PROPERTIES OF THE OIL SOURCE ROCK THE BOYABAT/SINOP BASIN UNITS

NURETTIN SONEL

Department of Geological Engineeing, Faculty of Science, The University of Ankara

ABSTRACT

Among The Boyabat Basin's deposits, there are some units reflecting petroleum source rock appereances. Our target has been determinations of Kusuri and Çağlayan formations source rock potentials. A research, included of petroleum source rock, has no been carried out till now.

Deposits in the basin have flish characters in general but it is also possible to observe carbonates including volcanic matters.

In order to determine source rock specifications of the area, measured stratigraphical cross-section were drown and systematic samples were collected. A number of analyses, such as orgaganic carbon amount, pyrolise, organic matter type, maturity and clay X-ray diffractometer analyses, were applied on the shale samples.

According to the analyses results, keregone types are Tip II and Tip III, there are sufficent amount of organic matters, maturity is good enough to give petroleum and gas.

As for the Kusuri formation, due to low amount of organic carbon and staying in limited area. It is not determinated as a petroleum source rock.

1. INTRODUCTION

From the wiev point of petroleum expolaration in Black Sea region, Boyabat basin is an impotant area (Figure. 1). General characteristics and thickness of the deposits in the area make the basin attractive place. Because of these properties of the area petroleum companies and researchers are interested in the area. Surveys for the purpose of different aims have been carried out in surrounding area up to now (Ericson, 1938; Blumental, 1940; Budgeleg, 1959; Ketin, 1962; Eren, 1979; Gedik, 1981; Gedik and Korkmaz, 1984; Akarsu and Aydın, 1986; Sonel and etc., 1988).

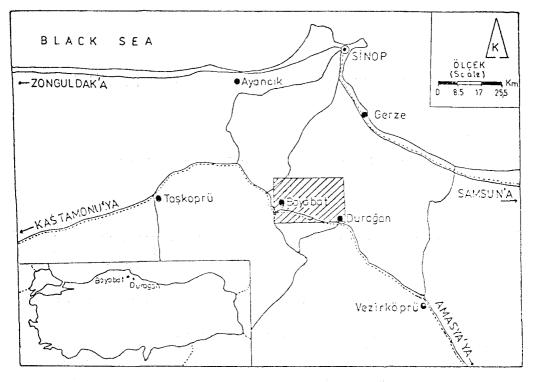


Figure-1:Location map of studied area

A number of surveys in the basin also have been performed. Surveys in the basin have aimed on pointing out general geological, stratigraphical and litho-stratigraphical conditions.

Although deposits in the area are prospects, laboratory analyses based on petroleum potential of the deposits couldn't be done till now. Owing to lacking of these analyses, our task have focused on this matter and aimed on pointing out petroleum potential of the basin by means of laboratory analyses. Deposits having more than 700 m. thickness and composed of different types sediments in Boyabat basin go on from Lias to end of Oligocene reservoir in these units (Fig. 3) For accurate determination, 4 measured stratigraphical cros-sections were done (Fig. 2). Systematic samples were taken and some of them were analysed Clay minerals, amount of total organic matter and maturity experiments were carried out (Fig. 4,5,6).

