Permeability Evaluation of Zubair Formation Using Well Logs*

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Abstract

This study is focused on the evaluation of formation permeability for a sandstone reservoir in three southern Iraqi oil fields, which are Zubair, North and South Rumaila at Zubair formation. Methods of determining permeability form logs are reviewed. A case history is presented showing how an optimum empirical relationship to predict permeability can be developed, with commonly available core and log data for a particular formation and area. Verifiable and accurate permeability prediction from well logs in a well with no core measurement data are presented by improved log derived permeability relationship. Sandstone grain size and sorting, and hence permeability are often related to the amount of interstitial silt and shale and this in turn may be reflected in the natural radioactivity. Because of this, in some areas permeability of sandstone can be estimated from carefully calibrated gamma ray curves as the proposed relationship ($\sqrt{k}$=1/2 Exp(4.5φ2+4 (1-IG))). For the South Rumaila and Zubair fields it is found that the permeability is a function of porosity, irreducible water saturation and volume of shale. We found that the correlation coefficient between predicted and observed permeability for the above function is increased by taking the square root of the permeability ($\sqrt{k}$).

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Region of the Study

- In the present study 16 wells from three oil fields (M, A and F) were chosen to evaluate the permeability in sandstone formation.
- The selected fields are located in the southern part of Iraq which is mainly covered by the Zubair formation.

Porosity Correlation

- The general expression for the conventional porosity-permeability transforms of the southern Iraqi fields can be written in form:

$$k = 14.34 * \varphi - 0.391$$

where k is permeability in (md) units, and porosity (fraction).

Porosity correlation

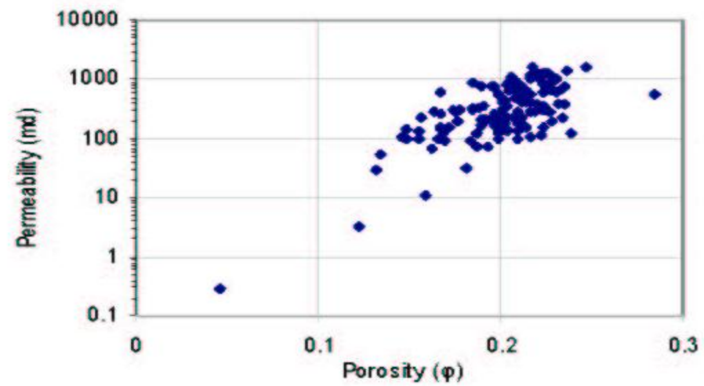


Fig. (4-1): Cross plot of porosity vs. permeability of the M field.

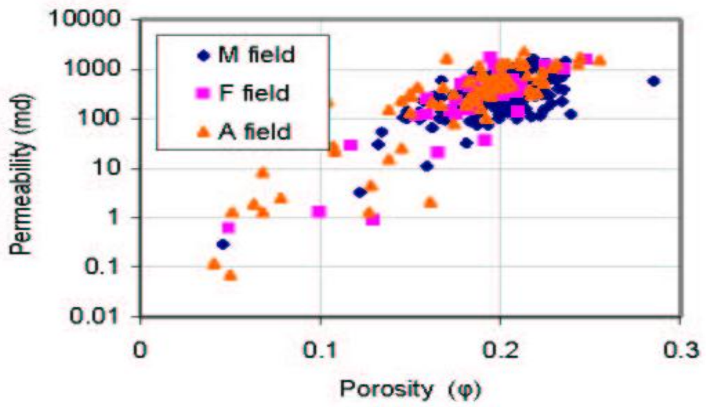


Fig. (4-2): Cross plot of porosity vs. permeability of the three fields.

