SPE 108142

Hydraulic Fracture Diagnostics in the Williams Fork Formation, Piceance Basin, Colorado, Using Surface Microseismic Monitoring Technology

David Abbott, Chris Neale, SPE, James Lakings, Microseismic Inc.; Lynn Wilson, SPE, Jay C. Close, SPE, Evan Richardson, Chevron

This paper was prepared for presentation at the 2007 SPE Rocky Mountain Oil & Gas Technology Symposium held in Denver, Colorado, U.S.A., 16–18 April 2007.

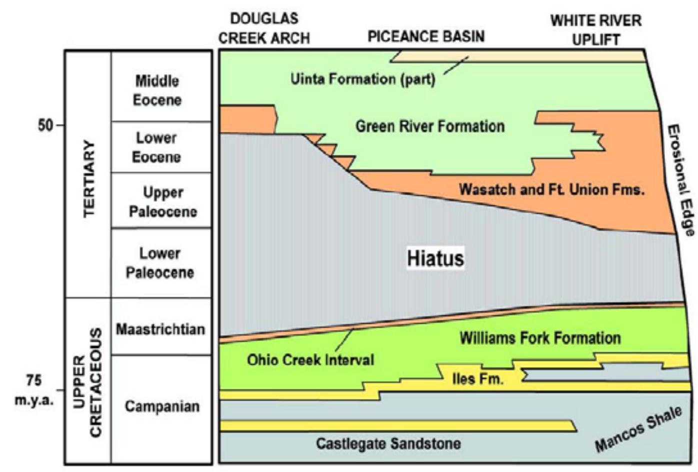
Abstract

A surface microseismic array was utilized to perform hydraulic fracture diagnostics during stimulation of the Chevron Skinner Ridge (SR) #698-22-1 well, Williams Fork Formation (Late Cretaceous), Garfield County, western Piceance Basin, western Colorado. Production from very low permeability Williams Fork gas sandstones requires fracture stimulation to enhance wellbore-to-reservoir connectivity. The use of surface microseismic monitors without borehole equipment in downhole configurations represents a relatively new and untested technology for hydraulic fracture diagnostics. Analysis of the surface microseismic data was carried out for five (5) hydraulic fracture stages to: (1) determine the applicability of the surface microseismic approach in the absence of an offset observation well; and (2) characterize fracture height, azimuth, length and symmetry with respect to rock properties.

Hydraulic fracture stimulations to date at SR have encompassed limited entry "waterfrac" treatment techniques. The hydraulic fracture characteristics were interpreted to document possible influences that natural fractures, horizontal stress trends and sandstone channel orientations may have had on hydraulic fracture emplacement. The Williams Fork Formation at SR contains natural fractures, and the primary open natural fracture sets strike generally east-west. Healed natural fracture sets strike generally northwest-southeast. The current principal horizontal stress trends are roughly east-west. The fluvial Williams Fork sandstone bodies have highly variable orientations due to meandering and braided stream depositional origins, but many channels trend roughly east-west and northwest-southeast. The SR #22-1 well is located in a deep and relatively narrow (1-2 mi wide) north-northwestsouth-southeast trending valley roughly 2,000 ft below the adjacent "mesa" tops, which is an important geomechanical consideration.

The surface microseismic data were of sufficient quality to enable successful interpretations of hydraulic fracture geometries. The hydraulic fracture stimulations were emplaced progressively uphole between 5,298 to 3,372 ft measured depth. The deeper stages grew mainly along east-west and northwest-southeast orientations, and the upper stages formed largely along northwest-southeast orientations. All stages showed asymmetric geometry. The lower stages may have been influenced by the northwest-southeast sandstone body and healed natural fracture orientations, along with east-west sandstone body, primary open natural fracture and horizontal stress directions. The upper stages may have been more influenced by the northwest-southeast sandstone body and healed natural fracture orientations, and topographic effects. Additionally, during some stimulation treatments, shallower stages appeared to be in vertical communication with previous deeper stages. A possible tectonic fault that had not been mapped due to widely spaced well control may have further influenced hydraulic fracture growth in one stage.

Figure 1. Piceance Basin Williams Fork and adjacent stratigraphy (Cole and Cumella, 2003.[17])



