Rock Physics Diagnostics, Effective Medium Models and AVO Analysis of the Stø Formation, Hammerfest Basin, Norway

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Abstract

- Rock physics diagnostic provides a robust tool for determining an effective medium model
- The effective medium model relates reservoir properties, such as porosity, clay content or water saturation to elastic properties
- Based on the derived elastic properties, half-space models can be created to model the seismic AVO response
- Furthermore, an effective medium model allows for robust rock physics modeling of reservoir parameters to evaluate other reservoir scenarios, not seen in the wells

Case study

- The rock physics diagnostic procedure was undertaken on the Stø Formation in the Hammerfest Basin, offshore Norway
- Various reservoir fluid and shale cap-rock conditions were modeled using the effective medium model, derived in the rock physics diagnostic procedure
- The AVO signature of the various reservoir scenarios was predicted. This can then be used to evaluate areas covered by the seismic but not yet drilled

Objective and Scope

- Develop effective medium model from well logs
- Rock physics modeling
- AVO analysis
- Relate elastic properties to reservoir properties
- Predict lithology and pore-saturating fluid

Reservoir Geology

- Stø Formation comprises three different litho-facies (from bottom to top)
    - Near-shore deposits (quartz arenite)
    - Transgressive mudstone
    - Prograding sandstone
- Overlain by the Late Jurassic Fuglen and Hekkingen cap-rock Formations
- Porosity ranges between 18 – 20 %
- Permeability ranges between 200 – 800 mD