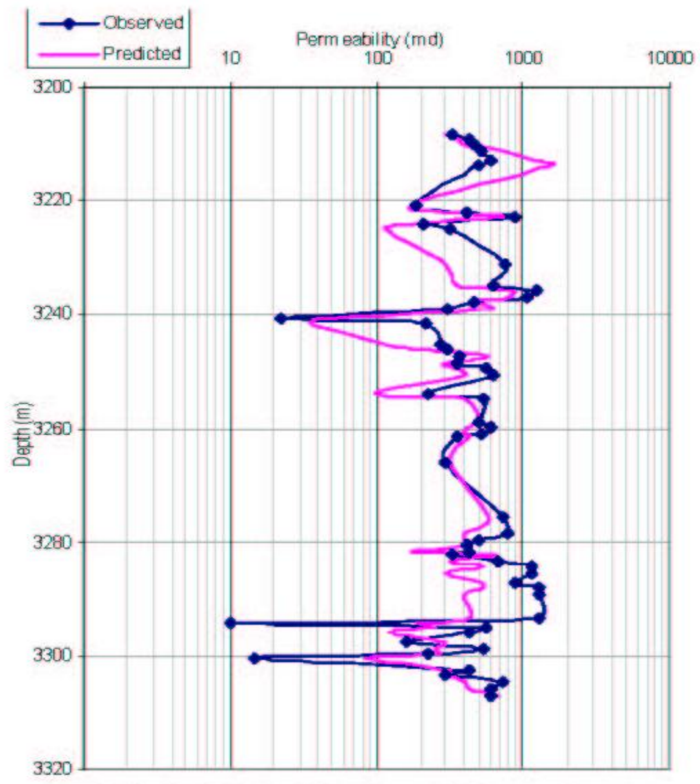


Fig. (4-3): Predicted and observed permeability profile for the F1 well.

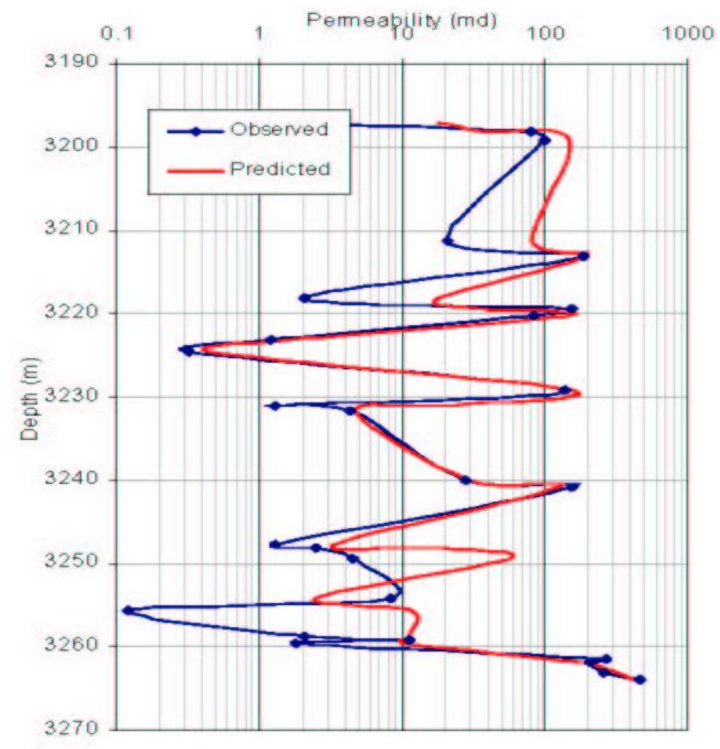


Fig. (4-4): Predicted and observed permeability profile for the A1 well.

