Regional Overview of
Petroleum Geology of Somalia

Prepared by RPS Energy on behalf of

SOMA OIL & GAS

For

Ministry of Petroleum & Natural Resources
Federal Republic of Somalia

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1. INTRODUCTION

Soma Oil and Gas (Soma) contracted RPS Energy (RPS) in August 2013 to carry out regional studies relating the petroleum geology and geophysics in the Federal Republic of Somalia. One objective of these studies was to provide Soma Oil and Gas with the technical background and knowledge to locate areas of the country where the company might focus its intended exploration efforts. The report also forms part of the work as contracted by Soma Oil & Gas to the Ministry of Petroleum and Natural Resources of the Federal Republic of Somalia.

As part of this work, legacy 2D seismic and well data were licensed by Soma Oil and Gas from Robertson Geospec International Ltd (part of CGG).

Data for twenty two wells and approximately 13,400 line km of legacy onshore and offshore 2D seismic data were received by RPS in the form of a SMT Kingdom Project. The onshore seismic and well data are restricted to the coastal area of Somalia –see Section 2.

Robertson Geospec also supplied well data and reports for the purchased wells.

Various geological reports and public domain data were also compiled.

This report documents :-

The Database of the legacy seismic and well data in Section 2

The Exploration History in Section 3

The Regional Geology and Stratigraphy in Section 4

The area covered by the legacy data has been divided into five Exploration Sub-areas and these are covered in Sections 5, 6, 7, 8 and 9.

Each of these sections describes the drilling results and shows representative seismic sections across each Sub-area.

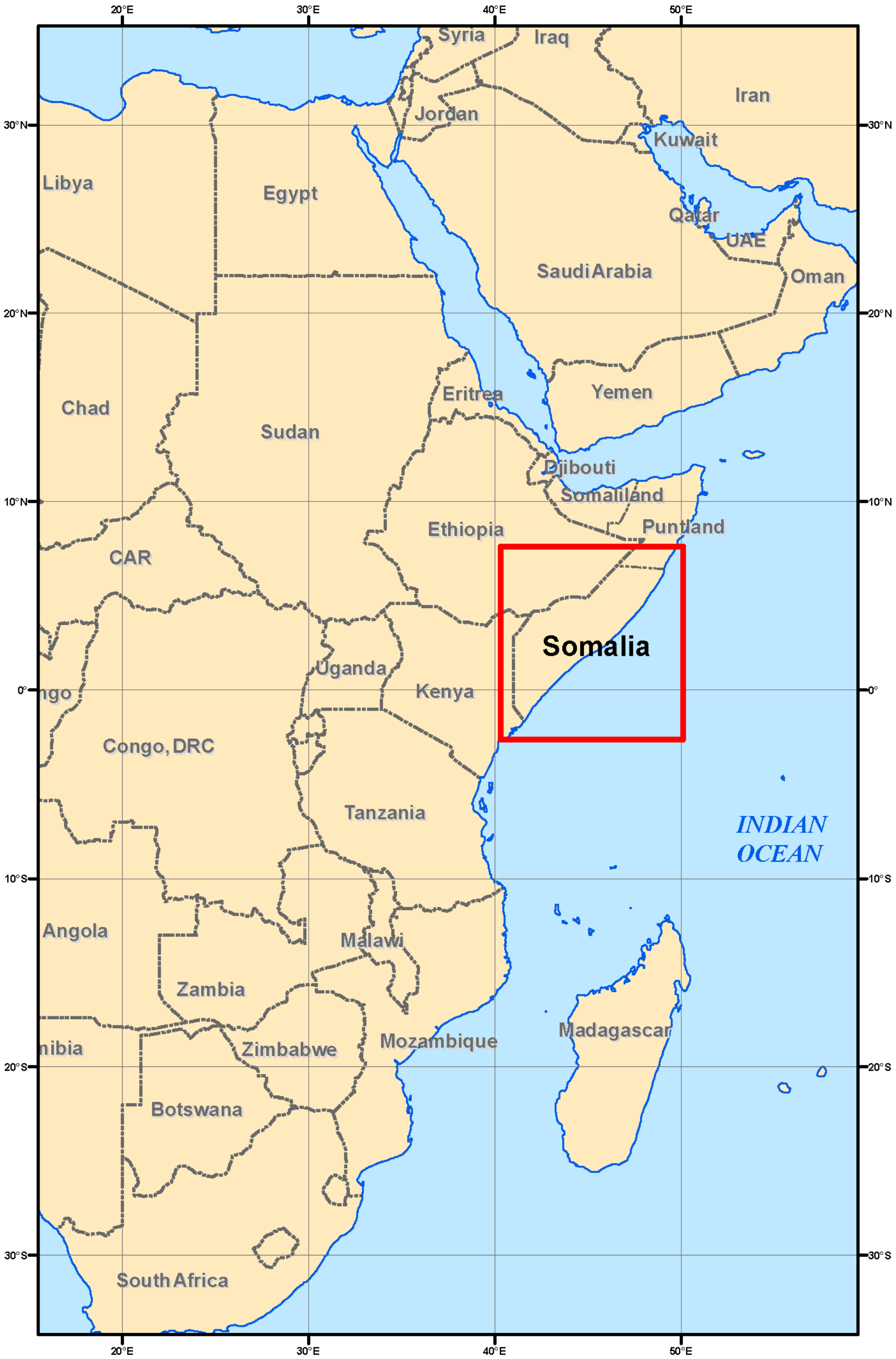


Figure 1.1: Location Map

2. DATABASE

The database described here is restricted to that data purchased by SOMA or in the public domain.

2.1 Well Data

Twenty two wells drilled between 1957 and 1990 have been drilled within the study area. Only two exploratory wells, Garad Mare-1 drilled in 1977 by AGIP and Meregh-1 drilled by EXXON in 1982 have been drilled offshore.

In addition, as part of the Deep Sea Drilling Project, three wells were drilled by the Glomar Challenger. These were DSDP-234 and DSDP-235 drilled in 1971 and DSDP-241 in drilled in 1972 (Figure 2.1).

Further descriptions of the well results are shown in Sections 3, 5, 6, 7, 8 and 9 of this report.

Well data consists of reports, LAS files and seismic and well montages which include seismic data where available.

A well summary is shown in Table 2.1 and well locations shown in Figure 2.1.

WELL	DATE	OPERATOR	STATUS	TD (m)	Formation at TD
Gira-1	1957	Sinclair	Dry	3890	Hamanlei Middle Jurassic
Obbia-1	1957	Sinclair	Dry	4884	Hamanlei Middle Jurassic
Marai Ascia-1	1958	Sinclair	Dry	4115	Hamanlei Middle Jurassic
Merca-1	1958/59	Sinclair	Dry	3998	Jessoma U Cretaceous
Duddumai-1	1959/60	Sinclair	Dry	3380	Hamanlei Middle Jurassic
Coriole-1	1960/61	Sinclair	Dry	3518	Jessoma U Cretaceous
Dobei-1	1961	Sinclair	Dry	2131	Coriole fm- Lower Tertiary
Dobei-2	1961	Sinclair	Dry	3829	Gira Fm U. Cretaceous
Brava-1	1962/63	Sinclair	Dry	3810	Adigrat-Lower Jurassic
Giamana-1	1964/65	Sinclair	Gas shows	4126	Coriole fm- Lower Tertiary
Oddo Alimo-1	1964	Sinclair	Dry	4465	Jessoma U Cretaceous
Coriole-2	1965	Sinclair	Gas shows	4069	Jessoma U Cretaceous
Afgoi-1	1965/66	Sinclair	Gas	4163	Jessoma U Cretaceous
Uarsciek-1	1967/68	Sinclair	Gas shows	4103	Jessoma U Cretaceous
Garad Mare-1	1977	AGIP	Gas shows	3921	Adigrat-Lower Jurassic
El Cabobe-1	1980	Arco	Dry	4428	Adigrat fm Lower Jurassic-Triassic
Kudha-1	1981/82	Deutsche-Texaco	Gas shows	4971	Upper Cretaceous
Meregh-1	1982	ESSO	Dry	4298	Lower-Middle Jurassic
Obbe-1	1982	Deutsche-Texaco	Dry	4865	Bari Gp Upper Jurassic
Afgoi-2	1984	MMW	Gas shows	4194	Jessoma U Cretaceous
Afgoi-3	1985	MMW	Dry	4359	Jessoma U Cretaceous
Mudun-1	1990	AMOCO	Dry	3045	Jessoma U.Cretaceous Santonian

Table 2.1: Summary of Well Data

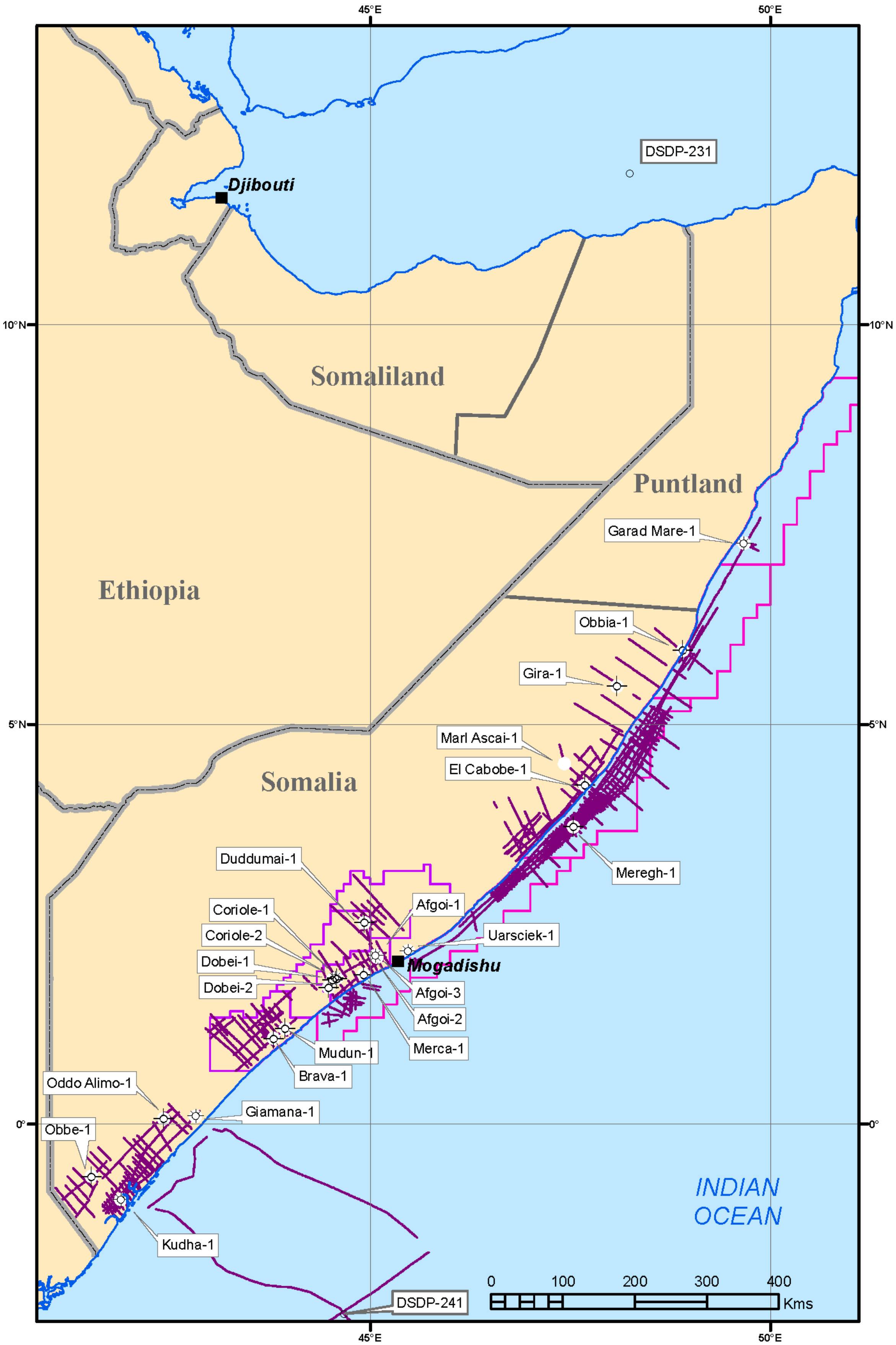


Figure 2.1: Seismic and Well Database Map

2.2 Seismic Data

The seismic line km described here are restricted to those data that is available. The locations of the seismic data are shown in Figure 2.1.

Nine 2D seismic surveys have been acquired onshore by various operators between 1970 and 1988 with a combined total of 4270 line km. Summaries of the acquisition and processing parameters are shown in Table 2.2 and Table 2.3.

