

Interior Evolution and Habitability

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Planetary habitability is usually thought to require water on (or near) the surface, a magnetic field to protect life against cosmic radiation, and transport mechanisms for nutrients. A magnetic field also serves to protect an existing atmosphere against erosion by the solar wind and thus helps to stabilize the presence of water and habitability. Magnetic fields are generated in the cores of the terrestrial planets and thus habitability is linked to the evolution of the interior. Moreover, the interior is a potential source as well as a sink for water and may interact with the surface reservoirs through volcanic activity and recycling. The simplest mechanism for recycling is plate tectonics. Plate tectonics is known to operate - at present - only on the Earth, although Mars may have had a phase of plate tectonics as may have Venus. Single-plate tectonics associated with stagnant lid convection – the present tectonic styles of the later planets - can also transfer water from the interior but a simple recycling mechanism is lacking. However, stagnant lid convection will evolve to thicken the lid and increasingly frustrate volcanic activity and degassing. This will keep the interior from running completely dry. Plate tectonics also facilitates generation of a magnetic field by effectively cooling the deep interior. For Mars and Venus it is likely that a present-day magnetic field would require plate tectonics to operate. An early field is possible even with stagnant lid convection but the dynamo will only operate less than 1 Ga under these circumstances. A question is then whether or not plate tectonics existed on Mars and Venus and if yes, why plate tectonics will cease to operate. Model calculations suggest relations to the yield strength of the mantle and the effect of water on the latter. Other models suggest at the existence of an asthenosphere (low viscosity zone underneath the lithosphere) is decisive and the dependence of its existence on the water content of the mantle.