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## Surface Tiltmeter Mapping Shows Hydraulic Fracture Reorientation in the Codell Formation, Wattenberg Field, Colorado

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### Abstract

This paper reports on a study conducted to measure the orientation of fractures created during initial fracture and refracture treatments in the Codell formation of the Wattenberg Field, Colorado. The Codell is a thin, low permeability sandstone that is laterally continuous across the field area. Due to the low permeability, stimulation is required for economic development of the Codell. Refracturing of Codell wells in Wattenberg Field has been successfully performed for the last decade and several reasons have been suggested for the success of Codell refracs including reorientation of fractures.

Surface tiltmeter mapping was performed during this study on several initial fracture and refracture treatments in the field to determine fracture orientation. The average azimuth of initial fracture treatments was N66°E. Significant reorientation occurred on some refrac wells and the average azimuth of refracture treatments was N29°E although highly variable.

It has been observed that fracture orientation can vary due to changes in pore pressure as the result of asymmetrical depletion and/or injection or due to structural features. In this case we believe that asymmetrical depletion is affecting the in-situ stress orientation and thus the fracture orientation. There were also indications of fracture complexity with some treatments showing a change in fracture orientation during the treatment and several showing higher than normal horizontal components.

The results from this study help explain the success of refracture treatments in the Codell. Refracture reorientation allows existing wells to contact new reservoir increasing gas recovery per well. There may be the potential to fracture wells for a third time (re-refracs) for additional fracture

reorientation and improved gas recovery. Mapping and production results are discussed in this paper.

### Background

The objective of surface tiltmeter mapping on this project was to determine the fracture orientation of initial fracture treatments and refracture treatments of the Codell formation in the Wattenberg Field. The primary focus of the project was to determine if refracture reorientation was playing a role in the restimulation success in the Codell. Refracture reorientation allows an existing well to contact new reservoir and improve ultimate recovery. The secondary objective was to determine fracture orientation in the J-Sand, a target zone below the Codell, in order to optimize well locations. A mix of fracture treatments was monitored during the project, initial treatments in both the Codell and J-Sand and refrac treatments in the Codell, in order to determine original fracture azimuth and refracture azimuth.

### Codell Formation

The Wattenberg Field is located in the Denver-Julesburg (DJ) Basin as shown in **Figure 1**. The producing area is a multiple pay accumulation in a basin center which is associated with a geothermal anomaly<sup>1-2</sup>. Productive zones within the field include the J (Muddy), Codell, Terry (Sussex) and Hygiene (Shannon) sandstones and the Niobrara chalks and shales as shown in **Figure 1**.



**Figure 1. Location of the Wattenberg Field (from Sonnenberg and Weimar<sup>1</sup>)**