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WATER SATURATION DEPTH TRENDS

INTRODUCTION

In the complex Santa Barbara Field, one of the petrophysical problems encountered is the evaluation of water saturation, due to uncertainties in the estimation of true formation resistivity. Conventional petrophysical evaluation of the induction logs may result in abnormally high values of water saturation.

The problem has been found in shaly sands as well as in clean sands whereas nearly no water has ever been produced from the field. Exploratory statistics (3D), complemented by a depth trend analysis, has clearly shown that the high saturation values are in part due to a combination of existence of higher dips and of more shale interbeds.

A depth trend analysis of the saturation was performed on the whole data set and for each stratigraphic unit; the saturation values used correspond to the arithmetic averages of the water saturation. The data distribution and our study seem to indicate that, if a cut-off were to be applied, it would have to be a function of depth and it should not be a single value.

A cut-off was chosen graphically on the whole data set and verified by each of the individual stratigraphic units. By attributing two colours to the two populations of data located on each side of the cut-off line we were able to evaluate the validity of the hypothesis by studying the map distribution of these two populations for every single stratigraphic unit. Note that the choice of cut-off is essentially directed towards visualizing the problem at hand.

All of the observations can be summarized in a few diagrams comparing Unit 6 and Unit 7 from Santa Barbara Field (Fig. 21). The box plot diagram of Net-to-Gross per unit clearly shows that Unit 7 corresponds to the top of a fining-upward sequence with abundance of shale intervals and that unit 6 is the base of a new fining upward sedimentary cycle and is much more sandy in nature. In Unit 6 only three measurements have abnormally high water saturation whereas many points are too high in Unit 7. The geographic distribution of the abnormally high values in Unit 7 is in complete agreement with the structure of the field with the abnormally high saturation values located in the zones of high dips in the recognized structure (Figs.22 to 24).

The statistical identification of the abnormally high water saturations in the low Net-to-Gross intervals and the understanding of their geographic distribution will help pinpoint where beds may be highly dipping. These findings can be extrapolated for the sandier intervals where saturation may be correctly measured but where the thickness is abnormally high because of the dip; in such cases this information can be used to make isopach-corrected thickness maps, even if the correction is only semi-quantitative. Finally, the values of dips so obtained may be input into more advanced petrophysical modeling applications.

