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Wet surface and dense atmosphere on early Mars suggested by the bomb sag at Home Plate, Mars

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We use the Mars Exploration Rover Spirit observation of a bomb sag produced by an explosive volcanic eruption to infer the atmospheric density at the time of eruption. We performed analogue experiments to determine the relationship between the wetness of the substrate and the velocity and density of impacting clasts and 1) the formation (or not) of bomb sags, 2) the morphology of the impact crater, and 3) the penetration depth of the clast. The downward deflection of beds seen on Mars is consistent with water-saturated sediment in the laboratory experiments. Collision angles < 20 degrees from vertical are needed to produce bomb sags. From the experiments we infer an impact velocity up to 4×10^1 m/s, lower than ejection velocities during phreatic and phreatomagmatic eruptions on Earth. If this velocity represents the terminal subaerial impact velocity, atmospheric density exceeded 0.4 kg/m^3 at the time of eruption, much higher than at present.