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Understanding how gravity flows shape deep-water channels. The Rhone delta canyon (Lake Geneva, Switzerland/France)

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Deep-water marine channels are highly dynamic environments due to the erosive power of sediment-laden currents that are continuously reshaping the morphology of these major sediment conduits. Proximal levees are prone to scarp failures generating gravity flows that can be transported thousands of kilometres from the original landslide. Nevertheless, the evolution of these underflows is still poorly understood because of the spatial scale of the processes and their difficult monitoring. For this reason, the smaller size, well-known boundary conditions and detailed bathymetric data makes Lake Geneva′s sub-aquatic canyon in the Rhone delta an excellent analogue to understand these types of sedimentary processes that usually occur in deep-water channels in the marine realm. A multidisciplinary research strategy including innovative coring via MIR submersibles, in-situ geotechnical tests, geophysical and sedimentological analyses, as well as acquisition of different multibeam bathymetric data sets, were applied to understand the triggering processes, transport mechanisms and deposit features of gravity flows throughout the Rhone delta active canyon. The difference between two bathymetric surveys in 1986 and 2000 revealed an inversion in the topography of the distal active canyon, as a former distal canyon was transformed into a mound-like structure. A 12 m-thick layer was deposited in the canyon and modified the sediment transfer conduit. Sediment cores from this deposit were retrieved in-situ in 2002 and 2011 via the "F.-A. Forel" and Russian MIR submersibles, respectively. These cores contained a homogeneous, sandy material. Its sediment texture, grain-size, high density and shear strength, and low water content suggests that it corresponds to a debris-flow deposit that possibly took place after the initiation of a mass movement due to a scarp failure in proximal areas of the canyon. In addition, in-situ geotechnical tests on the modern canyon floor have shown a soft top layer above a stiffer substratum. This soft layer, which increases in thickness towards distal areas, may act as a basal surface for hydroplaning, and might have allowed the debrite to be transported ∼9 km away from the source of the scarp failure. The rapid sediment loading, slope undercutting and oversteepening, and increased pore pressure due to high methane concentrations are the main factors for the slope instability and subsequent scarp failure. This study highlights how large mass movements in proximal sites influence the morphology of distal areas by damming the channel and, eventually, forming short-term meanders susceptible to further erosion, as revealed by multibeam bathymetries acquired in AD 2012 in the distal area of the subaquatic canyon.