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Solving the simultaneous equations of stress, temperature, depth, and critical resolved shear stress using calcite *e*-twin data

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The paleostress analysis of calcite *e*-twin data determines deviatoric stress tensor, $\mathbf{T}$, normalized by the critical resolved shear stress, τ_c, which depends on grain size, temperature and strain (Lacombe, 2010). The normalized tensor, $\mathbf{T}/\tau_c$, has the information of the orientations of stress axes, stress ratio, and the normalized differential stress, $\Delta\sigma/\tau_c$. It is known that mechanical twinning occurs on an *e*-plane if the resolved shear stress, τ, along the gliding direction of the plane exceeds τ_c. Based on this twinning condition, the author devised an inversion scheme using a statistical mixture model to separate normalized deviatoric stress tensors from heterogeneous *e*-twin data (another presentation in this session by the author).

It is shown in this presentation that a system of equations of normalized deviatoric stress tensors, temperatures, depths and τ_c values can be formulated. Combining the equations and the experimentally estimated temperature-τ_c-strain relationships (e.g., Lacombe, 2010), all the values are roughly estimated simultaneously. Contrarily, this technique allows us to constrain τ_c values from natural *e*-twin data from borehole cores.

The present technique was applied to a natural data set from a calcite vein sampled at the surface in a Miocene graben in the SW Japan arc. It is known that the area has experienced three tectonic phases: (1) multi-directional extension in the Early to early Middle Miocene, (2) arc-perpendicular compression in the Late Miocene, and (3) arc-parallel compression in the Quaternary. Since the twin density of the sample was low, the effect of strain was approximated to be zero. As a result, the two sets of solutions were obtained from the data. Both the stresses had similar $\Delta\sigma$ values at $\sim$25 MPa, but showed different depths and temperatures at the times of twinning: The extensional and compressional stressed showed 70 and 40 °C and 1.9 and 0.9 km, respectively. These stresses were consistent with the deformations in the first and second tectonic phases, suggesting that the area was uplifted by $\sim$1 km in the Late Miocene and $\sim$0.9 km in the Quaternary.