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Why plate tectonics is rare and how it started on Earth

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Observations suggest that plate tectonics operates only on Earth. Theoretical studies point out that plate tectonics is difficult to start on any planet. A fundamental feature of plate tectonics is mechanical recycling of the lithosphere. Two major obstacles to this process include the formation of a buoyant crust and the high strength of relatively cold rocks near the surface. Both factors prevent mechanical recycling of the lithosphere. In principle, both the buoyancy and the strength of the lithosphere can be overcome by sufficiently large forces. A giant impact or a superplume can provide such forces but they are of relatively short duration. It is unclear how they can produce a long-lived plate tectonics. Forces that are readily available such as those associated with mantle convection are insufficient to initiate plate tectonics. One of the key limitations of the current models is that they consider a solid or nearly solid planet. The difficulties for plate tectonics initiation on a completely solidified planet lead to a hypothesis that on Earth plate tectonics may have started during the magma ocean epoch, at the end of planetary accretion. According to this hypothesis, plate tectonics is a continuation of convection in the magma ocean.