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Mars, Moon, Mercury: Magnetometry Constrains Planetary Evolution

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We have long appreciated that magnetic measurements obtained about a magnetized planet are of great value in probing the deep interior. The existence of a substantial planetary magnetic field implies dynamo action requiring an electrically conducting, fluid core in convective motion and a source of energy to maintain it. Application of the well-known Lowe's spectrum may in some cases identify the dynamo outer radius; where secular variation can be measured, the outer radius can be estimated using the frozen flux approximation. Magnetic induction may be used to probe the electrical conductivity of the mantle and crust. These are useful constraints that together with gravity and/or other observables we may infer the state of the interior and gain insight into planetary evolution. But only recently has it become clear that space magnetometry can do much more, particularly about a planet that once sustained a dynamo that has since disappeared. Mars is the best example of this class: the Mars Global Surveyor spacecraft globally mapped a remanent crustal field left behind after the demise of the dynamo. This map is a magnetic record of the planet's evolution. I will argue that this map may be interpreted to constrain the era of dynamo activity within Mars; to establish the reversal history of the Mars dynamo; to infer the magnetization intensity of Mars crustal rock and the depth of the magnetized crustal layer; and to establish that plate tectonics is not unique to planet Earth, as has so often been claimed. The Lunar magnetic record is in contrast one of weakly magnetized and scattered sources, not easily interpreted as yet in terms of the interior. Magnetometry about Mercury is more difficult to interpret owing to the relatively weak field and proximity to the sun, but MESSENGER (and ultimately Beppi Columbo) may yet map crustal anomalies (induced and/or remanent).