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Hydroseismic Waveform Analyses

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Abstract

We study hydrodynamic research using seismic waveforms excited by earthquakes, man-made, and natural sources in order to understand (1) how crust deforms coseismically, (2) how fluids were formed, migrated, and trapped in the crust, (3) where the crustal fluids are, and what the hydraulic conduits are, and (4) how much fluids are moving, and in what patterns. We informally call this line of research "hydroseimsic waveform analyses". Using aftershock waveforms, we were able to generate very high resolution earthquake catalog. Such a catalog shows seismic lineation very consistent with the location of sub-vertical fault traces, validating the accuracy of the catalog. We then derive crustal hydraulic permeability by studying how the aftershocks diffuse outwards from the mainshock. Secondly, we use high resolution 3D seismic reflection datasets to conduct seismic attribute analyses to infer the fractures and faults, in addition to where the fluids are. We also use a Bottom-Simulation Reflector (BSR) to infer where focused fluid flows are. After that, we jointly interpret the fractures, faults, fluids, and BSR-derived fluid flow patterns to study the hydrogeology of a ridge offshore SW Taiwan. It shows how fluids are migrated from depths to the near surface, and how fractures influence the fluid migration patterns. Thirdly, we have developed methods to convert broadband seismic waveforms into ground tilt time series. We found rapid rain flow can increase the water level of the rivers, causing the nearby ground to tilt due to the additional loading from the water weight. Using minor rainfall event's seismic waveforms and precipitation data, we were able to fit the main event seismic waveforms, and derive the precipitation of the main event. This can potentially allow us to study decadal climate changes using seismic waveforms. We also study the ground tilt induced during the pumping test. Due to the removal of some groundwater, the ground bulges because of the unloading processes, which were recorded as ground tilts also by our seismometers. Such tilt time series allows us to study how shallow crust responds to fluid movements and removal. In the near future, we wish to use seismic waveforms to study the geological processes that occur on the interface of water column and seabed. Hydroseismic waveform analyses allow us to remote sense fluid movements. These techniques are cheaper, cover wider spatial and temporal coverage, and are easier to install compared with tiltmeters or drilling.

Keywords: -