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Geomechanics Aided Solutions for Improving Drilling and Completions by Integrating Acoustics Measurements for the First Time in Mandapeta Field, Onshore KG-PG Basin, India*

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Abstract

The Krishna Godavari (KG) Basin is a peri-cratonic passive margin basin on the east coast of India. The basin's characteristic feature is its en echelon horst and graben structure which is filled with sediments of Permian to Recent age. KG Basin is one of the most promising petroliferous basins on India. The Mandapeta Field is in the KG Basin with proven gas reserves in the Mandapeta Formation of Triassic age. Oil and Natural Gas (ONGC) Ltd is operating and undergoing a development campaign in this field where and witnessed high NPT due to various drilling challenges such as mud loss, tight holes, stuck pipe, etc. Bad borehole conditions have resulted in lower data quality being recorded in recent wells. Most of the drilling problems are reported in the Raghavapuram, Gollapilli and Mandapeta formations.

To minimize these drilling related risks, an integrated customized solution based on an iterative mechanical earth modelling (MEM) and wellbore stability analysis was adopted utilizing acoustic outputs and drilling events. 1-D MEMs were constructed for different wells in the area to develop a geomechanical understanding of the reservoir as well as in the overburden and underburden layers. Figure 1 and Figure 2 shows the MEM for well B and well C.

From the analysis it is observed that shales are relatively weaker than sands in both the Gollapalli and Mandapeta formations. Shear failure occurs more in shales as compared to the sands, as observed from caliper data. Estimated pore pressure values range from approximately 1.20 gm/cc to 1.41 gm/cc with an increasing trend from the top of the Gollapalli Formation. Measured SBHP suggests 0.59 psi/ft to 0.63 psi/ft. in the Mandapeta Sandstone at virgin conditions. The overpressure mechanism appears to be due to undercompaction. Mud weight has been on the lower side at the beginning of the section resulting in more over-gauged hole conditions in the Raghavapuram Formation.

Figure 3 is a cross-plot between compressional slowness and density (Hoesni, 2004), and differentiates between different mechanisms of overpressure generation. Based on the theory that compaction increases the grain-to-grain contact of the rock leading to a progressive increase in the density and velocity in these intervals. Under compaction follows the normal (virgin) curve, while any significant deviation from the normal trend reflects either a change in the shale composition (like the Raghavapuram) or a different overpressure mechanism such as an episode of unloading. In addition, pore pressure in shales is seen to be increasing with the increase in the porosity (Figure 4).

Shear failure variation with deviation and azimuth was analyzed in the target formations; key observations for the Gollapalli and Mandapeta formations are:

- The stable mud weight window becomes narrower with increasing deviation; higher mud weight is required to minimize shear failure with increasing deviation;

- Lower limit of stable mud weight window is equivalent to breakout mud weight which is about 1.30-1.63 gm/cc for any deviation of the Gollapalli Formation. In the Mandapeta Formation, breakout mud weight is about 1.45 gm/cc for deviation at 50 deg in E-W orientation, and 1.49 gm/cc at 50 deg in N-S.

- Upper limit of stable mud weight window is equivalent to mud loss mud weight which is about 1.92 gm/cc for any deviation.

- Wells with <35 deg deviation and drilling in the direction of E-W (Minimum Horizontal stress direction) require lower mud weight as compared to wells with higher deviation.

Apart from drilling optimization, geomechanical study had also helped in completion quality estimation for selection of good zones to perforate and hydraulically fracture. The stress barrier with higher breakdown and minimum horizontal stress values near target zones as per reservoir quality were analyzed to design perforation and hydraulic fracture. The minimum horizontal stress gradient ranges between 0.75 psi/ft. to 0.95 psi/ft. Recently a few wells have been completed using single stage hydraulic fracture treatments, connecting different sets of target layers with thin barriers. Closure pressure in datafrac and main treatment came close to predicted values with few exceptions due to presence of faults in the vicinity and tortuous paths at higher deviations of 50 deg-60 deg. Overall, the MEM model has given new insight to the operations team to improve hole conditions and complete wells to enhance production in more efficient ways.

