Microscale Rock mechanics: Determination with finite strain analyses

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Introduction

Analysis of the mechanics of rock and rock masses play a fundamental role in the crucial risk assessment with respect to destruction of e.g. installations, tunnels, bridge constructions geothermal boreholes and cables. In the field of the applied geoscience the finite strain analysis is an uncommon but powerful tool to quantitatively estimate the amount of deformation of rocks and rock masses under compressive and extensional stress regimes.

Here, we present first results of laboratory compression tests on core samples of limestone and conglomerate according to different matrix types (Fig. 1).

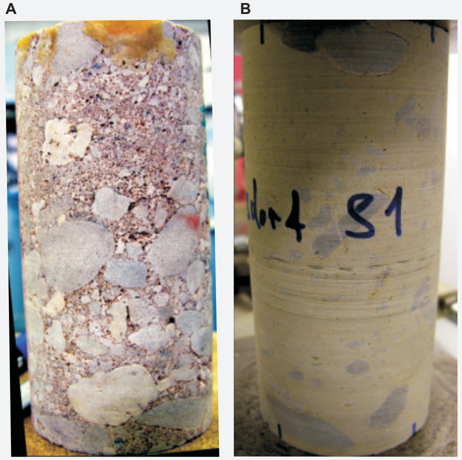


Fig. 1 Core samples before compression tests of a permocarboniferous grain supported conglomerate, calcite cemented (**A**) and a triassic (lower Muschelkalk) matrix supported limestone (**B**).

Methodology I

For geological strain analysis both the Fry-Method and their variations as also the Rf/phi-Method are suitable (e.g. Fry, 1979; Treagus & Treagus, 2002), due to the usually elliptical forms and the regular occurrence of the marker particles.

Due to the fact that most of the marker particles are irregularly shaped and rarely in mechanical contrast to the matrix, the Fry-Method as also the Rf/phi-Method cannot be used for our finite strain analysis. Hence we used the Intercept-Method by Launeau & Robin (1996) on digitized images with identifiable markers in core photographs (Fig. 2A and B).

Methodology II

Corresponding to different overburden pressure the normal load of the experimental setup was increased up to 52 MPa. Following the Intercept-Method (Fig. 2C-E), strain analysis was performed on both cores and on all of the different stress states. With a software-immanent analyses (SPO 2003; Launeau & Robin, 2003) the ellipticity value R and the angle φ were calculated (Fig. 2F).

