Southwest Indian Ridge. In the period 1996-2001, several tectono-magmatic earthquake swarms including unusually strong teleseismically recorded events indicated recent magmatic activity at the experiment site. The distribution of recorded microearthquakes reveals a prominent gap in seismicity of approx. 20 km diameter immediately beneath the volcano indicating elevated temperatures. Tomography results show distinct velocity anomalies in the area of the seismicity gap. An eminent circular low Vs anomaly was found at 4-6 km depth beneath the volcano, imaging a potential crustal magma chamber. Another anomaly of high Vp/Vs-ratios is located at the eastern rim of the seismicity gap, capped by a cluster of microearthquakes and underlain by another low Vs anomaly in the upper mantle. We propose anomalies of reduced seismic velocity to result from recent magmatic activity that is further manifested in elevated temperatures beneath the volcano. Clustering microearthquake foci might be associated with steep temperature gradients and thermal fracturing, where hot upwelling material is confronted with a cold, rigid crust. Our results provide the first direct observation of a melt lens beneath the ultraslow type of mid-ocean ridge and give unprecedented insights to potential magma pathways from the upper mantle to the crust.