Estimation of Effective Porosity and Saturation Volume by Extended Elastic Impedance approach: A case study

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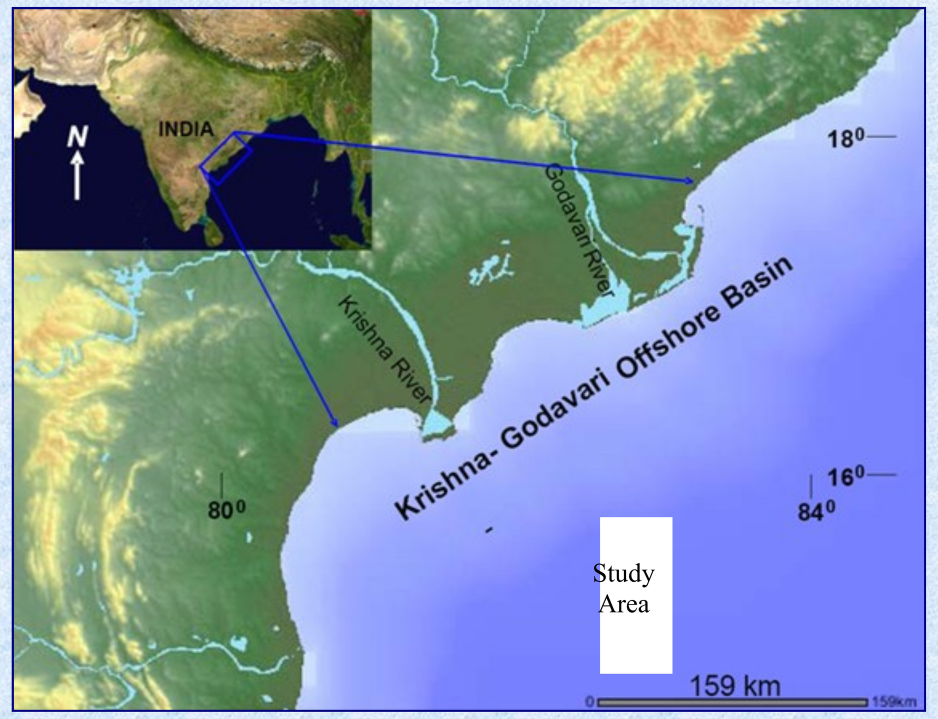