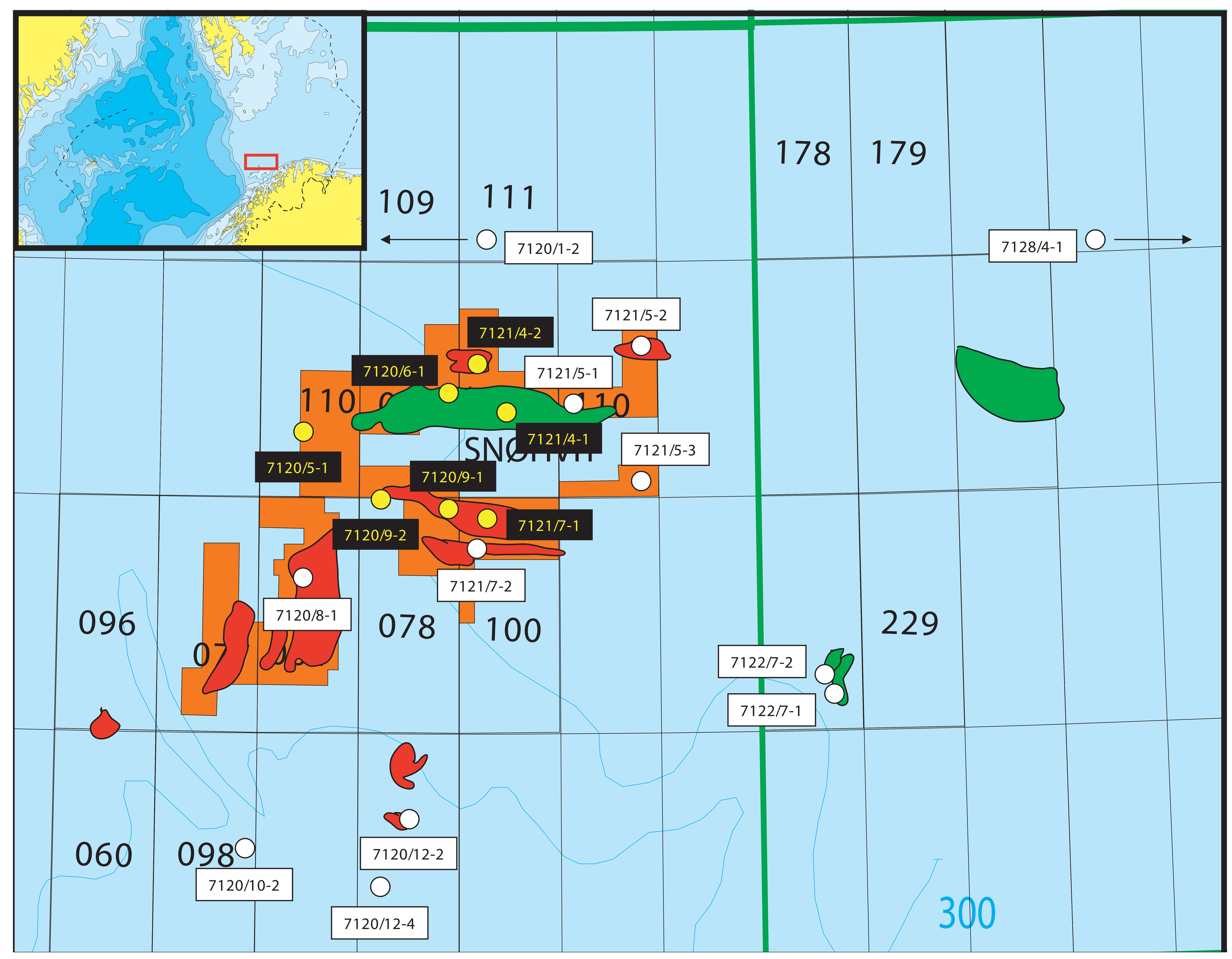

Figure 1. Location of the Stø Formation, Hammerfest Basin, Norway

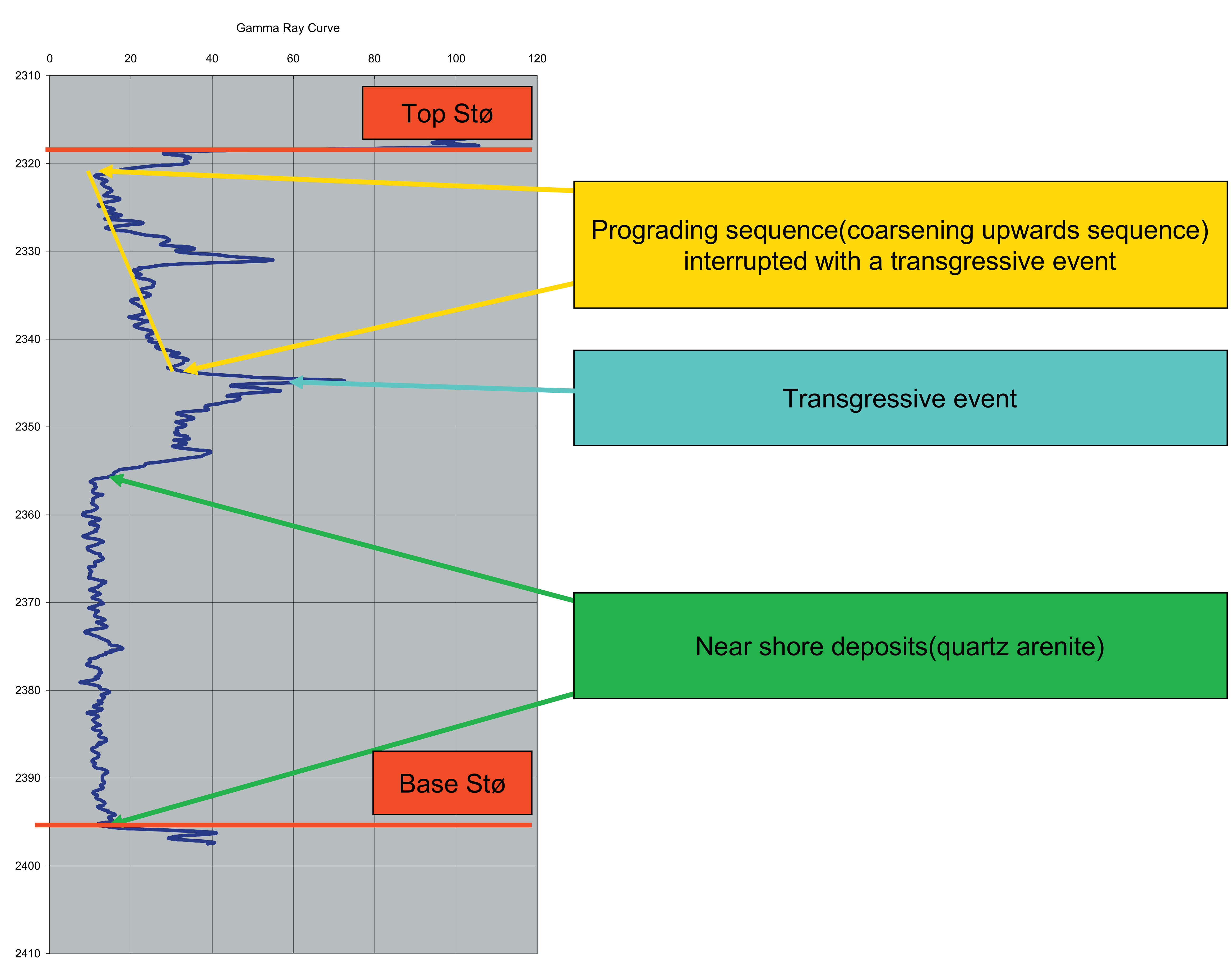

Figure 2. Log plot of the Gamma Ray curve from Well "A", detailing the main reservoir characteristics.