SURVEY	DATE	COMPANY	Acq.Contractor	Crew	Source	Instrument	SP Int	Geo Int	Channels	Spread	Fold
1970	1970	Group of German Oil Companies	Prakla-Seismis	Keppner	Dynamite	DFS III	150m	75m	24	0-75-1800m	600%
600	1973	Texaco	Mandrel (Petty-Ray)	6325	Geograph	Summit VII	125m	125m	48	3125-250-0-250-3125m	1200%
700	1974	Texaco	Petty-Ray	6310	Geograph	Summit VII	125m	125m	24	0-250-3125m	1200%
800	1975	Texaco	Petty-Ray	6310	Geograph	Summit 32	250m	125m	24	0-250-3125m	1200%
S-80	1980	Arco	Geosource(Petty-Ray)	6325	Geograph	MDS-8	100m	100m	48	2600-300-0-300-2600m	2400%
G-81	1981	Arco	Geosource(Petty-Ray)	6325	Geograph	MDS-8	100m	100m	48	3800-300-0-300-1400m and 0-300-5000m	2400%
80/81	1980/81	Deutsche-Texaco	Petty-Ray	6801	Vibroseis	DFS IV	100m	50m	48	0-275-2625m	1200%
Agfoi	1983	MMWR	Petty-Ray	6808	Vibroseis	MDS-10V	100m	50m	96	2600-250-0-250-2600m	2400%
VUY	1988	Amoco	Western Geophysical	758	Vibroseis	Sercel 368	25m	25m	240	2987.5-12.5-0-12.5-2987.5m	12000%

Table 2.2: Onshore Seismic Data - Acquisition Parameters

SURVEY	Proc. Contractor	Date	Processing	Data Quality	Area	Total km
1970	Prakla-Seismis	1971	Stack	Poor/Fair	El Cabobe	660
600	Mandrel(Petty-Ray)	1973	Stack	Poor/Fair	Juba	383
700	Petty-Ray	1974	Stack	Poor/Fair	Juba	531
800	Petty-Ray	1975	Stack	Poor/Fair	Obbia	404
S-80	Geosource(Petty-Ray)	1980	Stack	Fair	El Cabobe	217
G-81	Geosource(Petty-Ray)	1981	Stack	Fair	El Cabobe	388
80/81	Petty-Ray	1981	Stack	Fair/Poor	Juba	1041
Agfoi	Petty-Ray	1983	Migrated Stack	Fair	Agfoi-Coriole	670
VUY	SSC	1988	Migrated Stack	Fair/Good	Blocks 6,9 & 12	1687

Table 2.3: Onshore Seismic Data - Processing Parameters

Eight 2D offshore seismic surveys have been acquired by various operators between 1969 and 1989 with a combined total of 7416 line km. Summaries of the acquisition and processing parameters are shown in Table 2.4 and Table 2.5. A further 2D seismic survey acquired in 1980 by Geco of approximately 3888 km is not currently available for license so is not included in this report.

SURVEY	DATE	COMPANY	Acq.Contractor	Crew	Source	Instrument	SP Int	Geo Int	No of Groups	Spread	Fold
Ergol 69	1969	Deutsche Ergol	CGG	MV Wumme	Flexotir	Sercel SN328	200m	100m	24	2400m	1200%
Conoco 74	1974	Conoco	CGG	MV Lady Christine	Vaporchoc	Sercel SN328	100m	100m	24	2400m	2400%
Conoco 75	1975	Conoco	GSI	2904	Airgun	DFS III	328 ft	154 ft	48	0-1050-8758 ft	2400%
SOM-80	1980	Arco	Geco	MV Longva II	Airgun	DFS V	25m	50m	48	2400m	4800%
Reprocessed	1980	Lamon-Doherty Earth Observatory	CGG	N/A	Airgun	N/A	50m	100m	12	1200	1200%
SO2A74	1982	Exxon	GSI	2996-RC Dunlap	Airgun	DFS V	82 ft	82 ft	96	8656 ft	4800%
85-SOA-20	1985	Elf Aquitaine	Prakla	SV Explorer	Airgun	DFS V	25m	25m	120	2400m	4800%
89-105	1989	Pecten	Western	MV Western Ocean	Airgun	LRS 16	26.67m	13.33m	300	4000m	7500%
Not in dataset											
1980	1979/80	MMWR	Geco	Geco Alpha	Airgun	DFS V	25m	50m	48	2400m	2 x 2400%

Table 2.4: Offshore Seismic Data - Acquisition Parameters

SURVEY	Proc. Contractor	Date	Processing	Data Quality	Area	Total km
Ergol 69	CGG	1969	Stack	Fair/Poor	EL Cabobe	351
Conoco 74	CGG	1974	Stack	Fair/Poor	Garad Mare & Obbia	218
Conoco 75	GSI	1975	Stack	Fair/Good	Garad Mare & Obbia	121
SOM-80	Geco UK	1980	Migration	Fair/Good	Obbia & El Cabobe	1143
Reprocessed	CGG	2004	Migration	Fair/Good	DSDP 341	1349
SO2A74	GSI	1982	Stack	Fair/Good	EL Cabobe	2411
85-SOA-20	Prakla	1985	Migration	Fair/Good	Block 13	496
89-105	CGG Houston	1990	Migration	Good	Blocks M1 to M5	1327
						7416
Not in dataset						
1980	Geco	1980	Stack	Fair/Good	Mogadishu Area 1	3888

Table 2.5: Offshore Seismic Data - Processing Parameters

3. EXPLORATION HISTORY

This report only documents those activities relevant to the study area for which data is available. Seismic survey lengths refer to available seismic contained within the data package licensed by Soma and supplied by Robertson's, not actual seismic data acquired as some of the data is not currently available.

Modern exploration of Somalia began in 1952 and effectively ended in 1990. Historic exploration activity has been sporadic and largely inconclusive. Fourteen wells were drilled between 1957 and 1967 and only eight wells have been drilled since 1977, the last one in 1990. Only two wells have been drilled offshore. Seismic reflection and refraction data acquired prior to 1969 are no longer available and seismic data acquired onshore since 1969 tends to be poor quality. All of the licensed blocks in the study area were placed under force majeure in 1990 due to the civil war.

3.1 Pre 1969

Sinclair – Somal (later known as Arco) was operator for a consortium of companies that included Marathon, Conoco and Amerada. Sinclair and the consortium held a large concession along the Somali coast between 1952 and 1966. From 1966 to 1968 Sinclair operated as sole licensee (Figure 3.1).

Data acquired were:

- geological field mapping (120 party months)
- Aeromagnetic Surveys (13,000 sq km)
- Ground Magnetometer/Gravity (81000 sq km)
- Refraction/Reflection Seismic surveys (254 party months-refraction surveys had ceased by 1959)
- 18 deep wildcat wells (total depth drilled 66,682m/218,774 ft)

Total expenditure by the Operators was approximately $46,000,000.

14 wells were drilled in this area between 1957 and 1967. Well locations were based on seismic data which are no longer available. Wells were deep (down to 4400m) and tested Tertiary, Cretaceous and Jurassic play concepts. Most of the wells were dry, although Afgoi-1 drilled in 1965/66 was completed as a non-commercial gas discovery in the Upper Cretaceous Jessoma Formation. Minor gas shows were recorded mainly in the same formation at Giamana-1 (1964), Coriole-2 (1965) and Uarschiek-1 (1967) see Table 2.1.

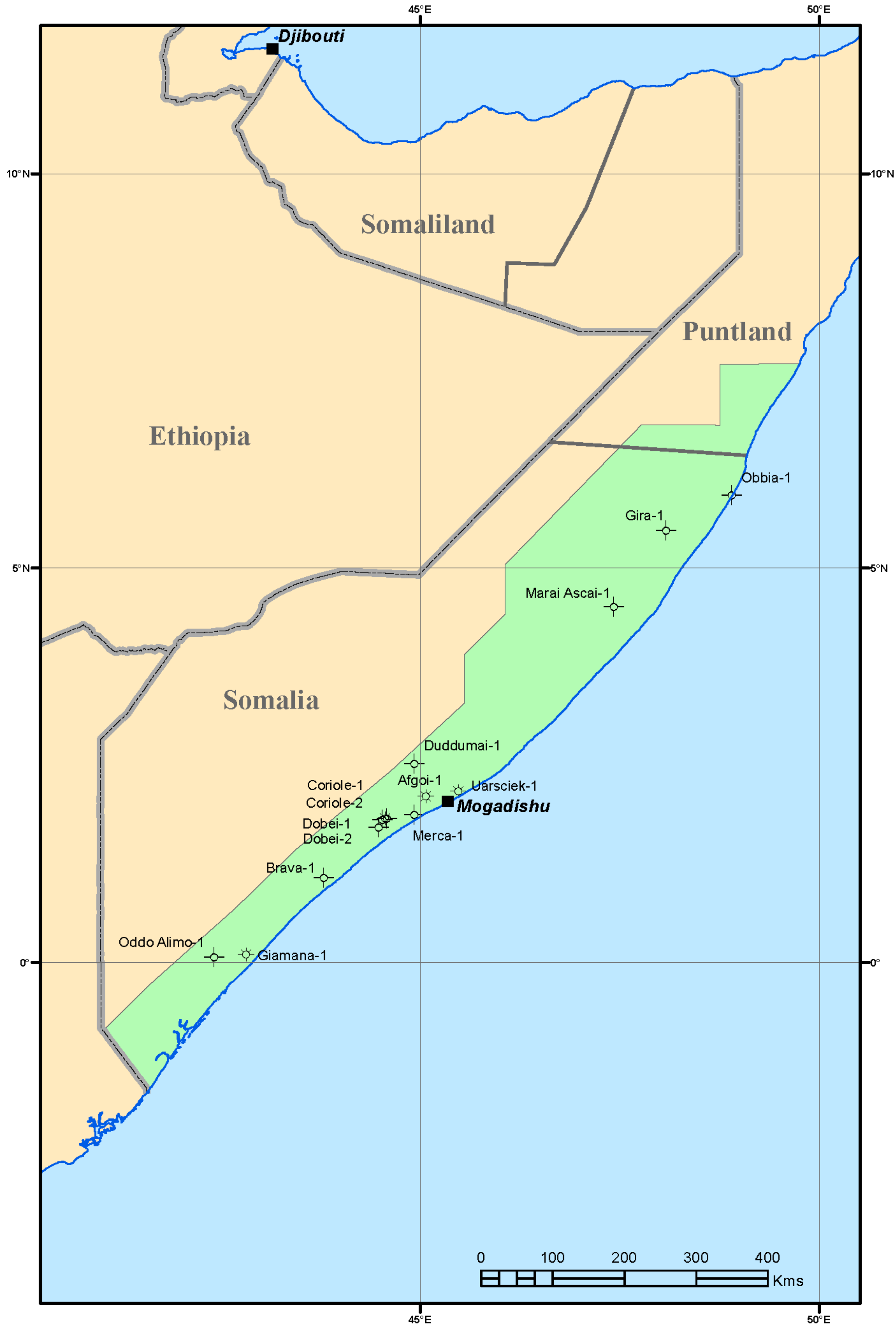


Figure 3.1: Sinclair Wells (1957-1967)

Gira-1 (Figure 3.2) was drilled onshore between June 1956 and January 1957 to a total depth of 3,890m (12,764 ft). The target was a large NE trending anticlinal structure (60km long 15-30km wide) with a vertical closure of 100m identified from seismic refraction data. The formation reached at TD was the Middle Jurassic Hamanlei Formation.

No hydrocarbon shows were evident although some oil staining was seen in a core from the Lower Cretaceous. Two DSTs were run in the Lower Cretaceous Adale Formation. The first produced salt water and the second was abandoned due to technical difficulties. Some fluorescence was observed in the Hamanlei.

The well was plugged and abandoned as a dry hole. Although no seismic data is available from this era, Line 807, acquired later by Texaco in 1975, is located within 2 km of the Gira-1 well location.

