

PS **Issues of Horizontal Well Log Interpretation: An Example
Longmaxi-Wufeng Shale in Fuling Gas Field of Eastern Sichuan Basin***

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Abstract

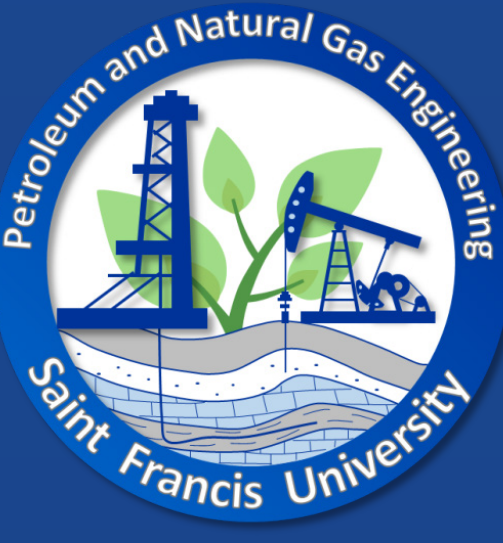
The wireline logs in horizontal wells provide a great opportunity to estimate the lateral variation of reservoir properties. This is a big benefit compared to the log data from vertical wells. But the interpretation of horizontal well log data also brings many new issues. One major issue arises from the log data acquired in horizontal wells. Due to the difference of detection depth and detection direction of various logging tools, the measured zones are not the same. This is not a significant problem for vertical wells, but it has caused some abnormal phenomenon that were observed in horizontal well log data. In this research, we summarized the abnormal phenomenon, then explained the reasons, and finally proposed the methods to deal with it. Another issue is the instability of horizontal wells in mudrocks to reduce the quality of logging data in multiple parts of the horizontal section. To generate a reliable assessment of the shale reservoir, this research proposed a method to detect the low-quality data by caliper logs. The third issue is related to identifying the formation tops in the horizontal section of horizontal wells. Repeat of formation tops becomes common in horizontal wells, especially in the areas where the structure is complex. This makes it a challenge to pick the formation tops in horizontal wells for shale reservoirs.

Longmaxi-Wufeng Shale in Fuling Gas Field is a high-quality, organic-rich mudrock. Shale gas production from this formation has been significantly increased in the last three years. In Fuling Gas Field, horizontal wells have been predominantly drilled with a few vertical wells, which is typical for shale reservoirs. In this research, we use it as an example to discuss the issues of petrophysical analysis of horizontal wells. First, we carried out the log correlation primarily based on gamma ray and the set of porosity logs, to estimate the spatial distribution of the Longmaxi-Wufeng Shale. Then, log normalization and quality control were completed to improve the reliability of the interpretation results. Uranium log with the differences among density, neutron, and acoustic logs were combined together to interpret TOC content, which was verified by core-measured TOC content. Finally, the volume percentage of clay minerals were estimated by CGR (gamma ray from thorium and potassium only) log and neutron log in aid of XRD data and ECS logs, as an intermediate step to proximately estimate the brittleness of organic shale.

Selected References

Wang, G., S. Long, Y. Ju, C. Huang, and Y. Peng, 2018, Application of Horizontal Wells in 3-D Shale Reservoir Modeling: A Case Study of Longmaxi-Wufeng Shale in Fuling Gas Field, Sichuan Basin: American Association of Petroleum Geologists Bulletin, v.102/11, p. 2333-2354. doi.org/10.1306/05111817144

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Issues of Horizontal Well Log Interpretation: An Example Longmaxi-Wufeng Shale in Fuling Gas Field of Eastern Sichuan Basin