Irreducible Saturation Method

- The laboratory measurements of permeability (k), porosity (φ), and irreducible water saturation (Sw) from capillary pressure data were obtained for four wells: M2, M3, M4 and M8, which penetrate oil sandstone formation in the M field.
- The generalized relationship for estimating permeability from measurements of φ and Swi is:

$$k = 62500 \frac{\varphi^{4.5}}{Swi^{0.68}}$$

Irreducible Saturation Method

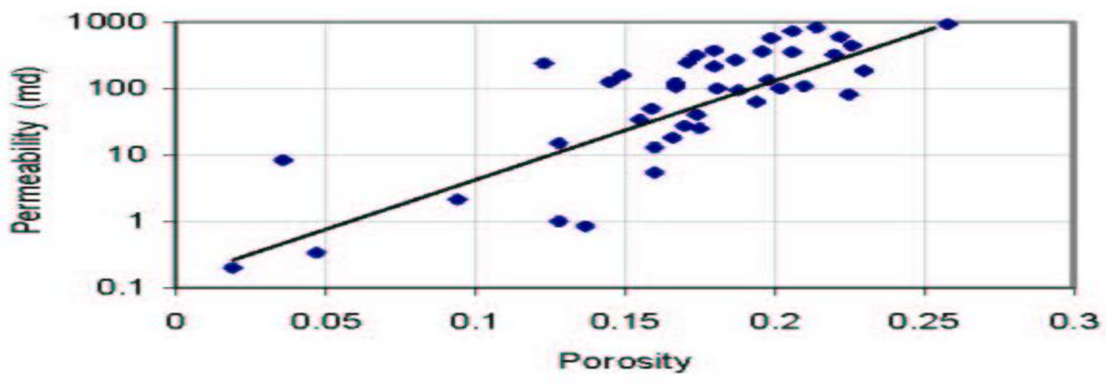


Fig. (4-5): Permeability versus porosity plot for M2, M3, M4, and M8 wells.

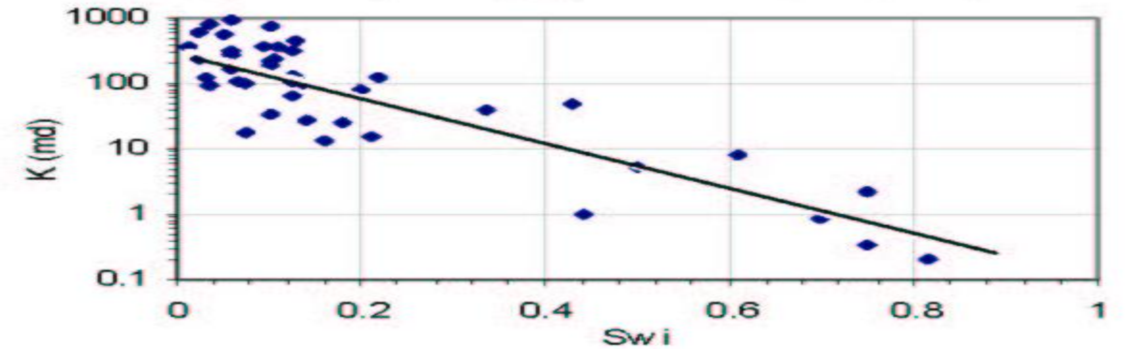


Fig. (4-6): Water Saturation and permeability cross plot for M2, M3, M4, and M8 wells.

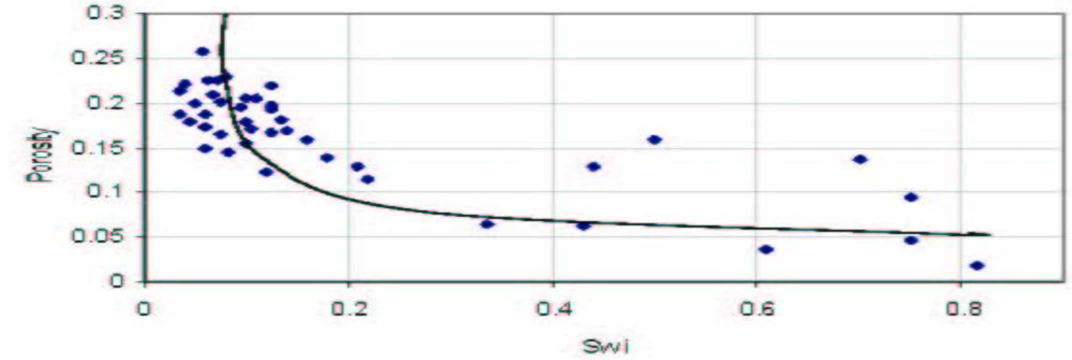


Fig. (4-7): Porosity versus irreducible water saturation for M2, M3, M4, and M8 wells.

