Δελτίο Ελληνικής Γεωλογικής Εταιρίας τομ. XXX/5, 33-38, 1994
Πρακτικά 7ου Επιστημονικού Συνεδρίου, Θεσσαλονίκη, Μάιος 1994
Bulletin of the Geological Society of Greece vol. XXX/5, 33-38, 1994
Proceedings of the 7th Congress, Thessaloniki, May 1994

ESTIMATION OF THE FORMATION PRESSURE ON ABNORMAL PRESSURE CONDITIONS AND TEMPERATURE VARIATION IN TORTONIAN PLIOCENE SECTIONS OF PREADRIATIC DEPRESSION

R. Liço*

ABSTRACT

In the formations of Tortonian Pliocene sections at Preadriatic Depression have been encountered abnormal pressure zones. Quantitative evaluation of these pressures and reconstructing of layer thickness have been the goal of several years study. The results of estimation of layer pressure at conditions of temperature variation are presented in this paper.

Formations with pressures higher than the hydrostatic ones vary in depth. The study of compaction and discovery of abnormally high pressures in thick sedimentary sections, from geologic point of view, are significant because shale rocks serves as source beds, as covering and as environment of migration of water and hydrocarbons.

The geophysical methods presently used in Albania are basis methods for the study of compaction, discovery of abnormal pressure intervals, for quantitative evaluation to determine direction of fluid migration.

For the purpose of improvement accuracy of pressure determination is performed correction for effect of temperature which change with depth and it is the principal cause of changes particularly in resistivity logs. For the quantitative evaluation the technique of normal compaction curve and equivalent depth one are used. Obtained results are compared with technology tests.

Regional geothermics studies, formation resistivity changes from temperature studies, and salinity and about density one, accomplished the last tree years, have served for these investigation.

These data obtained from a number of boreholes have helped to establish a stable series measurements and an accurate calculation method of layer pressure too.

This study is particularly useful for new wells projection at different continental structures and at new marine ones.

INTRODUCTION

During the past years technological drilling difficulties, in the structural coastal belt of Preadriatic depression are encountered. These have happened because one considerable part of crossections started from Pliocene up to Helvetian have high abnormal pressure. Several boreholes did not reach at projected depths because the abnormal pressure formations occur at shallow ones, with relatively high pressure.

So the study of compaction and calculation of formation pressures was one important task given for solution.

---

* Faculty of Geology and Mining, Polytechnic University of Tirana, Albania

To draw an accurate conclusion on the nature and distribution of abnormal pressure was necessary to get acquainted with a broad drilling information. A part of the data is obtained by technological methods, while the main and the more complete material is obtained by logs.

The goal of thermobaric complete studies at Preadriatic depression was to compile a more accurate approach of abnormal pressures. To put into evidence the most effective geophysical methods and for knowing of factors which influenced on measured values and the value of calculated pressure.

The performance of such a study made possible coming to the conclusion that the main reason of abnormal foundation is compaction phenomenon. Mineralogical change factor of shales do not influence at such depths where overpressures appears.

Based on studies of water samples, taken at about 50 wells it results that, their densities varies from 1.009 to 1.02 gr/cm^3. In consequence normal hydrostatic gradient is small and varies from 1.01 to 1.02 Mpa/10m while the temperature factor, though the temperature gradient is not big, from geothermic studies recently made, is proved that they vary from one region to the other and the influence is bigger at the formation resistivity.

TRENDS OF FORMATION COMPACTION AND POROSITY WITH DEPTH

In order to indicate compaction conditions it is necessary to construct a series of geophysical measurements indexes which are depended on porosity versus the depth.

The fig. 1 and 2 shows curves of variety R_a, σ and Δt versus the depth in zones with normal and abnormal pore pressure.

