[PS]Importance of the Hydrocarbon Expulsion Time and Erosion on the Petroleum System in Gemrik Field, Southeast Turkey*

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Abstract

Gemrik Province is located in a structurally complex area north of the Bozova Fault, southeast Turkey. Several source rock intervals have been identified in the study area, which are clayed limestone of the Karabogaz, Karababa-A, and Derdere Sferli. These source rocks are responsible for sourcing the Karababa-C reservoir rock. The source rocks are composed of Type II kerogen with the initial TOC ranging from 0.95 – 2.25 %. The HI values of these intervals range from 440 to 550. These values indicate that the Cretaceous Karabogaz, Karababa-A and Derdere Sferli source rocks have enough potential for hydrocarbon generation and they are mostly in oil window, but the hydrocarbon expulsion time and the preservation of trapped hydrocarbon are the other critical issues for the petroleum system. The hydrocarbon generation in Gemrik started in Middle Eocene time (42 Ma ago) and the expulsion occurred between Oligocene to Upper Miocene time (30 Ma-15 Ma ago). The area was exposed to the multiple erosions during Tertiary, as it was tectonically active. Especially, the region was uplifted during Middle to Upper Miocene time causing the removal of the Oligocene, Eocene and Paleocene sediments in the area. Because of that, the temperature decreased, the maturity remained stable and finally hydrocarbon generation and migration ended. In addition, the uplift resulted in the occurrence of the fractures on the seal rock resulting in the loss of the already trapped hydrocarbon. Gemrik Field is a good example to show the risks of oil and gas exploration in the areas where there is no hydrocarbon generation or expulsion for a long period of time.

Importance of the hydrocarbon expulsion time and erosion on the petroleum system in Gemrik Field, Southeast Turkey

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INTRODUCTION

The main hydrocarbon exploration fields in Turkey are located on southeast Turkey, the northern edge of the Arabian Plate. Gemrik Province is considered to be one of these prospective areas in the region, between Adiyaman and Şanliurfa cities. The main source rocks in the study area are the Cretaceous Karaboğaz, Karababa-A, and Derdere-Spheroidal, whereas the Karababa-C and Derdere Formations are the reservoir intervals. The inital TOC of the source rocks ranges from 0.95 – 2.25 %, the HI values change from 440-550 and the kerogen type is Type II. Even though the source rocks have enough potential for the hydrocarbon generation; hydrocarbon expulsion time and the preservation of trapped hydrocarbons are the other critical issues for the petroleum system.

This work focuses on the importance of the expulsion time and erosion on the petroleum system in Gemrik Field. 1D model is created by using 11 wells to evaluate the petroleum potential of the 'Gemrik-1' prospect in the study area. The hydrocarbon generation in the Gemrik Field started in the Middle Eocene (42 Ma) and the expulsion occurred between the Oligocene to Upper Miocene (30 - 15 Ma). The area was exposed to the multiple erosions during the Tertiary, as it was tectonically active. Especially, the region was uplifted during the Middle to Upper Miocene, causing the removal of the Oligocene, Eocene and Paleocene sediments in the area. As a result of that, the temperature decreased, the maturity remained stable and finally hydrocarbon generation and migration ended. Also, the uplift resulted in occurrence of the fractures on the seal rock, causing the loss of the already trapped hydrocarbons. We conclude that the hydrocarbon expulsion ended long time ago (15 Ma) due to the erosion. In addition, already trapped hydrocarbons could not be preserved in the study area since the area is tectonically active.

