Microseismic Monitoring During-Shale Field Development

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Microseismic monitoring has become an important facilitator to the development of shale fields. As many as 10% of the hydraulic fracture treatments performed in the U.S. are now monitored, with some operators opting to monitor every well as they develop their field. The number of stages monitored is likely up by 300% in the last 2 years and continues to grow.

Driving the increased penetration of this technology is an appreciation of the complexity of shales. The earlier assumption that one could get away with monitoring the first couple of wells in a field and then expect everything to remain the same thereafter has proven to be a poor one. The response of the rocks is seen to vary from well to well and stage to stage. Ever conscious of operating costs, operators have been seeking ways to monitor more wells at a lower unit cost. This has lead to the deployment of permanent monitoring arrays that can be used to cost effectively monitor most if not all the fracturing operations as the field is developed at a very low incremental cost. Such arrays can also be employed for monitoring other field operations and as receiver grids for active 3-D and 4-D imaging.

Another important development in the maturing of this technology is the extraction of more information from the data that is collected. The legacy analysis of the data, consisting of hypocenter estimates placed in time and space is now being supplanted by a more complete treatment. The original analysis was more directed at getting a better frac design. The more recent developments are directed at producing a better understanding of how the reservoir will perform as a result of the frac'ing. Such analysis consists first of extracting the failure mechanism of each microseismic event from the data as well as its magnitude. The nature of the failure mechanism is determinis-

tic of the stress regime in the reservoir. The distribution of event magnitudes also appears to be diagnostic as to whether new fractures are being created or existing fractures are being reactivated.

Taking this analysis further, one can use the temporal and spatial distribution of events, constrained by whatever other external data are available for the field, to begin replacing the hypocenter estimates with estimates of the fracture planes that created the microseismic events.With an assignment of permeability, the fracture model (Discrete Fracture Network or DFN) can be upscaled to a grid model that then can be used in a reservoir production simulation model to begin predicting well and field performance. History matching to actual production provides feedback to the model allowing for improved parameter selection. As the number of wells monitored in the field increases it becomes possible to further refine and improve the process just outlined. The goal is to give the operator a better handle on optimal well orientation, infill spacing, estimated ultimate recovery (EUR) and recompletion potential.