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How does organic matter affect the head velocity and run-out distance of cohesive sediment gravity flows?

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Despite over 50 years of multidisciplinary research on the flow mechanics and deposits of submarine saline density currents and sediment gravity flows, the flow dynamics and depositional processes of clay-rich gravity flows remain poorly understood. Cohesive clay can alter the flow rheology as a result of the electrochemical forces of attraction between individual particles. These forces may induce particle aggregation, leading to the formation of floccules and more pervasive cohesive structures, called gels. Through flocculation and gelling, clay particles can enhance or dampen turbulent forces in sediment gravity flows, such that increasing the cohesive sediment content causes a transition from turbulent, Newtonian flow, via transient-turbulent flow, to laminar, non-Newtonian debris flow. Because the flow rheology controls the depositional style, a thorough understanding of how flow composition relates to flow rheology is essential for our interpretation of the architecture and the palaeo-environmental setting of submarine deposits in outcrop and core.

In the natural environment, clay-rich sediments are commonly associated with the presence of organic matter. The effect of organic matter, in particular 'sticky' extracellular polymeric substances (EPS), on the flocculation and gelling within clay-laden flows is reasonably well known for tidal flows in shallow-marine environments, but the impact of cohesive organic matter on the dynamics of sediment gravity flows has not been explored yet. A complex interaction between physical and biological forces has been found to influence the stability of sedimentary deposits. Here, the influence of similar interactions for clay and EPS suspended within sediment gravity flows is presented.

The above research gaps were addressed by means of flume experiments that recorded changes in dynamic behaviour of sediment gravity flows with variable amounts of biologically cohesive xanthan gum (a commonly used proxy for natural EPS) and physically cohesive kaolin clay (one of the most common clay minerals on Earth). Provisional results indicate that very small quantities of EPS – several orders of magnitude smaller than the quantity of clay – are sufficient to enhance flocculation and reduce flow velocity compared to a flow that lacks EPS. This finding has the potential to change our understanding of sediment gravity flows in the natural environment, where biological matter is ubiquitous.