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Hydromagnetic scaling and core-mantle evolution of the Earth, Mars and Moon

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For fast rotating planet/moon, we derive hydrodynamic and electromagnetic scaling laws in the limit of negligible molecular diffusivity, viscosity and magnetic diffusivity effects. In the Earth, ancient Mars and Moon magnetic energy dominate over kinetic one and typical magnetic field is proportional to the third root of the buoyancy flux power driving the convection as it was obtained recently via numerical simulations. Besides, here we present new scaling laws for estimation of the long-time magnetic consequences due to different evolution scenarios of core-mantle system.

The currently accepted scenario with the inner solid core of the Earth crystallizing from the liquid core provides us with too small value of geomagnetic field during more than 3 billions years after formation of the liquid core. Since this is inconsistent with the available paleomagnetic records we are suggesting another scenario with a solid protocore which occupied almost all the core of just formatted Earth. This protocore is slowly melted under the surface influence of the overheated liquid core. It grows up to its modern size when the solid core is small relic of the protocore. Such protocore concept resolves the problem of the energy source for geodynamo and for plume activity in the mantle. In case of validity of this concept the mantle should be supplemented by silicate material from the protocore with primitive isotope composition of the lead but which can't be the result of the liquid core crystallization. Additional argument to the validity of this concept could be the primitive isotope composition of lead in combination with the primary helium enriched by isotope He-3.

Following the currently accepted crystallization concept Martian dynamo should be stopped only when the central solid core occupies almost all the volume of Martian core. So, nowadays the liquid core should be sufficiently smaller than the solid one. That contradicts to all the available models of the Martian interior. To resolve this paradox we apply our protocore concept to Mars. Using as well our hydromagnetic scaling we also justify the reason why the Martian dynamo was working not longer than few initial billions years.

Paleomagnetic samples from Moon demonstrate very high (a few times larger than on the modern Earth surface) intensity of the magnetic field that was in operation from about 4.2 till 3.6 billion years ago. The currently accepted compositional (under crystallization concept) and thermal dynamo of the Moon are not able to provide enough energy to support so higher magnetic intensity and for so long period. While a Lunar dynamo under our protocore concept could easy provide required energy source for the intensive compositional convection during that long period.