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Flocculation characteristics of freshly eroded aggregates

Andrew Manning (1,2,3), Valentin Wendling (4), Nicolas Gratiot (5), Cedric Legout (6), and Herve Michallet (7)

(1) HR Wallingford Ltd, Coasts & Estuaries Group, Wallingford, United Kingdom (a.manning@hrwallingford.com), (2) Department of Geography, Environment and Earth Sciences, University of Hull, Hull, HU6 7RX, UK (andymanning@yahoo.com), (3) School of Marine Science and Engineering, Plymouth University, Drake Circus, Plymouth, Devon, PL4 8AA, UK (andymanning@yahoo.com), (4) LTHE, Université Joseph Fourier, CNRS, G-INP, IRD. 460 Rue de la Piscine, 38400 Saint Martin d'Hères, France (valentin.wendling@ujf-grenoble.fr), (5) LTHE, IRD, Université Joseph Fourier, CNRS, G-INP. 460 Rue de la Piscine, 38400 Saint Martin d'Hères, France (nicolas.gratiot@ird.fr), (6) LTHE, Université Joseph Fourier, CNRS, G-INP, IRD. 460 Rue de la Piscine, 38400 Saint Martin d'Hères, France (cedric.legout@ujf-grenoble.fr), (7) Laboratoire des Ecoulements Géophysiques et Industriels (UJF, INPG, CNRS) BP53, 38041 Grenoble Cedex 9, France (herve.michallet@legi.grenoble-inp.fr)

In Europe, 260,000 square kms of soils already suffer erosion by water. This worrying level of land degradation is expected to increase in the context of climate change, with situations particularly critical in mountainous environments. This study aims at improving sediment transport parameterisation, by examining the kinetics of fine soil aggregates (size D, settling velocity Ws, density), once immersed in a turbulent flow. Thus observing the changing state, as soil aggregates become suspended sediment floc/aggregates.

Particle properties of two Mediterranean materials (black marl and molasse, both sampled in badlands) were tested in grid stirred experiments. Hydrodynamic properties were monitored with ADV and turbidity sensors. For each soil, three suspended sediment concentration (SSC) loads (1.5; 5; 10 g/l) representative of flood conditions were tested. Aggregate properties were obtained at four depths above the grid, using the video LabSFLOC technique and laser techniques. These acquisition heights are associated with the corresponding turbulence dissipation rates G of 1.5, 3, 7 and 19 ŝ-1. Once particles were injected in the tank, a quasi-equilibrium state was rapidly reached, after one to two minutes. The floc/aggregate properties did not vary with sediment load. The median diameter D_50 was measured to be around 60 microns for the clay loam soil and around 15 microns for the two badlands materials.

Examining the molasse samples, we see that the SSC at 1, 5, 10, 20 and 40 minute intervals were all +12 g/l at distances 10 cm and 15 cm above the nominal vertical mid-stroke grid position for the experimental SSC ranges. At the less turbulent zone, a 2 g/l base SSC reduced by 80% and at a nominal 10 g/l the SSC dipped by two orders of magnitude from the base concentration.

If we consider the population distribution for molasse at a base SSC of 10 g/l sampled 15cm above the grid after 40 minutes, D ranged from 39 – 273 microns. A small microfloc cluster only had Ws of 0.4-0.5 mm/s, an order of magnitude slower than the peak sample Ws of 5.8 mm/s. These fast settling aggregates spanned the macrofloc (> 160 microns) and microfloc transition from 100-220 microns, representing over half the SSC. The majority of the microflocs (< 160 microns) exhibited effective densities between 160-1600 kg/m̂-3, which suggests that some degree of flocculation has occurred. Furthermore, there are highly porous macroflocs demonstrating effective densities < 40 kg/m̂-3; these flocs fell at a Ws of about 1 mm/s and represented ∼4% of the total SSC.

A key fundamental research question to be addressed in this study was: do aggregates rapidly turn into flocs? The initial results indicate that aggregates do not easily/rapidly turn into flocs. However, despite their poor kinetics, particles were undoubtedly aggregated. The aggregation index was measured to be of 50% for badlands materials. The behaviour of the soils differ significantly from those observed for estuarine muds, floc size and settling velocity increases with suspended sediment concentration, where as the soils tested did not.