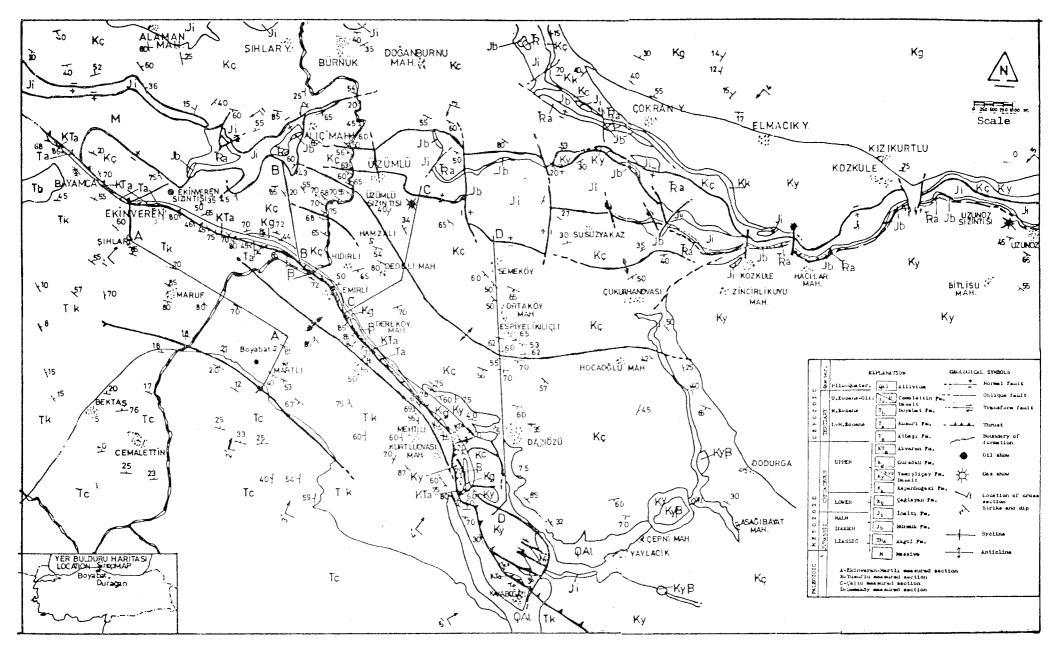


Figure-2:Geological map of the Northeast Boyabat (Sinop) area

T		,	1		1	T				
SYSTEM	SERIC	STAGE	FORMATION	SYMBOL	THICKRESS	SOUPLE POCK	815VR3238	SEAL	LITHOIDGY	EXPLANATIONS
			ALUVYON	0.AI	0.100				-	
ں	>-	DEF 1868 16	CEMALETTIN	Tc	8					blooky, abannelfilling, thin shele-
0	æ ≺	ECCENE	DOYABAT	Tb	250				ximbade	Yhite-orana eplored abundend fossile, helius-good perceity, fractured limestones)
NOZ	- K	3 3700 W	KUSURĪ	T _k	10/10/15/00					Altermence of mandetone, shale and mark dominance of mandature, lateral factor changes).
J	3 -	LOWER E	ATBAŞI	To	5,128					(Fed arry rolored earl, shale and and and sandarons alternances).
		2 4	AKVEREN	кта	8.			777		(Disserting, gree-white, highy effi- cified with merly intercelations).
5	8 0	ετ Α Ο ε ο υ	10 20 20 20 40 40 40	Kg	23001808					(industron-mark) shall-limestor intercals tions, thickness of sendators 2 ct. 1. fine to setter grates (for your contents), shall. This beds of signitial limestors),
0 Z	0 E 0	۵ ۵ ۵ ۵ ۵ ۲ ۲ ۲ ۲ ۲ ۲ ۲ ۲ ۲ ۲ ۲ ۲ ۲	20.00	Ку	000					*inle, buff, Cufite on epimerent in- tare ellers. Volume-essisentery sequ- ence but offer)
''	I~		Y: KAPAN BOĞAZI	K _k	0					Fed colored, wherey limestone, shorty micritic limestone).
S	æ U	WER CRETACECUS	स स स स स स	Kç	100,1500					(sitementions of earl, whele, wendstone Gray, pallowish and fine to ending executed and entering annual annual enterior. Interior to the control to early a state of early and early and early and early and early and early annual enterior of early and early annual ea
ш	S - C	M 1 4 M	-		2	<i>ZZi</i>				Gray-bales colcured, very fractured assats apparance, partly resfolded liesetons.
Σ	SKRUL	D365ER_	BÜRNÜK	1 ^p	20-220					(And coloured polygenia
PALEOBIC		LIASSIC	AK GOL MASÍF	₹a M	*100	<i>722</i>		<i>!!!!</i>		battern 1-20 cs conclonerate). ters-bloc coolured shale, przy and alightly astamorphised ampleton end claritous Meddito

Figure-3:Generalized stratigraphic columnar section of the Boyabat area

2. DETERMINATION OF PETROLEUM SOURCE ROCK

Petroleum source rocks are described as fine grained sedimantery rocks which produce economic amount petroleum and/or gas and sent into reservoir rocks and have black shales including kerogen matters, pyrites (Guillemont, 1964; Dow., 1978). Especially, black shales have good source rock properties. Besides, in a lesser extend, clayish limestone and marls are accepted as source rocks (Leverson, 1967; Momper, 1978; Kirklend and Evans, 1981). Lots of researchs have been performed on petroleum source rock determinations (Hunt and Jemiesen, 1956; Gehman, 1962; Baker, 1962; Erdman, 1962; Dunton and Hunt, 1962; Tissot and Welte, 1978; Espitalie and etc., 1977).

In order to get accurate petroleum source rock determinations, different kinds of analyses are performed.

2.1. Rock Evaluating Analyses

These analyses are used in determinations of kinds and evolutions of organic matters (Espitalie and etc., 1977). In these analayses, Samples are exposed to pyrolise with a special temperature program in an environment without oxygen (Tissot and Welte, 1978). During the pyrolise period, S. S2, Tmax, TOC, P1 and HI data of samples having organic matters are found. By means of determining the data, source rock potantials of the samples are determinated. Genetic potantial of a petroleum source rock is also determinated. Genetic potantial is described as amount of hydrocarbon in kg. out of 1 ton source rock (Tissot and Welte, 1978). Calculation procedure is as follows.

If S1 + S2 < 2 kg/ton it can't be petroleum source rock, it seldom produces natural gas.

If 2 kg./ton $<\mathrm{S1}+\mathrm{S2}<6$ kg. / ton it has medium graded source rock potantial

If S1+S2>6 kg./ton it is a source rock with a good potantial. It is possible to determine kerogen type by relations of TOC amount, get from pyrolise results, with Tmax. Pyrolise analyses results of 7 samples are given in figure-7.

2.2 Vitrinite Reflection Values (Ro)

By using these analyses which are applied to the deposites having rich organic matters maturity degree of the organic matters can be determinated (Tissot and Welte, 1978).

