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Electrical conductivity of silicate liquids and a magma ocean dynamo

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Are silicate dynamos possible? So far planetary dynamos seated in silicate material are unknown. Several lines of evidence motivate the consideration of a silicate dynamo in the early Earth: 1) Paleomagnetic evidence of a very early dynamo-generated field 2) models of the early thermal state of Earth in which the mantle may have been too hot to permit a core-generated magnetic field, and 3) the possibility of a deep and thick basal magma ocean. The key requirement is that the electrical conductivity σ of silicate liquids be sufficiently large at the relevant high pressure-temperature conditions ($\sigma > 1000$ S/m). Despite its importance, σ of silicate liquids is unknown above a few GPa in pressure, and measured values at low pressure are far too small to support a dynamo. However, observations of reflectivity from oxide liquids in shock wave experiments suggest a different mechanism of conductivity at high pressure (electrons, rather than ions). We have used ab initio molecular dynamics simulations to compute from first principles the value of σ at extreme conditions in systems with compositions that are simple (SiO_2) and rich (MgO-FeO-CaO-Al_2O_3-Na_2O-SiO_2). We use DFT+U with and without spin polarization combined with the Kubo-Greenwood formula. We find that the value of σ exceeds the minimum requirements and that a silicate dynamo seated in a basal magma ocean is viable.