Time Lapse Passive Seismic Emissions and Fracture Images From Microseismic

Charles Sicking[1], Jan Vermilye[1], Alfred Lacazette[1], Pete Geiser[1], and Laird Thompson[1]

[1]Global Microseismic Services

Abstract

Fracture networks consist of all of the fractures in the rock that are interconnected to form transmissive fracture fairways that can carry pressure from the hydraulic fracturing (frac) point to locations that can be great distances from the well. The fairway systems make up the principal long-range permeability pathways of many reservoirs. Microseismic monitoring can be used to directly image the fracture networks that are activated by the pressure changes caused by the frac pumping, by earth tides or by other mechanisms.

Tomographic Fracture Images (TFI™) are computed from microseismic trace data collected using either a surface or a buried array. The field records are processed to show cumulative seismic activity per voxel in successive time windows (Geiser et al, 2006; Dricker et al 2010; Shkarin et al, 2010). No attempt is made to identify individual microseisms. Consequently, the method captures a greater fraction of the available seismic energy than conventional microearthquake-based (MEQ) microseismic methods. More energy is captured for two reasons:

1. Conventional MEQ methods work only with events that are sufficiently large to be distinguished as MEQs and that have distinct, pickable P-wave and S-wave first arrivals. Small MEQs are many orders of magnitude more abundant than large ones. Hence there is more total energy in small, non-pickable events than in the small number of distinguishable large events. TFI captures the energy in both large and many small MEQs.
2. TFI captures the energy of Long-Period, Long-Duration (LPLD) events, which are low-frequency rumbles that can continue for seconds, minutes, or longer and do not have distinct first arrivals. Recent research (Das and Zoback, 2011; Zoback et al, 2012) indicates that LPLDs are probably the most important indicator of hydraulic fracture stimulation. LPLDs cannot be picked as distinct events, and therefore are invisible to conventional MEQ microseismic methods. TFI captures LPLD energy.

In summary, the semblance-based summation methods used for TFI capture a much greater fraction of the seismic energy generated during fracing than conventional MEQ methods, although individual events are not resolved.

In this talk, time-lapse animations and slides are used to show examples of seismic emission activity. Also shown are the TFIs that are computed from seismic emissions. In order to compute the TFIs seismic emissions are combined over long time intervals and the TFIs are computed from the accumulated seismic emission volumes. The examples are drawn from well frac job recordings and from passive recordings made in areas where there has been no drilling.