

Well-Seismic Bandwidth and Time-Lapse Seismic Characterization: Physical Considerations

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Abstract

Reservoirs are commonly heterogeneous. Injection of CO₂ related to enhanced oil recovery operations may cause strong lateral and depth-dependent changes of heterogeneity both within the reservoir and the surrounding formations. A seismic signal propagating through the reservoir and the surrounding formations before and after CO₂ injection undergoes different velocity dispersion and amplitude attenuation, which result in time shifts and in waveform distortions. This paper discusses the physical aspects of well log integration with seismic and time-lapse seismic characterization based on a thinly layered 1D model. The results show that discrete layering and interval multiple reflections (or scattering) within sedimentary sequences have a significant influence on synthetic seismograms. The multiple scattering of seismic waves within the heterogeneous reservoir and the surrounding rocks may form a long duration vibration or local coda wave. The velocity and density perturbations of the reservoir and the surrounding rocks caused by CO₂ injection will mainly result in the coda wave distortions from near the top of the reservoir to the base reflection below the reservoir. The changes of coda waves carry the information of injected CO₂ saturation and level. Large velocity changes of the reservoir and the surrounding rocks may cause a time sag in the basal reflection below the reservoir as well as later events, which mainly include primary reflection waves. These results have important implications for time-lapse seismic monitoring.