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Recovery of body-wave reflections from ambient seismic noise with application to mineral exploration

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Keeping pace with global metal and mineral demand requires the ongoing discovery of new ore-deposits, a task which is becoming increasingly difficult due to exhaustion of easily accessible deposits (i.e. near-surface and close to populated areas). The typical procedure for mineral exploration begins with geophysical surveys (e.g. magnetic, gravity, etc.) followed by a drilling program to investigate potential targets. With drill core samples only providing one-dimensional observations, the many holes required for mapping potential deposits can lead to very high costs. To reduce the amount of drilling, active seismic imaging is sometimes used as an intermediary step in the exploration procedure, however, the active sources (e.g. vibrating trucks or explosive shots) are still expensive and difficult (or impossible) to operate in remote or environmentally sensitive areas. Thus in most cases, the potential reward of this indirect measurement does not justify the financial risk.

In recent years, ambient seismic imaging using large and dense surface geophone arrays has emerged as a novel, low-cost and environmentally sensitive approach for exploring the sub-surface. This technique dispels with active seismic sources by exploiting weak coherencies in the multiply scattered background wavefield through cross-correlation and stacking of waveforms recorded at spatially separated stations. In theory, any sub-surface reflector (dictated by the impedance contrast between ore-body and host rock) will create an arrival in a station-pair's correlation function at a lag time equal to the traveltime of the reflected ray traveling from one station to the other. To enhance these weak arrivals we divide the array into many small sub-arrays and use double beamforming to steer pairs of these sub-arrays towards potential reflectors. The resulting cross-correlation functions (one for each unique sub-array pair) are then used to localize the dominant reflectors through regular cross-correlation beamforming. We evaluate the feasibility of this technique by processing both a synthetic and real dataset to detect and locate known reflectors.