EGU-567: Uncovering the impact of Gokceada Volcanic Zone on pressure and temperature conditions of Thrace Basin in the Northern Aegean Sea using 1D basin modelling and seismic velocity extraction

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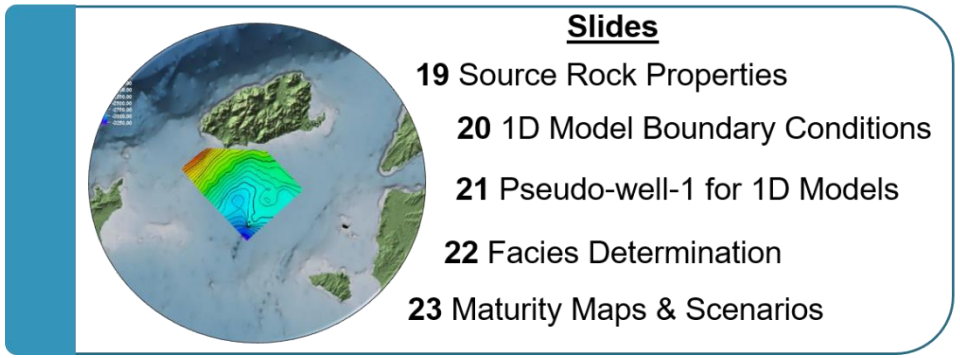
NAVIGATION TIPS

* **Tip 1:** You can directly go to the section menu by clicking the buttons!

BUTTONS

Button Types	Functionality
INTRODUCTION	Go to Section Menu
↵	Return to Section Menu
↵	Return to Main Menu

SLIDE LINKS



* **Tip 2:** You can directly go to slides by clicking slide links in the section menus!

MAIN MENU / OUTLINE

Introduction

- Regional Geology
- Gokceada Volcanic Zone (GVZ)
- Seismic Stratigraphy

Methodology

- PPFG & Temperature Graphs
- 3D Pore Pressure Modeling Workflow
- Basin Modeling Strategy

Results

- Impact of GVZ on pressure & temperatures
- 1D Basin Modelling – Burial History Charts
- 3D Pore Pressure Modeling

Conclusion

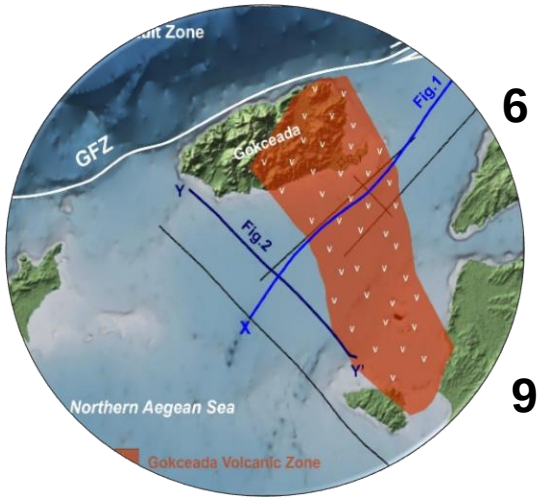
INTRODUCTION MENU

Motive & Aim

Slides

5 Motive & Aim

Regional Geology



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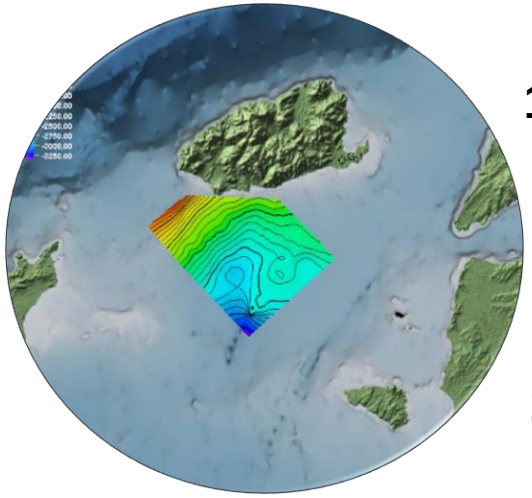
6 Regional Geology

7 Tectonostratigraphy

8 Karaagac Formation

9 Gokceada Volcanic Zone

Seismic Interpretations



Slides

10 Main Seismic Section – Fig.1

11 Seismic Interpretation – Fig.1

12 Perpendicular Direction – Fig.2

13 Seismic Interpretation – Fig.2

MOTIVE

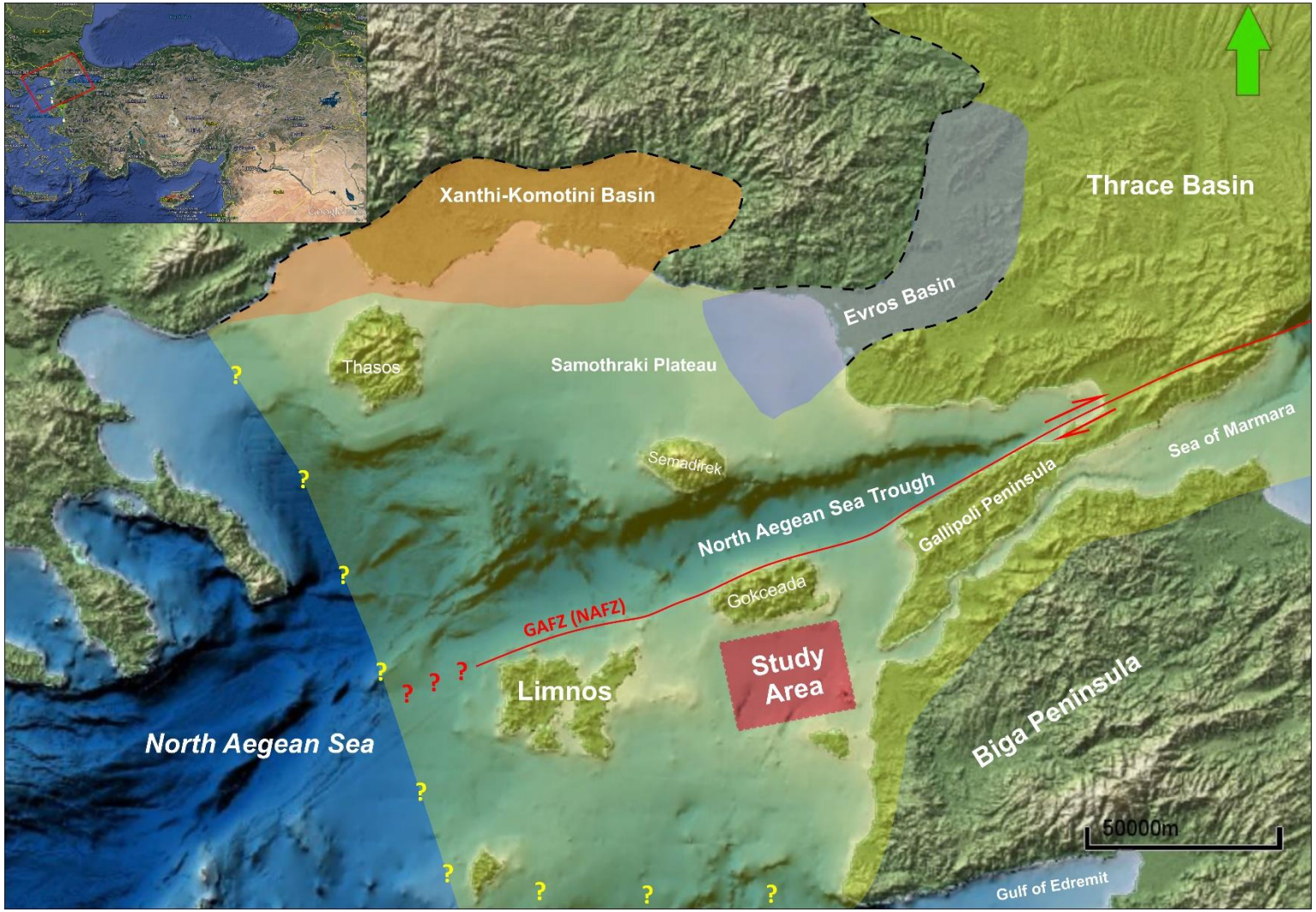
Problem definition:

- Products of intense volcanism from Eocene to Miocene can be observed on the island of Gokceada however its extent into offshore region is not known!
- Basin modelling and ppfg/temperature studies has not been conducted before.
- Understanding the impact of GVZ is crucial for a robust assessment of the prospectivity of the region.

Aim & Scope:

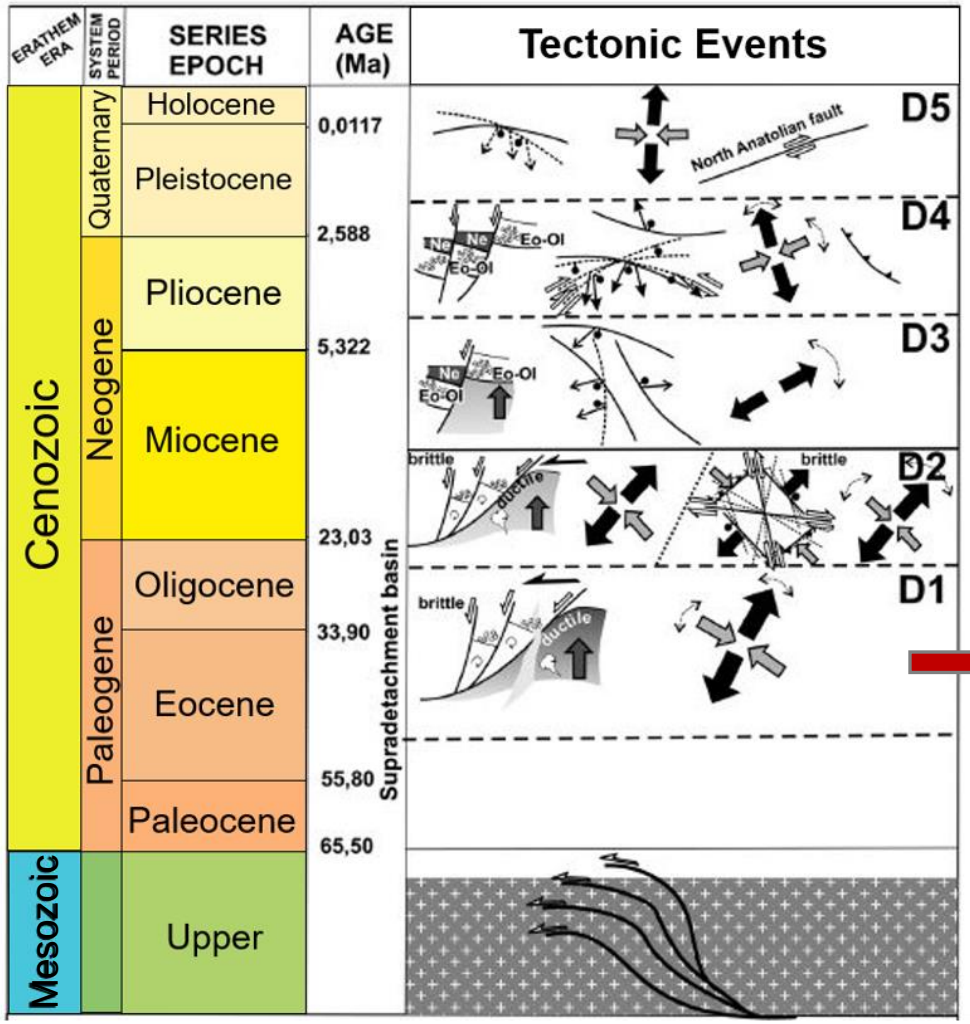
- Introducing the discovery, presence and extent of Gokceada Volcanic Zone in the Northern Aegean Sea.
- Revealing the pressure and temperature conditions of Southern Gokceada Offshore area and how they were affected by GVZ.

REGIONAL GEOLOGY



- Thrace Basin; Eocene-recent sedimentary succession, present at NE Aegean Sea
- Gas prone basin, conventional-unconventional fields with limited oil production
- Ganos Fault Zone (GAFZ) as the SW extent of the North Anatolian Fault Zone (NAFZ)
- Study area located at the offshore portion surrounding Gokceada island

TECTONOSTRATIGRAPHY

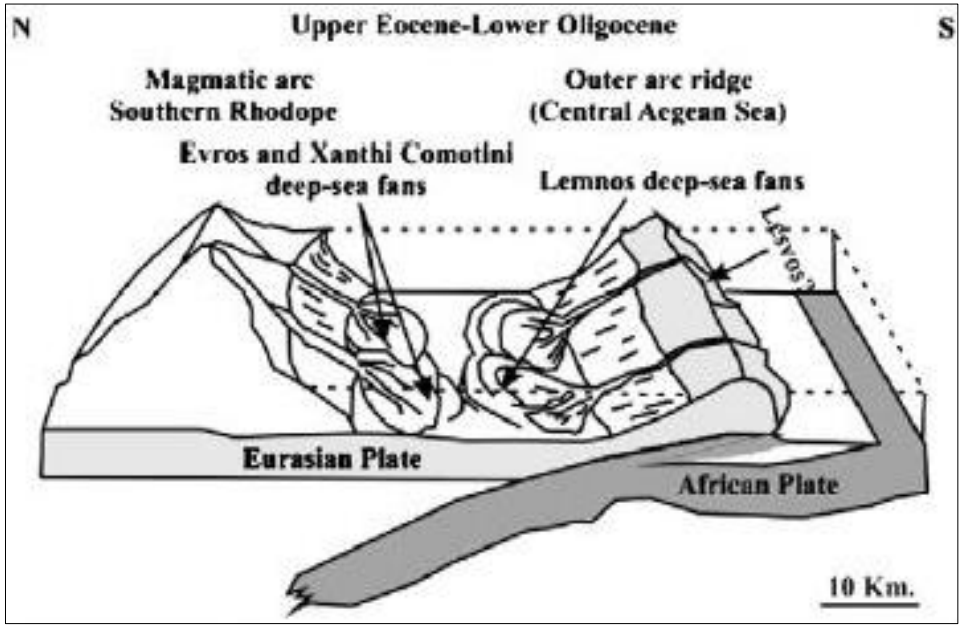


Modified from Kilias et al., 2015

Post-collisional extension phase controlled by high-angled normal faults and extensional wedges

Collisional phase

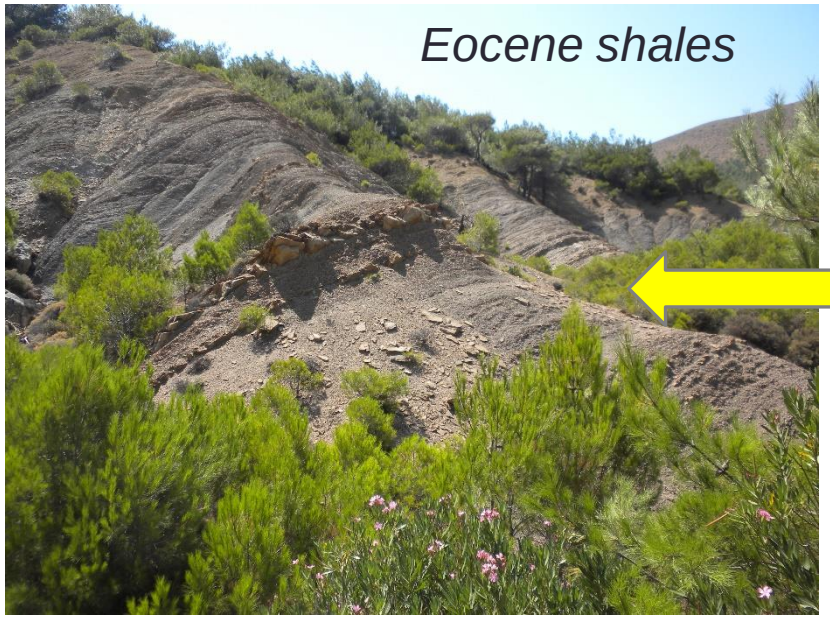
- Potential provenance of Eocene succession is from S, initiated by deep-sea fans



