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Pressure anomalies on the Totea-Vladimir structure (Getic Depression)

Mihai-Remus Şaramet[1], Cătălin Hamac[1], Ciprian Chelariu[1]

[1] "Alexandru Ioan Cuza" University of Iaşi, Department of Geology, 20A Carol I Blv, 700505 Iaşi, Romania

Abstract

The Totea-Vladimir structure belongs to the Getic Depression, which was formed at the beginning of the Lower Miocene in the South Carpathians foredeep. In terms of hydrocarbon accumulations, the Sarmatian and Burdigalian formations are of major trade interest. In this context, several technical problems were encountered at the entry of the drilling bits into the Burdigalian formations due to certain abnormal pressures, although their possible occurrence has been monitored in the geologist's cabin. The method used by the geologist was generically named "the Corrected d_c-exponent", and it pointed out the entry of the drilling bits into the overpressured Burdigalian formations, but it failed to establish the correct value of the recorded pressures; therefore, the necessary measures to avoid the kicks were not taken in advance. Consequently, in the present paper, to correctly establish both the entry into overpressured areas as well as the value of their pressure, it was used the method proposed by Bourgoyne and Young (1974) which, applied to "H" well, it rightly indicated the magnitude of the pressure at the entry of the drilling bit into the Burdigalian formations.
Regarding the causes of the pressure deviations in the Burdigalian formations opened by the "H" well, this paper shows that their presence is closely related to the tectonic events that have controlled the completion of the Totea-Vladimir structure architecture during the Sarmatian period.

Keywords: Totea-Vladimir structure, abnormal pressure, drilling, kick.

1. Introduction and geological settings

The Totea-Vladimir oil-bearing structure was named after Totea and Vladimir localities (Gorj county) which are located at about 50 km from the town of Târgu Jiu (Fig. 1).

From a geographical point of view, the Totea-Vladimir structure is situated between Motru and Olteţ rivers, in the central-western part of the Getic Piedmont, and geologically, it belongs to

Corresponding author's e-mail: saramet@uaic.ro

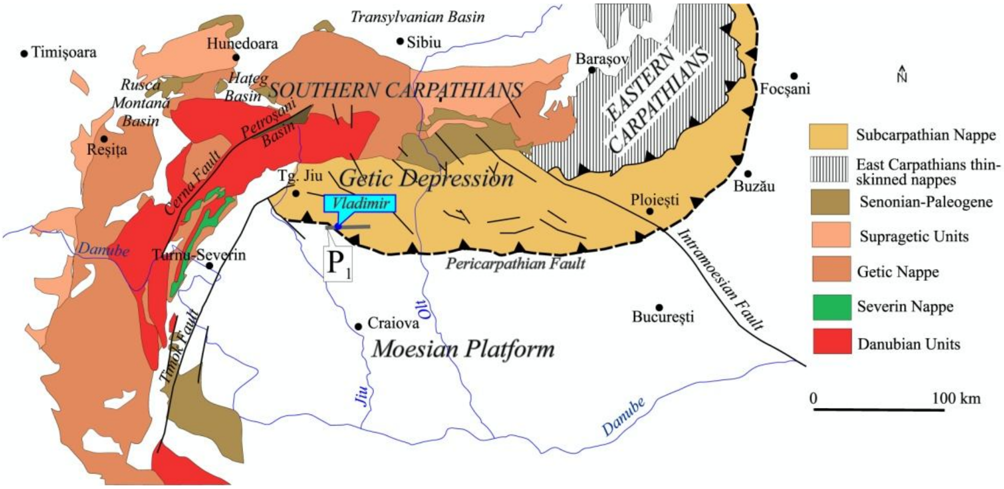

Fig. 1 The Getic Depression in relation to the Southern Carpathians units and the Moesian Platform (according to Tari et al., 2011, with amendments).

the Getic Depression, where its drilled wells have revealed significant deposits corresponding to the Romanian-Burdigalian period (Fig. 2).

In tectonic terms, the Totea-Vladimir structure had a complex evolution (Maţenco et al., 1997; Maţenco and Schmid, 1999; Răbăgia and Maţenco, 1999; Tărăpoancă, 2004; Tărăpoancă et al., 2007). At the beginning of the Lower Miocene and during the old Styrian movements, sediments of Burdigalian age were deposited in a sedimentary basin, of pull-apart type, developed within an extensional regime on normal transcurrent faults (strike-slip).

