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Research Article

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Lithology Determination with Well Log Measurements

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Abstract In this study, it was aimed to calculate the porosity, pollution and saturation of rocks by using sonic, density, neutron and g-ray logs taken in an oil well. The corrected values of these logs were calculated from the raw values of the density and neutron log. Using these corrected calculated values, the lithology of the rocks between 2095-2484 meters was calculated from the density neutron log values. As a result of these calculations, the lithology of the well was obtained from the well log data of the oil well.

Keywords Well Log, Lithology determination, Clayness calculation, porosity calculation

1. Introduction

Well logging application was first performed in France in 1926 by Conrad and Schlumberger. Resistivity measurements were first made on core samples and then in boreholes. In those years, logging processes first started as resistivity logs, and then these log types increased to more than 30 pieces. The well logging method is one of the most successful and most used methods in oil exploration methods. Generally, systems consisting of receiver, transmitter, cable, crane and recorder are used in well logging. In well log measurements, different measurement methods are used depending on the physical parameters of the formations to be measured (natural gamma, density, resistivity, natural potential neutron, etc.). As a result of the evaluation of well log measurements, information is obtained about the thickness, porosity, slope, temperature of the formations, and the yield and salinity of the water that may be present in the formation, by using the measured physical parameters. Developing technology and increasing consumption are in a rapid period in terms of utilizing natural resources and finding and operating underground resources. In order to investigate underground resources, well logging is the measurement and recording of various physical properties of the formations passed in drilling wells as a function of the well depth [1, 2, 3]. It is very easy to find porosity, calculate the amount of clay, and water and oil saturations in oil-yielding carbonate rocks. The porosities of carbonate rocks are found from porosity logs. The porosity and permeability of this type of rocks are generally high. The presence of porosity and saturation is important in terms of oil reserves in such lithologies. Sonic, density and neutron logs are taken as basis in determining porosity. These logs are affected by well conditions, rock porosity, physical properties of the fluid, composition of the rock and clay minerals. Therefore, these negative effects must be eliminated before starting the calculations [4, 5]. Porosity (Ø)

Porosity is one of the most important physical properties of rocks. The porosity of a porous rock is the ratio of the volume of the voids of this rock piece to the total volume.

$$F = \frac{a}{\Phi^m}$$

It is given as: Here a and m are constant values.

It is the ratio of the volume of the voids within a formation that can be filled with a fluid, filled by formation waters, to the volume of all voids. It is not possible to produce all the oil of a petroleum formation. There is always some oil left in the pores of the rock. This oil saturation, which fills a portion of the pore volume, is defined as residual oil saturation. Between resistivity and water saturation in a clean formation (without clay),

$$S_w = \left(\frac{R_0}{R_t}\right)^{1/t}$$

There is a connection. Here, S_w represents water saturation, R_o represents the resistivity of the formation that is 100% saturated with water, and R_t represents the actual resistivity of the formation containing hydrocarbons. Since $R_0 = F \cdot R_w$, water saturation,

$$S_w = \left(\frac{FR_w}{R_t}\right)^{1/n}$$

We can write it as: In the case of a washed out region, the saturation of this region is,

$$S_{x0} = \left(\frac{F R_{mf}}{R_{x0}}\right)^{1/n}$$

It looks like this. Here R_{mf} indicates the resistivity of the mud water. The value of n can vary between approximately 1.7-2.5 depending on the type of formation [4].

Clayness ratio of rocks: Clay minerals present in the rocks have an effect on the raw values in log readings. Clay minerals are present in many rocks. In this regard, the clay effect must be eliminated from the raw log values. There are many methods to remove the clayey (VSH) of this rock. By choosing the one with the lowest ratio among the calculated rock clayey values, the one closest to the actual rock clayey ratio is obtained. Corrected log values are calculated using this lowest clayey value.

Gamma-Ray Method: Finding the clay percentage in the formation using the Gamma-Ray log method,

$$VSHGR = \frac{GR - GRmin}{GRmax - GRmin}$$

It is found by the relation. Here, VSHGR; GR the clay percentages calculated from the gamma-ray log; It shows the values read for each meter from the gamma-ray log, and GRmax shows the highest gamma-ray values read in the log. This GRmax value is known to occur in shale or clay. Grmax is the lowest value read in the log [4]. *Netron Log Method*: In this method, to find the clayey ratio of the formation,

$$VSHN = \frac{\phi N - \phi Nmin}{\phi NSH - \phi Nmin}$$

The expression is used. Here ϕ NSH; The CNL reading of the clay point recognized by GR and sonic ϕ N is the value read from ϕ (CNL) for each meter [4].

Sonic Log Method: Calculation of clayey ratio in the formation,

$$VSHDT = \frac{DT - DTmin}{T}$$

$$VSHDT = \frac{1}{DTSH - DTmin}$$

It is done with the relation. Here DTSH; It is the sonic reading of the clayiest point recognized by GR [4]. *Resistivity Log Method*: The relationship that gives the clayey ratio in the resistivity log method,

$$VSHR = \left(\frac{RSH}{RT}\right)^{1}$$

It is in the form. Here, RSH is the resistivity value at the clayiest meter known from GR and sonic log [4]. Corrected Values: It is known that porosity logs are affected by clay minerals in the rock. Knowing the rock clayey ratio is necessary for all log evaluation studies. In order to make a healthy porosity and saturation assessment, these clay effects must be eliminated. The netron porosity value read in a clayey formation with all pores saturated with water,

$$\phi_N = \phi + VSH\phi NSH$$

It looks like this. Here, NSH is the maximum total reading value and VSH is the rock clayiness. Here, the rock matrix is assumed to have no effect. The corrected porosity per unit volume is,

$$_{Ncorr} = \frac{\Phi_N - VSH\Phi NSH}{1.0 - VSH}$$

It is given by the relation. Here, VSH is the lowest average clayey. Density value read in a clayey formation,

φ

$$\rho_{bcorr} = \frac{\rho_b - VSH\rho SH}{1.0 - VSH}$$

It is found as . ϕ NSH and ρ SH are the maximum values read from the logs. For each point, ϕN_{corr} cor and ρ_{bcorr} corr values are found for clayey correction using these formulas.

