Lava–Ground-Ice Interactions Associated with the Lost Jim Lava Flow, Seward Peninsula, Alaska

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Introduction
Lava–ice interactions can occur in a variety of conditions based on form of ice, duration of interaction, and degree of insulating ground cover, which will produce unique geomorphic expressions. In the case of ice-bearing permafrost, overlaying terrain or cooled lava crust can delay melting, but eventually the thermal pulse can penetrate the ground to induce melting [1]. Melting creates voided pore space into which the overlaying ground and lava can collapse, causing subsidence and pitting on the lava surface [2, 3]. Recognizing this lava-induced thermokarstification is a means of identifying the past extent of ground-ice. This is of particular use to interpret the lava emplacement environments on geologically-recent Mars and provide insight into the paleoenvironment [4, 5].

Lost Jim Lava Flow, Seward Peninsula, Alaska

Lost Jim Lava Flow (LJLF) is a ~2000-year-old pahoehoe lava flow in the Bering Land Bridge National Preserve. The flow slopes c.1° to the west, with >300 m of elevation change and exhibits classic inflation textures. Geomorphic features of both positive- and negative-relief occur throughout the flow. LJLF has lava thicknesses ranging from 3–30 m and permafrost in the region. The region contains approximately 3 m beneath the surface with thicknesses of 10–40 m [6, 7]. The black, red, and blue outlines below indicate the extent of Worldview-1 and IKONOS stereo images used to generate high-resolution, local topography.

Types of Depressions

LJLF has three categories of depressions: (A) pits, (B) margin pits, and (C) lava tube “skylights.” (A) Pits include smooth-rimmed elliptical/circular pits (~h, c, g, i), irregular pit clusters (~c, ~f, k), or accretion pits (~d). Average depth is ~2 m but the range varies up to 20 m. Pits with rim cracks indicate inflation. Other pits could not be classified as a particular formation mechanism, but some are expected to be from collapse. Indications of origin may be 1) distribution or shapes similar to thermokarst lakes or 2) depths greater than flow thickness. (B) Margin pits that formed on the terrain directly adjacent to the lava or on the very edge of the lava flow may represent lateral heat transfer. (C) Skylights follow an easily distinguishable sinuous trace. On average, they are twice as deep and steeper-walled than other pits.

Depressions in Elysium Volcanic Province, Mars

Young volcanism, such as at the Cerberus Fossae 2 and 3 units, may have occurred in the presence of ground-ice [6]. There is evidence of (A) subsidence and (B) margin pitting in the Tartarus Colles Lava Flow that may be due to ice melting. However, the pits on Mars are larger (~200 m for depressions, ~20 m for margin pits) and more widely distributed. This may be explained by emplacement mechanism, heterogeneities in the amount or distribution of ground-ice, and/or extent of an insulating layer.

Take-Away Points

• LJLF is an exceptional example of lava–permafrost interaction, which serves as an analog to understand similar processes on young Mars lava flows.
• Frequency of lakes on the terrain and of pits on the western edge of the mapped area suggest more easily accessible permafrost for melting.
• Pits along the flow–terrain boundary could represent subsidence from lateral heat transfer.
• Future work, including aerial campaign and in situ observations, are needed to conclusively identify pit formation mechanisms.

References: