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# Application of Relative Location Technique from Surface Arrays to Microseismicity Induced by Shale Fracturing

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## Abstract

A matched filter technique that uses cross-correlation and migration of the recorded waveforms has been successfully used to relatively locate microseismic events. In addition to producing consistent relative locations, the matched filter corrects for radiation pattern effects and near-surface structure. The relative locations produced using this methodology were compared with a proprietary, direct location method. The new results produce a solution set that reveals two parallel trends of microseismic events which are interpreted as 1500’ long fracture zones approximately 100’ wide. We observed asymmetric fracture growth and re-fracturing of the previously stimulated zones. Time correspondence of the observed evolution of seismic events with engineering pump curve data reveals approximate linear growth rates of several feet per minute and possible proppant placement along the induced fractures.

**Figure 1: 3D view of the seismic monitoring geometry. Surface vertical geophones were distributed along 10 arms (blue markers). Colored perforation locations represent injection points in the horizontal treatment well. Offset-to-depth ratio approximately 1:1.**

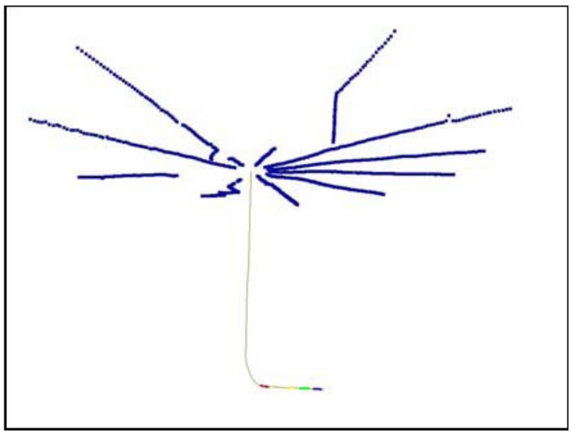
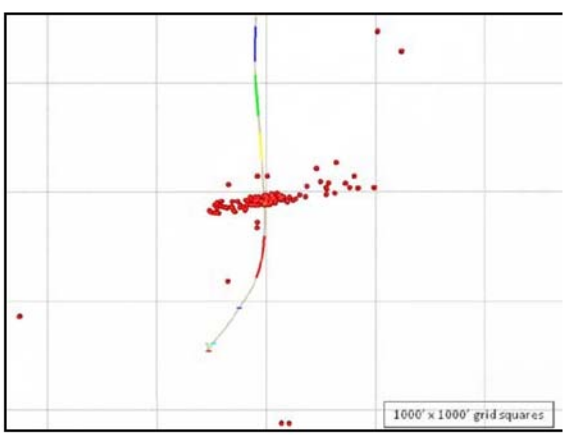


**Figure 2: Map view of the relative locations of the 140 strongest events induced in Stage 5. Some events off of the main trend are "false positives" due to the cross-correlation side lobes.**

**Figure 3: Similar to Figure 2 but with blanking criteria applied to origin times. The 100 strongest (best signal-to-noise ratio) events form a simple trend with an approximate 80° azimuth.**



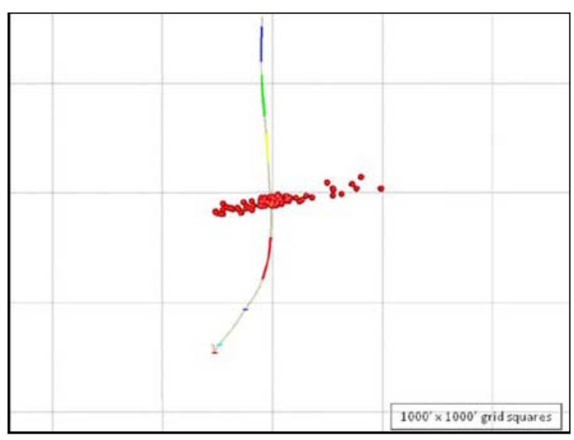
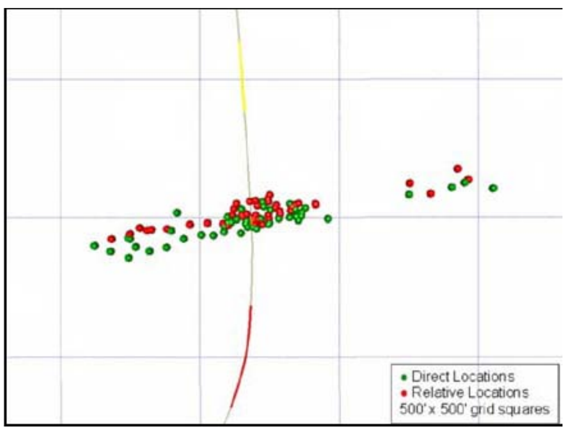