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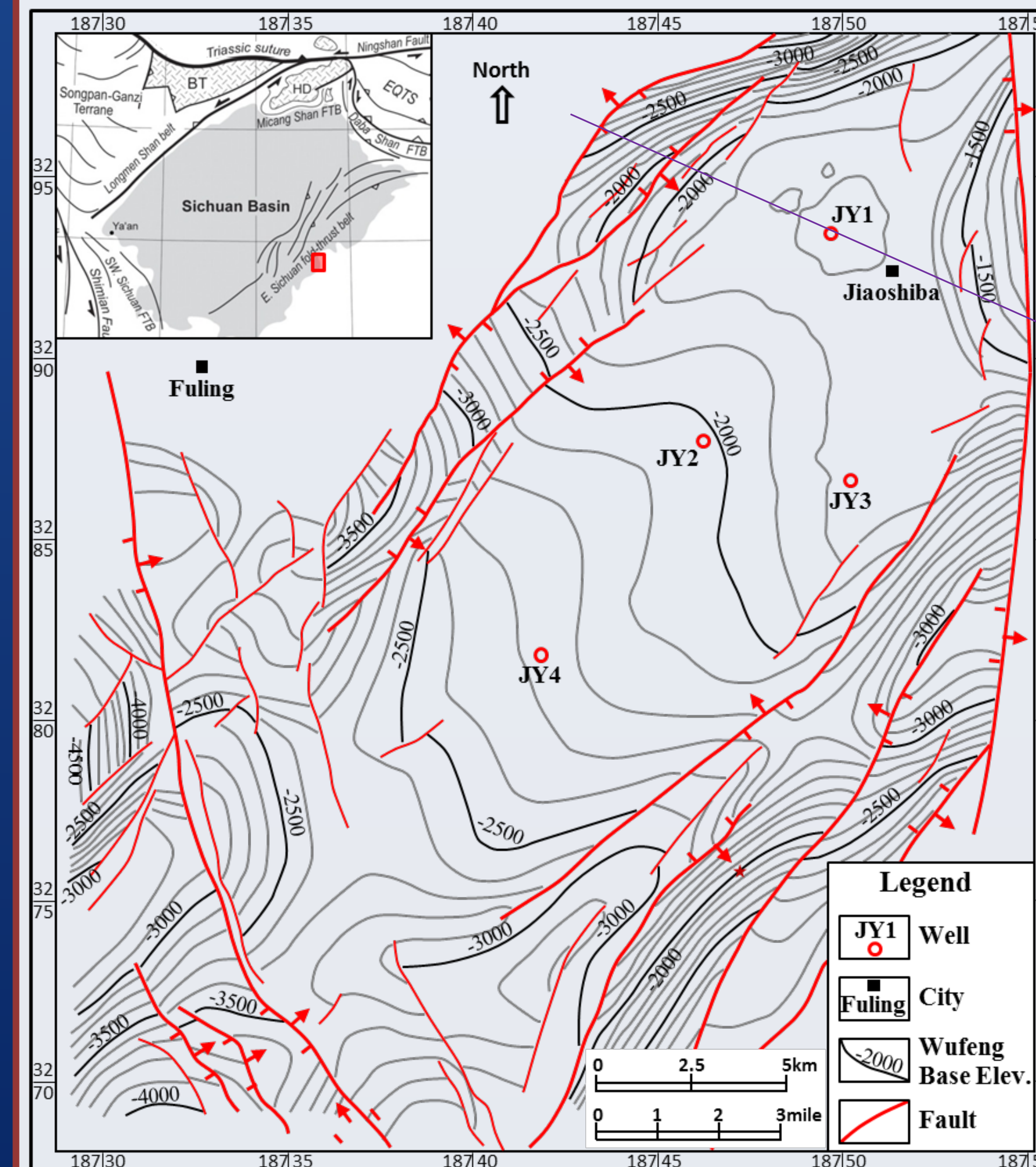
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❖ Introduction