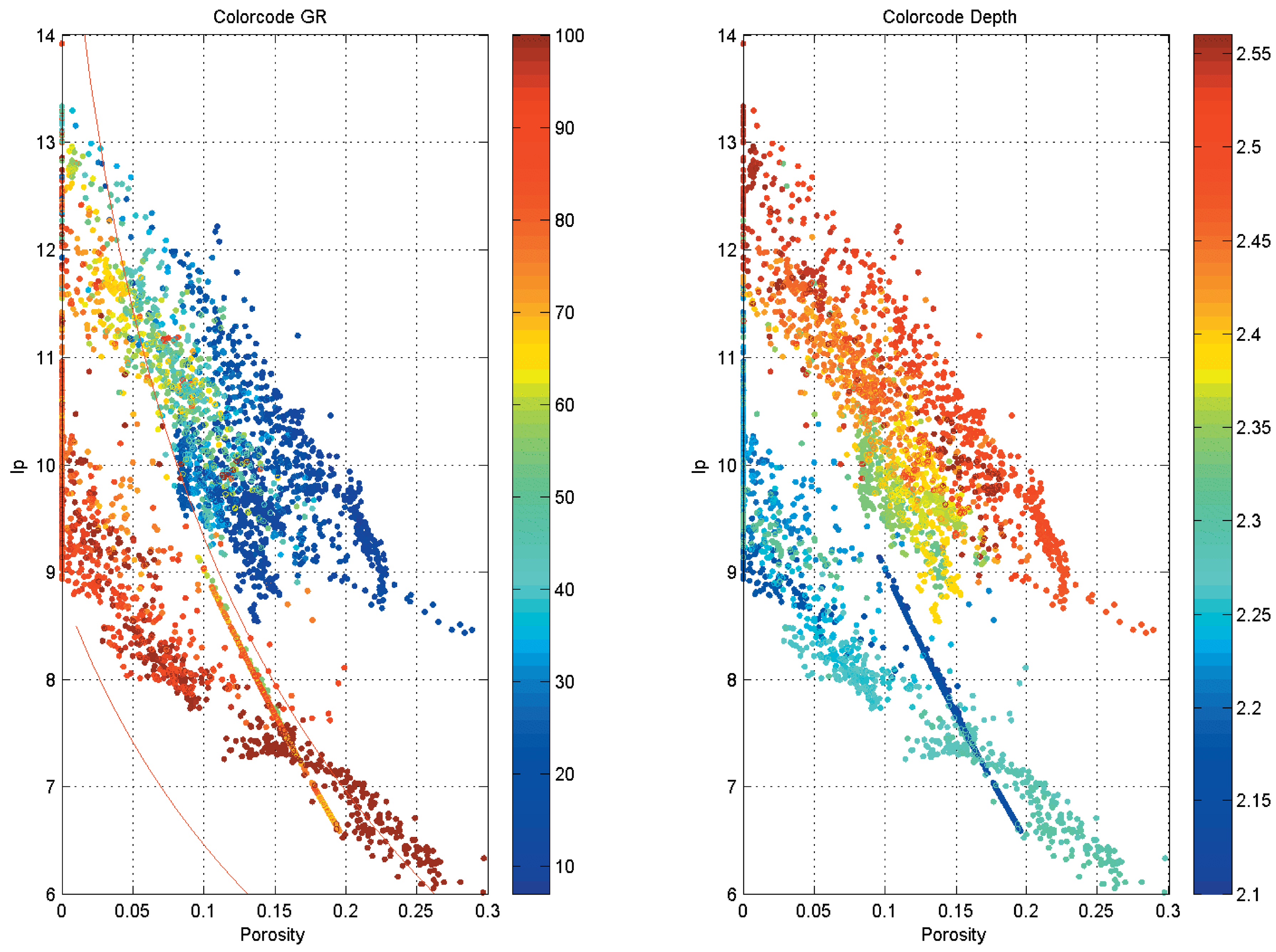

Figure 3. Acoustic Impedance vs. Porosity color-coded by GR on the left and depth (in meters) on the right. The data is overlain by the uncemented sand model

