Extended elastic impedance from a rock physics point of view – a Norwegian Sea demonstration

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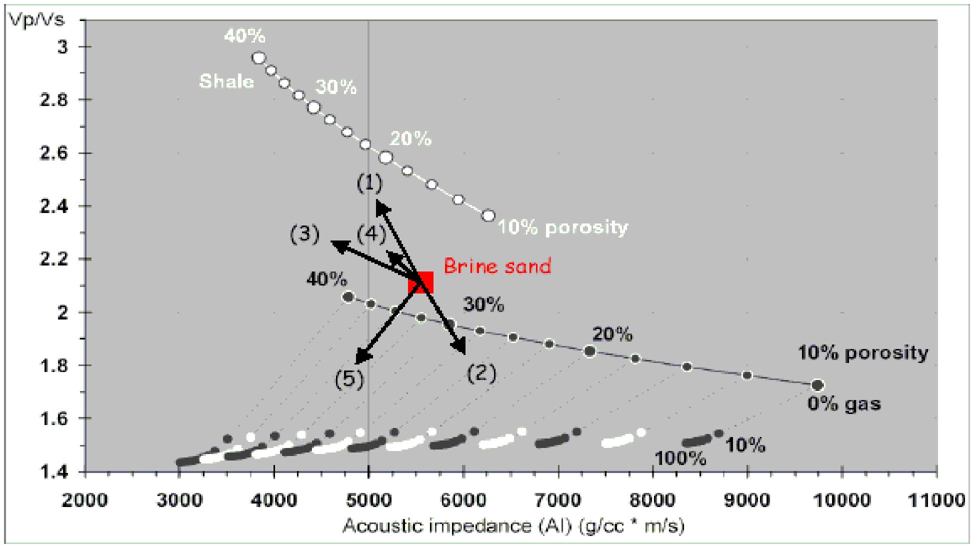
Outline

- Motivation
- Extended elastic impedance (EEI)
- EEI and rock physics trends
- Yttergryta AVO anomaly and seismic inversion results
- Pseudo-elastic impedance for prospect mapping

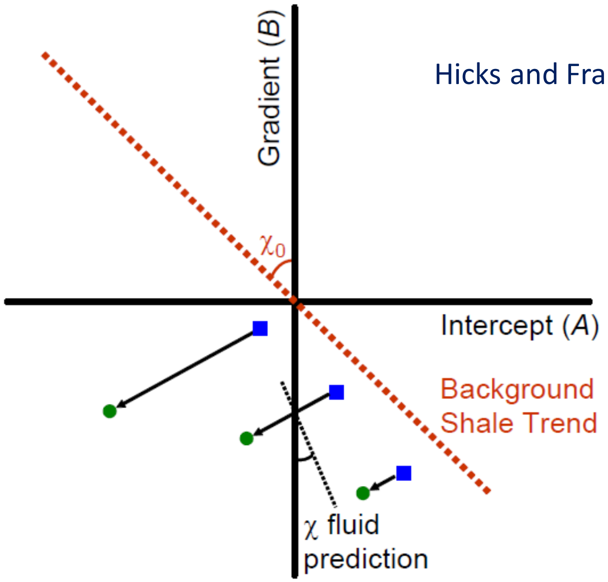
Motivation: Lithology and fluid mapping from seismic

AVO crossplot

Rock physics template



Ødegaard and Avseth, 2004



$$R_S(\chi) = A\cos\chi + B\sin\chi$$

$$\tan\chi_0 = -A/B$$

Model driven
(e.g.: Hertz-Mindlin, Hashin-Shtrikman + Gassmann)

Data driven
(e.g. Fluid factor, Extended elastic impedance)

Extended elastic impedance

Connolly, 1999

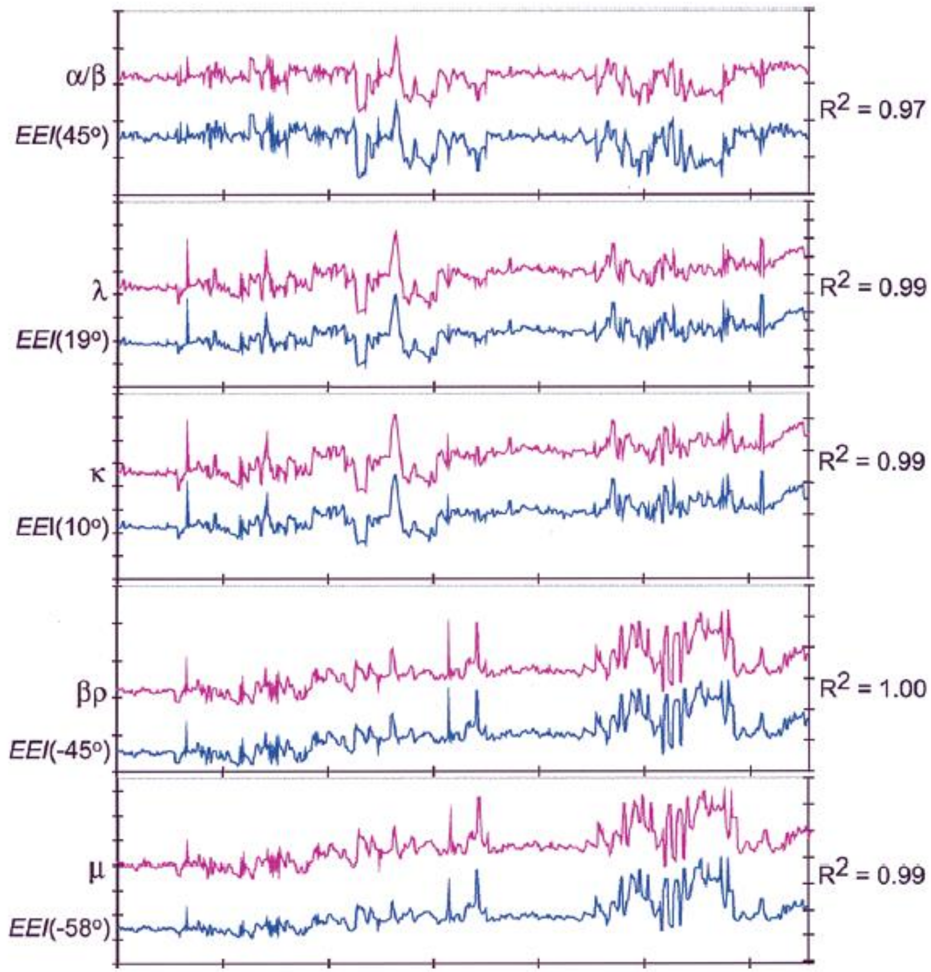
$$EI = V_P^{(1+\sin^2\theta)} V_S^{(-8K\sin^2\theta)} \rho^{(1-4K\sin^2\theta)}$$

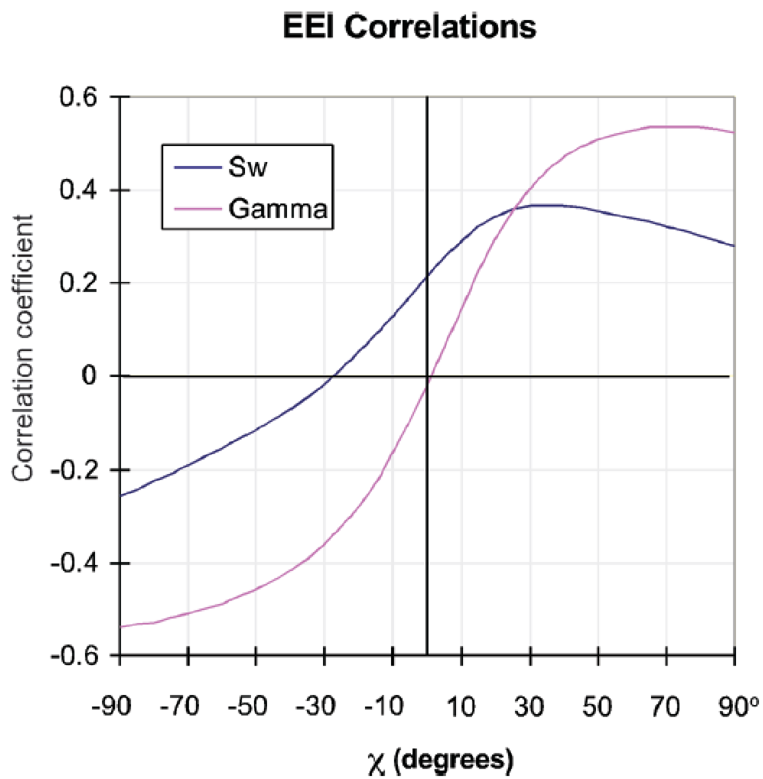
Whitcombe et al., 2002

$$EEI(\chi) = [V_{P0}\rho_0]\left(\frac{V_P}{V_{P0}}\right)^{(\cos\chi+\sin\chi)}\left(\frac{\rho}{\rho_0}\right)^{(\cos\chi-4K\sin\chi)}\left(\frac{V_S}{V_{S0}}\right)^{(-8K\sin\chi)}$$

