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Thermal and dynamic behaviour of supraglacial clasts and the origin of sorting in supraglacial debris covers

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The transition zone from a discontinuous to a continuous debris cover is an extensive part of many glacier ablation zones. Although responsible for the highest specific melt rates of debris-covered glaciers, transition zones have received little research and are poorly understood. Here we consider the interactions between emergent clasts and melting ice surfaces at Glacier d'Estelette and Miage Glacier (Italian Alps). Debris-ice interactions are complex because dispersed heterogenous debris both enhances and retards melt rate in the same locality, depending on the distribution of clast sizes. Observations reveal that thermal and dynamic clast interactions with the glacier surface increase the transport rate of coarse clasts, and initiate vertical sorting at the point when a continuous debris layer forms. This happens because, in summer, clasts exceeding the critical thickness for melt slide over the glacier surface. In contrast finer thermally-embedded material is transported at ice surface velocity and become covered by coarser material from upslope. Once established, debris-cover texture allows sorting to develop as the cover thickens downglacier. A two-layer temperature profile results, in which a coarse, drier clast layer of low thermal conductivity overlies a finer-grained, moist layer of higher thermal conductivity. Transition-zone processes establish inverse grading at the initiation of a debris cover, allowing subsequent sorting to operate as the cover thickens downstream. The processes by which this occurs are unknown, but analogy with periglacial active layers suggests convection within a frost-susceptible lower fine layer and eluviation of fines supplied by aeolian deposition and in-situ clast distintegration.