# Defining electro-log markers in poorly consolidated, heterogeneous clastic sediments using standard deviation data trends – an example from the Sava Depression, Pannonian Basin System

Marko CVETKOVIĆ[1]* and Tomislav MALVIĆ[1, 2]

[1] University of Zagreb, Faculty of Mining, Geology and Petroleum Engineering, Zagreb, Croatia, *corresponding author: marko.cvetkovic@rgn.hr

[2] INA Plc., Zagreb, Croatia, e-mail: tomislav.malvic@ina.hr

## Introduction

E-log markers are by default derived from well logs. The oldest approach considers defining markers using only electric logs (E-logs) such as spontaneous potential (SP) and resistivity (R). The newer approaches for defining markers also rely on newer well logs such as gamma ray, compensated neutron and others. Those are all focused mainly on recognizing motifs that can be observed on well logs and then correlated Sediments in which these motifs can be recognized are mostly thick marls in which the motif itself is controlled by minor change in marl porosity (Vrbanac, 2002).

This approach is valid for sediments in which thick marl or shale intervals occur but is not applicable when a high variation in lithological composition and depositional environment is present which is characteristic for the last phase in evolution of the Pannonian Basin System (PBS) (Malvić & Velić, 2011). Therefore, for the purpose of acquiring meaningful correlation, a new method of determining E-log markers is established.

In the Sava Depression, this last phase of the evolution of the PBS corresponds to the lithostratigraphic unit of the Lonja Formation, which is composed of sediments deposited during Pleistocene, Pliocene and Holocene (Malvić & Velić, 2011; Velić, 2002). Its base is determined by a well log marker α′. The morphology of this marker differs from ones determined in older sediments. Basically it separates the thick sandstone or marlstone sequences in its base from the frequent interchange of poorly consolidated sandstones, sands, clays and silts above.

For the purpose of structural and lithofacies analysis of those younger sediments, which belong to the Lonja Formation, E-log marker α′ had to be followed among the wells in explored area.

**Methodology**

As only E-logs are available from within this interval and no distinct motifs could be determined, an approach of using simple mathematics to determine changes in the environment was employed. Firstly, the value of standard deviation of the SP and R log values was calculated for the data interval radius of one, two and four meters. As digitalised well logs mostly have a resolution of 0.1 m this means that standard deviation was calculated based on 10, 20 and 40 data points. After this procedure, a cumulative standard deviation curve was plotted.

The result of this analysis pointed out obvious change in trend of the data and the interpretation was made similar to the interpretation of cumulative dip from dipmeter data (Velić et al., 2012). A high cumulative standard deviation value gain per depth correlates to the high variation in lithological composition characteristic for the Pliocene (i.e. the Lonja Formation). Lower cumulative value gain per depth correlates to the less frequent changes in lithology where thick beds of either sandstones or marls occur which is characteristic for Pontian (i.e. the Široko Polje Formation). Therefore, intersection of the tangents of these two trends clearly depicts the Lonja Formation bottom, i.e. E-log alfa (Figure 1). Cumulative curves for standard deviation (CSTDEV) of one, two and four meter radius were plotted and the intersection of trend tangents was determined. The results were plotted onto two well logs together with α′ determined in the INA Plc. (Figure 1). For Well–1 the best correlation between the marker form the database and the marker from CSTDEV was in the case of 1 m radius where in the case of Well–2 very good for all three cases. Therefore only the 1 m radius CSTDEV was used for further definition of $\alpha'$ using presented mathematical methodology.