Maravelis & Zelilidis, 2012

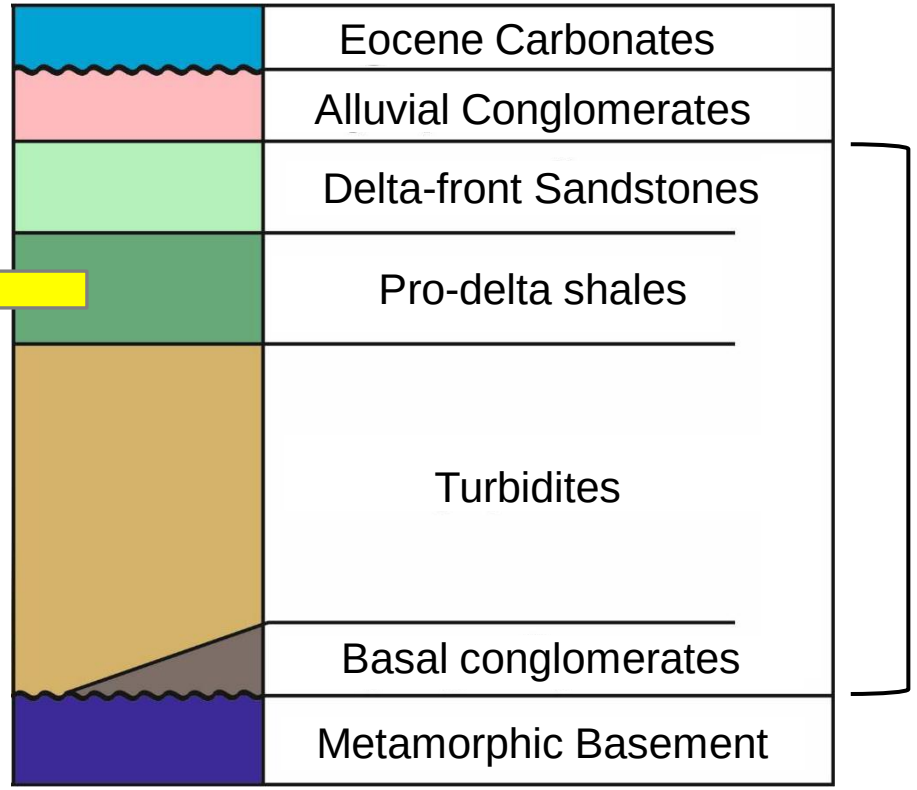
EOCENE SHALES – KARAAGAC FORMATION

Gokceada Onshore



- Eocene shales with high TOC content; potential source rock
- Reaching 100-200 m. thickness in eroded areas; original thickness must be larger

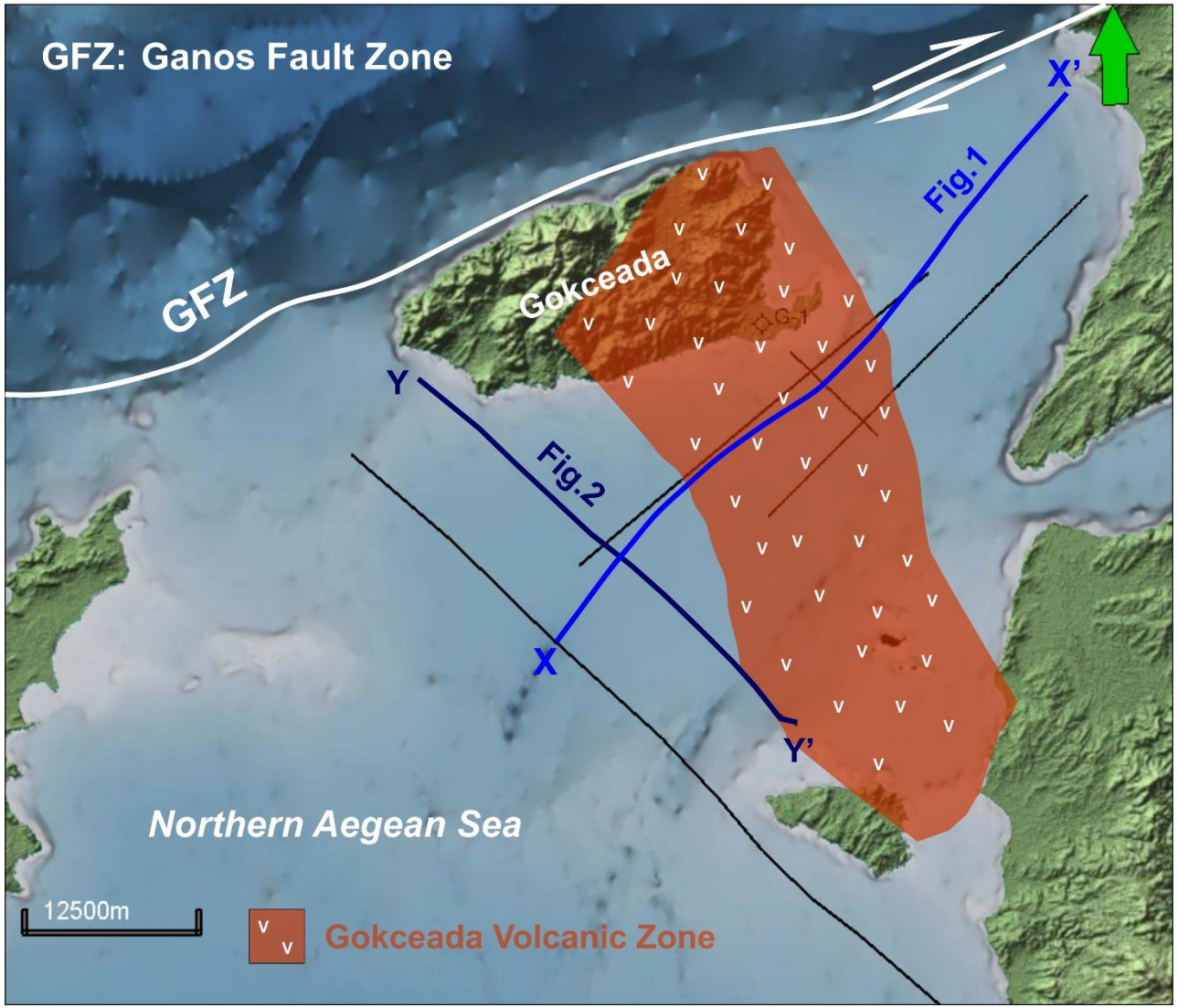
Early-Mid Eocene Succession



Modified from Siyako, 2007

- 2-3 km thickness
- Ypresian-Lutetian aged (Early Eocene)

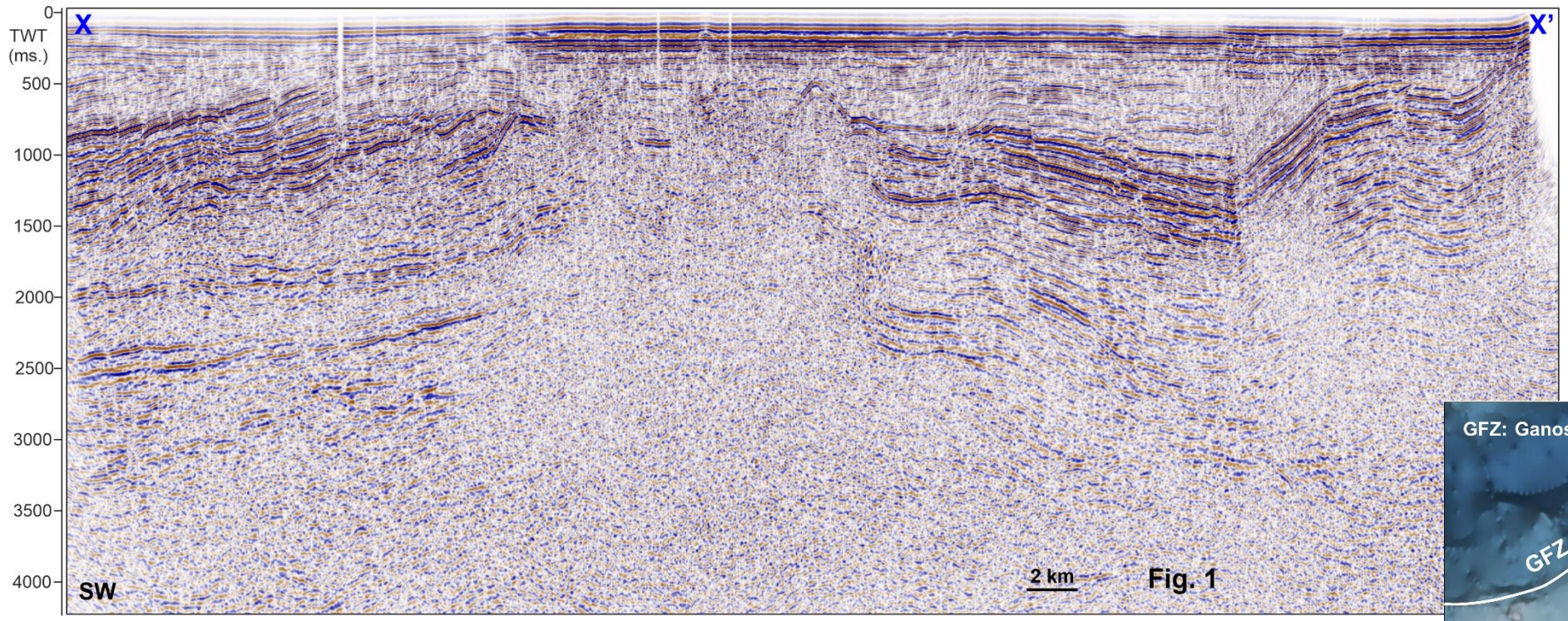
GOKCEADA VOLCANIC ZONE (GVZ)

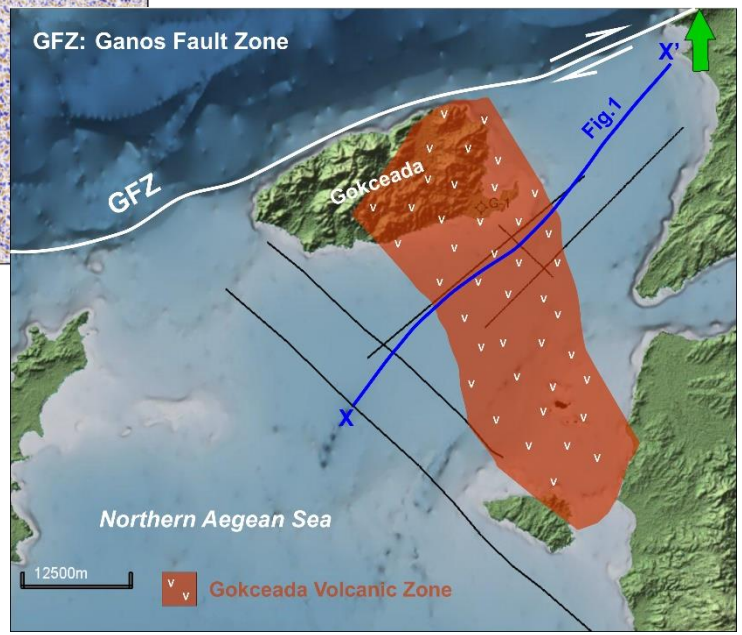


Gokceada Volcanic Zone (GVZ)

- Intense volcanism from Eocene-Miocene; products can be observed at onshore Gokceada as extinct volcanoes, cones, tuffs, rhyolites and volcano-sedimentary succession
- 30-40 km long volcanic region extends in a NNW-SSE orientation; observable on seismic sections for the offshore portion
- A significant heat source to consider for both potential hydrocarbon and geothermal exploration projects

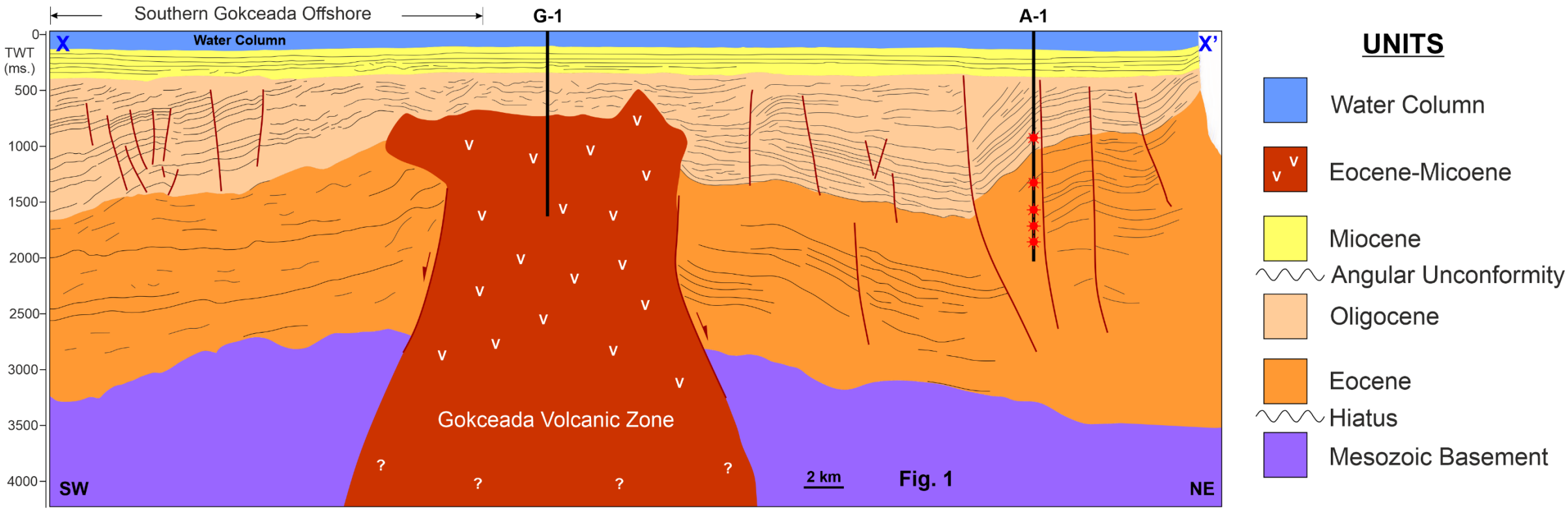
MAIN SEISMIC SECTION





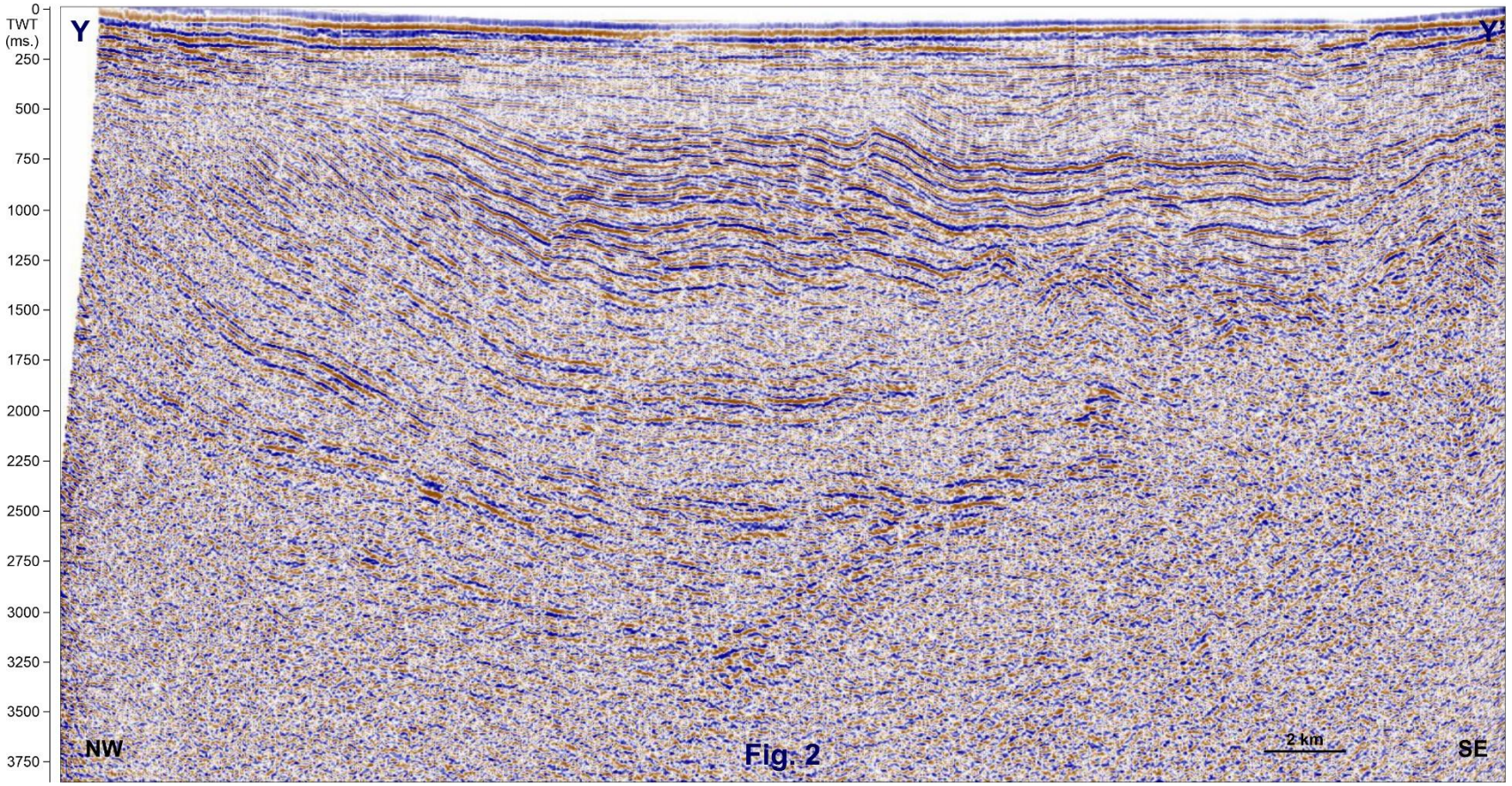
- Chaotic seismic facies in the middle distorting the continuity of the reflectors
- Characterised by cone and dome shaped, high amplitude geometries

