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Entangled external and internal controls on periglacial alluvial fan evolution: the Late Pleistocene Senne and Heller fans in the Münsterland Embayment and Elbe Valley (Germany)

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The morphology and depositional architecture of periglacial alluvial fans represent the interplay of external controls (tectonics and climate) with internal processes such as channel migration and lobe switching. However, the nature of this interaction is poorly understood. Here we present sedimentological data from two different Late Pleistocene alluvial-fan systems. The studied fans developed under similar tectonic and climate conditions, however, differ in size and drainage area, allowing to estimate the role of climate, tectonic and autogenic controls on flow processes and facies architecture. Both fans represent rather small tributary-junction fan systems that developed over a short time period. Such systems rapidly respond to climate change and the relatively low complexity of fans is well comparable to experimental fans.
Luminescence dating was used to determine the timing of fan onset and aggradation rates. Fan onset occurred in response to climate change at the end of MIS 3 when temperatures decreased and periglacial climate conditions were established in northern central Europe. A related increase in sediment supply and strongly variable precipitation patterns probably promoted fan formation. The sand-rich, steep sheetflood-dominated Heller fan (5°-17°) is related to a larger, low-gradient fan catchment. The steeper, dip-slope catchment of the Senne fan enhanced stream gradients and promoted the transport of coarser-grained sediments. This fan has a lower gradient slope (2-6°) and is dominated by channelized flows, alternating with periods of unconfined sheetfloods.
The major period of fan aggradation was approximately between 33-18 ka. Sediment mobilization probably occurred through sporadic high-energy floods during snowmelt, rapidly filling the available accommodation space. The highest aggradation rates are recorded from the early stage of fan building, during which more than 35 m thick sediments accumulated within a few thousand years. Meter-scale coarsening-upward successions, characterized by sandy sheetflood deposits at the base, overlain by multilateral or smaller single-storey gravelly channel fills are related to high-frequency climatic fluctuations or seasonal fluctuations in water and sediment supply. These coarsening-upward successions are commonly bounded by a paleo-active layer, from which ice-wedge casts penetrate downwards. The recurrent pattern of multistorey, multilateral and single-storey channel bodies with a lateral offset to vertical stacking pattern most probably was controlled by autogenic switch in avulsion-dominated systems.
The change in deposition from alluvial-dominated processes to aeolian sedimentation with minor alluvial influences records alternations of dry and ephemeral wetter phases that are related to rapid climatic variations. The main phase of aeolian sand-sheet deposition probably correlates with Heinrich event H1 between approximately 18-16 ka and reflects sedimentation in response to aridification and high mean wind speeds.

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