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3-D Analog Modeling of Cover Deformation Associated with Extensional Reactivation of a Variable Displacement Basement Fault

Scaled 3-D analog models have been used to study deformation patterns in cover sediments resulting from the extensional reactivation of a variable displacement basement fault. Displacement on the basement fault decreased to zero at the fault tips, simulating a pseudo-elliptical displacement profile. In particular, the development of fault-related folds has been investigated in 3-D. The experiments were scaled such that fault displacement and relative cover thicknesses were consistent with natural rift fault systems such as the Gulf of Suez – Red Sea rift. These fault systems are closely associated with extensional fault related folds.

Deformation was recorded and analysed in plan view using digital photography. Layered dry quartz sand was used to simulate homogeneous cover sediments above the pre-existing basement fault. Fault slip produced a transverse hangingwall syncline containing secondary faults trending parallel to the master fault. Deformation intensity decreased along strike away from the region of maximum displacement on the master fault. Subsequent models incorporated more complex cover sequences. Mechanically weak layers were introduced to simulate ductile units such as shales or evaporites, with stronger layers being used to simulate competent thick limestone and sandstone units. Ductile units promoted longitudinal extensional fault-propagation folds whilst more competent layers focused faulting and fracturing.

Serial sections displayed vertical and along-strike variations in deformation and highlight the 3-D nature of variable displacement fault systems. The models provide an insight into the geometries and kinematics of naturally occurring structures in 4D, providing a template for interpretation.