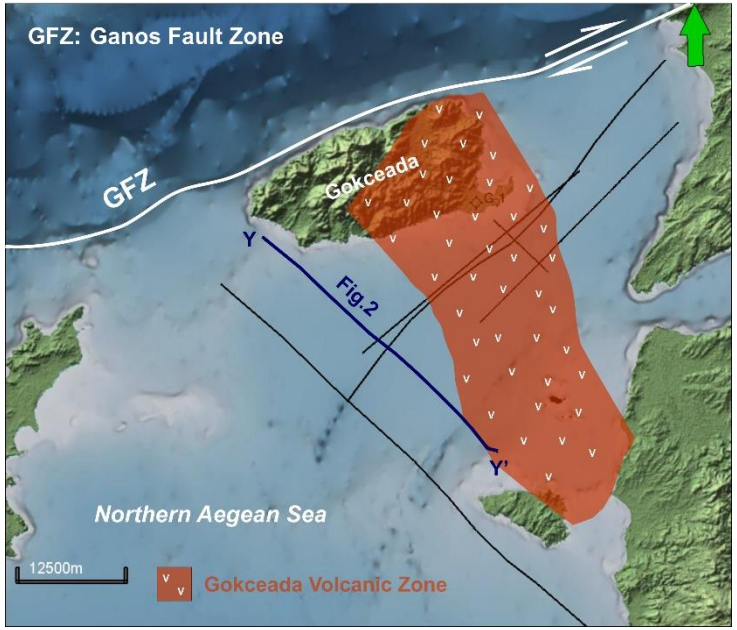
SEISMIC INTERPRETATION & FACIES ANALYSIS



- G-1 and A-1 wells are projected to the section, in A-1; frequency of gas shows increases in Eocene
- 450 m/Ma sedimentation rate for the Karaagac Formation; consistent with the thickness measured as 2-3 km.

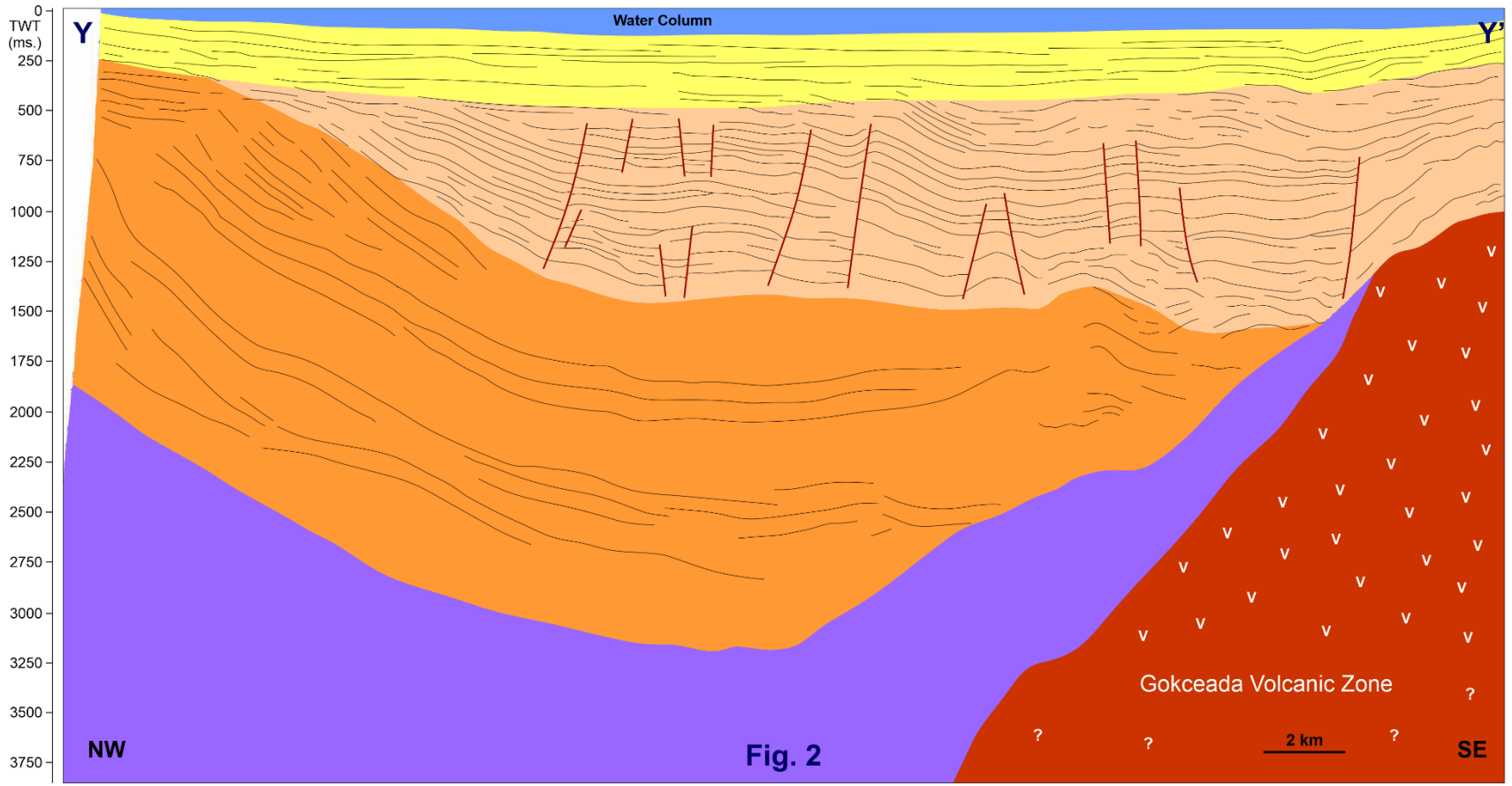
FIGURE 2 – PERPENDICULAR DIRECTION





- Same seismic facies can be observed

SEISMIC INTERPRETATION & FACIES ANALYSIS



UNITS

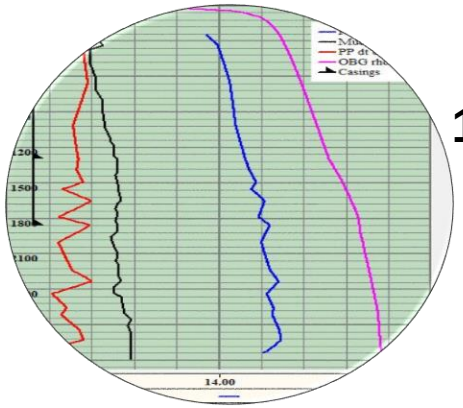
- Water Column
- Eocene-Micoene
- Miocene
- Angular Unconformity
- Oligocene
- Eocene
- Hiatus
- Mesozoic Basement

- Eocene and younger strata uplifted at NW as they outcrop on Gokceada

- High burial rates due to the extensional regime initiated at Early-Mid Eocene, dominated by perfect examples of growth wedge strata
- Gokceada Volcanic Zone migrates towards SE

METHODOLOGY MENU

Post-drill PPFG & Temperature Analysis



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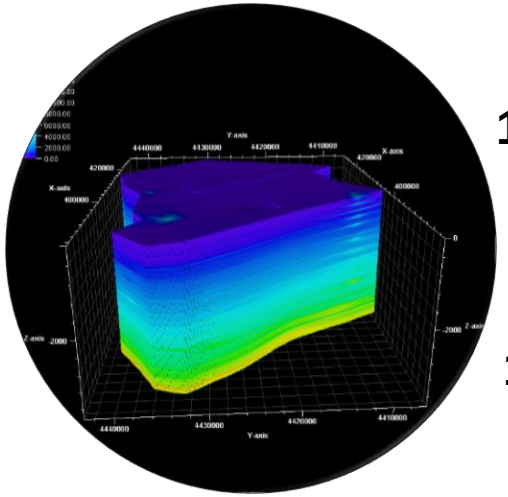
15 Temperature Analyser

16 PPFG Graphs

3D Pore Pressure Modelling



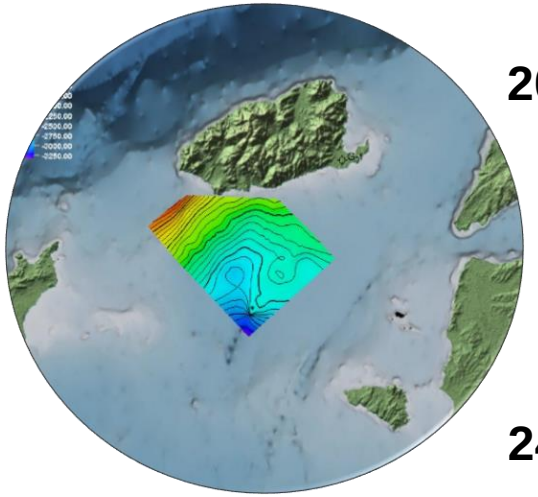
Slides

17 Velocity Extraction

18 3D Model Generation

19 Gokceada Offshore

Basin Modelling



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20 Source Rock Properties

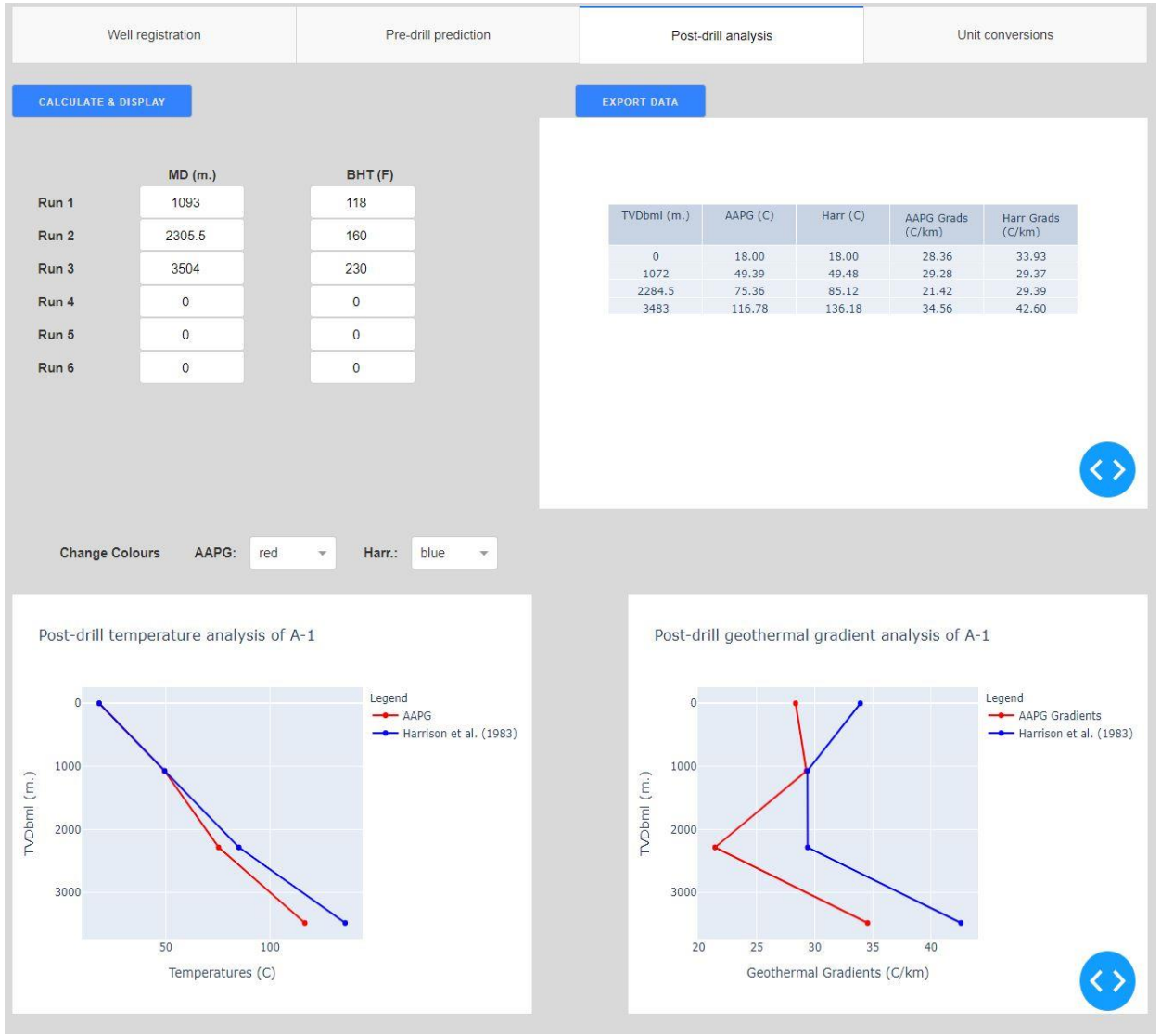
21 1D Model Boundary Conditions

22 Pseudo-well-1 for 1D Models

23 Facies Determination

24 Maturity Maps & Scenarios

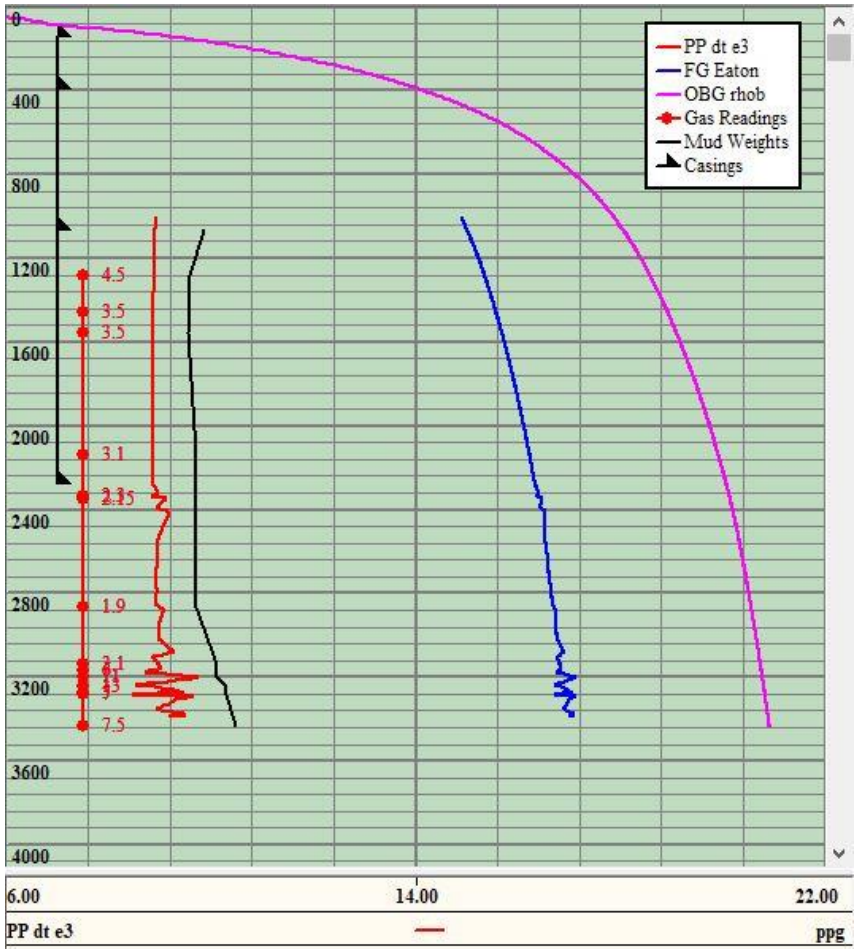
METHODOLOGY – TEMPERATURE PROFILES



- Bottom hole temperatures (BHTs) have been converted into static ones using AAPG correction and Harrison et al. (1983) formulas
- Industry-wide Horner plot method is not applicable for the wells in the region due to lack of robust recordings of circulation ending time and logging times
- An open source web application, named as *Temperature Analyser*, has been developed for pre & post drill evaluation of temperature conditions
- The application is available at; https://github.com/Ayberk-Uyanik/Temperature-Analyser

