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Architecture and dynamics of the magmatic system feeding the 2018 offshore Mayotte eruption from satellite gravity data

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In May 2018, a submarine eruption started offshore Mayotte (Comoros archipelago, Indian Ocean), and was first detected as a series of earthquake swarms. Since then, at least 6.4 km^3 of lava has erupted from a newly mapped volcanic edifice (MAYOBS campaigns), about 50 km east of Mayotte island. Since the onset of the eruption, GNSS stations on the island have recorded subsidence (up to 17 cm) and eastward displacement (up to 23 cm). We combine marine gravity data derived from satellite altimetry with finite element models to examine the magmatic system structure and its dynamics. First, we calculate the Mantle Bouguer Anomaly (MBA) by taking into account the gravitational effect of the bathymetry and the Moho interfaces, assuming a crust of constant thickness of 17.5 km and correction densities of 2.8 g/cm^3 and 3.3 g/cm^3 for the crust and mantle, respectively. We then invert the MBA to determine the anomalous density structures within the lithosphere, using the mixed Lp-norm inversion and Gauss-Newton optimization implemented in the SimPEG framework. The gravity inversion reveals two zones of low density, east of Mayotte island. The first is located NE of Petite Terre island between ~15 and 35 km depth, and the second is located further east, south of La Jumelle seamounts and extends from ~25 to 35 km depth. We interpret these low density regions as regions of partial melt stored in the lithosphere and estimate the volume of stored magma. Finally, we use the newly imaged low density bodies to constrain the magma reservoir geometry and simulate magma flow from this reservoir to the eruptive vent in a 3D, time-dependent, numerical model. The model parameters are adjusted by minimizing the misfit between the modeled surface displacement and that measured at the 6 GPS sites, between May 2018 and 2020. The deformation modeling reveals the temporal evolution of the magma flux during the eruption, and the resulting stress distribution in the crust explains the patterns of recorded seismicity. Together with the existing seismic and geodetic studies, the gravity data analysis and FEM models bring new constraints on the architecture of the magma plumbing system and the magmatic processes behind the largest submarine eruption ever documented.