Lithology determination by punctuation method from density and Neutron log: This method is preferred when well conditions are good. When the ρ_{bcorr} (mass density) and ϕ_{Ncorr} (neutron log) readings are punctuated in the chart given in Figure 1, the lithology of the rock can be determined, as well as its porosity and apparent matrix density.

				ble 1: well
Depth			ΦCNS NEUTRON	G.R
1900	62	2,6	12	52
1905	63	2.65	13	54
1910	63	2,59	12	47
1915	66	2,67	20	65
1920	66	2,70	14	54
1925	67	2.73	17	59
1930	66	2,54	13	45
1935	68	2,58	17	55
1940	67	2,53	17	40
1945	64	2,43	23	60
1950	63	2,57	17	40
1955	71	2,48	16	40
1980	70	2,60	13	50
1965	04	2,54	16	32
1970	65	2,66	20	63
1975	66	2,54	14	60
1980	68	2,55	30	55
			24	84
1985	70	2,63		64
1990	71	2,44	25	58
1995	65	2,65	24	70
2000	67	2,58	12	50
2005	76	2,55	23	67
2010	80	2,58	27	55
2015	65	2,55	12	48
2020	65	2,40	18	50
2025	68	2,68	8	50
2030	63	2,30	10	55
2035	66	2,55	10	67
2040	65	2,50	20	57
2045	64	2,40	18	50
2050	64	2,62	19	47
2055	80	2,48	25	90
2080	63	2,43	17	98
2085	64	2,65	19	90
		2,55		
2070	63		25	60
2075	70	2,65	17	87
2080	68	2,73	19	88
2085	69	2,62	16	94
2090	69	2,60	15	30
Death =	1	L ob dessib	1	
Depth	At sonic	qb density	CNS NEUTRO	
2290	58	2,63	28	57
	58 65			57 62
2290 2295	58 65	2,63 2,65	28 24	57 62
2290 2295 2300	58 65 75	2,83 2,85 2,88	28 24 27	57 62 70
2290 2295 2300 2305	58 65 75 67	2.63 2.65 2.68 2.60	28 24 27 10	57 62 70 56
2290 2295 2300 2305 2310	58 65 75 67 68	2,63 2,65 2,68 2,60 2,53	28 24 27 10 24	57 62 70 56 70
2290 2295 2300 2305 2310 2315	58 65 75 67 68 68 69	2.63 2.65 2.68 2.60 2.53 2.72	28 24 27 10 24 24	57 62 70 56 70 80
2290 2295 2300 2305 2310 2315 2320	58 65 75 67 68 69 62	2.63 2.65 2.68 2.60 2.53 2.72 2.71	28 24 27 10 24 24 24 18	57 62 70 56 70 80 58
2290 2295 2300 2305 2310 2315 2320 2325	58 65 75 67 68 69 62 67	2.63 2.65 2.68 2.53 2.72 2.71 2.71	28 24 27 10 24 24 24 18 14	57 62 70 56 70 80 58 60
2290 2295 2300 2305 2310 2315 2320	58 65 75 67 68 69 62	2.63 2.65 2.68 2.60 2.53 2.72 2.71	28 24 27 10 24 24 24 18	57 62 70 56 70 80 58
2290 2295 2300 2305 2310 2315 2320 2325 2330	58 65 75 67 68 69 62 67 70	2,63 2,65 2,66 2,53 2,72 2,71 2,71 2,71 2,73	28 24 27 10 24 24 18 14 23	57 62 70 56 70 80 58 60 80
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2290 2295 2300 2315 2315 2320 2335 2330 2335 2340 2335 2340 2345 2250 2355	58 65 75 67 68 69 82 67 70 66 6 6 6 6 83 68	2,83 2,85 2,88 2,80 2,53 2,72 2,71 2,71 2,71 2,71 2,73 2,72 2,85 2,40 2,85	26 27 30 24 24 19 14 23 25 16 21 24 19 24	57 62 70 86 70 80 80 80 80 80 80 82 85 85 85 85 85 85 70 70
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2290 2296 2305 2310 2315 2325 2320 2325 2330 2335 2340 2345 2345 2345 2345 2345 2345 2345 2365 2365 2365 2375 2390 2375 2390 2395 2395 2395 2395 2395 2395 2400 2405 2400 2405 2410	58 65 75 67 68 69 62 67 70 68 63 66 60 67 68 60 67 65 67 65 67 65 67 68 66 67 68 66 67 68 66 67 68 66 67 68 66 67 68	2,83 2,85 2,85 2,80 2,53 2,72 2,71 2,71 2,71 2,73 2,72 2,87 2,85 2,80 2,85 2,84 2,85 2,84 2,85 2,84 2,85 2,85 2,84 2,85 2,88 2,88 2,88 2,88 2,88 2,88 2,88	28 24 27 10 24 18 14 23 26 19 24 19 21 28 19 24 9 12 22 23 25 22 23 25 26 21	57 62 70 56 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 86 80 80 80 80 80 80 80 83 81 83 82 70 70 70 70 73 89 63 773 89
2290 2296 2208 2310 2315 2220 2325 2330 2335 2340 2345 2345 2345 2345 2345 2345 2355 2360 2365 2365 2365 2370 2375 2386 2390 2395 2390 240 245 240 245 245 245 245 245 245 245 245 245 245	58 65 775 67 68 69 62 67 70 68 63 62 67 70 66 58 63 66 66 67 64 57 65 65 68 66 67 65 67 65 68 66 68 66 67 65 68 66 68 66 68 66 68 66 63 64	2,83 2,85 2,85 2,80 2,53 2,72 2,71 2,71 2,73 2,72 2,85 2,80 2,85 2,86 2,85 2,84 2,85 2,88 2,88 2,88 2,88 2,88 2,88 2,88	26 24 27 90 24 18 19 25 21 24 18 14 19 21 24 25 25 22 26 24 19 12 22 22 23 25 22 22 23 25 24 21 25 22 21 24 22 25 21 25 21 25 21 36 6 8	57 62 70 86 70 86 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 81 82 83 82 83 82 70 70 70 70 70 70 73 63 73 83 83 83 73 84 87
2290 2296 2200 2305 2315 2215 2220 2335 2340 2345 2340 2345 2356 2356 2365 2365 2365 2365 2365 236	58 65 75 67 68 62 67 70 68 63 69 62 67 70 68 63 67 65 65 67 65 65 65 65 65 68 67 65 68 67 67 65 68 67 67 65 68 67 67 65 68 67 67 65 68 67 67 66 68 67 64 64	2.63 2.65 2.68 2.60 2.53 2.72 2.71 2.71 2.73 2.72 2.67 2.65 2.60 2.65 2.64 2.65 2.64 2.65 2.64 2.65 2.64 2.65 2.64 2.65 2.64 2.65 2.69 2.69 2.69 2.69 2.60 2.61 2.65 2.60 2.61 2.65 2.60 2.61 2.65 2.60 2.65 2.60 2.65 2.60 2.65 2.60 2.65 2.65 2.65 2.65 2.65 2.65 2.65 2.65	28 24 27 50 24 18 23 26 14 23 26 16 21 24 19 24 9 12 22 23 25 22 23 25 22 23 24 9 12 22 23 24 21 22 23 24 21 22 21 21 21 30	57 62 70 56 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 85 80 86 80 86 81 80 83 86 84 70 70 70 70 70 70 73 83 85 73 58 57 64
