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External forcing or autogenic processes: What controlled sediment-accumulation rates in the Oligocene/Miocene Upper Austrian Molasse Basin?

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Detailed characterization of variations in sediment production, routing, and transport processes in peri-orogenic basins offers insights into underlying external forcing mechanism from climate or tectonics. The correct interpretation of such environmental signals in the sedimentary record remains challenging and benefits greatly from high-resolution geochronology and a precise evaluation of all stratigraphic elements of the sedimentary system. Spatially averaged sediment-accumulation rates can help to investigate such environmental signals.
A key area to investigate environmental signal propagation in the late Oligocene/early Miocene is the Upper Austrian Molasse Basin due to the large amount of available data in the Alpine source area and the foreland. Deep-marine sedimentation, forming the Zupfing, Puchkirchen and Hall Formation, was controlled by a basin-axial submarine channel of 3-5 km width and >100 km length. Two basin-wide unconformities were recognized in seismic-reflection data: the Northern Slope Unconformity (NSU), and the Base Hall Unconformity (BHU).
We reevaluated and extended the biostratigraphic concepts of the Oligocene/Miocene Upper Austrian Molasse deposits. We used these high-resolution age constraints to determine age, duration of the unconformities and calculated spatially averaged sediment-accumulation rates. Calculations were run separately for three time intervals in submarine channel and six intervals in the overbank deposits, using a large (3300 km2) 3D seismic-reflection cube and lithology and density logs of 72 wells.
Our new stratigraphic concept indicates that the NSU was formed from <28.09 to 24.5 Ma due to tectonically induced oversteepening of the northern basin slope. Sediment-accumulation rates in the channel deposits do not record any autogenic or external environmental signal. The overbank deposits, however, do record such signals. During the Puchkirchen Formation (24.5-19.6 Ma), the sediment-accumulation rates on the overbanks remained stable except for a short period from 23.5-23.1 Ma showing a fourfold increase. We interpret this increase as a result of an autogenic migration of channel-meander bends visible in the seismic-reflection data that lead to an increase in flow stripping of turbidity currents onto the overbanks. Furthermore, we detect a 0.5-fold decreased accumulation rate compared to rates in the Puchkirchen Formation above the BHU from 19.6 to 19.0 Ma. During this time, turbidity-current deposits are increasingly mud-rich and a sea-level drop is inferred from previous studies. We interpret this pattern to be related to the previously proposed visco-elastic relaxation of the European plate leading to relief reduction in the Alpine hinterland and uplift in the Molasse Basin. From 19.0 to 18.1 Ma, accumulation rates are 4.5-fold higher than in the underlying Puchkirchen Formation, which we explain by the tectonically induced uplift of the Northern Calcareous Alps and increased erosion of the overlying Augenstein Formation. In this setting, overbank deposits are more suitable to detect environmental signals than channel deposits.