STRAIN LOCALIZATION OF SEDIMENTARY ROCKS DURING DUCTILE FOLDING PROCESSES

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Two main types of deformation during folding of rocks have been observed: ductile and brittle. In general, ductile deformation takes place at great depths, where the confining pressure is high and the manifestation of heat is important. On the other hand, brittle deformation occurs at shallow depths, where the confining pressure is low and the temperature is cooler. This paper focuses on the folding mechanics of granular rocks under high confining pressures, particularly, the formation of deformation bands during the folding process. The study is carried out using classical bifurcation theory together with a three-invariant plasticity model in the finite deformation regime.

Ductile deformation is a common folding mechanism. Experiments have shown that various types of rocks fold without breaking when deformed very slowly under high pressures. Moreover, it has been observed that during folding at great depths, significant amount of deformation occurs in a narrow region called deformation band. In order to study these aspects, we develop a basic model for folding of a single-layer of a ductile rock in the framework of nonlinear continuum mechanics.

Rocks are cohesive-frictional materials characterized by inelastic deformations, shear-induced dilatancy, and non-associative plastic flow. Yielding of rocks is pressure-dependent and non-symmetric in the deviatoric stress plane. Thus, a non-associative three-invariant plasticity model is appropriate to describe its mechanical behavior. These features are captured by the Matsuoka-Nakai (MN) yield criterion, a smooth version of the Mohr-Coulomb yield criterion. In this work, we utilize a shifted version of the MN yield criterion in order to capture the cohesive response of rocks.

A return mapping algorithm scheme in principal stress space is used to integrate the stresses over discrete loading increments, as well as to predict the onset of localization during the deformation process [1]. The algorithm is based on a spectral representation of stresses and strains for finite deformation. The analysis of the boundary value problem developed for the folding model is performed with a finite element code. The finite deformation calculation is carried out using a Lagrangian description.

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References
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