METHODOLOGY – PPFG GRAPHS

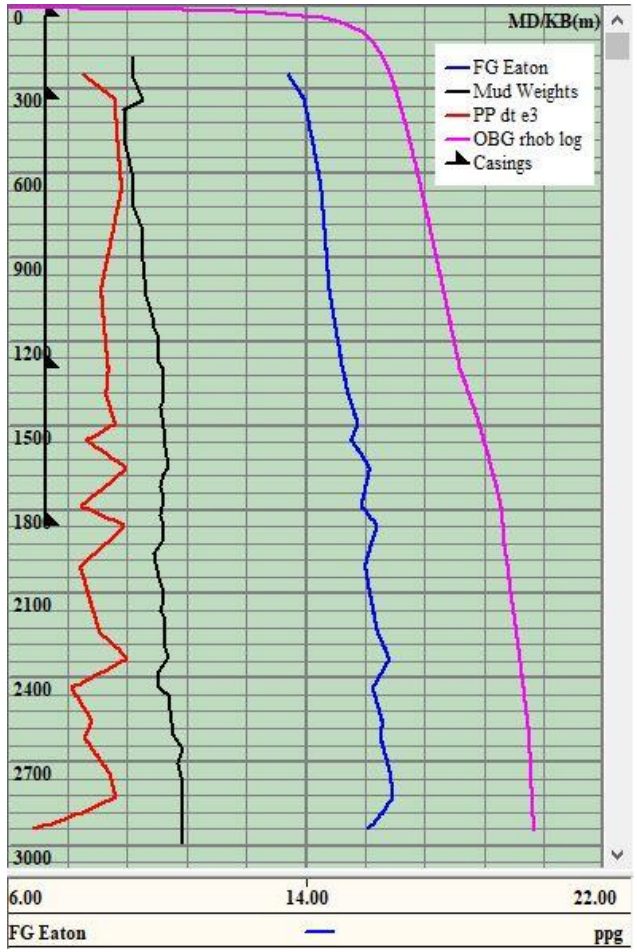
A-1 Well



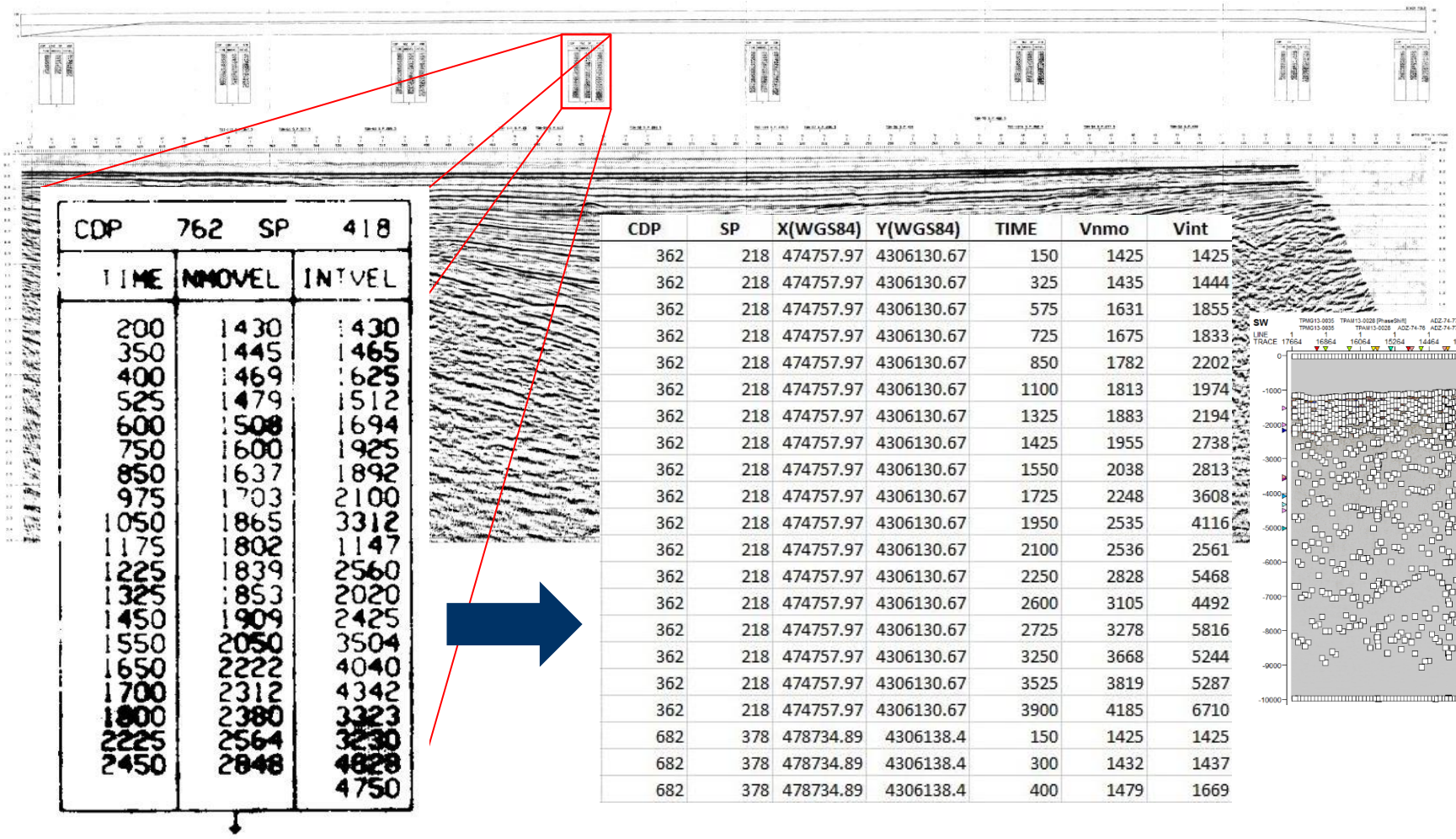
LOGs

- GR
- DT
- RHOB
- Checkshot/VSP

G-1 Well



METHODOLOGY – POINT DATA EXTRACTION

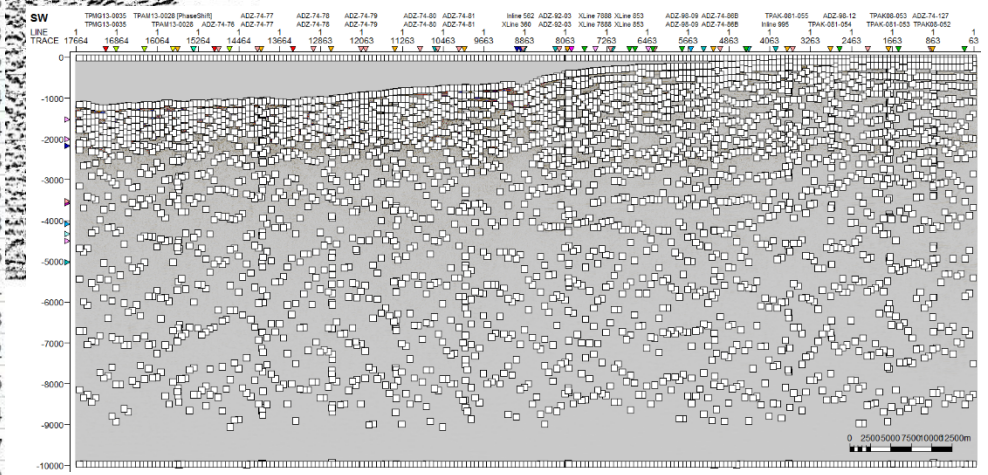


CDP 762 SP 418

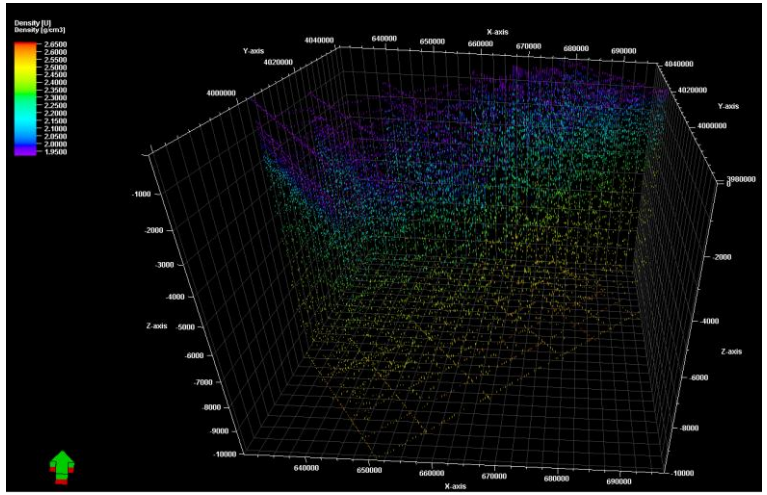
TIME	NMOVEL	INTVEL
200	1430	1430
350	1445	1465
400	1469	1625
525	1479	1512
600	1508	1694
750	1600	1925
850	1637	1892
975	1703	2100
1050	1865	3312
1175	1802	1147
1225	1839	2560
1325	1853	2020
1450	1909	2425
1550	2050	3504
1650	2222	4040
1700	2312	4342
1800	2380	3323
2225	2564	3230
2450	2848	4828
		4750

CDP	SP	X(WGS84)	Y(WGS84)	TIME	Vnmo	Vint
362	218	474757.97	4306130.67	150	1425	1425
362	218	474757.97	4306130.67	325	1435	1444
362	218	474757.97	4306130.67	575	1631	1855
362	218	474757.97	4306130.67	725	1675	1833
362	218	474757.97	4306130.67	850	1782	2202
362	218	474757.97	4306130.67	1100	1813	1974
362	218	474757.97	4306130.67	1325	1883	2194
362	218	474757.97	4306130.67	1425	1955	2738
362	218	474757.97	4306130.67	1550	2038	2813
362	218	474757.97	4306130.67	1725	2248	3608
362	218	474757.97	4306130.67	1950	2535	4116
362	218	474757.97	4306130.67	2100	2536	2561
362	218	474757.97	4306130.67	2250	2828	5468
362	218	474757.97	4306130.67	2600	3105	4492
362	218	474757.97	4306130.67	2725	3278	5816
362	218	474757.97	4306130.67	3250	3668	5244
362	218	474757.97	4306130.67	3525	3819	5287
362	218	474757.97	4306130.67	3900	4185	6710
682	378	478734.89	4306138.4	150	1425	1425
682	378	478734.89	4306138.4	300	1432	1437
682	378	478734.89	4306138.4	400	1479	1669

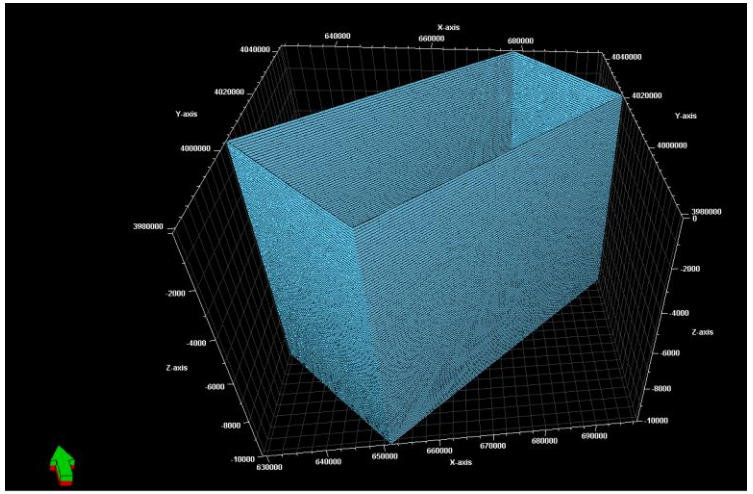
2D View



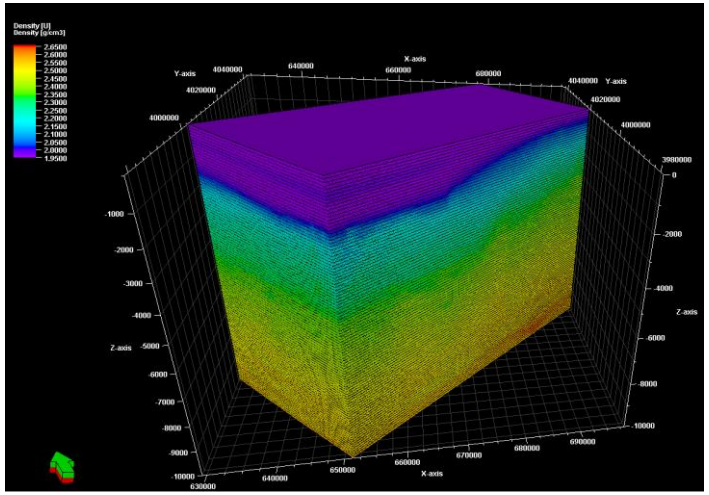
METHODOLOGY – 3D PORE PRESSURE MODELING



- Upscaled Point Data
- Data Intensity Control
- Quality Check



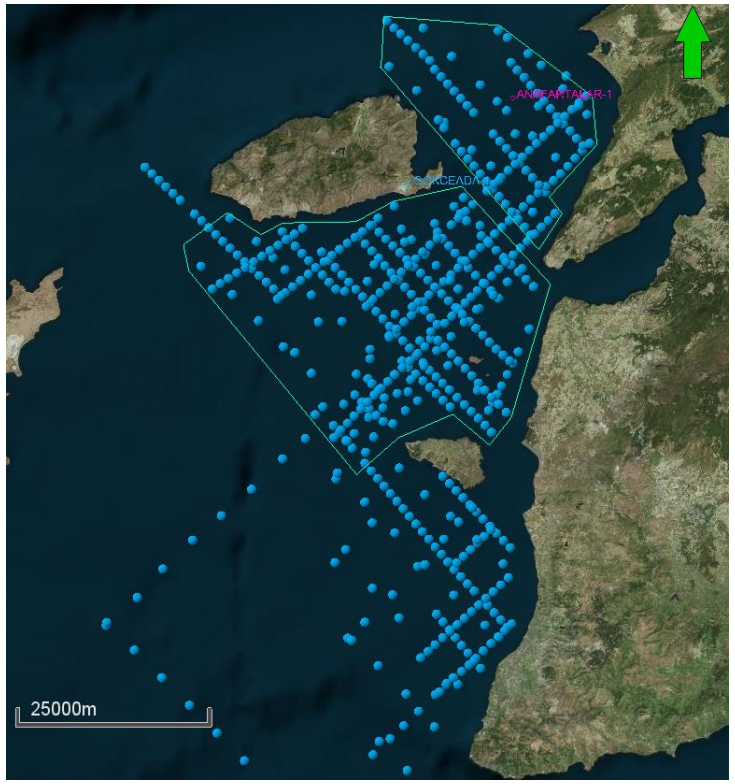
- Boundary for 3D Models
- Optimum Boundaries for fast process



