Do foliation refraction patterns around buckle folds represent finite strain?

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Axial plane foliation associated with geological folds may exhibit a divergent or convergent fan. To test the hypothesis that the foliation orientation coincides with the major principal finite strain, numerical finite-element (FE) simulations of single-layer buckle folding are performed (Figure 1; Frehner & Exner, subm.). Four different strain measures are considered: (1) finite strain (recording the entire strain history), (2) infinitesimal strain (current strain), (3) incremental strain (recording the strain history from a certain shortening value until the end of a simulation), and (4) initially layer-perpendicular passive marker lines.

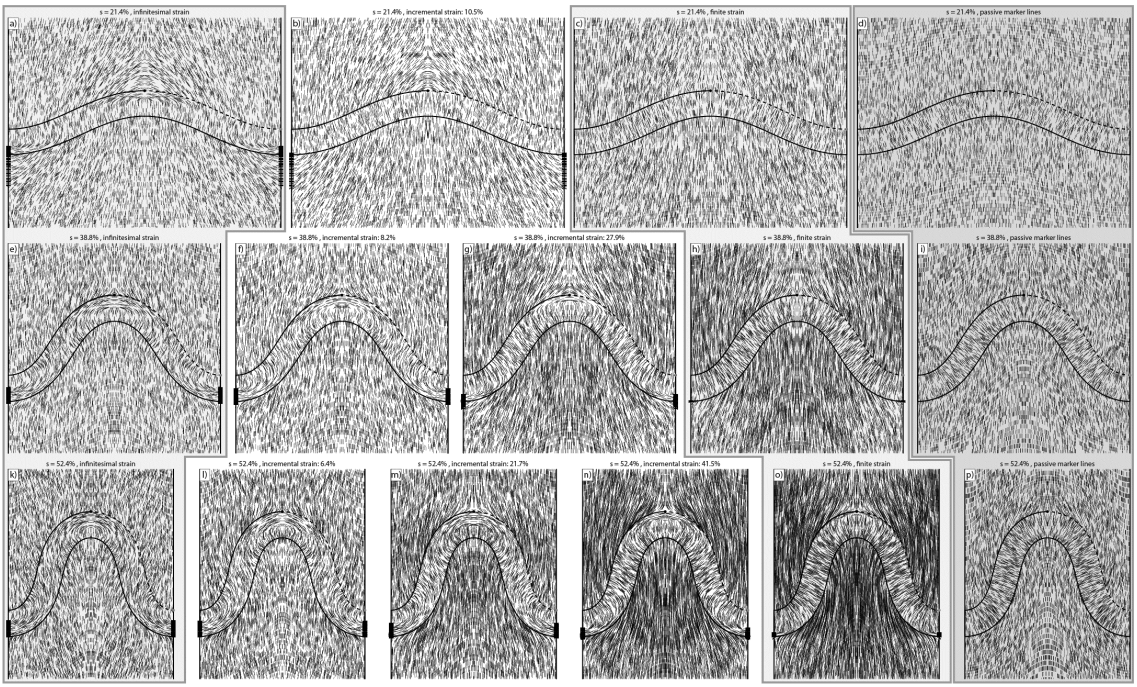

Figure 1: Snapshots of a FE simulation of a single-layer buckle fold with a viscosity ratio of 100 between the folding layer and the surrounding matrix. Top to bottom represents increasing shortening. Lines represent the orientation and magnitude (indicated by line length) of the major principal strain for the infinitesimal (a, e, and k), finite (c, h, and o) and incremental strain measures (b, f, g, l, m, and n). The amount of strain recorded by the later strain measure is indicated above the respective snapshots. d), i) and p) show the orientation of initially vertical passive marker lines.

Since all strain measures result in similar divergent fan patterns in the matrix at the outer arc of the fold (Figure 2), these patterns do not necessarily reflect the finite strain. In the stronger layer differences of the convergent fans between the different strain measures are identified. The main difference is associated with a 90° major principal strain rotation from a layer-perpendicular to a layer-parallel

orientation at the outer arc, which was also observed in one of the studied natural folds (Figure 3). However, because in natural folds a bedding-parallel foliation is challenging to identify as it may coincide with sedimentary structures, also the convergent foliation fan pattern in natural folds is not very well suited for strain estimates.

