Deformation geometry due to the activation of multiple sets of faults with different orientations in the Sambagawa schist

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Assuming that deformation caused by multiple sets of faults in the brittle region of the Earth crust is homogeneous, its geometry can be deduced from combining the activity of each fault. Using the theory of infinitesimal strain, the combined deformation is just the summation of each of the displacement gradient caused by individual faulting. The method is the same as that to calculate the combined deformation in crystals caused by operation of different slip systems (e.g. Groshong, 1972; Takeshita, 1996, J. of GSJ).

The senior author, Mr. Mori has developed a routine to calculate the geometry of combined deformation by multiple faulting, using the fault data set obtained in fields. The necessary fault data for the analysis are the strike and dip of fault, orientation of striation (i.e. rake angle), and displacement and its sense along a fault. First, in the fault coordinate systems, where the pole to fault plane and slip direction are parallel to the z-axis and x-axis, respectively, the displacement gradient tensor of individual faults only has non-zero component, du_x/dz, where du_x/dz=displacement along a fault/width of a fault zone. Although the combined displacement gradient tensor (CDGT) can be calculated by adding all of the individual DGT, the one which is converted to the reference coordinate systems (i.e. geographical coordinate systems) must be added.

The length of the principal axes of the calculated strain ellipsoid (i.e. stretch) and their orientations can be solved as the eigenvalue and eigenvector problem. Further, the kinematic volticity number, which can evaluate the ratio of rigid-body rotation to the total strain (i.e. the ratio of simple to pure shear component), can be also calculated from the CDGT.

We will report the results, which have been obtained for the normal faults developed in the oligoclase-biotite zone of the Sambagawa metamorphic rocks, central Shikoku. In the area, conjugate sets of normal faults develop during exhumation (D2-stage), which strike NE-SW to E-W and dip north, and strike NNW-SSE and dip east, respectively (Takeshita and Yagi, 2004). The analyzed fault data (186 faults) was originally obtained by Yagi (1997MS). Since the striation orientations are measured for only 31 fault data sets (17% of total faults), it is only possible to make the deformation analysis on these faults. Furthermore, the unknown displacement along each fault has been inferred from the obtained relationship between the displacement and width of fault zone for 36 faults. In this way, the deformation analysis has been performed for the 31 fault data sets in the area with the width of 1000m.

As a result of the deformation analysis, the extension, intermediate and shortening principal strains have been calculated to be 0.5, 0 and -0.5%, respectively (i.e. plane strain). Here, the calculated strain is inferred to be much smaller than the real one, because of the limitation of acquisition of fault data. On the other hand, the following orientations have been obtained for the principal strain axes: the elongation axis, N70^{o}W1^o; intermediate axis, N20^{o}E27^o; shortening axis, S18^{o}W63^o (lower-hemisphere projections), which conform to the principal stress directions inferred by Takeshita and Yagi (2004), using the Angelier (1979) method. Although the kinematic volticity number is calculated to be ca. 0.3 for the fault data sets, the real one could be much higher, showing a higher shear strain component with a-top-to-the-WNW sense, because the real faults include much more north-dipping faults than the analyzed faults.

Furthermore, in order to accurately analyze the strain, we calculate the CDGT for 6 faults in an all striped outcrop. The principal strains thus obtained as follow. The elongation strain, 11%; intermediate strain, -3%; shortening strain -8%. Accordingly, the amount of strain caused by D2-normal faulting during exhumation is not so small to be neglected.