Contrast Enhanced Through Casing Hydraulic Fractures Mapping

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Hydraulic fracturing is being performed in more than 60 years in more than a million wells and counting. Despite the long history in hydraulic fracturing, the growth of fractures over time is not well understood. The creation of hydraulic fractures can be monitored in real time via micro-seismic method. However, this method is only effective during fracturing process. After hydraulic fractures are created, the growth of fractures remains unknown. There is a lack of methods to effectively characterize fractures in the post fracturing period.

The induction logging and inversion method is a non-destructive way to gain high resolution images of structures in formation surrounding the borehole area. Induction logging tool is first introduced for borehole containing oil-based mud or air-drilled borehole because electrode based resistivity tools cannot work in nonconductive boreholes. Induction tool becomes widely used later due to its easiness to run and less effort on chart correction. Induction logging depends on strong electromagnetic (EM) response from target formation. However, responses from hydraulic fractures are too weak to be detected.

This work presents an enhanced contrasts imaging method for through casing hydraulic fractures. The forward scatterings of hydraulic fractures are modeled by integral equations. A fast numerical method for integral equations named the mixed order BCGS-FFT method is introduced. The classic BCGS-FFT method is an fast and efficient method to solve the integral equation. However, the classic higher order BCGS-FFT method cannot apply to hydraulic fractures with both their dielectric and magnetic contrasts enhanced. The mixed order and mixed type basis functions are used to handle both dielectric and magnetic contrasts of fractures. The inverse problem is solved by the distorted born iterative method. Examples of through casing hydraulic fracture imaging with both synthetic and experiment data will be presented.