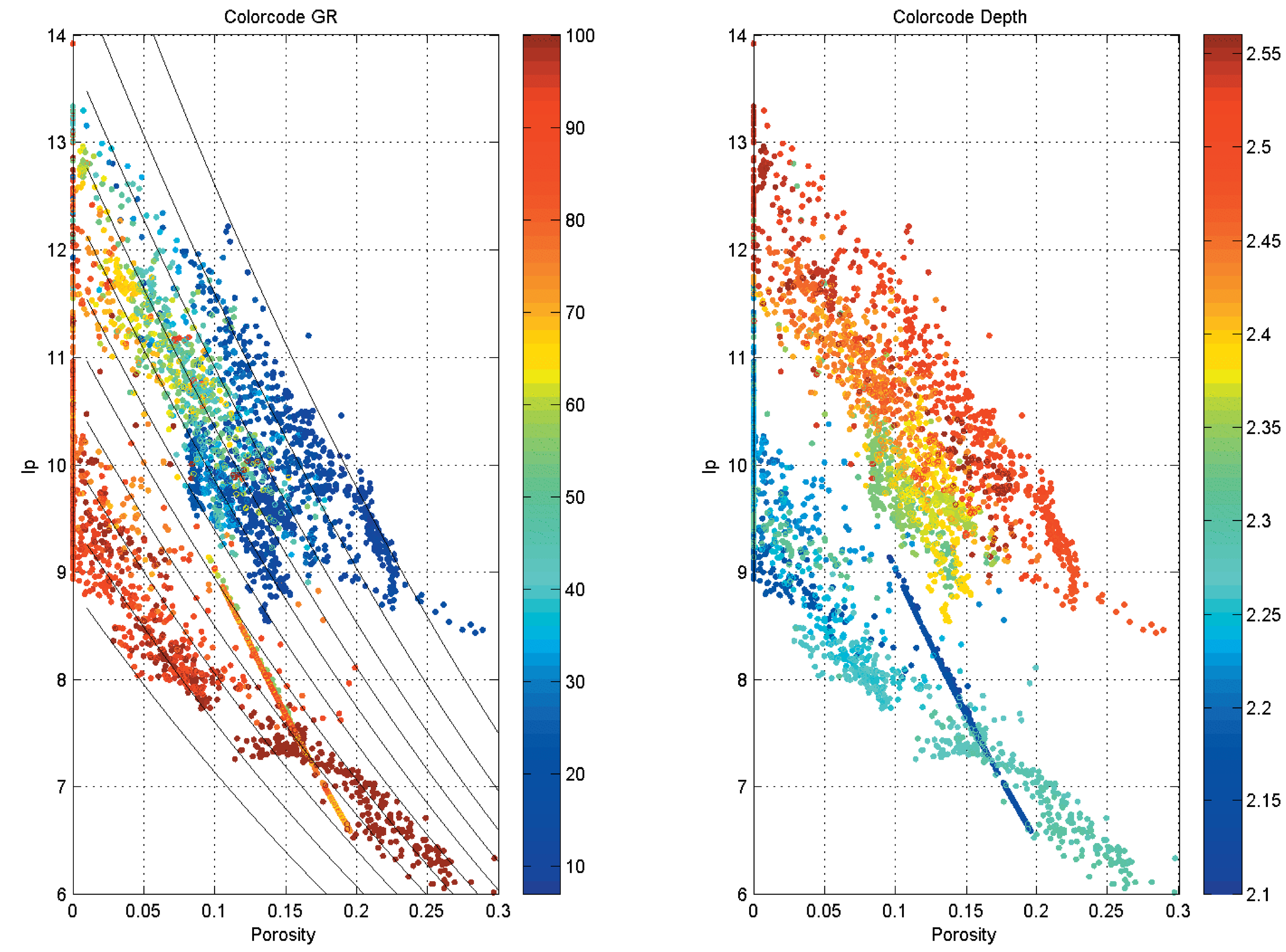

Figure 4. Acoustic Impedance vs. Porosity color-coded by GR on the left and depth (in meters) on the right. The data is overlain by the Raymer model.

