ROCK MAGNETIC EFFECTS INDUCED IN BASALT AND DIABASE BY >20 GPa EXPERIMENTAL SPHERICAL SHOCK WAVES

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Introduction: Hypervelocity impacts represent a major mechanism for the evolution of the solid matter in our solar system. Impact shock waves can modify both the bulk magnetic properties and the remanent magnetization of rocks [1]. Understanding the physical mechanisms associated with shock-induced changes in magnetic properties is important for interpreting the paleomagnetic records of lunar rocks, meteorites, and cratered planetary surfaces. One way to experimentally test the effects of shock on rock magnetic properties is to conduct experiments where explosively generated shock waves travel through a spherical sample [2]. This approach is advantageous because: (1) its shock durations are similar to natural impacts, (2) target rocks are not contaminated by impactors (3) a wide range of pressures and temperatures may be investigated in a single shock experiment. Following Ref. [2], we conducted spherical shock experiments on (Ti-)magnetite-bearing basaltic lava flow and diabase dike samples from the Osler Volcanic Group near Lake Superior, Canada [3]. Our goal was to characterize magnetic changes induced in these rocks by pressures >20 GPa.

Results: Consistent with prior spherical shock experiments on the Saratov meteorite [2], both the shocked flow and dike samples exhibited concentric zonation: a central void space was surrounded by an inner layer of impact melt (Zone 1, most shocked), a middle partially melted layer (Zone 2), and an outer layer of unmelted rock with solid-state shock features (Zone 3, least shocked). Zones 1 and 2 acquired thermoremanent magnetization from shock heating. Zone 3 showed evidence for shock demagnetization of the primary (pre-shock) magnetization, but not substantial remagnetization. Shocked samples had higher remanent coercivities than unshocked samples of the same parent rocks. Coercivity changes may be related to domain wall pinning in multidomain ferromagnetic grains or grain fracturing.

Conclusion: Some target rocks within impact craters and shock stage >S3 meteorites have experienced shock pressures >20 GPa. Our spherical shock experiments demonstrate that shock-induced magnetic effects at these pressures likely include coercivity changes, shock demagnetization and thermal remagnetization. This work will guide future interpretations of the remanent magnetization and bulk magnetic properties of highly shocked materials from planetary surfaces.

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