2290 2296 2296 2310 2215 2200 2225 2330 2335 2340 2340 2345 2350 2355 2360 2365 2370 2375 2375 2370 2375 2370 2385 2390 2396 2390 2396 2396 2400 2405 2410 2415 2450 2445 2450	58 65 75 67 68 69 62 67 70 68 63 62 67 70 68 63 67 65 67 65 67 65 67 65 67 65 67 65 68 66 67 68 68 66 63 64 64 64	2.63 2.65 2.65 2.60 2.53 2.72 2.71 2.71 2.73 2.72 2.67 2.65 2.60 2.65 2.60 2.65 2.60 2.65 2.60 2.65 2.60 2.68 2.69 2.68 2.69 2.68 2.69 2.68 2.71 2.69 2.68 2.61 2.67 2.69 2.68 2.61 2.65 2.61 2.65 2.65 2.65 2.65 2.65 2.65 2.65 2.65	28 24 27 90 24 16 12 25 16 21 24 16 12 25 16 21 24 9 12 22 22 22 23 25 22 22 23 25 22 22 23 25 22 22 23 25 22 21 24 22 25 22 26 21 21 24 22 21 24 22 21 24 22 21 24 25 21 21 14 8 20 19	57 62 70 56 70 56 80 80 80 80 82 66 70 66 70 66 70 66 70 66 82 66 70 60 63 65 65 67 74 63 82 70 70 73 69 63 70 73 73 69 63 57 64 70
2290 2296 2306 2310 2315 2310 2315 2230 2335 2330 2335 2340 2345 2350 2345 2350 2365 2366 2366 2366 2366 2366 2370 2365 2360 2365 2360 2400 2405 2400 2405 2415 2400 2405 2415 2435 2435	58 65 775 67 68 69 62 67 70 68 63 62 67 70 66 58 63 66 66 67 65 67 65 67 65 67 68 67 68 67 68 67 68 64 64 64 64 64 64 64	2.83 2.85 2.85 2.80 2.53 2.72 2.71 2.71 2.73 2.72 2.85 2.80 2.85 2.84 2.85 2.84 2.85 2.84 2.85 2.84 2.85 2.84 2.85 2.84 2.85 2.84 2.85 2.88 2.88 2.88 2.88 2.88 2.88 2.88	28 24 27 10 24 18 14 23 26 19 24 19 24 19 24 9 12 22 23 25 22 23 25 26 21 24 9 12 22 23 25 26 21 24 25 26 21 24 8 20 19 24	57 62 70 56 70 90 80 90 80 80 80 80 80 80 80 80 80 80 80 80 80 85 80 86 80 83 81 83 82 70 70 70 70 70 70 70 70 70 70 70 70 70 70 70 70 70 70 70 70 70 70 70 70 70 70 70 70 70 73 56 57 64 70 70 85 65
2290 2296 2300 2310 2315 2220 2335 2335 2335 2340 2335 2340 2355 2355 2356 2356 2356 2356 2356 2356	58 65 75 67 68 69 62 67 70 66 63 63 66 63 67 65 67 65 67 65 67 65 67 65 67 65 68 63 68 63 68 63 64 64 66 63 63 64 64 64	2.63 2.65 2.65 2.60 2.53 2.72 2.71 2.73 2.73 2.73 2.73 2.73 2.73 2.65 2.60 2.65 2.64 2.65 2.68 2.64 2.65 2.68 2.68 2.69 2.68 2.69 2.68 2.71 2.65 2.60 2.65 2.71 2.65 2.72 2.65 2.60 2.65 2.60 2.65 2.71 2.65 2.60 2.65 2.60 2.65 2.60 2.65 2.60 2.65 2.60 2.65 2.60 2.65 2.60 2.65 2.60 2.65 2.65 2.65 2.65 2.65 2.65 2.65 2.65	28 24 27 10 24 16 23 25 26 16 21 24 19 24 19 24 10 24 10 25 22 22 22 22 22 23 24 21 22 22 23 24 25 21 25 21 24 25 21 24 25 21 22 21 22 21 22 21 14 8 20 19	57 62 70 56 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 85 80 86 81 81 82 83 82 70 70 73 83 82 70 73 83 73 84 70 70 73 85 64 70 73 86 73
2290 2296 2310 2315 2208 2310 2215 2220 2225 2330 2335 2340 2345 2350 2345 2355 2350 2365 2370 2375 2390 2395 2390 2395 2390 2395 2390 2405 2405 2410 2415 2425 2425 2445 2445 2455 2465	58 65 75 67 68 69 62 67 70 68 63 62 67 70 68 63 67 65 67 65 67 65 67 65 67 65 67 65 68 66 63 64 64 64 64 64	2.83 2.85 2.85 2.80 2.53 2.71 2.71 2.71 2.73 2.72 2.85 2.80 2.85 2.84 2.80 2.85 2.88 2.84 2.89 2.85 2.88 2.89 2.89 2.89 2.89 2.80 2.80 2.80 2.80 2.80 2.80 2.80 2.80	28 24 27 90 24 18 19 25 26 26 27 9 24 18 19 22 20 25 22 22 22 22 23 25 22 22 23 25 22 22 23 25 22 21 24 21 25 22 21 24 21 25 22 21 24 21 25 21 26 21 27 21 28 21 29 21 20 20 19 24 18 10	57 62 70 56 70 56 80 60 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 85 85 87 81 82 70 70 70 73 88 87 70 88 82 70 70 73 88 87 70 73 88 87 70 73 80 80
2290 2296 2206 2305 2310 2315 2230 2335 2330 2335 2340 2245 2350 2345 2350 2365 2365 2366 2365 2366 2365 2366 2365 2365	58 65 75 67 68 69 62 67 70 68 63 66 58 63 66 67 67 65 65 65 68 69 68 63 64 64 63 63 64 65	2.63 2.65 2.68 2.60 2.53 2.72 2.71 2.71 2.73 2.72 2.67 2.65 2.60 2.65 2.64 2.65 2.64 2.65 2.64 2.65 2.64 2.65 2.65 2.69 2.69 2.60 2.60 2.60 2.71 2.60 2.60 2.60 2.71 2.65 2.60 2.60 2.71 2.65 2.60 2.60 2.71 2.65 2.60 2.65 2.66 2.65 2.65 2.65 2.65 2.65 2.65	28 24 27 10 24 21 23 28 14 23 28 18 21 28 19 24 19 24 12 25 22 23 25 22 26 21 24 22 25 22 26 21 24 22 25 22 26 21 21 22 23 25 24 22 25 21 24 22 21 21 22 21 3 3 3 4 3 3 3 4 3 3 3 4 3 4 3 5 3 10 </td <td>57 62 70 56 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 81 81 82 70 70 70 70 70 70 70 70 70 70 70 70 70 70 70 70 70 70 70 70 70 70 70 70 70 70 70 70 70 70 70 70 70 80 <</td>	57 62 70 56 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 81 81 82 70 70 70 70 70 70 70 70 70 70 70 70 70 70 70 70 70 70 70 70 70 70 70 70 70 70 70 70 70 70 70 70 70 80 <
2290 2296 2310 2310 2315 2220 2325 2330 2335 2330 2335 2340 2345 2355 2360 2365 2370 2375 2390 2395 2390 2395 2390 2395 2390 2395 2390 2395 2390 2405 2405 2410 2415 2425 2425 2445 2445 2455 2455	58 65 75 67 68 69 62 67 70 68 63 62 67 70 68 63 67 65 67 65 67 65 67 65 67 65 67 65 68 66 63 64 64 64 64 64	2.83 2.85 2.85 2.80 2.53 2.71 2.71 2.71 2.73 2.72 2.85 2.80 2.85 2.84 2.80 2.85 2.88 2.84 2.89 2.85 2.88 2.89 2.89 2.89 2.89 2.80 2.80 2.80 2.80 2.80 2.80 2.80 2.80	28 24 27 90 24 18 19 25 26 26 27 9 24 18 19 22 20 25 22 22 22 22 23 25 22 22 23 25 22 22 23 25 22 21 24 21 25 22 21 24 21 25 22 21 24 21 25 21 26 21 27 21 28 21 29 21 20 20 19 24 18 10	57 62 70 56 70 56 80 80 80 80 80 80 80 80 82 65 66 70 80 83 85 65 70 73 68 73 66