Fig: 1: Approximate Location of Study Area

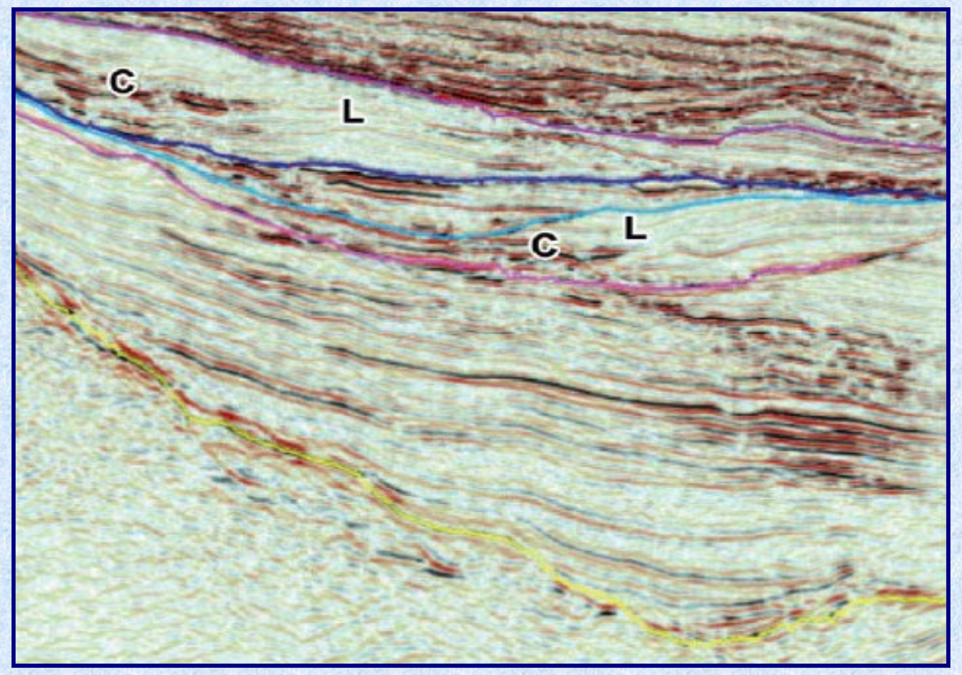
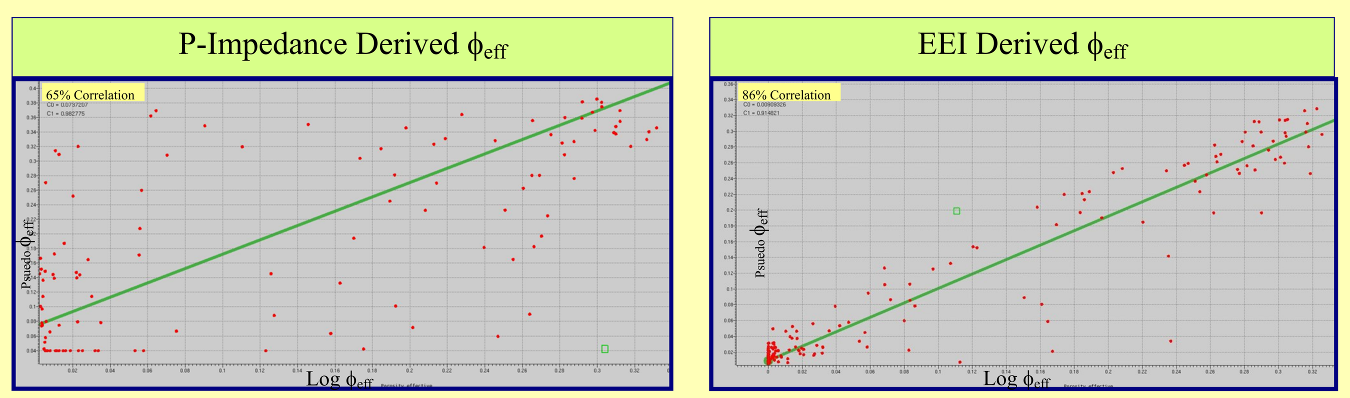


Fig:2: A seismic depth section of the study area: Complex Channel-Levee

Introduction:

1. Effective porosity and saturation are the key parameters in reserve estimation and field development planning .
2. Transform based on single property viz., amplitude, sweetness, P-Impedance generate is only an average outcome, devoid of finer details.
3. Extended elastic impedance approach can be adopted for obtaining effective porosity and saturation (Arsalan et al, 2009).



EEI Theory:

Two-term linearization of Zeoppritz equation for reflectivity (Aki & Richards 1980),

$$R = A + B\sin^2 q \qquad (1)$$

When sin²q replaced by tan χ :

$$R(\chi) = A + B\tan\chi \qquad (2)$$

allows angle to vary from -90° to +90°,

Whitecombe et al. defined EEI as

$$EEI(\chi) = \alpha_0 \rho_0 \left[\left(\frac{\alpha}{\alpha_0}\right)^p \left(\frac{\beta}{\beta_0}\right)^q \left(\frac{\rho}{\rho_0}\right)^r \right] \qquad (3)$$

