Diagnosing the style of deformation in analog models: An example exploring the development of the Pakistani Fold-and-Thrust Belts.

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The recent proliferation of techniques that allow for the precise determination of analog model kinematics has greatly improved our ability to understand the exact nature of deformation occurring in them. These techniques, which include both Eulerian and Lagrangian methods, can determine a robust vector field of velocities (or displacements) that elucidate the kinematics of a model over a prescribed interval of time or displacement. The style and orientation of deformation, however, cannot be easily visualized by simply evaluating the velocity field or the scalar magnitudes of deformation. While, cumulative strain within a model can be determined by mapping the shape change of an initially regular reference grid, such measurements do not yield high-resolution information about the time varying change in deformation style that may occur over smaller intervals. In analog models, as in nature, the style of deformation will evolve along with changing boundary conditions and the variation of topography. To more fully describe the evolution and activity on such resultant structural features requires the determination of the full deformation tensor and its associated principal values, at numerous discrete stages. In this way, we can quantitatively investigate the influence of evolving model parameters on shortening directions and compare this to natural data indicative of shorter intervals of deformation (e.g., earthquakes P and T axes). And contrast to long-term shortening (or extension) directions indicated by geologic derived shortening data. Premised a conceptually simple gridding algorithm, I determine the full finite deformation tensor field and associated principal values from a surface velocity field at stages while the model evolves. In Pakistan, one of the key questions is how the lobate fold-and-thrust belts of the Sulaiman formed in relationship to the major modern tectonic features (e.g., Chaman Fault Zone) and/or basement structures. We revisit a series of models, including one in which the crust below the Katawaz Basin has migrated over time, that explore the development of these fold-and-thrust belts. We compare the results of these models, in terms of changes in the locus, magnitude and orientation of maximum shortening directions, within the series of models and to numerical and, of course, available geological and geophysical data.