Planetary (and exoplanetary) lessons for the Deep Earth

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The solid bodies of our solar system are made up mainly of rock (e.g. Vesta, Earth), rock+ice (Ganymede), or rock+ice+gas (Uranus). Solid bodies in other planetary systems may occupy different regions of this phase diagram [1], while more exotic worlds (e.g. carbon-dominated) may also exist [2]. Here I will discuss three aspects of the deep Earth which are shared with other solid bodies, and two which set it apart.

ACCRETION. The final stage of planetary accretion involves large, stochastic impacts. Such impacts probably formed the Earth's Moon, stripped Mercury's mantle, and tilted Uranus over. The Earth's bulk chemistry was likely altered by impact erosion [3]. Mars-sized bodies and larger will have developed pervasive magma oceans due to the gravitational energy released [4]. The role of impacts in adding or subtracting volatiles is currently very poorly understood, but may have an important effect on subsequent evolution. Impacts may also affect dynamo behaviour [5].

DYNAMOS. Extant or ancient dynamos are surprisingly common, probably including asteroids [6], the Moon [7], Mercury, Mars, Ganymede and the Earth. Dynamos are powered by mantle cooling, internal heat generation and/or (most efficiently) core solidification [8]. The style of solidification depends on the slopes of the adiabat and melting curve, and can result in different styles of core convection [9-10].

FLUID COUPLING. Core-mantle coupling has an influence on rotational dynamics (e.g. Mercury, Venus and the Moon [11]) and perhaps dynamo generation [12]. Similar coupling occurs between the ice shells and subsurface oceans of some icy satellites, and may have similarly observable effects [13].

The above processes are common to many bodies in this solar system and elsewhere. However, the Earth differs from some other bodies in at least two important ways.

PLATE TECTONICS. Most sizeable silicate bodies undergo mantle convection. However, the Earth is the only body known to currently possess plate tectonics, perhaps because its volatile inventory reduces the effective yield strength. Neutron stars may have plate tectonics; whether super-Earths do or not is under debate. Europa shows features reminiscent of spreading centres [14]; Venus and Enceladus may undergo some kind of episodic resurfacing, but the form of this mechanism is unclear.

TIDES. Tides are unimportant for Earth, but dominate the energy budget of satellites such as Io and Enceladus. Tidal dissipation in close-in exoplanets may lead to "super-Ios" [15]. Tides can also be used to constrain the interior structures of planetary bodies, including at least one exoplanet [16].

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