Where α = P-wave velocity, $p = \cos\chi + \sin\chi$,

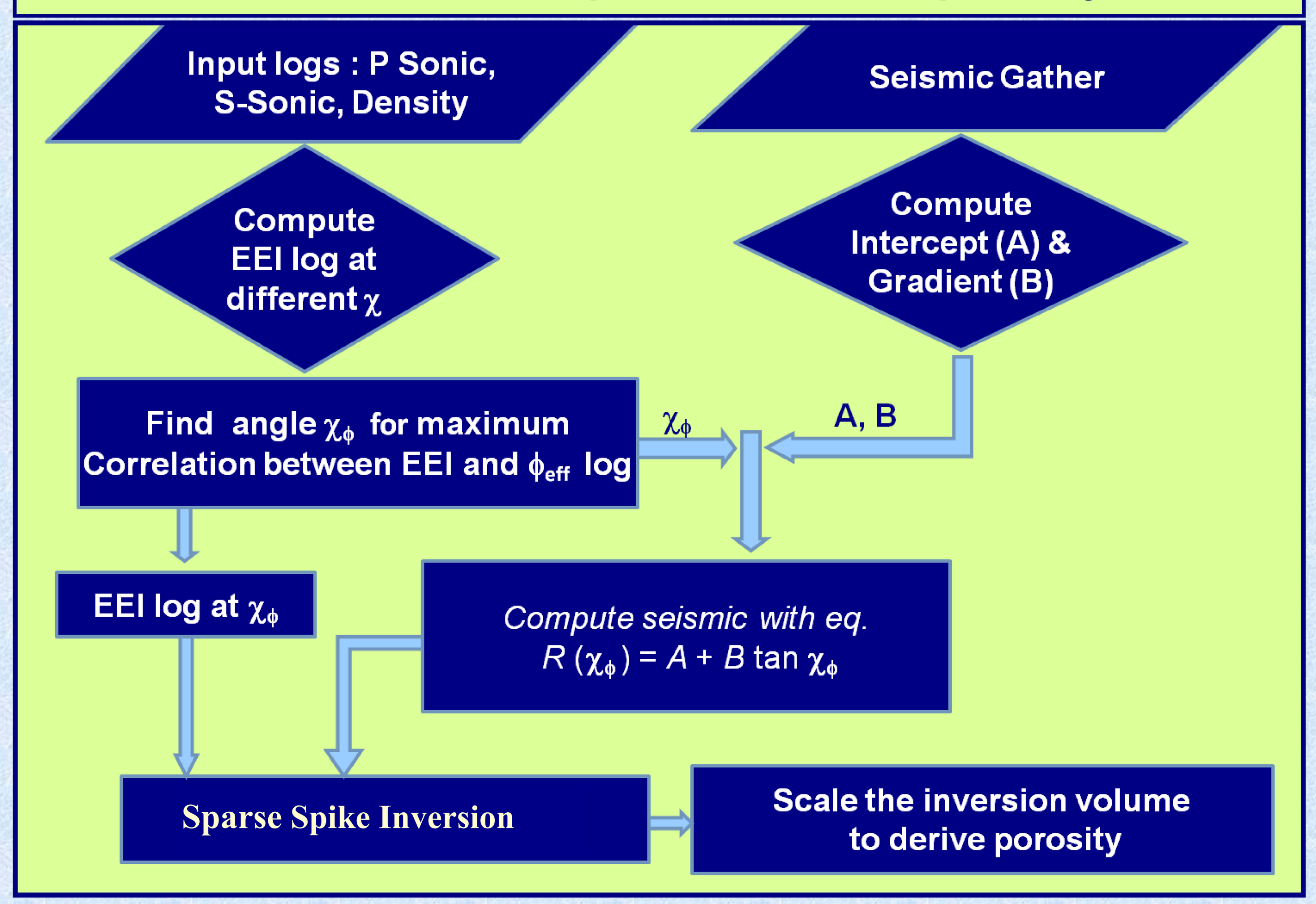
β = S-wave velocity, $q = -8K\sin\chi$

ρ = density, and $r = (\cos\chi - 4K\sin\chi)$,

α_0, β_0, and ρ_0 : the average of P velocity, S velocity, and density respectively.

K is the average of $(V_S/V_P)^2$ in the time/depth interval.