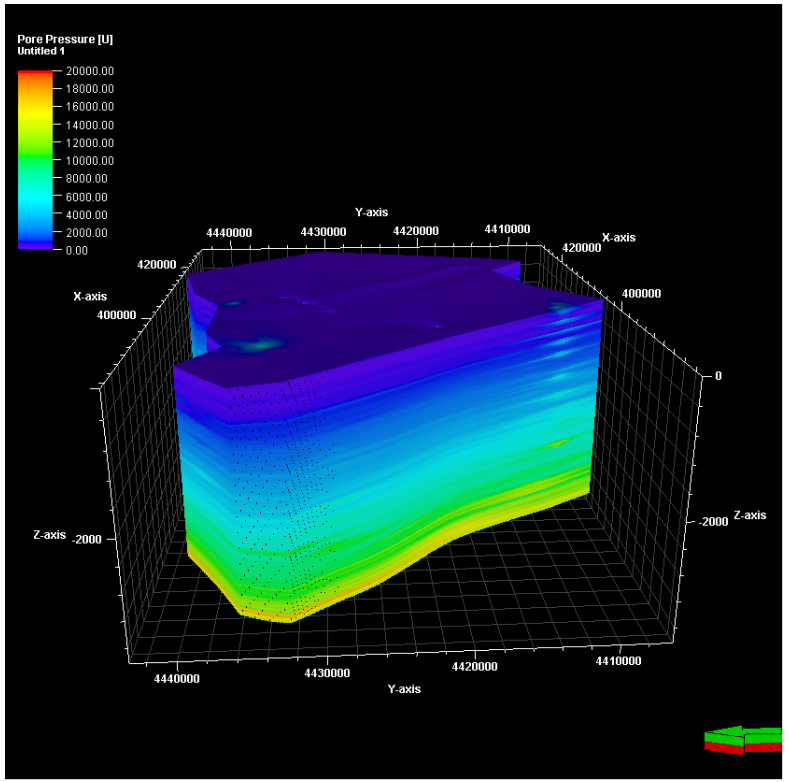
- 3D Petrophysical Cube
- Interpolation method issue (Gaussian, Krigging, Moving Average, etc.)
- Quality Check

METHODOLOGY – GOKCEADA CASE

Point Data Intensity Map View

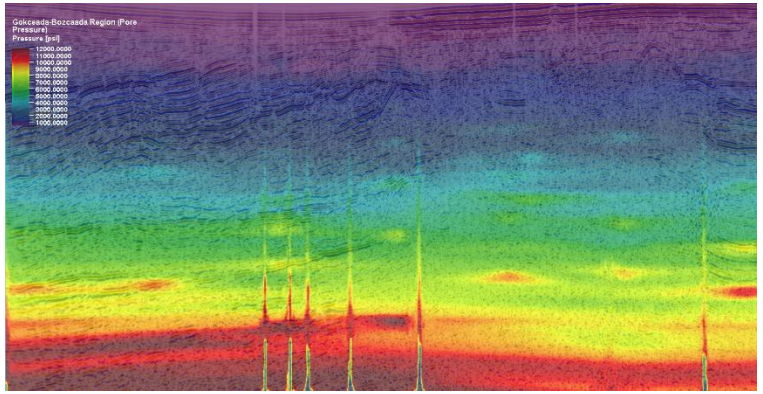


Pore Pressure Cube



- Bowers (1995) method

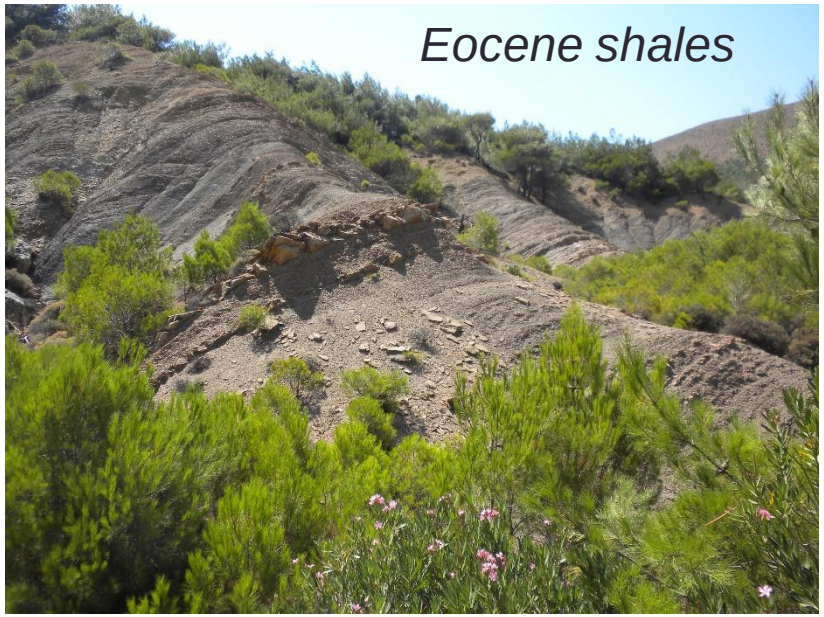
Reflected Pore Pressure Cube



- Pore pressure cube intersected with seismic section (Fig.1)
- Allows evaluation of pressure regime in a vertical & lateral sense
- Helps detection of meaningful pressure anomalies

METHODOLOGY – BASIN MODELLING

- Source Rock properties

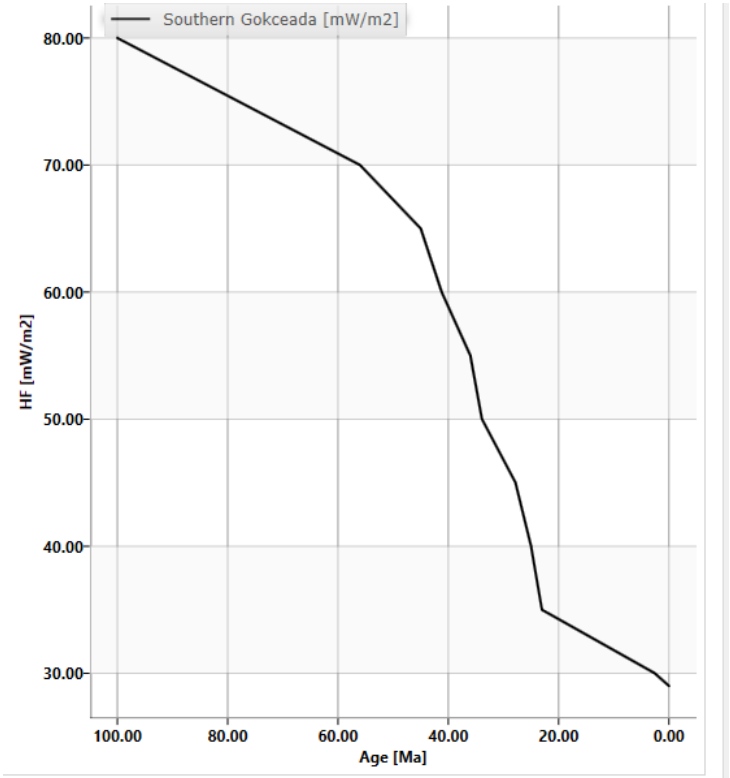


- Type III Kerogen, 13% TOC
- Pyrolysis results indicate a mature source rock profile
- T_{max} ; 440-450 ^{0}C
- Varying thickness at onshore Gokceada and Gallipoli Peninsula reaching 100-200 m.
- Depositional environment; pro-delta shales

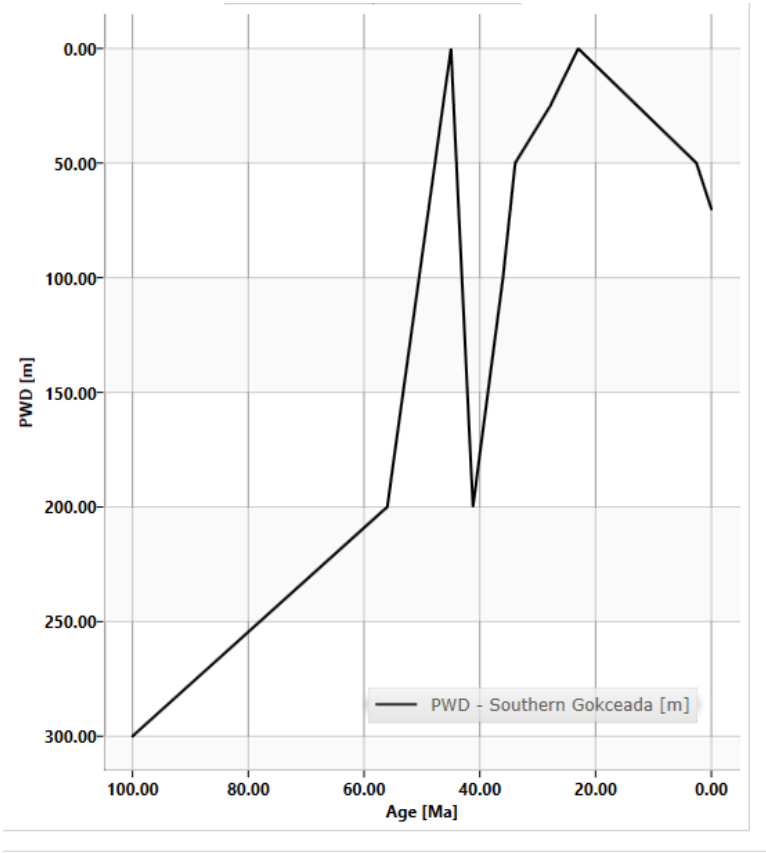
METHODOLOGY – BASIN MODELLING

- Boundary Conditions for the Thrace Basin in the Northern Aegean Sea

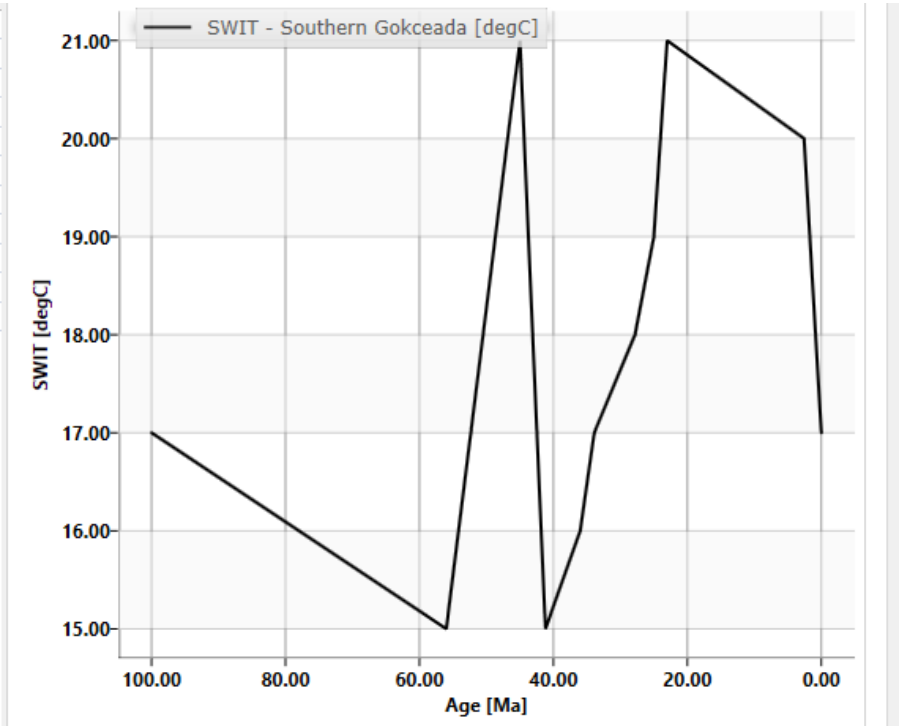
Heat Flow History



Palaeowater depths

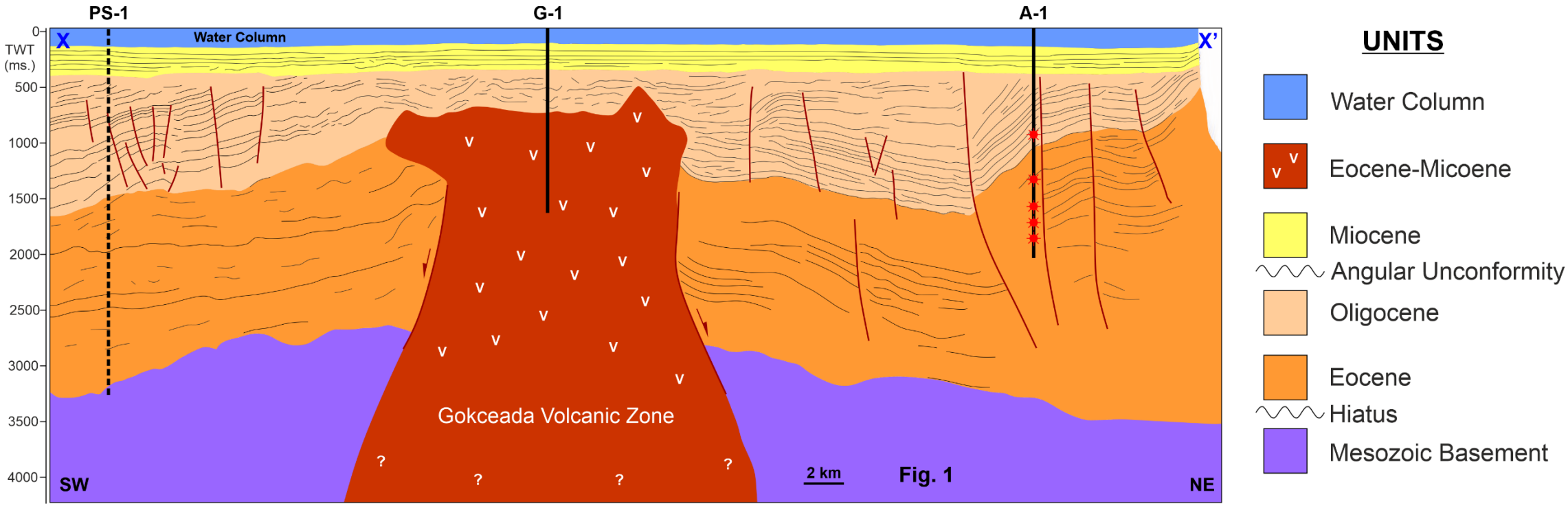


Sediment-water interface temperatures



METHODOLOGY – BASIN MODELLING

- Facies Determination for Pseudowell-1



- A pseudo-well (PS-1) has been assigned for the 1D Basin Modelling study
- Thickest point has been selected to represent the whole sedimentary succession

METHODOLOGY – BASIN MODELLING

- Facies Determination for Pseudowell-1

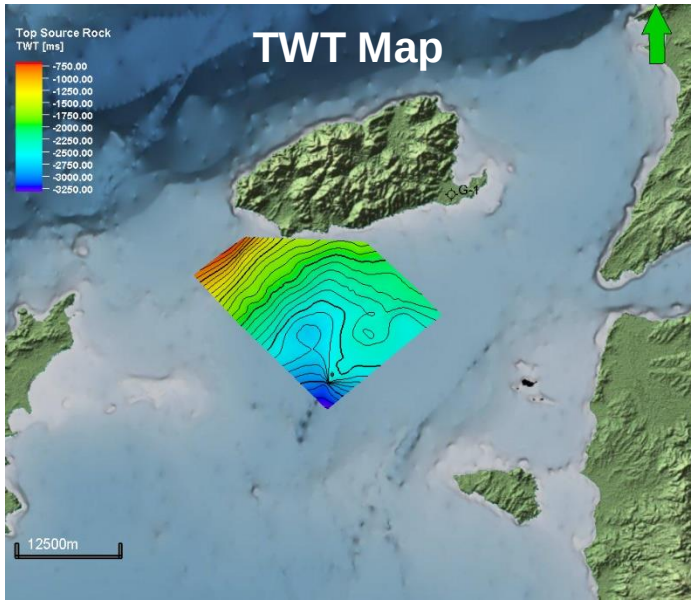
	Period	Facies	Code	Color	Lithology group	Lithology	Petroleum systems	Kinetics group	Kinetics	TOC [%]
	Quaternary Sediment	10	10		Clastic sediments	Siltstone (organic	Overburden Rock			
2	Miocene Succession	9	9		Clastic sediments	Sandstone (typica	Reservoir Rock			
3	Danismen Fm. Erode	8	8		Clastic sediments	Sandstone (typica	Reservoir Rock			
4	Danismen Fm.	7	7		Clastic sediments	Sandstone (typica	Reservoir Rock			
5	Osmancik Fm.	6	6		Clastic sediments	Sandstone (typica	Reservoir Rock			
6	Mezardere Fm.	5	5		Clastic sediments	Shale (typical)	Seal Rock			
7	Ceylan Fm.	4	4		Clastic sediments	Tuff (basaltic)	Seal Rock			
8	Sogucak Fm.	3	3		Carbonate rocks	Limestone (organ	Reservoir Rock			
9	Ficitepe Fm.	2	2		Clastic sediments	Conglomerate (ty	Overburden Rock			
10	Karaagac Fm.	1	1		Clastic sediments	Shale (organic ric	Source Rock	Kerogen-oil-gas	Burnham(1989)_	13.00
11	Basement	0	0		Metamorphic rock	Slate				