During the new Styrian movements of the Middle Miocene and alongside the tectonic inversions of the Badenian, the normal transcurrent faults become reverse faults and the induced compressions lead to overthrust of the Getic Depression Miocene deposits over the Moesian Platform Miocene deposits in order to form the Subcarpathian Nappe (Fig. 3 and 4).

The Moldavian transpressional movements of the Sarmatian caused the formation of the flower structures from Totea-Vladimir and Colţeşti. Their architecture en échelon folds is the result of the strike-slip fault activity that separates the two structures.

In Figure 4, the presence of the piggyback basins is highlighted as a consequence of salt deposits sintectonic sedimentation on the Subcarpathian Nappe, which was moving over the Moesian Platform since the Badenian age. Later on, the Subcarpathian Nappe was formed at the end of the Lower Sarmatian, and the geological formations of the Dacian Basin were laid over it until the Romanian age (sensu Jipa and Olariu, 2009).

2. Pressure anomalies assessment. Case study: the "H" well (Totea-Vladimir structure)

In order to avoid some unpleasant geological incidents while drilling hydrocarbon wells on the Totea-Vladimir struc-

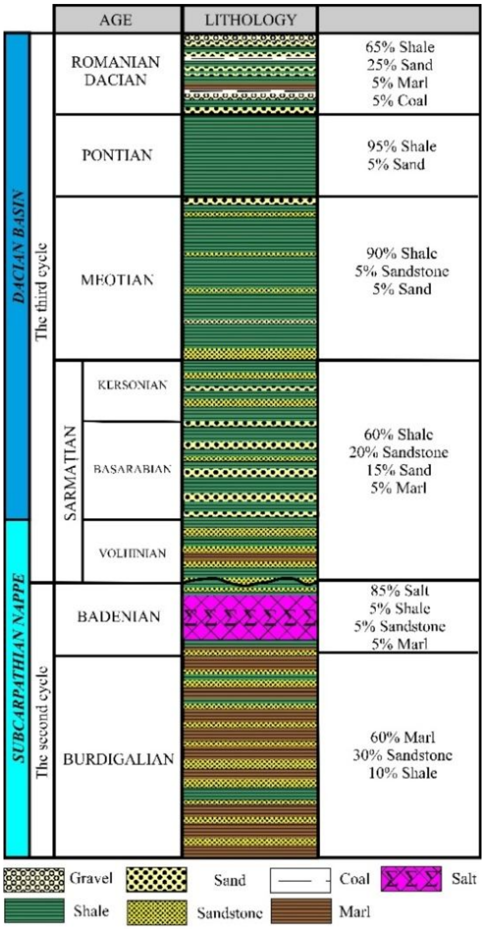

Fig. 2. Lithological column of deposits ranging from Burdigalian to Romanian age, within the Totea-Vladimir structure (after Şaramet et al., 2014).

ture, the drilling parameters were monitored and inserted into a program for reporting the possible situation when drilling bit enter into the overpressured formations, based on a calculation method that is referred to as "the corrected d_c-exponent". Certain corrections were made to the original method, proposed by Jorden and Shirley (1966), regarding the variation regime of the pressure gradients, the fluids from the pores of the rocks and the drilling fluid (Rehm and McClendon, 1971). Subsequently, the drilling bit wear corrections were introduced within the method (Mouchet and Mitchell, 1989).