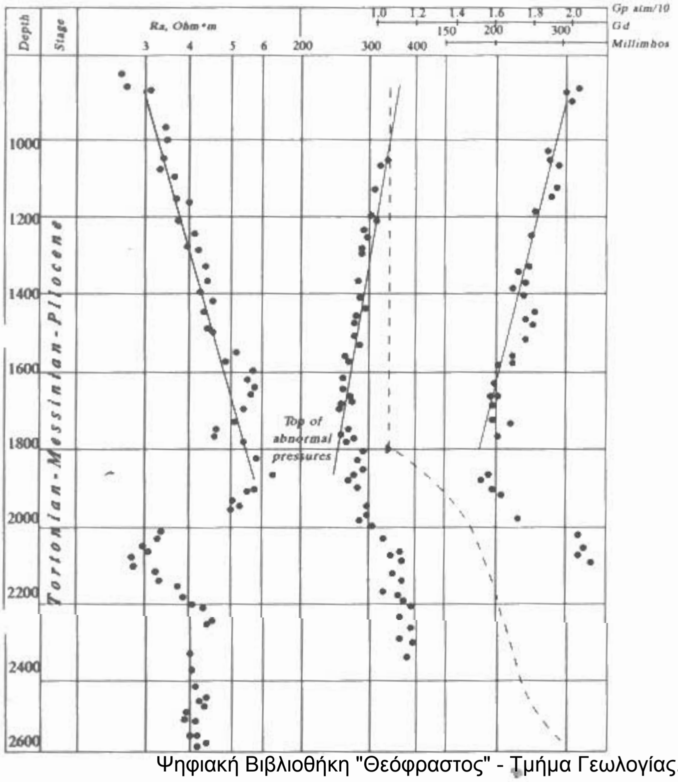

Fig. 1: Dependence of resistivity, conductivity, travel time and gradients of pressures in well Div-55 in Divjaka region.
Ra - apparent resistivity; Gd - apparent conductivity; Dt - travel - time; Gp - gradient of layer pressure

In the study on the conditions of composition and estimation of layer pressures it is used analytical dependence.

Changes of formation porosity with depth as result of compression was studied by the following equation [1]

$$\frac{\Phi}{\Phi_0} = \frac{\exp[-0.014 \cdot a_n(\tau,t) \cdot H]}{1-\Phi\,[1-\exp(-0.014 \cdot a_n(\tau,t) \cdot H]} \quad [1]$$

Where $a_n(\tau,t)$ is the coefficient of the non reversible compression of the formations, τ - time, t - temperature and Φ_0- porosity in surface conditions (H=0).

To accomplished the calculations about compaction was necessary to determine the $a_n(\tau,t)$. In Divjaka region this coefficient was 40. 73E-03, in Frakull it is 31.14E-03 and in Povelca 34.40E-03.

Φ is determined by acoustic log.

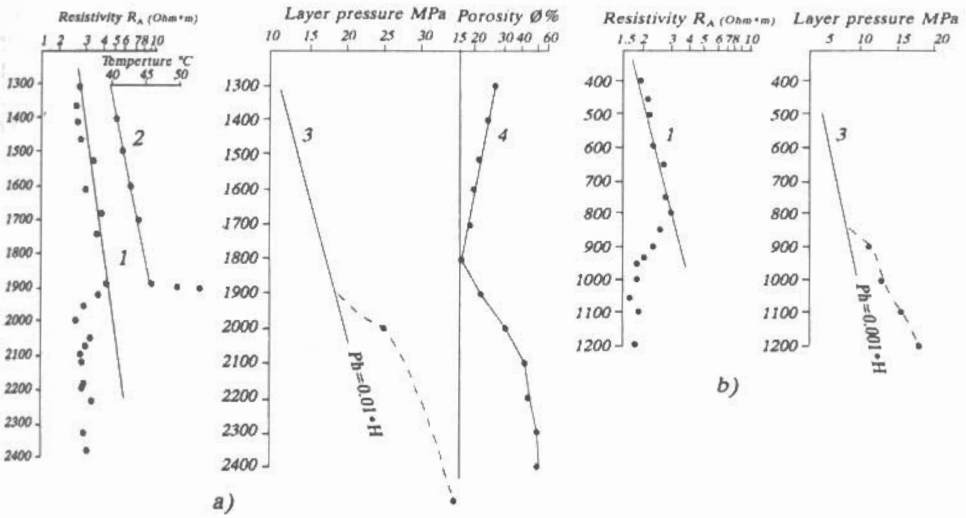

Fig. 2: Compaction and layer-pressure curves, calculated by resistivity logs.

a) well Div-5; b) well Kavaja-2;
1. Dependence of the resistivity versus depth
2. Dependence of temperatures versus depth
3. Dependence of layer-pressure versus depht
4. Dependence of porosity versus depth

Trends of normal composition is defined mainly by acoustic and resistivity logs. From studies performed in Preadriatic Depression has been concluded that except porosity on value of resistivity at zone with higher pressure also influences the pore pressure and the temperature. As indicated from fig. 1 and 2, resistivity in the zones with abnormal pressures changes twice or even more. At Kavaja and Durres wells resistivity changes up to 3-4 times. In fig. 2 at top zones with abnormal pressures it is noticed a jump of temperature up to 8°C. This temperature increase is caused by an immediate increase of pressure. The analysis of logs indicate that at first of 700-800m depth resistivity do not obey to the low of normal compress.

