

Continental rifting on Earth and Mars - A comparison

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The formation of continental rift systems on Earth is connected to prerift uplift generated by upwelling mantle plumes and extensional stresses which originate from remote plate boundary forces. Continental rifting and continental breakup on Earth are therefore intimately connected to Earth's plate tectonic environment.

Recently, Martian candidate analogues to terrestrial continental rifts have been investigated in detail and it has been shown that the Tempe Fossae, Acheron Fossae and Thaumasia Highland Rifts bear many structural similarities to continental rifts on Earth. However, the question of the rift formation process has so far not been addressed and an active mechanism involving mantle plumes and local doming has usually been assumed. Rifts are also sometimes thought to be at least indirect evidence for plate tectonics, although the connection of Martian rifts to plate tectonic forces has so far not been discussed.

We have investigated whether forces connected to plate movement are necessary to initiate rifting and show that lithosphere scale faulting at the Thaumasia Highland Rift is feasible even in the absence of mantle plumes or tensional plate-boundary forces. Rather, stresses originating from horizontal differences of the gravitational potential energy will be shown to be almost sufficient to induce rifting, supporting the hypothesis of a passive rifting mechanism in the Thaumasia Highlands. The emplacement of magma bodies in the upper crust could then sufficiently weaken the lithosphere to initiate lithosphere scale faulting and thus induce rifting. This hypothesis is in good agreement with the observation of rift-related volcanism as well as the fact that faults seem to initiate at volcanoes and propagate away from them before interconnecting.

We conclude that rifting on Mars is feasible even if key factors connected to conti-

mental rifting on Earth, i.e. plate boundary forces and convection induced drag on the lower lithosphere, are absent. The absence of forces connected to plate tectonics is also consistent with the observed moderate extension of only a few kilometers. These values are typical for young terrestrial rifts (e.g., the Kenya-rift) and failed arms and suggest that large scale plate movement and subduction did not play a role in Martian rifting.