

Fracture Analysis from Standard Triple-Combo Log Suites*

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Abstract

For a realistic approach of the potential of unconventional reservoirs, it is important to assess the degree of fracturing – both open and healed (cemented) fractures. The standard and most accurate approach is from interpretation of image logs. However, there are many areas where image logs have not been run, although there will probably be an abundance of standard open-hole logs. The procedure described here involves the interpretation of standard open-hole logs and consists of examining rates of change of curve magnitudes with depth. If the change to apparent high porosity cannot be reasonably explained as a consequence of depositional variations, an open fracture is assumed. Conversely, if the change is to low porosity, a healed (cemented) fracture is assumed. All log traces, as well as the caliper and density correction curves are examined. For each log, the interpreter defines a minimum change in curve magnitude from one depth increment to the next. Additionally, a minimum change over a defined depth window is defined.

Results of fracture identification from individual logs are stacked to identify potential fracture clusters. By comparing this analysis with image logs over the same intervals, we have found that there is good correlation, especially if clusters occur. It is understood that log resolution does not allow identification of individual fractures; however, fracture swarms can be recognized. Examples of the technique from a variety of reservoirs are included.

Introduction

Recognition of the presence of fractures is an important factor in the understanding of reservoir behavior. As the well is drilling, “chattering” on the drill floor can be an indication of fractures. Whole core examination will also reveal the presence of both open and healed fractures. Standard open-hole log interpretation of fracture recognition is the identification of “cycle skips” on acoustic compressional measurements.

The most accurate petrophysical measurement of fractures comes from image logs – acoustic imaging or micro resistivity imaging. However, this group of logs is not run routinely. There is a need to be able to estimate fracture intensity (both open and healed) from commonly available triple-combo log data. This presentation offers such a solution.

Discussion of Fracture Characteristics

- Open fractures have very high porosity (theoretically 100% porosity) occupied by fluids or gas.
- Closed (healed or cemented) fractures have very low porosity (theoretically close to zero) and generally with a grain density higher than neighboring unfractured sequences.

A major issue in the approach is resolution of the log measurements. Any log measurements of this type cannot identify individual and isolated fractures. The best that can be expected is recognition of clusters of fractures.

Methodology

The basic principal is examination of rates of change of curve magnitude with depth. If a curve is changing too rapidly to be a consequence of sedimentary or diagenetic processes, a fracture is inferred:

- If the change is to high porosity, an open fracture is recognized.
- If the change is to low porosity or high grain density, a closed (healed) fracture is recognized.

There is no published documentation as to the rates of change of curve magnitude as related to the presence of fractures. In the procedures documented in this presentation, the interpreter has the following choices (which will be different for each curve):

- Minimum change over a single depth increment.
- Depth window for the analysis.
- Minimum changes over the depth window.

As a starting point, the inputs of [Table 1](#) are used.

- Recognize change to high porosity.
- Recognize change to low porosity.
- Recognize change to both high and low porosity.

Each curve is analyzed individually, together with a summation of all curve fracture indicators. Clearly, open fractures and closed fractures are recognized separately. Experience indicates that recognition of fractures at the same depth level from different logs are more reliable than fractures indicated from only a single log.

Examples

Data are presented for a Mississippian carbonate section in Kansas ([Figure 1](#)), a Cretaceous clastic interval in Wyoming ([Figure 2](#)), a Mississippian carbonate section in Oklahoma ([Figure 3](#)), and a Paleozoic carbonate interval in the Middle East ([Figure 4](#)).

Conclusion

Recognition of fractures, particularly open fractures, is crucial in the understanding of reservoir performance. Direct indicators of fractures are available from examination of cores. Wireline image log interpretation is a standard approach to the recognition of fractures. However, image logs are not commonly run due to high logging costs. The vast majority of wells logged have a standard triple-combo log suite. This presentation offers a system of estimating the presence and intensity of the fracture system when image logs are not available. The technique will also indicate sequences that are probably not fractured.

