Erosion instability of a sediment in a two-dimensional set-up

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We study experimentally the destabilization of a sediment layer under the action of a continuous flow. The experimental set-up is essentially two-dimensional, consisting of two glass plates separated by a thin spacing *b* of typically few millimeters (Fig. 1). This set-up allows an easy visualisation and produces a well controlled laminar flow, with a analytically known velocity profile [Gondret et al. 1997]. This set-up has already given interesting results in the case of a gas flow over a liquid as the shear is homogeneous in space and time [Gondret and Rabaud 1997, Gondret et al. 1999]. In the present configuration, the particles are monodispersed glass beads ($d = 225 \pm 25$ μm) and are submitted to the action of a constant flow of pure water. The cell can also be inclined of an angle α from the horizontal allowing avalanches at the surface of the sediment layer.

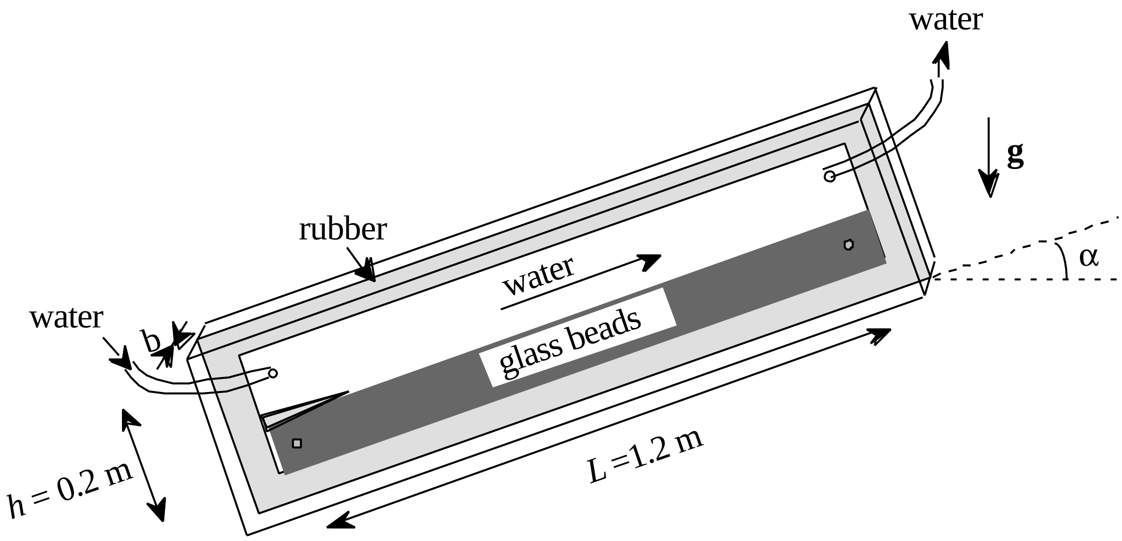

Fig. 1: Experimental set-up.

Varying the flow rate and the inclination angle, different states for the sediment are observed (Fig. 2). At low angles and low flow rate, the sediment is solid. At angles higher than typically 30° and low flow rates, avalanches are observed. Note that the inclination angle at which start the avalanches increases slightly with the flow rate. At low inclination angles and sufficiently high flow rate, an erosion process occurs, thereby leading to the formation of structures such as ripples and dunes (Fig. 3), with a wavelength that increases in time from typically 3 cm at the early stages of formation. However the set-up does not allow a permanent state as no particles are introduced at the begining of the cell. Permanent states can be observed by inclining the cell of a positive angle above 30°: for a particular flow rate, the transport of particles by downward avalanches compensates exactly the one by sandwaves, and roll waves very similar to breaking (plunging) waves are observed (Fig. 4).

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P. Gondret, P. Ern, L. Meignin and M. Rabaud, 1999, Experimental evidence of a non-linear transition from convective to absolute instability, *Phys. Rev. Lett.* **82**, 1442-1445.

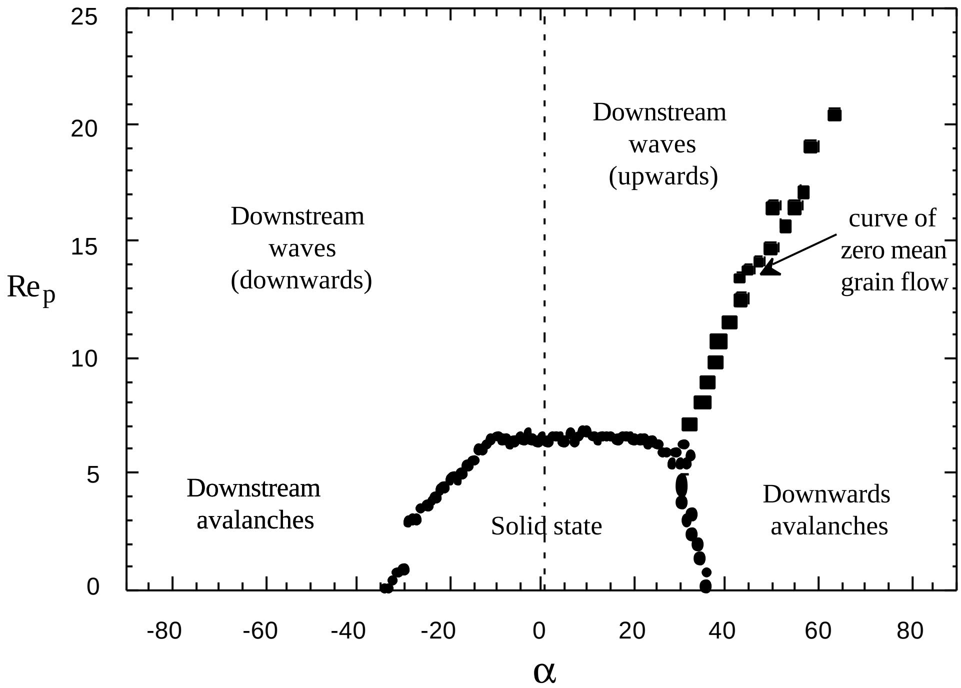

Fig. 2: Phase diagram of the observed sediment layer in the plane of the particle Reynolds number Re_p and inclination angle α of the cell. (Re_p is based on the fluid velocity and the particle diameter).

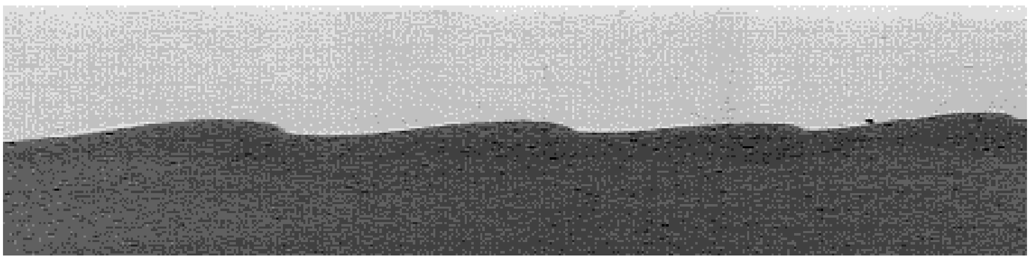

Fig. 3: Video image (15cm long) of the sediment surface for a low inclination angle (α = 0°) and moderate flow rate (Re_p = 7).

Fig. 4: Video image (15cm long) of the sediment surface for a high inclination angle (α = 50°) and large flow rate (Re_p = 15)