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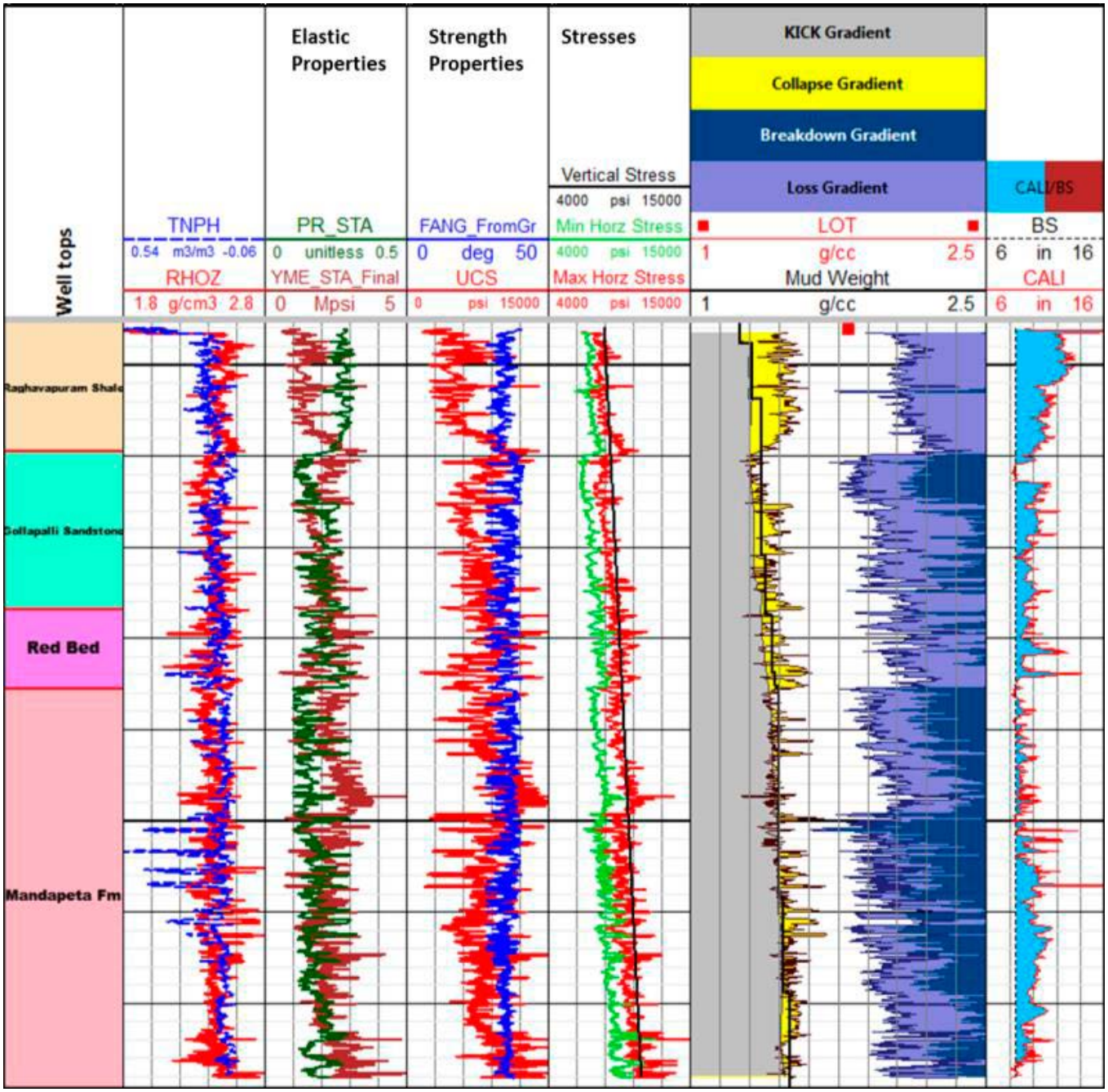

Figure 1. 1D mechanical Earth model for well B.