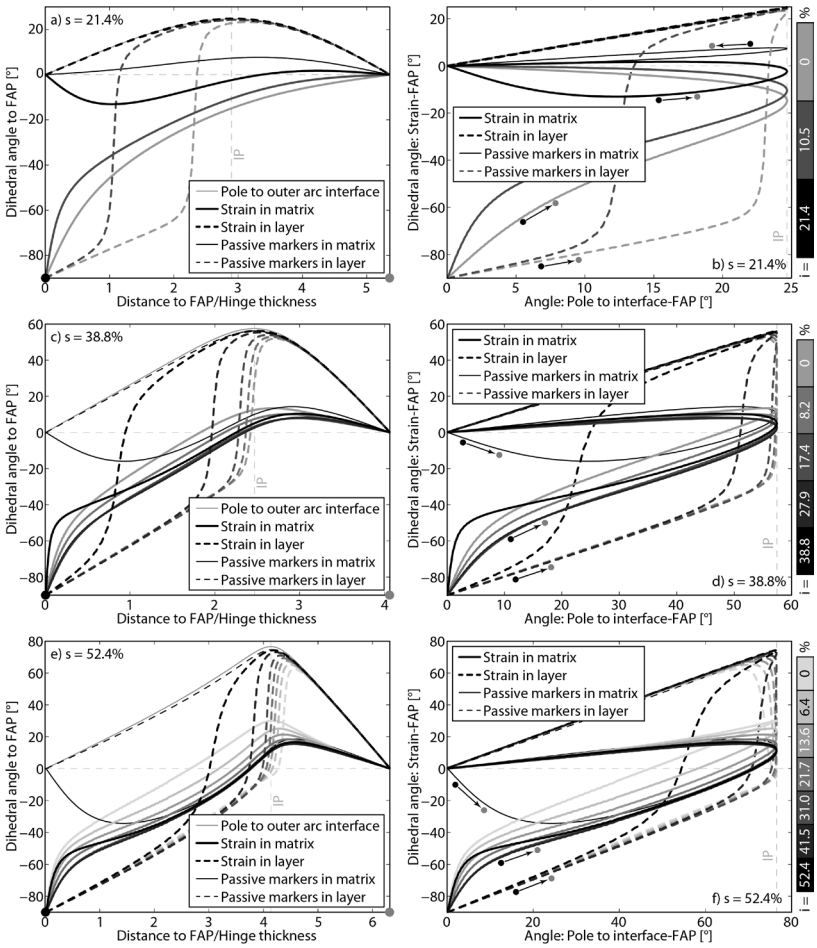

Figure 2. Strain and fold interface orientation data for the simulation in Figure 1. Line gray levels represent different strain measures (black: finite strain, lightest gray: infinitesimal strain, intermediate gray: different incremental strains). Positive values indicate a convergent fan; negative values a divergent fan. IP: Inflection point. a), c), e) Angle between major principal strains and fold axial plane (FAP) plotted versus normalized distance from FAP. b), d), f) Angle between major principal strains and FAP plotted versus angle between pole to fold interface and FAP. Arrows indicate the direction from antiform to synform.

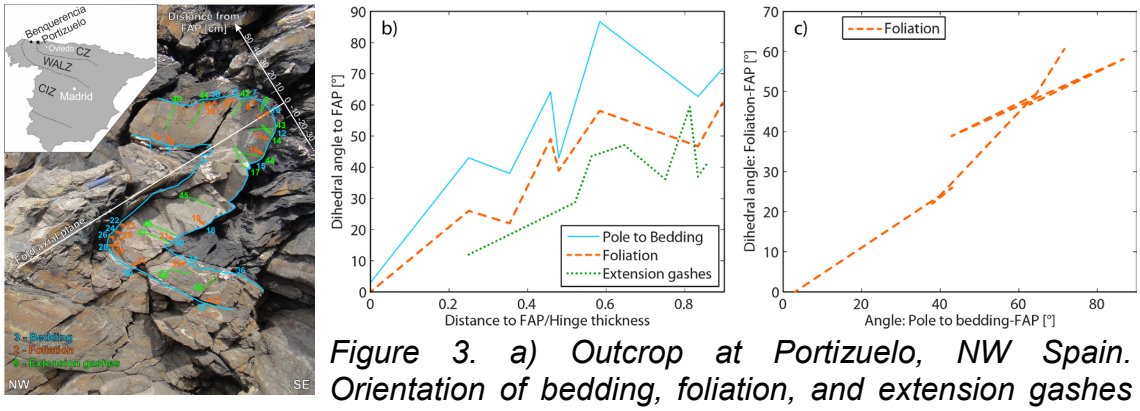

Figure 3. a) Outcrop at Portizuelo, NW Spain. Orientation of bedding, foliation, and extension gashes (b and c) were measured at the positions indicated by numbers in a) within the sandstone and plotted in the same way (b and c) as in Figure 2.

REFERENCE

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