Curve	Minimum Slope	Depth Window	Minimum Deflection
Density (RhoB, gm/cc)	0.02	2.5 Ft	0.05
Neutron (Porosity, fraction)	0.02	2.5 Ft	0.05
DT (micro seconds per foot)	1	2.5 Ft	3
DT _{matrix} (micro seconds per foot)	1	2.5 Ft	3
Rho _{matrix} (gm/cc)	0.02	2.5 Ft	0.05
Pe	0.4	2.5 Ft	1
Uma	0.4	2.5 Ft	1
GR	2.5	2.5 Ft	5
Rt	4	2.5	0

Table 1. Input data used to characterize fractures from a standard open-hole log suite.

Open fractures
 Closed/cemented fractures

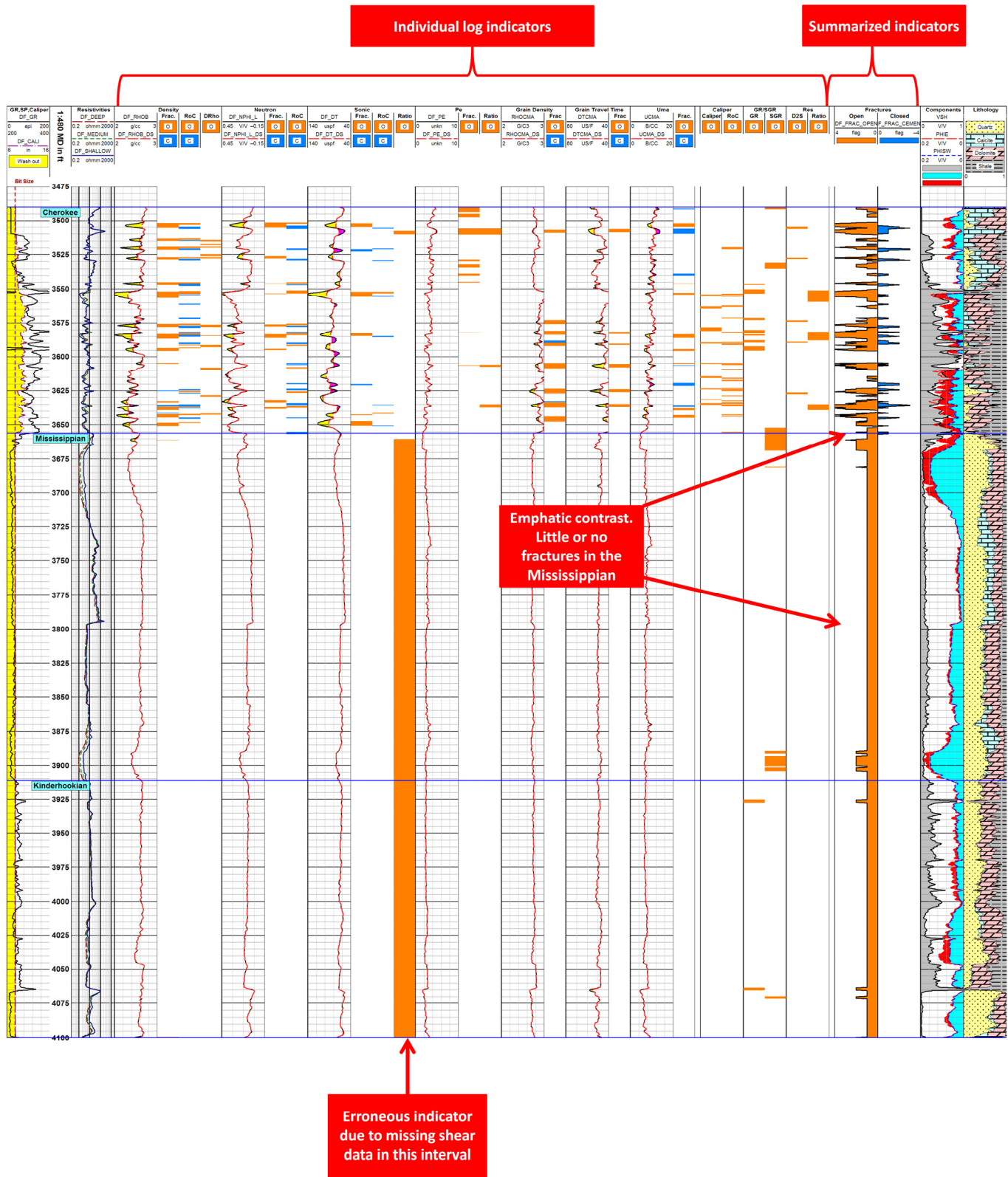


Figure 1. Example from electric log suite over a Mississippian carbonate section in Kansas.

