Experimental imaging of a vertical vein using controlled-source seismic interferometry

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Seismic methods are desirably implemented in the imaging of economically viable hard rock mineral deposits, due to the technique's intrinsic higher resolution in comparison to traditionally used geophysical methods. Traditional surface seismic methods are inadequate in the imaging of steeply dipping targets, due to unfavourable geometrical relationships between the surface sources, surface receivers, and the target. There is poor recovery of data when geological features have a dip greater than approximately 65°, as the reflected wave propagates at an angle that reaches the surface outside the aperture of the receiver array or does not reach the surface at all. Steep dips also cause the overall travel path to be much longer than the depth of the target, causing a loss of energy and associated amplitude and high frequency attenuation which results in a low signal to noise ratio and associated processing issues. This study investigates the viability of using vertical seismic profiles (VSP) in combination with seismic interferometry as a new method of imaging thin and nearly vertical veins, and develops techniques for the same, and for which a thin, nearly vertical barite vein at the Collier Point Barite property in eastern Newfoundland serves as a well constrained target for study. Seismic interferometry is a technique in which, a signal pair is cross-correlated to reproduce a virtual source-receiver pair and reconstruct the associated wavefield. These methods can virtually move a source into a downhole location, which avoids the geometric limitations associated with surface-seismic methods. The parameters of the field experiment are optimized using ray-tracing analysis, finite-difference modelling and a study of the physical properties to ensure reflection detectability. The unprocessed dataset is highly contaminated by tube-waves which are removed using spiking deconvolution and F-K filtering. The pre-processed dataset is then subjected to seismic interferometry methods and is processed using standard CMP processing flows. It is noted that the seismic response to the barite target varies significantly through the profile. A 1-D synthetic seismogram modelling program is used to study the variations in the seismic response of the target, and propose a geological interpretation for the same, which is consistent with descriptions in prior geological reports. The study demonstrates that VSP's in combination with the seismic interferometry procedure has proven to be an appropriate tool towards detecting and imaging vertical to near-vertical subsurface bodies of economic importance which may otherwise not be imaged appropriately using surface-seismic methods.

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