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The antidune question for bedforms in deposits of dilute pyroclastic density currents

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Dilute pyroclastic density currents (PDCs) are mixture of volcanic particles and gas that can be produced during explosive volcanic eruptions. Like turbidites, they travel on the ground driven by their higher density compared to the ambient fluid, which is due to the load of suspended particles. Dilute PDCs have a low enough particle concentration so that their deposit can contain cross stratification, but high enough so that they do not lift off as ash clouds.

Since the 1970's most dune bedform cross stratifications found within dilute PDC deposits have been interpreted as antidunes, mainly due to the fact that they can exhibit more aggradation on the stoss than on the lee side. However, several studies have challenged this interpretation in the last few years (stepwise aggradation, differential draping, flow reversal, near-bed load blocking).

In order to decipher which are the valuable arguments to confirm or infirm the antidune interpretation, we document deposits from different eruptions: Tungurahua (Ecuador), Laacher See (Germany), Purrumbete (Australia), Ubehebe (USA), Stromboli (Italy), Yasur (Vanuatu).

We consider fluid dynamics arguments on the formation of gravity waves within the shallow water approximation and for internal gravity waves within a stratified medium. Indeed, antidunes are by definition sedimentary prints of stationary gravity waves. We also consider the possibility of cyclic steps as a parental phenomenon for the formation of dilute PDC bedforms.

Finally, results of wind tunnel experiments for boundary layer conditions give another independent set of data to interpret cross stratifications within dilute PDC deposits.

Whereas we cannot rule out an interpretation as antidunes for some bedforms (lensoidal stoss-depositional structures, low aspect ratio bedforms in train), others can clearly be disregarded based on geometrical considerations. Overall, the interpretation as antidune cannot be simply based on stoss-deposition, and needs to take into account other parameters like the 3D shape, the possible truncations within a bedform, the organization between several berforms in trains, as well as the possible composite growth of a bedform. Interpretation as antidune is not straightforward at whole within dilute PDC deposits and requires careful description.