Table 1: Well log values of oil wells.

Depth At		ic qb density			ΦCNS NEUTRON		G.R	
2095	<u>∆t son</u> 70		2.3		19	-	50	
2100	_	65		4	10	\rightarrow	54	
					11	-+		
2105	69		2,5			\rightarrow	40	
2110	64		2,66		19		50	
2115	62		2,64		11		45	
2120	61		2,70		12		70	
2125	65		2,65		10		70	
2130	63		2,6		16		35	
		67					76	
2135			2,50		15			
2140	64		2,65		11	\rightarrow	50	
2145	65		2,5		10	_	50	
2150	64		2,5	8	13		50	
2155	63		2,6	0	12		37	
2160	65		2.7	5	17		80	
2165	65		2.3		16	-+	90	
2170	63			_	11	-+	60	
			2,5			\rightarrow		
2175	65		2,6	6	12	\rightarrow	54	
2180	66		2,7		18		78	
2185	67		2,0	6	18		85	
2190	67		2,6	6	27		67	
2195	76		2.1		15	-+	90	
						\rightarrow		
2200	73		2.3		21	\rightarrow	75	
2205	60		2,6	6	24		50	
2210	73		2,2	5	23		74	
2215	74		2.4		22		88	
	68		2,6	× 4	9	-+	70	
2220						\rightarrow		
2225	63		2.2	U .	23	\rightarrow	45	
2230	71		2,6		23		75	
2235	67		2,7	1	24		75	
2240	76		2.6		22	-	80	
					24	\rightarrow	70	
2245	68		2,6		24	\rightarrow	79	
2250	71		2,67		20		80	
2255	70		2,6	9	21		70	
2260	63		2,6	3	10		50	
2265	67		2,4		15	-	38	
	65				12	\rightarrow	54	
2270			2,4			\rightarrow		
2275	82	82			16		25	
						_		
2280	74		1,9		14		34	
2280 2285				6		+		
	74	do d	1,9	8	14		34	
2285	74		1,9 2,6	8	14 27 S NEUTRON		34 80 G.R	
2285 Depth 2485	74 70 ∆t sonic 55	2	1.9 2.6 ensity	8	14 27 S NEUTRON 15		34 80 G.R 70	
2285 Depth 2485 2490	74 70 Δt sonic 55 64	2	1,9 2,6 ensity 2,70 2,72	8	14 27 5 NEUTRON 15 25		34 80 G.R 70 95	
2285 Depth 2485	74 70 ∆t sonic 55	2	1.9 2.6 ensity	8	14 27 S NEUTRON 15		34 80 G.R 70	
2285 Depth 2485 2490	74 70 Δt sonic 55 64	2	1,9 2,6 ensity 2,70 2,72	8	14 27 5 NEUTRON 15 25		34 80 G.R 70 95	
2285 Depth 2485 2490 2495 2500	74 70 Δt sonic 55 64 80 59	2	1,9 2,6 2,70 2,72 2,68 2,67	8	14 27 5 NEUTRON 15 25 24 23		34 80 G.R 70 95 83 90	
2285 Depth 2485 2490 2496 2500 2505	74 70 Δt sonic 55 64 60 59 60	22	1.9 2.6 2.70 2.72 2.68 2.67 2.67 2.67	8	14 27 5 NEUTRON 15 25 24 23 22		34 80 G.R 70 95 83 90 80	
2285 Depth 2485 2490 2496 2500 2505 2505	74 70 Δt sonic 55 64 60 60 60	22	1.9 2.6 2.70 2.72 2.68 2.67 2.66 2.67 2.66	8	14 27 5 NEUTRON 15 26 24 23 22 20		34 80 G.R 70 95 83 90 80 55	
2285 Depth 2485 2490 2495 2500 2505 2505 2510 2515	74 70 Δt sonic 55 64 60 59 60 60 60 60		1.9 2.6 2.70 2.72 2.68 2.67 2.66 2.67 2.66 2.67 2.68 2.69	8	14 27 8 NEUTRON 15 25 24 23 22 20 17		34 80 G.R 70 95 83 90 80 55 75	
2285 Depth 2485 2490 2496 2500 2505 2505	74 70 Δt sonic 55 64 60 60 60		1.9 2.6 2.70 2.72 2.68 2.67 2.66 2.67 2.66	8	14 27 5 NEUTRON 15 26 24 23 22 20		34 80 G.R 70 95 83 90 80 55	
2285 Depth 2485 2490 2496 2500 2500 2510 2515 2520	74 70 Δt sonic 55 64 60 60 60 64 66		1.9 2.6 2.70 2.72 2.68 2.67 2.68 2.67 2.68 2.67 2.68 2.69 2.70	8	14 27 5 NEUTRON 15 25 24 23 22 20 17 25		34 80 70 95 83 90 80 55 75 80	
2285 Depth 2485 2490 2496 2500 2506 2510 2515 2515 2520 2525	74 70 Δt sonic 55 64 60 60 60 64 66 64		1.9 2.6 2.70 2.72 2.75 2.75 2.67 2.67 2.67 2.68 2.67 2.68 2.69 2.70 2.64	8	14 27 S NEUTRON 15 25 24 23 22 20 17 25 17		34 80 70 95 83 90 80 55 75 80 79	
2285 Depth 2485 2490 2496 2500 2505 2510 2515 2520 2525 2520 2525 2530	74 70 ∆t sonic 55 64 60 60 60 60 64 60 64 60 64 60 64 60 64 60 64 60		1.9 2.6 2.70 2.72 2.75 2.67 2.67 2.67 2.67 2.68 2.69 2.70 2.64 2.68	8	14 27 5 NEUTRON 15 25 24 23 22 20 17 25 17 28		34 80 G.R 70 95 83 90 80 55 75 80 79 90	
2285 Depth 2485 2490 2500 2505 2510 2515 2520 2525 2520 2525 2530	74 70 Δt sonic 55 64 60 60 60 64 66 64		1.9 2.6 2.70 2.72 2.72 2.68 2.67 2.67 2.67 2.66 2.70 2.66 2.70 2.66 2.70 2.66 2.70 2.66 2.70	8	14 27 S NEUTRON 15 25 24 23 22 20 17 25 17		34 80 70 95 83 90 80 55 75 80 79	
2285 Depth 2485 2490 2496 2500 2505 2510 2515 2520 2525 2520 2525 2530	74 70 ∆t sonic 55 64 60 60 60 60 64 60 64 60 64 60 64 60 64 60 64 60		1.9 2.6 2.70 2.72 2.72 2.68 2.67 2.67 2.67 2.66 2.70 2.66 2.70 2.66 2.70 2.66 2.70 2.66 2.70	8	14 27 5 NEUTRON 15 25 24 23 22 20 17 25 17 28		34 80 G.R 70 95 83 90 80 55 75 80 79 90	
2285 Depth 2485 2490 2496 2500 2500 2510 2515 2520 2520 2530 2530 2530 2530	74 70 55 64 60 69 60 64 65 64 60 64 65 64 60 64 60 64 63		1,9 2,6 2,70 2,77 2,77 2,77 2,77 2,67 2,67 2,68 2,69 2,68 2,66 2,66 2,66 2,66 2,66	8	14 27 5 NEUTRON 15 25 24 23 22 20 17 25 17 25 17 26 24 14		34 80 70 95 83 90 80 55 75 80 79 90 100 92	
2285 Depth 2485 2490 2490 2505 2505 2510 2515 2525 2530 2535 2530 2535 2530 2535 2540	74 70 ∆t sonic 55 64 60 64 60 64 60 64 60 64 65 64 60 64 65 64 60 64 63 59		1,9 2,6 2,70 2,72 2,72 2,67 2,67 2,67 2,66 2,66 2,66	8	14 27 8 NEUTRON 15 25 24 23 22 20 17 25 17 28 24 11 11		34 80 70 95 83 90 80 55 75 80 79 90 100 92 83	
2285 Depth 2485 2490 2500 2510 2515 2520 2525 2530 2530 2535 2530 2536 2540 2545 2540	74 70 ∆t sonic 55 64 60 64 66 64 65 64 60 64 65 64 60 64 60 64 60 64 60 64 60 64 63 59 60		1,9 2,6 2,70 2,77 2,77 2,77 2,77 2,67 2,67 2,68 2,69 2,68 2,66 2,66 2,66 2,66 2,66	8	14 27 5 NEUTRON 15 25 24 23 22 20 17 25 20 17 25 20 17 25 24 17 26 24 11 10		34 80 6 R 70 95 83 90 80 83 90 80 75 80 75 80 75 90 100 92 83 90	