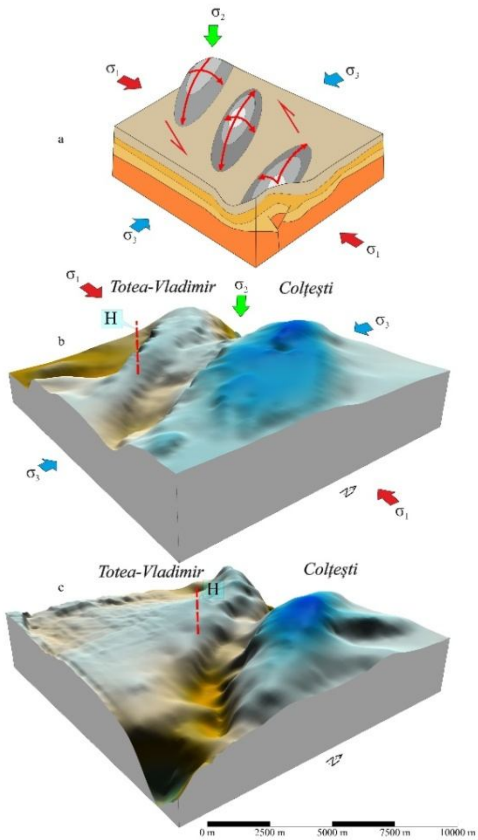

Fig. 3 Blockdiagram representing the Totea-Vladimir structure: a) tectonic sketch representing *en échelon* folding (according to Cramez and Letouzey, 1988); b) structural map at the entry to the Upper Burdigalian; c) structural map at the entry to the Lower Burdigalian).

In the case of the "H" well (drilled on the Totea-Vladimir structure) where several formation kicks were encountered during drilling the Burdigalian formations, both the values of the d_c-exponent depending on depth, and also the corre-

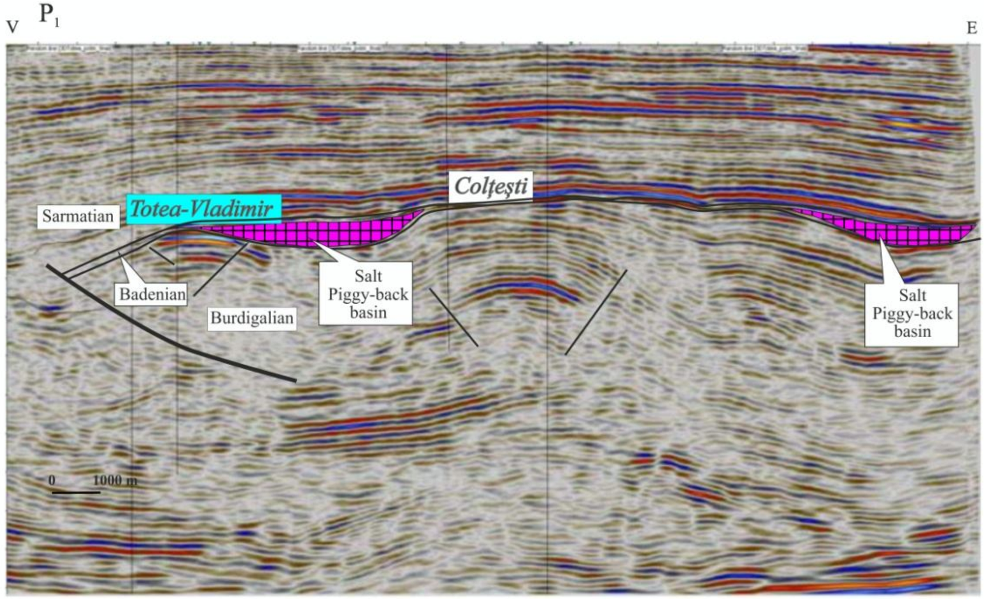

Fig. 4 Seismic Profile (P_1) in the W-E direction, within the Totea-Vladimir and Colţeşti structures, identifying the piggy-back basins from the Badenian (location shown in Fig. 1).

sponding values of the normal compaction line of clay, marked d_{csn}, were recalculated and graphically represented. Placing the d_c-exponent values below the normal compaction trend line of d_{csn} clay, it certainly indicates the entry of the drilling bit into the overpressured zone (Fig. 5a). In this figure, during the Romanian-Dacian period, the normal compaction line was sectioned and shifted due to a change in diameter of the drilling bit.

Based on the variation of the d_c-exponent and the normal compaction line d_{csn}, in 1975, Eaton (from Mouchet and Mitchell, 1989) develops a method for estimating the fluid pressure into the pores of rocks (P_{PE}). The values resulted for the "well H" were plotted according to depth by using this method (Fig. 6).

Given the above aspects, the highlighting of pressure anomalies through the d_c-exponent method is dependent on some issues that concerns drawing the normal compaction line of the clay. Accordingly, the corrected d_c-exponent method gives satisfactory results only when the drilling is made in clays and marls (Fertl, 1976). For other rocks such as arenites, carbonate rocks etc., the results can be unconvincing and, in this situation, other methods are used, such as the one proposed by Bourgoyne and Young (1974).