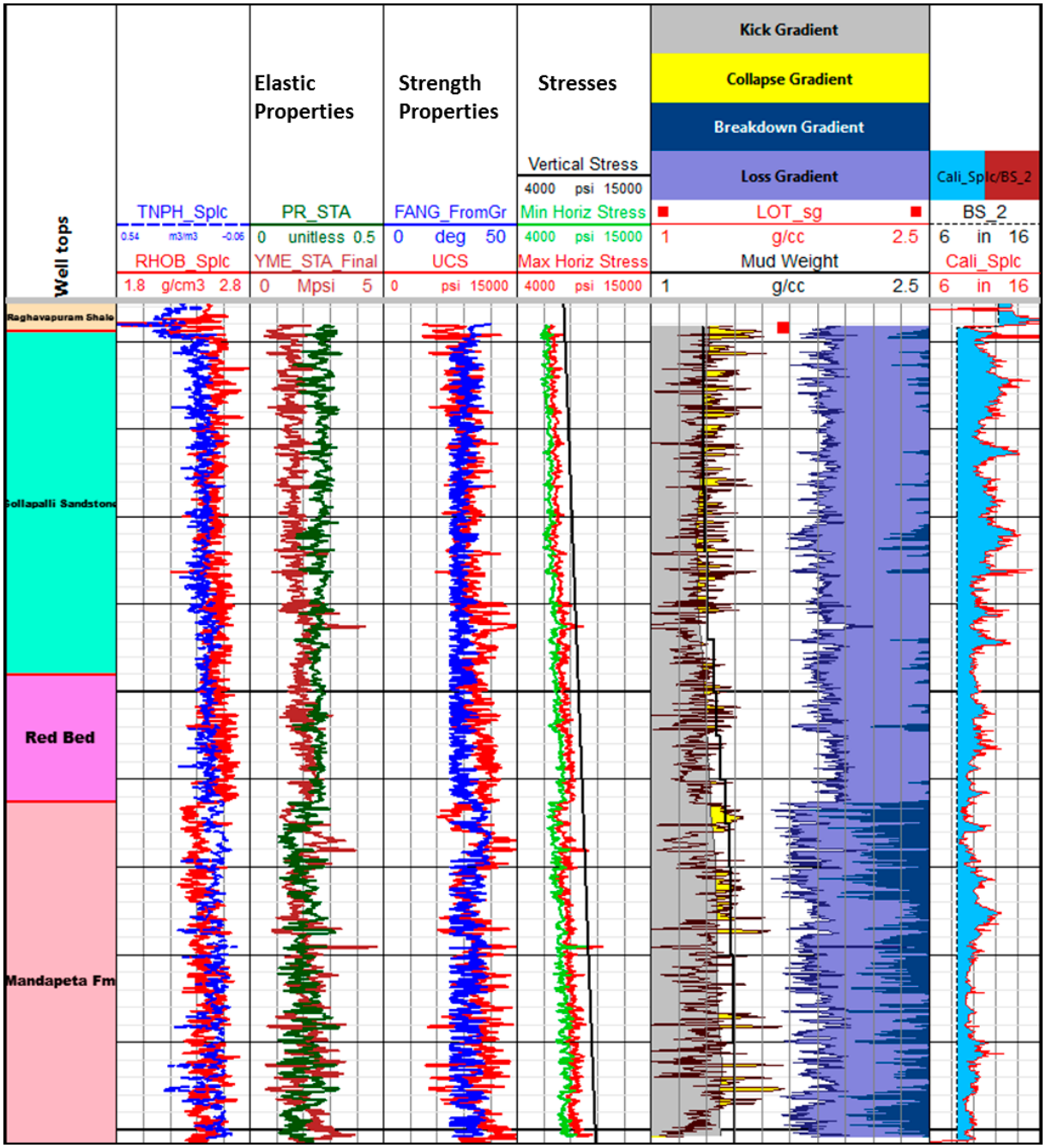

Figure 2. 1D mechanical Earth model for well C.

