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Initial development of an NIR strain measurement technique in brittle geo-materials

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Visible-Near Infrared Spectroscopy (VIS-NIR) is a technique developed for the non-contact measurement of compositional characteristics of surfaces. The technique is rapid, sensitive to change in surface topology and has found applications ranging from planetary geology, soil science, pharmacy to materials testing. The technique has also been used in a limited fashion to measure strain changes in rocks and minerals (Ord and Hobbs 1986). However, there have been few quantitative studies linking such changes in material strains (and other rock physics parameters) to the resulting VIS-NIT signature. This research seeks to determine whether improvements in VIS-NIR equipment means that such a technique is a viable method to measure strains in rock via this remote (non-contact) method.

We report new experiments carried out using 40 mm Brazilian Tensile discs of Carrera Marble and Darley Dale Sandstone using an Instron 600LX in the University of Portsmouth Rock Mechanics Laboratory. The tensile test was selected for this experiment as the sample shape and sensor arrangements allow access to a ‘flat’ surface area throughout the test, allowing surface measurements to be continuously taken whilst the discs are strained to failure. An ASD Labspec 5000 with 25 mm foreoptic was used to collect reflectance spectra in the range 350-2500 nm during each tensile test.

Results from Carrera Marble experiments show that reflectance at 2050 nm negatively correlates (by polynomial regression) with axial strain between 0.05-0.5%, with r2 of 0.99. Results from Darley Dale Sandstone data show that reflectance at 1970 nm positively correlates with axial deformation between 0.05-0.5%, with r2 of 0.98. Initial analyses suggests that the VIS-NIR possesses an output that scales in a quantifiable manner with rock strain, and shows promise as a technique for strain measurement. The method has particular application for allowing our laboratory measurements to “ground truth” data taken from drone and other remote sensing techniques that could employ this method. However, further work is underway to understand the exact nature of the correlations – for instance, whether reflectance is related to deformation to the mineral lattice, macro-surface or micro-surface.