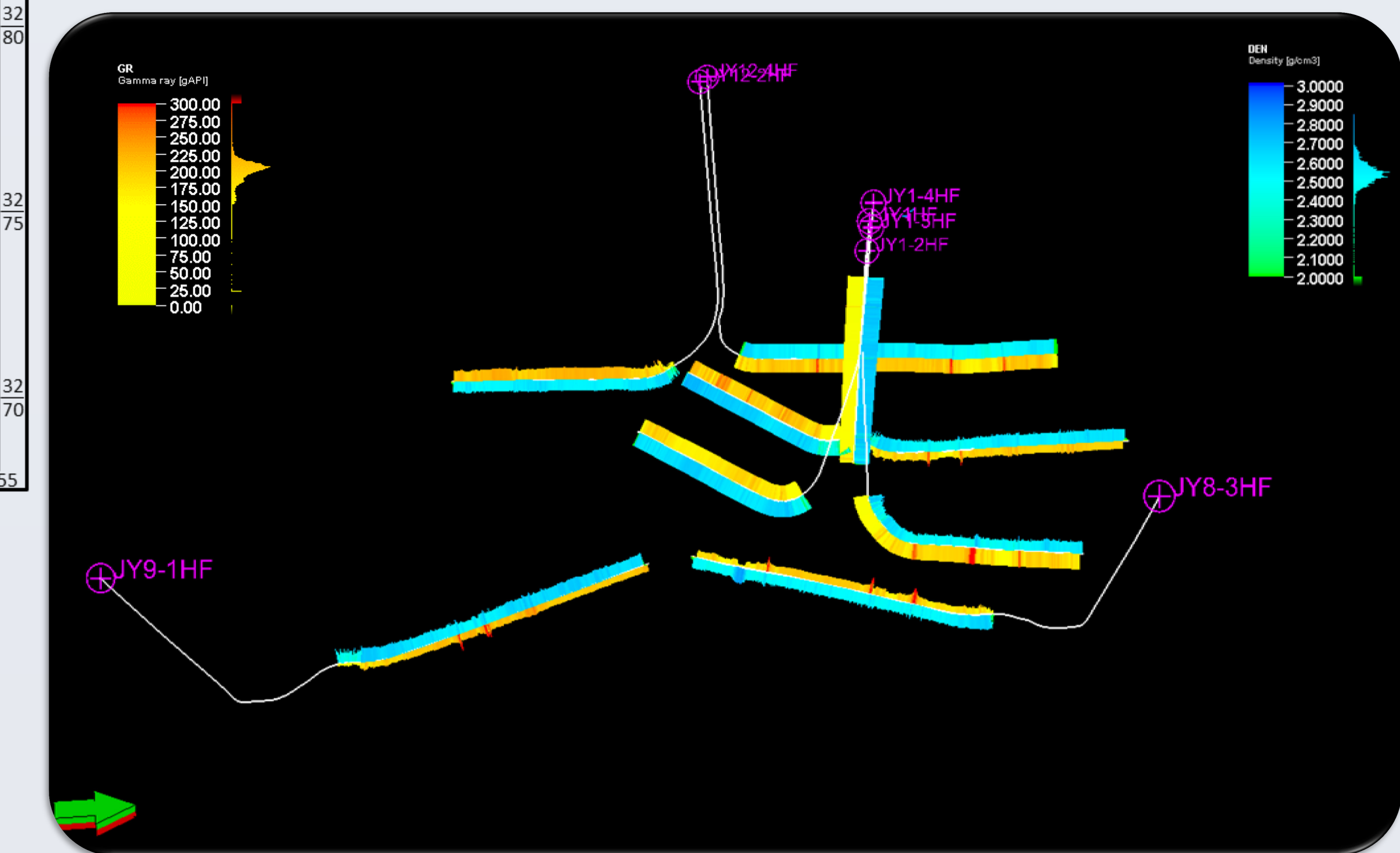
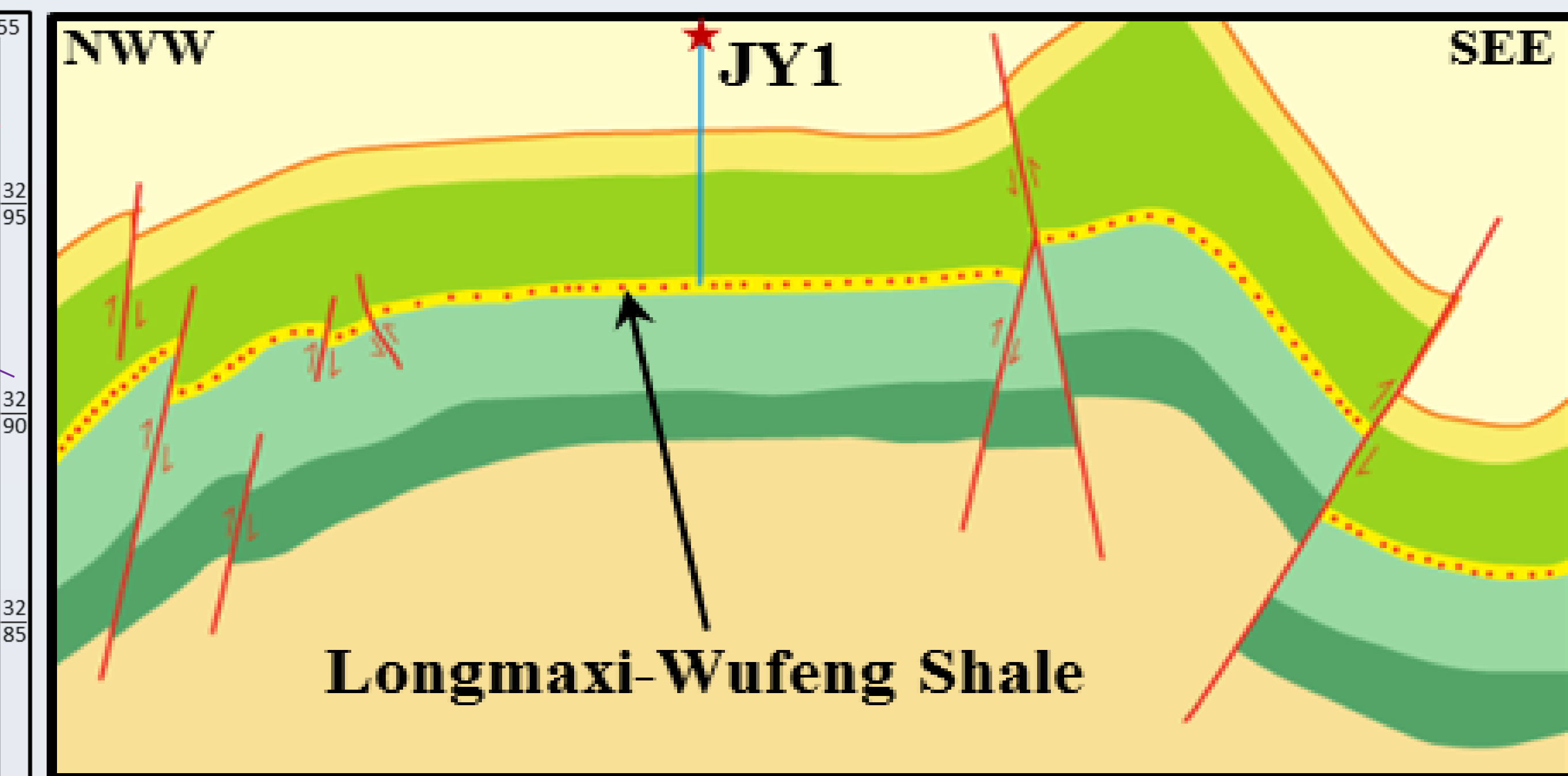
The wireline logs in horizontal wells provide a great opportunity to estimate the lateral variation of reservoir properties. This is a big benefit compared to the log data from vertical wells. But the interpretation of horizontal well log data also brings many new issues. One major issue arises from the log data acquired in horizontal wells. Due to the difference of detection depth and detection direction of various logging tools, the measured zones are not the same. This is not a significant problem for vertical wells, but it has caused some abnormal phenomenon that were observed in horizontal well log data. In this research, we summarized the abnormal phenomenon, explained the reasons, and proposed methods to deal with it. Another issue is the instability of horizontal wells in mudrocks to reduce the quality of logging data in multiple parts of the horizontal section. To generate a reliable assessment of the shale reservoir, this research proposed a method to detect the low-quality data by caliper logs. The third issue is related to identifying the formation tops in the horizontal section of horizontal wells. Repeat of formation tops become common in horizontal wells, especially in the areas where the structure is complex. This makes it a challenge to pick the formation tops in horizontal wells for shale reservoirs.