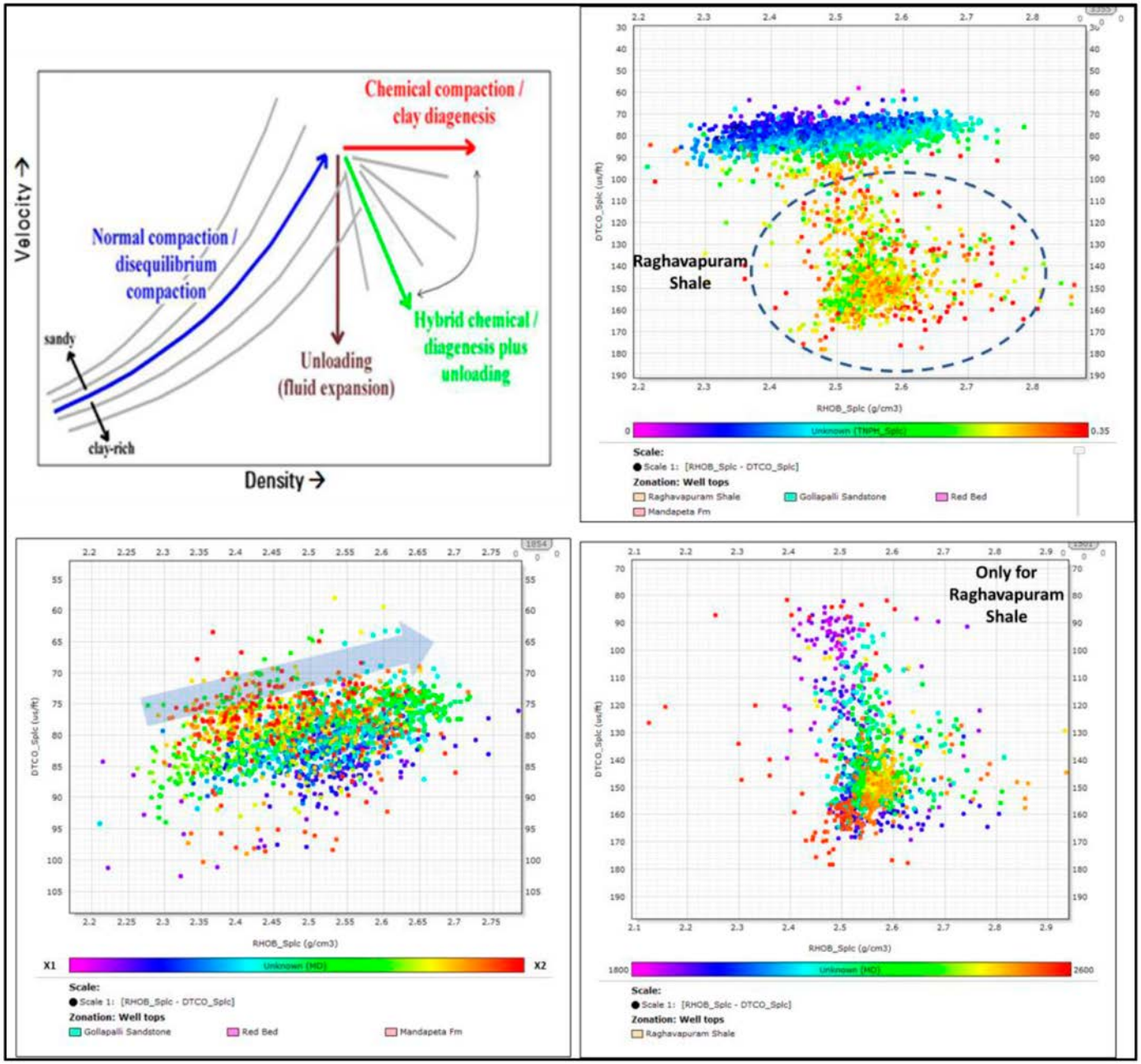

Figure 3. Hoseni plot: cross-plot between compressional slowness and density in well C.