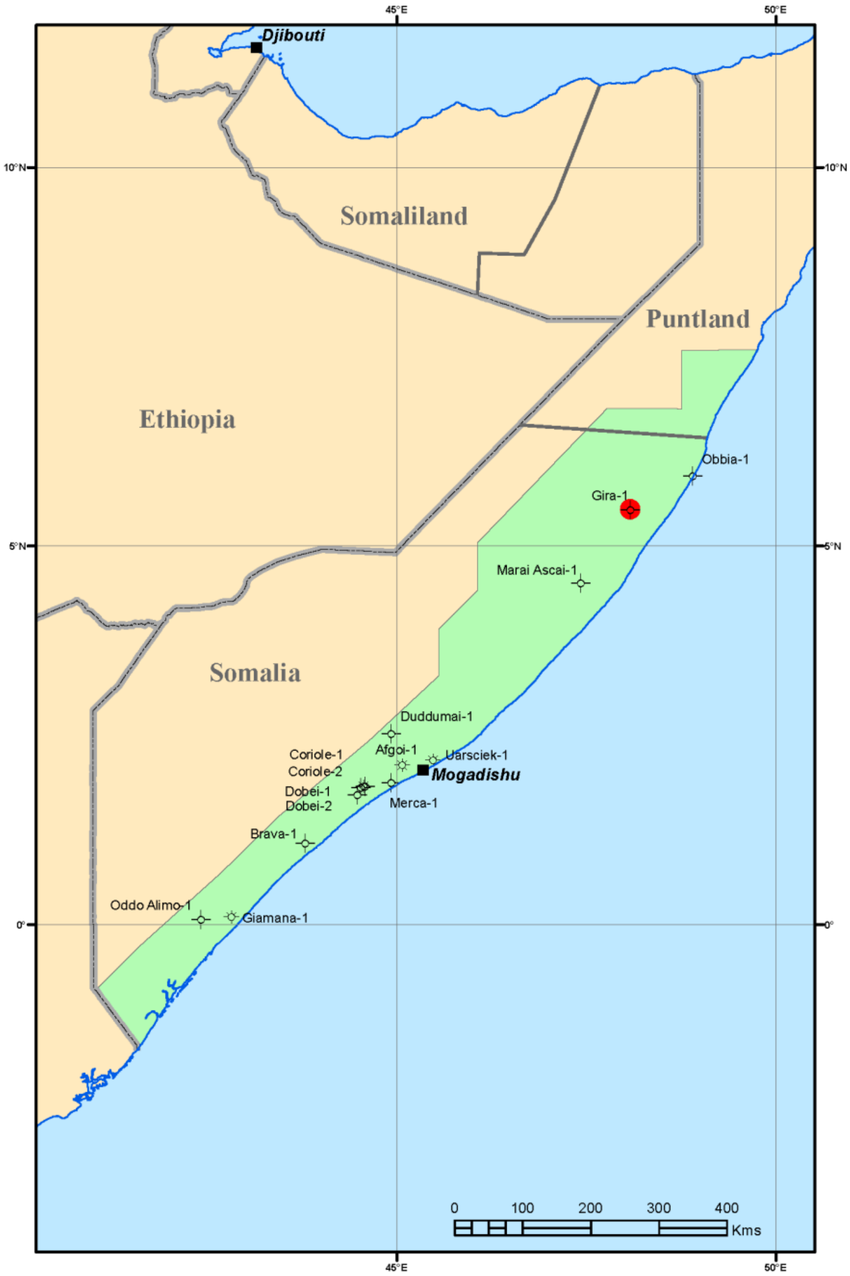


Figure 3.2: Gira-1 (1957)

Obbia-1 (Figure 3.3) was drilled onshore between March and November 1957 to a total depth of 4,884m (16,023 ft). The target was a large NE trending anticline approximately

30km long by 5 km wide with several hundred metres of vertical closure identified from seismic refraction data. At TD the well reached the Middle Jurassic Hamanlei Formation.

There were two DSTs performed at Obbia-1. The first DST recovered salt water in the Tertiary Scusciuban Formation. The second DST recovered salt water from the Upper Cretaceous Belet Uen Formation. No hydrocarbons were recovered. Minor fluorescence was observed from cores cut in the Belet Uen and Lower Cretaceous Cotton Formations.

The well was dry and consequently plugged and abandoned. Although no seismic data is available from this era, the south eastern end of Line 801, acquired later by Texaco in 1975, is located within 4 km from the Obbia-1 well location.

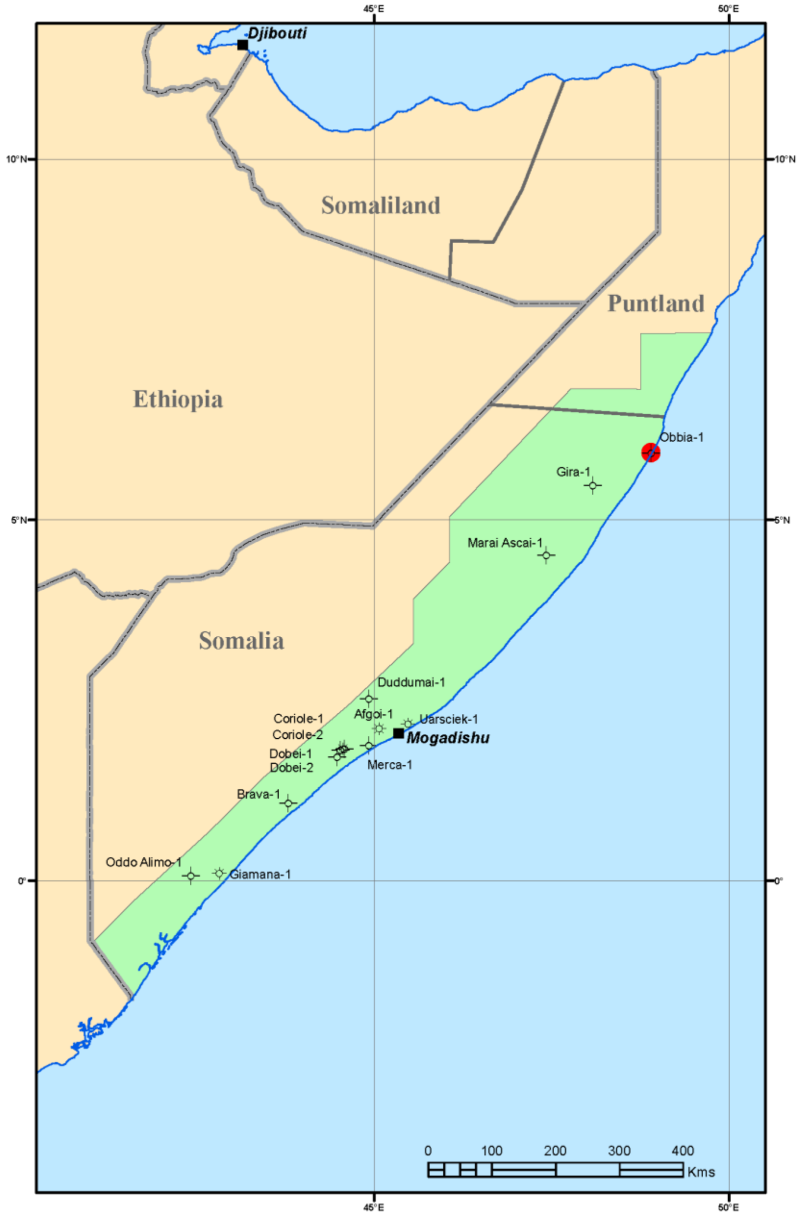


Figure 3.3: Obbia-1 (1957)

Marai Ascia-1 (Figure 3.4) was drilled onshore between January and September 1958 to a total depth of 4,115m (13,500 ft). The target was a large NE trending anticline approximately 150 km long and up to 80 km wide with 600m of vertical closure defined by seismic refraction data. At TD the well reached the Middle Jurassic Hamanlei Formation.

No formation tests were run and the cores cut showed no hydrocarbon indications. The well was plugged and abandoned as dry. Although no seismic data is available from this era, Line S-80-G103-P2, acquired later by Arco in 1980, traverses the Marai Ascai-1 well location.

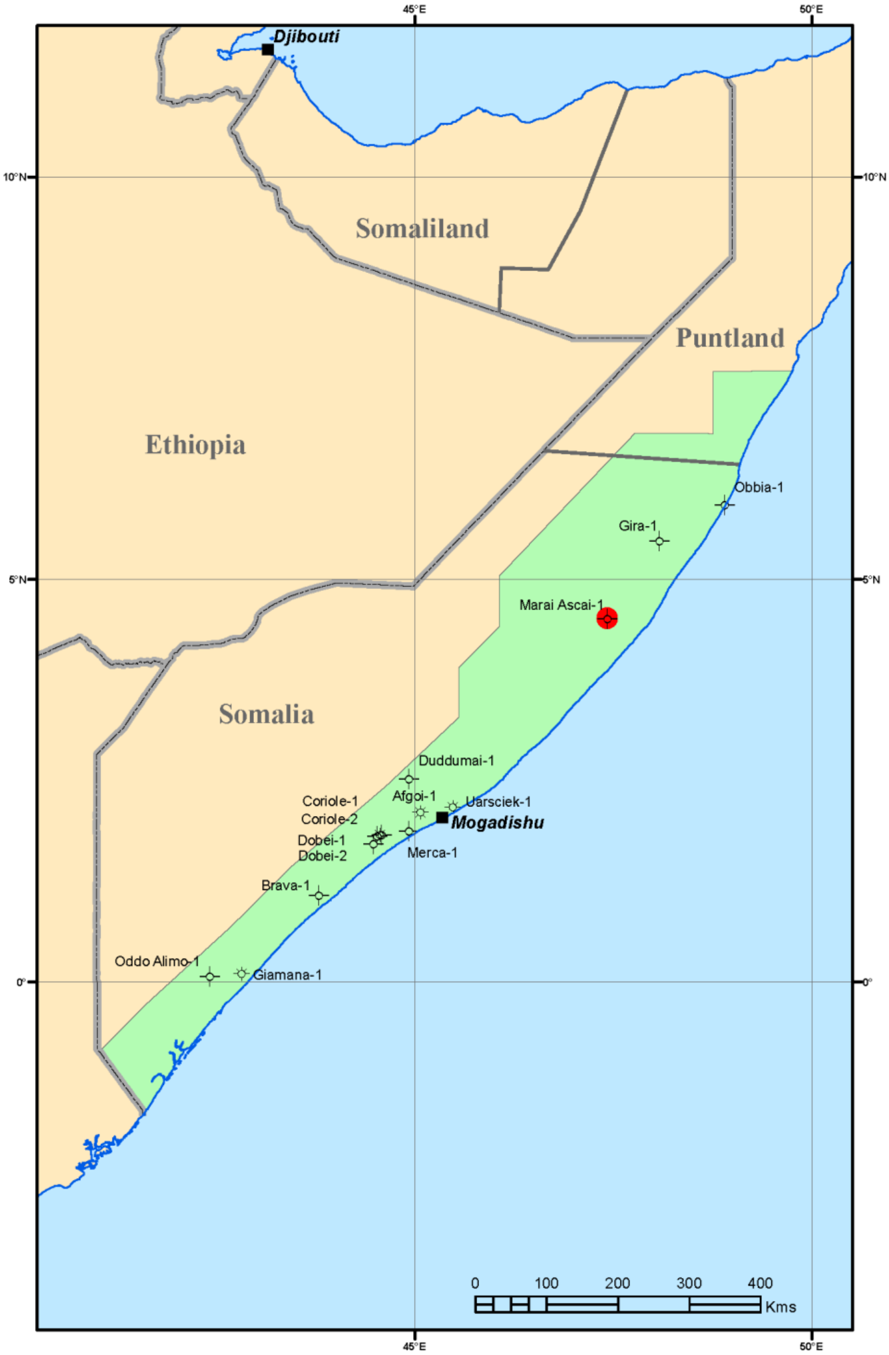


Figure 3.4: Marai Ascai-1 (1958)

Merca-1 (Figure 3.5) was drilled onshore between November 1958 and November 1959 to a total depth of 3,998m (13,118 ft). The target was a NE trending anticline of 20km long closure trending towards the coast with a major fault on the south eastern flank defined by seismic refraction data.

The well reached the Upper Cretaceous Sagleh Formation at TD. Two thick (approximately 480m) intervals of volcanics were recognised in the Lower Tertiary. A number of dead oil stains and trace gas were noted in the Lower to Middle Eocene Schebeli Formation.

No formation tests were run and the well was plugged and abandoned as dry. Although no seismic data is available from this era, Line TUS-09, acquired later by the MMWR (Ministry of Mines and Water Resources)) in 1983, traverses the Mercia-1 well location.

Interpretation of this seismic data indicated that the well was drilled off structure.