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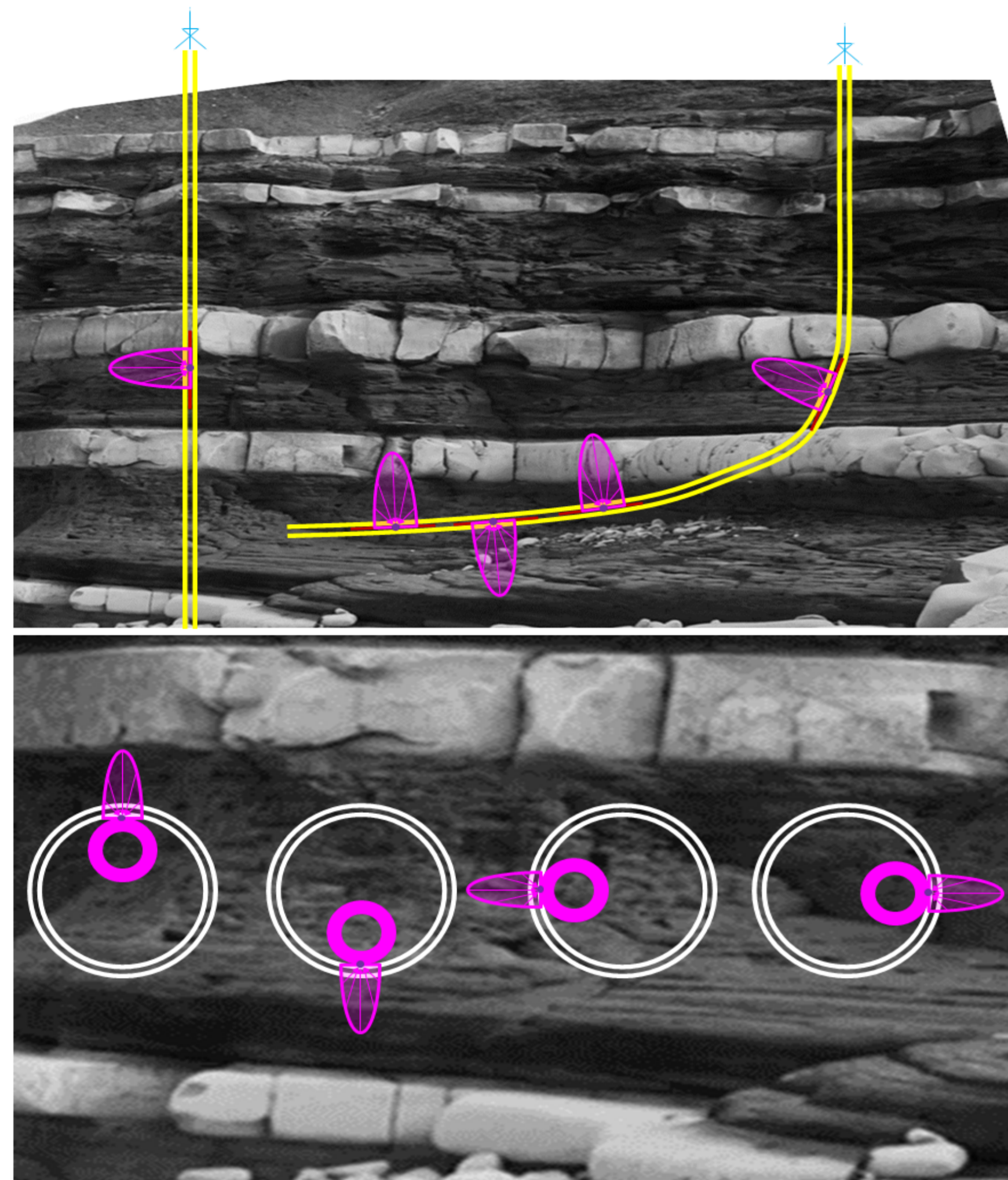
❖ Study Area and Dataset