Rock Physics Diagnostics and the Effective Medium Model

- Trial and error process using several different effective medium models
- Uncemented sand model fails to describe the data (see figure 3)
- Raymer model describes the data quite adequately (see figure 4)
- Raymer model utilized to transform acoustic impedance values in seismic data to porosity values

AVO Modeling

- Half Space models for various reservoir scenarios were created and the AVO characteristics was modeled using the Hilterman approximation to the Zoeppritz equation
- In conjunction with the effective medium model, the AVO behavior gain insight into possible responses in the inter-well region
- As opposed to statistically derived models, the effective medium models are more robust when moving away from well-control

Conclusion

- Rock Physics Diagnostics aids in the interpretation of seismic data
- The rock physics diagnostic procedure provides a tool to define the best effective medium model for a given location
- Furthermore, the effective medium model can be used to model various reservoir scenarios, and evaluate the differences in AVO response
- An effective medium model can be used to transform elastic impedance values from seismic to reservoir properties

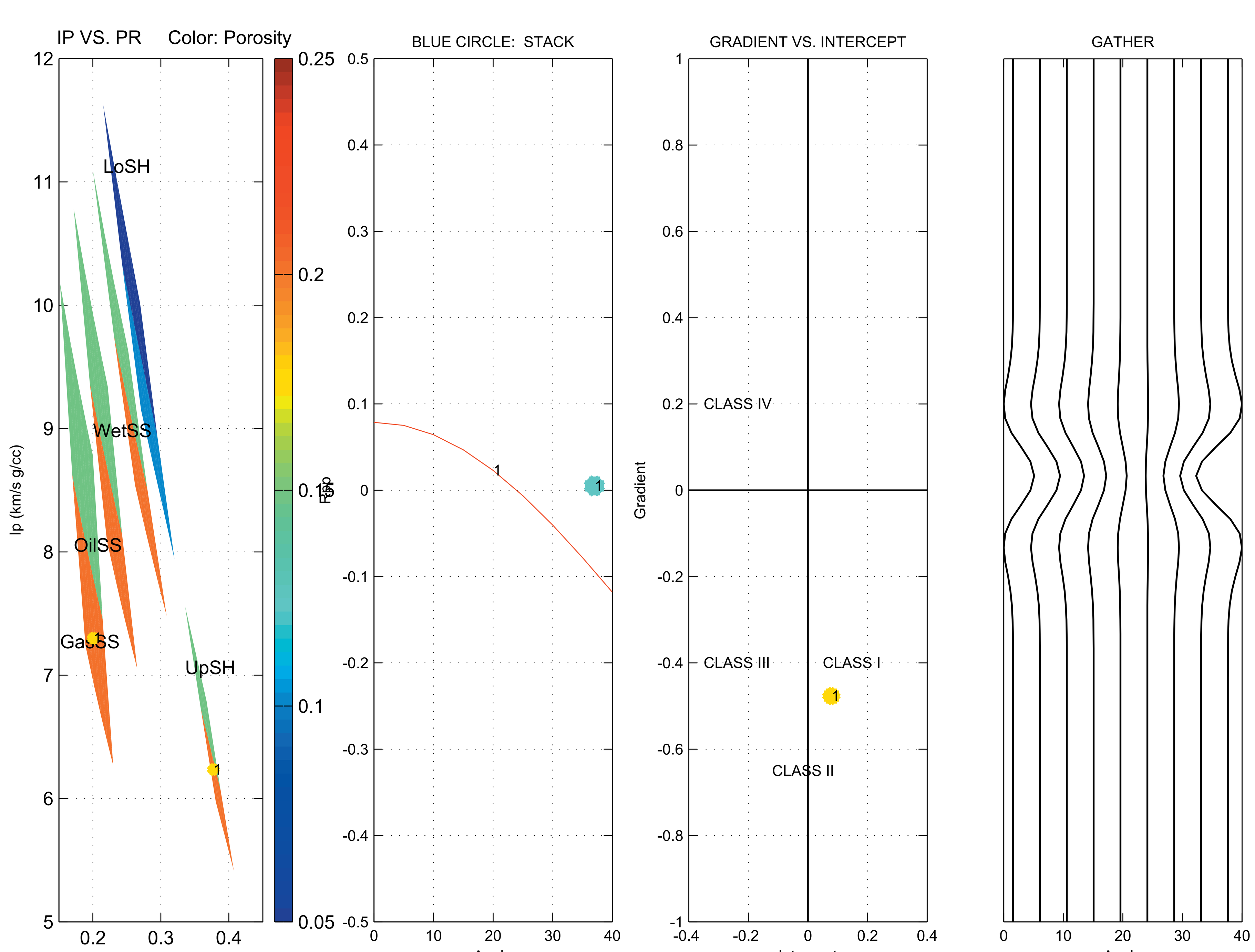

Figure 5. AVO response, shown is an example of the first of the modeled instances, exhibiting response between shale and gas sand.