			N.C		SS	ļ ,	1=-			VI	TION	ITE SR		ORGA CAR	<u>BON</u>	C N \$		
STUTEM	SERTE	STAGE	PORMATION	STABOL	THECKNESS	LITHOLOGY	SAMPLE LOCATION	EXPLANATIONS	CLAY	e EES		ა ა ა	\perp	7 0 X			GOOD	FOSSILE
		UPPER CRETACEOUS	ig.										1				4	Arbitoides media Likraphites quadretu: Creturbebdus cresulatus Microrhabdulus decesetus
O		UPPER	rodpator	u^►				Volkanoredisantery serie (mandatons, shale, mrl, tuff, tuffite, aglomers and thyka										Predicospineara cretacea Discoryclina spp. Clobigarine sp. Flanorbulina sp.
					F5750		Faul t							1	T			Assilins sp. Globotruncans sp. Valvulinidas
					-													Miliolidae Fotaliidae Fertulariidae
					-		SE 21									İ		
					-													
н					5000 -	医生生												
		ß	2		_		• SE 21	·]]				١.	0-73			
					-				TLLITE, SIMEC- ITTE, CHLORITE,	hou	r-10	4 Aπο Ve <i>g</i> e	- 1					,
	S	Э			-				KAOLINITE	20,	-15, Eoal	Voode V-55	n-					·
					-					-								
0		0			-													
	٥				E -					1								Epistowiem sp.
	-	ĸ	1		4000-													Lenticulana sp. Cretartubdua cf. Euhoplites sp.
					-		5E 21											
	0	b			-		- SE. 20											
2		1			-													
		4					SZ 19											
c.	sa		-		0 -		.SF. 15											
		1			3000													
}	}				-										1			
	ь	H		4			SE 17		TLLITE, SIMECTI	+				1	0.6	7		
0		-	•		-				KAOLINITE					ı		l		
		2			-			This formation begins with dark gray-black co- lored, 150 m thick shale from below, a unit with										
	4				_			thick, messive ted and intercaletion of sandstone shale is situated as graded on these shale.										
		υ			2000-		• Sac. 16	1										
			נ		-			present poor sorted and vary grading. Grain size										
ø	£				-		SE 15											
		CL.						and 1-40 cm. thick beds. On the upper level, sandstone beds decrease.	ILLITE, SIMECTI					١,	0.98	3		
					c .		,	Whereas, shale beds increase. Sandstone in medium and of the unit present gray	TE, CHLORITE.	ur	-30,1	egeta en-2	1					
	-	a	eo		, -		SE 12	colour, fine grain size, 1 to 40 cm. thick beds, heavy texture and gradings partly, corosity of			aly-j							
					-			sandstones in the lower levels is less, 10-19 per- cent than upper levels.										
я		>≥			9 1000 — —		SE 11	**										
	æ				-		SE 10	levels. These shales seem as if mother rock of	TLLITE, CHLORI-						0.8			Trocholina of, elongate
			7		_		s z 9		TE, KAOLINITE									Trocholina multuspira selongata alpira
		0			-		582 8 592 7		HITTE OU ANT					0.	,,			Protopenaroplis striata Psendocyclamina lithus Calpionella alpina Globochasta alpina
					-		SE 6		TLLITE, CHLORIT	1 1				•	57	1.20		Cladorocopsis mirabilis Nautiloculina solithica Bachinalla irregularis Nilislidas
-	ှာ	וי	نه		-		SE 2		TLLITE, DICKITI TLLITE, KAOLINI TE SIMECTITE, CHLO	SCI hou	-5. -200,	Amor	,-					
-	SH C		7		A 0 -		SE 1 Feult)		RITE	35,	caly	-35	+	+-	\vdash	H	\dashv	'
	JURA SSI	HALA.	1	4				Gray-withe colored, familty, massive and partly										0 400
┖┻	ל	n.						Cestiforous reef limestons		ı				1	1	1 1		

