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Reduced Atmospheric Ion Escape Above Martian Crustal Magnetic Fields

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Evolution of atmosphere is tightly related to planetary habitability, during the history of solar system. Disappearing of liquid water on Mars and Venus is frequently understood as a consequence of enhanced atmospheric escape, when their magnetic dynamo ceased billions of years ago, as comparing to present Earth with active dynamo and deep oceans. However, such a hypothesis that planetary dipole magnetic field protects its atmosphere from Solar wind's erosion does not have enough supporting evidence, but has been questioned recently. The fast-changing solar wind conditions and the varieties between different terrestrial planets made comparison between dipole magnetic and non-magnetic bodies hard to clarify magnetic field's effect alone. Mars is a natural laboratory since its partially distributed Crustal field on its southern hemisphere and a lack of Earth-like global magnetic field. Locally distributed Crustal field provide a hemisphere possessed magnetic environment which gives The Mars Atmosphere and Volatile Evolution (MAVEN) mission a good chance to observe magnetic fields and planetary ions' behavior simultaneously. Two years' MAVEN data show a reduced atmospheric ion escape above Martian Crustal Field region suggests magnetic field's protective effect on heavy planetary ions. The effective altitude of magnetic field's protective effect is from 400 km to 1800 km and reduces a maxim escape rate of 40 percent. Two physical mechanisms contribute to this protective effect which forms an upper limit and a lower limit of net O+ fluxes. This is the first time directly shows Crustal Field's protective effect on heavy planetary ions. Since a locally small Crustal Field could protect its atmosphere and slow down solar wind erosion process, the protection of a planet's strong dipole field on escaping ions should be more effective. Planetary magnetic field may significantly affect a planet's climatic evolution and deeply changing the fate of extraterrestrial life.