Monitoring and Characterization Based Upon Geophysical Onset Times

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Abstract

Geophysical methods are increasingly called upon to monitor fluid injection and production.

Geophysical monitoring of flow related processes is hampered by difficulties in relating changes in fluid saturation and pressure to observable quantities such as seismic amplitude changes, variations in electric fields, and surface deformation. Problems are particularly acute when relating changes in the amplitudes of observable geophysical quantities to the magnitudes of fluid related changes in a reservoir. In such cases the relationship depends strongly upon the rock physics model that is chosen.

In this talk I present an alternative approach to reservoir monitoring and characterization that is based on the notion of an onset time. An onset time is the calendar time at which a measured quantity begins to deviate from its background or initial value. In many cases involving injection and production, the onset time is related to the arrival of a fluid front or a rapid increase in pressure.

Under the relatively general condition that a change in fluid saturation and/or pressure leads to a change in a geophysical attribute, it can be shown that onset times are sensitive to flow properties, such as permeability, and not sensitivity of the details of the rock physics model. Several examples of the use of onset times for monitoring and characterization will be given, involving both geodetic and seismic observations. One example involves the geodetic monitoring of ground deformation associated with the geological storage of injected carbon dioxide at In Salah, Algeria.

Seismic time-lapse monitoring of injected carbon dioxide at the Frio site in Texas provides yet another example.