Fuling Gas Field is an anticline with many boundary faults. Our well data is from 9 wells (1 vertical well and 8 horizontal wells) in the northern Fuling Gas Field, including conventional log data, well location, and well trajectory. In addition, one well has ECS log also.



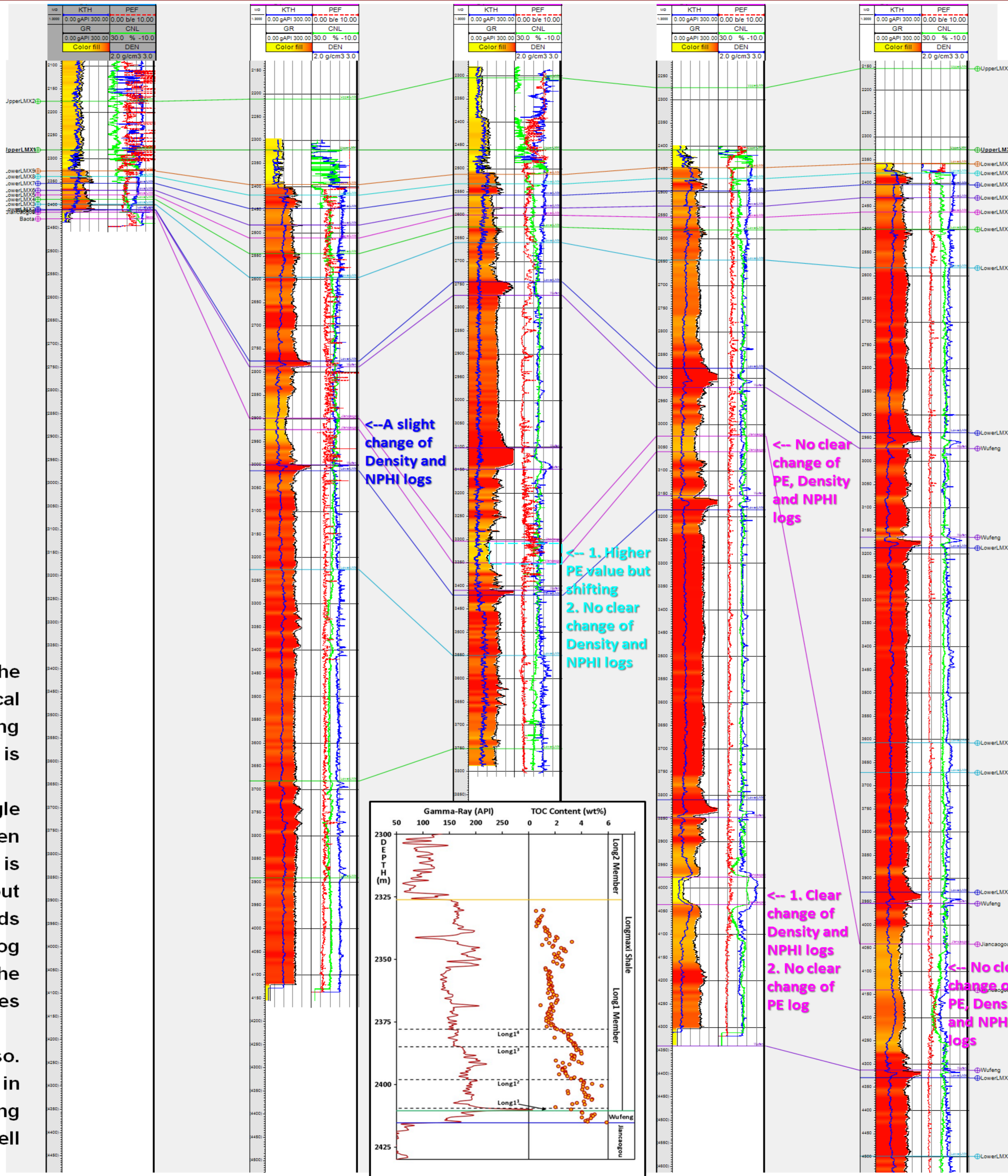
❖ Issues Related to Logging Process: Direction and Position of Logging Tools