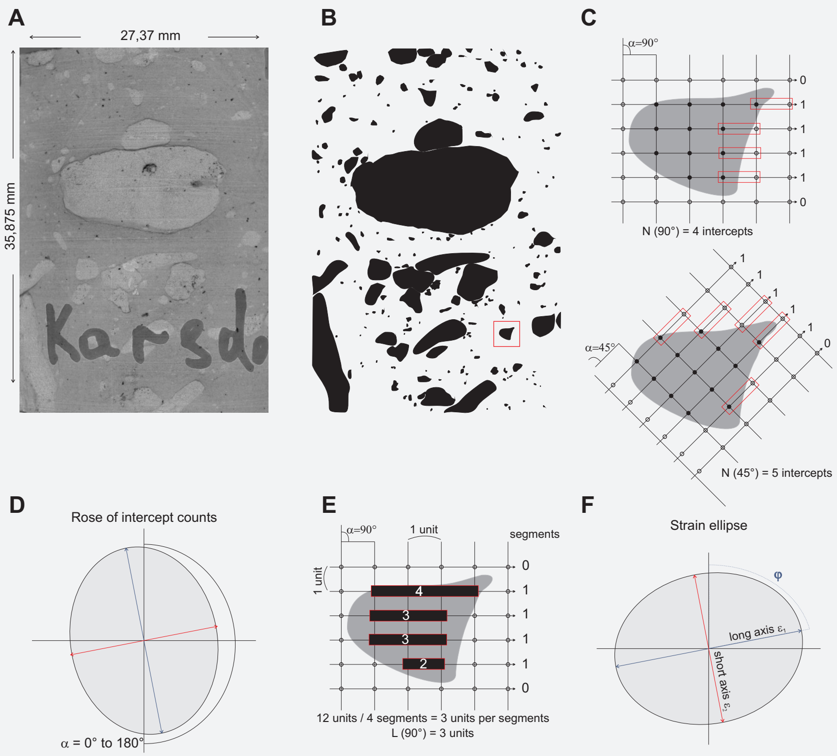


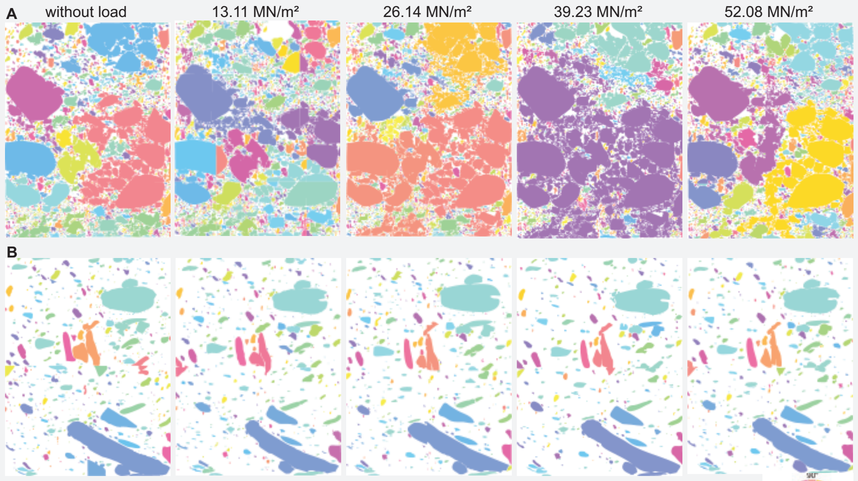
Fig. 2 Detail of a digitized core photograph of a limestone sample with identifiable clasts (**A**). The shape of these clasts were marked (**B**) and uploaded into SPO 2003 (Launeau & Robin, 2003). The software-imanent analysis uses the Intercept-Method (**C**) by counting the number of intercepted segments of objects by a set of parallel lines along a number of several directions (α = 0° - 180°).The number of intercepts is the number of times, a cursor migrating along a line moves out of phase (Launeau & Robin, 1996). The total numer of intercepts N (α) is pictured in a Rose-diagramm (**D**). Counting the number of analysis points falling into the phase (**E**) divided by the number of intercepts, gives the mean intercept length L(α) (Launeau et al., 2010).The ellipticity R (ratio of long axis ε_1 / short axis ε_2) of the strain ellipse (F) is an indicator of the deformation degree of the rocks, while the angle φ represents the orientation of the long axis ε_1 relative to the core axes direction (Förster, 2011).

Conclusion

- Estimation of the deformation of rocks is a useful tool for understanding the mechanics of rocks during load pressure
- The method and the results could be improved by i.a.:
  - Other different lithologies should be used for fabric analysis
  - Strain deformation analysis subdivided for diffent grain sizes
  - Estimation of the different E-Modules and comparsion with the fabric analysis

Results

The strain is quantified as extension or compression and as rotation of the particles. The rotation of the particles under the different stress states of the core samples may be related to straining or shearing of the marker particles (Fig. 3A and B). Ellipticity data (R-values) are an indicator of the deformation grade of the rocks. Normalized to the initial load (R=1) the triassic limestone samples show higher deformation than the conglomerate samples (Fig. 4A and B). This may be a result to the different rock texture of both lithologies (Fig. 1).



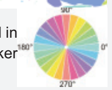
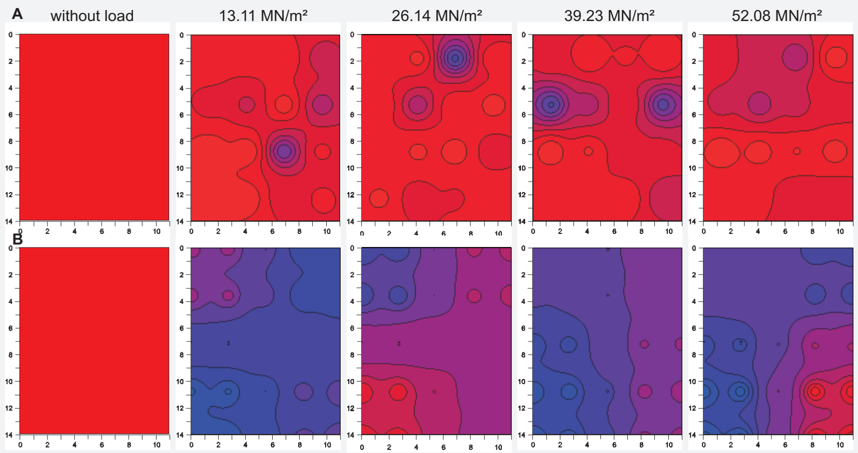


Fig. 3 Rotation of the marker particles under different loads induced in grain supported conglomerates (**A**) and in matrix supported limestones (**B**).The rotation of the particles may be related to straining or shearing of the marker particles. Right box: Color palette for the different degrees of rotation.



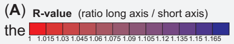


Fig. 4 Normalized R-values under different loads induced in grain supported conglomerates (**A**) and in matrix supported limestones (**B**). Different deformation degrees may be a result of the different rock textures. Right box: Colors for the different degrees of rotation.

References

Fry, N. (1979): Random point distributions and strain measurement in rocks. Tectonophysics 60, 89-105.; *Launeau, P. & Robin, P.-Y.F.* (1996): Fabric analysis using the intercept method. Tectonophysics 267, 91-119.; *Treagus, S. H. & Treagus J.E.* (2002): Studies of strain and rheology of conglomerates. Journal of Structural Geology 24, 1541-1567.; *Launeau, P. & Robin, P.-Y.F.* (2003): SPO 2003 - Shape Preferred Orientation 2003. http://www.sciences.univ-nantes.fr/geol/SPO.; *Förster, A.* (2011): Finite strain analysis in marine landslide sediments. 18. Tagung für Ingenieurgeologie, 16.-19. März 2011, Technische Universität Berlin, 35-42.