EEI (0) = AI EEI(45) α Vp/Vs

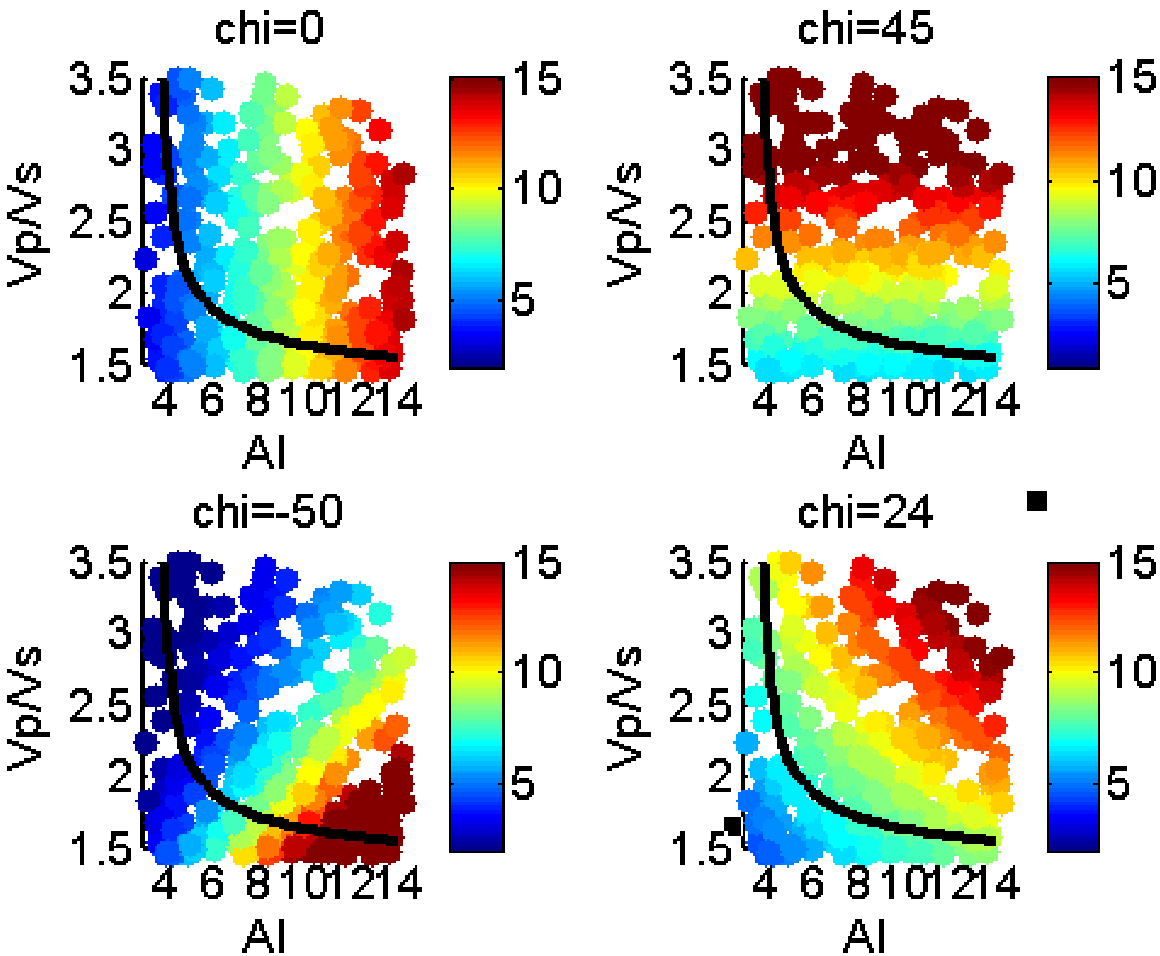
Extended elastic impedance can be correlated to elastic parameters and petrophysical properties



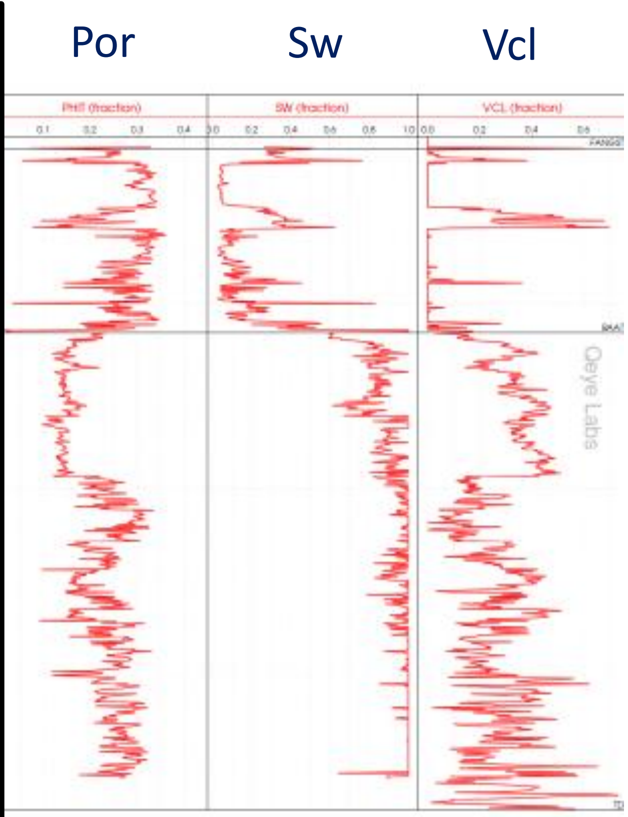


Whitcombe et al., 2002

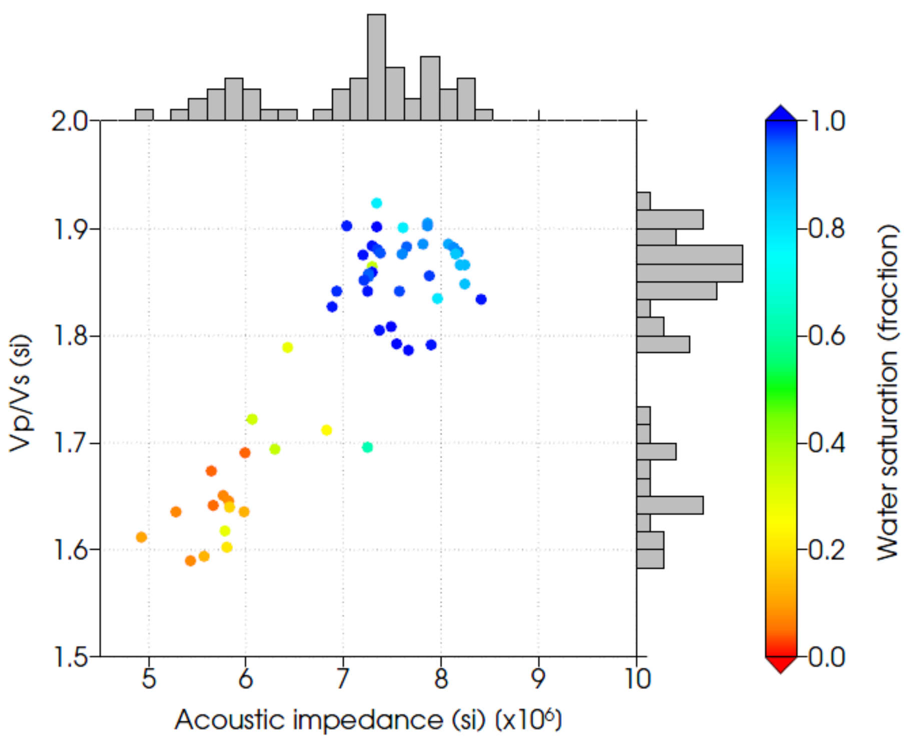
Extended elastic impedance versus rock physics templates

