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Seismic structure of lithosphere emplaced at ultra-slow spreading rates

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About 57% of the Earth's surface is covered by oceanic crust and new ocean floor is continuously created along the ~60.000 km long mid-ocean ridge (MOR) system. About 25% of the MOR spread at an ultra-slow spreading rate of <20 mm/yr. At ultra-slow spreading rates the melt supply to the ridge is thought to dramatically decrease and crustal thickness decreases to a thickness of <6 km. However, we know little about the processes shaping crust at reduced spreading rates. A formation of crust from a magma chamber would suggest the creation of a well stratified crust, with an extrusive upper crust (layer 2) and a lower gabbroic crust (lower 3) and a well-defined crust-mantle boundary and hence a seismic Moho. In contrast, decompressional melting without formation of a magma chamber would support a crustal structure where seismic velocities change gradually from values typical of crustal rocks to mantle rocks. Here, we report results from a survey from the ultra-slow spreading Cayman Spreading Centre in the Caribbean Sea, sampling mature crust along a flowline from both conjugated ridge flanks. The seismic refraction and wide-angle survey was conducted using ocean-bottom-seismometers from Germany, the UK, and Texas and a 5500 cubic-inch airgun-array source towed by the German research vessel METEOR in April 2015. Typical crustal P-wave velocities support a thin crust of 3 to 5 km thickness. However, a well-defined Moho boundary was not observed. Thus, velocities change gradually from crustal-type velocities (<7.2 km/s) to values of 7.5-7.8 km/s, supporting mantle rocks. In addition to P-waves, we have sampled S-waves along the profile, yielding for the first time Vp/Vs ratios for lithosphere emplaced at ultra-slow spreading rates. Interestingly, about 15 to 20% of the lithosphere has Vp/Vs ratos of >1.9, supporting serpentine. Domains of high Vp/Vs ratio also occur right at the seafloor, supporting large-scale exposure of mantle as proposed by geological evidence from ultra-slow spreading ridges.