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Controls on lava-snow interactions from propogation styles during the 2012-13 Tolbachik eruption

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Knowledge of how volcanism interacts with hydrosphere/cryosphere is critical for understanding the functioning and evolution of the Earth, establishing volcanism-climate linkages, and estimations of related hazards. Until now, no special studies have been focused on interactions between snowpack and advancing incandescent lava during volcanic eruptions, even though snow is the most widely distributed form of solid H_2O on the planet. It was thought a priori that snow might melt rapidly in front of active lava flows producing vigorous floods. Here we present results of unique field observations made in the snowpack in front of advancing basaltic lava flows during the 2012-13 eruption at Tolbachik volcano, Kamchatka, Russia. Our observations in the first time demonstrate that in reality heat transfer through lava/snow boundary occurs relatively slowly, so that melting of the majority of the snow pack occurs over the span of several hours-days after emplacement of the lava flows, producing only local and sporadic meltwater floods. Two fundamentally different styles of lava propagation result in two strikingly different responses of snowpack: i) 'a'a lava advancing in a rolling caterpillar-track motion propagates on top of snowpack; the melt water accumulates in (saturates) the layer of snow buried underneath the lava flow and does not interact notably with the lava material, and ii) pahoehoe lava advancing as inflating lobes propagates beneath/inside snowpack, locally generating slowly growing 'snow-domes'; the melt water precipitates down into incandescent lava producing chilling and local thermal shock/quench fragmentation (minor hyaloclastite production). Our observations show that lava-snow interactions can vary significantly depending on styles of flow front advance. Lava flows emplaced over areas covered with snow bear features that can be distinguished in old stratigraphic sequences and used for paleoclimatic reconstructions on Earth, Mars and other planets.