'UNDERCLAST PORES' FORMED BY SHALLOWMOST GROUNDWATER FLOW DISTINGUISH TORRENTIAL CHANNEL DEPOSITS FROM DEBRIS FLOWS

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Underclast pores excavated by very shallow groundwater flow focussed underneath coarse gravels to boulders provide a diagnostic criterion to distinguish extremely poorly sorted torrential channel deposits (fluid flow deposits) from similar-appearing deposits of debris flows.

In the Northern Calcareous Alps, except perhaps for major trunk valleys, stream-dominated alluvial fans and talus slopes (many dominated by ephemeral alluvial processes) represent the main sediment storage in valleys and along mountain flanks. On the surface of present-day alluvial fans and talus slopes, the distinction of debris flows from deposits of torrential floods is straightforward. By contrast, in many 'vertical' outcrops of fan and talus successions, extremely poorly sorted debris flows may be difficult to distinguish from similar deposits that accumulated from torrential fluid flows. With respect to bed geometry in outcrop intersection, bed thickness, mean clast size, sorting, and absence of clast size segregation across beds, both types of deposit appear similar. In addition, both deposits may be vertically associated (often in cut-and-fill patterns) with sediments of unequivocal alluvial origin, such as sieve deposits. Debris flows and fluid flows are characterized by different types of downflow imbrication; in two-dimensional outcrops of lithified deposits, however, it is difficult to clearly identify abc-axes of clasts for distinction of imbrications. Furthermore, in both types of deposits, imbrication often is absent in outcrop scale. Whereas a primary matrix of carbonate mud to argillaceous mud is diagnostic of cohesive debris flows, a matrix of winnowed sand is not a good sole criterion for fluid flow/debris flow distinction.

Inspection of numerous fresh exposures in presently-active stream-dominated fans and torrential streams, including the days after floods, indicates that in coarse-grained, extremely poorly sorted fluid flow deposits, larger clasts are underlain by a widespread type of pore here called 'underclast pores'. The pores are present immediately below clasts of coarse gravel to boulder size, are limited in extent to the clast above, are widest near the central part of the clast underside, and taper out towards the clast margins, but also may partly engulf the clast from below. In fresh torrent deposits, closely below the actual sediment surface, many underclast pores are partly or, more rarely, completely filled by an (net) upward-fining layer a few millimeters to a few centimeters thick of carbonate-lithic sand to carbonate mud. Because of later infiltration of carbonate mud into the remnant pore space (a widespread process in talus and fan deposits of the NCA), in lithified deposits, underclast pores commonly are completely clogged by geopetally-laminated sediment. In lithified deposits, because of weathering, the sediment-filled former underclast pores may be overlooked if not specifically searched for. For the interpretation of underclast pores, three observations are significant. (1) In underclast pores, geopetal fillings mainly of silt to mud are widespread below larger clasts where at the surface of the pebbly to bouldery deposit, no sand to mud had accumulated at all or is confined to a few small, thin patches. (2) Underclast pores are limited in presence to (ephemerally active) torrential channels on stream-dominated fans and on talus slopes. (3) In these deposystems, underclast pores are limited to sediments of very poor to extremely poor sorting from mud to cobbles or boulders.

During flood stage, when a larger clast comes to rest on stream bed, formation of underclast pores starts. During peak to waning flood, because the clast focusses subsurface flow within the uppermost centimeters of sediment (hyporheic flow of limnology) into a smaller volume than the flow within the surrounding sediment, according to the Law of Stationary Current Flow, below the larger clasts hyporheic flow is more rapid than in the surrounding sediment, and finer-grained material underneath the clast is swept out. During waning flood, depending on availability of fine-grained sediment, the underclast pore in turn may become partly filled by geopetals of fine sand to carbonate mud. Because of the described conditions of formation, underclast pores can form only in fluid flows, irrespective of whether the extremely poorly sorted clastic material *originally* might have been brought to site by debris flows, and subsequently reworked by torrential floods. In fresh debris flow deposits, no underclast pores were found by the author. In fully lithified successions, underclast pores that commonly are completely or partly filled by geopetally-laminated internal sediments (silt to mud) are an unequivocal criterion to distinguish extremely poorly sorted torrential deposits from genuine debris flow deposits.