STRUCTURAL FEATURES

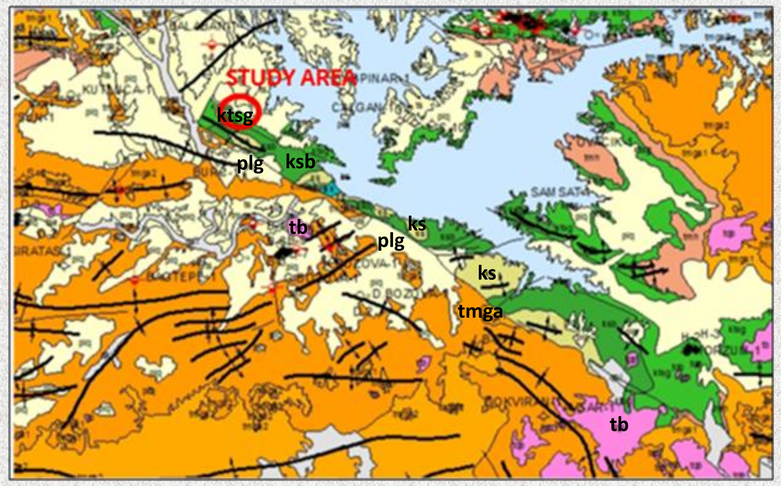
The study area is located in a structurally active region. The Gemrik Field was affected by the two main tectonic stages. First tectonic stage is a compressional tectonic event occured in the Late Cretaceous and was caused by the subduction of the Arabian Plate underneath the Anatolian Plate along the Bitlis-Zagros Suture Zone (Sengor, 1980). It is the early stages of the closure of the southern Neotethys. Tectonic uplifts occured through this time that created the structural traps and fractures, increasing the porosity (Cater and Gillcrist, 1994).

The second tectonic stage developed in the Middle Miocene. Opening of the Red Sea (Girdler et al. 1974) moved the Arabian Plate to the north and caused the collision of the Arabian and the Anatolian plates. The southern branch of the Neotethys Ocean closed along the Bitlis-Zagros Suture Zone. (Sengor et al. 1985; Yigitbas and Yılmaz 1996a, b; Huesing et al. 2009). The Dead Sea Fault Zone extending from the Red Sea to southern Turkey developed in this period. The Dead Sea Fault continues through northeast Turkey on the name of the East Anatolian Fault.

GEMRIK-1			
FORMATION	TYPE	BEGIN AGE	THICKNESS (m)
FIRAT_LICE_ERO	EROSION	15	-1260
FIRAT_LICE_DEP	DEPOSITION	23	60
MIDYAT_ERO	EROSION	30	-600
MIDYAT_DEP	DEPOSITION	50	1200
U_GERMAV_DEP	DEPOSITION	59	600
UPPER_GERMAV	FORMATION	65	300
LOWER_GERMAV	FORMATION	71	300
BOZOVA_ERO	EROSION	72	-20
BOZOVA_DEP	DEPOSITION	73	20
BOZOVA	FORMATION	75	200
SAYINDERE	FORMATION	79	200
SAYINDERE_SR	FORMATION	80	150
KARABOGAZ	FORMATION	81	50
KARABABA_C_ERO	EROSION	82	-30
KARABABA_C_DEP	DEPOSITION	83	30
KARABABA_C	FORMATION	84	30
KARABABA_B	FORMATION	86	45
KARABABA_A	FORMATION	88	15
DERDERE_LIM_ERO	EROSION	91	-100
DERDERE_LIM_DEP	DEPOSITION	92	100
DERDERE_LIMESTONE	FORMATION	93	50
DERDERE_DOLOMITE	FORMATION	94	70
DERDERE_SPHEROID	FORMATION	95	30
SABUNSUYU	FORMATION	111	150
AREBAN	FORMATION	113	15