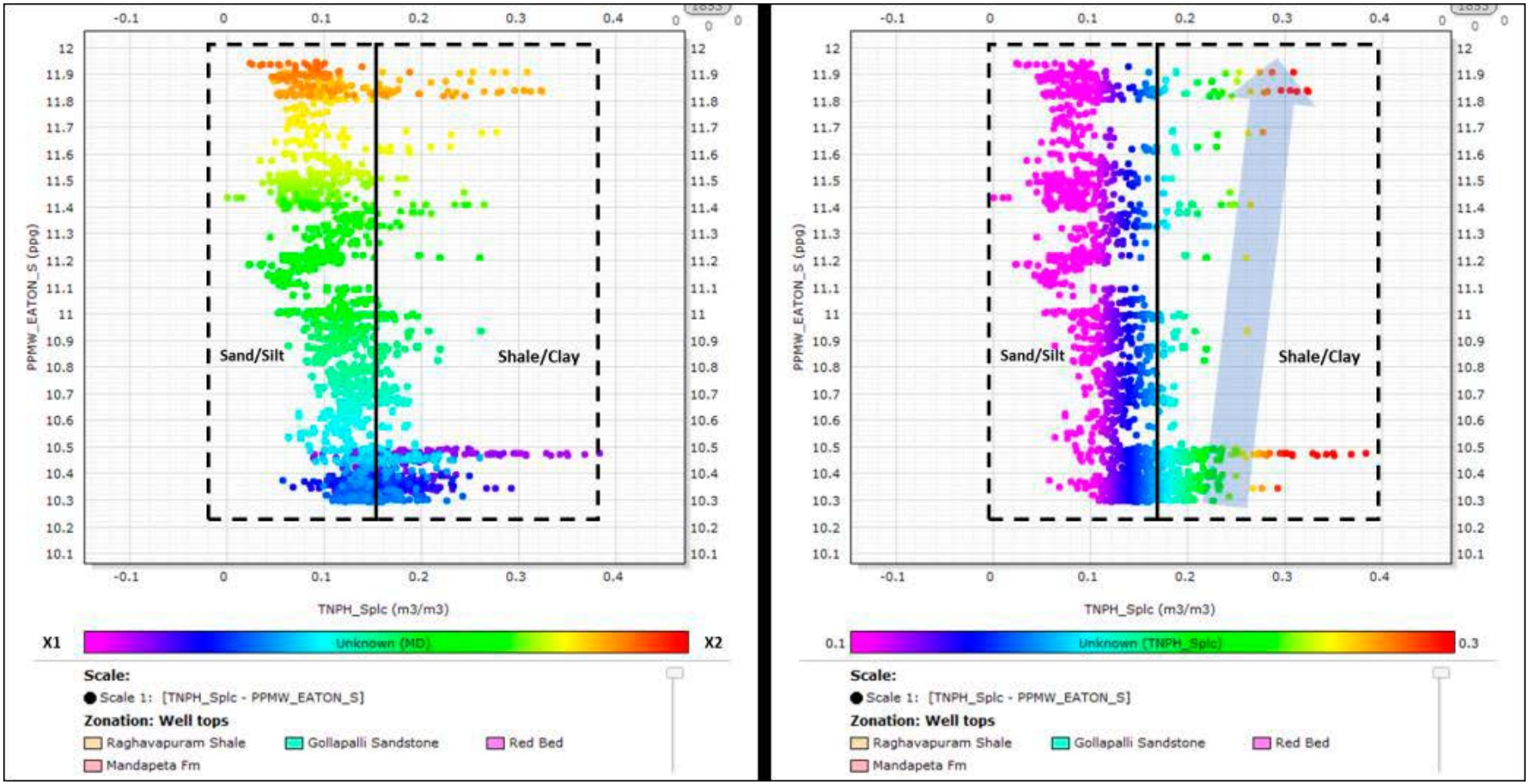

Figure 4. Pore pressure and porosity cross-plot in well C.

