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Fizzy Super-Earths: Impact of Magma on Bulk Density of Lava Worlds

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Lava Worlds are a potential emerging population of Super-Earths that are on close-in orbits around their host stars with likely partially molten mantles. To date, few studies address the impact of magma on the observed properties of a planet. At ambient conditions magma is less dense than solid rock; however, it is also more compressible with increasing pressure. Therefore, it is unclear how large-scale magma oceans affect planet observables, such as bulk density. We update ExoPlex, a thermodynamically self-consistent planet interior software, to include anhydrous, hydrous (2.2 wt% H_2O), and carbonated magmas (5.2 wt% CO_2). We find that planets with magma oceans larger than ~ 1.5 $R_\oplus$ and ~ 3.5 $M_\oplus$ are modestly denser than an equivalent mass solid planet. From our model, three classes of mantle structures emerge for magma ocean planets: (1) fully molten, (2) surface magma ocean, and (3) one consisting of a surface magma ocean, solid rock layer, and a basal magma ocean. The class of planets in which a basal magma ocean is present may trap volatiles that commonly dissolves within magma. Planets with basal magma oceans may sequester dissolved volatiles on billion-year timescales, in which a 4 $M_\oplus$ mass planet can trap more than 130 times the water than in Earth's oceans and 980 times the carbon in the Earth's surface and crust.