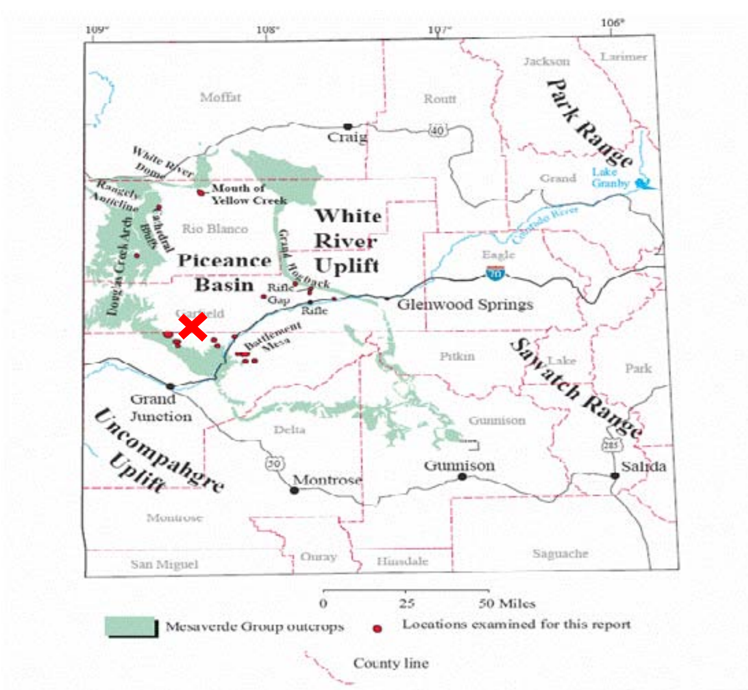


Figure 2. Piceance Basin map (cf. Johnson, 1989[22]) with Skinner Ridge location (marked with an "X.").

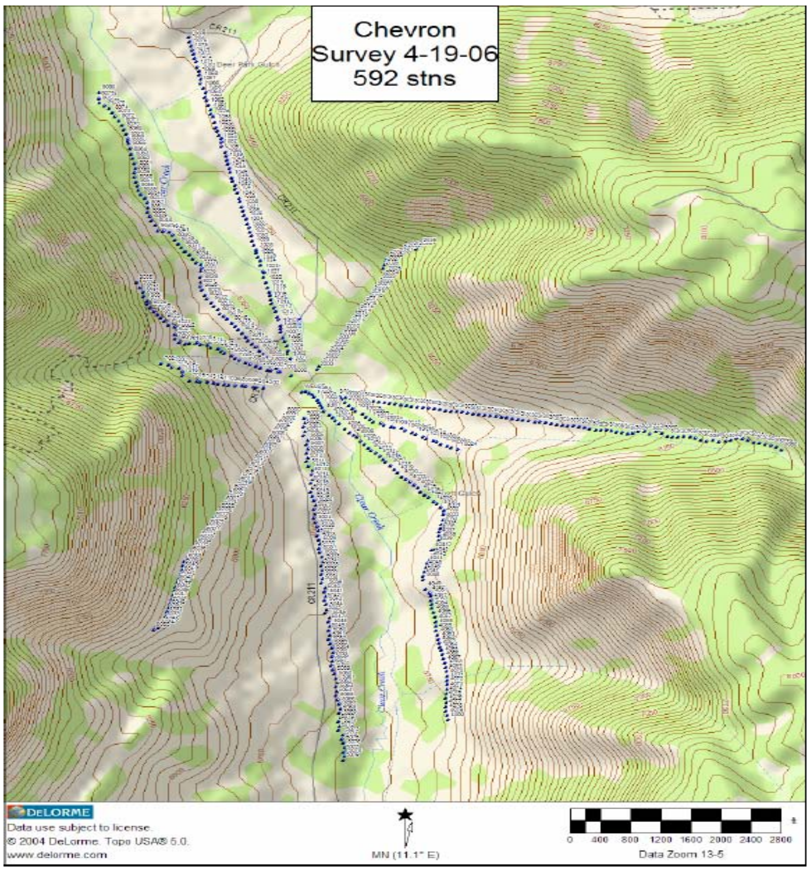


Figure 3. Field seismometer array map for Skinner Ridge #698-22-1.