Estimated Kronostratigraphy of the Gemrik-1 prospect

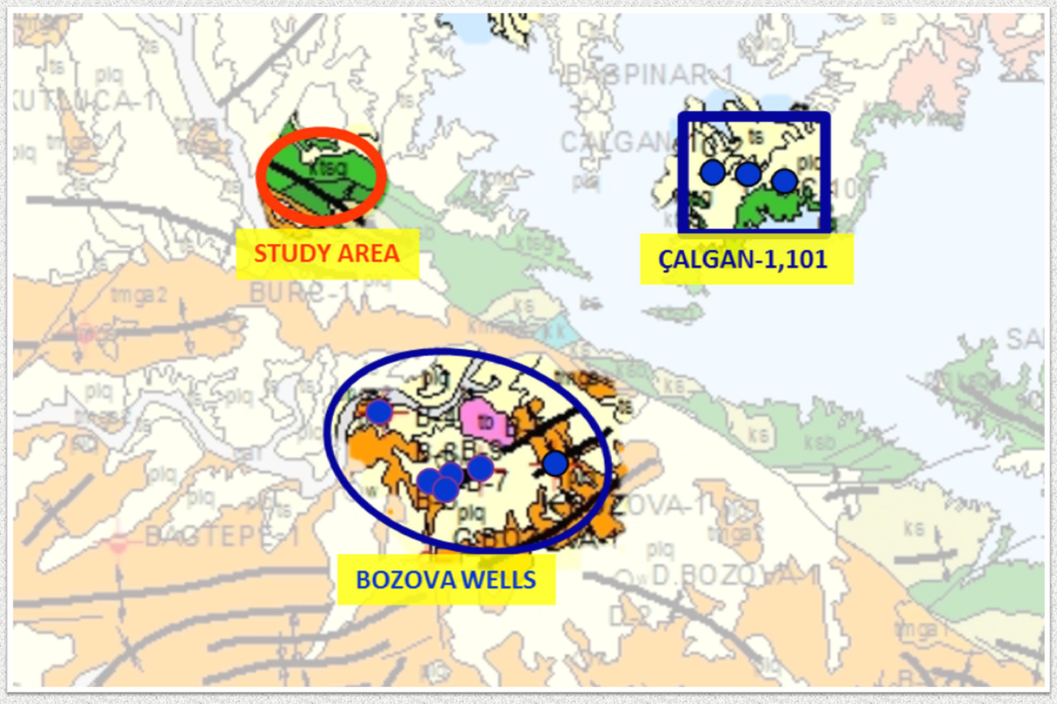
Location of the study area in southeast Turkey. The Gemrik-1 prospect is marked by the red star. DSF: Dead Sea Fault, EAF: East Anatolian Fault, NAF: North Anatolian Fault.



Outcrops in and around the Study Area. ktsg: Germav Formation, ksb: Bozova Formation, ks: Sayındere Formation, plg: Unnamed, tmga: Gaziantep marn, limestone, tb: Bazalt

AGE	FORMATION GROUP	LITHOLOGY	DEPOSITIONAL ENVIRONMENT	PETROLEUM SYSTEM ELEMENTS
Pliocene	LAHTI		*TERRESTRIAL*	
Lower Miocene	FIRAT_LICE		*OPEN – SHELF*	
Eocene-Oligocene	MIDYAT		*CARBONATE PLATFORM*	
Paleocene Upper Maastrichtian	GERMAV		*DEEP SEA*	
Upper Campanian Lower Maastrichtian	BOZOVA		*DEEP SEA*	
Upper Campanian	SAYINDERE		*DEEP SEA*	SEAL ROCK SOURCE ROCK
Middle Campanian	KARABOGAZ		*TIDAL FLAT-LAGOON*	SEAL ROCK SOURCE ROCK
Upper Coniasian Lower Campanian	KARABABA		*LAGOON-SHALLOW SEA*	RESERVOIR ROCK SOURCE ROCK SEAL ROCK
Cenomanian	DERDERE		*INTERIOR SHELF*	SOURCE ROCK RESERVOIR ROCK
Albian-Cenomanian	SABUNSUYU		*TIDAL FLAT-LAGOON*	
Aptian-Albian	AREBAN		*BEACH*	

Generel Stratigraphy in the Region



The Bozova and Çalgan Wells around the study area

MODEL STRATIGRAPHY

Our model bottom starts with the Cretaceous Mardin Group, since the intervals older than Mardin Group do not have any importance for the petroleum system. Mardin Group is composed of Areban, Sabunsuyu, Derdere, and Karababa Formations from bottom to top.

One of the most important formations in the Mardin Group is the Derdere Formation. It includes organic rich spheroidal fossiliferous limestone at the bottom which is a **SOURCE ROCK,** and shallow marine carbonates at the top represent the **RESERVOIR** interval.

The other important formation is Upper Coniasian-Lower Campanian Karababa Formation and it is divided into 3 informal units:

- *Karababa A Member*: Organic rich clayey limestone with marl **(SOURCE ROCK)**
- *Karababa B Member :* Micritic limestone
- *Karababa C Member :* Porous limestone unit **(MAIN RESERVOIR ROCK)**

Karababa-A Formation was deposited in a deep marine environment that changed into shallower marine conditions during the deposition of the Karababa-B and Karababa-C.

Karabogaz Formation unconformably overlies the Mardin Group and it carries **SOURCE ROCK** potential which is composed of limestone and chert.

Sayındere Formation is argillaceous limestone which conformably overlies the Karababa Formation. The reason that makes the Sayındere Formation important is the dark colored, organic rich limestone interval at the lower part. This organic rich interval indicates **SOURCE** and **SEAL ROCK** characteristics.