Irreducible Saturation Method

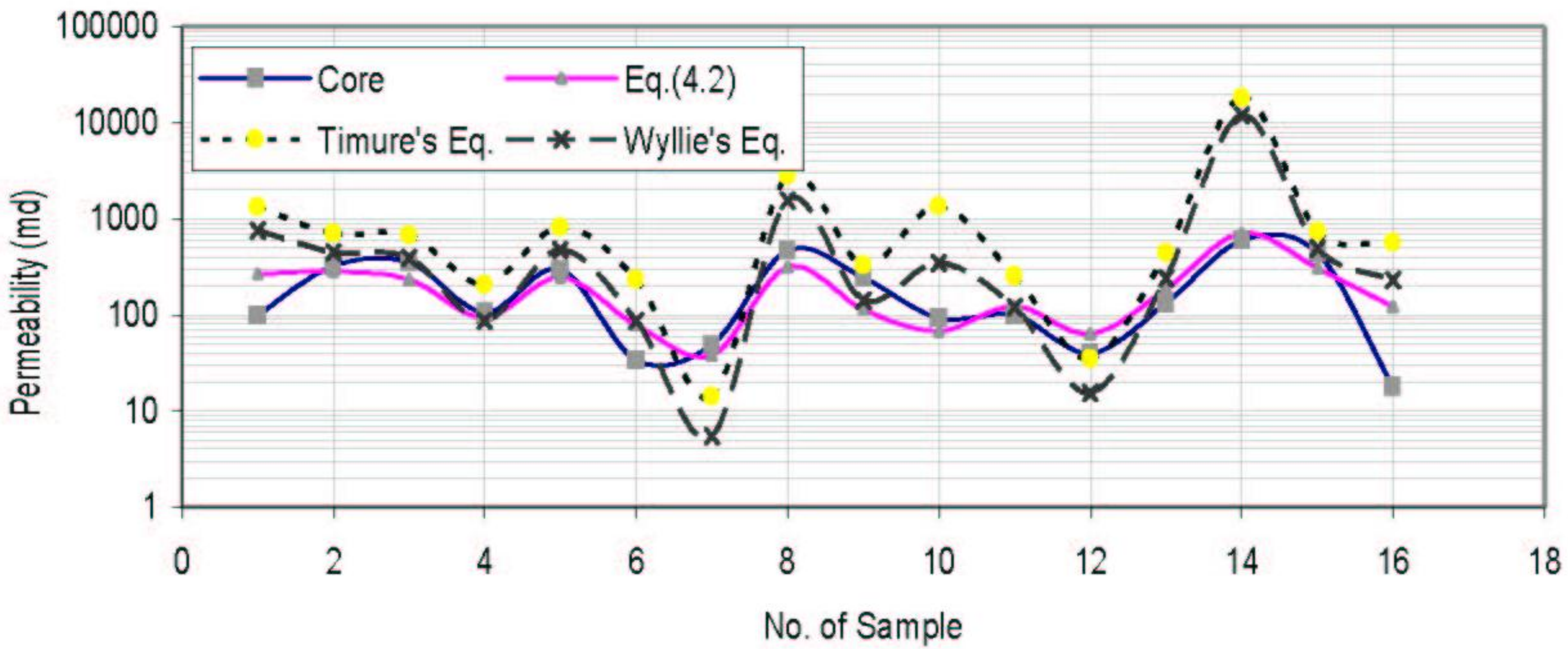
