Geophysical Research Abstracts
Vol. 12, EGU2010-15447-1, 2010
EGU General Assembly 2010

Water, Ice and Fire: Exploring the moons of our solar system with magnetic fields

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The moons in our solar system display an enormous richness of phenomena. This holds in particular for the moons in the outer solar system, which are often considered, along with their parent planets, mini-solar systems of their own. In this lecture, we will give a selected tour on some of the amazing properties of solar system moons, which have been revealed by magnetic field measurements or where magnetic fields play a crucial role. Of particular importance are magnetic fields in the search for liquid water outside of Earth. Liquid water is generally considered one of the key ingredients for life, at least as we know it. Magnetic field measurements near Jupiter's icy moons Europa, Ganymede, and Callisto provide to date the strongest evidence for the existence of saline subsurface oceans under the moons icy crusts, in addition to the unique dynamo field at Ganymede. Sufficiently concentrated saline water can possess an electrical conductivity such that it can be probed with naturally occurring time variable magnetic fields. Magnetic field measurements also played a crucial role in the discovery of the water geysers on Saturn's moon Enceladus, which is thus also considered a candidate for a subsurface ocean. Induction magnetic fields at Saturn's moon Titan due to the presence of water are, however, still elusive. Jupiter's moon Io, in contrast, is on the other end of the spectrum and devoid of water. It is the volcanically most active moon in our solar system. Here magnetic fields help to decipher properties of its volcanic plumes and its atmosphere. But magnetic fields are also the reasons why the moons can generate auroral spots of emissions in the parent planets atmospheres, which can be as energetic as the whole aurora on Earth combined.