BOZOVA-1		
Formation or event name	P. Thick.	Total Thick.
MIDYAT	1238	**1238**
U_GERMAV	618	**667**
L_GERMAV	49	

BOZOVA-2		
Formation or event name	P. Thick.	Total Thick.
MIDYAT	1236	**1236**
U_GERMAV	612	**666**
L_GERMAV	54	

BOZOVA-3		
Formation or event name	P. Thick.	Total Thick.
MIDYAT	1287	**1287**
U_GERMAV	546	**599**
L_GERMAV	53	

BOZOVA-4		
Formation or event name	P. Thick.	Total Thick.
MIDYAT	1218	**1218**
U_GERMAV	662	**728**
L_GERMAV	66	

BOZOVA-7		
Formation or event name	P. Thick.	Total Thick.
MIDYAT	1207	**1207**
U_GERMAV	633	**699**
L_GERMAV	66	

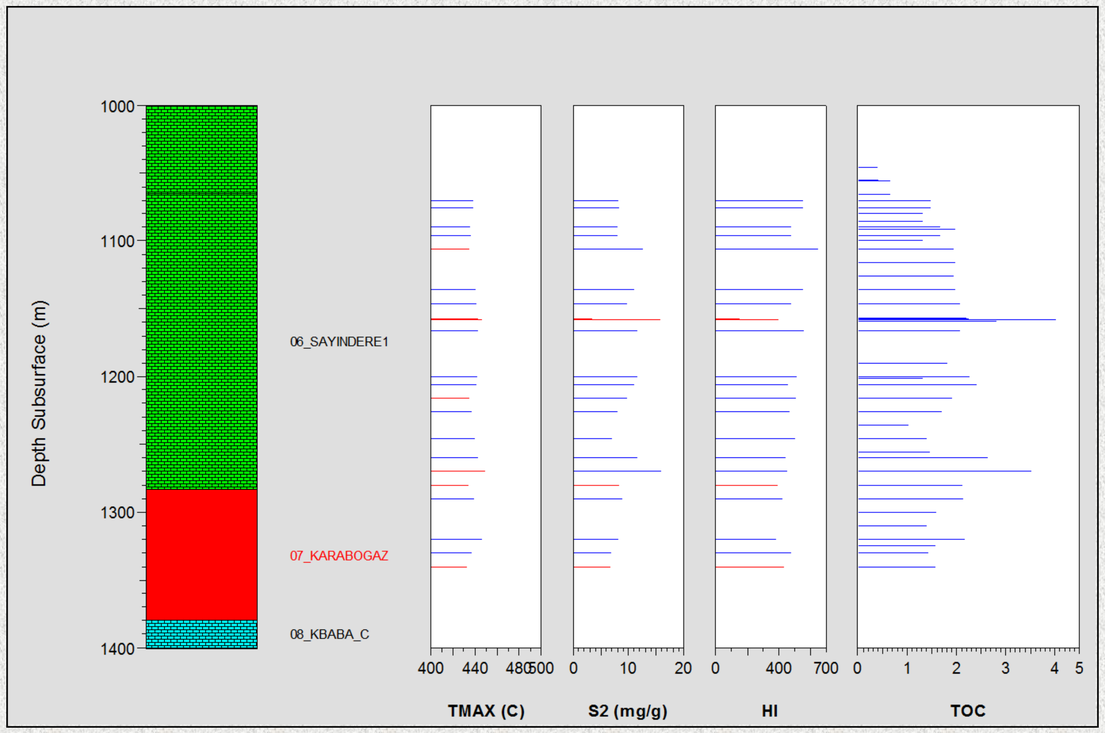
BOZOVA-8		
Formation or event name	P. Thick.	Total Thick.
MIDYAT	1200	**1200**
U_GERMAV	626	**685**
L_GERMAV	59	

BOZOVA-9		
Formation or event name	P. Thick.	Total Thick.
MIDYAT	1220	**1220**
U_GERMAV	629	**684**
L_GERMAV	55	

Average Midyat Thickness : 1200 m.
Average Germav Thickness: 675 m.