2285 Depth 2485 2490 2490 2505 2505 2510 2515 2525 2530 2535 2530 2535 2530 2535 2540	74 70 ∆t sonic 55 64 60 64 60 64 60 64 60 64 65 64 60 64 65 64 60 64 63 59		1,9 2,6 2,70 2,72 2,72 2,67 2,67 2,67 2,66 2,66 2,66	8	14 27 8 NEUTRON 15 25 24 23 22 20 17 25 17 28 24 11 11		34 80 70 95 83 90 80 55 75 80 79 90 100 92 83	
2285 Depth 2485 2485 2495 2500 2500 2500 2515 2520 2525 2530 2535 2530 2535 2530 2535 2530 2540 2540 2550 2535 2535 2540 2550 2500 2550	74 70 Δt sonic 55 64 60 69 64 66 64 66 64 63 59 60 64 63 64 63 64 63 64 63 64 63 64 63 64 63 64 63 64 63 64 63 64 63 64 63 64 63 64 63 64 64 63 64 64 63 64 64		1,9 2,6 2,70 2,77 2,77 2,67 2,67 2,67 2,67 2,67 2,67	8	14 27 6 NEUTRON 15 25 24 23 22 20 17 25 17 25 17 26 24 14 11 10 10		34 80 6.R 70 95 83 90 80 55 75 80 79 90 100 92 83 90 100	
2285 Depth 2485 2490 2496 2500 2506 2510 2510 2520 2520 2520 2520 2528 2530 2538 2530 2545 2540 2545 2540 2545 2540	74 70 ∆t sonic 55 64 60 64 60 64 60 64 60 64 65 64 60 64 65 64 63 59 60 64 63 69 60 64 63 69 60 64		1.9 2.6 ensity 2.70 2.72 2.68 2.67 2.68 2.67 2.68 2.69 2.70 2.68 2.65 2.66 2.65 2.66 2.65 2.66 2.65 2.66 2.65 2.66 2.65 2.66 2.65 2.66 2.65 2.66 2.66	8	14 27 8 NEUTRON 15 25 24 23 22 20 17 26 17 26 24 17 28 24 17 28 24 11 10 10		34 80 G.R 70 95 83 90 80 80 80 85 75 80 79 90 100 92 83 90 100 98	
2285 Depth 2485 2490 2500 2500 2515 2520 2515 2520 2535 2530 2535 2530 2535 2545 2550 2545 2550 2566	74 70 ∆t sonic 55 64 60 69 60 64 66 64 66 64 65 64 66 64 66 64 63 59 60 64 63 69 60 64 66 64		1.9, 2.6 2.77 2.72 2.72 2.66 2.65 2.66 2.66 2.66 2.66 2.66 2.6	8	14 27 6 NEUTRON 15 25 24 23 22 20 17 25 24 20 17 25 24 20 17 25 24 20 17 25 24 20 17 17 26 24 11 11 10 10 11 11 11 11 11 11 12 12 12 12 12 12 12		34 80 G.R 70 95 83 90 80 85 75 80 80 85 75 80 90 100 90 90 100 98 99 90	
2285 Depth 2485 2485 2495 2500 2500 2500 2515 2520 2525 2530 2535 2535 2535 2535 2535 2535 2540 2555 2557 2557 2577 2577 2577 2577 2577 2577 2577 2577 2577 2570 2575 2570	74 70 ∆t sonic 55 64 60 69 60 64 65 64 60 64 65 64 60 64 60 64 60 64 60 64 60 64 63 60 64 68 64 62		1.9 2.6 2.77 2.77 2.77 2.77 2.68 2.67 2.67 2.67 2.68 2.66 2.66 2.66 2.66 2.66 2.66 2.66	8	14 27 6 NEUTRON 15 25 24 23 22 20 17 25 17 25 17 25 17 25 17 25 17 26 24 14 11 10 16 16 14 9		34 80 6 R 70 95 83 90 80 83 90 80 75 80 75 80 75 80 75 80 75 80 90 100 92 83 90 100 92 83 89 90	
2285 Depth 2485 2490 2500 2500 2515 2520 2515 2520 2535 2530 2535 2530 2535 2545 2550 2545 2550 2566	74 70 ∆t sonic 55 64 60 69 60 64 66 64 66 64 65 64 66 64 66 64 63 59 60 64 63 69 60 64 66 64		1.9, 2.6 2.77 2.72 2.72 2.66 2.65 2.66 2.66 2.66 2.66 2.66 2.6	8	14 27 6 NEUTRON 15 25 24 23 22 20 17 25 24 20 17 25 24 20 17 25 24 20 17 25 24 20 17 17 26 24 11 11 10 10 11 11 11 11 11 11 12 12 12 12 12 12 12		34 80 G.R 70 95 83 90 80 85 75 80 80 85 75 80 90 100 90 90 100 98 99 90	
2285 Depth 2485 2495 2500 2500 2500 2515 2520 2525 2530 2530 2535 2530 2540 2545 2530 2540 2545 2550 2575	74 70 55 64 60 69 60 64 60 64 65 64 60 64 60 64 63 59 60 64 63 64 62 63		1,3, 2,6 2,77 2,77 2,77 2,77 2,77 2,77 2,77	8	14 27 5 NEUTRON 15 25 24 23 22 20 17 25 17 26 24 17 26 24 11 10 10 16 16 14 9 9 18		34 80 G.R 70 95 83 90 55 75 80 79 90 55 75 80 79 90 100 92 83 90 100 92 83 90 88 98 89 80	
2285 Depth 2485 2490 2500 2505 2515 2520 2515 2520 2515 2520 2530 2535 2540 2545 2545 2540 2545 2575 2580	74 70 ∆t sonic 55 64 60 64 60 64 60 64 60 64 60 64 60 64 63 69 64 62 63 60 64		1.3. 2.6 ensity 2.70 2.77 2.72 2.68 2.67 2.68 2.66 2.68 2.66 2.68 2.66 2.68 2.60 2.68 2.60 2.68 2.60 2.68 2.60 2.68 2.66 2.68	8	14 27 5 NEUTRON 15 25 24 23 22 20 17 25 17 28 24 11 11 10 16 16 16 10		34 80 G.R 70 95 83 90 80 85 75 80 79 90 100 92 83 90 100 92 83 90 100 98 96 89 80 54	
2285 Depth 2485 2485 2500 2500 2500 2500 2515 2520 2515 2520 2530 2535 2530 2535 2530 2545 2530 2545 2550	74 70 ∆t sonic 55 64 60 64 66 64 60 64 66 64 63 59 60 64 63 64 63 64 63 64 63 64 62 63 60 57		1,3, 2,6 2,77 2,77 2,77 2,77 2,68 2,67 2,67 2,67 2,68 2,66 2,66 2,66 2,66 2,66 2,66 2,66	8	14 27 5 NEUTRON 15 25 24 24 23 20 17 25 20 17 25 20 17 25 24 17 26 24 11 10 10 16 16 16 10 15		34 80 6.R 70 95 83 90 80 83 90 80 75 80 75 80 75 80 75 80 90 100 92 83 90 100 92 83 90 100 92 83 80 80 80 80 80 80 80 80 80 80 80 80 80	
2285 Depth 2485 2490 2500 2505 2515 2520 2515 2520 2515 2520 2530 2530 2530 2530 2545 2550 2545 2550 2545 2575 2580	74 70 ∆t sonic 55 64 60 64 60 64 60 64 60 64 60 64 60 64 63 69 64 62 63 60 64		1,3, 2,6 ensity 2,70 2,72 2,72 2,72 2,72 2,72 2,72 2,72	8	14 27 5 NEUTRON 15 25 24 23 22 20 17 25 17 26 24 17 20 17 25 17 20 17 26 24 14 11 10 16 16 16 16 10 15 24		34 80 G.R 70 95 83 90 55 75 80 79 90 55 80 79 90 100 92 83 90 100 92 83 90 54 83 90 52 83 90 52 83 90 52 83 90 75 75 95 95 77 95 77 95 78 55 77 95 78 55 77 95 78 55 77 95 78 55 77 95 78 55 77 95 78 95 78 90 78 95 78 95 78 90 78 95 78 90 77 90 77 90 77 90 77 90 77 90 77 90 77 90 77 90 77 90 77 77 77 90 77 77 77 77 77 77 77 77 77 77 77 77 77	
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Application

