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The role of subsurface heterogeneities, including lithology and fissures, on the quality of landslides seismic images

G. Grandjean, A. Rochat, and A. Romdhane
BRGM, ARN, Orleans, France (g.grandjean@brgm.fr)

Seismic methods have demonstrated their high capacity for characterizing landslides structures, particularly in the uppermost layers where weathering, fissures or sliding blocks can be observed. Indeed, advances in processing P-wave first arrivals traveltimes or Rayleigh wave dispersion lead to develop new imaging methodologies for producing P-wave (Vp) or S-wave (Vs) distributions in 2D or 3D, and this, even in highly contrasted media providing that heterogeneities' size are larger than the seismic wavelengths.
In the present paper, we show how heterogeneous structures can affect the coherence of the seismic signals in terms of amplitude, frequency or dispersion characteristics. From several random models, geostatistically coherent and representative of what can be encountered in landslide contexts, different velocity fields are synthesized. Several kinds of heterogeneities are taken into account: lateral variations in lithology, increasing roughness of layer's interfaces, and degree of fissuring at the surface. Related seismograms are then numerically computed in the 2D elastic approximation by using a FDTD simulation code, and a parametric study is carried out for trying to understand how the heterogeneity's features impact the seismic wave propagation. The selected seismic parameters, such as amplitude variation with offset, spectral shifting or distortion of the dispersion waves' behavior, are used to compare and classify seismic responses according to the landslide's features. An interpretation is then proposed to synthesize this theoretical approach. In order to validate these results, we finally compare seismic criteria of real data with those obtain from our synthetic cases.
In conclusion, this study brings interesting results for understanding how complex media, such as landslides, can interact with seismic waves and affects the recorded signal properties. Providing that adapted seismic parameters are used, an estimation of the signals perturbation, and thus of the heterogeneity level can be foreseen. Knowing that such information could be extremely important for constraining hydrogeomechanical simulations, we encourage integrating our approach in seismic works dedicated to landslides characterization.