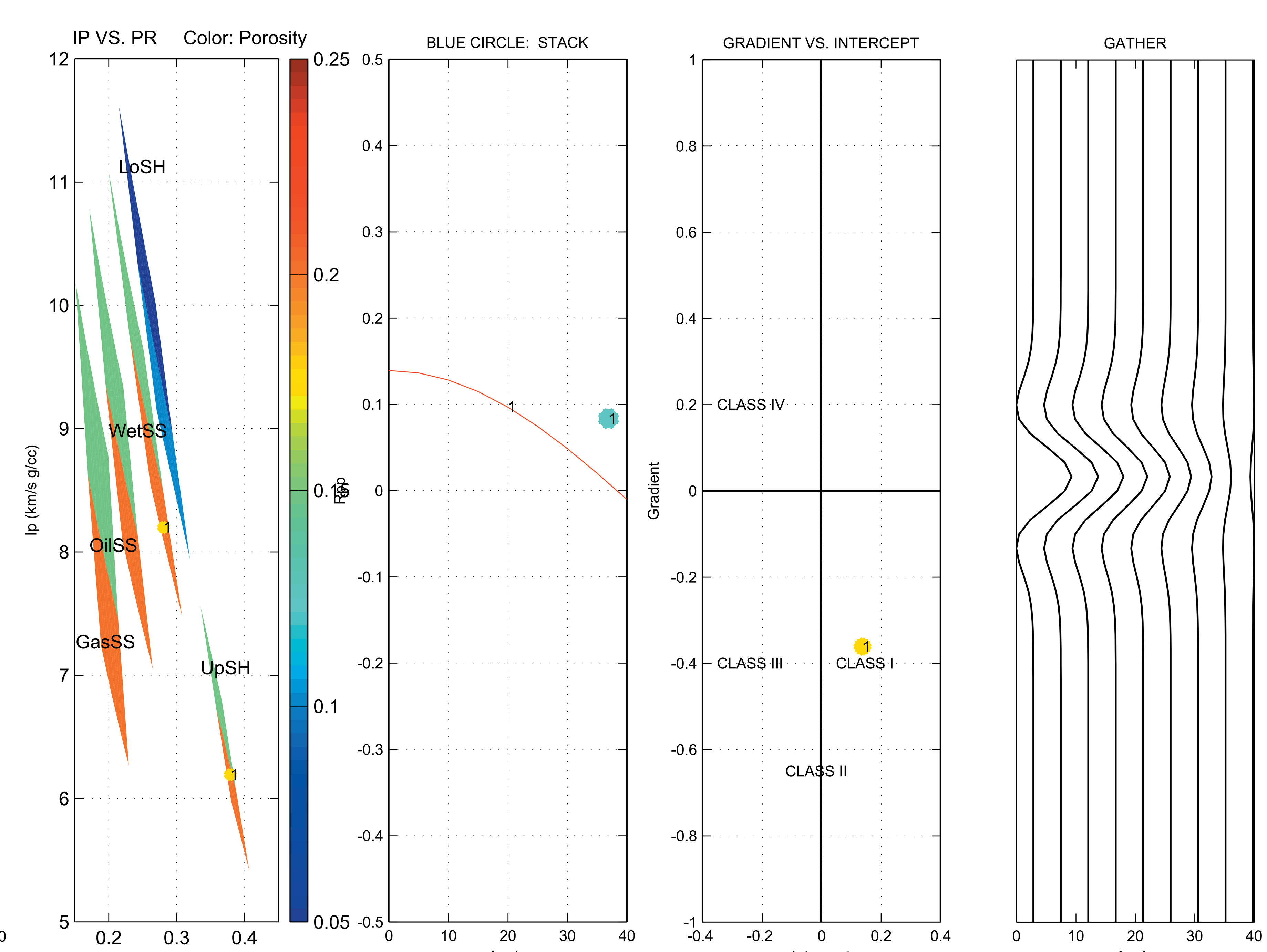

Figure 6. AVO response, shown is an example of the second of the two modeled instances, exhibiting response between shale and wet sand.