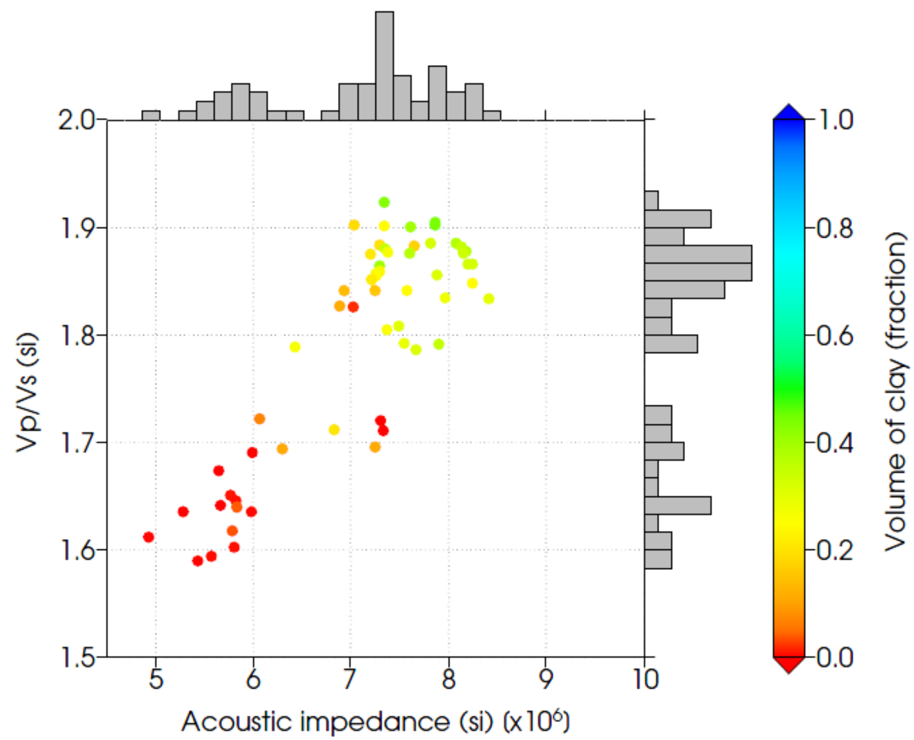


Yttergryta gas/condensate field – petrophysical well log data

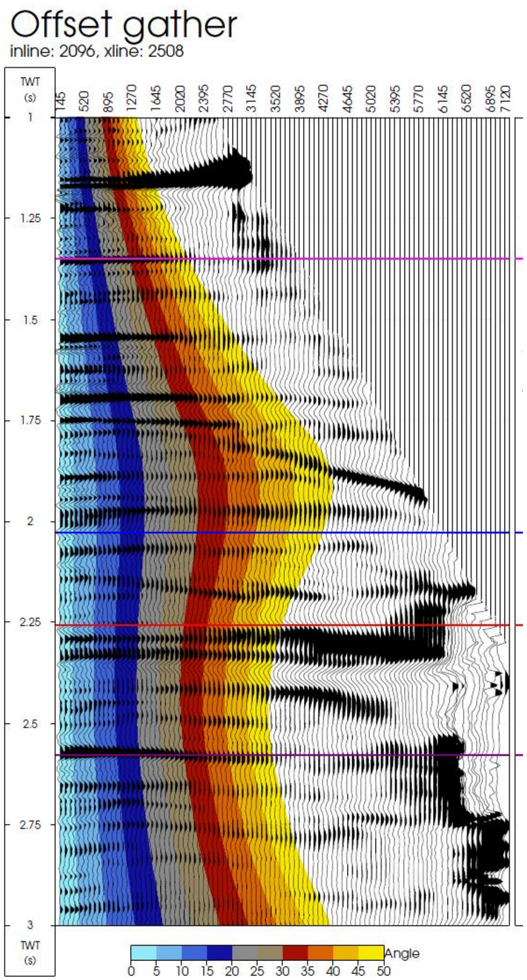


Rock physics crossplots, Yttergryta target zone

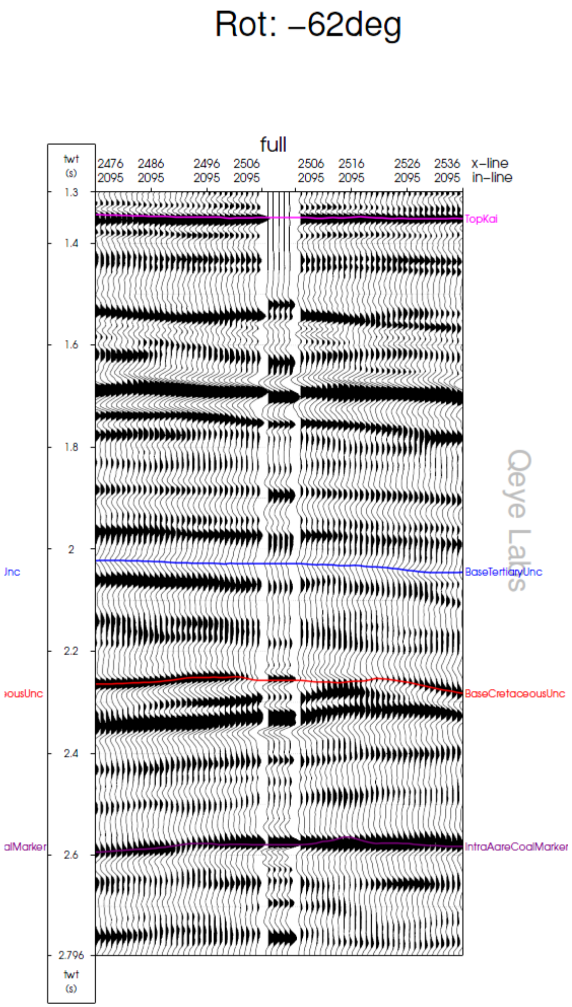




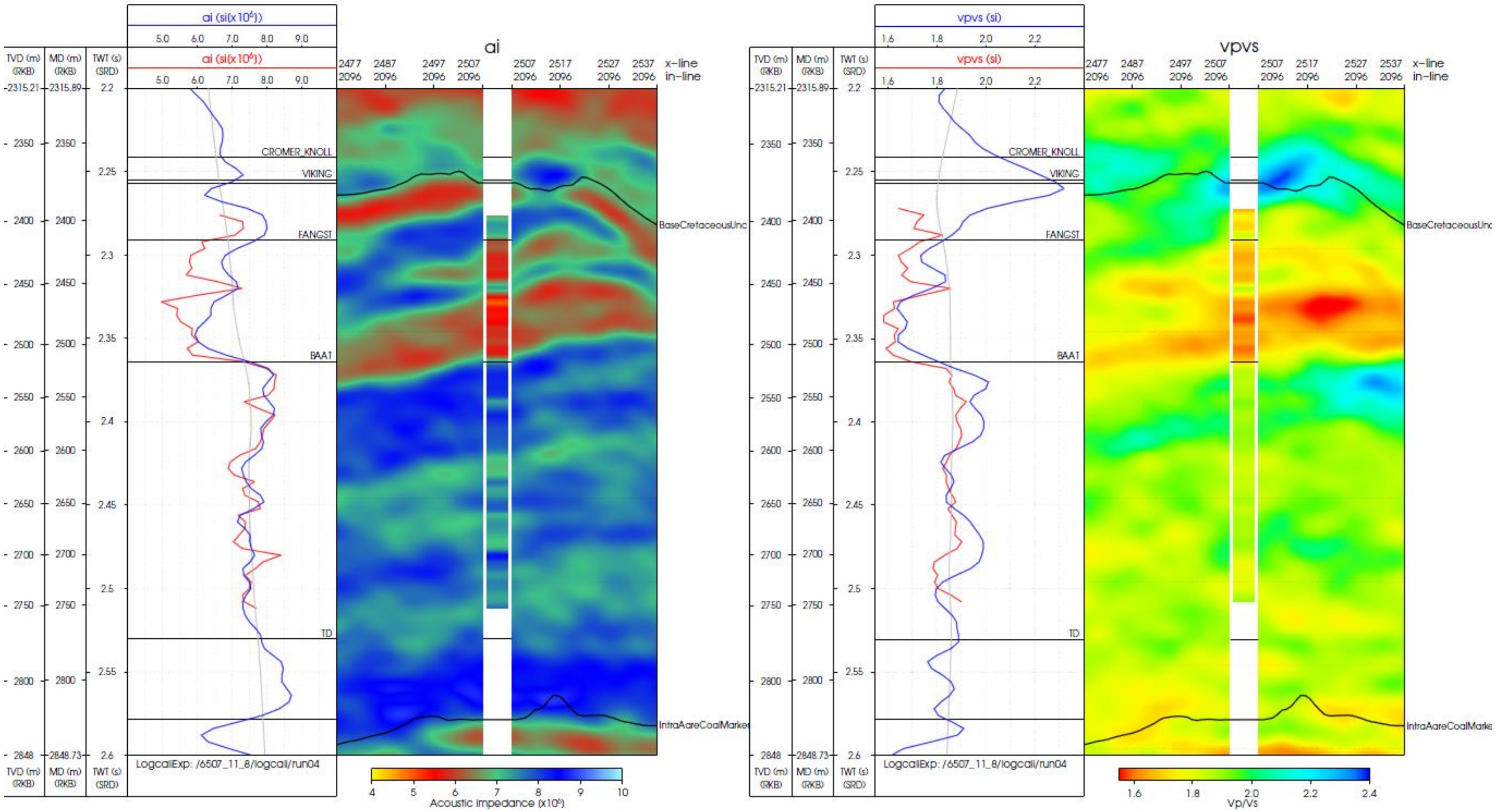
CDP gather and well tie, Yttergryta



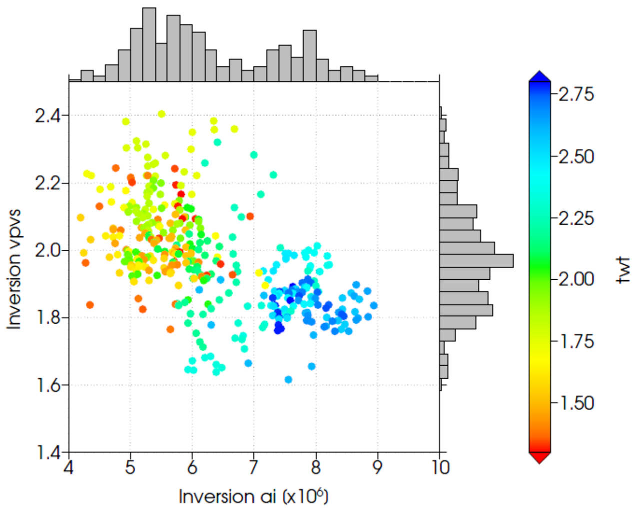
AVO anomaly
(class II-III)

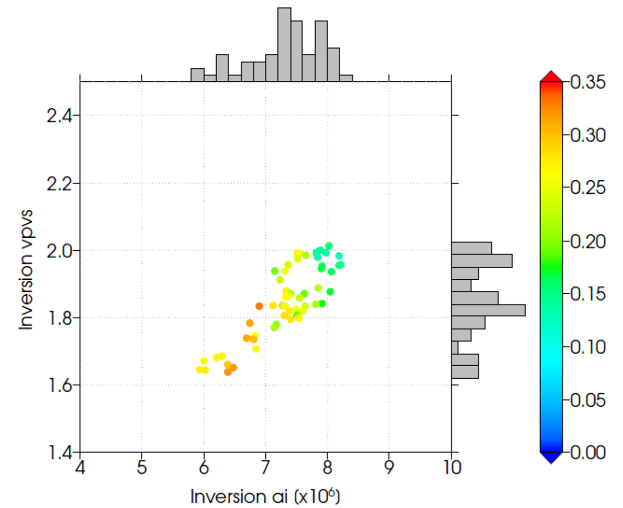


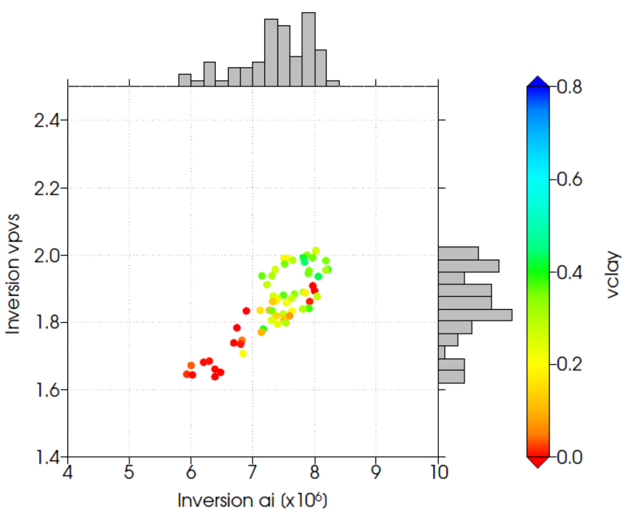
Simultaneous seismic AVO inversion of AI and Vp/Vs

