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A Brief Review of the Minimal-Effort Time-Lapse Seismic Concept

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Editorial

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Abstract

Multiple, time-separated/time-lapse 3-D (TL 3-D) seismic surveys are becoming increasingly used as means of monitoring petroleum reservoir production. Typically, the separate monitoring surveys are all performed in a manner very similar to the original, exploration survey, this is not always the most efficient manner in which to collect the information necessary to make production decisions. Once the petroleum signature is recognized in the original (exploration) survey, considerable information is available to allow the monitoring survey(s) to be designed so that the production can be monitored in a, manner more efficient than simply repeating an exploration grade survey. Empirical and mathematical techniques are being developed to determine the minimal effort (most efficient) TL 3-D schemes. These minimal effort schemes promise to reduce costs for reservoir monitoring and to allow TL 3-D monitoring to be applied cost effectively to smaller reservoirs. The demand for Minimal Effort TL 3-D (ME TL 3-D) surveys will likely result in a new breed of specialized (faster, better, cheaper) seismic crews.

Minimal-Effort Time-Lapse 3-D

The paradigm in the seismic industry today is to collect process and interpret data with as much resolution as possible, the limit most often being technology. This approach is justified in exploration because by definition the target is not known. In Time Lapse 3-D (TL 3-D) imaging, however. the target is known when monitoring surveys are collected. Since the target is known, the problem becomes one of recognizing changes in this known target over time. Information from the original (exploration) survey may now be used to design the subsequent surveys, which detect the changes, in a way that requires less investment in data collection. processing and interpretation. Such intelligently designed monitoring we call Minimal Effort TL 3-D (ME TL 3-D).

The Inverse Problem

Knowing the target when the monitoring survey is designed presents a type of inverse problem: How little resolution can be tolerated and still accomplish the goal of detecting the changes in the reservoir response so that efficient reservoir production decisions to be made? If this lower bound on resolution can be determined then the monitoring survey can be designed to collect only the necessary data. A principle which is important in the minimal design of the monitoring surveys is that it is easier to detect the changes in a parameter already recognized to be significant than it was to recognize the significance of the parameter in the first place. For example, it may be that the signature of petroleum in place may not be recognized in the exploration survey until wells have been drilled and petrophysical and production data have been analyzed: however, once the petroleum signature is recognized any changes in it may be rather easily detected in subsequent surveys. The problem now is to design the monitoring surveys to minimally detect the changes.

Conclusion

I have described the minimal-effort time-lapse 3-D concept in an abstract sense as the result of solving an inverse problem. It would be of great interest if this inverse problem could be solved and the minimal-effort method successfully employed in current time-lapse surveys.