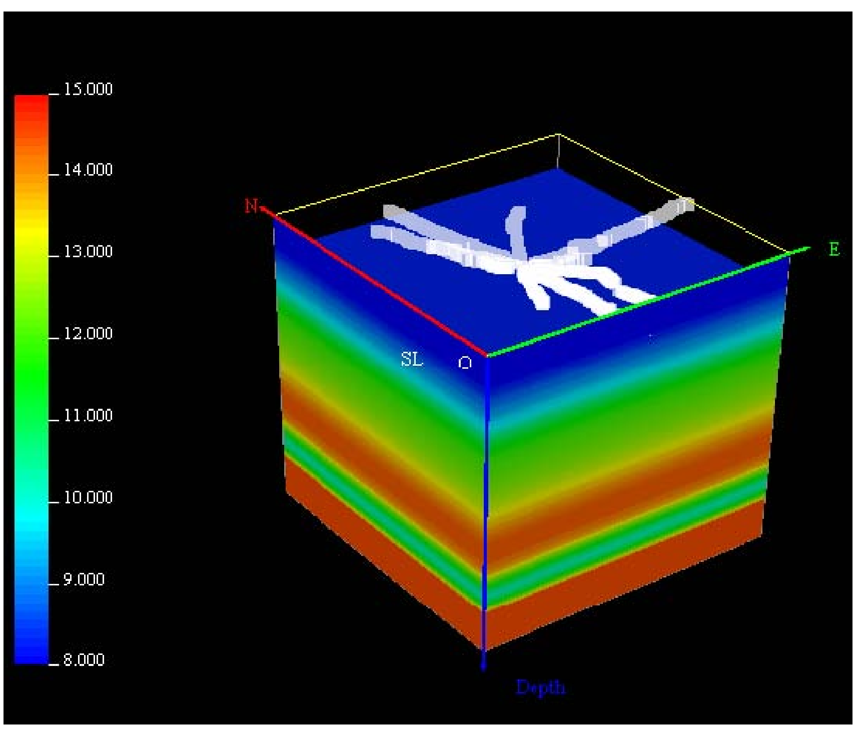


Figure 4. Final velocity model for Skinner Ridge #698-22-1.

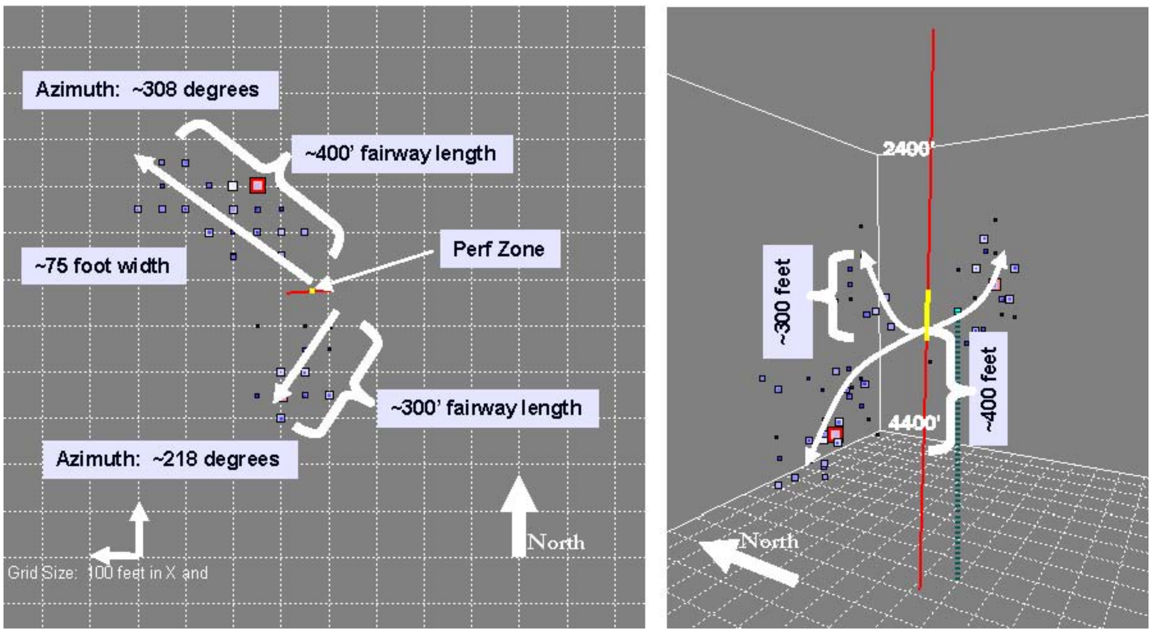
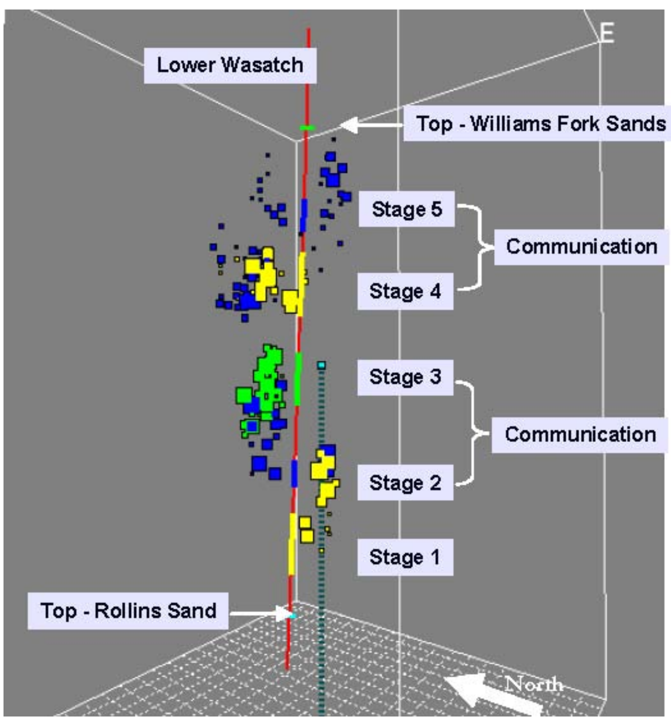


Figure 5a-b. Stage 5 interpretation example, map and cross section views, Skinner Ridge #698-22-1.



6. Spatial composite view of stage communication, Skinner Ridge #698-22-1.