Rank-1 connection and kink strengthening of geological structures

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In the field of materials science including crystallography and metallurgy, localized sharp bends in materials, called kink bands, have been investigated by previous studies. In recent years, the strengthening of materials by kink band formation (kink strengthening) has attracted much attention, and next-generation structural materials based on this principle are expected to be developed. In geoscience, they are known as kink folds from microscopic to outcrop scales, and called mega-kinks at geologic belt-plane scales. In geologic cross sections in the forearc fold zone, the method balanced cross section, which approximates the geologic structures to kink folds, has been used. This method is based on the assumptions that (1) deformation is plane strain, (2) the volume change due to deformation is zero and (3) the deformed blocks are parallel, also leading to another one that the kink interface is symmetrically tilted. However, the mathematical validity of these assumptions with symmetric tilting of the kink interface in the balanced cross sections has not been examined. In this presentation, we reconsider these assumptions in balanced cross sections based on a linear algebraic kink formation condition (Rank-1 connection). Rank-1 connection is the deformation compatibility condition (Hadamard’s compatibility) where two regions of different homogeneous deformation maintain continuity without failure. The kink formation under this condition of continuous deformation without fracture results in material strengthening. The kink interface formed by a single slip system with the Rank-1 connection is symmetric tilt. Thus, the assumptions in the creation of the balanced geologic cross section can be reconsidered as the Rank-1 connection, and the geological deformation on the cross section is based on the Rank-1 connection. Furthermore, the existence of Rank-1 connection seen on the geologic map implies a strengthening of the geologic structure and can be viewed as a natural mechanism to counteract crustal deformation.

Keywords: Geological structure, Balanced cross section, Kink folding, Kink strengthening, Rank-1 connection