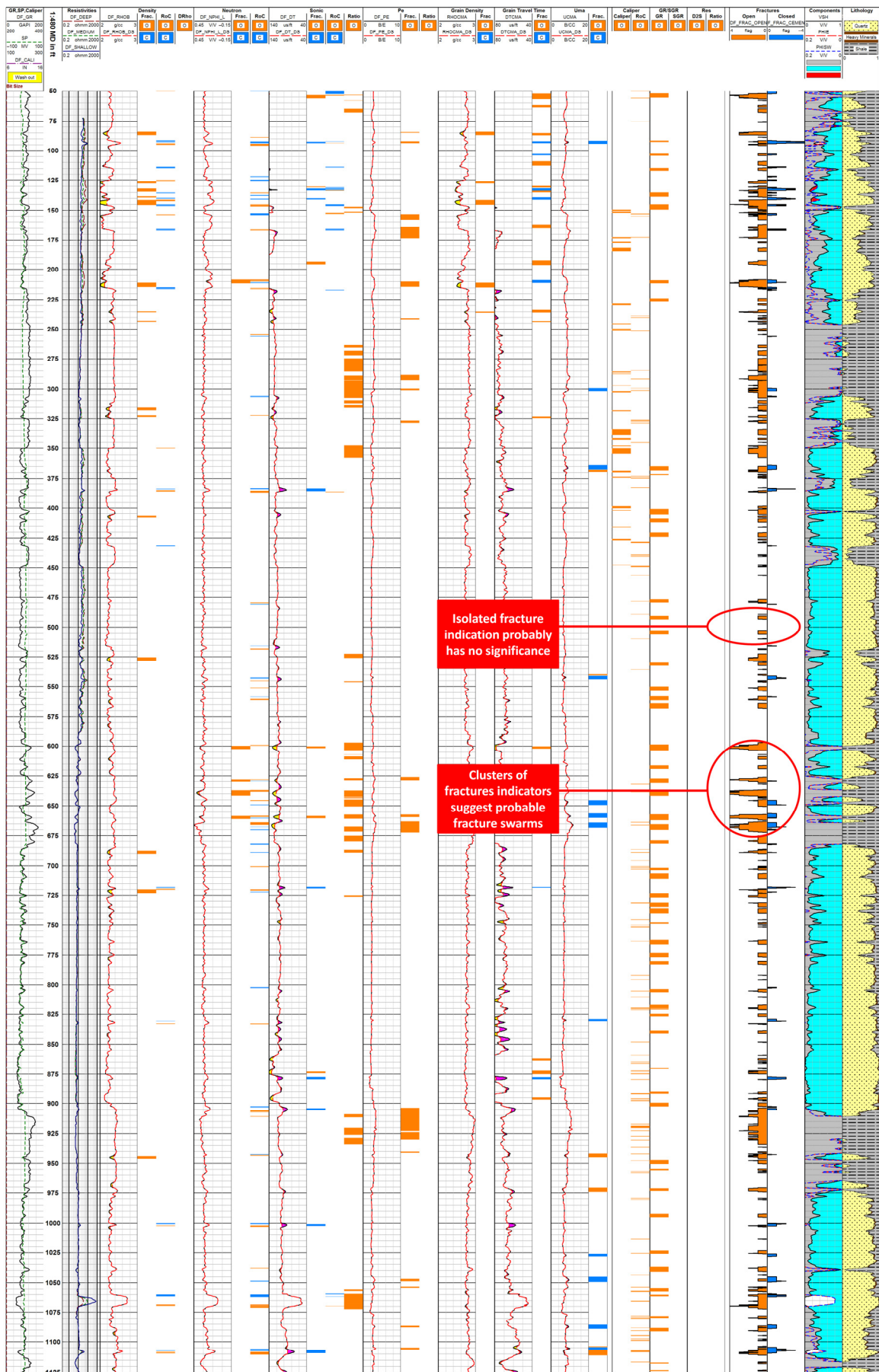


Figure 2. Example from electric log suite over a Cretaceous clastic interval in Wyoming.

