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Seismic Reflection Monitoring of Pore Pressure Variations in the Deep Seismogenic Zone: A Feasibility Study

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4D seismic reflection techniques are rapidly becoming a standard tool for monitoring changes in pore fluids during oil field production. The application of this technology for documenting temporal variations in natural processes at depth is still very preliminary. One process of special interest is the detection of fluids in the seismogenic zone of major subduction boundaries. 3D (and potentially 4D) imaging near the updip limit of the seismogenic zone has already received substantial attention. In this study we use synthetic seismic sections to explore the feasibility of using time lapse techniques to detect variations in pore fluids at depths commensurate with the *lower* limits of interplate seismogenesis, which is where rupture often initiates during large events. Base velocity models for the Shikoku, Japan, and Oaxaca, Mexico, subduction complexes were extracted from published refraction surveys. Synthetic seismograms were computed using acoustic finite difference codes implemented in MATLAB by the CREWES project. The base models were perturbed by velocity variations within the interpolate zone to mimic the effects of pore pressure change and synthetic seismograms recomputed. The "before" and "after" images were then differenced to identify the fluid perturbations. Trials were run with various levels of additive noise. The results demonstrate that the detection of fluid changes at lower crustal depths is limited by noise rather than seismic resolution, and that differencing techniques ("seismic interferometry") can be very sensitive to even subtle variations at depth. These synthetics suggest that monitoring of fluid pressure variations at great depth is a feasible, albeit challenging, goal for controlled source seismology. They also suggest some new techniques for minimizing the noise that can obscure target variations.