			ž		19	۲	_						TRIN		ORC		. c	ARB.		
¥	M	E A	Ä	님	NG.) gg	a fi	EXPLA	NAT	IONS	CLAY	1	ETLEC			мерфом		ρĸ		
STSTEM	SERUE	STAGE	FORMA TEON	STABOL	THECKNESS	LITHOLOUY	SAMPLE LOCATION				ANALYSIS	HTO CAS	OIL	S ¥ 5	104			CS GOOD	Fos	SILS
	,				5840							T				Ī	Ť		· · · · · ·	
υ		63	"																	
I O			, a																	
20	⋨	子 五	8 0	T _k											[]					
z	TERTLARY	LONER-MIDDLE BOCENE	>														ł		•	in firmosa al'Agonemais
E C	TER	7 6	ATBAŞI	Ta	5199		(F) +					-					\perp	_/	Disconsta	of rex m triloculinoid geneifer
		38	LXVER.	KT.	- 5030 -		6.1 6.2 6.3					-		****		+	\dashv		Chia eso Li	lodoenais dia: "pus hus grandis
			た760- KU	X _E	4950 -		13										士	7	Miscellia Globorota	ee miscella ia psysiomanard
		UPPER																-\\	Clobotrum	e harvilea miditrapoide man avitum
	ဟ	3 5	*															1 /	Optimizatel	a triluculinoid ##70. dae
		<u> </u>					• Ç.37												Disco reli Globotrum	THE RETOR
ນ																		V	:	oories Liru:isns
	Þ	S					ç.35													
							ç. 3 4													
	0	Þ																		
н			4																	
		0					· ç. 33													
	ഖ														1			ļ		
		ឆ					۲.32												As Samula	y section
0	υ						·	This unit is char		S. 61. 1. 6										
		υ	⊢				ير.ي	that formed from t							1			į		
			1	K _Q			ı	sandatone and shall bedded on the bott								-	ŀ			
								between medium and			<u> </u> 	11		:		-	1	- 1		
Z	_					CTALL C. ET	c. 29	Conture is disappe	er to the	upwarde.Upper										
"	4	į.					· C.28	part of the sandat and has the thin The ratio of sands through the upper	tone unit i	s thin bedded	:									
		`	4				C.27	The ratio of manda	stone/shale	descrease							1			
		6					ç,25	through the upper ratio of the shale	20.000											
	(-	-					ç.24	are gray, dark gray												
		~					5.23	colored.Sandstones					1							
							ç.22	and partly clayer.					Ì							
		ပ						and showing the se	edizentary	structures.										
S	ع		11				Ç.21													. 11
"	_						ç.20													· ·
							\$.19 \$.18													\$
	}	~	^				Ç.17 Ç.18													i de la companya de l
E	æ		v				- 1											ĺ		
		ω					8:15 8:13										1			
		>										1						1		
×	U		٦				-ç.12 -ç.11									1	.04			
		0											.							
		1					Ç.9									,	اد.			
			٠				7.6 7.6					SCI	-5,A	norpho-						
	 			-	500 Fault	, , , , , , , , , , , , , , , , , , , ,	6.3					20,	Wood aly-3	norpho- egetal- en-30 O			1.67			
		Ę				٢											}		As Semel	dy section,
1	SEC	DOGGER-WALM	+	J ₁		A A A A		Gray-white colore											0	hoo
	JURASSIC	000	1					partly fosilferous	s reaf lime	etone .										acuts.
1	15	ıβ	i	i	L a	$\mathbf{L}^{\mathbf{L}}\mathbf{L}^{\mathbf{L}}\mathbf{L}$	i	l			1	1. 1	I	L	1	LL	_L		l	1

Figure-5:Çaltu measured section

ř.	KESOZOIC	_]										С	E	N O	z	0	1 0	-						s T	STEI
	CRETIL CIEOUS	5.									т :	ε	R	т	r		в 3	r						5 1	RIE
,	LOVER CRETACEOUS	[אמן	20 SET						ж.	1	a a	L i	E 2	0	C E	N E			UPPER	EOCE	NE-01.3	GOCTENE			570.G
MS.	Crgtv a th	P. F.	12 T	ĸ	ì	;	5		υ		R		1						C E	на	LE	тт	t n	POR	MATEON.
k	× _¢	kT.	T _a							T _K											T _C			s r	нваз
	3	Fault.	¥-	ŝ		œ.		38	0	0			158				200		rn	71	۶ 8		6.7870	тас	IOTES5
2,72,72						11, 11	77	Ne.		10						作成 (# 16 mm) AUL 13						11 11 11 11 11 11 11 11 11 11 11 11 11			панотога
	E	,			ŭ.			26.2 0-14	9		يا 5	CT.TH	88 88	e 1	. L	16	KI 19	, i	E E				. NU. 24	Seump I	e Locat
	Thick and emastive sandations with alternated thinks beduat tower levels endeatons is roder- nie to complex grained and purpus, while first to sequence grained, enteed and cross bedded upparts	Limestons, marn and shale alternated budded	It composed of red-green and multice loured marm and shales	yers presents some seathennium, and record yers presents some seathennium, structures and gray, polygenic, moderate to thick and thin bedded, which graded and less horizo, extent,	moderate to thin layers, send contain de with hodded some silty bents, Sendy and while layers are	ontary structures, name, green to care green. This unit begins with warstwill sorted,	Sandstone is fine grained, layered 5 on thick, which are compact graded and show some sedi-	This unit composed of sandstand that the data tends that	thick.	This unit is similar to AB, the bebble layers in between the sandstone are nearly 10 cm					bandy lenses are appeared. Upward it converted to sundstones of Cumwlettin formation	This unit just shows the characters of order. In the middle of the unit lamines				nic substances)	upper horizon sminly more, couplemerate is massivebedded, badly zortad, cross-bedded and some places irregular bedded, compact, polyme-	(It composed of conglomerate, mandatons and more, which you consist conglomerate and in the		·	** ** * * * * * * * * * * * * * * * * *
Wacite, Chlorite																			•					CLAY AMILYSIS	
Wooden-20 Con 1v	Illite, Sinecttin, SCI-4, Amorphour Chlorite, Kaoli-15, Vegeral-15, nite nite 100 SCI-6-5, Amorpho- Hillit, Illite-Si-SCI-6-5, Amorpho-																						_	05 10 13 15 20	VI TRUMITE REPLECTIONS
40.43							0.59					€0.92												ď	
_ [[As Samakdy section	As Semekäy section									to and done												0 0	