Flow Chart to compute EEI derived porosity



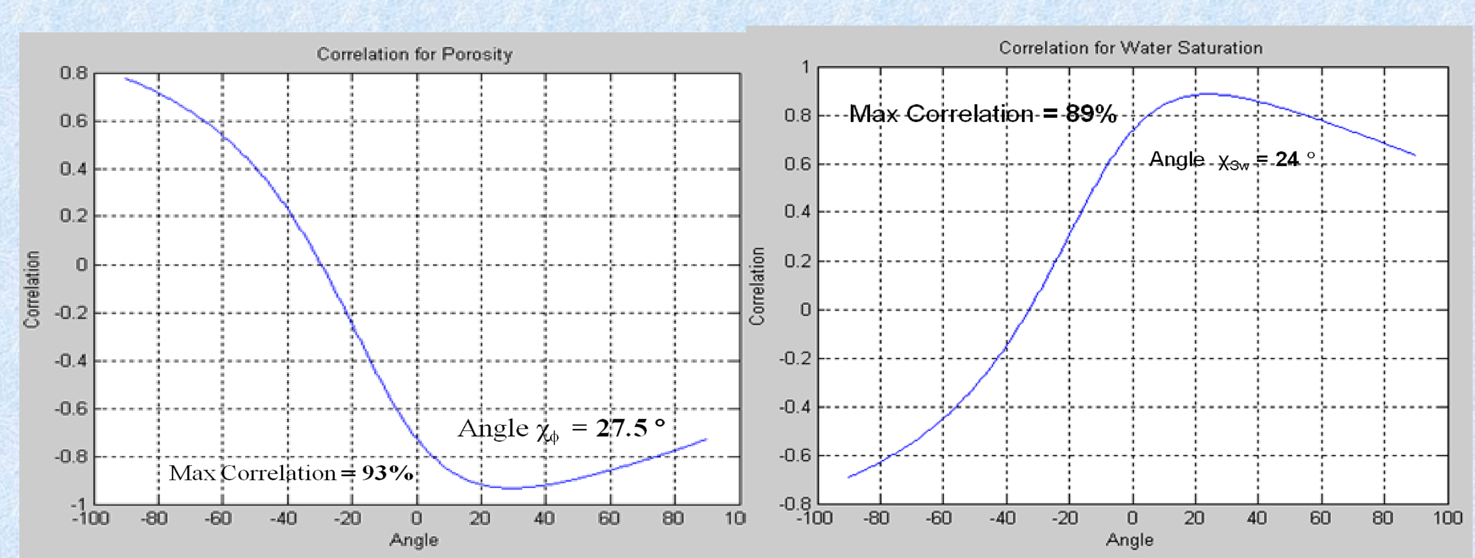
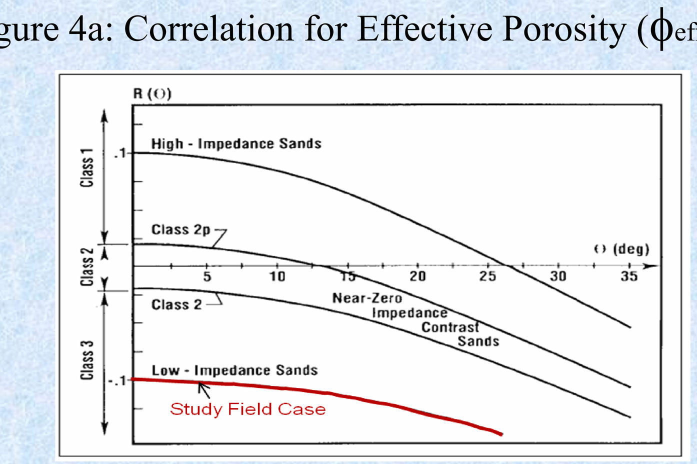


Figure 4a: Correlation for Effective Porosity (ϕ_{eff}) Figure 4b: Correlation for Water aturation (Sw)



