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Tectonic and gravity extensional collapses in over-pressured Coulomb wedges by limit analysis, with application to the active margin off Antofagasta (Northern Chile)

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Two modes of extensional collapse are examined by analytical means in a cohesive and frictional wedge of arbitrary topography and resting on an inclined weak décollement. The first mode consists of the gravitational collapse by the action of a normal fault and its conjugate shear plane bounding a half graben, rooting on the décollement and completed by the seaward sliding of the frontal part of the wedge. The second mode results from the tectonics extension at the back wall with a similar half graben kinematics and the landwards sliding of the rear part of the wedge. The predictions of the maximum strength theorem (MST), part of the kinematic approach of limit analysis, not only match exactly the solutions of the critical Coulomb wedge (CCW) theory in the extensional context, but generalises them in several aspects : wedge of finite size, composed of cohesive material, arbitrary topography, pre-existing faults. These additional features allow us to determine the exact failure geometry of the body. We show in particular that the MST predicts the effect of a uniform cohesion on the slope required to trigger gravitational collapse in a physical experiment. Applying the theory to the second type of extension, the theory correctly predicts the stability condition, and the succession of failure geometries observed during the evolution towards crit- icality of an initially super-critical extensional wedge. Application to the active margin off Antofagasta in Northern Chile allows us to draw quantitative bounds on the pore pressures and cohesion compatible with gravitational collapse. The above results predict the onset of failure. Sequential limit analysis consists in following the evolution of deformation by performing an incremental step of deformation, based on the current failure geometry, and repeating application of the MST. Application to Northern Chile offers a prediction of the sequence of activation of the normal faults, the topography, and the seaward advance of the wedge tip in a quasi-static mode. We show that this evolution is controlled by the history of fluid over-pressure, the material cohesion, and the frictional weakening at normal faults.