At all the Preadriatic Depression is studied salinity change versus depth.

This one confirms that average water density is 1.01 to 1.02 gr/cm^3 and good recognition hydrostatic pressure values up to abnormal top zones. Average rocks density is defined with geophysical prospecting methods and logs as well.

Average rock density values are found at about 2.5 gr/cm^3 up to 3000m depth, compaction lines reconstruction gave the possibility to define overpressure top or blockage depth of fluid movement which is reconstructed for all Preadriatic Depression already. These data serves to draw overpressure maps, see fig. 3.

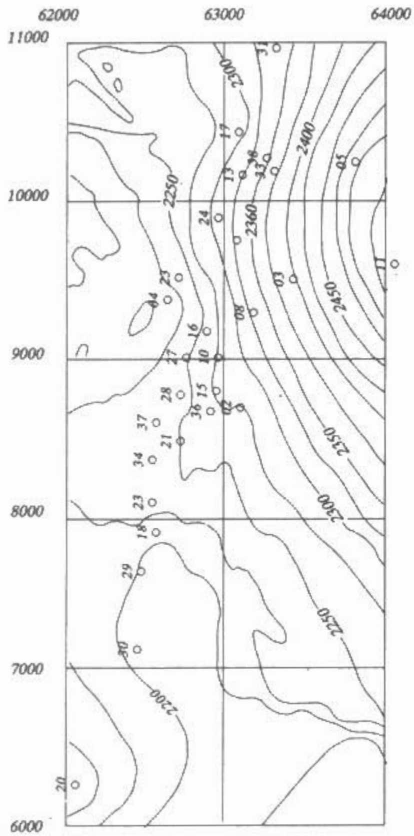

Fig. 3: Map of the top of super-pressure formations. Region of Povelça

O Drilled boreholes

~ Isolines of the top of super-pressure

Compaction line reconstruction for every old and new well at Preadriatic Depression gave the possibility to recognize the disequilibrium distribution. Porosity gradients change for equivalent thickness and depth from 1.5-2 confirm that sedimentation velocity and burying had been different.

ESTIMATION OF FORMATION PRESSURES

To determine the layer pressure some year ago was applied the equivalent depth approach. But, the performed studies has confirm that in pressure calculation accuracy it is necessary to take into consideration temperature influence also. For that purpose it is used parallely with graphical way and analytical way, which take into account temperature influence. This approach u is called the normal compression curves of shale.

Calculation of abnormal pressure with resistivity logs with normal compaction curves are performed through the formula:

$$Pa=Pn+\frac{1}{10}.\frac{AVG(\delta v-\delta u).\Delta H}{lg\frac{R_A,H_2}{R_A,H_1}+\frac{\alpha(R_A)}{2.3}G.\Delta H}.lg\frac{R_{A,n}}{R_{A,a}} \qquad (2)$$

R_A, H_2; R_A, H_1 - are reading values at depth H_2,

H_1; $R_{A,n}$ and $R_{A,a}$ - are reading values at the

same depth, at normal trend and at abnormal trend of R_A $\Delta H=H_2-H_1$.

Geothermic gradient is taken from the catalogue of Geothermic Studies carried out in Albania, while, $\alpha(R_A)$ is found in experimental way through the formula:

$$\alpha(R_A) = [2.2-1.6.10^{-2}.t].10^{-2}$$

For temperature changes from 40°C to 80°C $\alpha(R_A)$ changes from 0.013 up to 0.01. The results of the calculation of layer pressures are given in tab. 1, which belongs to different regions of Preadriatic Depression. While at fig. 2

are given the results of pressures obtained at well Div-55 and Kavaja-2/b. The study pressures and their gradients at most of the boreholes indicate that three values are not representing increasing values.

The results which are given in tab. 1 presents the changes between the pressures obtained with the techonological way. The results indicate that normal compaction curves approach very small differences between direct measurements by layer test and normal computation curves approach it results to an accurate define of a(P.) and geothermical gradient.