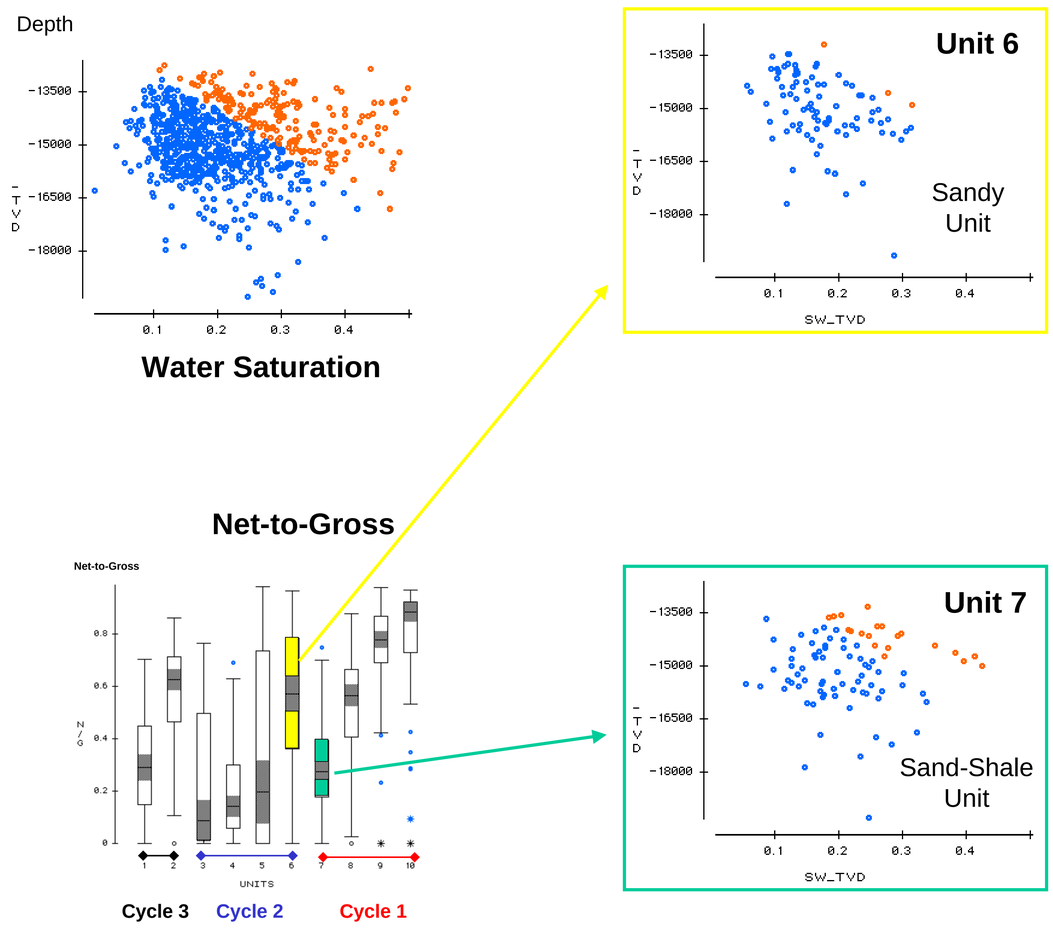

Fig. 21 Water saturation depth trend analysis using an arbitrary cut-off varying with depth

