Pre-existing Zones of Weakness: An Experimental Study of Their Influence on the Development of Extensional Faults

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We use scaled experimental (analog) models to investigate how the properties of pre-existing zones of weakness influence deformation patterns during extension. In the models, a homogeneous layer of wet clay (simulating brittle rock) undergoes two phases of extension whose directions differ by 45°. To vary the properties of the first-phase fault fabric, we vary the magnitude of the first-phase extension. Specifically, as the extension magnitude increases, the number, average length, and average displacement of the first-phase normal faults increase. Deformation during the second phase of extension depends on the properties of the first-phase fault fabric (and, thus, on the magnitude of the first-phase extension). For a poorly developed pre-existing fault fabric, new normal faults (which strike perpendicular to the second-phase extension direction) accommodate most of the extension during the second phase. For a well-developed pre-existing fault fabric, many of the first-phase normal faults are reactivated as oblique-slip faults during the second phase of extension. New normal faults also form. These second-phase normal faults are shorter and more likely to strike obliquely to the second-phase extension direction. They are also less likely to cut pre-existing faults than the second-phase normal faults that form in models with a poorly developed fabric. In all models, the pre-existing faults act as nucleation sites for the second-phase normal faults. In models with a well-developed fabric, however, the pre-existing faults also act as obstacles to the lateral and vertical propagation of the second-phase normal faults. We classify the faults patterns as first-phase dominant, second-phase dominant, or neither phase dominant, depending on which fault population (if any) controls the final deformation pattern. The relative magnitude of extension during the two phases of deformation determines the dominance of a particular fault population. Intersecting fault patterns result when first-phase faults are dominant, parallel fault patterns result when second-phase faults are dominant, and zigzag fault patterns result when neither the first-phase nor the second-phase faults are dominant. These fault patterns are common in many extensional basins (e.g., the Jeanne d'Arc basin of eastern Canada, the Suez rift of Egypt, the Pattani basin of Thailand), and likely reflect the influence of a pre-existing fabric.