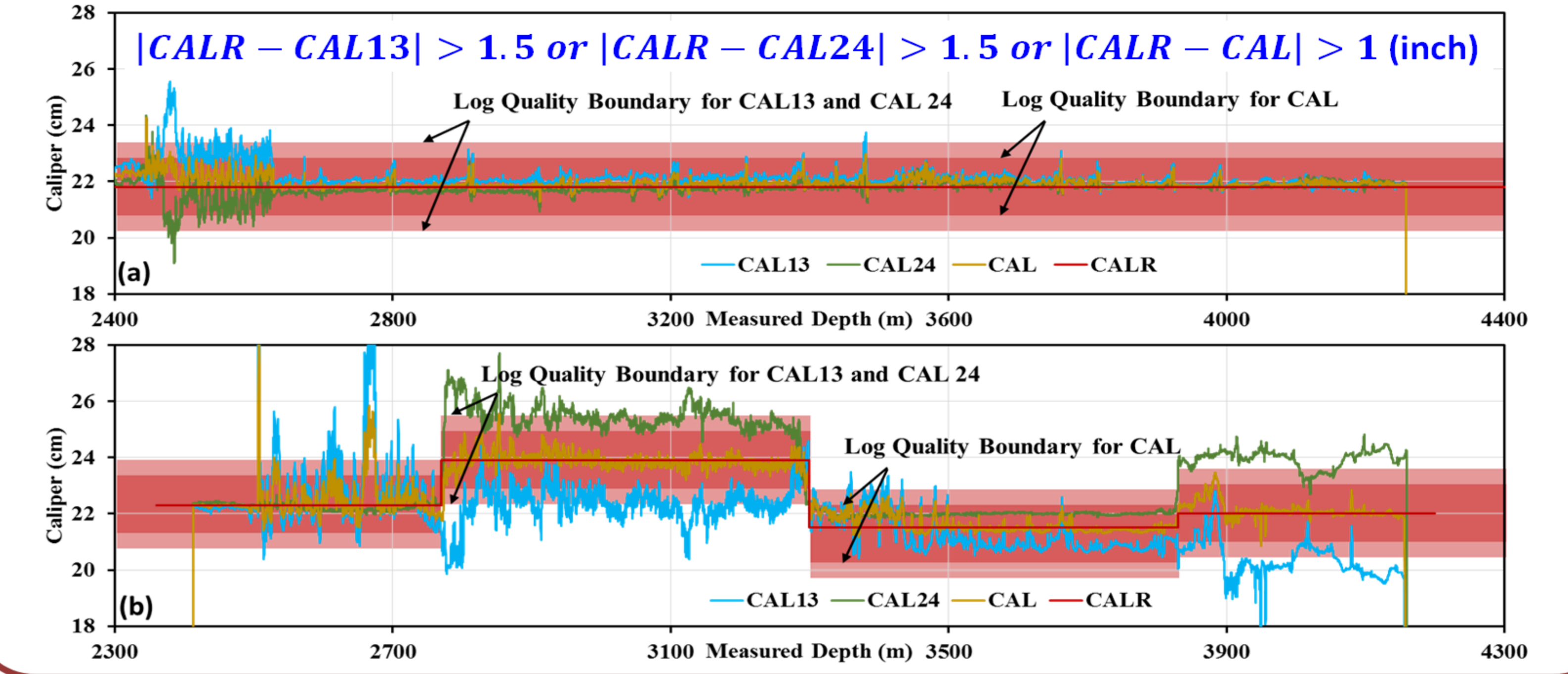
Property value from logging tools usually stands for the weighted average of rocks within an ellipsoid. In vertical well, the logging tool is about perpendicular to the bedding surface, thus the signal recorded in logging tool is primarily from the some formation.

