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The integrated stress-strain analysis of calcite twins: Consistent stress and strain determined from natural data

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Stress and strain are different physical entities. Do the stress and strain determined from *e*-twins in a sample of polycrystalline calcite have similar principal orientations and similar shape ratios? Köpping et al. (2019) tackled this question by applying Turner's (1953) classical method of paleostress analysis to natural data. However, despite the assumption of the method, the orientations of P- and T-axes of an *e*-twin lamella do not have a one-to-one correspondence with the principal orientations of the stress that formed the lamella. And, the method cannot determine a shape ratio. Another difficulty arises when one tackles the question: Natural calcite has usually been subjected to polyphase tectonics with different stress conditions. One has to separate stresses and to evaluate corresponding strains from a sample. Once lamellae are grouped according to the stresses, the strain achieved by the formation of a group of twin lamellae is easily evaluated by the method of Conel (1962) if the total strain represented by a group is small.

The present authors tackled the question by combining Conel's strain analysis method with a novel method of paleostress analysis of mechanical twins, which clusters the directional data of *e* -twins by means of a statistical mixture model and determines stresses for each group of data. And, the appropriate number of stresses is determined by means of Bayesian information criterion. The method also determines the probabilities of each lamella to be formed by the stresses, which are called the memberships of the lamella. The strain achieved under a stress condition can be computed using the memberships. We applied this integrated stress-strain analysis method to Data Sets I and II from two calcite veins in a Miocene forearc basin deposit in central Japan. Since the sampling area was close to a triple-trench junction, the young formation has experienced polyphase tectonics.

As a result, we obtained the consistent stress and strains from both of the data sets. Three stresses were obtained from Data Set I, and the corresponding strains were 0.17, 0.25 and 0.13%. Two stresses were obtained from Data Set II, and the strains were 0.39 and 0.42%. The stress and strain determined from the data sets for each deformation phase were consistent with each other. That is, the principal axes had difference as small as < 20 degrees, and the shape ratios of stress and strain had also similar values. It is not straightforward to generalize this result, but both the stress and strain analyses seem to give appropriate results, providing that polyphase

deformations are coped with.