**Figure 4: Map view comparison of relative (red) and absolute/direct locations (green) for the top 46 strongest events of Stage 5. We see excellent agreement between the two methods.**

**Figure 5: Map view comparison of two sets of relative locations of the 13 strongest signal-to-noise ratio events from stage 4. Locations relative to stage 4 largest event and locations relative to the stage 5 largest event are shown. Inset: Zoomed view of locations. The arrows connect slave events from the stage 4 master to the corresponding slave events of the stage 5 master based on origin time.**



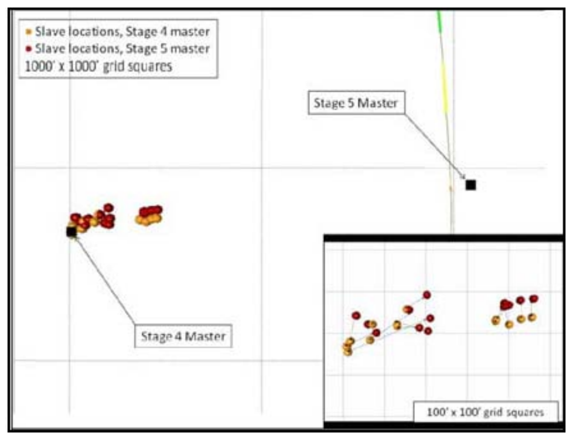



**Figure 6: Map view of located events for five stages using matched filter technique. Event color corresponds to treated wellbore interval.**

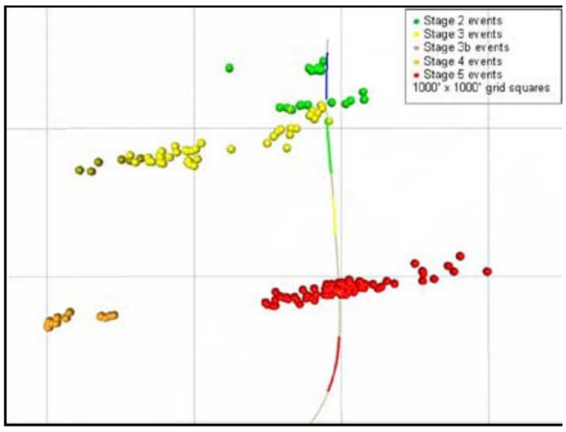



**Figure 7: Stage 3 injection data (calc. bottomhole pressure; slurry injection rates and proppant concentration) and relative distance and size of microseismic events. Each black circle represents detected microseismic event and its size is proportional to released seismic moment. Distance of each event from the injecting point is negative if the event was located west of the well (lower plot) and below the well (upper plot).**

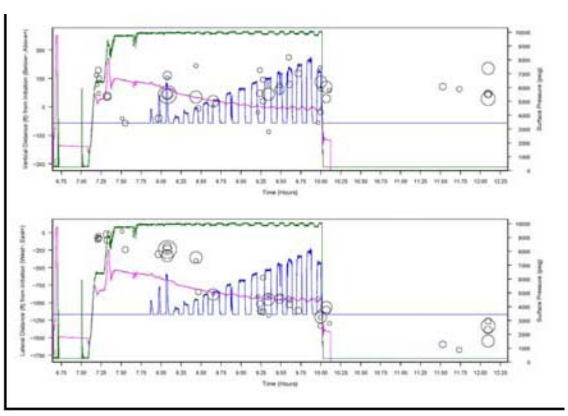


**Figure 8: Stage 5 injection data; similar scale and reference as in figure 7.**