This method was developed to compensate for the changes that occurred on the drilling parameters during its advance (Bourgoyne et al., 1986). Thus, the authors proposed a mathematical model for calculating the speed of the drilling bit advancement as a function of several variables, including the pore pressure gradient. To highlight the overpressured areas, the authors have defined a drilling competence parameter (K_p).

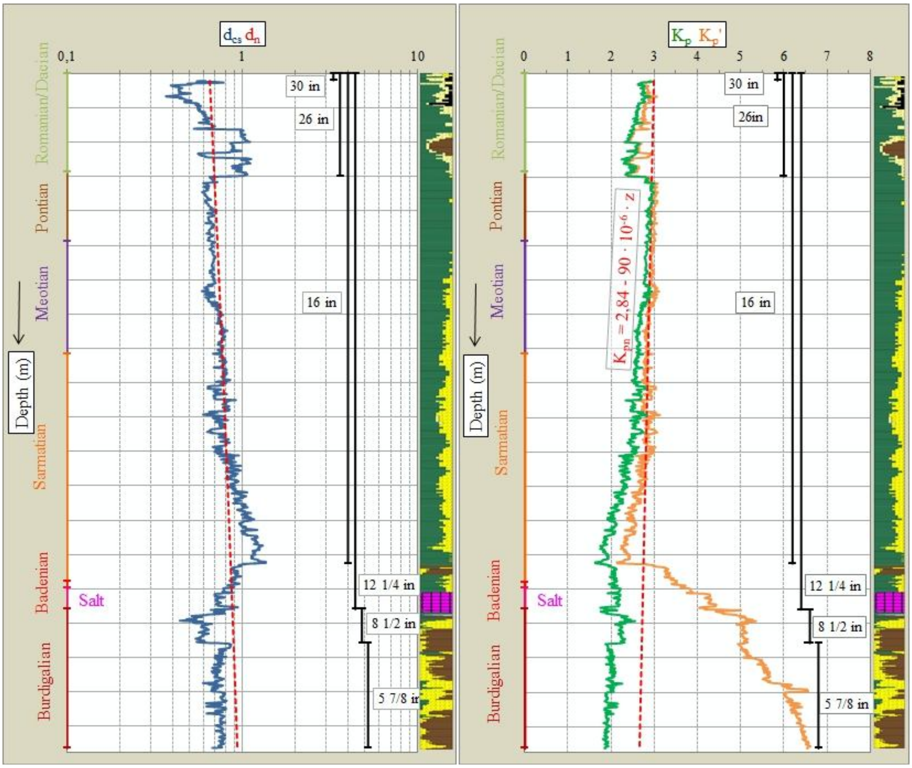

Fig. 5 Identifying abnormal pressure formations: a) "the corrected d_c-exponent method"; b) Bourgoyne and Young method.

Considering the "H" well, at the entrance to the adjacent geological formations of the Badenian salt, the deviation of the K_p parameter values, from its normal compaction trend K_{pn}, reveals the entry of the drilling bit into an overpressured zone (Fig. 5b). Within this method, also for the "H" well, it was calculated and plotted, depending on depth, the variation of the fluid pressure into the pores of the rocks (P_{PE}), which indicates the same overpressurization at the entry of the drilling bit into the adjacent Badenian salt formations.

Analyzing the Figures 5 and 6, although both methods indicate the same depth of the drilling bit penetration in the overpressured area, yet one can ask the question: which one of them can also pinpoint the correct value of the corresponding pressure? To answer this question, we used the pressure tests carried out by closing the "H" well as a result of the formation kick. The pressure values thus obtained were graphically represented in Figure 6 by the two red coloured dots. Following on this figure which of the curves associated to the two methods of identifying abnormal pressures is approaching more to these dots, it appears that only the Bourgoyne and Young method offers satisfactory results, the curve of the d_c exponent recording much lower values.

