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Comparison of pyroclastic dune bedforms from Tungurahua, Laacher See, Ubehebe, and Stromboli volcanoes.

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Dune bedforms (used here without genetic implication) produced by dilute pyroclastic density currents (PDC) are a common feature in deposits of explosive volcanic eruptions. Pyroclastic dunes have a wide range of length, grain size distribution, and internal structure. Here, we compare deposits from Tungurahua (Ecuador), Laacher See (Germany), Ubehebe (USA), and Stromboli (Italy).

During the 2006 eruptions at Tungurahua, low energy pyroclastic surges were emitted together with dense pyroclastic flows and produced dune bedforms which outcrop at the surface of the deposits, allowing for shape analysis in regards to topography. Usually, dune position is randomly distributed, without occurrence of trains. Lengths range from 1 to 20 meters and diverse sedimentary patterns are observed in cross sections. Most dunes are stoss depositional climbing dunes, with the particularity that there is more deposition on the stoss than on the lee side. This leads to a slight upstream migration of the crest. This climbing structure is partly cut by episodic phases of erosion on the stoss side, but never on the lee which shows continuous aggradation. Thus, these dunes are not migrating, only the position of the crest oscillates due to differential sedimentation on lee and stoss side. In outcrops near the vent, smooth structures made up of lensoidal backset beds that can be fine to very coarse grained (blocks of up to 10 centimetres) represent another type of bedforms.

The large phreatomagmatic eruption at Laacher See produced a thick succession of pyroclastic deposits containing bedsets with primary cross stratifications. Compared to Tungurahua, bedforms are very similar in what concerns their internal structure, but they have larger dimensions (5-25m length) and a different granulometry containing clasts of lapilli- and block-size. Most structures are very sharp crested. Smooth bedforms are observed more rarely and are often occurring in trains. Two main types are observed, which were formerly interpreted as “antidune” and “chute and pool” structures. However, comparing these structures observed in cross section at Laacher See with similarly cross bedded surface outcrops at Tungurahua, we propose a re-interpretation of these structures.

At Ubehebe crater, superficial phreatomagmatic explosions have produced base surges that deposited up to 50 meters of stratified material, with cross stratification occurring in the central part. Dunes are much smaller in length (0.5 to 2 meters) compared to Tungurahua and Laacher See, but show a comparable grain size distribution as at Tungurahua. Most bedforms occur in trains of several dunes. They are smoothly rounded and made up of subhorizontal laminae. Additionally, we found stoss depositional climbing structures with downstream migration of the crests as well as structures showing only backsets. Moreover, there is a large amount of overturned beds dipping away from the crater.

At Stromboli, we observed structures stacked on top of each other with overlapping relationships, thereby showing the influence of the bed morphology on the development of new structures. Cross stratifications are very similar in structure, size, and grain size to Ubehebe dunes and we thus conclude that both have been produced by the same type of current.

We interpret that the deposition from relatively slow, oversaturated, and subcritical currents has generated the sharp climbing bedforms at Tungurahua and Laacher See. The origin of smooth shaped lensoidal backsets structures (formerly interpreted as “chute and pool”) is still under debate; they may be antidunes or caused by subcritical stoss side accumulation. At Ubehebe and Stromboli, the smooth bedforms and their subhorizontal cross

stratifications are interpreted as antidunes produced by a basal underflow of only a few centimetres in height. Moreover, the occurrence of overturned beds at Ubehebe suggests that such underflows were dense and in a fluidized state and travelled and interacted with an erodible bed of deposits.