Reservoir Monitoring with Continuous Acoustic Measurements

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This paper describes a technique of detecting changes in the subsurface, possibly caused by extraction of oil and gas from reservoirs, by using techniques of phase conjugation of continuous acoustic signals. This technique can equally be applied as an alternative to conventional seismic surveying methods.

The method is based on measurements of the response of the subsurface to continuous acoustic signals at a number of fixed frequencies. Changes in the subsurface will result in changes in amplitude and phase of the returned signal. These changes are all that are required to identify alterations in the subsurface. Without knowledge of the subsurface velocity field, temporal images of the changes can be produced from the superposition of reconstructed continuous signals. If the velocity field is estimated from conventional processing flows, the changes can be imaged in depth by backpropagating the changed signals through the subsurface velocity model. Alternatively, if the changes in the subsurface can be predicted or modelled, the changes in the returned signal can be used to improve the velocity model of the subsurface. Backpropagating the changed response as a continuous signal produces high amplitude intensity in the areas where changes have taken place.

The methodology exploits on lock-in amplifier concepts that detect amplitude and phase of fixed frequency signals against a reference signal. Lock-in amplifier operation can be simulated from digitised data provided that the reference signal phase is also recorded. Lock-in amplifiers can easily reject interfering signals that are 1 million times (120 dB) larger than the signal being measured without using prefilters. Integration of signal can be made over extended periods and monitoring of the signal can be continuous. All this means that the source signal does not have to be of high power, so that it may be compact and fixed in position.