Sample Nr.	Formation	81	S2	Tmax	P1	TOC	HI	Kerog	en Type
ÇAĞ. 3,4	Çağlayan	0.02	3.35	434	0.02	1.66	193	TİP	II
CAG. 5	Çağlayan	0.22	2.33	444	0.09	1.60	146	TİP	II .
ČAĞ. 6	Çağlayan	0.09	2.00	442	0.04	1.44	140	TİP	H
ÇAĞ. 8	Çağlayan	0.02	1.16	434	0.02	1.19	88	T†P	Ш
Ç. 5	Cağlayan	0.00	0.65	438	0.00	1.03	56	TiP	\mathbf{III}
Č. 8	Cağlayan	0.01	0.68	444	0.01	1.30	45	TİP	Ш
Ç. 11	Çağlayan	0.01	0.59	440	0.02	1.09	51	TIP	III

Figure 7. Pyrolyse results of shale samples

S1- Genetic petantial amount transforming into hydrocarbon, S2-Hydrocarbon formed by thermal cracking of kerogene Tmax. -Maximal temperature (C°) of S2, TOC-Total organic carbon, H1-Hydrogene index

2.3. Amount of Total Organic Carbon (TOC)

This analyses is composed of amount of carbon related to kerogen and carbon which is produced from kerogen but not discharged from the rock (Durant and etc., 1972; Jonathan and etc., 1976; Hunt, 1983).

According to total organic carbon amount of the samples, petroleum source rock determinations can be made. Generally 0.5 % is accepted as a lower limit of organic matters for a normal source rock (Dow, 1978; Mamper, 1978; Tissot and Welte, 1978; Hunt, 1983; Welte, 1965; Melver, 1967; Ala and etc., 1980). Analyses results of our 18 samples are shown in figure 48.

Figure 8.	Total	Organic	Carbon	(TOC)	results	of	shale	sample	es
-----------	-------	---------	--------	-------	---------	----	-------	--------	----

Sample Nr.	Formation	TOC (%)
ÇAĞ. J	Çağlayan	0.43
ÇAĞ. 3,4	Çağlayan	1.66
ÇaAĞ. 5	Çağlayan	1.60
ÇAĞ. 6	Çağlayan	1.44
ÇAĞ. 8	Çağlayan	1.19
ÇAĞ. 10	Çağlayan	0.68
KU. 5	Kusuri	0.59
KU. 13	Kusuri	0.82
Ç. 5	Çağlayan	1.03
Ç. 8	Çağlayan	1.30
Ç. 11	Çağlayan	1.08
K. 8	Cağlayan	0.76
SE. 4	Çağlayan	1.21
SE. 5, 7	Çağlayan	0.57
SE. 10	Çağlayan	0.83
SE. 13	Çağlayan	0.88
SE. 17	Çağlayan	0.87
SE. 23	Çağlayan	0.75

2.4. Clay Mineral Analyses

In order to determine geochemistrial evulation of deposits and potantial of rocks of petroleum source, these analyses are being used for a long time. A number of researchers have determined that hydrocarbon production and water loss are happend during the smeetite conversion to illite (Weaver, 1960; Perry and Hower, 1972; Foscolos and Kodama, 1974). Water with 150 degrees temperature being in the deposits which sunk deep provides dissolution of hydrocarbon. Conversion of montmorillonite to illite is concluded with a big amount of water in sufficent temperature (Perry and Hower, 1972).

Degree of metamorphism is also determinated by means of crystallinity index. While crystallinity index is getting smaller with sinking, incresement propational to sharpness are observered (Foskolas and Kodama, 1974).

Making use of illite crystallinite degree, diagensis, antimetamorphism of a rock can be determined (Weaver, 1960; Foscolas and Kodema, 1974.).

Clay mineral XRD results and crystallinity indexes of our 12 samples are shown in figures-9, 10, 11 and 12 respectively.

2.5 Spore colour Indexes (SCI)

Because of temperature increasements related to sinking, colours of spores changed. These colours are as follows: Yellow (in kow diagenesis period, index 2), Yellowwish-brown (In katagenesis, index 3-3.5) and black (in metagenesis, index 4 and more) (Staplin, 1969; Gunther, 1976).

Organic matter kinds and spore coloure index of our 6 samples are shown in figure-13

3. LABORATORY ANALYSES

Measures stratigraphical cross-sections were made and systematially samples were taken from the units which have petroleum source rock specifications in Boyabat basin (Fig. 4,5 and 6). Rock evaluation (Fig. 7)., total organic carbon amount (Fig. 8), organic matter kinds and maturity X ray difractometrics analyses (fig, 9, 10 and 11) were applied to the samples and crystallinity indexes were determined (fig. 12).