The thickness of the Midyat and the Germav Formation in Bozova Wells

1D modeling was performed in the study area to evaluate the petroleum potential of the «Gemrik-1» prospect. The BasinMod petroleum modeling software was used for the study. The Midyat and Fırat-Lice Formations are absent, while the Germav Formation outcrops in the study area. Hence, the 'estimated' original thickness of these formations were determined with the help of the nearby Bozova and Calgan wells on the south and the east of the Bozova Fault. These wells were chosen because they penetrated the removed formations in the study area and they have available geochemical data. The average thickness of the Midyat and Germav Formation was calculated as 1200 m. and 675 m., respectively. These wells were also used to determine the thickness of the other formations, and to construct burial and maturation history in Gemrik Field.

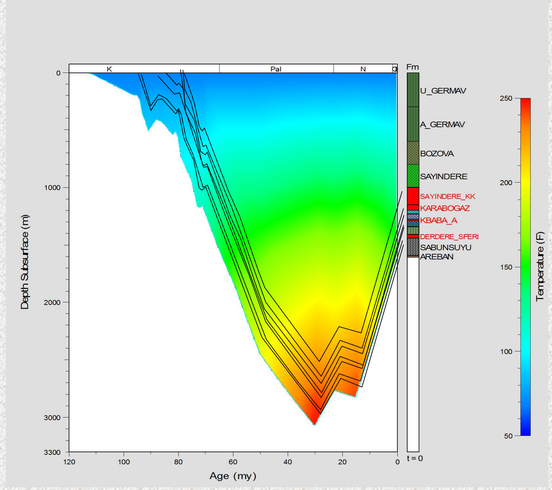


ÇALGAN-1 Well Geochemical Log

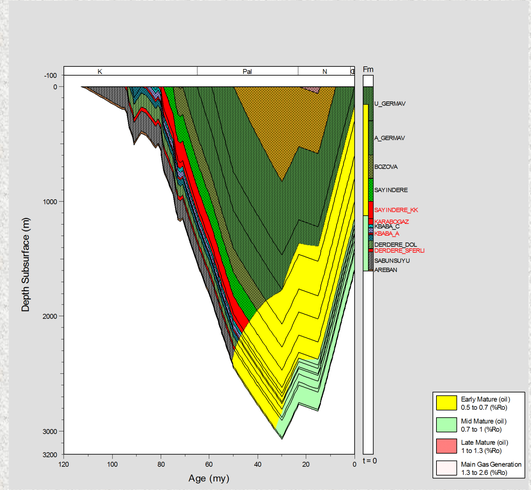
The cross mark symbols in the table below show the available data for the Calgan1 and 101 wells. Geochemical log of the Karabogaz Formation for the Calgan-1 well is shown on the left. According to the log data, the present TOC of the Karababa Formation is more than 1, HI is more than 400 and the Tmax is above the 435 ^{0}C . These values prove that the Karabogaz Formation is a potential source rock in the region. Also, Derdere-Spheroid, Karababa-A, and Sayındere Formation are considered to be the other source rock intervals and their source rock characteristics are shown at the table below.

KUYULAR	Zemin Rakımı	KB	KB-ZR	X	Y	SON DERİNLİK	SON DERİNLİKTEKİ FORMASYON	POR	BASINÇ	SICAKLIK	OLGUNLUK		PIROLIZ	KK_ TIPI	SONDAJ BAŞLAMA-BİTİŞ TARİHİ
											VITRINIT	SCI			
CALGAN_1	626.50	629.7	3.2	446890.00	4156175.00	1356	Kbb-C	X		X		X	X	X	11/08/1978_05/10/1978
CALGAN_101	657.70	663.8	6.1	450470.00	4155880.00	1403	DERDERE	X		X					29/06/1983_02/08/1983

KAYNAK KAYA	KEROJEN TİPİ	İLKSEL %TOC	İLKSEL HI
SAYINDERE	Type II (BMOD-1D LLNL)	2.25	620
KARABOĞAZ	Type II (BMOD-1D LLNL)	1.90	620
KARABABA-A	Type II (BMOD-1D LLNL)	1.05	530
DEREDERE-SFER	Type II (BMOD-1D LLNL)	0.98	440

