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Effect of bed roughness on the mobility of cohesive sediment gravity flows

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Novel flume experiments offer a unique insight into the importance of bed roughness for the mobility of sediment gravity flows (SGFs). Turbulence production and bed friction were found to compete in controlling flow mobility. Hyperpycnal plumes are bottom-hugging SGFs that are crucial drivers for sediment transport from rivers into lakes and oceans. Recent laboratory studies have shown the importance of clay type and concentration for the behaviour of SGFs (Baker et al., in press, J. Sed. Res.). However, the importance of bed roughness, such as in the Mississippi River Delta, has rarely been considered. Lock-exchange experiments were conducted to investigate how the head velocity and runout distance (ROD) of clay-laden SGFs vary with five different grain-related roughness types: smooth, sand, fine gravel, coarse gravel, and artificial grass. The results demonstrate a complex relationship between bed roughness and flow mobility, where head velocity and ROD generally decreased from smooth bed via sand to grass, but were anomalously large for fine gravel. We infer that increasing the vertical length scale of the roughness elements initially increased SGF mobility, because higher turbulence production delayed suspension settling, thus outcompeting higher bed friction, especially for the fine gravel. The large roughness for the coarse gravel, and especially the grass, caused the bed friction to effect the flow mobility more effectively, resulting in lower head velocities and RODs. Capture of clay between the grass blades may have further promoted flow deceleration, resulting in short RODs. In summary, bed roughness influences SGF mobility through the competition between turbulent and frictional forces, where a rougher bed does not necessarily result in a slower flow. This outcome may have important implications for the areal distribution of sediment by SGFs in the marine environment, and eventually for the 3D architecture of sedimentary sequences in prodeltas and submarine fans.