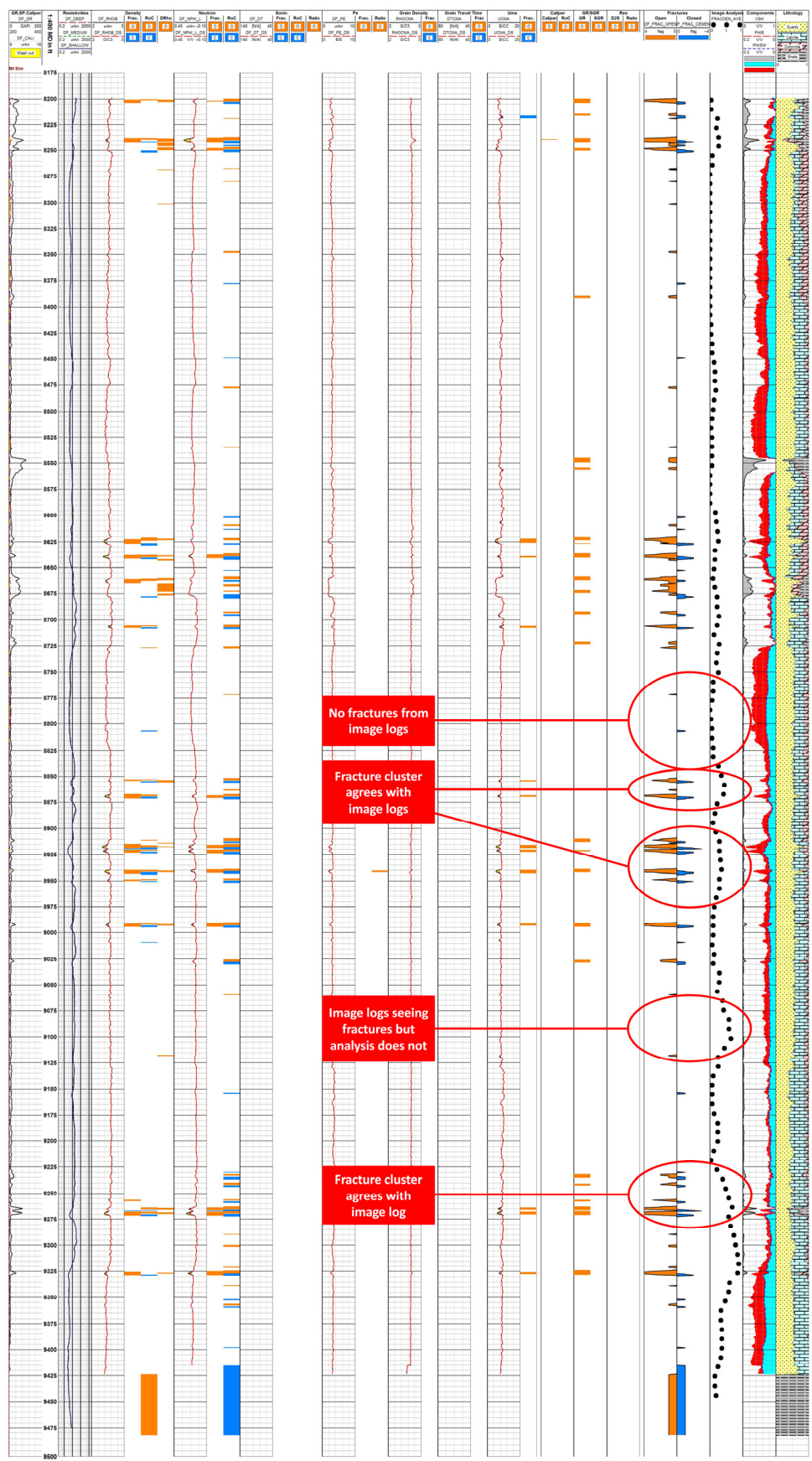


Figure 3. Example from electric log suite over a Mississippian carbonate section in Oklahoma. An image log is also available from this well for comparison.

