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Nature of magma chamber reservoir from seismic full waveform inversion of ultra-long offset multi-channel seismic reflection data at the Axial Volcano in the Pacific Ocean

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Magma chamber reservoirs host melt from the deep Earth, which erupts to form the volcanic edifices, the upper oceanic crust, and cools to form the lower gabbroic crust. It also sources heat for hydrothermal circulation and for the formation of black smokers along ocean spreading centres. The top of magma reservoirs is generally imaged using seismic reflection imaging techniques, designed as axial melt lens (AML) reflection, whereas wide-angle seismic data provide smeared low velocity anomaly underneath. Therefore, the precise nature of axial magma reservoirs remains elusive. We propose to characterise the nature of the magma reservoir at the Axial Volcano using a state-of-the-art full waveform inversion applied to ultra-long offset data.

Axial Volcano in the Eastern Pacific Ocean is a large submarine volcano, like a mini-Iceland, which is being formed by the interaction between the intermediate-spreading Juan de Fuca Ridge and the Cobb hotspot. It hosts many hydrothermal vent fields and has erupted three times (1998, 2011 and 2015) in recent years and therefore has been the subject of extensive geological and geophysical studies over the last 30 years, including setting up of a permanent, real time, wired-to-shore, multi-parameter seafloor observatory, a three-dimensional (3D) multi-channel seismic survey, and ultra-long (12 km) multi-channel seismic (MCS) data.

In this study, I plan to use MCS data collected in 2019 on board the US R/V Langseth, comprising of 8 ultra-long offset 2D profiles crossing the volcanic plateau. A 936-channel, 11700-m-long Syntron digital streamer with receiver groups spaced at 12.5 m was towed at a nominal depth of 16 m. The source vessel deployed an array of 36 air guns, totaling approximately 6600 cubic inches in volume, towed at an average depth of 12 m. Shots were fired every 37.5 m along the track, and data were recorded at a sampling rate of 2 ms for 12 s long records.

After processing these data using a conventional processing strategy to obtain a seismic image, we redatum both the seismic sources and receivers to the seafloor (SOBE), perform conventional first arrival P-wave travel time tomography of the first arrivals, followed by the application a time-domain, full-waveform inversion (FWI) scheme, resulting in the generation of high-resolution velocity models of Axial Volcano magmatic system possibly down to 6 km below the seafloor. We should be able to characterise the detailed nature of the magma reservoir, including their internal structures (imbricated sill, melt/mush zonation) and magma plumbing system and link them with eruptions dynamics at the seafloor.

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