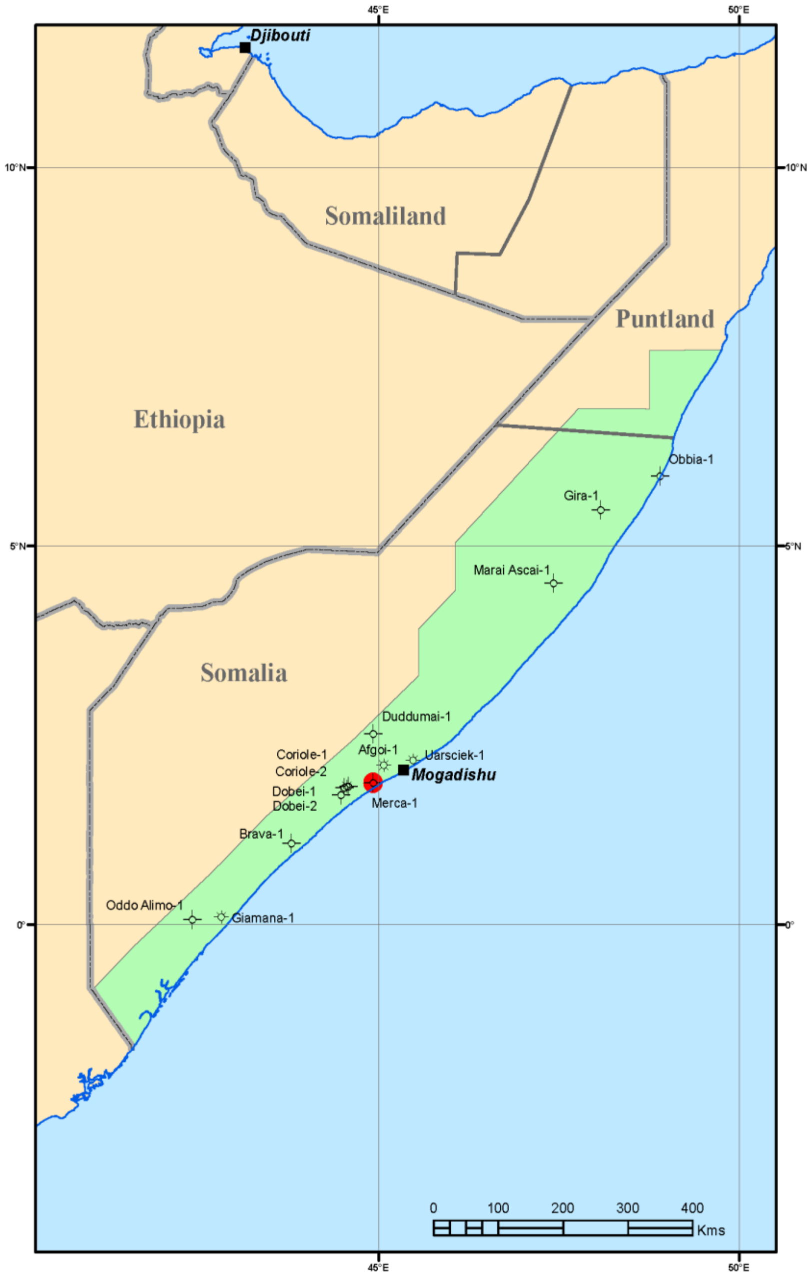


Figure 3.5: Merca-1 (1958)

Duddumai-1 (Figure 3.6) was drilled onshore between December 1959 and May 1960 to a total depth of 3,380m (11,090 ft). The target was a large NE trending anticline 20km long by 6 km wide on seismic reflection data. The well reached the Middle Jurassic Hamanlei Formation at TD. There were no tests taken, although three cores were taken in the Middle and Upper Jurassic. Slight dead oil staining was seen in the Middle Eocene and Upper Miocene.

The well was plugged and abandoned as dry. Although no seismic data is available from this era, Line TUS-03EXT, acquired later by the MMWR (Ministry of Mines and Water Resources)) in 1983 and VUY-41 and VUY-42 acquired in 1988 by Amoco, traverse the Duddumai well location.

Interpretation of this seismic data indicated that the well was drilled on the flank of a structure.

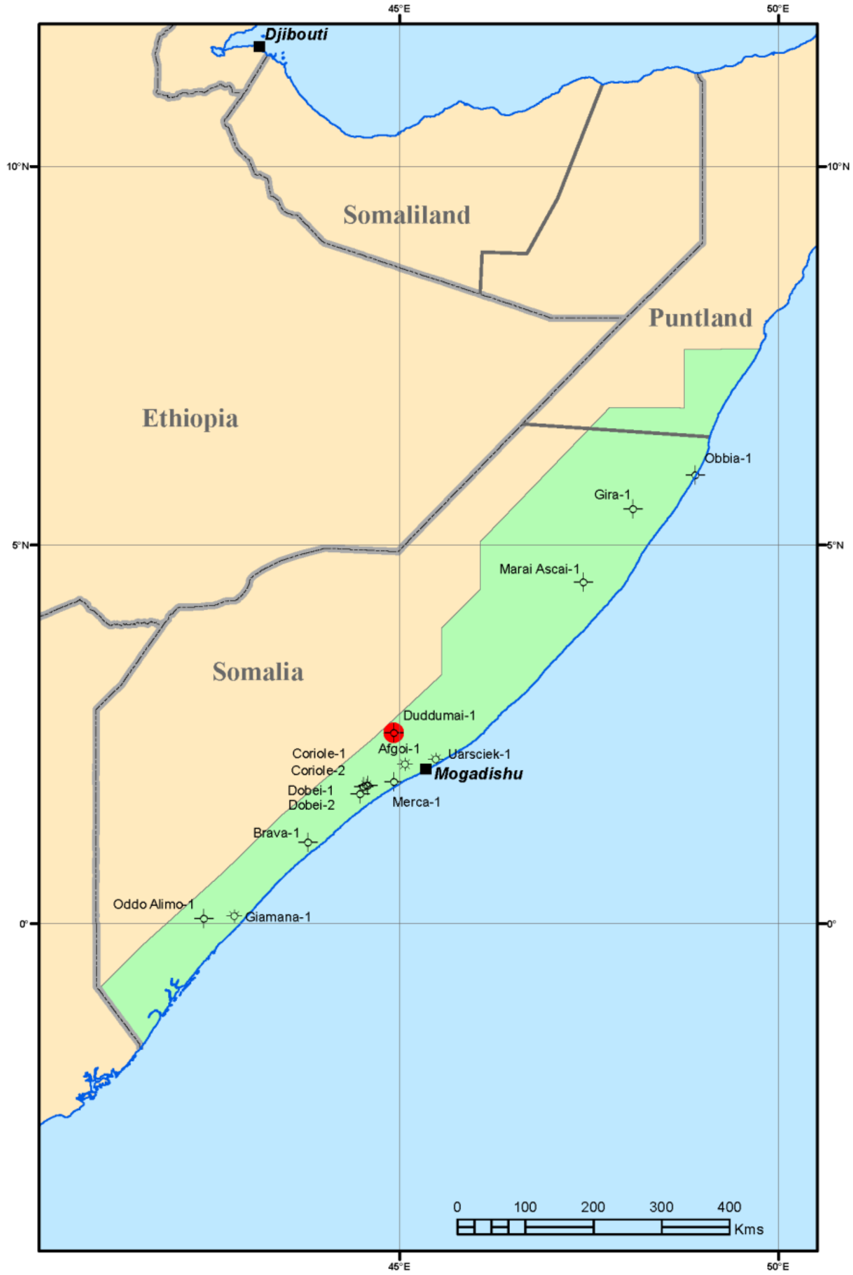


Figure 3.6: Duddumai-1 (1959)

Coriole-1 (Figure 3.7) was drilled onshore between July 1960 and March 1961 to a total depth of 3,518m (11,543 ft). The target was a 30km long fault bounded anticline defined by seismic surveys. The well reached the Upper Cretaceous Jessoma Formation at TD.

Oil staining was observed from cores cut in the Eocene and Upper Cretaceous. DSTs run in the Eocene Coriole Formation recovered 2 bbls of 44º oil and salt water.

2 mmcfpd gas and minor condensate were observed in DSTs run in volcanics in the Upper Cretaceous Gira Formation.

The well was plugged and abandoned and not commercially viable. Although no seismic data is available from this era, Line TUS-15, acquired later by the MMWR (Ministry of Mines and Water Resources)) in 1983 does run within 400m of the well location.

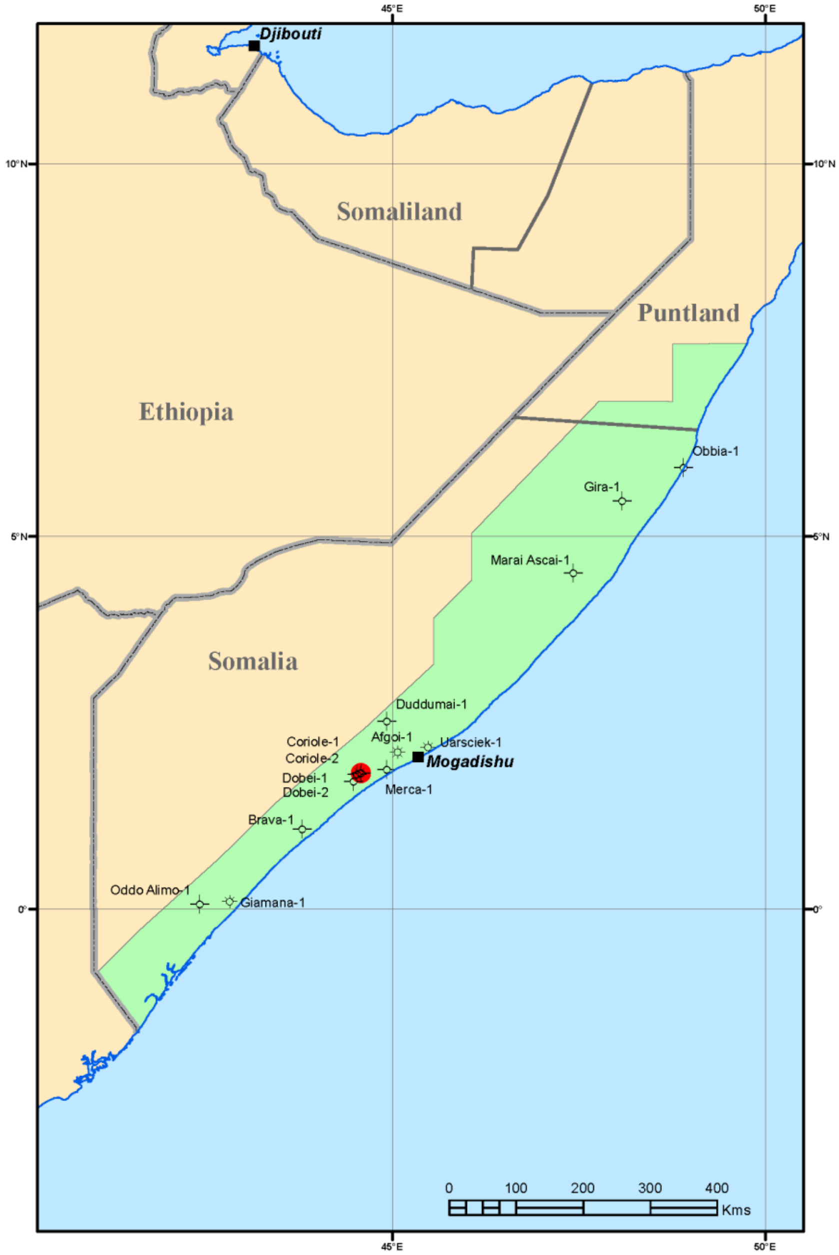


Figure 3.7: Coriole-1 (1960)

Dobei-1 (Figure 3.8) was drilled onshore between March 1961 and April 1961 to a total depth of 2,131m (6,991ft) in the Lower Tertiary Coriole Formation.

This was the second well to be drilled on the Coriole structure and was located 6.75 km southwest of the Coriole-1 well.

Dobei-1 targeted the Eocene dolomite within the Coriole Formation seen in the Coriole-1 well. Dead oil stains were recorded in core taken from the Coriole Dolomite.

No DSTs were run and the well was plugged and abandoned as dry.

Although no seismic data is available from this era, Line TUS-04 West, acquired later by the MMWR (Ministry of Mines and Water Resources)) in 1983 does run within 500m of the well location.

