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Backset ripples, a form of cyclic steps? Examples from deposits of pyroclastic current.

Guilhem Amin Douillet (1), Pierre Dietrich (2), and Fritz Schlunegger (1)

(1) Universität Bern, Institut für Geologie, Bern, Switzerland (guilhem.douillet@geo.unibe.ch), (2) Department of Geology, University of Johannesburg, Johannesburg, South Africa

Ripple-size structures with a purely aggrading, backset architecture are recognized in deposits of pyroclastic currents. They are observed uniquely within steep laminasets formed during the August 2006 eruption of Tungurahua (Ecuador) . These backset ripples are interpreted to represent the sedimentary signature of trains of Froude-jumps (jump from upper to lower flow regime), either self initiated or triggered by a basal topographic pool, and may thus represent a form of cyclic steps.

Backset ripples with a length from <5 cm to >25 cm, and a thickness of up to 10 cm were recognized. They are found on the steep (10-25º) lee-side of larger dune bedforms. These backset ripples often organize "in-trains", i.e. in periodic repetitions on the same laminaset with up to four backset-ripples aligned. Two types of structures are recognized: "scour-based" and "self-initiated" backset ripples, which can concur in a single train. The "scour-based" backsets form against steep truncations that cut the upflow part of planar laminae, whereas the self-initiated backset seem to grow spontaneously from flat beds through low angle bundled beds, or structures resembling ripples or climbing ripples. The fully aggrading nature of the structures enables to preserve the signature of all stages of the parental flows.

The steep slopes on which the backset ripple trains are present are likely to maintain Froude-supercritical conditions for thin flows. The backset ripples have their stoss-laminae depleted in fines and a coarser content in comparison to their lee-continuation. This suggests a sudden decrease in competence (the ability to transport coarse bedload material) and increase in turbulence (increasing the transport away of the fines in suspension). Such a change is likely to occur at a Froude-jump, as suggested for coarse lags elsewhere. In opposite to most documented cyclic steps, erosion does not take place on the lee part of beds, but uniquely as truncations of stoss sides. The stoss part of a laminae is however much thicker than its lee continuation. It is unclear whether stoss-truncations are linked with variations in a Froude-jump intensities/locations or are unrelated features.

Our understanding is that fully aggrading cyclic steps occur on slopes that force supercritical conditions for thin underflows, but at flow velocities that allow the formation of ripple bedforms. These in turn produce local breaks in slope and pools that force the formation of Froude jumps. The highly depositional dynamics that is generally inferred from pyroclastic deposits is key in the construction and preservation of backset ripples. In analogy with experimental and monitoring data, we interpret the parental flows as particulate density currents with a flow thickness lesser than the created bedforms (i.e <10 cm).

We foresee a risk of misinterpretation of similar features from the rock record, namely purely aggrading climbing ripples (i.e. climbing ripples where both stoss- and lee-side lamina are preserved). Whereas conventional climbing ripples relate to thick subcritical flows with strong deposition rates, cyclic steps relate to thin supercritical flows relative to the size of the structures.