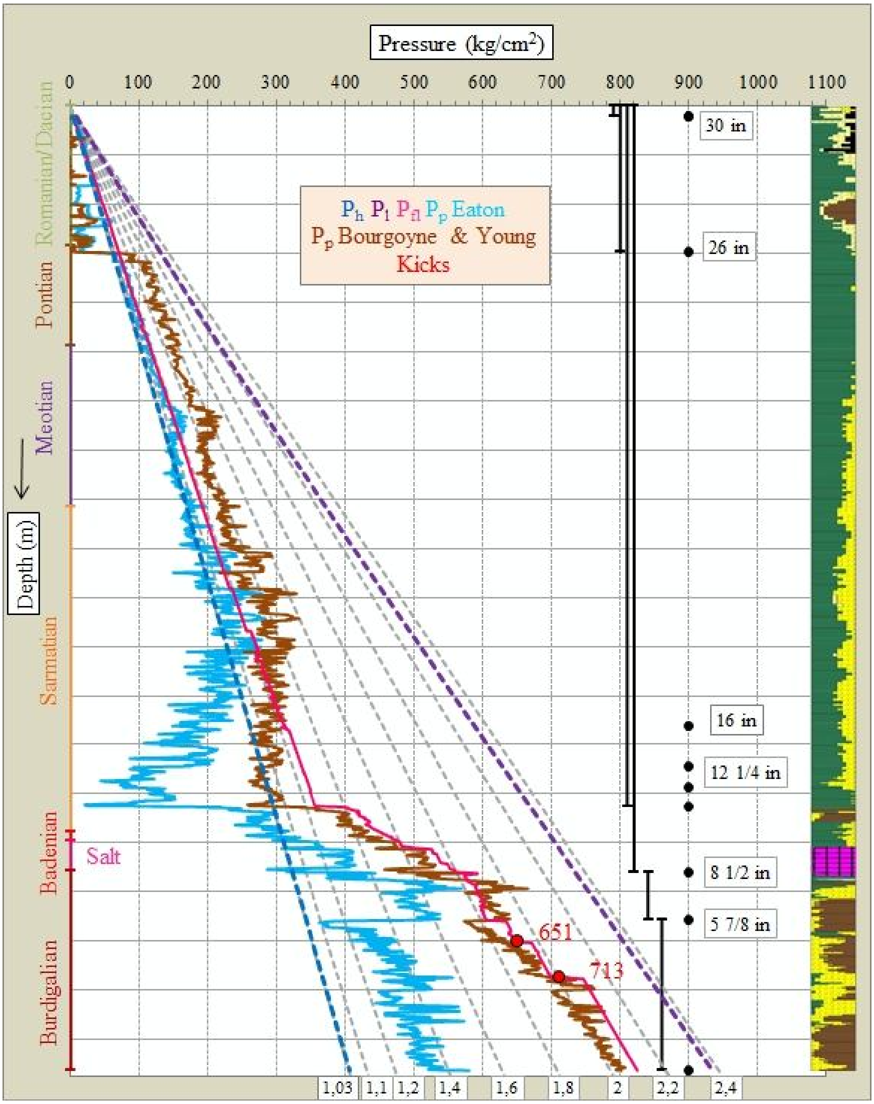

Fig. 6 Pressure graphic according to depth, during the drilling of H well (black dots indicate a change in the drilling bits during the well's digging; red dots represent the measured pressure in the case of kicks).

3. Conclusions

From this case study, it can be concluded that, within the Totea-Vladimir structure, the pressure anomalies of the Burdigalian fluid formations in "H" well are of tectonic nature to a large extent, due to the faulting and folding mechanisms, but in particular, to the uplifting layers that form the flower type structure (Fig. 3 and Fig. 4).

The Burdigalian formations, originally located at greater depths, have preserved their corresponding pressures; raising them, they were transferred to the surface where the presence of Badenian salt was a real "barrier" in the fluid migration path. This background explains why in the Burdigalian formations located under the Badenian salt, the well encountered formation kicks due to the presence of overpressured fluids.

At the same time, its kicks were not reported in a timely manner since the d_c-exponent method, which was used in the geologist's cabin, has indicated the entry of the drilling bit in the overpressured areas, and it did not correctly specified their pressure value. As a result, at least for the wells that will drill on the Totea-Vladimir structure in the future, it will be necessary for the identification of the pressure anomalies through the d_c-exponent method to be verified using the Bourgoyne and Young method, in order to highlight the extent of the formation pressures in the overpressured zones.

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