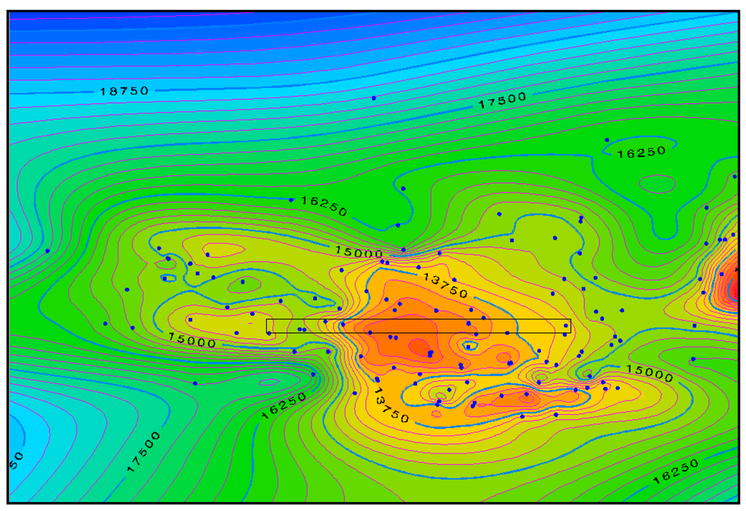

Fig. 22 Location map of well data

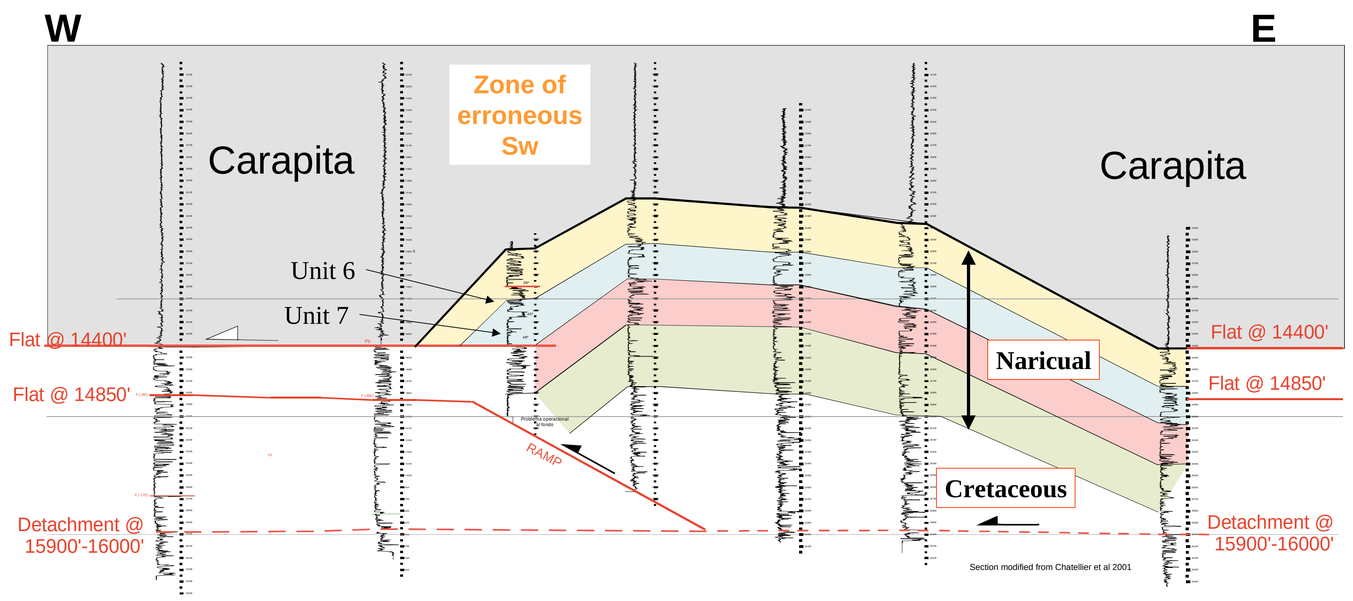

Fig. 23 Good agreement between abnormally high water saturations and high bedding dips

MOST STRIKING RESULTS

- The units with high Net-to-Gross show very little to no abnormally high water saturation averages whereas the units with low Net-to-Gross consistently include more anomalous water saturation averages.

- For each unit there is a well defined geographical distribution of the anomalous water saturations indicating that the existence of calculated high saturation is linked to changes within the structure of the field.

- The study of the water saturations in any individual well shows that the link between anomalies and low Net-to-Gross is real and that the distribution of abnormally high water saturation is not random.

The maps of water saturation anomalies are in total agreement with the structure of the field and can be used to predict zones with highly dipping beds. In zones of low dips, no anomalies are found.

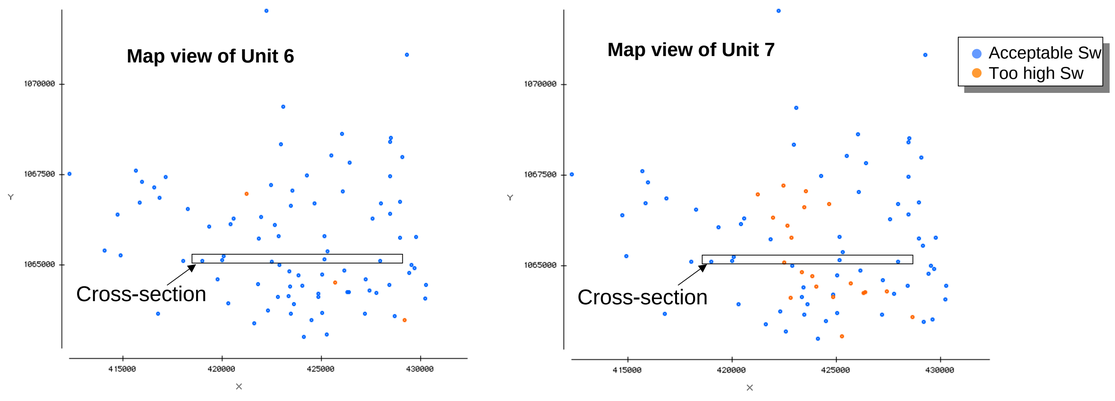

Fig. 24 Areal distribution of the anomalous saturation values

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