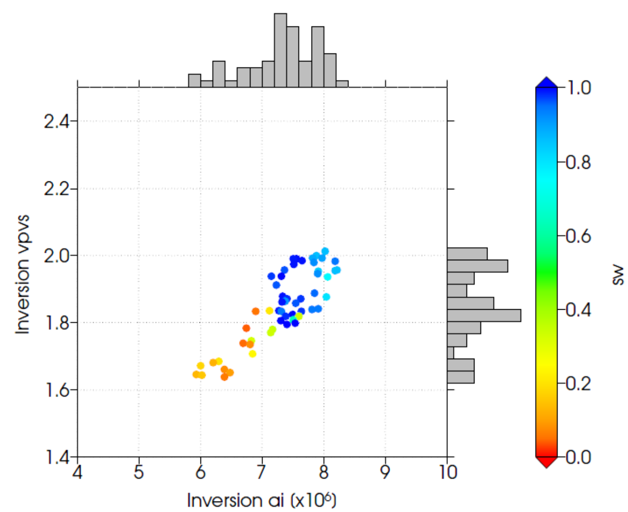


Rock physics crossplots of inversion results at Yttergryta
AI versus Vp/Vs









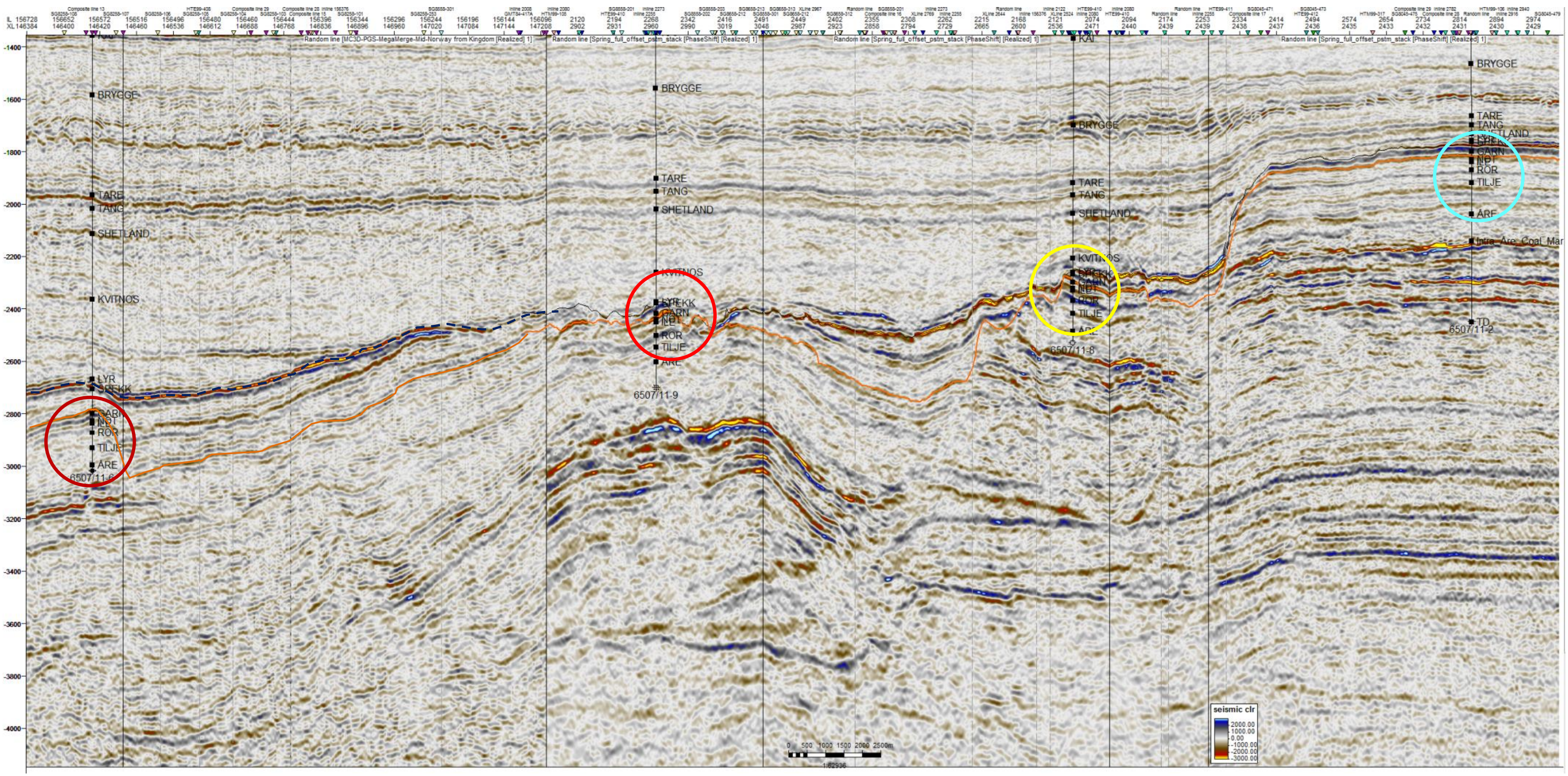
Depth trends affect seismic properties of target zone