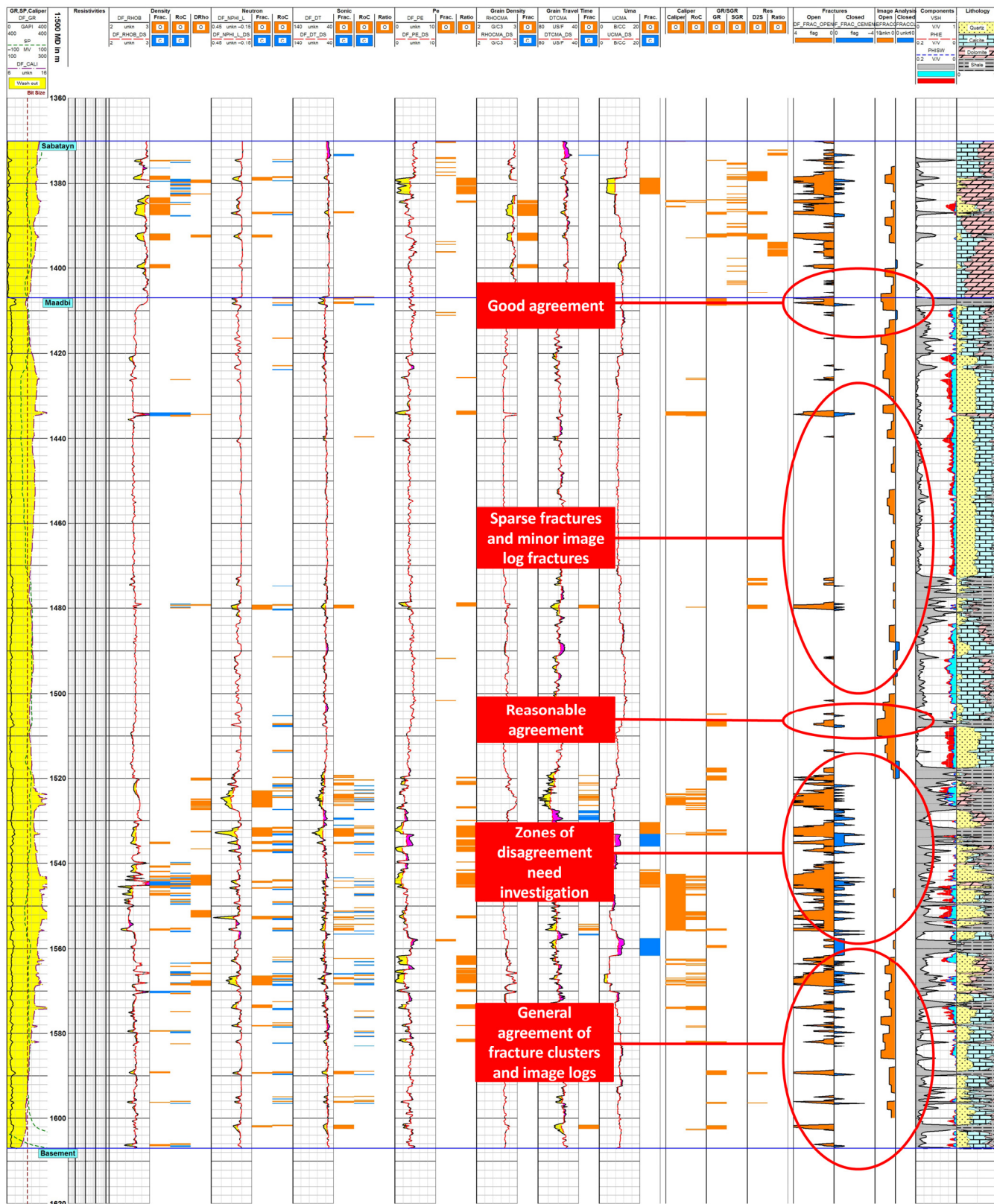


Figure 4. Example from electric log suite over a Paleozoic carbonate interval in the Middle East. An image log is also available from this well for comparison.