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Interplay between magmatism, hydrothermal venting and crustal accretion at the ultraslow-spreading Mid-Cayman Spreading Center from wide-angle refraction seismic data

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Ultraslow-spreading centers (<20 mm/yr full rate), owing to their thicker lithosphere and an overall lower, more variable melt supply, are great places to study the variables of crustal accretion, including relationships between faulting, magmatism and hydrothermal venting. In particular, the Mid-Cayman Spreading Center (MCSC), a $\sim$110 km-long ultraslow-spreading center in the Caribbean Sea, accretes highly variable oceanic crust. Additionally, there are multiple oceanic core complexes (OCCs) along axis, two hydrothermal vent fields, and basalt, gabbro, and mantle material have been dredged from the seafloor, all of which indicate complex crustal accretion processes at work. The CaySeis experiment, an ocean bottom seismometer (OBS) survey of the MCSC, was carried out April 2015, providing this study with three wide-angle refraction lines both parallel to and across the axial valley. 2-D velocity models of these three lines have been produced from compressional wave travel-time tomography, giving us a smooth image of the crustal structure. Notably, the internal structure of an OCC, which hosts an off-axis hydrothermal vent, was imaged, revealing an inclined high-velocity body near the surface and a lower velocity area beneath, which suggests exhumed gabbro bodies and either increased fracturing or cooling magmatic sills driving the Von Damm Vent Field. These tomographic models show both along- and across-axis variations in seismic velocity, but interpreting these variations is non-unique, as many factors including lithology, temperature, and partial melt affect seismic velocity. For example, certain seismic velocities and gradients can represent either thin mafic crust or exhumed serpentinized mantle peridotite, and low velocity zones can represent increased fracturing, higher temperature, partial melt, or a combination of the three. It is important to differentiate between these explanations in order to constrain the melt supply at the MCSC, both spatially and temporally, and how it relates to hydrothermal venting and seafloor morphological structures we observe, such as faults and OCCs. We use a synthetic seismogram modeling technique in order to improve features in the velocity model such as velocity gradients and low velocity zones. Synthetic seismograms were computed using the finite-difference method of the acoustic 2-D wave equation for a range of velocity models where the tomography models were perturbed in different areas with an array of vertical velocity gradients. The synthetic data was then compared to the real data by looking at the reflection arrivals and the amplitudes before and after these arrivals. With this method, we can look for Moho boundaries, mid-crustal boundaries, and better constrain areas of lower seismic velocity and upper crustal velocity gradients, which help to differentiate between these various factors that control seismic velocity. The along-axis line shows variable upper crustal boundaries along axis, including thicker extrusive basalts beneath the Beebe Vent Field. The two across-axis lines show variations in upper crustal and Moho boundaries across the axial valley, indicating areas of mafic crust and possibly exhumed mantle that vary in time (across-axis) and space (along-axis).