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3-D Finite Amplitude Folding

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We conduct 3-D numerical experiments on the viscous folding instability in order to study the growth in amplitude of an initially horizontal layer as a function of viscosity contrast and compression directions. Fold axes form perpendicular to the main compression direction, even if the strain rate in this direction is only a few percentages larger then the strain rate in the other directions. Comparison of analytical and numerical growth rates shows an excellent agreement at small initial amplitudes. At large amplitudes, linear theory breaks down and layer parallel stretching dominates the folding instability. We derive a new analytical theory that correctly predicts the amplitude development of 3-D folds up to finite amplitudes. Simulations with initial random perturbation on an otherwise horizontal layer show that the patterns of finite amplitude folds are relatively insensitive to the overall compression directions. Finally it is demonstrated that the folding instability reduces the differential stress of the strong layer. The Christmas-tree way of visualizing the strength of a compressed lithosphere is thus invalid if a folding instability (of for example the mantle lithosphere) occurs.