Sigrid gas discovery

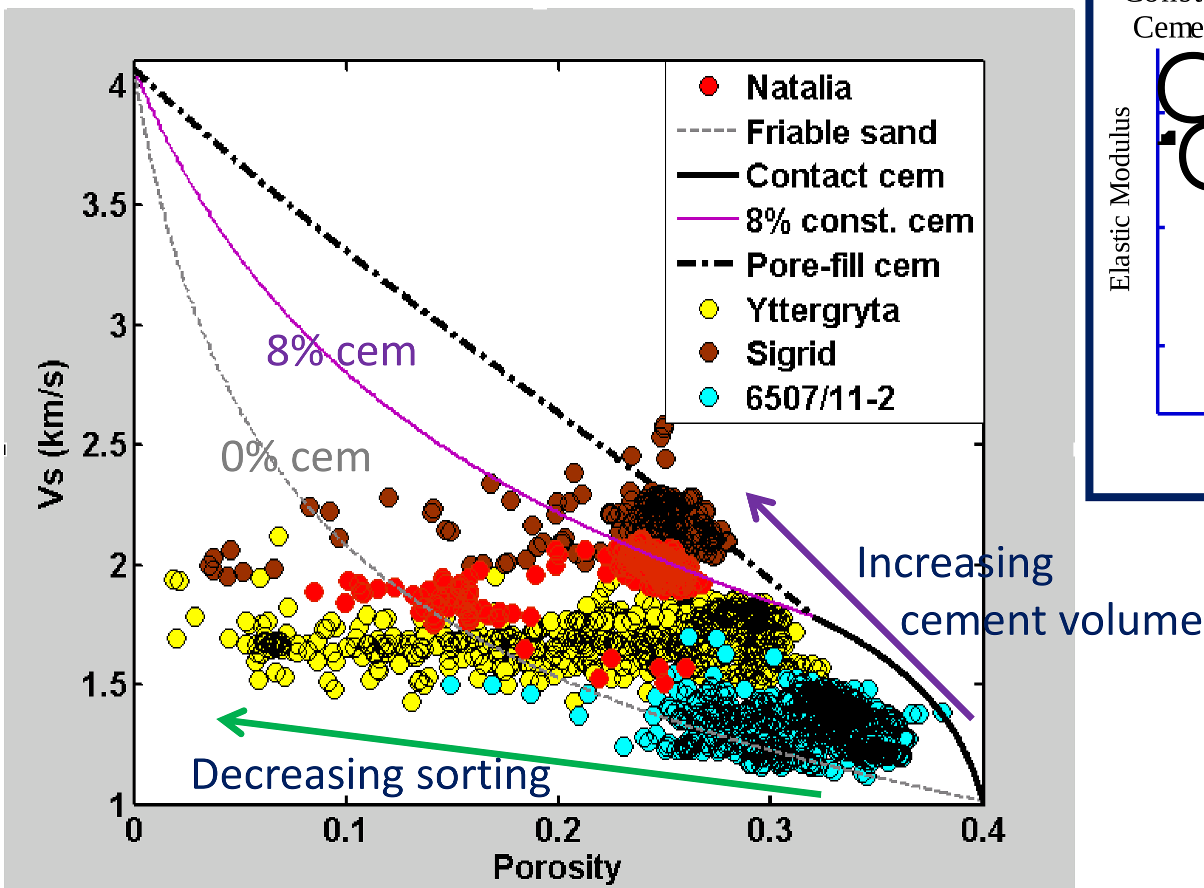
Natalia

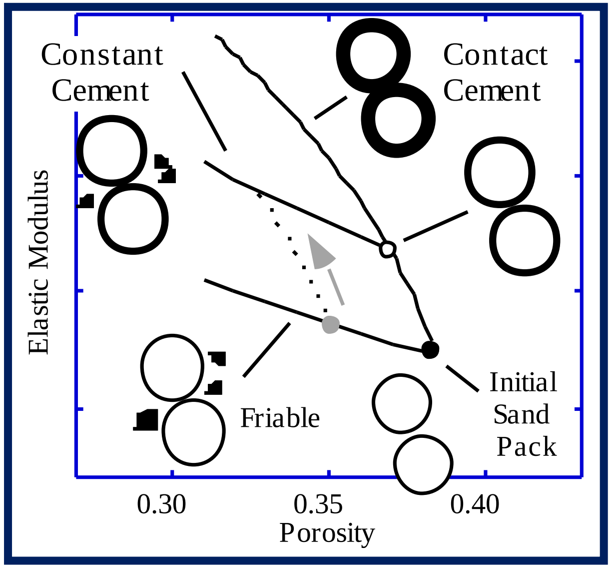
Yttergryta well

6507/11-2

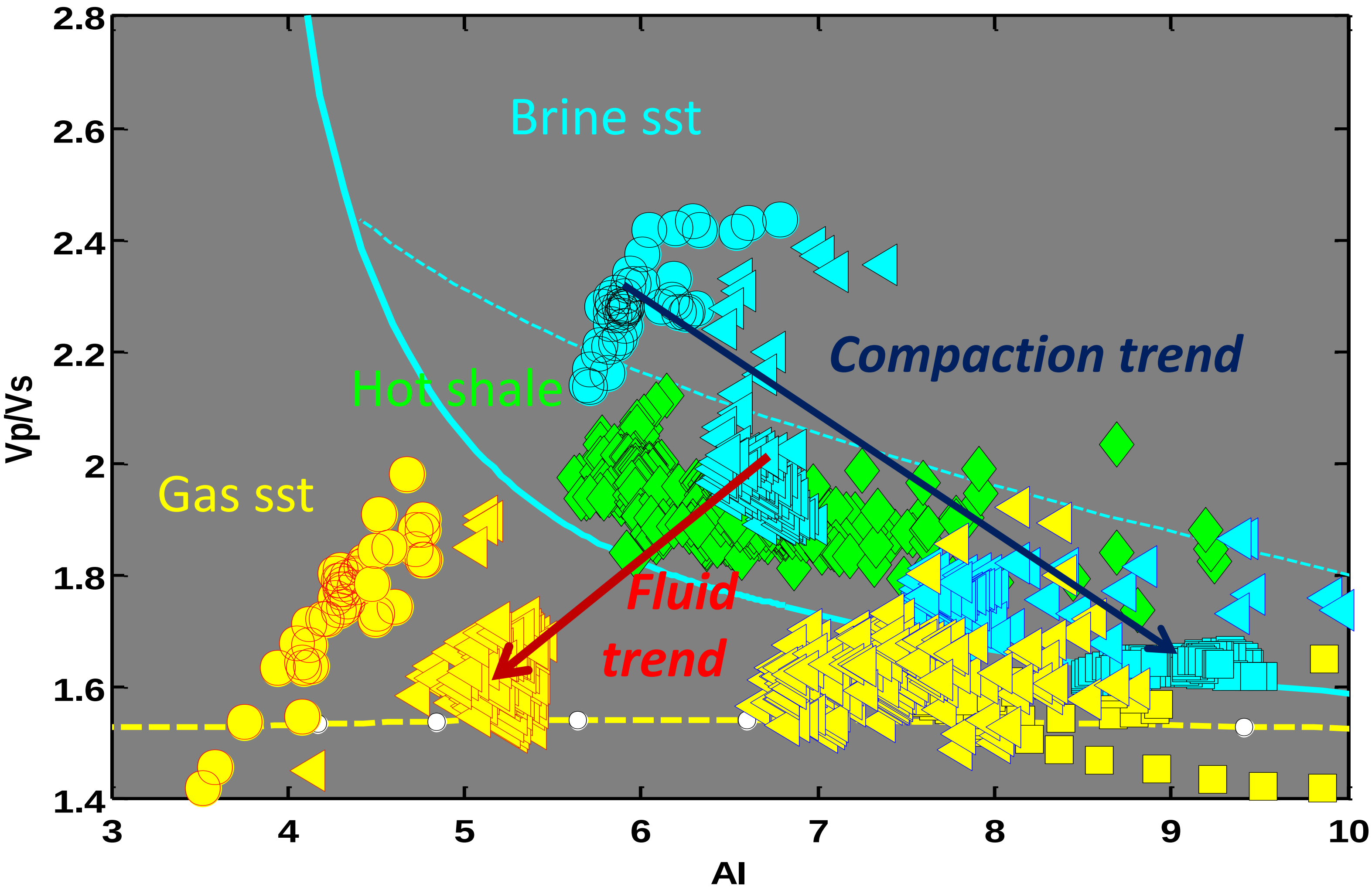


Rock physics diagnostics of rock texture from porosity-Vs

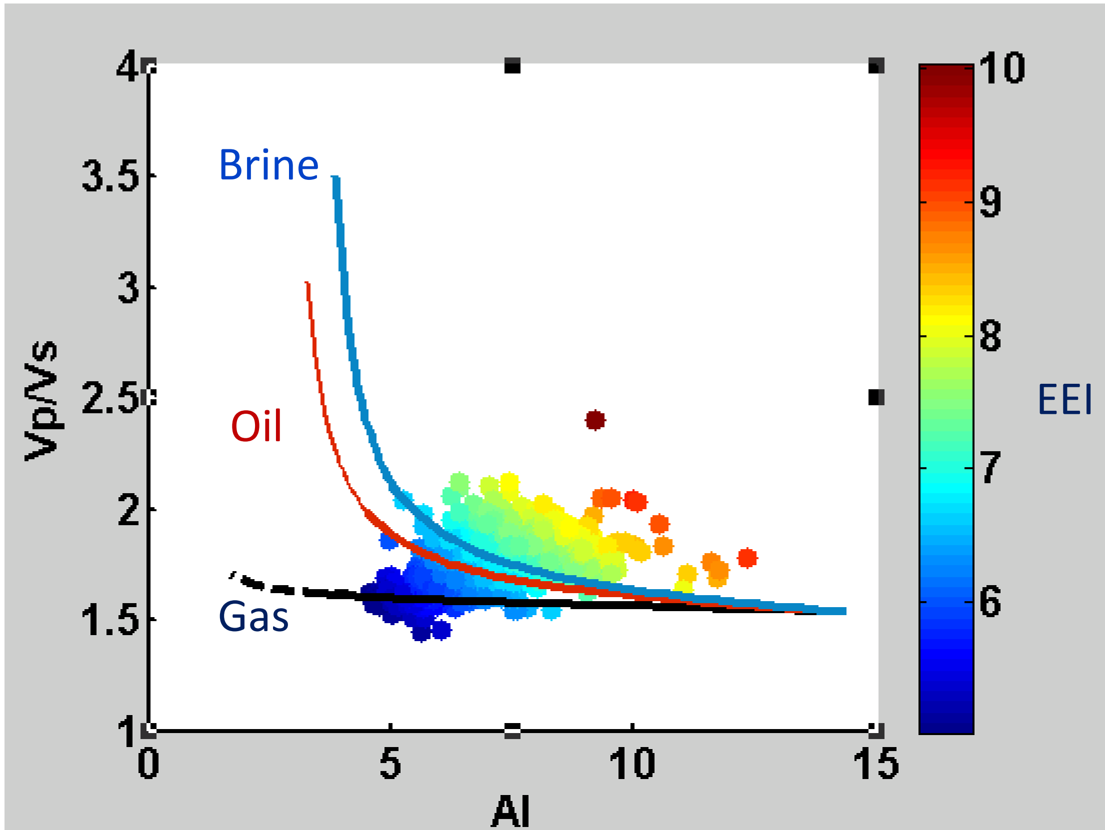




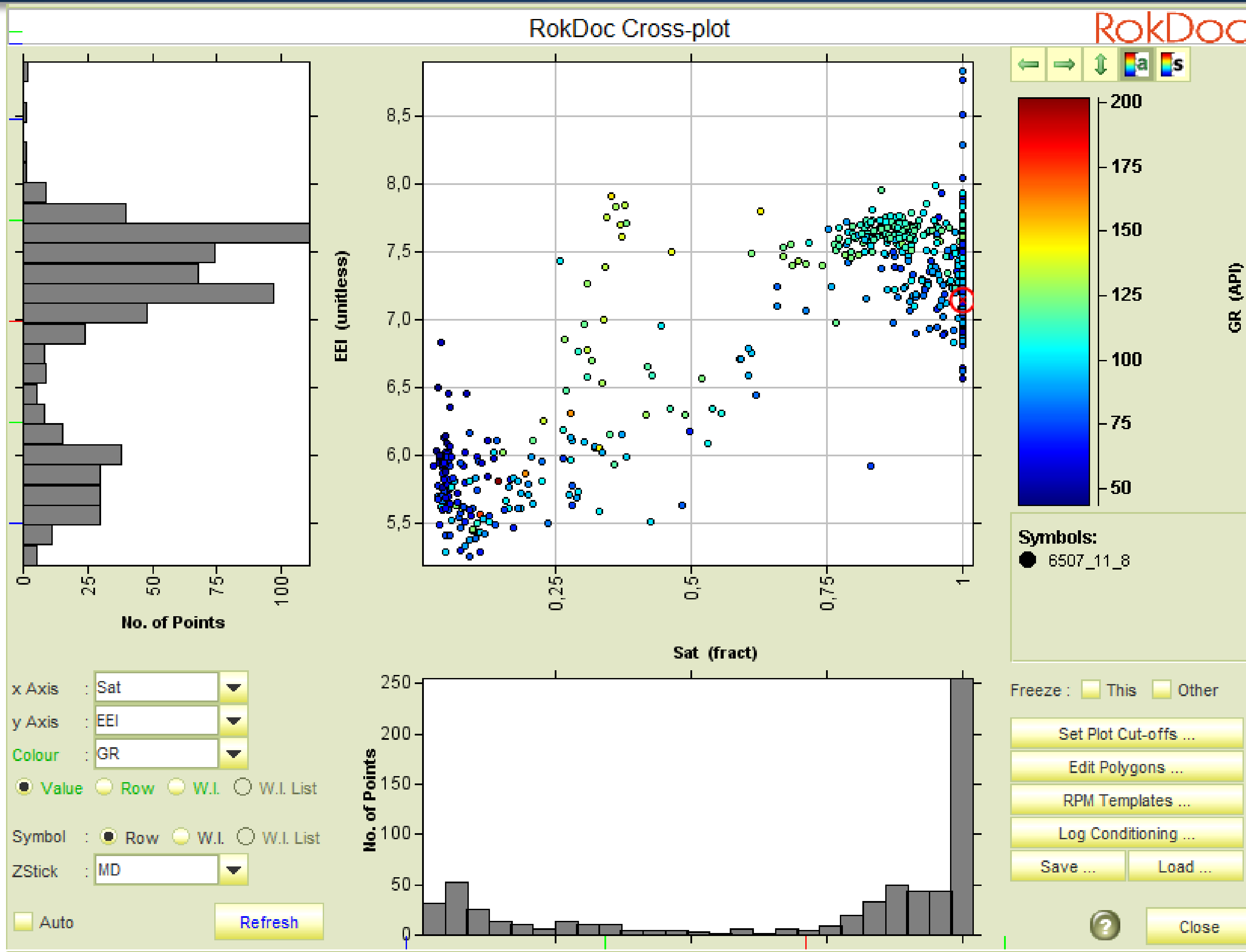
Rock physics template analysis show large change in fluid sensitivity



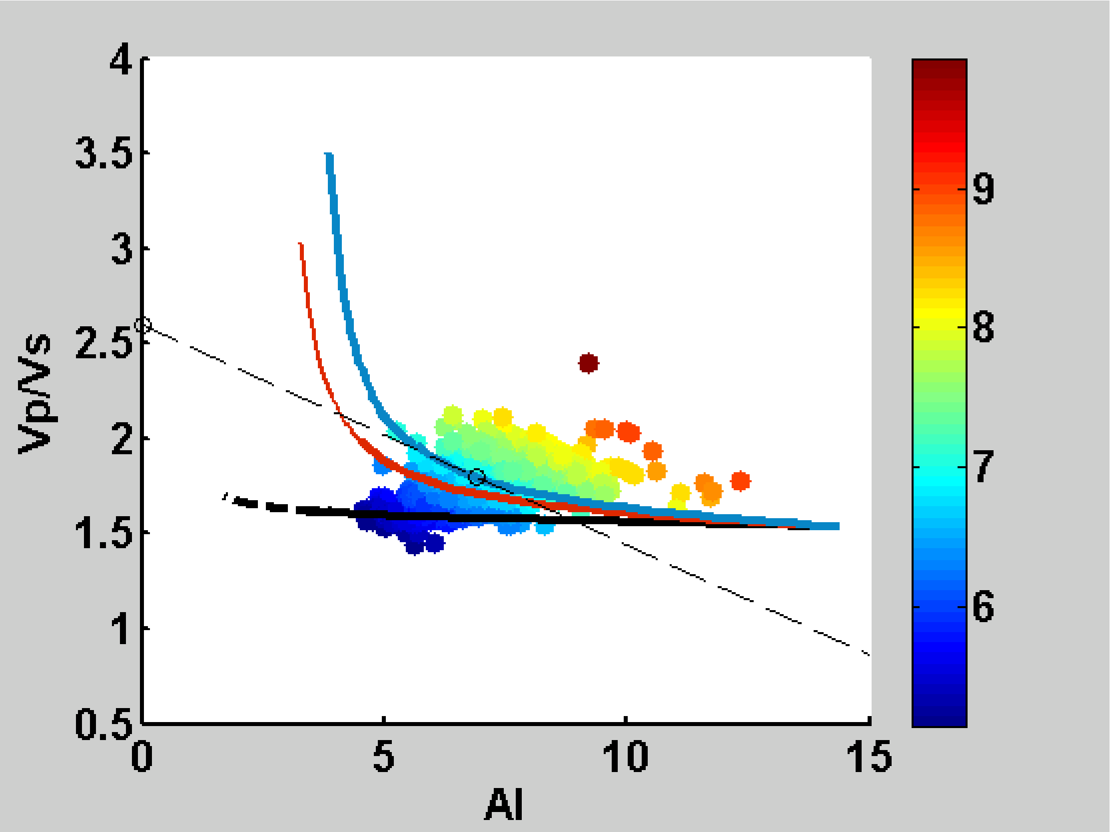
RPT crossplot of Yttergryta well log data and Extended Elastic Impedance at $\chi=24^{o}$