In the horizontal well, at different part of well, the angle between wellbore and bedding surface is different. When the wellbore is about normal to the bedding surface, it is the same as vertical well; when the wellbore is about horizontal to the bedding surface, the logging tool records signal from multiple layers close to the wellbore, so the log value stands the average of multiple layers; when the angle is between 0° and 90°, the logging tool measures multiple layers.

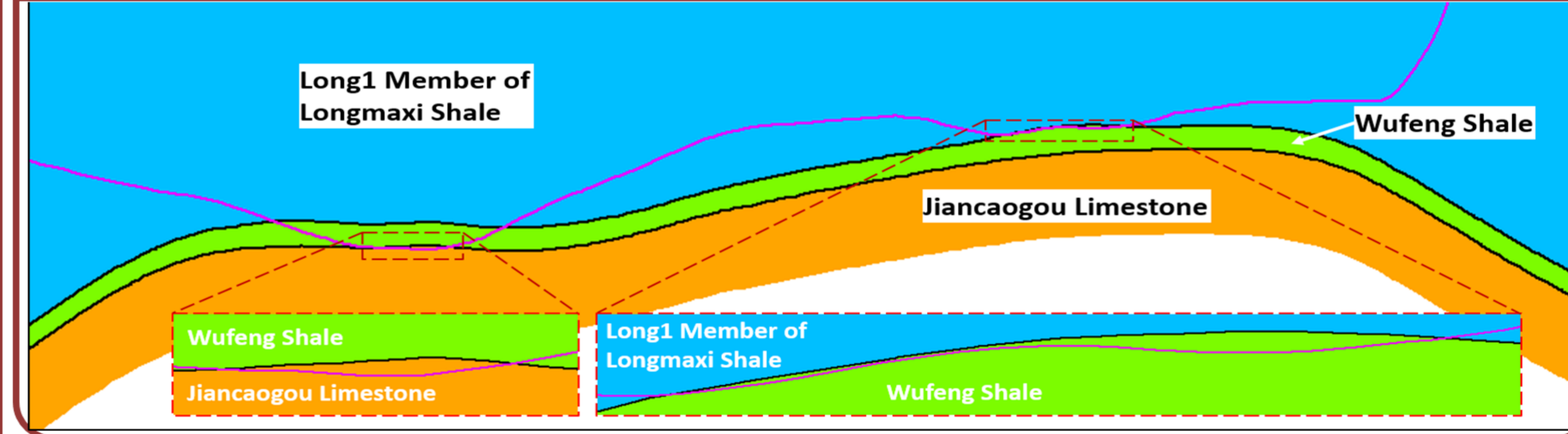
The position of logging tool in wellbore is important also. The measurement with different location of logging tool in wellbore should be similar in vertical well since measuring the same layer, but will be very different in horizontal well because possibly measuring different layers (figure left).



❖ Instability of Wellbores in Horizontal Wells



❖ Repetition of Formation Tops in Horizontal Wells



❖ Conclusion

This research identifies the issues of logging data in horizontal wells, using data from Fuling Gas Field, eastern Sichuan Basin. In most segments of horizontal wells, wellbore is not perpendicular to the bedding surface, causing the logging tools recording signals from multiple layers and the measured layers different with different position of tools in wellbore and different investigation range. Therefore, the log curves at the same measured depth may respond to different rocks. The other two issues are the instability of wellbore in horizontal wells and repetition of formation top in horizontal wells.

❖ Acknowledgement

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