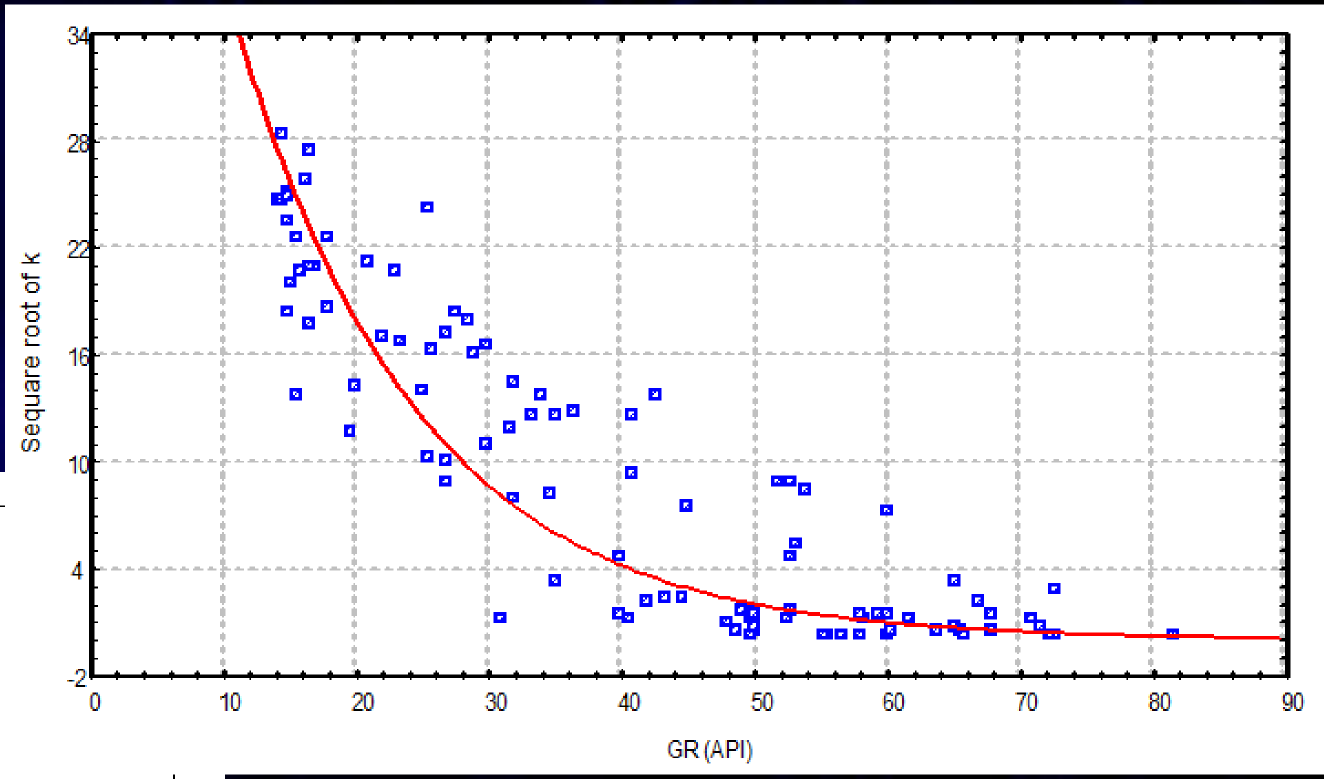