Table 1: Table of layer pressure and their gradient defined by the restitivity and the travel times of sounds

			RA	OM	Δt	μs/m	Layer pressure		Hydrostat	Grad of	Poros
Region	Well	Depth	normal	abnormal	normal	abnormal	with RA	with Δt	pressure	layer press	
		1000	3,2		340						37
		1100	3,5		325						34
		1200	3,7		320						32,5
		1300	4		300						28
		1400	4,2		290						25.8
		1500	4,4		270						21
		1600	4,8		265						20
Divjaka	5	1700	5,2		260						19
		1800	5.5		250						17
		1900	5.8	5.5	245	275	19.7	19.9	19,38	1,35	22
		2000	6,3	3,6	240	305	23.89	24.2	20.4	1.5	29
		2100	7	2,7	225	360	27.33	26.5	21.42	1,55	41,5
		2200	7,4	4	220	370	26,24	27,1	22,44	1.6	43.B
		2300	B,3	4	215	385	27,98	27,95	23.46	1.7	47
		2400	9	4	200	400	29,56	30,2	24,5	1.8	50
		1900	4,7		250	375			19,38		
		2000	4.95	3.4	235	300	22,3	23	20.4		
		2100	5,1	3,15	220	290	24,38	25,6	21.42		
Kavaja	2	2000	5,4	3,2	207	290	25,75	26,1	22,44		
		2300	5,7	3,3	200	285	26,32	27,4	23,46		
		2400	8	3,55	190	275	29,05	31,3	24,5		
		2500	8,2	3,7	180	270	30,66	31,8	25,62		

Table 2: Table of layer pressured defined by equ. Depth approach; normal compaction curves and measured

Region	well	Depth	Hydrostatic pressure Mpa/10m	Layer pressure Mpa Measured	Defined with equ.depth appr	Defined with norm.comp. curves	Gradient of layer pressure
	1/B	1980	21,78	24	24	25	1,5
	2	1970	19,9	26	24	26,2	1,6
	4	2350	23,7	33	32	32,5	2,02
Povelce		2060	20,8				1,62
	7	1975	19,9	25	23	25,5	1,5
	9	2175	22	30,1	28	30,8	1,52
	10	2202	22,24	26,8	25,5	27	1,33
Divjake	2/B	2100	21,4	26,1	25	27,4	1,54
Kavaje	3	1500	10,1	13,5	12,5	13	1,51
Frakull	18	1650	18,15	21,6	19	21	1,45
Ardenice	5	2500	25,5	32,3	30	33,5	1,45
Durres	15	1100	11,1	17	16,5	18	1,6
Panaja	8	2100	21,2	29	27	29,5	1,55
	12	2300	23,23	33	31	31	1,58

Differences of results between two geophysical approaches ranging from 3 - 9% of the normal computation curves gave some results with technological measurements.

CONCLUSION

This study suggests that resistivity and acoustic logs are the more effective in separation and evaluation of layer high pressures by an error of =10%.

The comparison of the results obtained by equivalent depth approach normal compaction curves and measured values by layer test confirmed that normal compaction curves approach is more accurate. It allows to take into account temperature influence. For temperature influence. For temperature ranges 40°C-80°C, temperature correction coefficient $\alpha(R_c)$ changes from 0.013 to 0.010.

Layer pressure values and their gradient ones are not represented as values which continuously increase. More common values of gradient layer pressures change from 1.4 to 1.7 Mpa/10m, while in the complete shale parts of the section, these values go up to 2.2.

In some structures the passage towards the high pressures zone is immediate. We can see it at the Durresi and Kavaja region structures, while at the southern structures this passage is gradual.

REFERENCES

DORBIN, V.M. (1989). The predictions of formations abnormal pressures with geological and geophysical methods. *Moscow*.

LIÇO, R., SHEHU, A. (1991). Some properties of geophysical measurements of wells in estimation of migration direction and quantities of water expulsion during compaction of Miocene-Pliocene cross-sections in preadriatic depression. *First National Symposium in Geophysics. Tirane*.

MAGARA, K. (1988). Compaction of rocks and migration of fluids.

LIÇO, R. (1993). Abnormal pressures encountered in Tortonian-Pliocen coross-section of preadriatic Depression and its estimation with conventional geophysical methods. *Florina, Greece 1993. 2nd Congress of Hellenic Geophysical Union.*