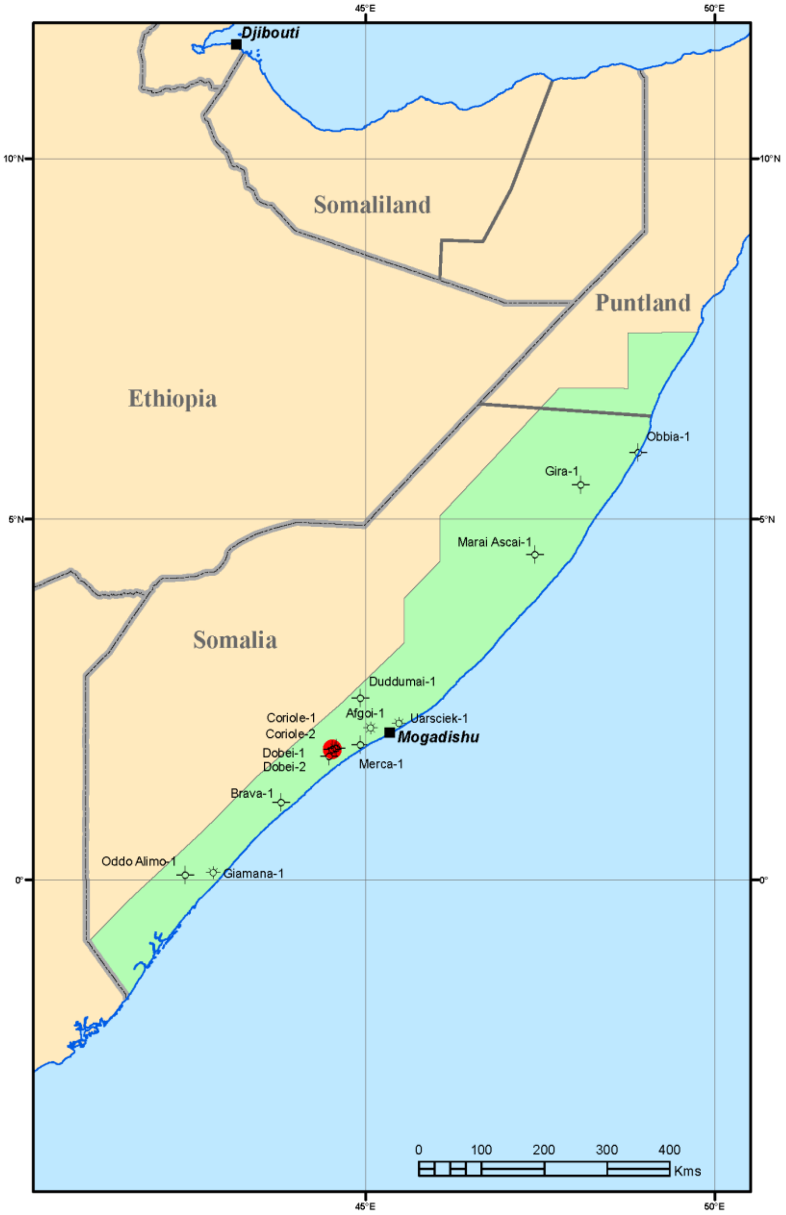


Figure 3.8: Dobei-1 (1961)

Dobei-2 (Figure 3.9) was drilled onshore between May and September 1961 to a total depth of 3,830m (12,565 ft). The well reached the Upper Cretaceous Gira/Jessoma Formation.

This was the third well to be drilled on the Coriole structure and was located 5km south west of the Dobei-1 well. The objective for this well was to test the Eocene Coriole dolomite.

No significant shows were recorded although some fluorescence was noted in cores from Gira/Jessoma Formation near to TD. No tests were run and the well was plugged and abandoned as dry.

No seismic data is available for this well.

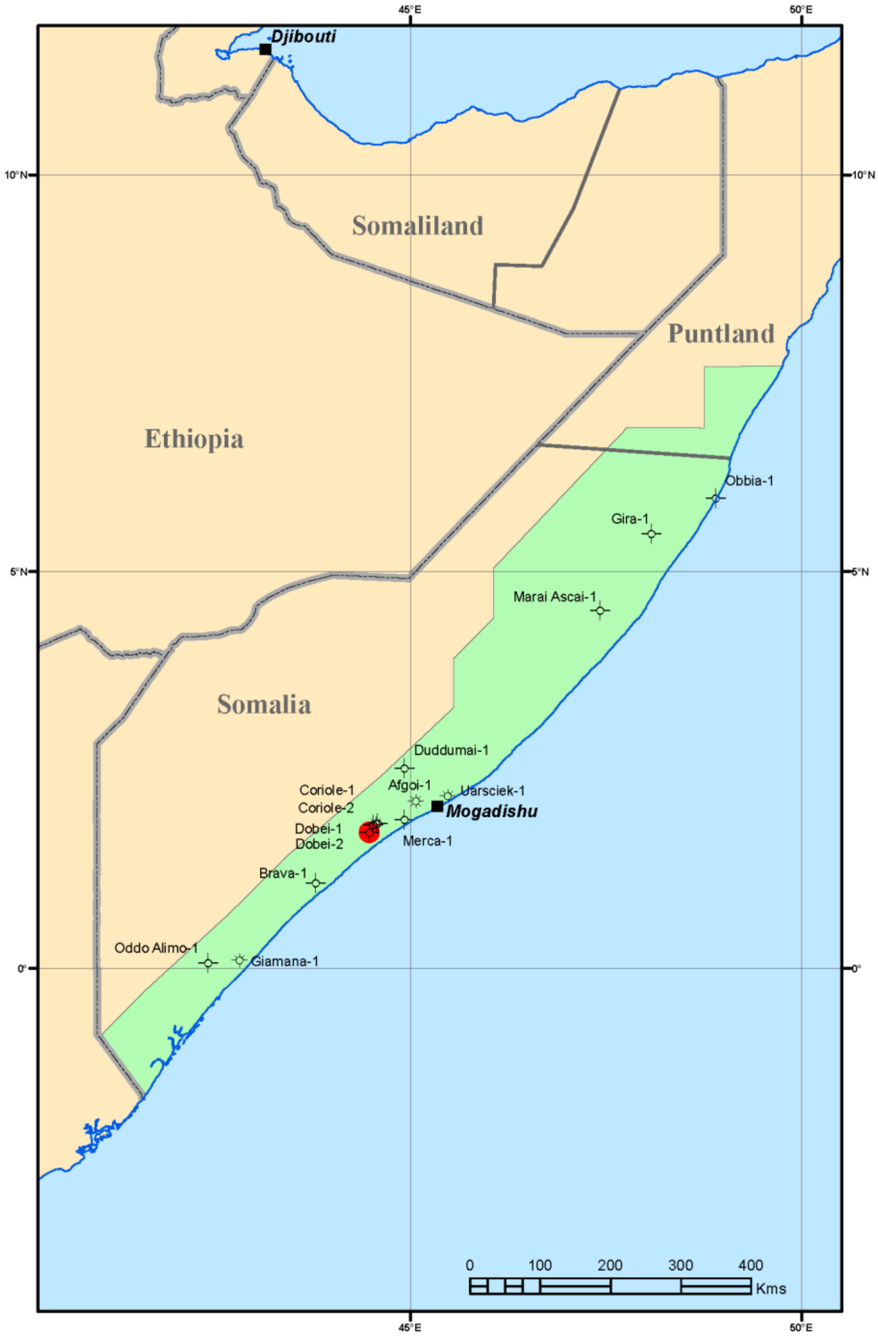


Figure 3.9: Dobei-2 (1961)

Brava-1 (Figure 3.10) was drilled onshore between November 1962 and June 1963 to a total depth of 3,810m (12,500 ft). The well reached the Lower Jurassic/Triassic Adigrat Sandstone Formation.

The well was drilled on a large structure defined by seismic. No hydrocarbons were encountered from DSTs or core.

The well was plugged and abandoned as a dry hole. Although no seismic is available from this era, Lines VUY-13 and VUY-16 acquired by Amoco in 1990 traverse the well location.

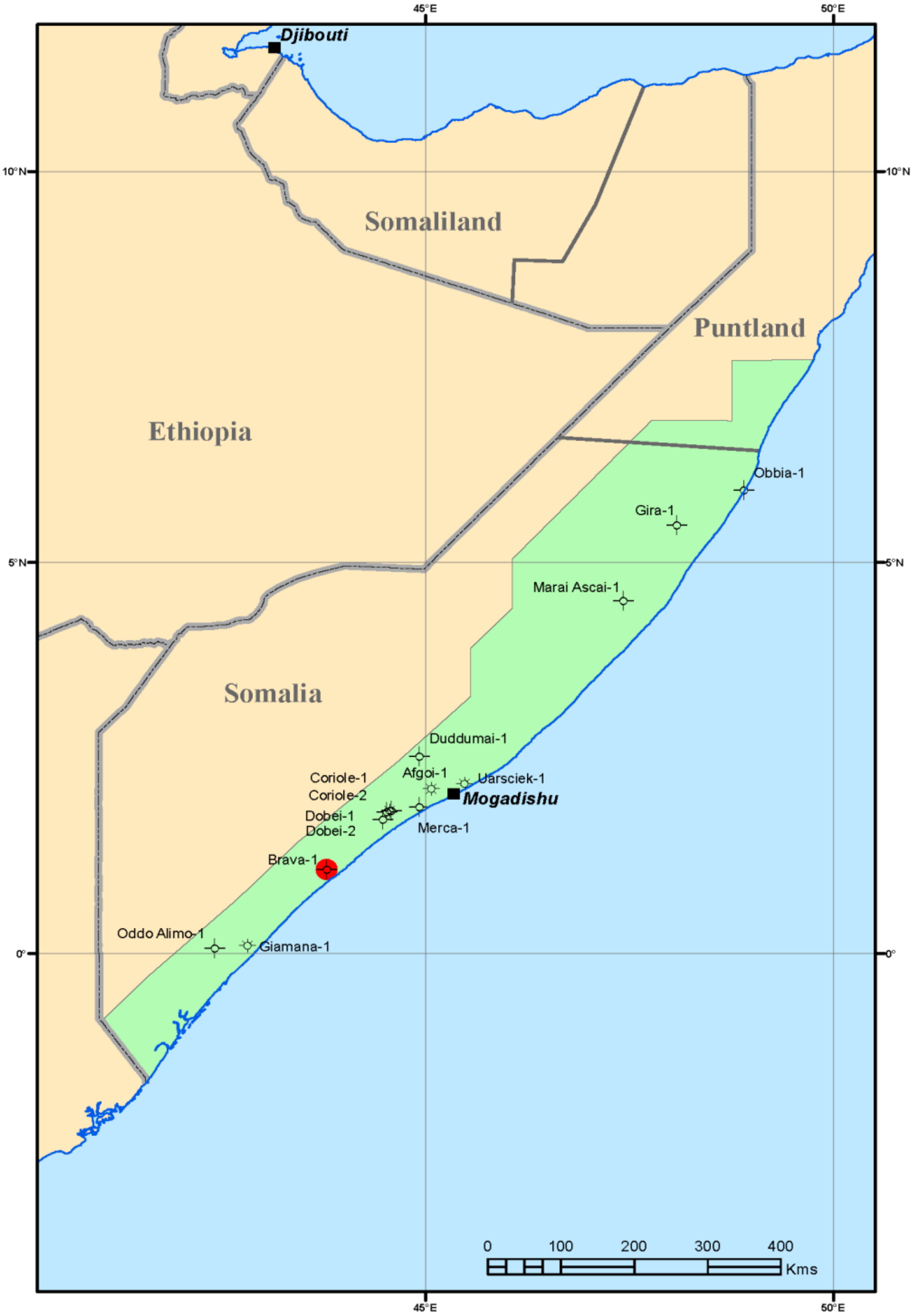


Figure 3.10: Brava-1 (1962)

Giamana-1 (Figure 3.11) was drilled onshore between November 1964 to January 1965 to a total depth of 4,126m (13,537 ft). The well reached Lower Tertiary Coriole Formation.

The well was drilled on an anticlinal feature with up to 290m vertical closure identified on seismic with some evidence of Tertiary sand pinch out. Minor gas shows were noted in the Eocene with some fluorescence in the cores. A DST was run but failed due to a mechanical failure. The well was plugged and abandoned as dry.

Although no seismic is available from this era, Line 81-02 acquired by Deutsche-Texaco in 1983 comes within 800m of the well location.

