Migration of pores as a mechanism of high porosity bands formation in the unconsolidated sedimentary rocks

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Uniaxial compression of poorly lithified rocks leads to the formation of thin layers (or bands, in the two dimensional case) parallel to the compression axis, which are characterized by increased porosity. The standard model of the formation of such bands, as well as deformation bands of other types, associates them with the narrow zones of localization of plastic deformations. In the case of increased porosity, it is assumed that transverse tensile deformations are localized within the band, which cause the band to dilate. Here, the formation of a band of localized deformations is treated as a loss of stability phenomenon. Based on observations, we propose a fundamentally different model of formation of bands possessing increased porocity, according to which the microdefects in sediment packing (pores) rather than the deformations are localized in the narrow zones. The localization of pores, which are initially randomly distributed in the medium, occurs as a result of their migration through the geomaterial. The migration and subsequent localization of pores are driven by a common mechanism, namely, a trend of a system to lower its total energy (small variations in total energy are equal to the increment of free energy minus the work of external forces). Migration of a single pore in a granular sedimentary rock is caused by the force f driving the defect. This force was introduced by J. Eshelby. An important feature of our model is that the formation of an incompact band here does not have a sense of a loss of stability. Quite the contrary, the formation of high porosity bands is treated as a gradual process spread over time. The origination of band systems directly follows from our model itself, without any a priori assumptions postulating the existence of such systems and without any special tuning of the model parameters. Moreover, based on the proposed model, we can predict the high porosity bands to always occur in the form of systems rather than as individual structures. A single band may only be formed when the force resisting the pore motion, fc, is absent. The calculations were conducted for the case of a plane strain in an infinite elastic medium loaded by uniaxial compressive stress. At the initial state, a random spatial distribution of N round pores having a diameter a was specified in some bounded domain Ω. At each iteration for each pore the driving force on a defect, f, was calculated, which is caused by the influence of all other pores. The position of the pore was varied along the direction of the acting force f if $|f| > fc$. The iterative process for the given initial conditions was terminated when the criterion $|f| \leq fc$ had been met for all pores. Our calculations showed that the migration of pores results in the formation of a relatively regular structure composed of quasi parallel linear elements extended along the axis of compression. We associate these formations with the systems of high porosity bands.