EUROENGEO
3RD EUROPEAN REGIONAL CONFERENCE OF IAEG
ATHENS 2020
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Comparison of roughness indices on chalk and sandstone fractures

Marie-Laure Wattier[1], Sara Vandycke[2], Françoise Bergerat[3], Paul Wertz[4], Samir Mohammad[5], Jean-Pierre Tshibangu[1]

[1]UMONS, Belgium, marie-laure.wattier@umons.ac.be
[2]FNRS, UMONS, Belgium, sara.vandycke@umons.ac.be
[3]CNRS, Sorbonne Universités UPMC Univ Paris06, France, francoise.bergerat@sorbonne-universite.fr
[4]SA Carrières Feidt, Luxemburg, pw@stones.lu
[5]UMONS and ULB, Belgium, Samir.Mohammad@ulb.ac.be

The characterisation of roughness on natural rock fractures can be used to assist in the management of rock structures or underground works, but also to refine flow models used in applications such as oil production, water production, or underground fluid injection. The analysis of roughness on natural rock fractures has been widely explored for igneous rocks, but much work is still required to characterize sedimentary rocks, which present a vast range of lithologies and microstructures. In addition, studies often focus on the large scale (rock mass scale, metric or above), while some numerical models may benefit from a deeper understanding of small-scale roughness (centimetric scale or less). This study focuses on small-scale roughness via widely used statistical and fractal parameters. To represent typical hydrocarbons reservoirs or aquifer rocks, a selection of three Cretaceous chalks from the North-West European Basin and one Lias sandstone were studied.

Chalk samples were collected in Harmignies (Belgium), at Cap Blanc-Nez and Arras (France); the Luxemburg sandstone in Ernzen, Luxemburg. UCS and porosity were measured: sandstone (UCS=54MPa, Ø=18%), Obourg formation white chalk (6MPa, Ø=43%), Blanc-Nez chalk (UCS=19MPa, Ø=23%),) Arras chalk (UCS=7MPa, Ø=43%).
Fracture samples were subdivided in 30x30mm square grids, each numerised with a laser device mounted on an X-Y cross-motion table. The resulting surfaces, with Z elevation points measured with +/-30µm accuracy (X-Y steps of 172µm), were processed to issue four classic roughness parameters: Ra (asperities height), Z2 (RMS value), fractal dimensions Dyard (yardstick method) and Dvar (semi-variogram method). A series of lab-generated surfaces were also analysed with the same method. They were produced by fracturing 40x40mm cores by means of either Brasilian tensile test or by shear test. Globally, the results presented are compiled from 3D topographic surface acquisition of about 350 scans.

		Mean Dyard	**Mean Dvar**	**Mean Z2**
Lab-generated	Chalk	1.0064	1.315	0.62
	Sdst	1.0047	1.356	0.34
Natural	Chalk	1.0033	1.277	0.35
	Sdst	1.0080	1.361	0.46

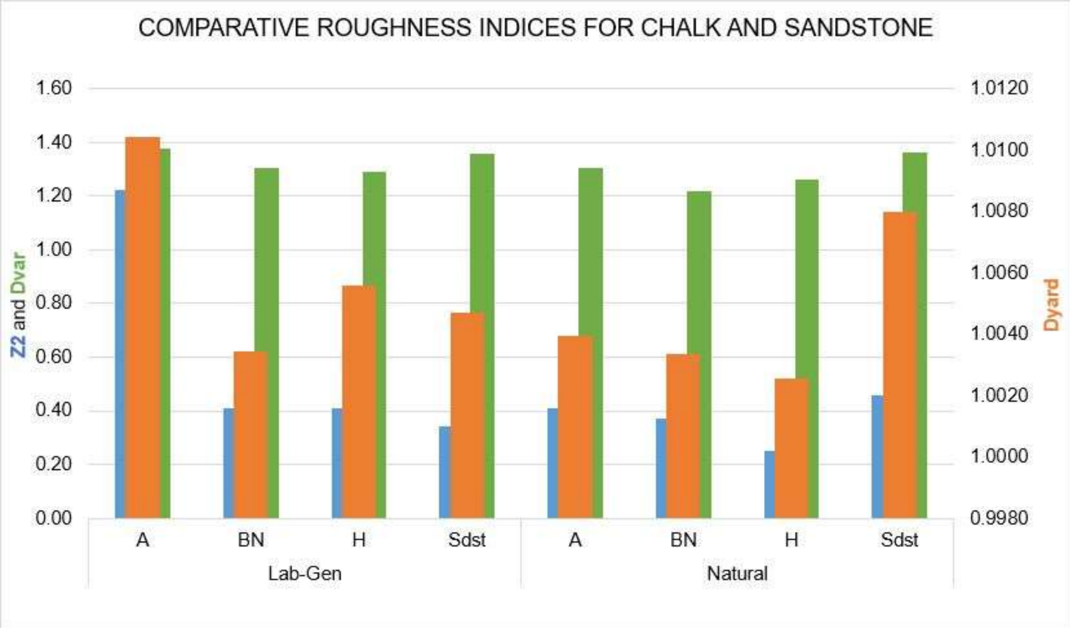

Figure 1- Comparative roughness indices Z2, Dvar and Dyard for three chalks and a sandstone, natural fractures and lab-generated fractures.

Roughness indices are in accordance with samples visual observation. Parameters Z2 and Dyard correlate well, while Dvar seems to express variations. The average asperities height Ra showed inconclusive results. While lab-generated fractures in shear or tensile mode tend to produce rougher surfaces than what is observed in the field on natural fractures, some disparities can be found, notably for the sandstone, for which alteration processes may have enhanced surface roughness over time. Within chalk samples, fault surfaces are rougher than joint surfaces for the chalk samples coming from Cap Blanc-Nez and Harmignies, however for surfaces collected in Arras, joint surfaces are rougher than the very smooth faults.

In conclusion, the same roughness characterisation process was successfully applied with use of fractal dimensions Dvar and Dyard, and statistical Z2 onto two very different lithologies: a sandstone and three chalks issued from different formations. The computations reveal differences, which not only distinguish the clastic, grainy and rougher sandstone from the chalk, but also highlight disparities between the chalks themselves.

REFERENCES

Bandis, S., Lumsden, A., Barton, N., 1983, Fundamentals of rock joint deformation, International Journal of Rock Mechanics, Mining Sciences and geomechanics, Vol 20, Iss 6, pp. 249–268

Belem, T., Homand-Etienne, F., Souley, M., 1997, Fractal analysis of shear joint roughness, International Journal of Rock Mechanics, Mining Sciences, Vol 34, Iss 3–4, pp.130.e1-130.e16

Chen, Y., Liang, W., Lian, H., Yang, J., and Nguyen, V.P., 2017, Experimental study on the effect of fracture geometric characteristics on the permeability in deformable rough-walled fractures, International Journal of Rock Mechanics & Mining Sciences, Vol 98, pp.121-140

Liu, X.G., Zhu, W.C., Yu, Q.L., Chen, Li, 2017, Estimation of the joint roughness coefficient of rock joints by consideration of two-order asperity and its application in double joint shear tests, Engineering Geology, Vol 220, pp.243–255.