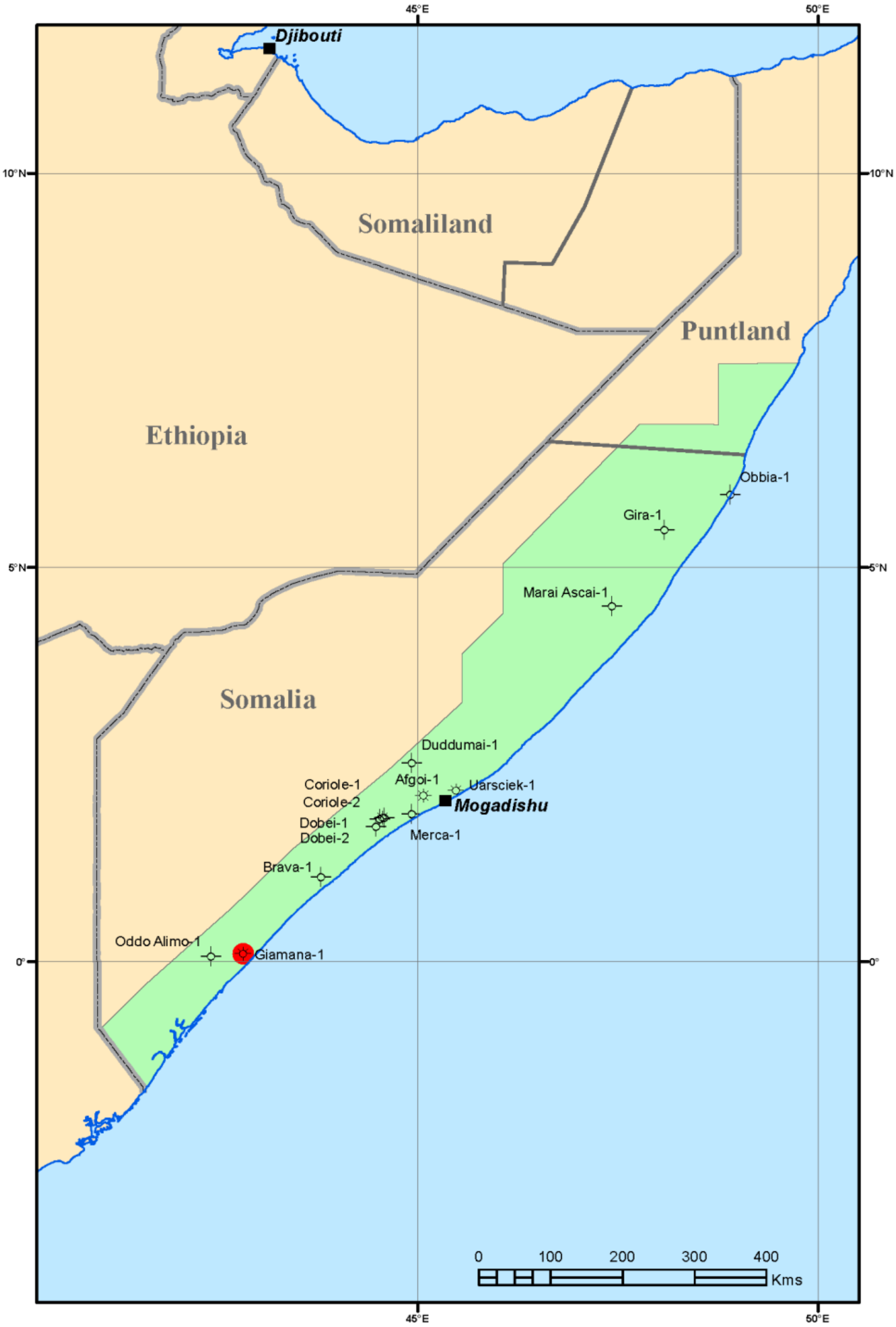


Figure 3.11: Giamana-1 (1964)

Oddo Alimo-1 (Figure 3.12) was drilled onshore between August and November 1964 to a total depth of 4,465m (14,648 ft). The well reached the Upper Cretaceous Jessoma Formation. The well was drilled on structure located 45km west of the Giamana-1 well. This structure was mapped at the Top Eocene (Aden Group) and defined on seismic data. This structure was the largest in the area of approximately 400 sq km in extent.

Gas shows were noted with an estimated 4mcf dry gas recoverable from a DST in the Oligocene of the Somal Formation.

The well was plugged and abandoned as dry. Although no seismic is available from this era, Line 81-07 acquired by Deutsche-Texaco in 1983 comes within 1300m of the well location.

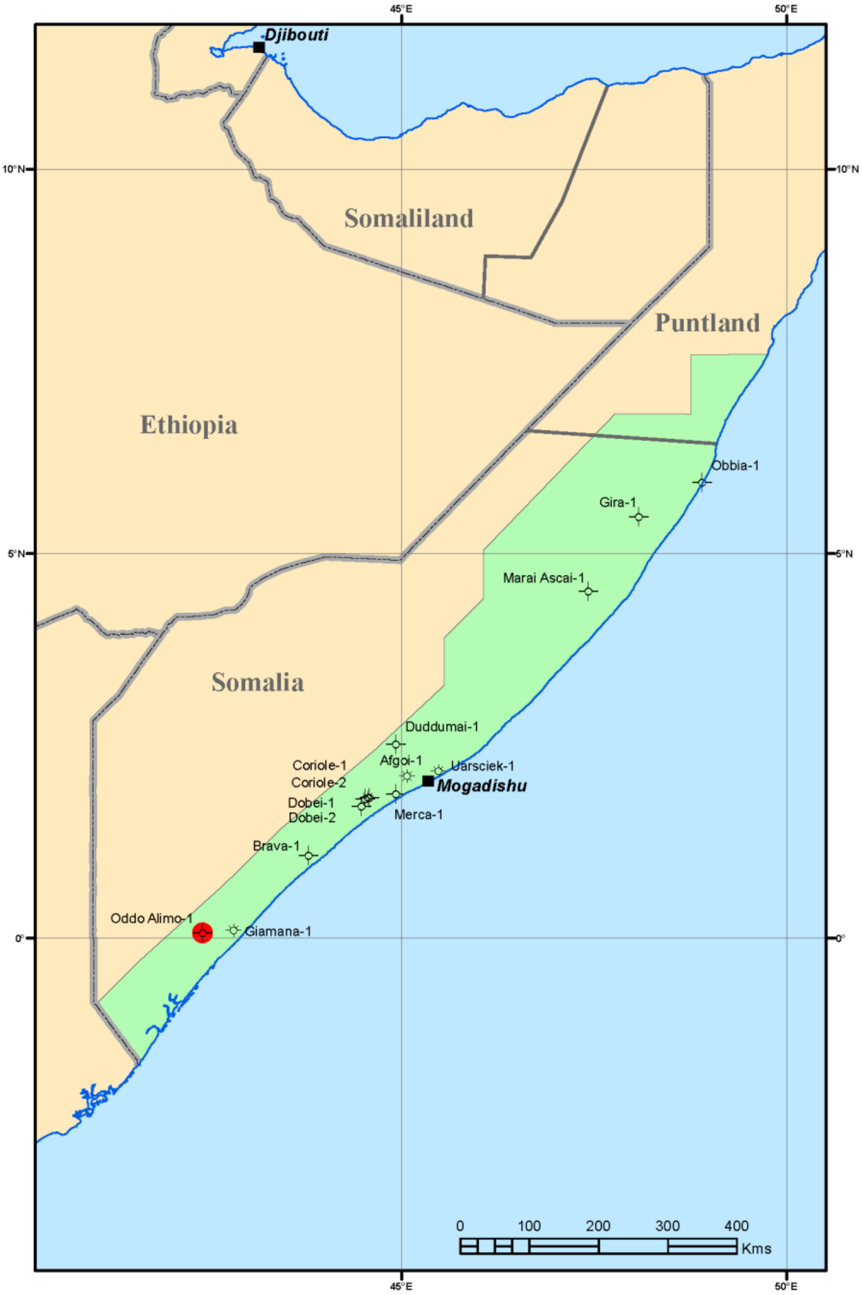


Figure 3.12: Oddo Alimo-1 (1964)

Coriole-2 (Figure 3.13) was drilled between July and September 1965 to a total of 4,069m (13,349 ft). This was the last well to be drilled on the Coriole Structure, previously drilled by Coriole-1, Dobei-1 and Dobei-2 between 1960 and 1961.

The well reached the Upper Cretaceous Jessoma Formation and was designed to target Lower Tertiary limestones and sandstones on the west side of the Coriole Structure. Minor gas shows were noted but untested in the Upper Cretaceous sandstones.

The well was plugged and abandoned as dry. Although no seismic is available from this era, Line TUS-04 West, acquired later by the MMWR (Ministry of Mines and Water Resources)) in 1983 does traverse the well location.

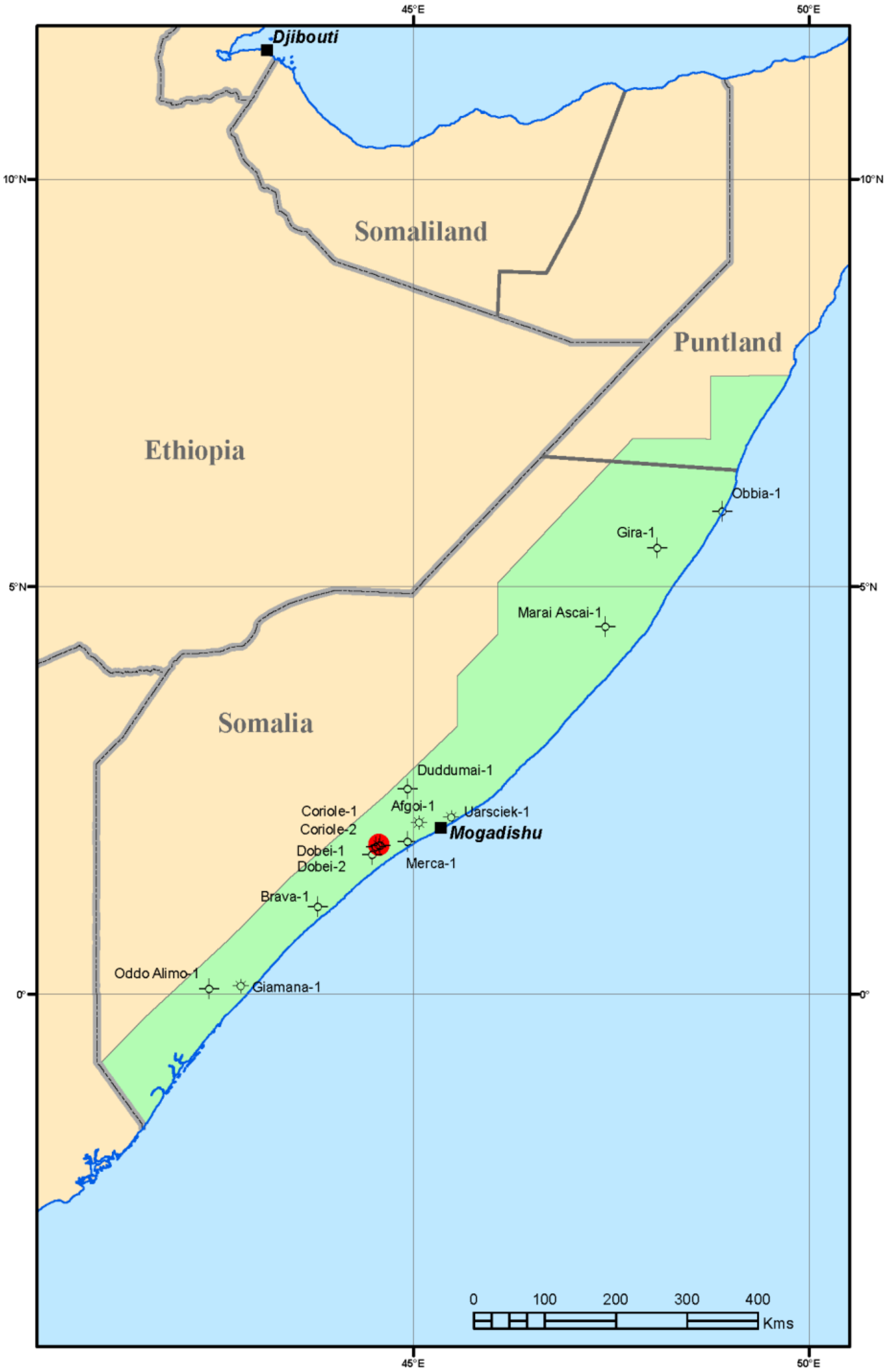


Figure 3.13: Coriole-2 (1965)

Afgoi-1 (Figure 3.14) was drilled between September 1965 and January 1966 to a total depth of 4,164m (13,661 ft). The objective of the well was to test the Afgoi structure which had been mapped as a faulted anticline from seismic data.

The well reached the Upper Cretaceous Jessoma Formation. Basalt intrusions were found in the Paleocene and Upper Cretaceous.

Gas was observed in the Paleocene and Upper Cretaceous with DSTs in the Paleocene and Upper Cretaceous initially flowing 9 mmcfd. This flow stabilised to 6.4 mmcfd with a small amount of liquids (8-10 bbl per mmcfd) of 50-54º API from one interval in the Lower Tertiary. However poor permeability and limited extent meant that flow rates quickly dropped off and were deemed non-commercial.

The well was plugged and abandoned as shut-in gas.