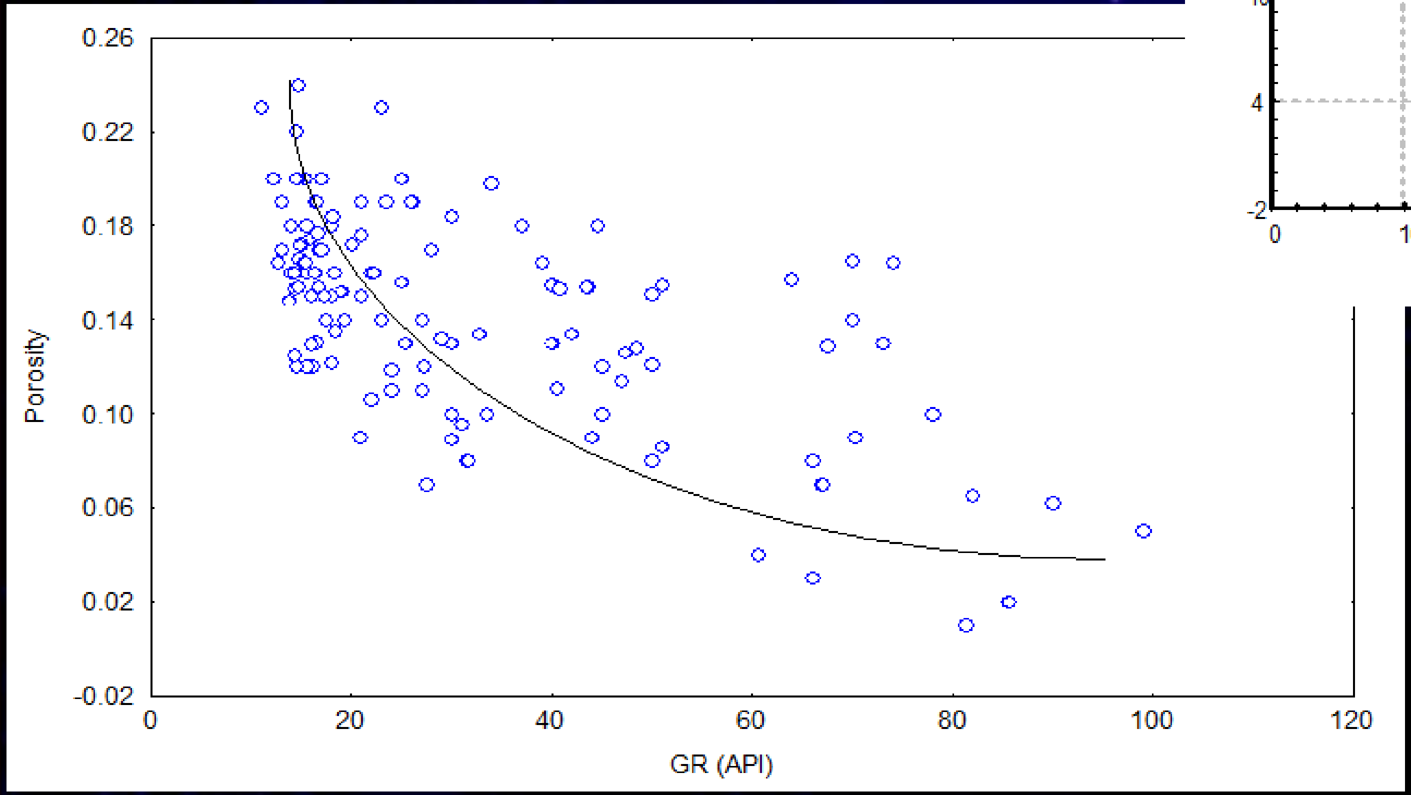