Extended elastic impedance at $\chi=24^{o}$ versus water saturation

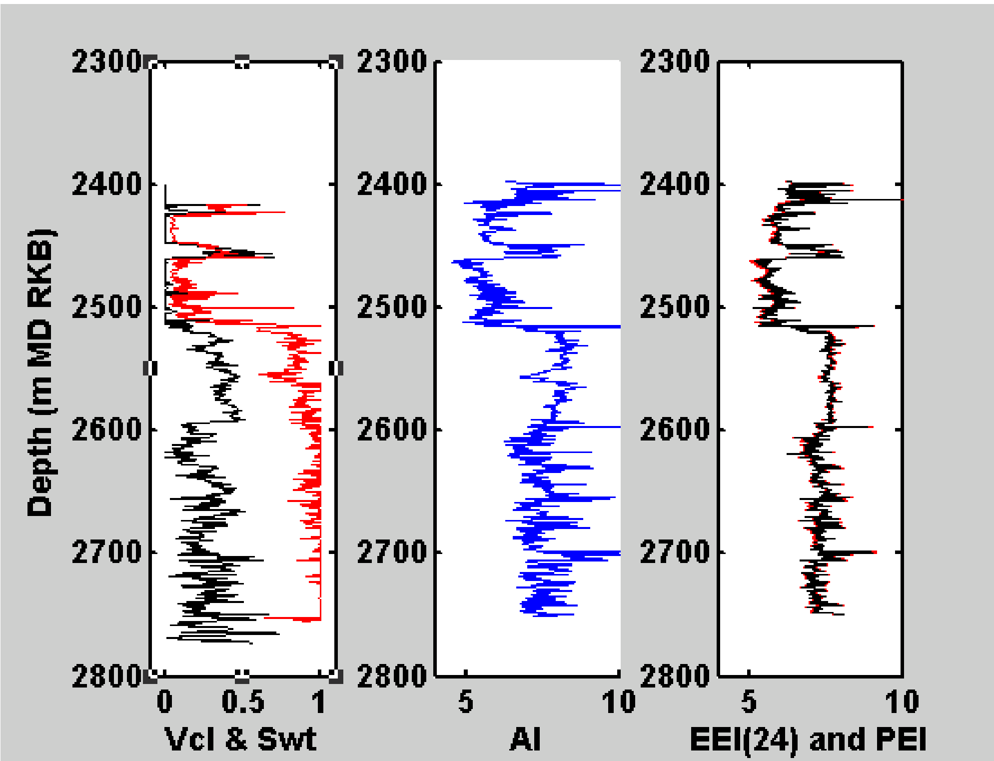


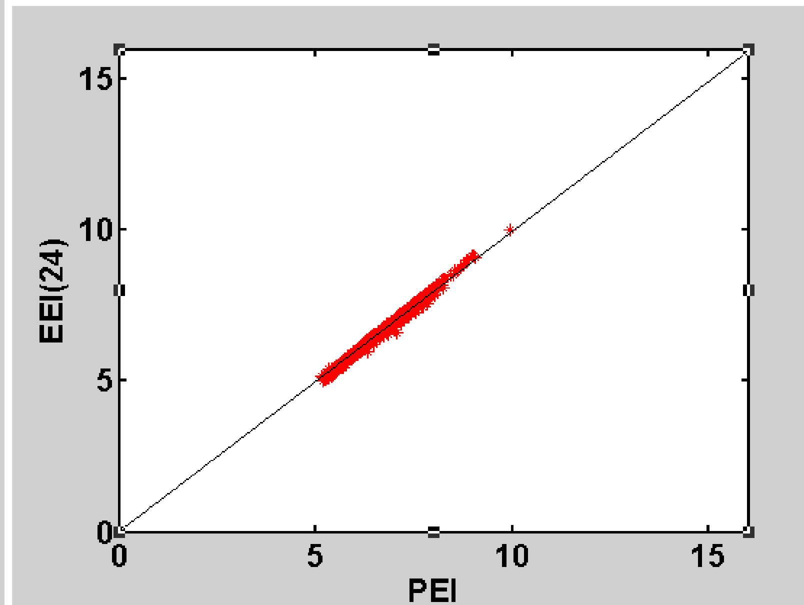
Defining pseudo elastic impdance guided by rock physics template: PEI=6.9 + 3.5(0.116 AI + Vp/Vs - 2.6)



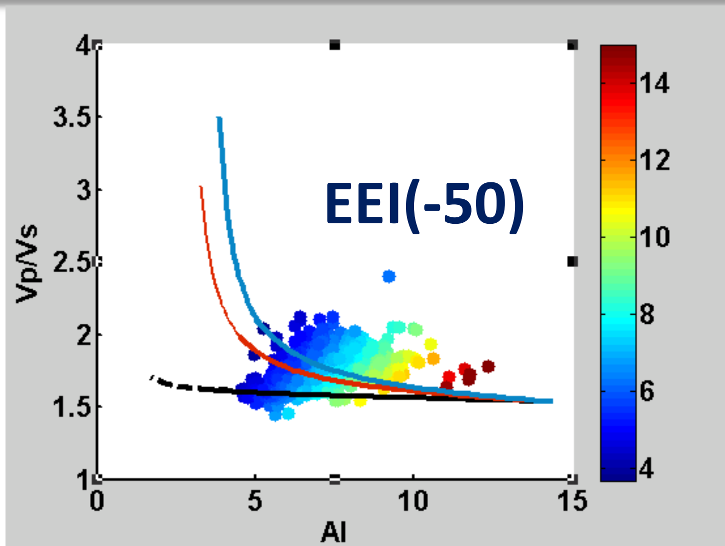
$$PEI = AI_T + \gamma(a \cdot AI + Vp/Vs - V_{P0}/V_{S0})$$

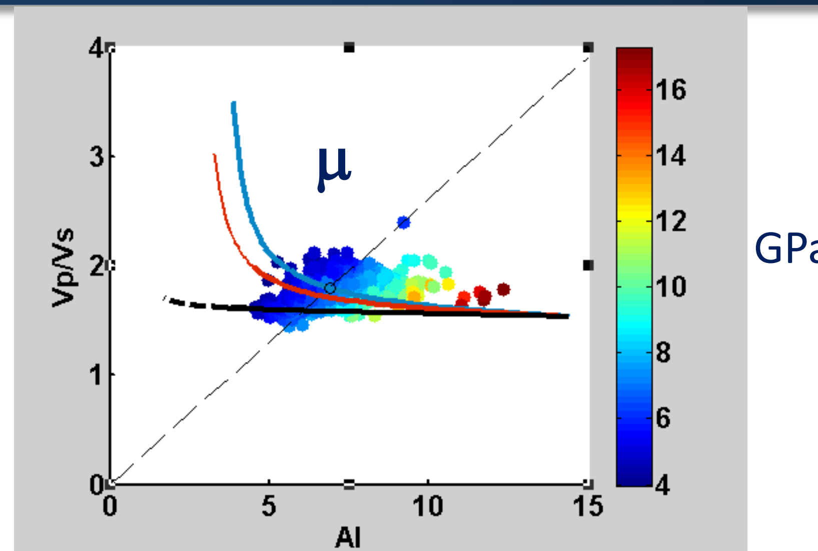
Extended elastic impedance at $\chi=24^{o}$ versus PEI

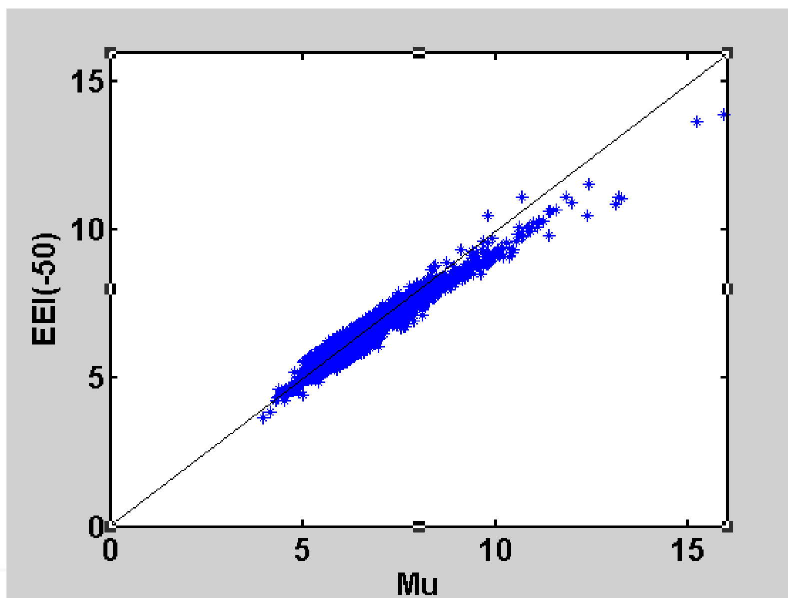




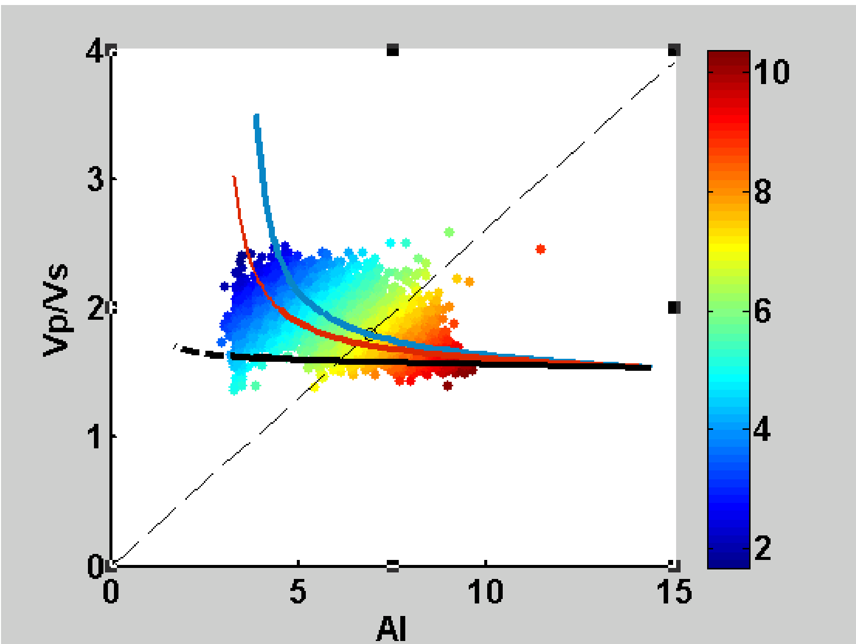
Rock physics templates and extended elastic impedance at $\chi=-50^{o}$ versus shear modulus