Although no seismic is available from this era, Lines TUS-04EXT and TUS-08, acquired later by the MMWR (Ministry of Mines and Water Resources) in 1983 do traverse the well location

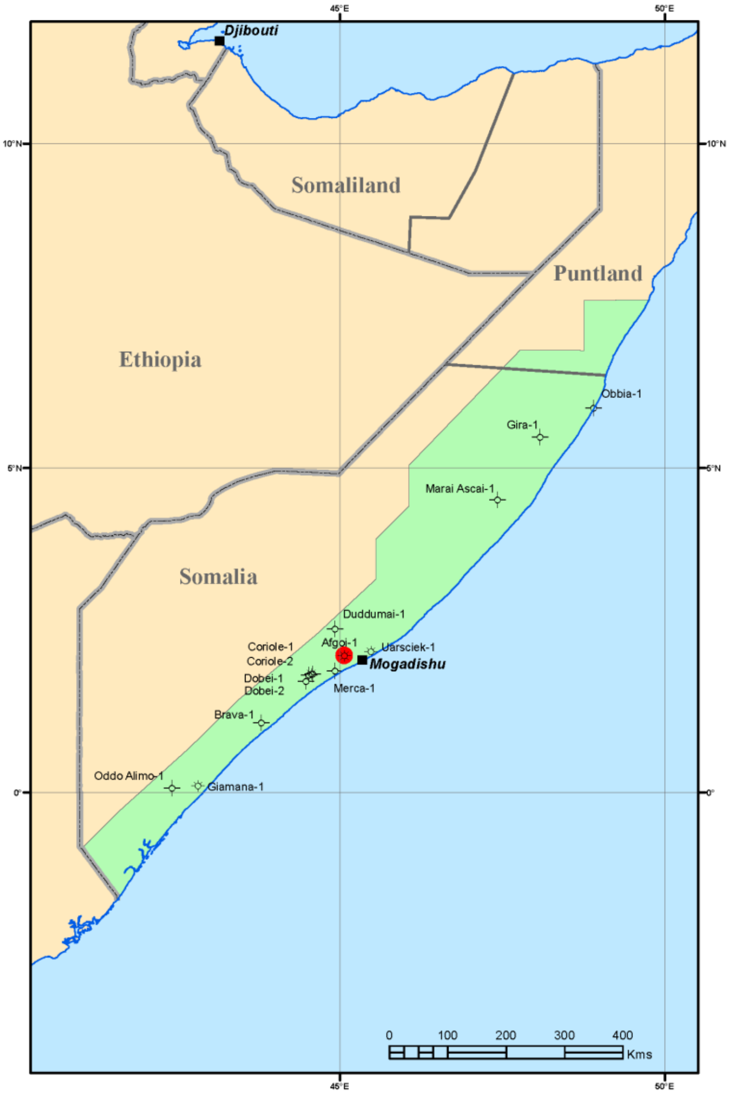


Figure 3.14: Afgoi-1 (1965)

Afgoi-1 was the last well drilled by the Sinclair-Marathon-Conoco and Amerada consortium. From 1966 to 1968 Sinclair was the sole operator.

Sinclair drilled their last well, **Uarsciek-1** (Figure 3.15**)**, between November 1967 and March 1968 to a total depth of 4,104m (13,464 ft). The objective of the well was to test a NE trending anticline of approximately 200 sq km defined by seismic data located 46 km east of the Afgoi-1 well.

The well reached the Upper Cretaceous Jessoma Formation. Minor gas shows were recorded in the Eocene, Paleocene and Upper Cretaceous. The well was plugged and abandoned as dry. No seismic is available over this well.

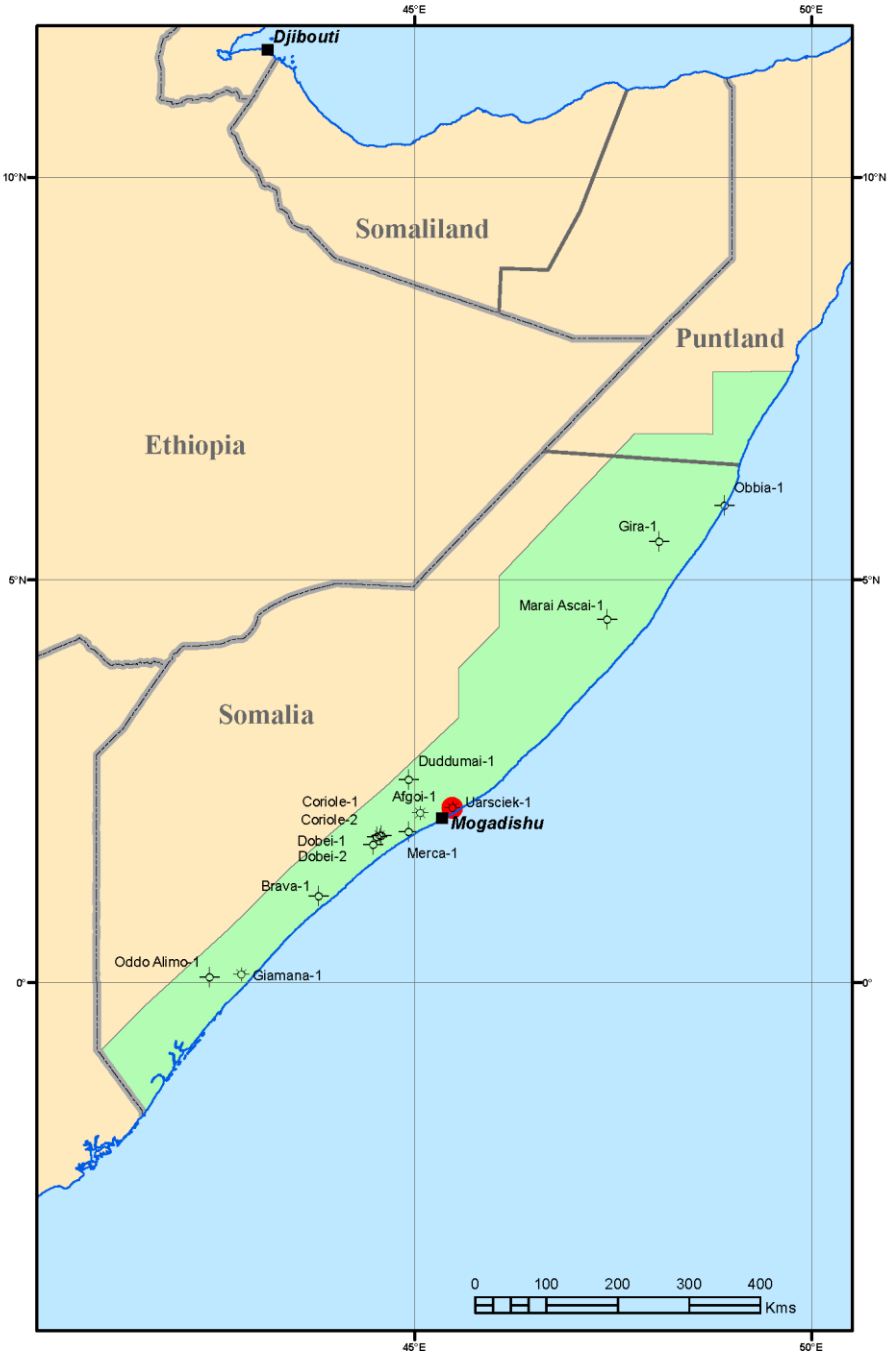


Figure 3.15: Uarsciek-1 (1967)

During 1969 350 kms of 12 fold 2D seismic data were acquired by CGG for Deutsche Ergol using Flexotir offshore El Cabobe (Figure 3.16).

The survey acquired by the MV Wumme using a 2400m cable and 24 groups with a fold of 1200%. These data were processed to stack by CGG.

Data quality is fair-poor (Table 2.4 **and** Table 2.5). There is no record of licensing or wells drilled.

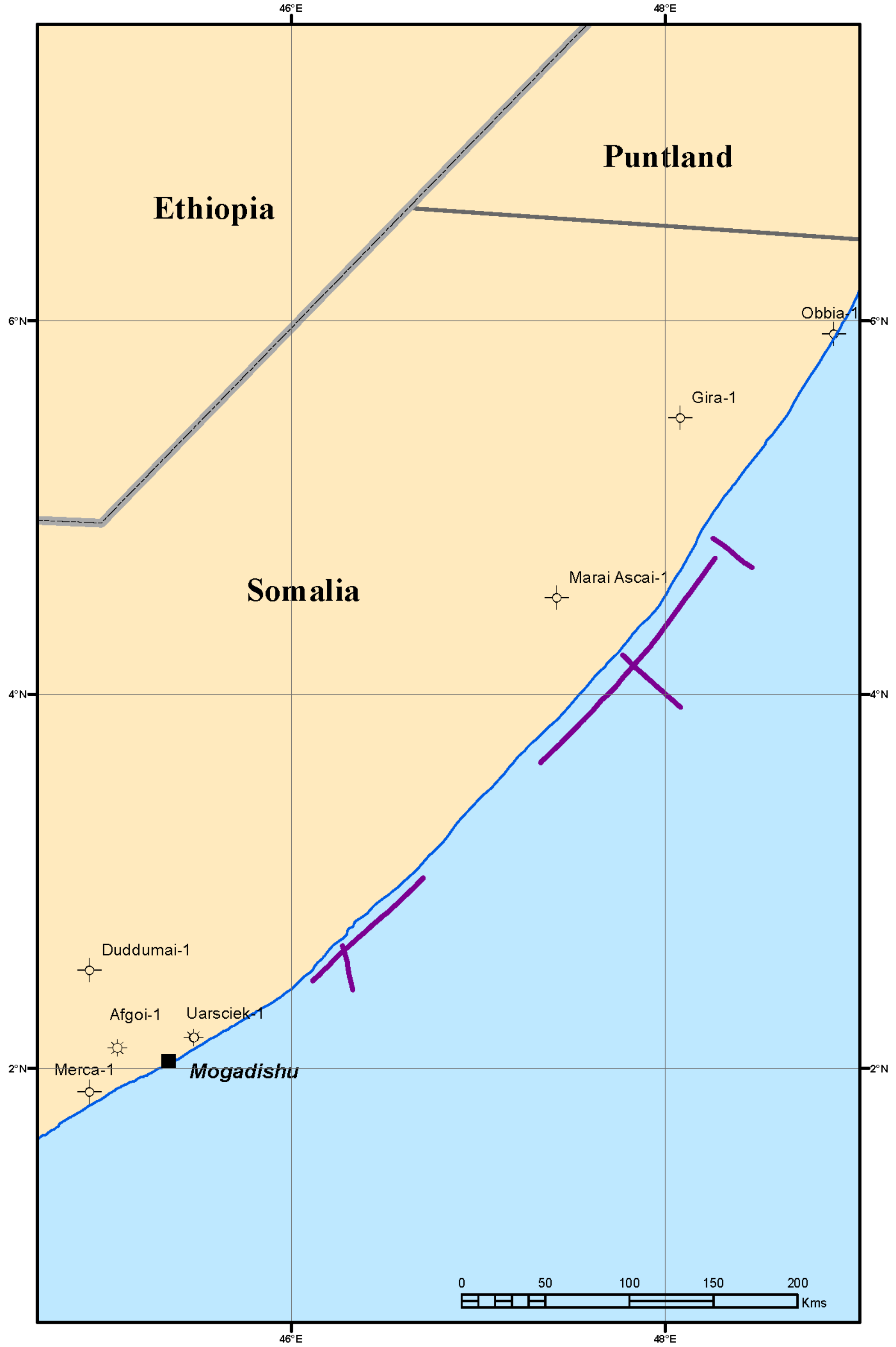


Figure 3.16: Ergol Offshore (1969)

3.2 Post 1969

During 1970, 660 km of 2D seismic data were acquired onshore by Prakla-Seismos for Group of German Oil Companies using dynamite in the El Cabobe area (Figure 3.17). The survey was acquired using dynamite and an offend spread of 1800m with 24 groups, a shotpoint interval of 150m and 600% coverage.

The seismic data was processed to stack by Prakla-Seismos,. Data quality is poor to fair (Table 2.2 and Table 2.3). No wells were drilled and there is no record of licensing.