Fig. (4-8): Profiles of predicted and observed permeabilities for well M4.

Permeability and Gamma ray Transform





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Permeability and Gamma ray Transform

$$\sqrt{k} = \frac{1}{2} Exp(4.5\,\varphi^2 + 4(1 - IG))$$

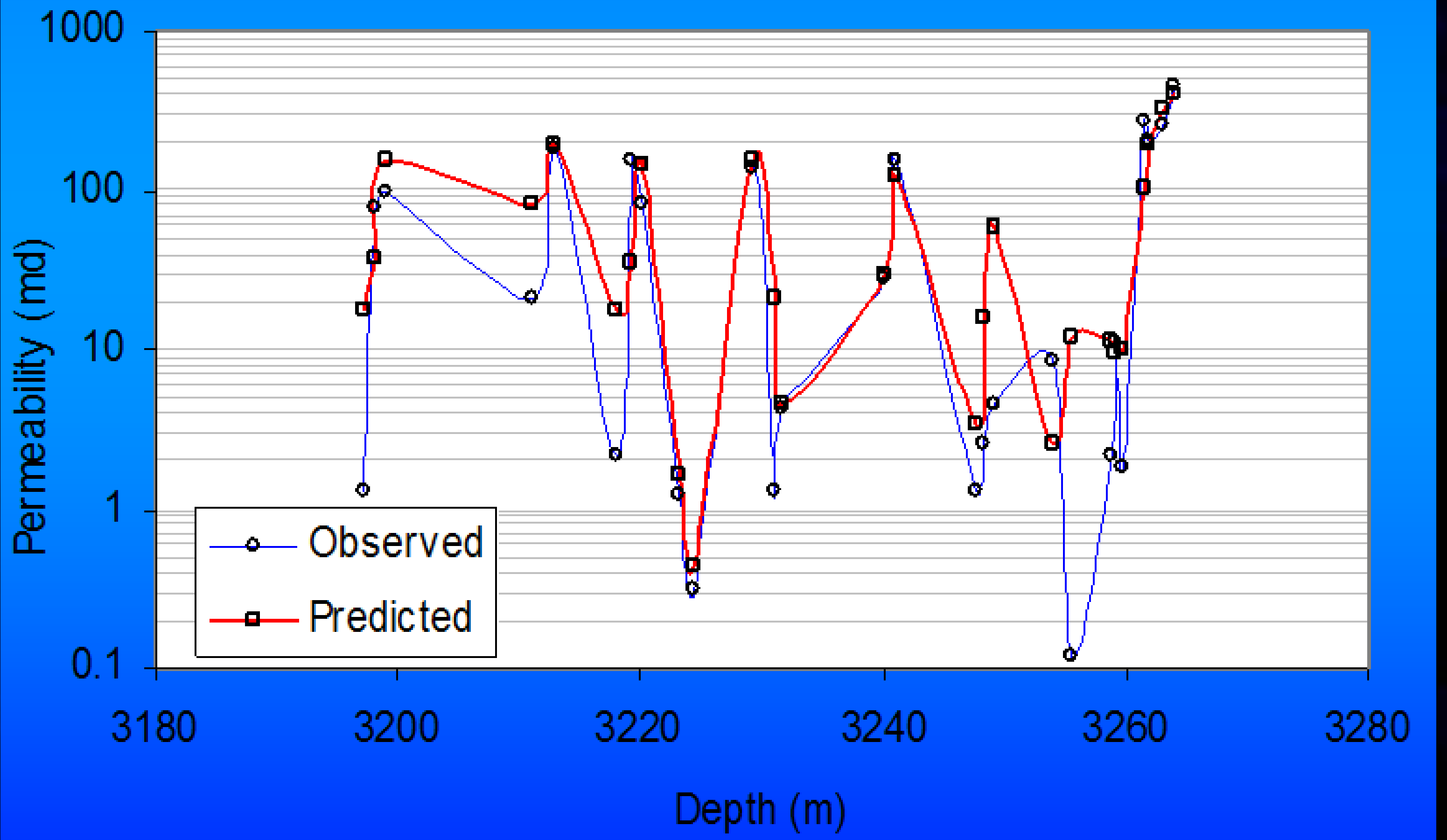

Fig. (4-44): Predicted and observed permeability versus depth

CONCLUSIONS

1. Porosity alone is not enough to explain the permeability variations. Even, if the porosity- permeability data, that were used, came from the same field.

2. In some areas permeability of sandstone can be estimated from carefully calibrated gamma ray curves, as shown by the following proposed relationship:

$$\sqrt{k} = \frac{1}{2} exp(4.5\varphi e^2 + 4(1 - IG))$$

CONCLUSIONS

3. For the M and A fields it is found that the permeability is a function of porosity, irreducible water saturation, and volume of clay :

$$k = f(\phi, Swi, Vsh)$$

It also found that the correlation coefficient between predict and observed permeability for the above function is increased by taking the square root of the permeability.