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Volcanism and outgassing of stagnant-lid planets: Implications for the habitable zone

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Rocky exoplanets are typically classified as potentially habitable planets, if liquid water exists at the surface. The latter depends on several factors like the abundance of water but also on the amount of available solar energy and greenhouse gases in the atmosphere for a sufficiently long time for life to evolve. The range of distances to the star, where surface water might exist, is called the habitable zone. Here we study the effect of the planet interior of stagnant-lid planets on the formation of a secondary atmosphere through outgassing that would be needed to preserve surface water.

We find that volcanic activity and associated outgassing in one-plate planets is strongly reduced after the magma ocean outgassing phase, if their mass and/or core-mass fraction exceeds a critical value. As a consequence, the effective outer boundary of the habitable zone is then closer to the host star than suggested by the classical habitable zone definition, setting an important restriction to the possible surface habitability of massive rocky exoplanets, assuming that they did not keep a substantial amount of their primary atmosphere and that they are not in the plate tectonics regime.