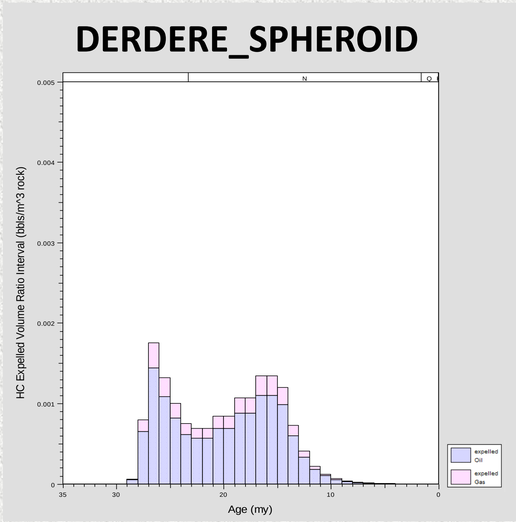


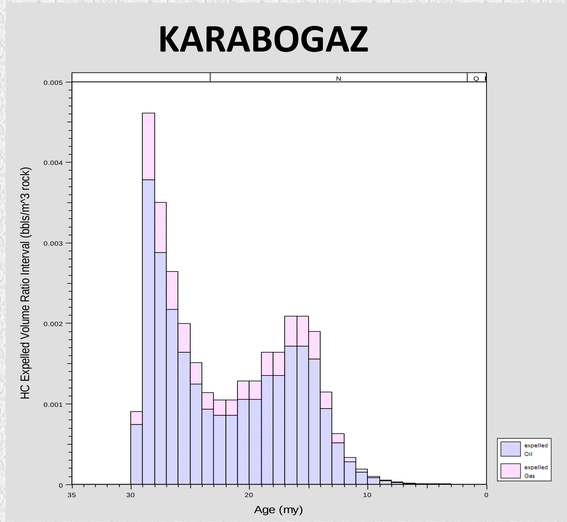
Burial History Chart

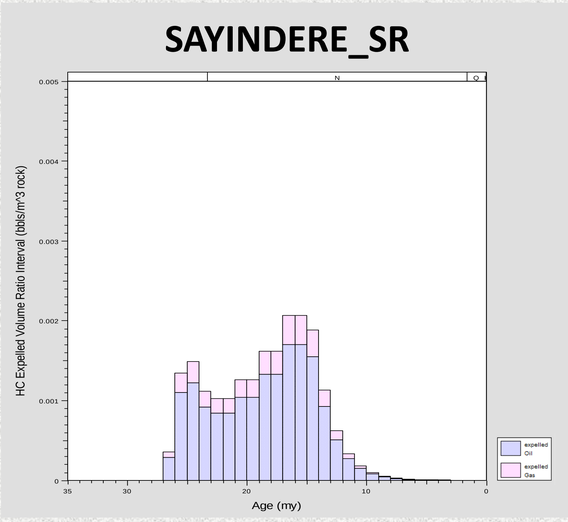


Burial History Chart

Burial history diagrams on the right shows that the region was burried and uplifted several times. Maximum burrial occured in 30 Ma (Oligocene) and the sediments reached the maximum temprature. Then the region was uplifted and burried again between 30-14 Ma. The erosion has been affected the study area since 14 Ma. The source rocks enter the early oil window 50 Ma (Lower Eosene) and the maximum burial depth makes the source rocks mid mature (approximately 32 Ma). The maturity diagram shows that the Derdere-Spheroid, Karababa-A and the Karabogaz Formations are in the Mid Mature window, whereas the Sayındere Source rock is immature.