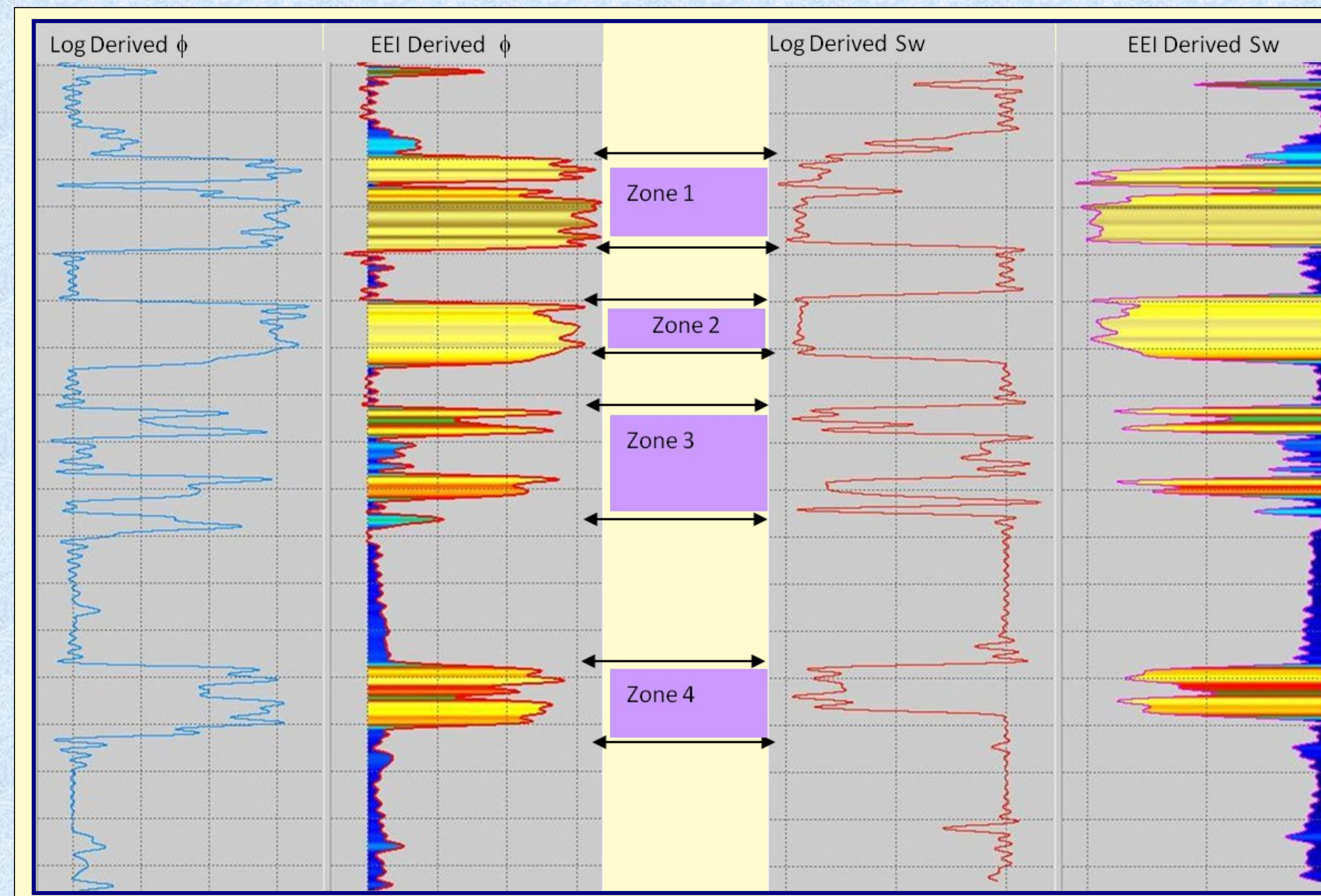


Figure 5a Comparison of log derived and EEI derived Effective Porosity

Figure 5b Comparison of log derived and EEI derived Saturation

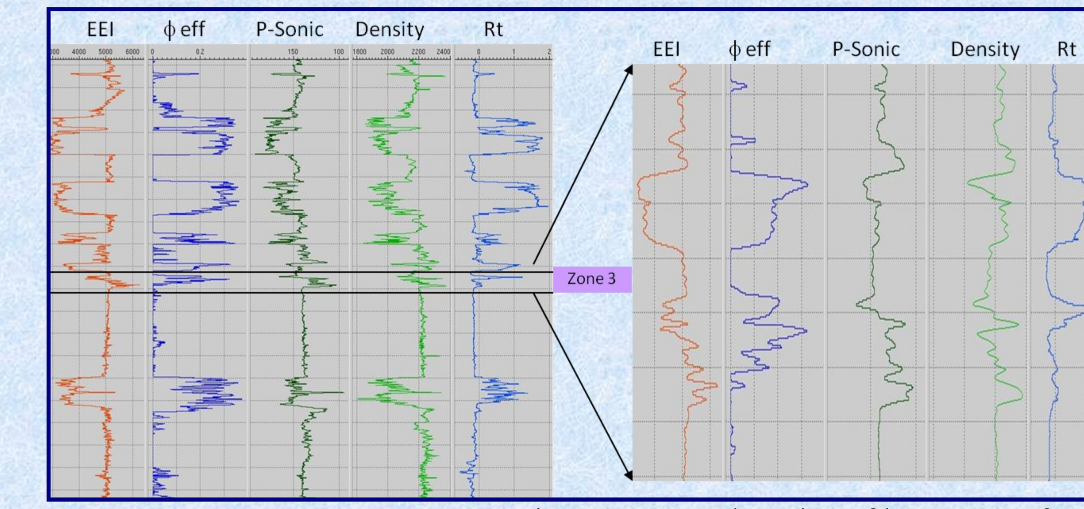


Figure8. Zoomed portion of lower part of zone 3

Discussions:

1. Correlations between Effective Porosity log and saturation log with EEI is up to 90%, at particular angles.
2. Zone 1, 2 and 4 : low EEI value on the log and porosity match is very good is porosity section.
3. In the 3rd zone the lower zone porosity could not be captured clearly.

-The reason for this is possibly: The zone 1, 2 and 4 are clean channel sands, where as the zone 3 is having laminations of sand and shale : may be part of levee.

