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Deposits related to supercritical flows in glacifluvial deltas and subaqueous ice-contact fans: Integrating facies analysis and ground-penetrating radar

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Bedforms related to supercritical flows have recently received much interest and the understanding of flow morphodynamics and depositional processes has been greatly advanced. However, outcrop studies of these bedforms are commonly hampered by their long wavelengths. Therefore, we combined outcrop-based facies analysis with extensive ground-penetrating radar (GPR) measurements. Different GPR antennas (200, 400 and 1500 MHz) were utilised to measure both long profiles and densely spaced grids in order to map the large-scale facies architecture and image the three-dimensional geometry of the deposits. The studied delta and subaqueous ice-contact fan successions were deposited within ice-dammed lakes, which formed along the margins of the Middle Pleistocene Scandinavian ice sheets across Northern Germany. These glacilacustrine depositional systems are characterised by high aggradation rates due to the rapid expansion and deceleration of high-energy sediment-laden flows, favouring the preservation of bedforms related to supercritical flows.

In flow direction, delta foresets commonly display lenticular scours, which are 2 to 6 m wide and 0.15 to 0.5 m deep. Characteristically, scours are filled by upslope dipping backsets, consisting of pebbly sand. In a few cases, massive and deformed strata were observed, passing upflow into backsets. Across flow, scours are 2 to 3 m wide and typically display a concentric infill. The scour fills are commonly associated with subhorizontally or sinusoidal stratified pebbly sand. These facies types are interpreted as deposits of cyclic steps and antidunes, respectively, representing deposition from supercritical density flows, which formed during high meltwater discharge events or regressive slope failures (Winsemann et al., in review). The GPR-sections show that the scour fills form trains along the delta foresets, which can be traced for up to 15 m.

The studied subaqueous ice-contact fan succession relates to the zone of flow transition of a supercritical plane-wall efflux-jet and is characterised by deposits of chutes-and-pools, antidunes and humpback dunes (Lang & Winsemann, 2013). In the GPR-sections, long wavelength (2 to 40 m) sinusoidal reflectors with lateral extents of up to 175 m represent the dominant radar facies, which is interpreted as deposits of stationary aggrading antidunes. This radar facies is associated with lenses (2 to 15 m wide, 0.5 to 1.5 m thick) filled with planar upflow-dipping reflectors, and sheet-like sigmoidal downflow-dipping reflectors, which are interpreted as deposits of chutes-and-pools and humpback dunes, respectively.

Facies transitions occur from cyclic steps or chutes-and-pools to antidunes and from antidunes to humpback dunes, and are interpreted as related to the evolution of bedforms under spatially and temporarily changing flow conditions.

References:

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