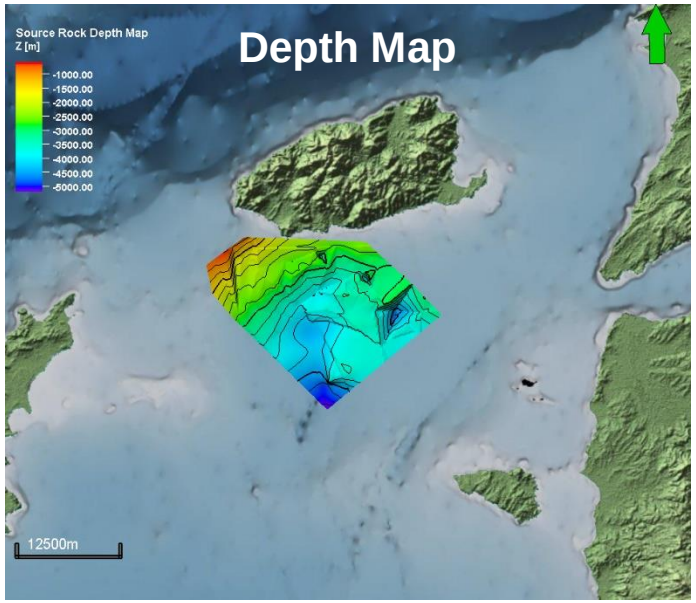
- Eocene shales; Type III Kerogen, 13% TOC

- Uplift & erosion phase causing an angular unconformity has been implemented for the Oligo-Miocene transition

METHODOLOGY – BASIN MODELLING

- Maturity Mapping





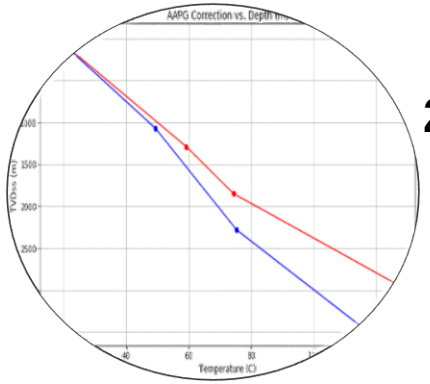
Source Rock Scenarios

Property	Good Source Rock	Poor Source Rock
Thickness (m.)	100	25
TOC (%)	13	1
Geothermal Gradient (^{0}C/km)	35	28

- TWT Map of Eocene shales has been converted into Depth map
- 2 scenarios has been generated based on the source rock potential

RESULTS & DISCUSSION MENU

Post-drill PPFG & Temperature Analysis



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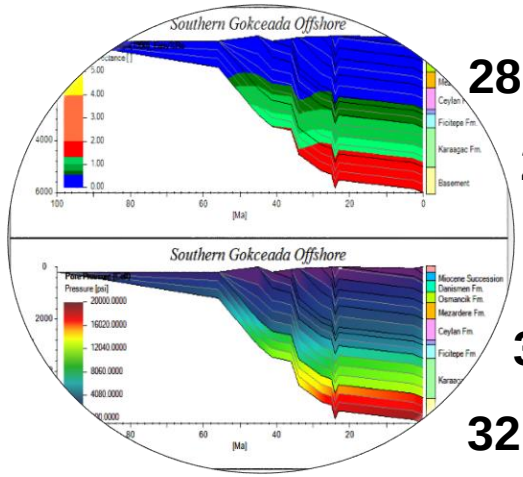
27 Wells PPFG

Basin Modelling



Slides

28 Maturity vs. Pore Pressure

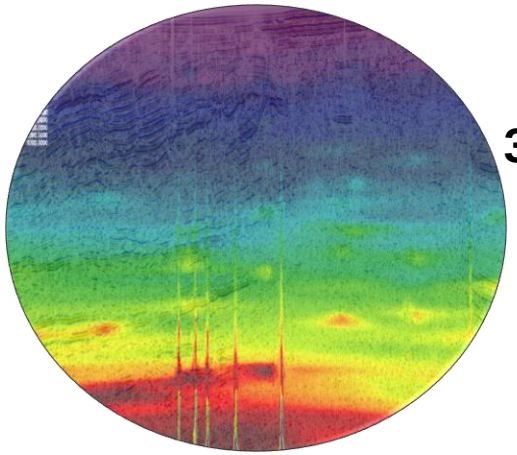
29 Temperatures & Gradients

30 Sedimentation Rates

31 Maturity Maps – Vitrinite Ref.

32 Maturity Maps & Scenarios

3D Pore Pressure Modelling

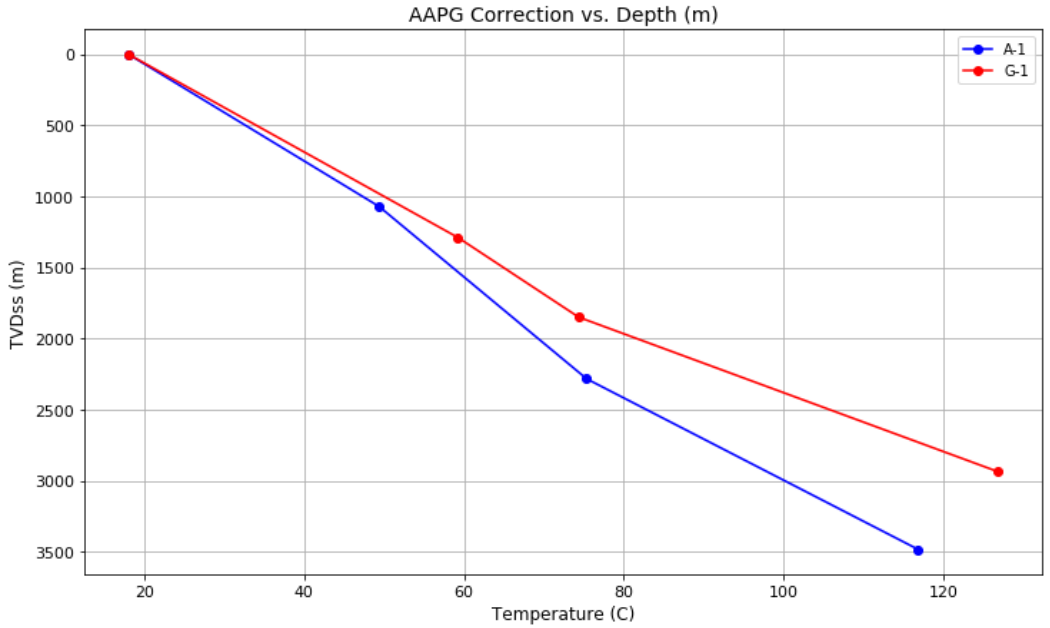


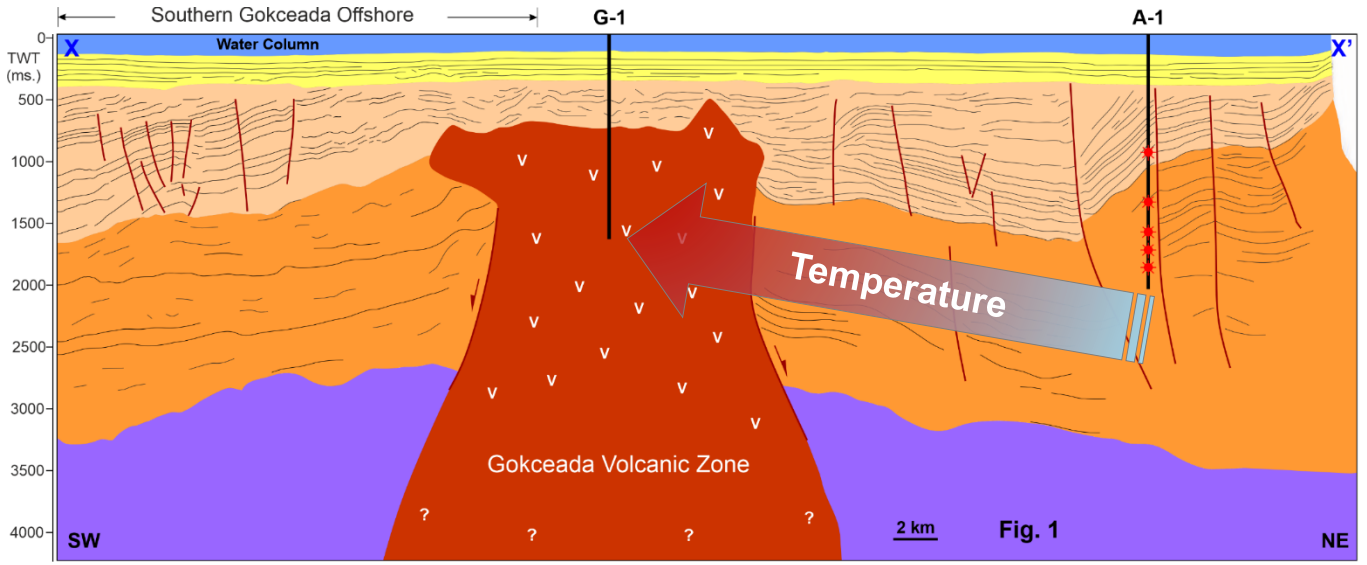
Slides

33 Pressure Regime on Seismic

34 Prospectivity - Play Cross Section

RESULTS & DISCUSSION – WELLS TEMPERATURE



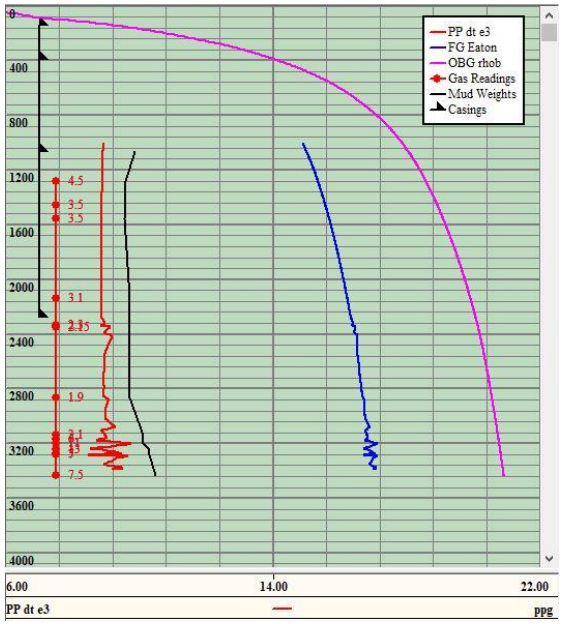


Temperature

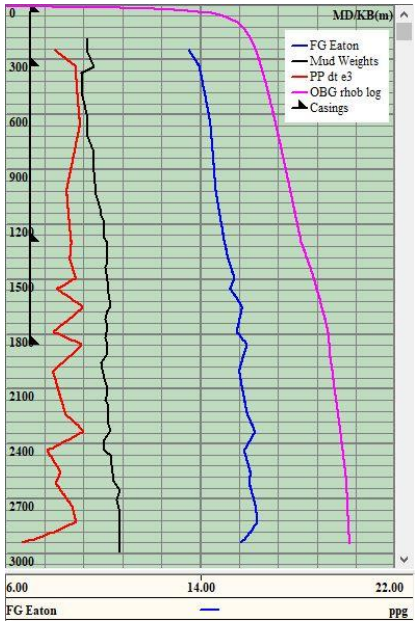
- Higher temperatures and geothermal gradients in G-1; towards Gokceada Volcanic Zone
- Similar trend is expected towards Southern Gokceada Offshore

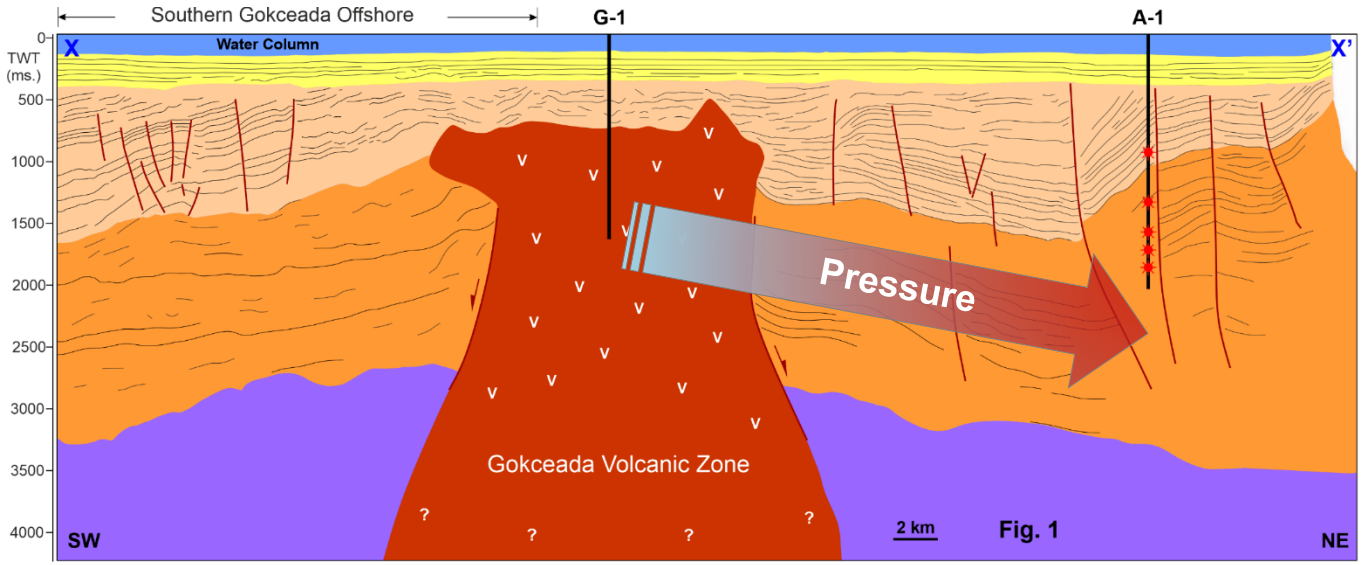
RESULTS & DISCUSSION – WELLS PORE PRESSURES

A-1



G-1

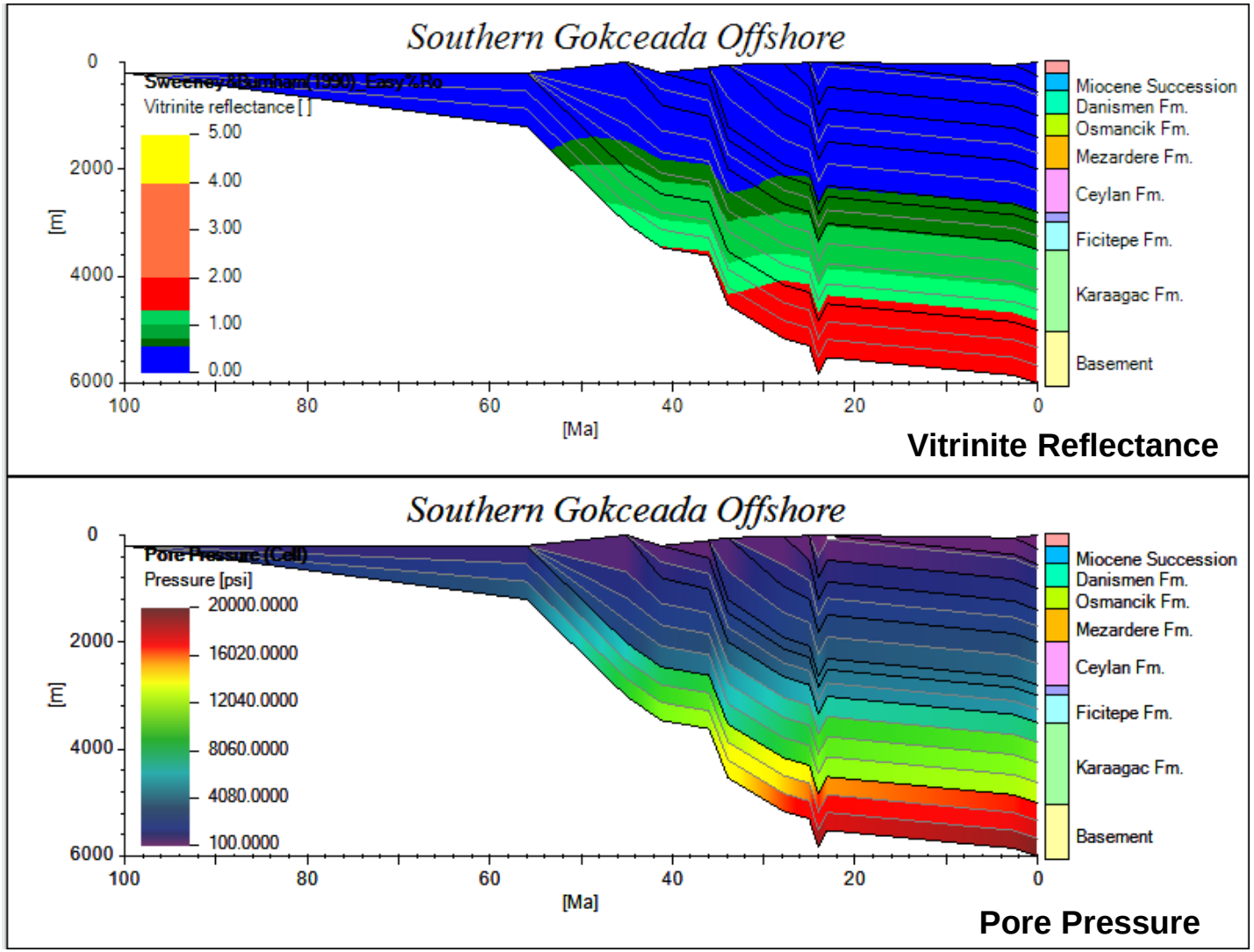




Pore Pressure

- Unlike temperatures and geothermal gradients, pressures decrease in G-1; towards Gokceada Volcanic Zone (GVZ)
- Pressure increases in A-1 coincide with the depths at where gas shows occurred
- Declining pressure values are related with GVZ products characterised by low porosity & permeability