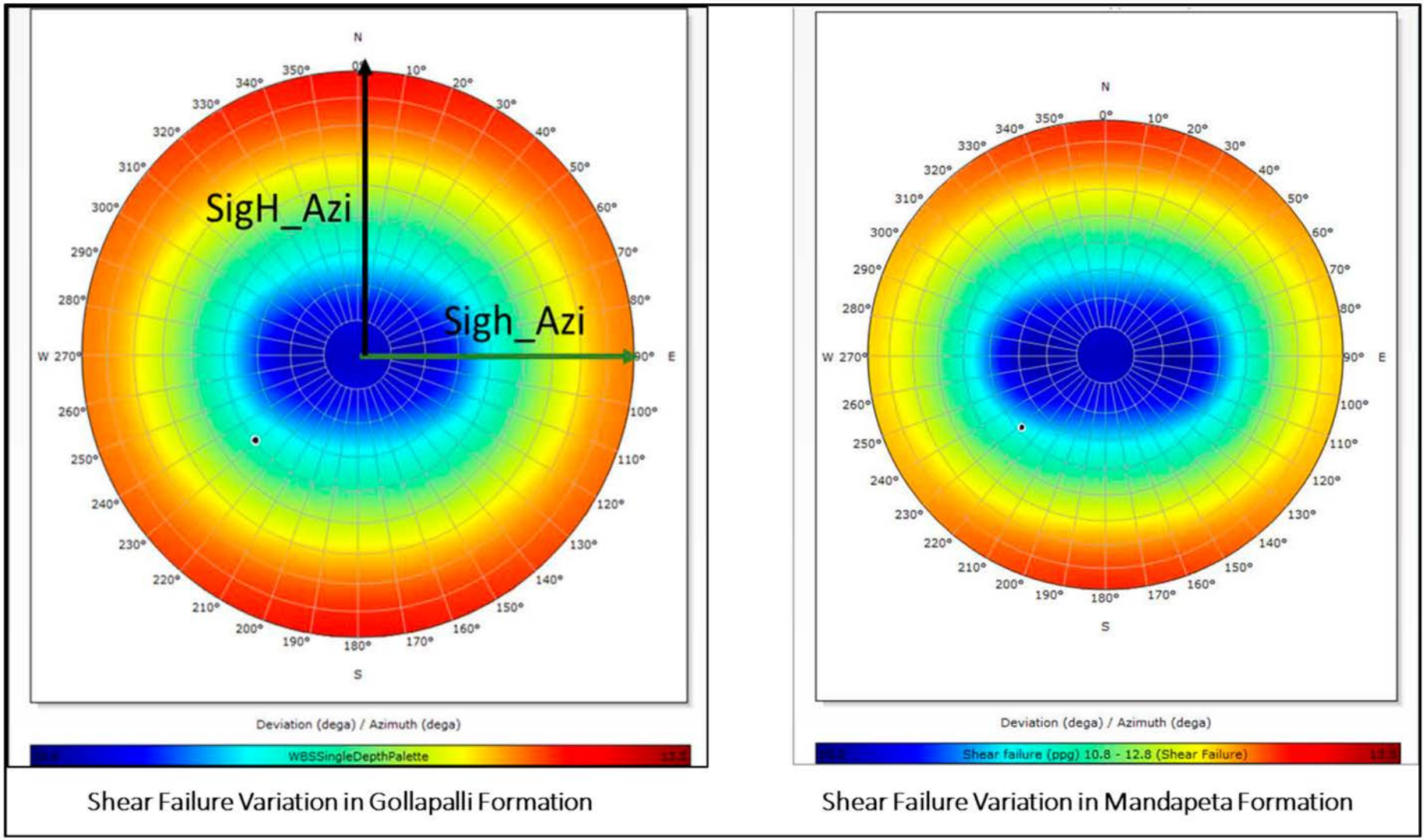

Figure 5. Trajectory sensitivity analysis in Gollapalli and Mandapeta formations in well C.