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Rheological Behavior in Decollement Folding: Appalachian Plateau

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In a pioneering study Sherwin (1972, ms) modeled decollement folding for subregions of the Appalachian Plateau, one centered on the Fir Tree Point Anticline, NY. Here, mean fold span ≈ dominant wavelength L_d ≈ 11.2 km, and stiff layer thickness H ≈ 2.2 – 2.4 km, yield L_d/H ≈ 4.6 to 5.2. Decollement occurs within a weak layer with thickness H_1 ≈ 0.8 to 0.5 km, or T = H_1/H = 0.4 to 0.2. A satisfactory 3-layer isotropic viscous model satisfied criteria: (i) mechanical layers consistent with lithology in stratigraphic section; (ii) high deformation within observed interval, with negligible structural relief below; (iii) proper L_d/H; and (iv) viscosity ratio 1/R = η_1/ηgot too large (≤ 150). Models satisfying (i) – (iv) were found for viscous layers, with neglect of gravity, but yielded maximum relative rates of amplification q_d ≈ 5; for observed 10% layer-parallel shortening, amplification of 10 – 100 requires q_d = 23 – 46. (ii) implies a 2-layer model is adequate; for this, with power-law stiff layer (stress exponent n), Schmalholz et al. (2002) verified that gravity could be neglected for such decollement folding and likewise felt modest values of q_d were acceptable. They obtained approximations: $L_d/H \cong \pi\theta^{-(1/6)}, \theta = n\left(\eta_1/\bar{\eta}\right)/\left(H_1/H\right)^3, q_d\left[2\pi\left(H/L_d\right)\right]^2 \cong 2n$. A fit for larger q_d requires n ≈ 10 and 1/R ≈ 1000. Replacement of the welded base by a weak surface permits reduction in 1/R by a factor of 4; if, alternatively, the weak layer is anisotropic, the above results for a welded interface remain valid if η_1 is identified with the viscosity in layer-parallel shear, η_S. Arguing from an estimate of layer-parallel shear to shortening viscosity ≈ 0.03 (Chapple & Spang, 1974) allows a reduction in 1/R by a factor of 6. Other issues in estimation of rheological behavior and its uniqueness will be discussed based chiefly on this example.