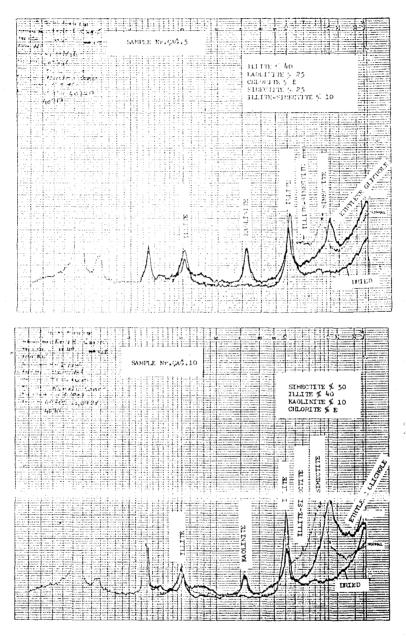


Figure-9: The x-ray difrackometric analysis results of clay mineral sample for ÇAĞ.5 and 10 of Çağlayan formation.

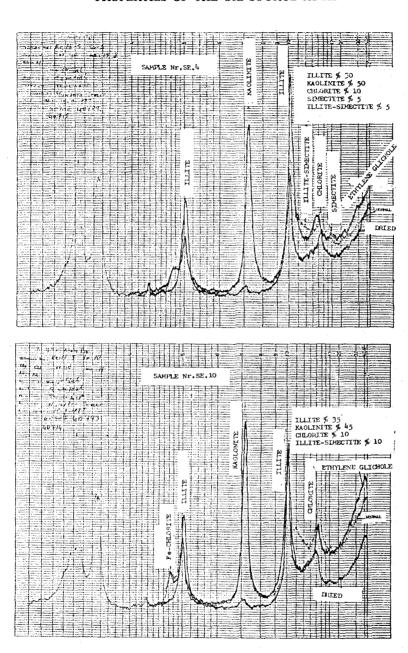


Figure-10: The x-ray difractometric analysis results of clay mineral sample for SE. 4 and 10 of Çağlayan formation.

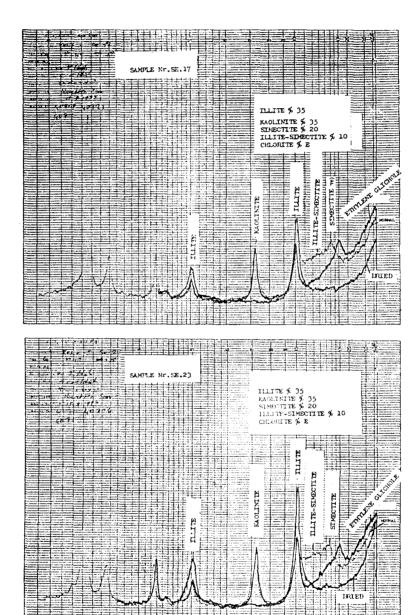


Figure-11: The x-ray difractometric analysis results of clay mineral sample for SE.17 and 23 of Çağlayan formation.

IRLED

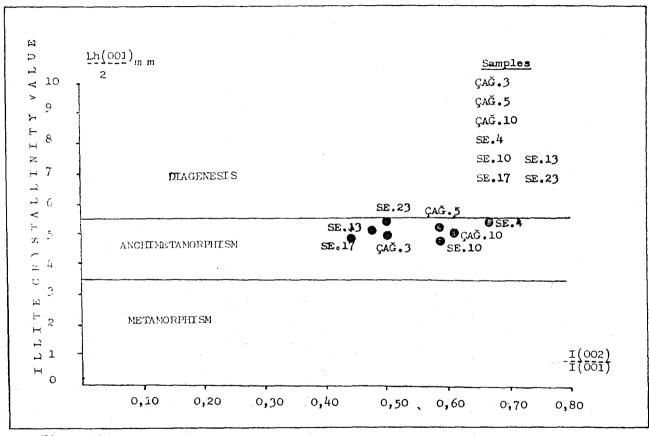


Figure-12: The illite crystallinity values of the samples of Çağlayan formation

Sample Nr.	Formation	SCI	Amerphour	Vegetal	Wooden	Coaly
ÇAĞ. 5	Çağlayan	6.5	4^	25	20	15
ÇAĞ. 10	Çağlayan	4.0	15	40	15	30
Ç. 8	Çağlayan	5.0	20	20	30	30
SE. 4	Çağlayan	5.5	10	20	35	35
SE. 13	Çağlayan	5.0	30	15	25	30
SE. 23	Çağlayan	4.5	10	15	20	55

Figure 13. Maturation and different organic matters of shale samples

SCI-spor color index

Amoung these analyses, organic geochemistrial analyses and maturity experiments were accomplished in research laboratories of petroleum company of Turkey and clay mineral difractometric analyses were completed in research center of Hacettepe Universicity and Union Turkey Cement Producers.

3.1. Determination of Laboratory Data

Most of 18 samples, on which total organic carbon analyses were carried out, belong to Çaglayan formation (Fig. 8). According to data of the samples, the formation has petroleum source rock specifications. The samples with the numbers of ÇAG. 3,4,5,6,8, C.8 and C. 11, which were taken from the lower part of the formation, have rich organic matter contents.

From this point' it is said, Çağlayan formation can be a good petroleum source rock and can produce petroleum and naturel gas.

Two samples of Kusuri formation exhibit the values on limit level. According to these data this unit can not be accepted as a petroleum source rock.

Genetic potantial values calculated from pyrolise results of 7 samples were found between 0.65 and 2.55 (fig 7). Although, ÇAG. 3, 4 and ÇAG. 5 marked samples exhibit medium degree source rock potantial, genetical potantials of other samples are less than 2. that means, this unit can not be petroleum source rock and rarely produce gas.