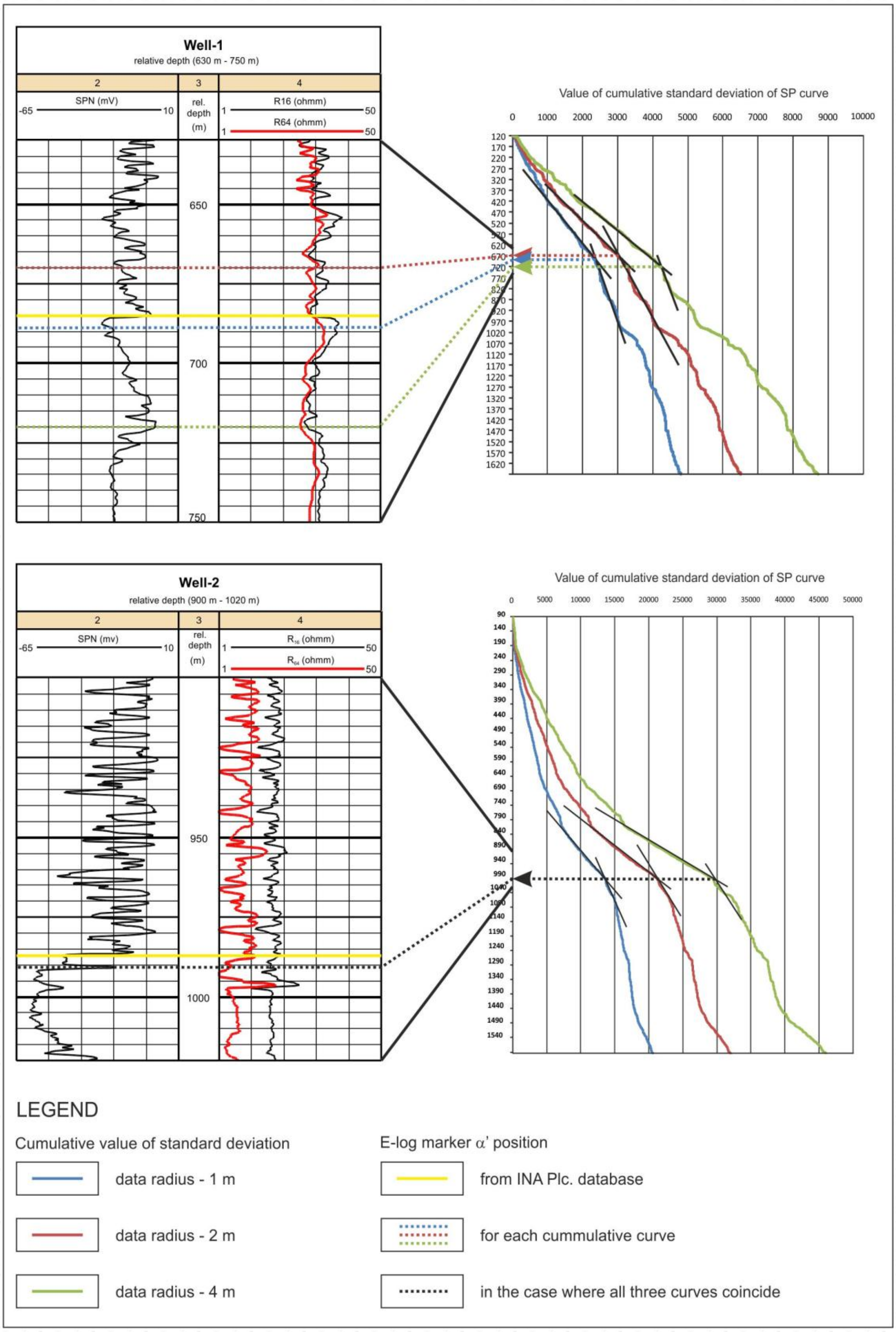


*Figure 1: An example of CSTDEV curve analysis in two wells*

## Results

The results of the CSTDEV curve analysis for all wells were compared to the $\alpha'$ from the INA Plc. database. In most cases, only a minimal difference between the marker determined by CSTDEV curve. Using the 2D seismic section (Figure 2) it is easy to prove that mathematical (i.e. CSTDEV) approach was more accurate for determining E-log $\alpha'$ (Pontian/Pliocene) then looking for "characteristic" shape of e-log curves. Consequently, e-log determined mathematically can be used for a more accurate structural mapping of the Lonja Formation bottom.

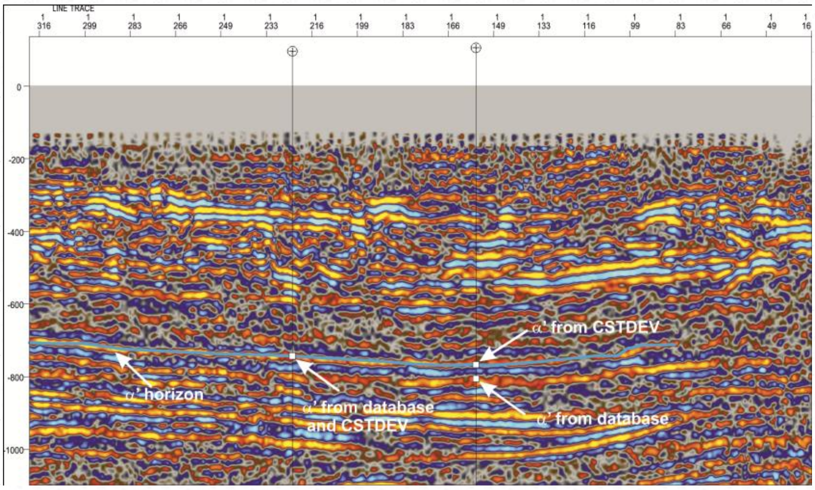


*Figure 2: Seismic section showing two wells and the position of the Pontian/Pliocene border horizon and positions of the $\alpha'$ marker defined from logs and mathematically in two cases*

## References

MALVIĆ, T. & VELIĆ, J. (2011): Neogene Tectonics in Croatian Part of the Pannonian Basin and Reflectance in Hydrocarbon Accumulations. –In: SCHATTNER, U. (ed.): New Frontiers in Tectonic Research: At the Midst of Plate Convergence, InTech, Rijeka, 352 p.

VELIĆ, J., WEISSER, M., SAFTIĆ, B., VRBANAC, B. AND IVKOVIĆ, Ž. (2002): Petroleum-geological characteristics and exploration level of the three Neogene depositional megacycles in the Croatian part of the Pannonian basin. Nafta 53, 6-7, 239-249.

VRBANAC, B. (2002): Chronohorizons Based on Resistivity Curve Variations - Upper Miocene Sediments of the Ivanić Grad Formation in the Sava Depression (NW Croatia). Geologia Croatica, 55, 1, 11-23.