IDENTIFYING FRACTURE-FILLING MATERIAL IN OIL-BASED MUD WITH DIELECTRIC BOREHOLE IMAGING

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Abstract:

Natural fractures maintain a significant role in many hydrocarbon plays, in both conventional and unconventional reservoirs. In exploration and development scenarios, specific fracture properties, such as orientation and density, are important. However, more critical is their internal architecture: are the fractures open to fluid flow or filled with minerals?

Borehole microresistivity imaging tools are widely used to determine these fracture characteristics. In wells drilled with water-based muds, open fractures are filled with conductive borehole fluid that enables distinguishing open, water-filled fractures from resistive, mineral-filled fractures and the surrounding rock. However, many wells today are drilled with oil-based muds. In this case, mineral-filled fractures and oil-basedmud-filled fractures are equally highly resistive and cannot be directly distinguished using resistivity images only.

The latest-generation wireline oil-based-mud microresistivity imagers operate in the megahertz frequency range, radiating the electrical current capacitively through the nonconductive mud column and delivering photorealistic borehole images. Both electrical conductivity and dielectric permittivity components constitute the measured signal. The quantitative interpretation uses a sequence of modelbased parametric inversion runs to first estimate the mud properties of the log and subsequently invert for the standoff of the microelectrode buttons to the rock surface and the formation resistivity and dielectric permittivity within the volume of investigation.

Our example case shows highly resistive, high-angle fractures from the resistivity images with their orientation and density. The standoff image determines if the mud column penetrates the fracture plane, showing an apparently high standoff compared with the surrounding rock. If the standoff appears high in the fracture plane, the fracture is classified open to fluid flow. However, are these fractures indeed fully dilated and open or are they filled with different materials—are they partially mineralized with calcite and partially open, filled with mud?

To further determine the fracture fill and susceptibility to fluid flow, a new workflow employs the material dependency of the relative dielectric permittivity. The relative permittivity is estimated as function of resistivity and frequency pixel by pixel on the resistivity image. The estimate formula is empirically derived from several hundred laboratory measurements on core plugs with different fluid saturations and salinities. The resulting borehole image enables distinguishing materials in the volume of investigation.

Bio:

Peter SCHLICHT is the Technical Director for Geology at Schlumberger Wireline Headquarters, based in Bucharest, Romania. He joined Schlumberger in 2001 as a wireline field engineer and had several assignments as geology expert to operations in Africa and the Middle East. Peter was research program manager for pre-salt formation evaluation at the Schlumberger Research and Engineering Center in Brazil until 2014. As geology advisor he currently works on hard- and software technology development and interpretation engineering for borehole imaging and coring. Peter holds a diploma degree in geology and paleontology from University of Cologne, Germany.