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Application of ESG's Clustering Algorithm to Identify Faults and Fracture Networks that Influence Production

ESG successfully performed its 2nd look re-processing services on microseismic data acquired from a 2-stage vertical fracture in the Montney formation. By applying proprietary clustering algorithms, ESG detected an underlying fracture network which differed between the two stages and offered explanation of the observed differences in production data between the stages.

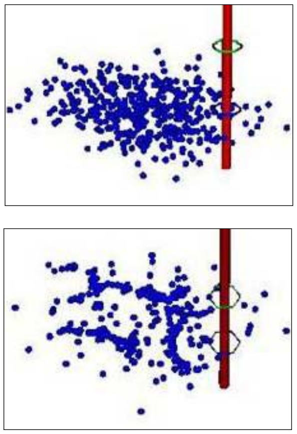

Fig. 1: Example of microseismic events located for Stage 1 before (top) and after (bottom) application of clustering methods.

As microseismic monitoring of hydraulic fracture treatments has gained acceptance in the energy industry, it has become well established that operators cannot expect simple bi-wing fractures to be formed during fracture stimulations. Instead, it is much more normal to observe highly complex fracture networks, as the stimulation interacts with pre-existing natural fractures in the target zone. Using innovative analysis tools such as ESG's clustering algorithms, it is possible to break down seemingly unconnected groupings of microseismic events into defined faults and fractures, adding a geological context to the microseismic interpretation and helping producers understand hidden reservoir characteristics that may influence production.

Background

Microseismic data was acquired by an alternate vendor for a vertical 2-stage hydraulic fracture in the Montney formation in Alberta, Canada. A 12-level vertical sensor array was located in an observation well 590 meters from the production well. ESG was asked to re-process the microseismic data by the client, with no indication as to why the data required re-processing.

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A velocity model was developed for the site using dipole sonic log data. ESG performed sensor orientation using perforation shot data and event location using an azimuth-based location algorithm. ESG's proprietary Particle Swarm Optimization (PSO) analysis was applied to the data to refine event locations and the velocity model. A total of 1199 events were located, from which a representative data set was established with a minimum moment magnitude of -1.2 (Fig. 2 and Fig. 3).

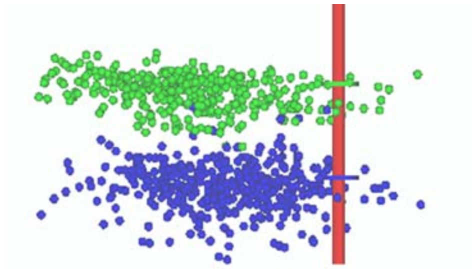

Fig. 2: Events recorded during Stage 1 (blue) and Stage 2 (green) in depth view.

A calculation of the stimulated reservoir volume (SRV) based on seismic deformation was performed for each of the fracture stages. SRV represents the volume of a reservoir that is effectively stimulated to increase production. The SRV calculated for Stage 1 was found to be three-times higher than the SRV for Stage 2, indicating substantial differences in production between stages. As well, significant seismic deformation occurred near to the production well for Stage 1, suggesting that fractures were well coupled to the production well. In contrast, the majority of seismic deformation associated with Stage 2 tracked along a N30°E azimuth away from the production well.

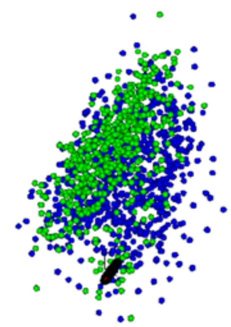

Fig. 3: Events recorded during Stage 1 (blue) and Stage 2 (green) in plan view.

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ESG applied its proprietary clustering algorithms to the event data for Stages 1 and 2 to identify if any underlying fracture networks were present. Fig. 4 provides the results of ESG's proprietary cluster analysis. Microseismic event locations are displayed prior to the analysis, after the 3rd iteration of the algorithm and after the 6th and final iteration.

The final result for Stage 1 reveals two main parallel fractures with a northeast azimuth connected to each other and the production well by a series of smaller cross-fractures. In contrast, the final result for Stage 2 reveals a single large dominant fracture with a northeast azimuth. This fracture does not appear to be well coupled with the production well.

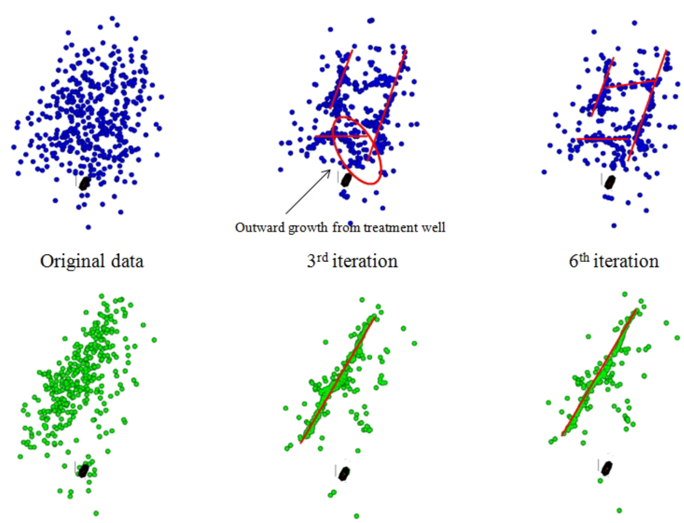

Fig. 4: Identification of underlying fracture networks after 3 and 6 iterations of ESG's clustering algorithm for data from Stage 1 (top - blue) and Stage 2 (bottom - green). The fracture network for Stage 1 shows good coupling with the production well (black cylinder) compared to Stage 2.

After receiving the results of the microseismic evaluation, the client revealed that they had observed significantly lower production from Stage 2. The cluster analysis combined with SRV results provided insight to the client about the characteristics of the two fracture stages and suggested that underlying fractures may be linked to observed differences in production.

This case study highlights how advanced microseismic analysis can be used to gain insight into the factors within the reservoir that most influence production

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