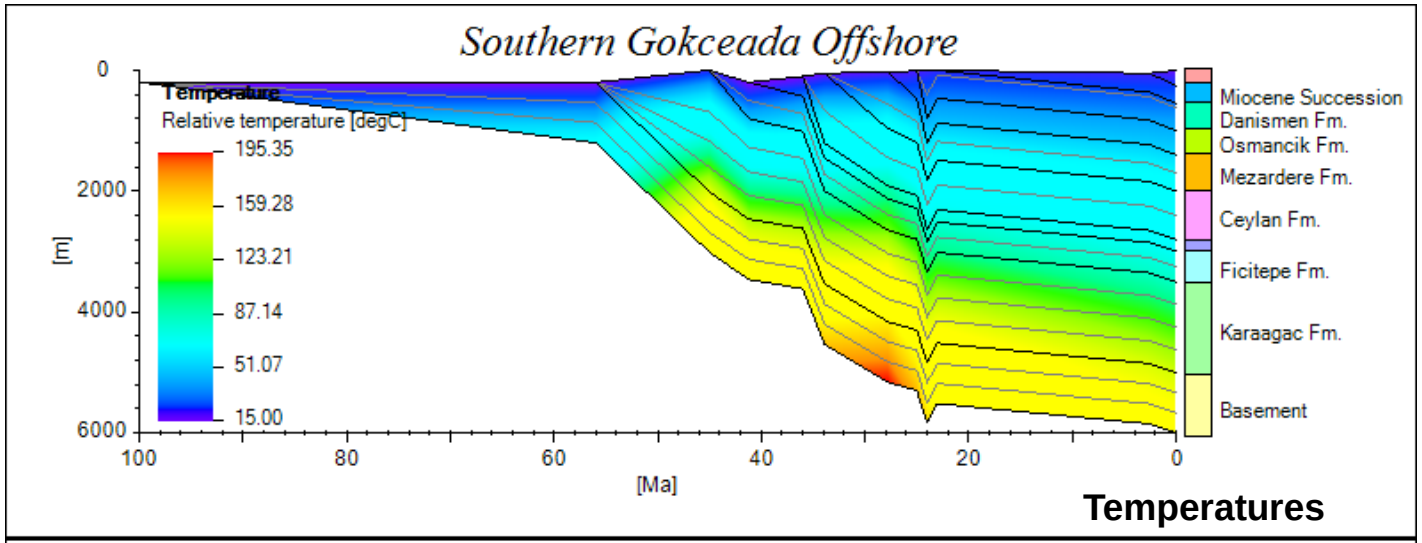
RESULTS & DISCUSSION – 1D BASIN MODELLING



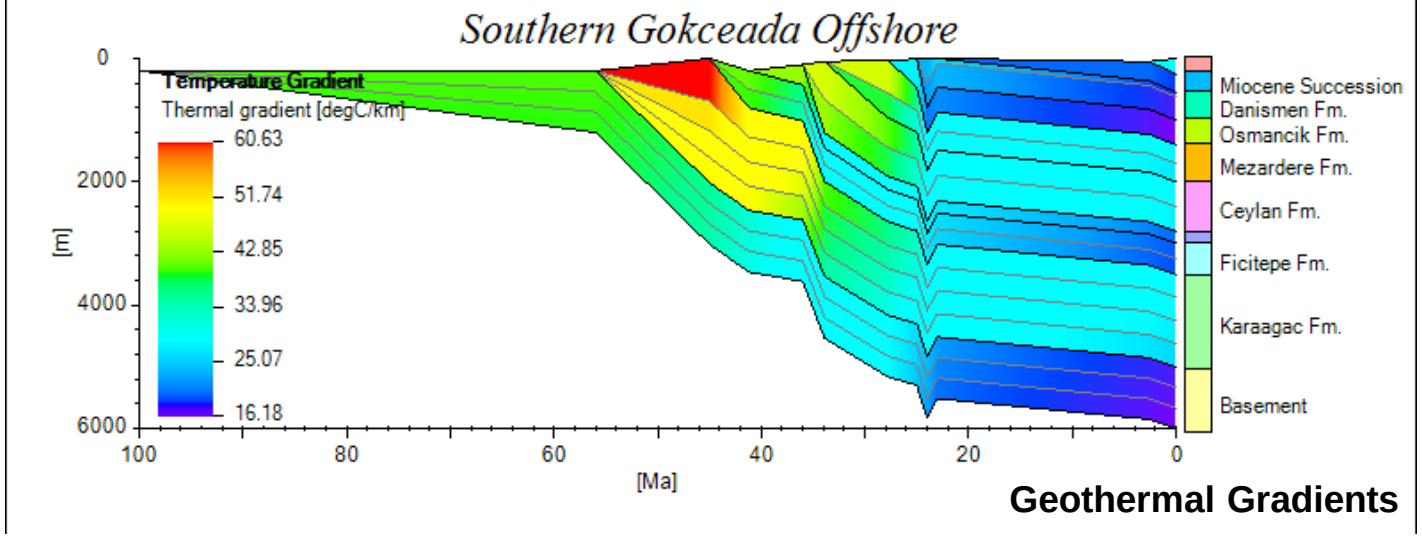
Maturity vs. Pore Pressure

- VR Burial history chart illustrates that Eocene shales of Karaagac Formation are in a mature state
- Pore pressures range between 5000-12000 psi for the Karaagac Formation
- Hydrocarbon generation might be one of the reasons for pressure development

RESULTS & DISCUSSION – 1D BASIN MODELLING



Temperatures

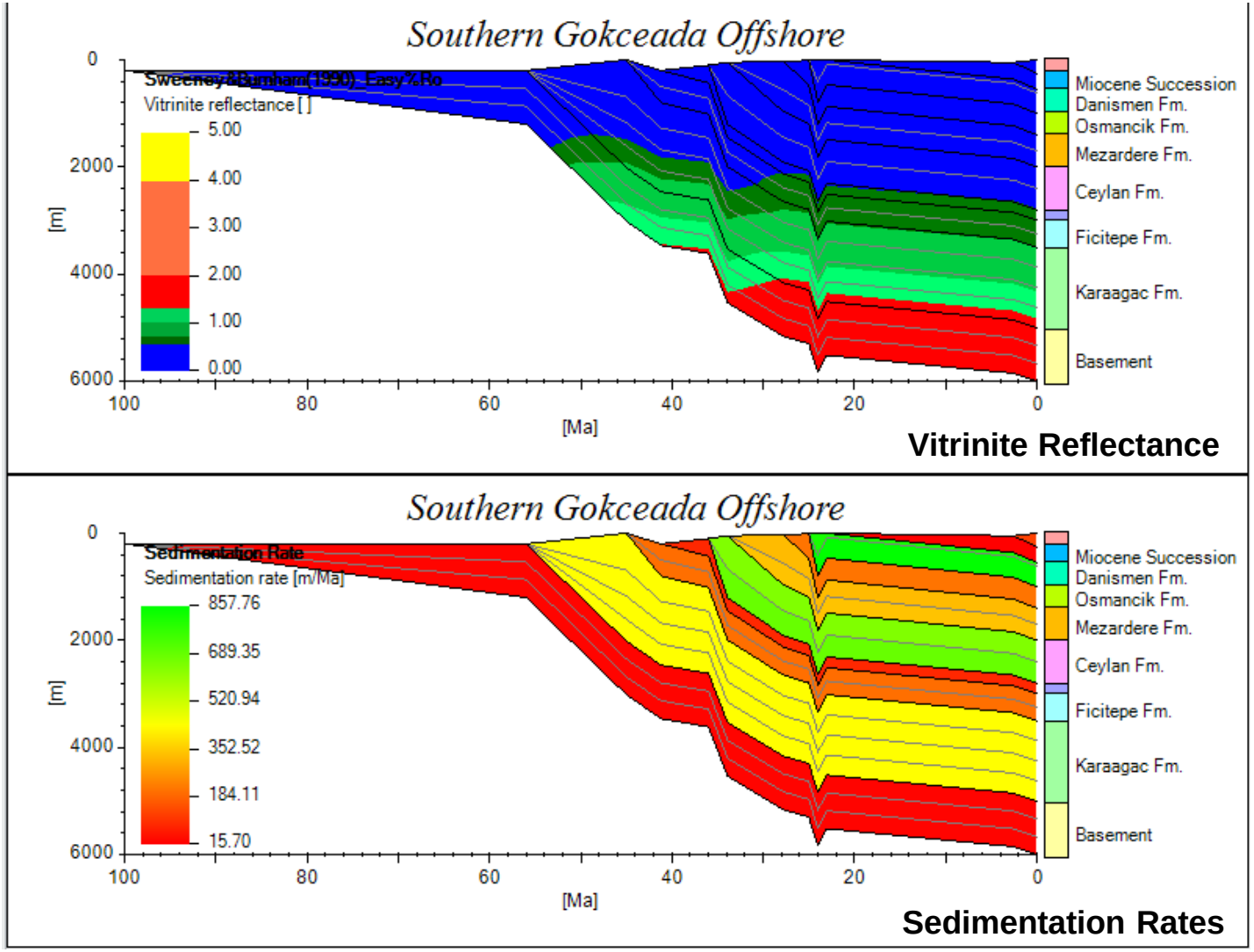


Geothermal Gradients

Temperatures & Geothermal Gradients

- Present-day temperatures are highest in the Karaagac Formation, 150-160 ^{0}C for the deepest part
- By the effect of the Gokceada Volcanic Zone, geothermal gradients reach 35-45 ^{0}C/km interval during Eocene-Oligocene
- High temperatures might have caused fast maturation as well

RESULTS & DISCUSSION – 1D BASIN MODELLING



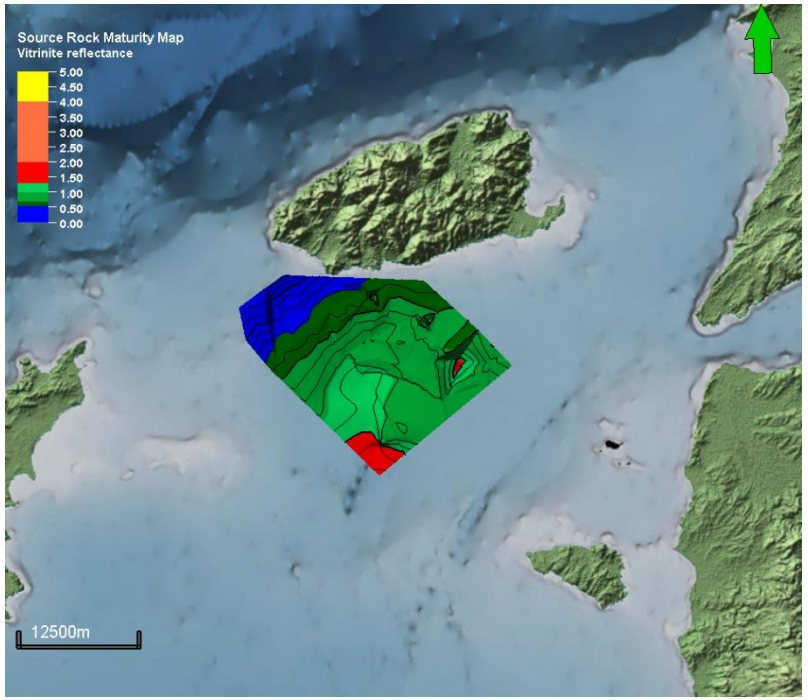
Sedimentation Rates

- High burial rates due to the extensional regime initiated at Early-Mid Eocene might be the main generator of pressure mechanism as disequilibrium compaction
- 450 m/Ma sedimentation rate for the Karaagac Formation; consistent with the thickness measured as 2-3 km.
- High burial rates also resulted with fast maturation

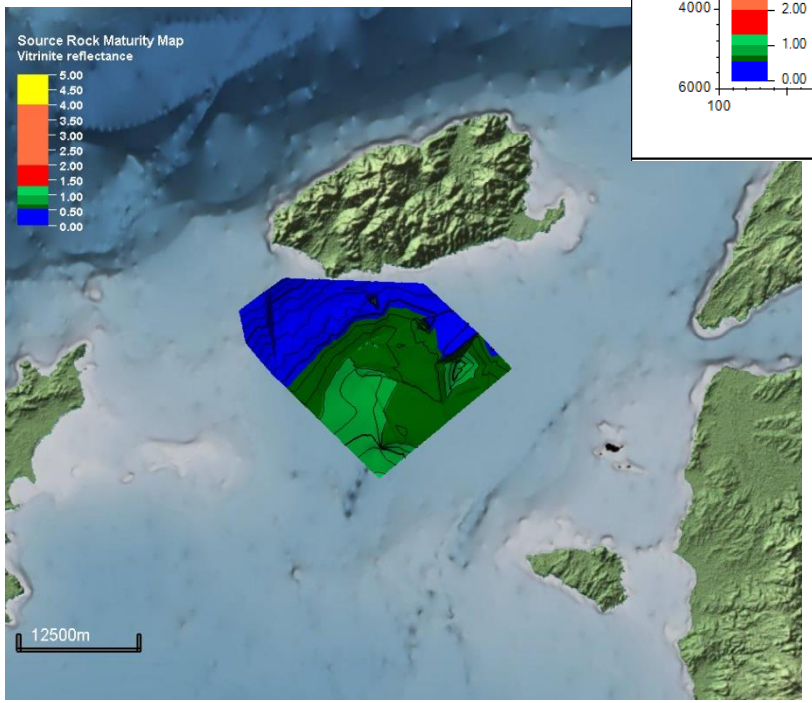
RESULTS & DISCUSSION – MATURITY MAPS

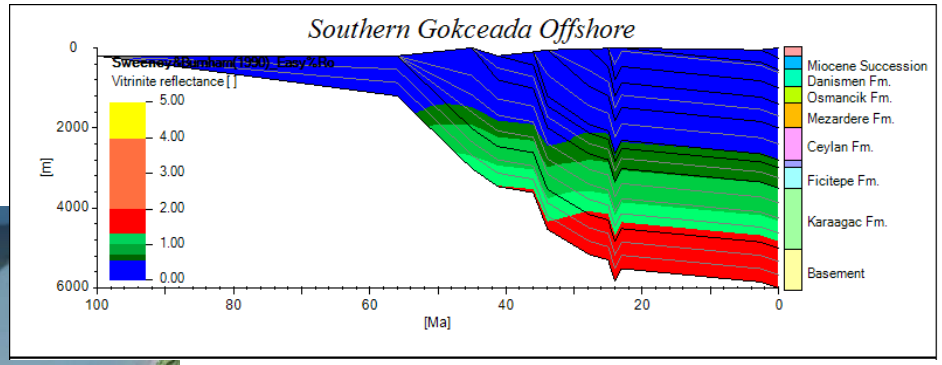
- Vitrinite reflectance maps for both source rock scenarios

