

A fuzzy logic approach for detecting fractured zones with conventional well logs

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Conventional well logs, such as resistivity, porosity, density correction, and caliper logs, often exhibit abnormal values in response to fractured zones within a borehole. However, no single log response is completely diagnostic of fracturing since each log responds to a number of formation properties and borehole conditions. Furthermore, for a specific log, it is difficult to define quantitatively what response might be expected in the presence of a fracture. For instance, a fracture occurring in sandstone typically generates a much different caliper log response than a fracture occurring in shale.

To overcome these difficulties, we are developing a statistical-fuzzy logic approach using conventional, digital well logs. The technique first uses statistical methods (e.g., regression and population distribution analysis) on individual or combined log responses from intervals of similar

lithology, based on cutting sample information. These results are then used to construct fuzzy logic membership functions. Each membership function provides a quantitative basis for evaluating whether an individual log response, or combination of responses, is related to fracturing. The product of the vector of membership function values with a user-defined, weight vector (whose summation equals one) gives an indication of fracture probability. This approach, iterated down the length of the borehole, produces a curve of fracture probability (0 = low probability of fracturing, 1 = high probability of fracturing).

Although well logs have recently been developed specifically for fracture identification, our statistical-fuzzy logic approach provides a method of fracture identification using the vast database of existing, conventional well logs.