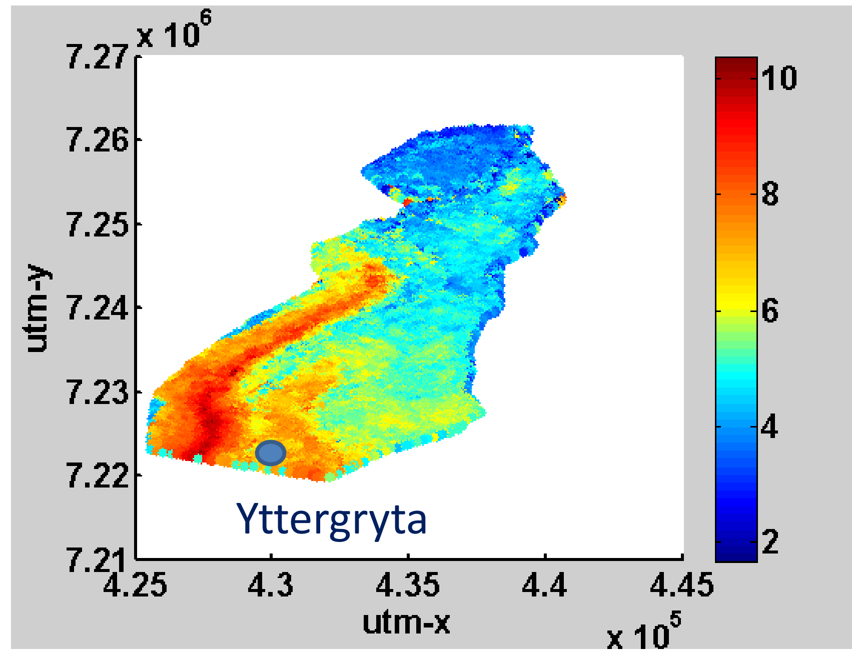






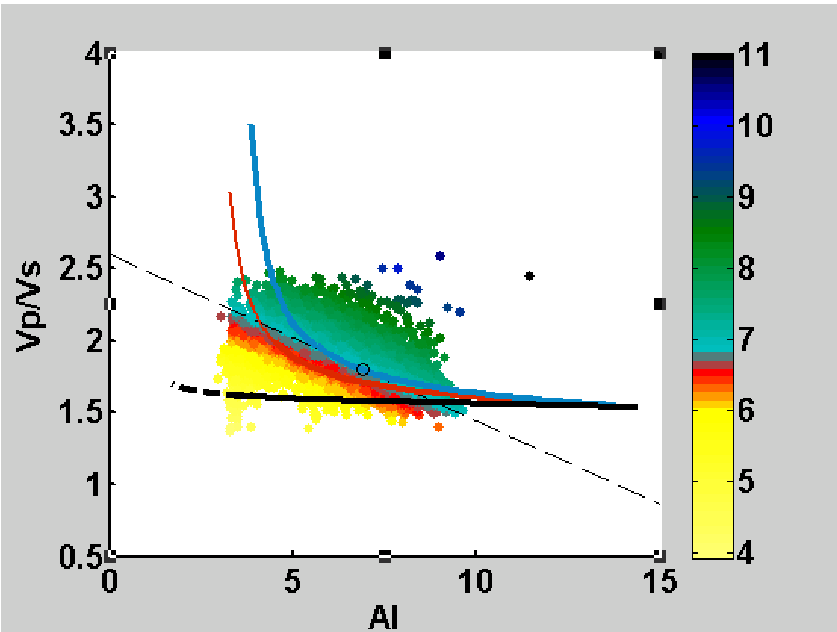
Seismic inversion data (AI and Vp/Vs) classified using pseudo-elastic impedance: PEIL=6.9 - 3.5(-0.261AI + Vp/Vs)

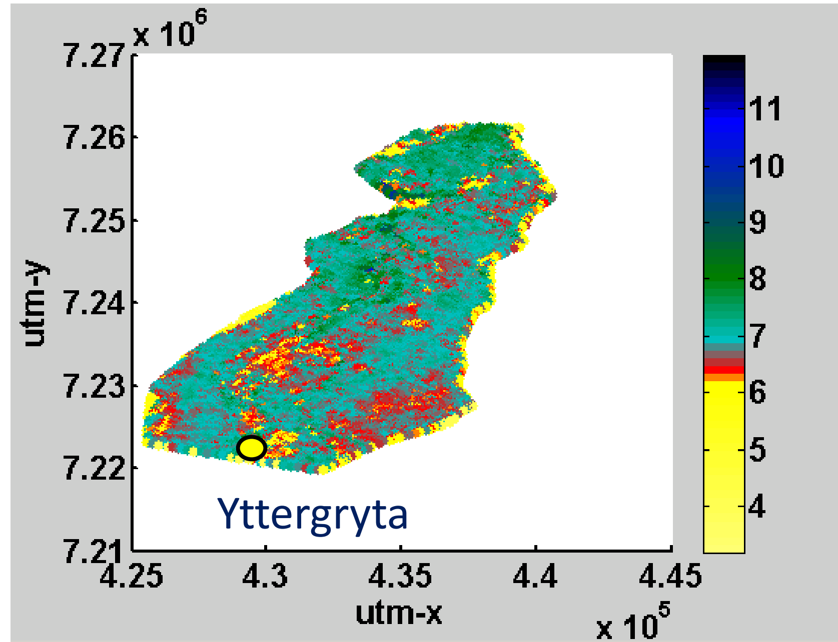




This attribute will show compaction and lithology

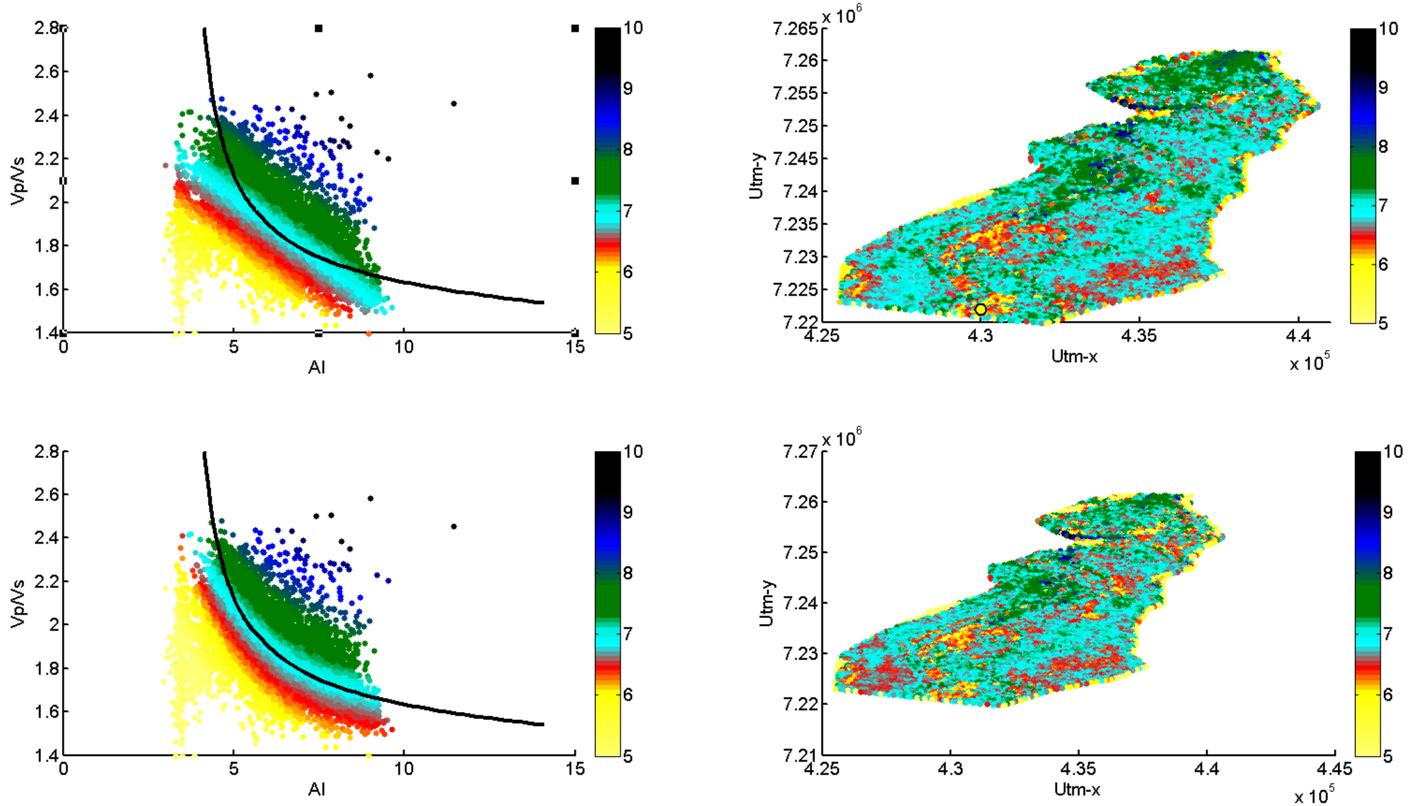
Seismic inversion data (AI and Vp/Vs) classified using pseudo-elastic impedance: PEI=6.9 + 3.5(0.116 AI + Vp/Vs - 2.6)