Depth (m)	∆t sonic		CNS NEUTRON	G.R	
1900	62	2,6	12	52	
1905	63	2,65	13	54	
1910	63	2,59	12	47	
1915	66	2,67	20	65	
1920	66	2,70	14	54	
1925	67	2,73	17	59	
1930	66	2,54	13	45	
1935	68	2,56	17	55	
1940	67	2,53	17	40	
1945	64	2,43	23	60	
1950	63	2,57	17	40	
1955	71	2,48	16	40	
1960	70	2,60	13	50	
1965	64	2,54	16	32	
1970	65	2,66	20	63	
1975	66	2,54	14	60	
1980	68	2,55	30	55	
1985	70	2,63	24	64	
1990	71	2,44	25	58	
1995	65	2,65	24	70	
2000	67	2,58	12	50	
2005	76	2,55	23	67	
2010	80	2,56	27	55	
2015	65	2,55	12	48	
2020	65	2,40	18	50	
2025	68	2,68	8	50	
2030	63	2,30	10	55	
2035	66	2,55	10	67	
2040	65	2,50	20	57	
2045	64	2,40	18	50	
2050	64	2,62	19	47	
2055	80	2,48	25	90	
2060	63	2,43	17	98	
2065	64	2,65	19	90	
2070	63	2,55	25	60	
2075	70	2,65	17	87	
2080	68	2,73	19	88	
2085	69	2,62	16	94	
2090	69	2,60	15	30	
2000		2,00	10		
epth (m)	Δt sonic	ρb density	φ ΦCNS]	Neutron	G.I
1945	64	2.43	2	3	60

