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The effect of giant impactors on the magnetic field energy of an early Martian dynamo.

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Through the cratering record embedded on its surface, Mars is one of the key planets required for investigating the formation and impact frequency in the early history of our Solar System. This record also holds clues to the events that may have caused the observed hemispheric dichotomy and cessation of the magnetic field that was present within the first 500 Myr of the planets' formation. We investigate the influence of giant impacts on the early Martian dynamo using the numerical dynamo modelling code PARODY-JA [1]. We hypothesize that the input heat from a giant impact will decrease the total heat flux at the CMB through mantle heating which leads to a decrease in the Rayleigh number of the core. As boundary conditions for the heat flux anomaly size, we use numerical results of a 750 km diameter impactor from the Monteux and Arkani-Hamed, 2014 [2] study which investigated impact heating and core merging of giant impacts in early Mars. We also determine the decrease in Rayleigh number from the change in total heat flux at the CMB using these results, where the decrease after impact is due to shock heating at the CMB. We calculate the time-averaged total magnetic field energy for an initial homogeneous heat flux model using a range of Rayleigh numbers (5×10^3 - 1×10^5). The Rayleigh number is then decreased for three new models - homogeneous, north pole impact and equatorial impact - and the time-averaged energy again determined. We find that the energy decreases more in our impact models, compared with the homogeneous, along with a variation in energy between the north pole and equatorial impact models. We conclude that giant impacts in Mars' early history would have decreased the total magnetic energy of the field and the decrease in energy is also dependent on the location of the impact. The magnetic field could have been disrupted beyond recovery from a planetesimal-sized collision; such as the suggested Borealis basin forming impact, or through the cumulative effect of multiple large impactors; such as Utopia, Hellas and Isidis basin forming impacts.

[1] Aubert, J., Aurnou, J. Wicht, J., 2008. The magnetic structure of convection-driven numerical dynamos. Geophys. J. Int., 172, 945–956.

[2] Monteux, J., Arkani-Hamed, J., 2014. Consequences of giant impacts in early Mars: core merging and Martian dynamo evolution. J. Geophys. Res. (Planets) 119, 480–505.