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GPR imaging and characterization of fractures in limestone cliffs

J. Deparis (1), S. Garambois (1) and D. Jongmans (1)
(1) LIRIGM, Université Joseph Fourier, Grenoble, France

The growing urbanization in mountains areas leads to an increase of natural risks. Among main natural hazards, rock fall is a sudden and difficult to predict phenomenon. Existing discontinuities play a major role in the stability assessment, which is generally based on surface geological observations and mechanical computations. Their reliability however suffers from the lack of information within the rock mass, particularly about the geometry and the properties of the fractures. Geophysical investigations, and particularly radar measurements, can be performed is such extreme conditions (high cliffs) and are able to provide detailed information with a satisfying compromise between penetration depth and resolution. In this study, we present GPR measurements acquired on cliff walls with different geological contexts and geometries. GPR data were performed at different frequencies and with two acquisition modes (TE & TM), and provide detailed images of the fracture network. Among these measurements, CMP (Common-Mid-Point) acquisitions appear necessary to get the horizontal velocity structure allowing precise time to depth conversions and migration processing. On the contrary, GPR tomography, which was conducted between the cliff wall and the horizontal plateau, yielded too smoothed images for getting valuable information. In one example, the GPR interpretations in terms of locating open fractures were confirmed by borehole measurements and observations after mining. Complementary to the fracture geometry, GPR data were also tentatively used for obtaining quantitative information on fracture properties (filling and aperture). This approach is based on the frequency dependence of radar wave reflectivity, which has been inverted using the neighbourhood algorithm. Preliminary numerical tests show the effectiveness of the method in retrieving fracture properties with different filling materials and aperture values. The potentialities of jointly analysing two GPR acquisition modes (TE & TM) as well as AVO (Amplitude Versus Offset) data deduced from

CMP acquisitions are also studied both numerically and on real data. For all these developments, the influence of the radiation pattern of GPR antennas is tested and discussed.