Relations between total organic carbon and T max of 7 samples, on which pyrolise experiment carried out, were established (Fig. 14). According to these relations; space which is shown by the data, point out type II and III of kerogen types. These results provide good connections with genetic potantial data.

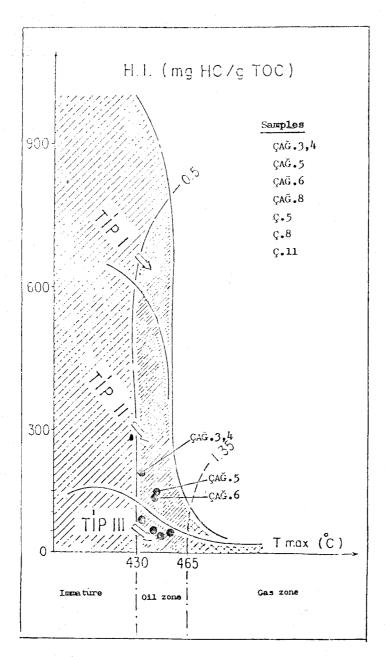


Figure-14:Organic material type and maturity of shale samples

Kerogen types of the samples taken from Çağlayan formation point out that units may give petroleum at lower parts and gas upper parts. These specifications may also shown that Çağlayan formation has deposits in an environment which has been getting shallower.

According to the matter types and maturity analyses, organic matters in Çağlayan formation matured enough and reached metagenes period (Fig. 14). Spore colour indexes shows that the formation reachs a petroleum and gas giving level. Different types of matters are found into organic matters types. It is know that these types of matters may produce petroleum and gas.

Spore coloure indexes have a little high values. These show that samples may not be taken from lower part of the formation.

X-ray diffractometric analyses of 12 samples, taken from Çaglayan formation which exhibits petroleum source rock appearance were carried out. Amoung these samples for 8 samples only clay mineral x-ray analyses performed.

Analyses results are follows; illite 25-35 %, Kaolinite 10-50 %, smectite 20-50 %, illite-smectite 10-20 % and chloride 10 %. During clay-mineral paragenesis, smectites are getting reduced with increasing depths and complex layered illites, smectites and chlorides replace with smectites (Fig. 9, 20 and 11). Generally, big amount of complex structure clay minerals are seen in the samples, besides, this amount is getting bigger by increasing depths. From this point, Çaglayan formation is mature enough to give petroleum and gas. This conclusion agrees with pyrolise and maturity analyses results.

Besides occurrence periods of clay minerals also agree with occurence and maturity periods of petroleum. Illite crystallinite indexes, calculated from x-ray diagrams of illite minerals, show that the formation sank enough to produce petroleum and may give petroleum.

4. CONCLUSION

According to geochemistrial and x-ray diffractometric analyses of the samples belonging to Caglayan formation, followings are found.

1. Amount of total organic matters of 16 samples taken from Caglayan formation are around 0.43-1.66 %. These data indicated that the formation could be a petroleum source rock.

- 2. Amount of total organic matters of 2 samples taken from Kusuri formation are around 0.59-0.82~%. From the wiev point of petroleum source rock, these data show that the formation is in a limited area.
- 3. Genetic potential values calculated using pyrolise data of 7 samples taken from Caglayan formation, are between 0.65 and 2.55. If it is though that genetic potential value of a petroleum source rock is more than 2, in this case, it is though that lower part of the formation may be a medium degree petroleum producing source rock.
- 4. According to the matter types and maturity analyses, kerogene types are tip II and tip III and the formation may give petroleum and natural gas.
- 5. Spore colour indexes of the samples show that formation reach enough maturity to give petroleum and natural gas.
- 6. By applying x-ray difractometer analyses on 12 shale samples, Clay mineral paragenesis of illite, illite-smectite and kaolinite were determineted. Occurency of illite and illite crystalinity index agree with petroleum occurency zones. These data indicate that Caglayan formation could be a petroleum source rock and organic matter reach a mature level.
- 7. In order to determine petrolem potantial of the units reflecting source rock appearance, systematic geochemistrial and clay-mineral analyses must be done

REFERENCES

- AKARSU, İ., ve AYDIN, M., 1986, Sinop-İnebolu-Küre-Taşköprü-Kastamonu-Boyabat-Durağan arasının genel jeoloji raporu. TPAO arşivi, rapor No: 1325.
- ALA, M.A., and etc., 1980, Organic geochemistry and source rock characteristics of the Zagros Petroleum Province. Southwest Iran. Jour. Pet. Geol., 3, 1, 61-89.,
- BADGLEY, P.C., 1959, Sinop Havzasının petrol olanakları. Petrol İşleri Genel Müdürlüğü arşivi.
- BAKER, E.C., 1962, Distribution of hydrocarbons in petroleum. Bull. Amer. Assoc. Petr. Geologist 47, 78-84,
- BLUMENTHAL, M., 1940, Gökırmak ile Karadeniz arasındaki Pontid silsilesinin jeolojisi hak. rapor. Rapor No: 1067, MTA, Ankara.
- DOW, W.G., 1978, Petroleum source beds on continental slope and rises. A.A. P. G. Bull., 62, 9, 1584-1606.

