Development of Fractures in Multilayers of Contrasting Strength and Ductility

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The effect of mean ductility, interlayer thickness, and magnitude of shortening on fracture development in bedded rock was investigated by shortening multilayer cylinders (5 cm dia.) 4 to 14% normal to layering at 5, 25, 50 and 100 MPa confining pressures in a triaxial apparatus. Multilayers were constructed by stacking two 1.4-cm thick layers of Berea sandstone (relatively strong and brittle) with interlayers of Indiana limestone (relatively weak and ductile). Sandstone layers fracture at all conditions. Fractures have preferred orientation symmetric to the cylinder axis, and display systematic spacing. At the lowest Pc and mean ductility, fractures in the sandstone are dominantly opening mode (joints) and oriented at high angles to layer boundaries. At greater Pc and mean ductility, fractures are dominantly shear mode (faults) and display conjugate geometry. Fractures propagate from the sandstone into the limestone and may link across the limestone interlayer as shortening is increased. Linkage is enhanced with decreasing mean ductility and interlayer thickness, and increasing shortening. At high mean ductility, fractures are confined to the sandstone layers. Fracture mode and orientation are consistent with Mohr-Coulomb failure, and a spatially heterogeneous stress state where the most tensile stress occurs in the sandstone. Fracture spacing depends on layer and interlayer thickness, mean ductility and ductility contrast, and magnitude of shortening.