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Fold morphologies and effective mechanical properties in 3D

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Folds are ubiquitous in shortened layered materials. While theoretical predictions infer that cylindrical folding is the predominant mode, natural examples usually show more complex geometries. We numerically study the process of finite amplitude viscous folding in a variety of settings: different partitioning of the two shortening rates and superposed simple shear, mimicking natural systems such as orogenies and wrench folding. The numerical model has to be large in order to isolate potential boundary effects to small parts of the domain, avoid numerical inaccuracies, allow for interactions between many folds, and to obtain realistic fold morphologies. We therefore specifically developed an unstructured-grid finite element code that is capable of efficiently solving Stokes flow problems in 3D at high resolution over large strains. All necessary code components are written in MPI for parallel processing. The employed iterative solver renders it possible to solve for incompressible flow fields directly, thus avoiding costly Uzawa iterations. Our results illustrate the large strain evolution of the fold morphologies in the various settings and show how several generations of folds interact. In order to better understand the development of the folding instability and its further evolution over large strain we investigate the average stress response of the studied system and quantify it in terms of effective mechanical anisotropy.