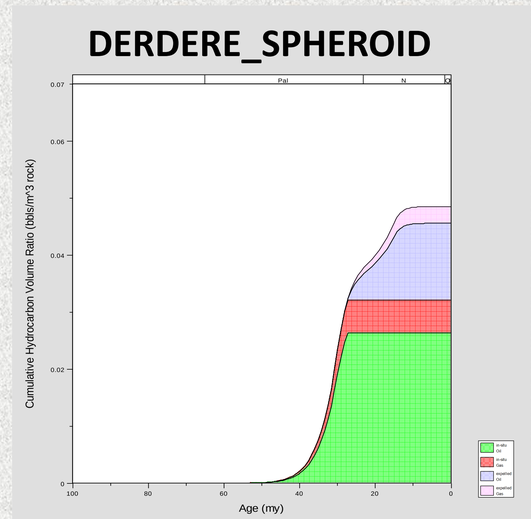


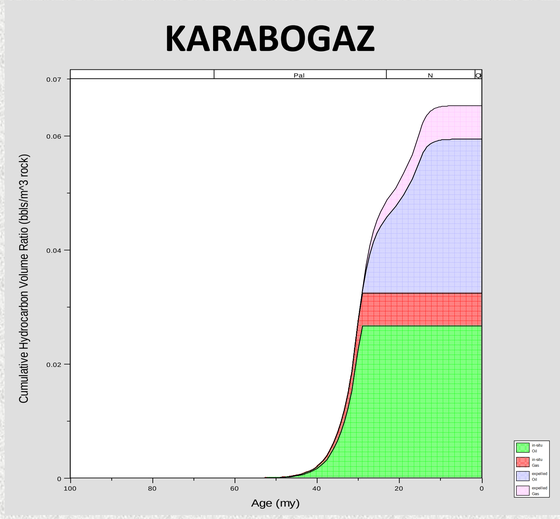


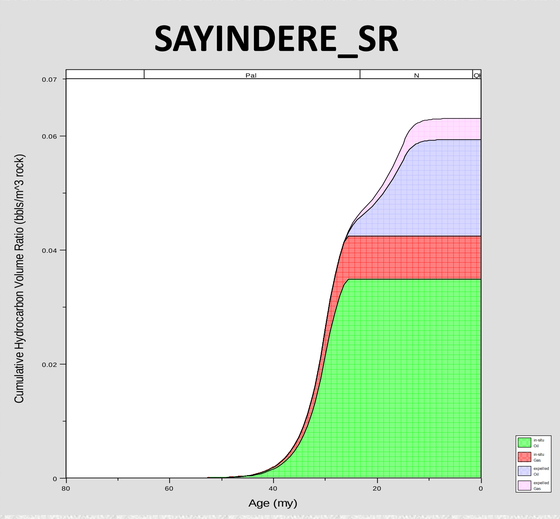


Age vs HC Expulsion Volume Ratio for Derdere-Spheroid, Karabogaz and Sayındere Formations

Cumulative Hydrocarbon Volume Ratio vs Depth







Age vs Cumulative HC Expulsion Volume Ratio for Derdere-Spheroid, Karabogaz and Sayındere Formations

Depth/Cumulative Hydrocarbon Volume Ratio graph indicates that the Sayındere, Karabogaz and Derdere-Spheroid source rocks could generate and expel hydrocarbons, whereas the Karababa-A could only generate hydrocarbon.

The Sayındere Formation is the thickest source rock interval in the study area with the higher TOC ratio than other formations. However, according to the HC Expelled Volume Ratio Interval/Age graphs, the Karaboğaz source rock has the highest hydrocarbon generation potential since the Sayındere Formation is in the early mature window, whereas the Karaboğaz Formation is mid mature. The maximum expulsion occurred in 29-28 Ma with the increasing burial depth and temperature. The decrease in expulsion took place with the uplift and another burrial stage made the expulsion rate higher. However, the continuous erosion after the latest burrial stage resulted in the decrease in temperature and the hydrocarbon generation and expulsion ended.

The hydrocabon generation from the all source rocks started in the Middle Eocene (42 Ma) and the expulsion started in Oligocene (approximately 30 Ma). However, the expulsion ended in the Upper Miocene and no generation/expulsion from any of the source rocks are observed in the study area since then.

CONCLUSION

The hydrocarbon potential of the Gemrik-1 prospect in southeast Turkey was evaluated using the nearby wells in the study area. The area is tectonically active and was exposed to the several erosions during the Tertiary. The 1D modeling study indicates that the all source rocks in the region have enough potential for the hydrocarbon generation, and this generation started in the Middle Eocene (42 Ma). Hydrocarbon expulsion from the Derdere_Spheroid, Karabogaz and Sayındere source rocks took place between Oligocene to Upper Miocene (30-12 Ma) but the the generated hydrocarbons could not be expelled from the Karababa-A Formation. Our study shows that hydrocarbon generation and migration has been stopped since 12 Ma in the region because of the tectonic activity. The long-term erosion in the area caused the decrease in temperature, maturity remained stable and the Oligocene, Eocene and Paleocene sediments were removed. Since the erosion has been affective in the region for millions of years, possibly the fractures occurred in the seal rock resulting in the leakage of the already trapped hydrocarbons. Hence, the region is not considered to be a propective area.

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