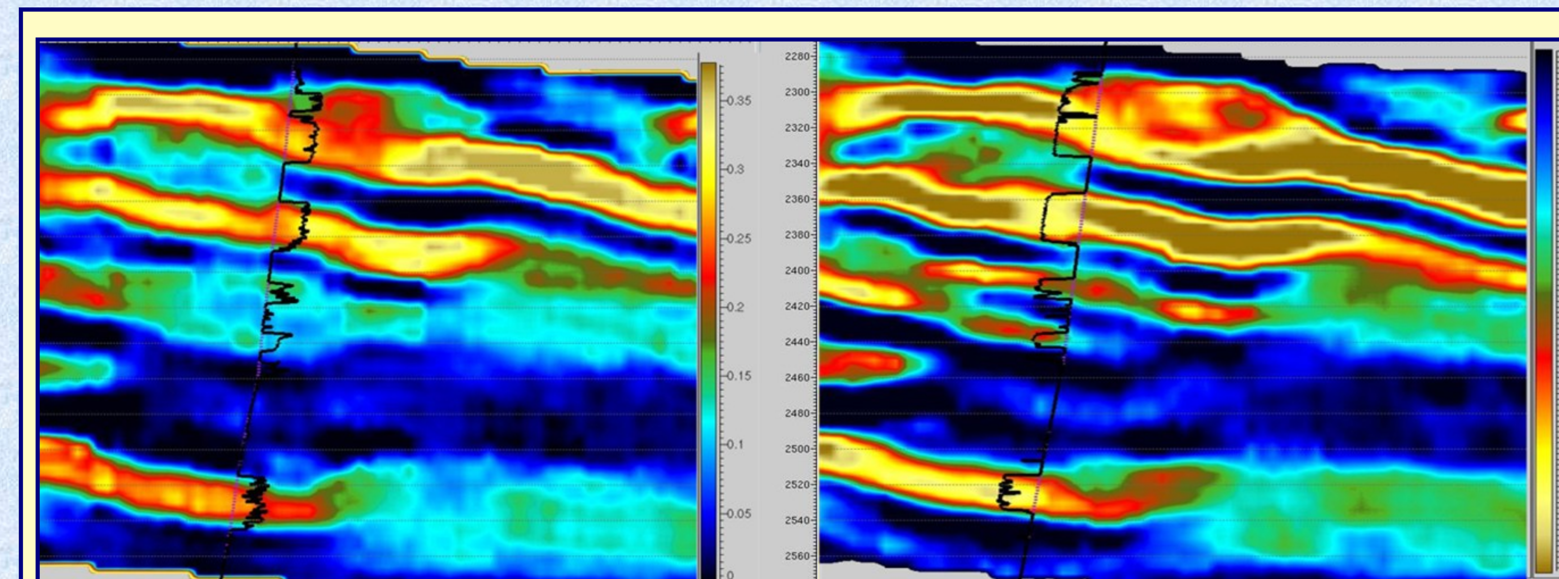


Figure6a: Section showing Effective Porosity ϕ_{eff} Figure6b: Section showing water saturation (Sw)

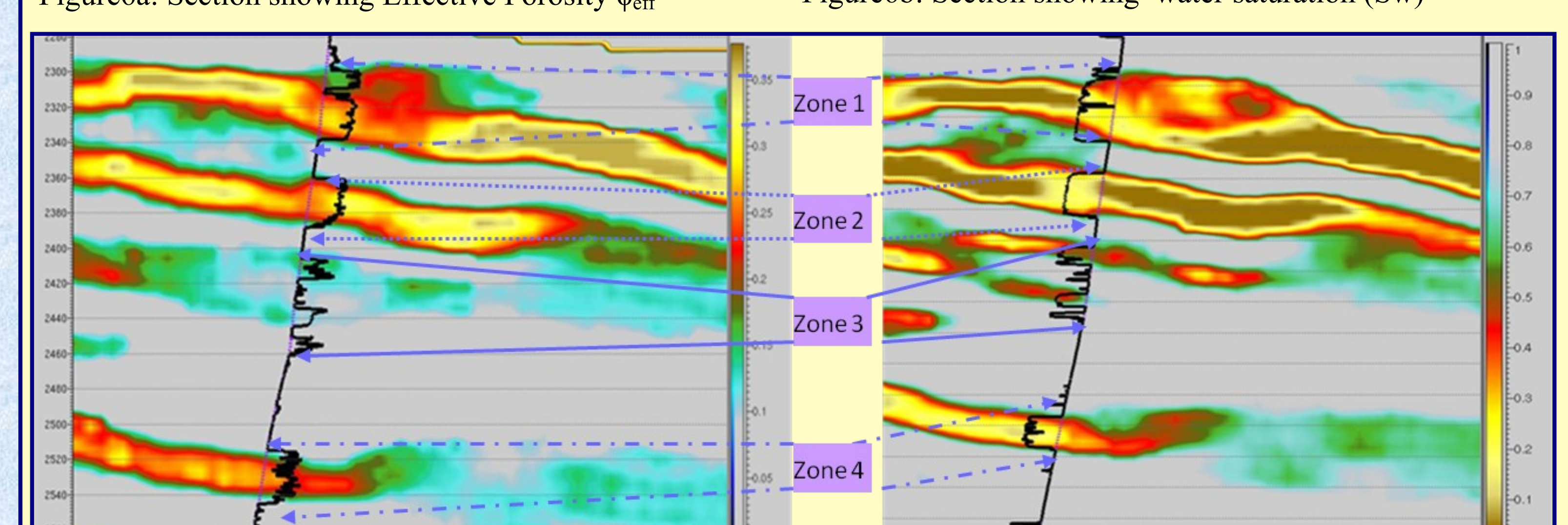


Figure 7a: Section showing ϕ_{eff} with 10% cut off Figure 7b: Section showing Sw volume with 70% cut off

Conclusions:

. EEI derived porosity has better correlation(>85%) compared to the P-impedance derived porosity(65%).

. Well overlaid sections indicate good property match at the well and fair property distribution away from the well.

. A very good match of ϕ_{eff} and Sw, allows EEI-derived volumes to be used in mapping the character of reservoir sand in 3D space and further quantitative reservoir characterization.

. EEI approach can be adopted in other similar fields.

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References:

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