 Table 2: For example, if GR reading is made for 1945m

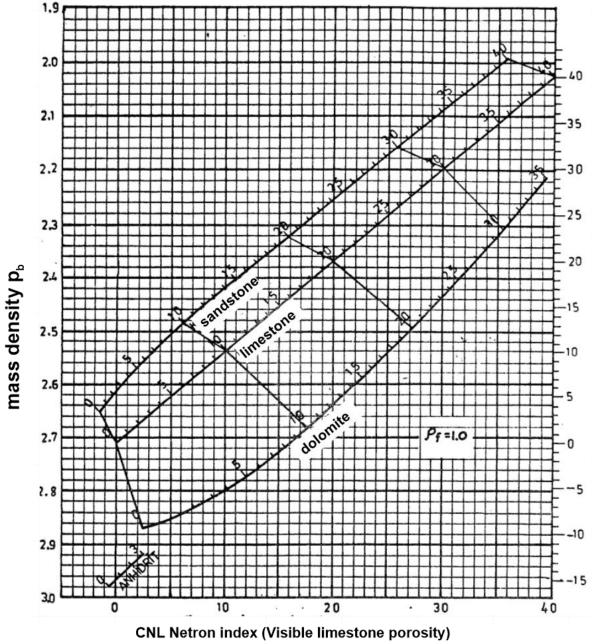
The GR value at a depth of 1945 meters appears to be 60.

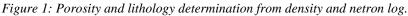
 $VSHGR = \frac{GR - GRmin}{GRmax - GRmin} \frac{60 - 25}{100 - 25} = 004666$ available as

Pb=2.43, QCNL=23

The point on the Density-neutron clustering chart where the values overlap is found. From this point it is drawn parallel to the porosity line. The porosity value is read from this point that intersects the porosity line. Ø DN=20.1

The distances of the parallel drawn on the point to both sides of the points are read. For this example, the distance to Limestone was found to be 17mm and to Dolomite was 15mm. Assuming this distance as 100, the inverse ratio gives lithology values of 46.88% Limestone and 53.12% Dolomite.





Result

When these operations are done for each point, Total amount of limestone: 2868.31; Total amount of sandstone: 2837.67; Total amount of dolomite: 8089.99; Total ØDN: 3599.04

The average lithology and effective porosity value is found by dividing the total values by the number of points read. % Limestone: 20.81407%; %Sandstone: 20.56282%; %dolomite: 58.62311%; %ØDN : 26.08% values are reached.

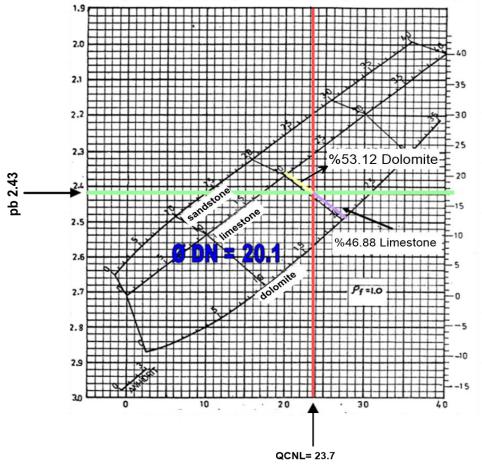


Figure 2: Lithology determination made for a depth of 1945 meters.