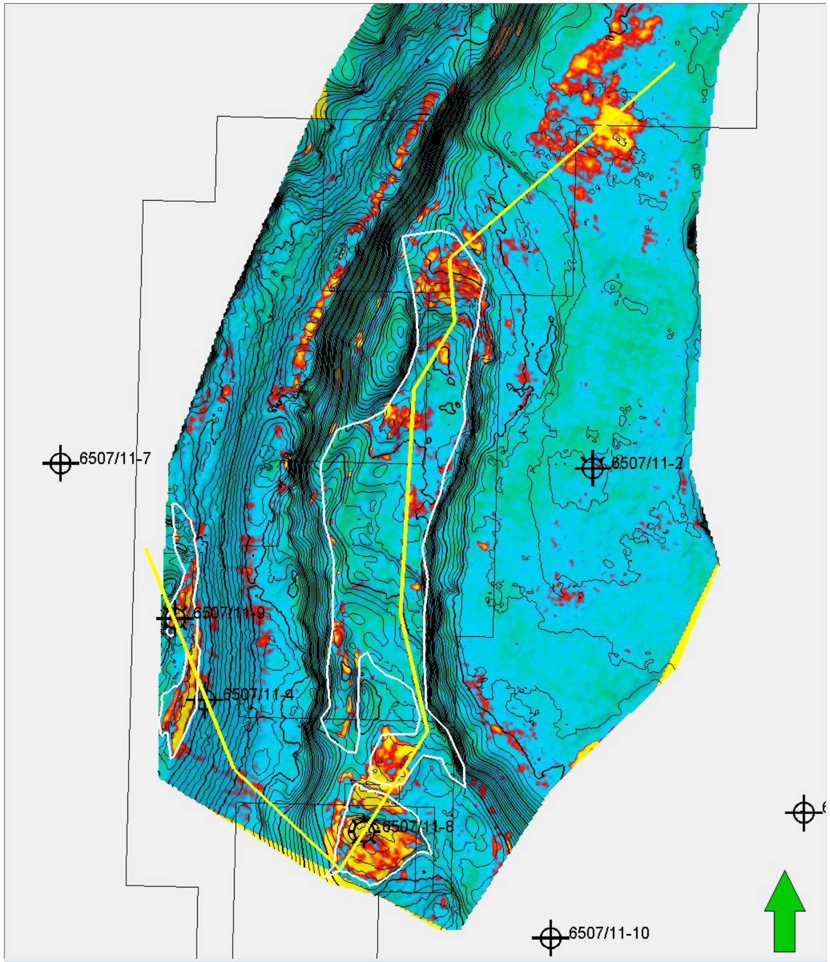
$$PEI = AI_T + \gamma(a \cdot AI + Vp/Vs - V_{P0}/V_{S0})$$

Curved pseudo-elastic impdance, honoring the compaction trend

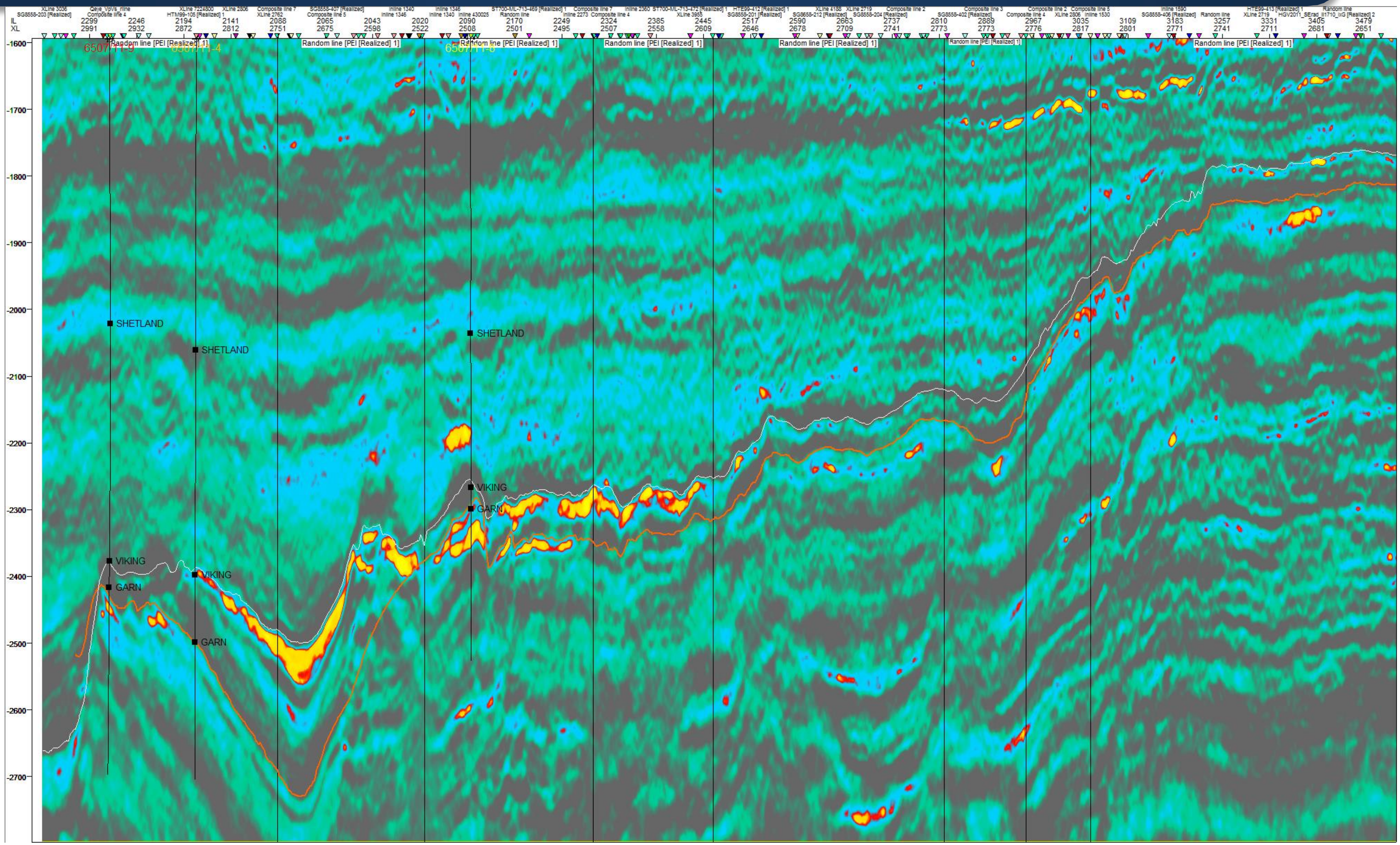


$$CPEI = AI_T + \gamma(a \cdot AI^4 + b \cdot AI^3 + c \cdot AI^2 + d \cdot AI - V_{P0}/V_{S0})$$

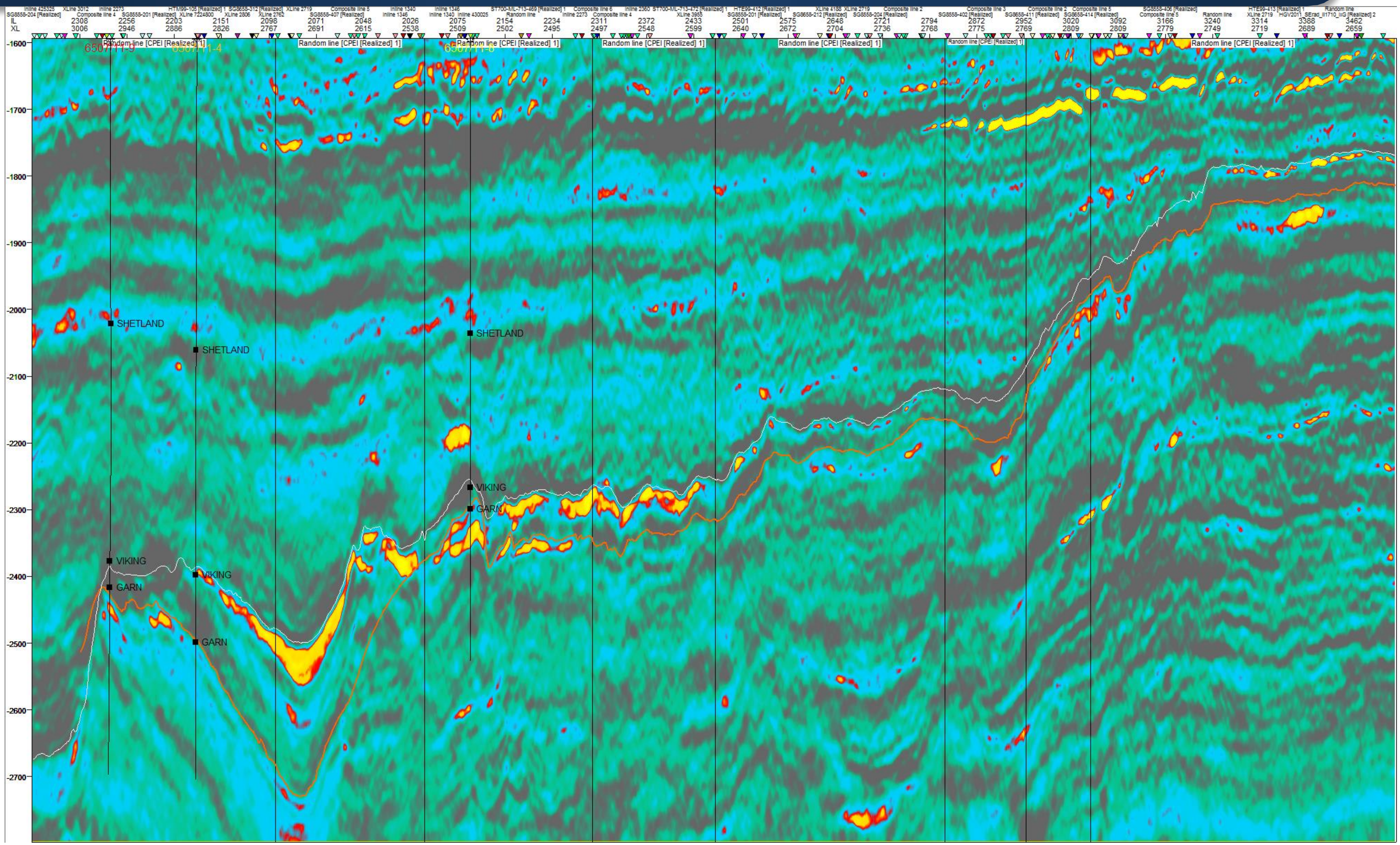
Curved pseudo-elastic impdance, honoring the compaction trend



PEI cross-section (random line)



CPEI cross-section (random line)



Conclusions

- Extended elastic impadance can easily be linked to trends in rock physics templates.
- We have shown how to create pseudo-elastic impdances, i.e. regression lines in AI-Vp/Vs domain calibrated to extended elastic impedances. These can be calibrated to local rock physics models.
- A higher order ”curved” regression line better capture compaction trends than a 1st order linear regression.
- The pseudo-elastic impedances can easily be implemented to classify seismic inversion data into fluid and lithology cubes.
- We have demonstrated how to map potential prospects in the Yttergryta area in the Norwegian Sea, using the pseudo-elastic impedance approach.

Acknowledgements

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