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Outgassed atmospheres of magma ocean exoplanets

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Magma oceans (MOs) should be common among the growing population of discovered exoplanets as they are thought to be ubiquitous stages of the early evolution of rocky planets. During the lifetime of the MO, exchanges between the interior and exterior envelopes of the planet are very efficient. In particular, volatile elements initially contained in the solid planet can be released and form a secondary outgassed atmosphere. Here, we determine the trends in the composition and thickness of such secondary atmospheres in H-C-O-N-S system. We track the effects of evolving planetary sizes and MO depth as well as the oxygen fugacity of the MO, which provides the first order control on atmosphere chemistry. We find that small planets and shallow MOs, being generally more reduced, are dominated by H_2, while larger planets and deeper MOs vary from CO to CO_2-N_2-SO_2 atmospheres, with increasing fO_2. In the former case, low molecular mass of the atmosphere combined with lower gravity of the planet yields a large vertical extension of the atmosphere, while on the latter, i.e., on the Super-Earths, secondary outgassed atmospheres are likely significantly shrunk. Both N and C are largely outgassed regardless of the conditions, whereas S and H outgassing are strongly dependent on fO_2, planetary mass, and the depth of MO. We further use these results to assess how much a secondary outgassed atmosphere can alter the mass-radius relationships of terrestrial exoplanets.