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The effects of 10 to >160 GPa shock on the magnetic properties of basalt and diabase

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Abstract

Hypervelocity impacts within the solar system affect both the magnetic remanence and bulk magnetic properties of planetary materials. Spherical shock experiments are a novel way to simulate shock events that enable materials to reach high shock pressures with a variable pressure profile across a single sample (ranging between ~10 and >160 GPa). Here we present spherical shock experiments on basaltic lava flow and diabase dike samples from the Osler Volcanic Group whose ferromagnetic mineralogy is dominated by pseudo-single-domain (titano)magnetite. Our experiments reveal shock-induced changes in rock magnetic properties including a significant increase in remanent coercivity. Electron and magnetic force microscopy support the interpretation that this coercivity increase is the result of grain fracturing and associated domain wall pinning in multidomain grains. We introduce a method to discriminate between mechanical and thermal effects of shock on magnetic properties. Our approach involves conducting vacuum-heating experiments on untreated specimens and comparing the hysteresis properties of heated and shocked specimens. First-order reversal curve (FORC) experiments on untreated, heated, and shocked specimens demonstrate that shock and heating effects are fundamentally different for these samples: shock has a magnetic hardening effect that does not alter the intrinsic shape of FORC distributions, while heating alters the magnetic mineralogy as evident from significant changes in the shape of FORC contours. These experiments contextualize paleomagnetic and rock magnetic data of naturally shocked materials from terrestrial and extraterrestrial impact craters.

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Keywords

basalt and diabase, magnetic properties, magnetite, shock