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An Atmospheric Theory for Generation of Crustal Magnetism on Mars

Francisco J. Arias
Department of Fluid Mechanics, Polytechnic University of Catalonia ,
ESEIAAT C/ Colom 11, 08222 Barcelona, Spain
francisco.javier.arias@upc.edu

Abstract

In this work, an atmospheric mechanism for the generation of crustal magnetism on Mars is discussed. Here, and alternative to what the standard *ancient dynamo hypothesis* asserts -as per which, the scattered pockets of crustal magnetism on Mars are the remnants of an ancient epoch during which a young Mars might have had a hypothetical sizeable magnetic field- crustal magnetism is generated by the interaction of electrically active dust storms magnetising their own dust with the formation of heavy clusters , which snow out of the atmosphere and are deposited in the Martian soil. Using some idealisations, an upper limit for the mass loading of the magnetised dust that could be generated per lightning strike for a given dust storm was estimated. The atmospheric theory for the cause of the crustal magnetism of Mars offers a phenomenological explanation for several complexities and patterns observed among the intriguing east-west lineation trending without the requirement of additional hypotheses, which seem to become necessary if the ancient dynamo theory is maintained. Furthermore, the atmospheric mechanism for the generation of the crustal magnetism on Mars -which is currently active- holds irrespective of the validity of an ancient dynamo on Mars; however, whether the mechanism was partially or entirely responsible for the largest magnetic anomalies observed on Mars still remains an open question.

1. Introduction

The object of this work was to analyze a mechanism for the generation of crustal magnetic field on Mars driven by the atmosphere and more precisely by the self-interaction of electrical activity of dust storms magnetizing its own dust with the formation of heavy magnetic clusters which snow out of the atmosphere and finally deposit in the martian soil. This atmospheric mechanism -which is active today, offers an alternative explanation to the ancient dynamo hypothesis which states that the scattered pockets of crustal magnetism on Mars could be the remnants from an ancient epoch where the young Mars might have had a hypothetic sizeable magnetic field driven by the circulating motion of molten material within its core. Several spatial features observed in the crustal magnetism of Mars can be explained by the atmospheric mechanism without the need for additional hypothesis which seem to pop up all over if an ancient dynamo theory is pursued.

Only two conditions are required for the atmospheric continuous generation of crustal magnetic field on Mars, namely: **(1)** there must be electrical activity in dust storms; and **(2)** Martian dust must be magnetic. Both conditions seems extensively demonstrated in the last years by theoretical and detailed laboratory studies as well as numerical simulations and direct data from recent Mars mission, [1]-[4].

The atmospheric theory for production of crustal magnetism on Mars could be easily tested by carefully measurements of the local concentrations of hydrogen peroxide in the magnetic anomalies. In fact, according with the atmospheric model for generation of crustal magnetism on Mars, magnetized clusters are generated by the electrical activity of dust storms, but this is precisely the same mechanism which is claimed to be the responsible for the mismatch in the excess of concentration of hydrogen peroxide H_2O_2 detected on Mars as discussed in preceding section. Therefore, within the atmospheric hypothesis, it is expected that the magnetic anomalies on Mars also should be anomalies of hydrogen peroxide. This simple test will be of crucial importance, because if high concentrations of hydrogen peroxide are associated with the magnetic anomalies, this will be not just a very pow-

erful argument in favour of the atmospheric theory because there is not any other mechanism known, so far, which can connect magnetic anomalies with concentrations of H_2O_2, but also will proof definitively the existence of electrical activity in dust storms and the generation of hydrogen peroxide inside. Nevertheless, if high concentrations of H_2O_2 are not detected in the magnetic anomalies, this will be not a definitive proof against the atmospheric theory because although both, magnetized clusters and H_2O_2 are generated inside the storm they can be transported in different ways by the convective currents.

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