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Influence of 3-D geometry on slope stability and slope-failure dynamic illustrated by physical experiments involving pore-fluid overpressure and quasi-3D analytical models

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Submarine slope failure occurs in many different environments all over the world. Determination of the risk posed by these mass movements requires detailed analyses (mapping, sampling, laboratory testing and two or three dimensional numerical modeling) of sea-floor stability. However, such extensive analyses are not always possible and simplified analyses that encapsulate the basic physics behind mass movements are needed for rapidly assessing sea-floor stability. Such rapid estimate can be obtained using 1-D infinite slope analysis, based only on the balance of forces acting on a slope- parallel plane. The limitations of this kind of analysis are (1) that it evaluates the potential for slope failure along a plane that is parallel to the slope surface and (2) that it does not account for the finite size of the slope instability. Yet, recent statistical analyses on numerous submarine landslide data support the idea that many submarine slides share similar characteristics. For example, there are some correlations between parameters such as the instability's slope angle, length and width.

In order to depict the influences of 3-D geometry and pore-fluid pressure on mass stability, we have carried out a series of analogue experiments using a relative new technique consisting in injecting compressed air in sandbox models to trigger their gravity-controlled deformation. This technique allows us to create slope instabilities of any chosen size and shape by controlling fluid overpressure at any point in the model.

We compare our experimental results with predictions of a quasi-3D analytical model

of slide we have developed.

In contrast with what an infinite slope model would predict, our model indicates that the onset of sliding depends on (1) the fluid overpressure along the detachment but also within the sliding sheet itself, and (2) the shape of the detachment (height, length, width ratios) owing to frictional resistance at the toe and along the lateral edges of the slide. Physical experiments also show that the 3-D geometry of slide's boundaries controls the dynamics of gliding.