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Analysis of volcanic deposits from the 2001 eruption of Mt. Cleveland, Alaska using multisensor satellite data and field observations

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Abstract:

Eruptive characteristics and histories of Aleutian stratovolcanoes are some of the least understood because of their remote locations, yet they have the ability to cripple the heavily traveled air routes in this region. Remote sensing is useful for gathering information on remote eruption deposits and compliments field observations. Mount Cleveland, on the western part of Chuginadak Island, has been one of the most active of these Aleutian volcanoes over the past century, its most recent eruption disrupted air traffic from February to March 2001. Using field observations of pyroclastic fan deposits preceding an a'a lava flow down the western flank of Mount Cleveland in 2001 this study attempts to associate spectral characteristics of these deposits (from Advanced Spaceborne Thermal Emission and Reflectance Radiometer (ASTER), Landsat 7 Enhanced Thematic Mapper Plus (ETM+), Second European Remote Sensing Satellite (ERS-2), and RADARSAT-1) to similar characteristics around the entire volcano. By also using Advanced Very High Resolution Radiometer (AVHRR) and Moderate Resolution Imaging Spectroradiometer (MODIS) data this study will present a more accurate chronology of the 2001 eruption. Field observations of the pyroclastic fan deposit reveal the existence of two separate stratigraphic deposits, an initial smooth ~10-30 m thick a'a block and ash deposit overlain by a rougher ~1-15 m thin breadcrust bomb deposit. The southern and northeastern parts of the fan are dominated by the thin breadcrust bomb deposit with an average bomb area of 2.38 m^2, while the northwestern part is dominated by very large a'a blocks with pull-apart fractures and a much larger average block area of 22.44 m^2. Initial Landsat 7 ETM+ and photographic analysis of this pyroclastic fan displays a slight coloration difference between the two deposits. The stratigraphic sequence of the pyroclastic fan from 2001 suggests that there was 1) a warm to hot debris flow from the collapse of an active a'a flow on top of snow, and 2) a cooler thin flow composed of breadcrust bombs from the summit crater and debris. Here as well, the underlying snow melted and flowed with the bombs down the flank. The pathways provided by these pyroclastic debris flows are later the channels for the overlying a'a lava flows. This is seen repeatedly in older deposits on the island. This study shows that this stratigraphic sequence (pyroclastic debris flow to a'a flow) is an important eruption process on snow covered stratovolcanoes. The pyroclastic debris flows are a primary hazard on high steep-sided inhabited volcanoes due to their relatively high volume (at Mt. Cleveland in 2001 >3.3×10^6 m^3) and rapid emplacement, and thus are potentially tsunamigenic in addition to the direct hazard to nearby residents.