- DUNTON, M.L., and HUND, J.M., 1962, Distribution of low molecular weiht hydrocarbon in recent and ancient sediments. Am. Assc. Petr. Geol. Bull. 46, 12, 2224-2258.
- Durand, B., and etc., 1972, Etude de la matiere organique insoluble des argiles du Toarcien du Bassin de Paris. I Etude par les procedes optiques analyse elementaire, etude en microscopie et diffiraction electroniques. Rev. Ist. DFr. Petr. 27, 865-884.
- DUNNOYER DE SEGONZAC, G., 1969, Les minereax argileux dans la diagenecse passage Carte Geol., Alsace et de Lorraine, 29, 320 p.
- ERDMAN, J.G., 1967, Geochemical origins of the low molecular weight Hydrocarbon Constituents of petroleum and natural gases, in proceeding 7 th. World Petroleum Congress Mexico, Elvsevir, London, v. 2. p. 13-24.
- EREN, R.H., 1979, Kastamonu-Taşköprü bölgesi metamorfitlerinin jeiolojik ve petrolojik etüdü (doktora tezi) İ.T.Ü. Mühendislik Fakültesi.
- ERICSON, D.B., 1938, Boyabat hakkında rapor. Rapor No: 817, MTA, Ankara.
- ESPITALIE, J., andt etc., 1977, Etude de la matiere organique insoluble (kerogene) des Argiles du Bassin de Paris. Revue de L'institut Français, du petrole. XXVIII-I, p. 37-66.
- FOSCOLOS, A., and KODAMA, K., 1974, Diagenesis of Claypace days. Amer. Mineral., 51, 1057-1067.
- GEDİK, A. ve diğ., 1, 81, Sinop Havzasının jeolojisi ve petrol olanakları. TJK. Bil. Tek. Kurul. Bi. Özeti.
- GEDİK, A., ve KORKMAZ, S., 1984, Sinop Havzasının jeolojisi ve petrol olanakların. Jeol. Müh. Yayın organı.
- GEHMAN, H. M., 1962, Organic matter in limestones. Geochim. et Cosmoihim. Acta V. 26, p. 885-897.
- GUILLEMET, J., 1964, Cours de Geologie du petrole societe des Editions Technip., Paris.
- GUNTHER, P. R., 1976, Polynomorph color and dispersed coal particle reflectance from three Mackenzie delta holes. Geoscience and Man. vol. 15, 35-39.
- HUNT, J.M., and Jemiesan, B. N., 1956. Oil and Organic Matter in sourse rocks of petroleum. Bill. Amer. Ass. Petr. Geol. 40, 3, p. 447-488.
- HUNT, M.J., 1983, Geochemistry of petroleum. Woods Hole Oceanographic Institution Woods Hole, Massachussetts.
- KETİN, İ., 1962, 1/500 000 ölçekli Türkiye Jeoloji haritası. Sinop paftası ve izahatı, MTA, Ankara.
- KIRKLAND, D.W., and EVANS, K., 1981, Sourse rock potantial of evaporitic environment.

 A.A. P.G. Bull., 65, 2., 181-190.
- JONATHAN, D., and etc., 1976, Les methodes d'étude physico-chemique dela matiere organique. Bull. Centre Rech. Pau. SNPA, 10, 1, 89-108.
- LEVORSEN, A.I., 1967, Geologie of Petroleum. W. H. Free and Comp., San Fransisco. Mc Iver, R.D., 1967, Composition of kerogen eluc.o its role in the origin of petroleum. Proceeding of the 7 th world petr. cong., Mexico, 2, 25-36.

- MOMPER, J. A., 1978, Oil migration limitations suggested by geological and geochemical considerations. A.A.P.G. Bull. Contining Educ. Course note. Series 8, Physical and chemical constraints on petroleum migration.
- PERRY, E. A. D., and HOVER., I., 1972, Late state devhydratation in deeply buried pelitic sediment. A.A. P. G. Bull. Sb., 2013-2021.
- SONEL, N., ve diğ., 1988, Boyabat (Sinop) Havzası Ekin veren fayının petrol aramalarındaki önemi. 42. Türkiye Jeoloji Kurul. Bil. özeti.
- STAPLIN, F.L., 1969, Sedimentary organisc matter, organic metamorphism and oil and gas occurence. Bull. Canada. Pet. Geol., 17, 47-66.
- TISSOT, B.P., and WELTE, D.H., 1978, Petroleum Formation and Occurence. Springer Verlag, Berlin-Heidelberg-New York.
- WEAVER, C., 1960, Possible use of clay minerals in the search of oil. A.A. P.G. Bull., 44, 1505–1516.
- WELTE, D.H., 1965, Kohlenwasserstoffgenese in Sedimentgesteinen. Untersuchungen über den thermischen Abbau an Kerogen unter besonderer Berücksichtigungen der N-Parafinbildung. Sonderdruck aus der Geologischen Rundschau. Band 55, s. 131-144, Ferdineand Enke Verlag, Stuttgart