Derinlik (m)	ΦDN	%KALKER	%DİĞERLERİ	Derinlik (m)	ΦDN	%KALKER	%DİĞERLER
1900	19,5	62,5	37,5 K	2095	-	-	-
1905	16,1	63,4	36,6 D	2100	15	100	-
1910	20,1	53,3	46,67 K	2105	20	-	100 K
1915	20,6	-	100 D	2110	20,1	-	100 D
1920	14	9,1	90,9 D	2115	15,1	100	-
1925	14,15	-	100 D	2120	12,9	29,41	70,59 D
1930	24,7	-	100 K	2125	14	88,24	11,76 D
1935	26	68,75	31,25 K	2130	22	74,42	22,58 D
1940	28	31,25	68,75 K	2135	29,2	-	100 K
1945	20,1	46,88	53,12 D	2140	14,9	84,85	15,15 D
1950	24,5	89,66	10,34 D	2145	19	-	100 K
1955	32,1	-	100 K	2150	21,5	46,66	53,34 K
1960	19,5	81,25	18,75 K	2155	19,5	66,66	33,34 K
1965	26,5	37,5	62,5 K	2160	13	-	100 D
1970	21,1	-	100 D	2165	-	-	-
1975	25,2	-	100 K	2170	26,8	-	100 K
1980	-	-	-	2175	16	69,7	30,30 D
1985	16,3	-	100 D	2180	15,2	-	100 D
1990	40	33,34	66,66 K	2185	-	-	-
1995	25	-	100 D	2190	26,9	-	100 D
2000	21	33,34	66,66 K	2195	-	-	-
2005	30,5	40	60 D	2200	-	-	-
2010	33,9	-	100 D	2205	25,1	-	100 D
2015	23,4	-	100 K	2210	-	-	-
2020	40	-	100 K	2215	36	-	100 K
2025	23,6	-	100 D	2220	14	100	-
2030	-	-	-	2225	-	-	-
2035	26,5	100	-	2230	22,8	-	100 D
2040	25	-	100 K	2235	20,9	-	100 D
2045	35,8	-	100 K	2240	22,1	-	100 D
2050	16,1	62,5	37,5 K	2245	22,1	-	100 D
2055	34	-	100 K	2250	20,6	-	100 D
2060	32,5	-	100 K	2255	19,6	-	100 D
2065	21	-	100 D	2260	15,5	80	20 K
2070	32,5	2	98 D	2265	30,9	-	100 K
2075	19,5	21,87	73,13 D	2270	32,2	-	100 K
2080	23,9	-	100 D	2275	-	-	-
2085	20,5	54,84	45,16 D	2280	-	-	-
2090	21,1	87.1	12,9 D	2285	25,5	-	100 D

 Table 3: Well lithology values obtained using density and netron log

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Derinlik (m)	ΦDN	%KALKER	%DİĞERLERİ	Derinlik (m)	ΦDN	%KALKER	%DİĞERLERİ
2290	-	-	-	2485	14.5	-	100 D
2295	25,2	-	100 D	2490	20,8	-	100 D
2300	25,2	-	100 D	2495	23	-	100 D
2305	18,2	18,75	81,25 K	2500	22,7	-	100 D
2310	34	41,66	58,34 D				
2315	20,2	-	100 D	2505	22	-	100 D
2320	16,7	-	100 D	2510	20,1	-	100 D
2325	13	-	100 D	2515	16,5	-	100 D
2330 2335	18,8	-	100 D	2520	22	-	100 D
	20,9	-	100 D	2525	20	31,25	68,75
2340	19	-	100 D	2530	24,7	-	100 D
2345 2350	22,3	-	100 D	2535	25	-	100D
2355	20.5	-	- 100 D	2540	20	100	-
2355	20,5		100 D	2545	17.9	37,5	62.5 K
2365	14,1	68.75	32,25 K	2545	17,9		100 K
2370	12.5	29,41	70.59 D			-	
2375	21,5	-	100 D	2555	37	-	100 K
2380	21,5		100 D	2560	35,2	-	100 K
2385	23		100 D	2565	34,2	-	100 K
2390	22,5	-	100 D	2570	21,7	-	100 K
2395	21,5	-	100 D	2575	18,1	21,88	78,72 D
2400	22,3	-	100 D	2580	15,7	81,25	18,75 K
2405	21	-	100 D	2585	17,8	43,75	56,25 D
2410	21,7	-	100 D	2590	23,7	-	100 D
2415	23	-	100 D	2595	19,3	21,88	78,72 D
2420	20,7	-	100 D	2595	18,5	100	70,72 D
2425	29,3	-	100 D				-
2430	18,3	-	100 D	2605	25	-	100 D
2435	15,3	34	66 D	2610	20,6	-	100 D
2440	10	76	24 D	2615	17,9	-	100 D
2445	18,8	-	100 D	2620	17,1	48,49	51,51 D
2450	19,1	-	100 D	2625	23	-	100 D
2455	22	-	100 D	2630	20,2	-	100 D
2460	20,2	6	94 D	2635	20,6	-	100 D
2465	13,9 15,5	81,82	18,18 D	2640	21,1	61,3	38,70 D
2470		21,22	78,78 D	2645	21,1	100	-
2475 2480	24,9 18,9	-	100 D 100 D	2645	16.5	21.88	- 78.12 D
2480	18,9	-	100 D	2050	10,5	21,88	78,12 D

Clayness values can be calculated by using gamma-ray and sonic logs from well log data. Using the lowest average clayey values obtained from Gamma-ray, corrected values of the log of netron and formation density are found. According to the calculated corrected values, lithology determination was made between 1900-2650 meters using the punctuation method of these logs. In the examination, percentages of limestone, sandstone and dolomite were measured every 5 meters. In this case, it was determined at which meters the hydrocarbon-containing rock was located.

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