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3D CHARACTERIZATION OF CRACK PROPAGATION IN BUILDING STONES
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Abstract

Opening of fractures can strongly modify mechanical characteristics of natural stones and thus significantly decrease stability of historical and modern buildings. It is commonly thought that fractures origin from pre-existing structures of the rocks, such as pores, veins, stylolythes (Meng and Pan, 2007; Yang et al., 2008). The aim of this study is to define relationships between crack formation and textural characteristics in massive carbonate lithologies and to follow the evolution of fractures with loading.

Four well known Spanish building limestones and dolostones have been analysed:
Amarillo Triana (AT): a yellow dolomitic marble, with fissures filled up by calcite and Fe oxides or hydroxides;
Blanco Tranco (BT): a homogeneous white calcitic marble with pore clusters orientated parallel to metamorphic foliation;
Crema Valencia (CV): a pinkish limestone (mudstone), characterized by abundant stilolythes, filled mainly by quartz (80%) and kaolin (11%);
Rojo Cehegin (RC): a red fossiliferous limestone (packstone) with white veins, made up exclusively by calcite in crystals up to 300 micron.
All lithotypes are characterized by homogeneous mineralogical composition (calcitic or dolomitic) and low porosity (<10%).

Three cores 20 mm in diameter have been obtained for each lithotype.
Uniaxial compressive tests have been carried out in order to induce sample fracturing by a series of successive steps with application of a progressive normal stress. Crack propagation has been checked after each stress level application by microCT-RX following Hg impregnation of the sample (in a Hg porosimeter). Combination of both tests (microCT-RX and Hg porosimeter) guarantees a better characterization of small defects and their progressive propagation inside low-porous rocks than by employing solely microCT-RX (Fusi et al., 2009).

Due to the reduced dimensions of sample holder (dilatometers) in porosimeter, cores have been cut with a non standard h/d = 1.5. Several cycles of: a) Hg impregnation with mercury porosimeter, b) scanning with microCT system, c) uniaxial compression, have been performed on each core.

Cores have been firstly impregnated with mercury in Thermo Fisher Scientific Pascal porosimeters 140 and 240, in order to fill up the pores and obtain a good density contrast between rock matrix (2.71 g/cm3 for calcite and 2.86 g/cm3 for dolomite) and voids filled by mercury (13.6 g/cm3). Microporosity coincides with structural features of the rock, such as stylolythes (CV), fissures (AT), clusters of pores (BT) and/or veins (RC).
At the end of each cycle of impregnation-scanning-loading, the cores have been impregnated again in both porosimeters 140 and 240 in order to fill up the new micro cracks and fractures.

Uniaxial compression has been performed with a GDS Vis (Virtual Infinite Stiffness) loading apparatus, in axial displacement control. For each core four to six loading steps have been performed on the basis of the maximum loading obtained in previous uniaxial tests on standard cores of the same lithologies. Once the

maximum load of each step has been achieved, the specimen has been unloaded at the same velocity.

A BIR Actis 130/150 industrial micro CT was used for imaging the interior of the samples (100keV/80mA). The dimensions of the voxel, corresponding to the resolution of the images, are 0.024x0.024x0.027 mm. Core position has been accurately checked in order to maintain the same orientation and numbering of CT slices throughout the cores after different loading cycles.

The main results of this study, clearly imaged by microCT scanning, can be summed up as follows:

- in all the lithotypes (AT, BT, CV and RC) fracture patterns are unrelated to major textural characters of the rock (fig. 1).
- In all the cases, first phases of fracture opening can be seen in CT images but there is not a corresponding load drop in the stress-strain curve.
- For all the samples, fractures begin to open at about 50% or less of the maximum load.

References
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