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Acoustic probing and triggering of frictional instability in granular media

X. Jia[a*], S. Wildenberg[a], J. Léopoldès[a], A. Tourin[a], and A. Mangeney[b],

a. Institut Langevin, ESPCI Paris, Université PSL, CNRS
b. Institut de Physique du Globe de Paris, Université de Paris, CNRS

* email : xiaoping.jia@espci.fr

Laboratory studies of granular friction have emerged as a powerful tool for investigating seismic fault slip, including dynamic triggering of earthquakes and landslides. However, the physical origin of triggering by seismic waves still remains a challenging issue. The emerging view owing to advances in granular mechanics is that dynamic perturbation causes elastic softening in sheared granular materials leading to failure, i.e., stick-slip or unjamming transition by the acoustic fluidization [1]. Here we will describe two related experiments on the vibration-induced unjamming in granular media.

Firstly, we will discuss a "quicksand" experiment where a remote ultrasonic probing is used to track the motion of a ball sinking in a dense granular suspension under horizontal vibration (100 Hz) until to a maximum depth of penetration (Fig. 1a). This work allows us to shed new light on soil liquefaction, showing that the loss of mechanical resistance (or shear strength) may be caused by the acoustic lubrication of grain contacts via micro-slips (without macroscopic rearrangements), rather than by the pore pressure increase [2].

Secondly, we will show that this mechanism of acoustic lubrication can also explain the triggering of granular flows of thin dry layers below the avalanche angle by nanometer-amplitude ultrasound (100 kHz) (Fig. 1b). As a function of the distance of the slope to the avalanche angle (failure), two distinct regimes have been observed, i.e. an intermittent creep flow or continuous inertial one, due to the ultrasound-induced reduction of the interparticle friction and accordingly of the shear strength of layers [3]. This lab observation of subcritical bifurcation behavior helps to better understand landslides or rockfalls triggered by seismicity, e.g., in the crater of the Piton de la Fournaise volcano (Fig. 1c) [4].

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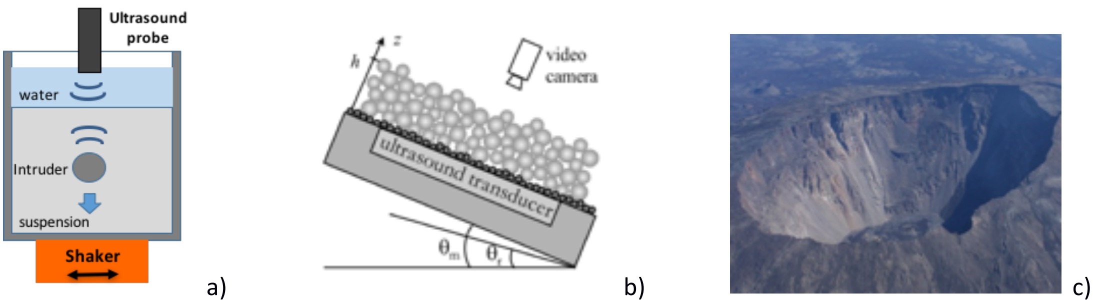

Figure 1 : (a) A steel ball sinks in a dense glass bead packing saturated by water under horizontal vibration. (b) A granular layer composed of glass beads (~ 300 µm) are deposited on an ultrasonic transducer. The angles of avalanche and repose are denoted by θ_m and θ_r. (c) Dolomieu Crater in the Piton de la Fournaise (La Réunion).