Good Source Rock



Poor Source Rock



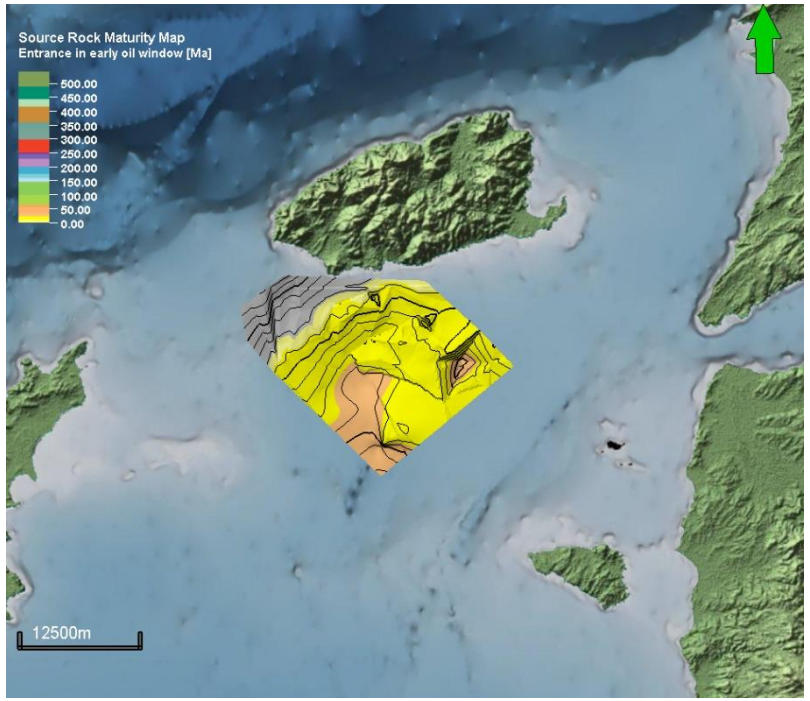


- Vitrinite reflectance maps demonstrate areas at where Eocene shales of Karaagac Fm. are mature
- Same trend can be observed when the maturity maps are compared with the 1D modelling VR chart

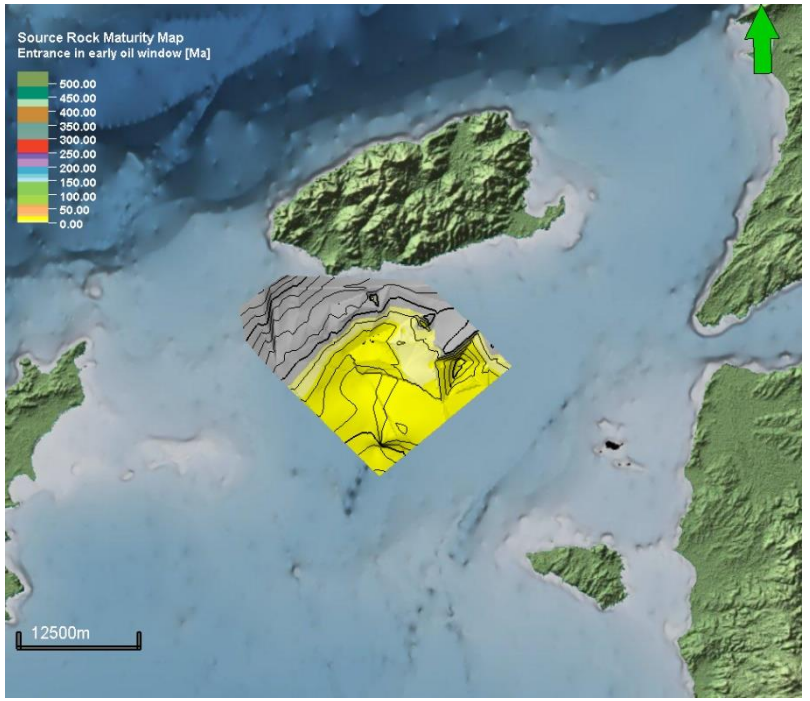
RESULTS & DISCUSSION – MATURITY MAPS

- Maturation in terms of geological ages

Good Source Rock

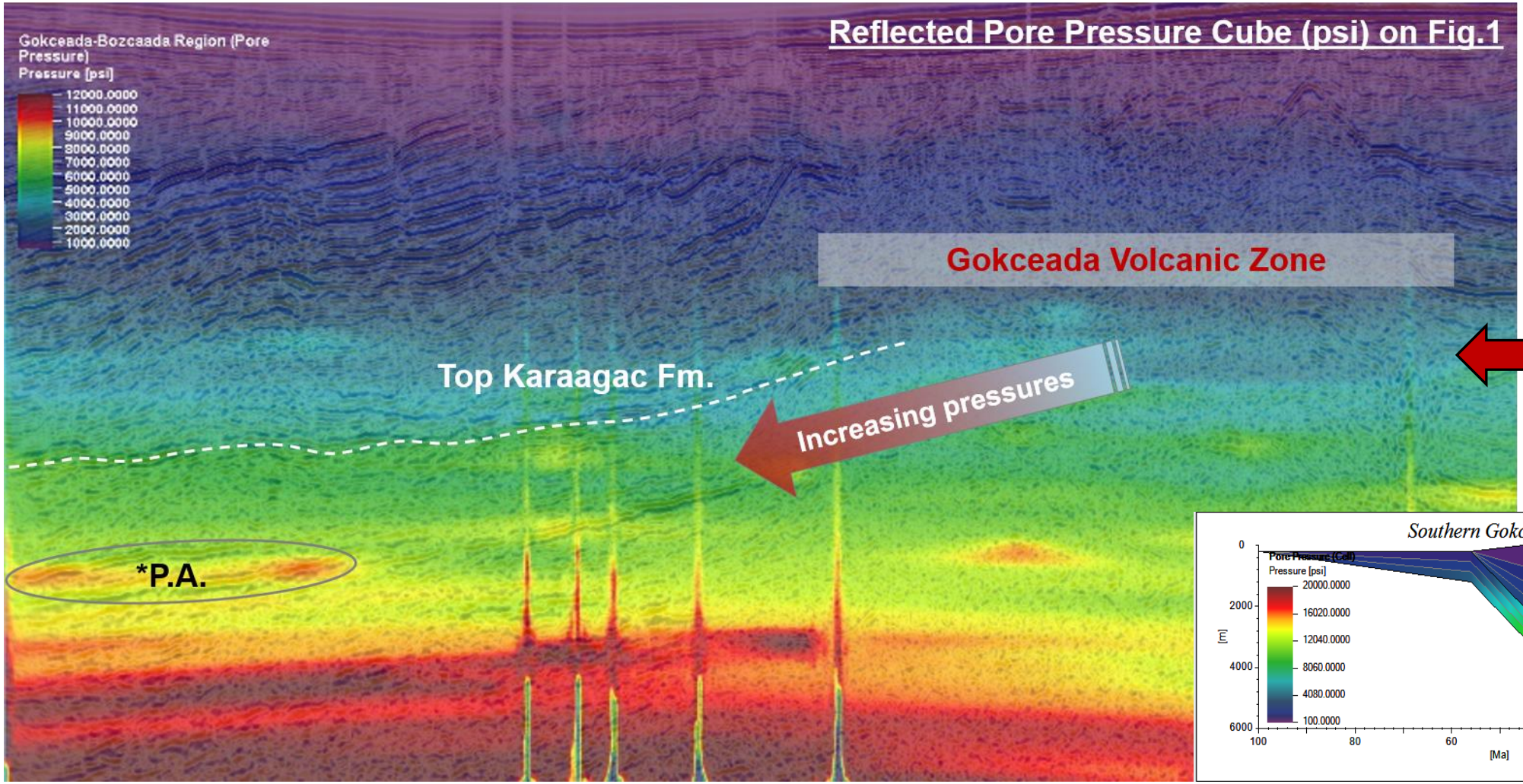


Poor Source Rock



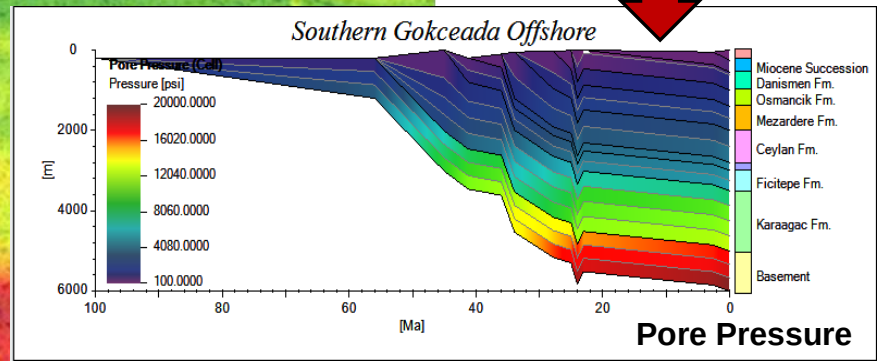
- Entrance to the early-oil window is Oligocene
- Both scenarios illustrate the presence of a potential kitchen area
- Kitchen area is restricted by Gokceada Volcanic Zone to the ESE

RESULTS & DISCUSSION – 3D PORE PRESSURE MODELING

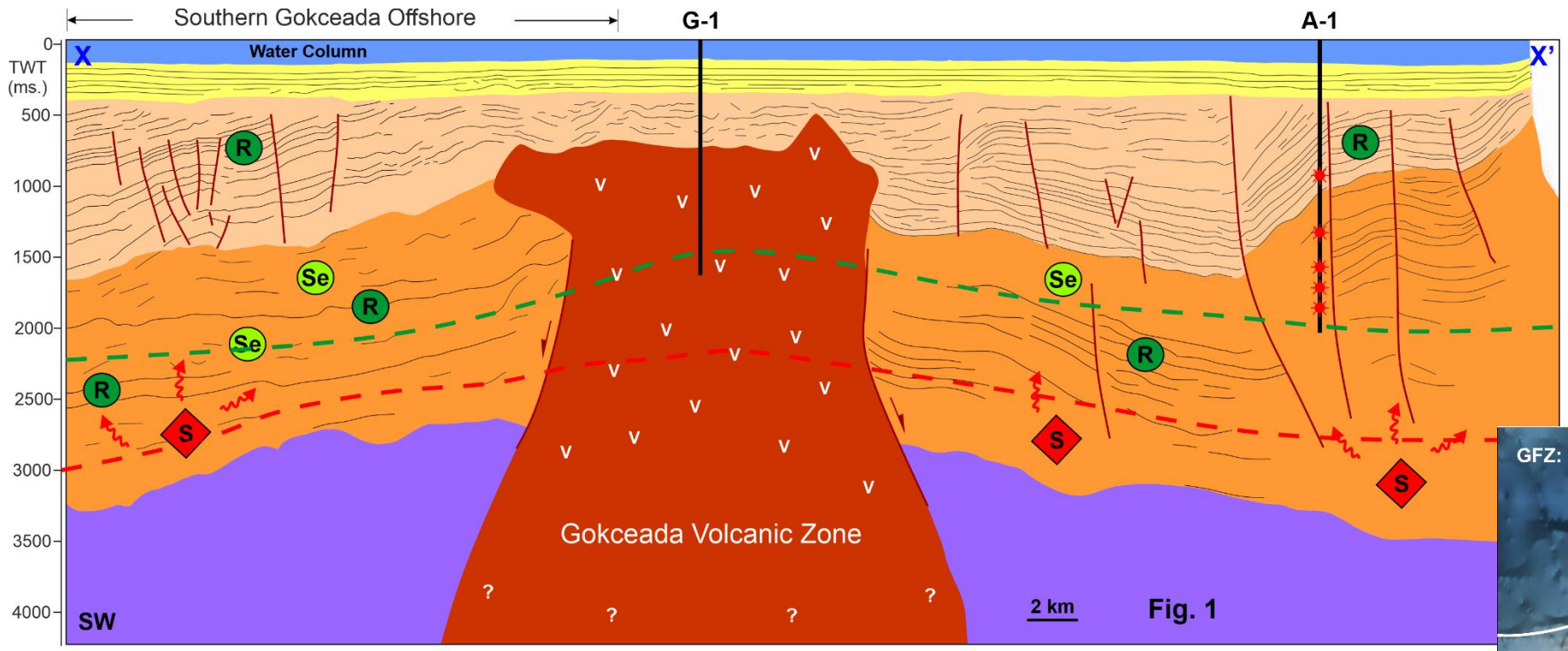


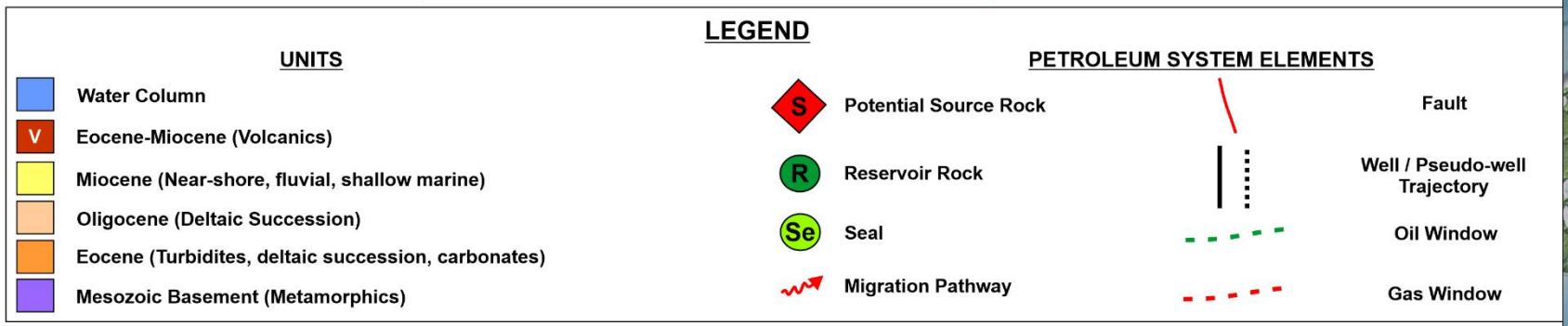
***P.A. :** Pressure Anomaly in Eocene aged turbidites

1D Basin Modelling and 3D PP modeling methods validate each other!



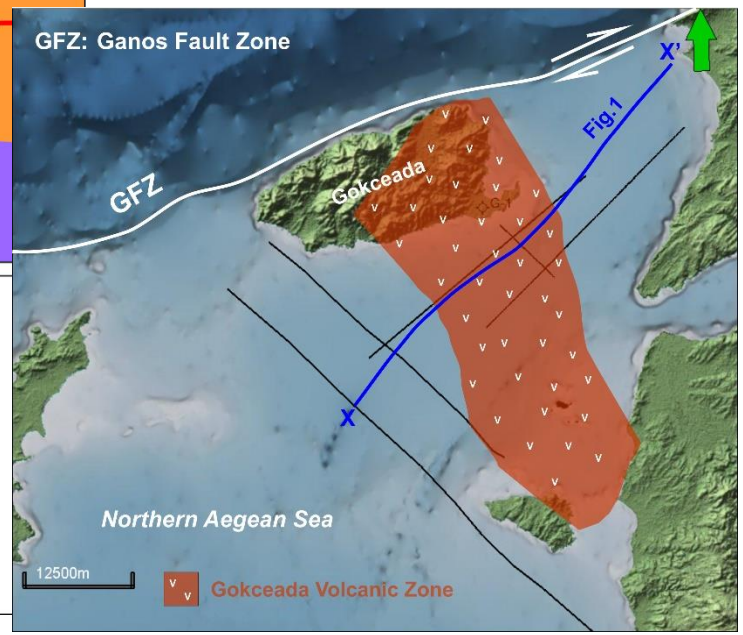
PROSPECTIVITY





Play Cross Section

Emphasises the influence of GVZ on petroleum system elements



CONCLUSIONS

1) This study introduces the discovery, presence and extent of Gokceada Volcanic Zone (GVZ) in the Northern Aegean Sea. An integrated workflow involving seismic & well log interpretation, post-drill ppfg & temperature analysis, conversion of interval velocities into a 3D pore pressure model and 1D basin modelling has been conducted for the first time.

2) Well log analysis has shown that temperatures increase towards GVZ while pressures behave as opposite.

3) Outcomes of 1D Basin modelling and 3D pore pressure models clearly indicate the effect of GVZ on the temperature & pressure conditions in the Southern Gokceada Offshore region.

4) Eventhough various methods applied in this study use different inputs, the results match and validate each other.

5) The findings of this study can act as a reliable foundation for pore pressure prediction & temperature analysis which are essential for the potential offshore exploration projects in the area.

THANK YOU