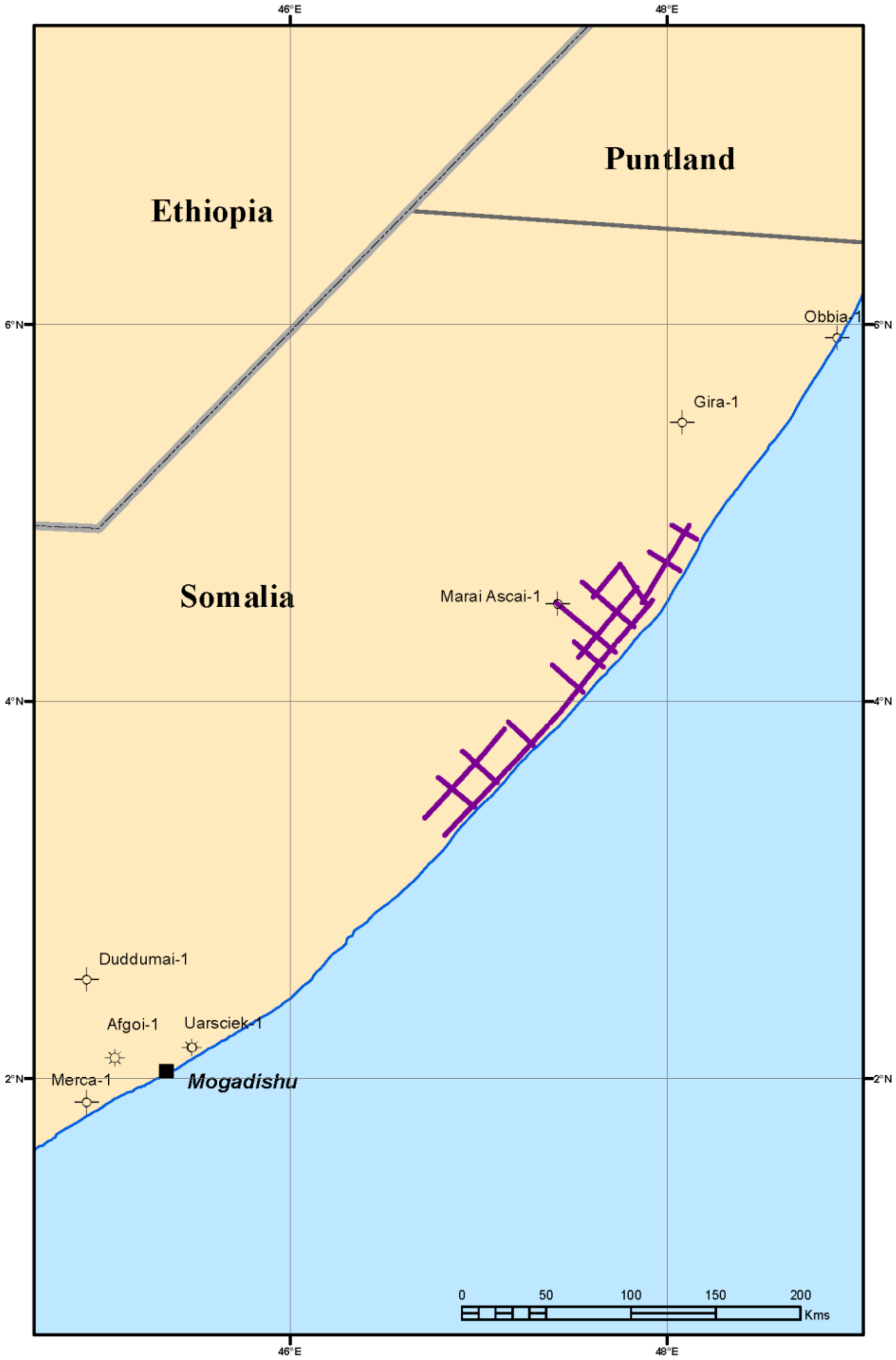


Figure 3.17: Group of German Oil Companies (1970)

Between 1971 and 1972 the Glomar Challenger drilled three wells (DSDP-234,235 and 241) in deep water between 300km and 500km offshore Somalia (Figure 2.1).

These were part of the Deep Sea Drilling Project. These wells were drilled in water depths in excess of 4000m.

DSDP-234 drilled into 200 m of Tertiary sediments. DSDP-235 drilled 700m into Cretaceous sediments. DSDP-241 drilled 1174m through the Tertiary into Cretaceous Early Senonian sediments

Between 1973 and 1974, 914 km of 2D seismic data were acquired onshore by Petty-Ray Geophysical (previously Mandel Industries) for Texaco in Juba area in southern Somalia (Figure 3.18). The survey was acquired using Geograph (thumper/weightdrop) with a split spread of 3125m. The shotpoint interval was 125/250m using 48/24 groups and 1200% coverage.

These data were processed to stack by Petty-Ray Geophysical. Data quality is poor-fair (Table 2.2 and Table 2.3).

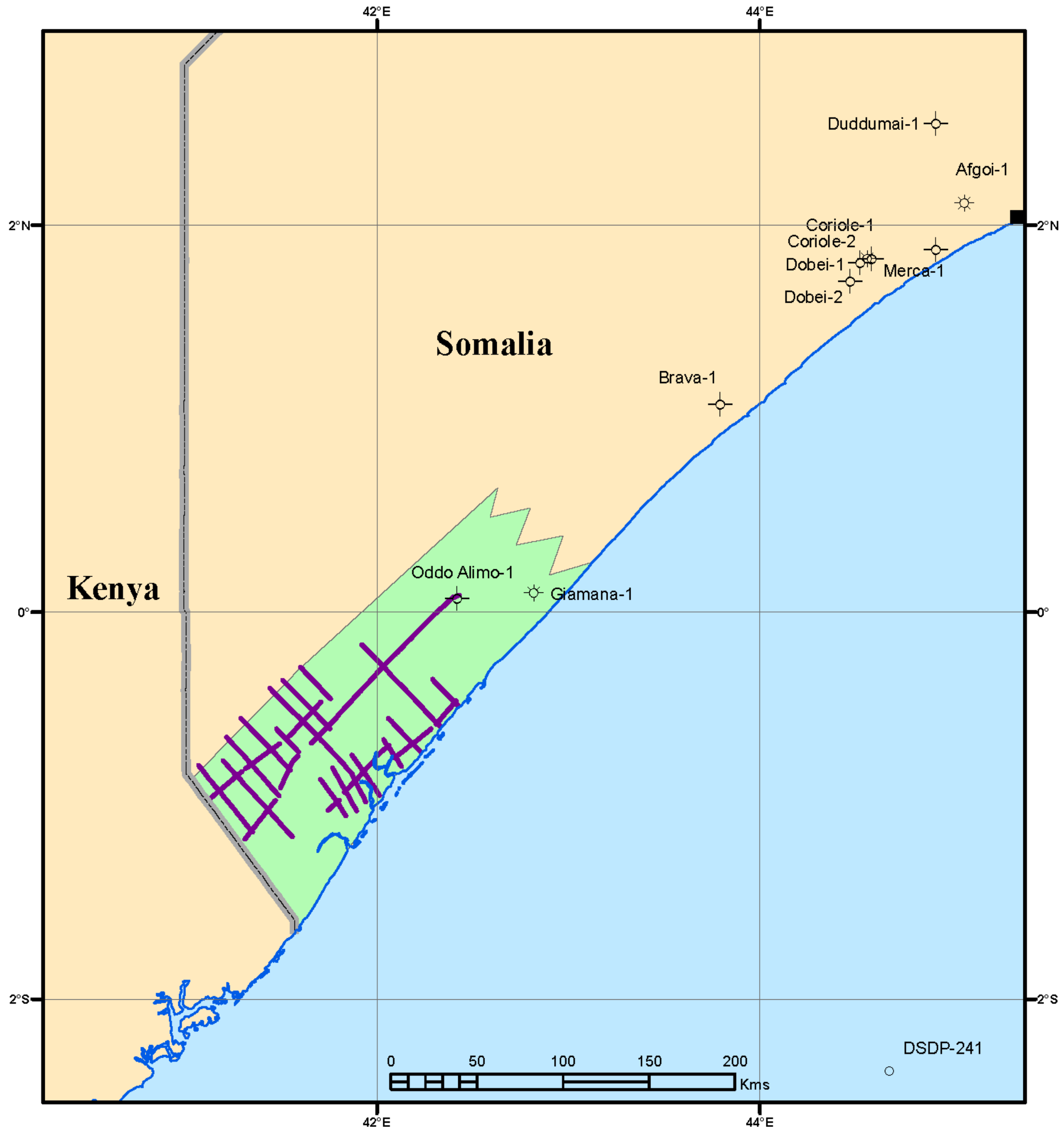


Figure 3.18: Texaco Juba (1973-1974)

In 1975 404 km of 2D seismic data were acquired onshore by Petty-Ray Geophysical (previously Mandrel Industries) for Texaco the Obbia area (Figure 3.19). The survey was acquired using Geograph (thumper/weightdrop) with a split spread of 3125m. The shotpoint interval was 250m using 24 groups and 1200% coverage.

These data were processed to stack by Petty-Ray Geophysical. Data quality is poor-fair (Table 2.2 and Table 2.3).

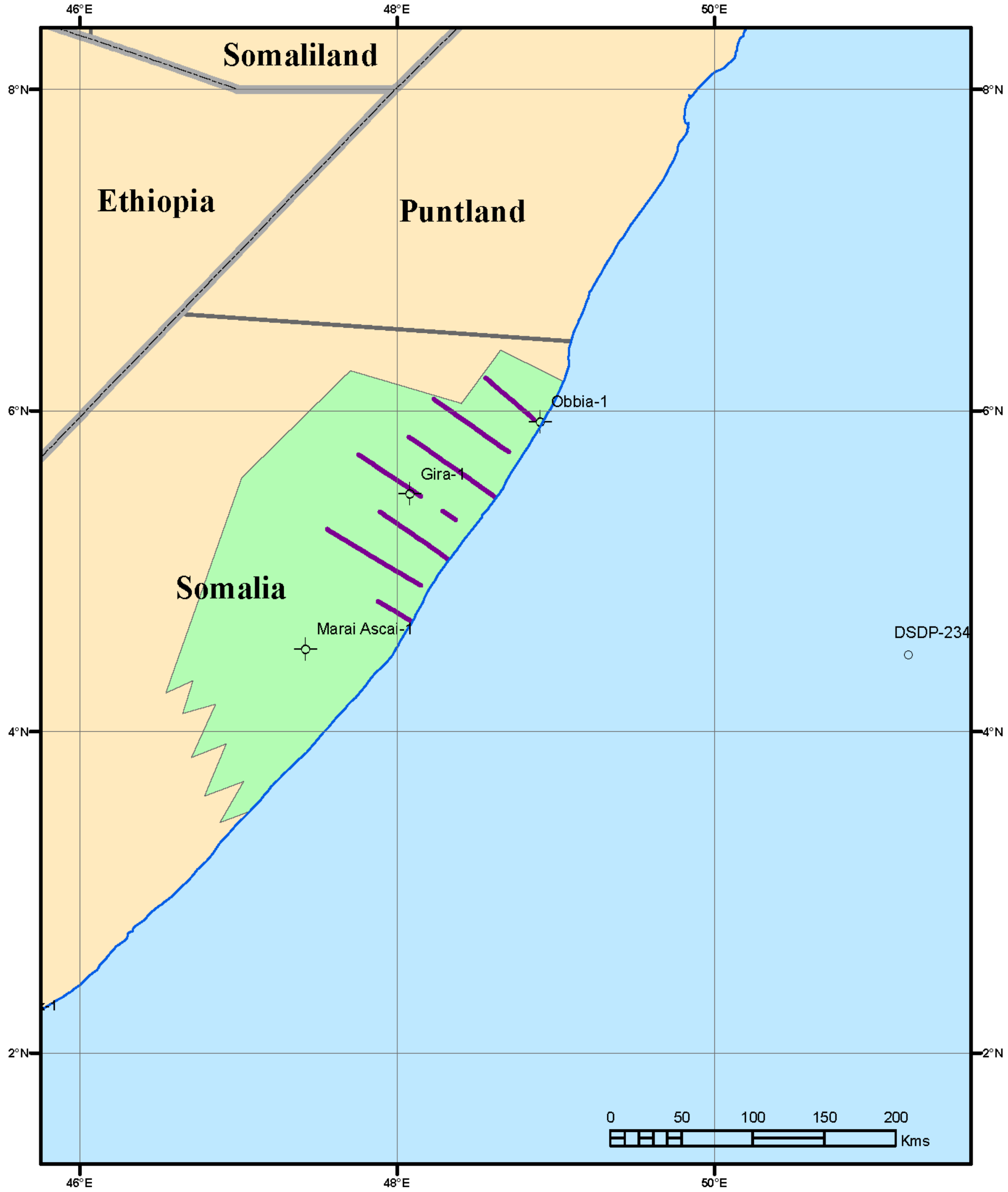


Figure 3.19: Texaco Obbia (1975)

Between 1973 and 1976 Conoco acquired 339 km offshore Garad Mare and Obbia.

In 1974 218 km of 24 fold 2D seismic data were acquired by CGG for Conoco using Vaporchoc. The survey was acquired by the MV Lady Christine using a 2400m cable and 24 groups with a coverage of 2400%. These data were processed to stack by CGG. Data quality is fair-poor.

In 1975, a further 121 km of 24 fold 2D seismic data were acquired by GSI for Conoco using airguns. The survey was acquired by Crew 2904 using a 8758ft (2669m) cable and 48 groups with a coverage of 2400% (Figure 3.20).

These data were processed to stack by GSI. Data quality is fair-good (Table 2.4 and Table 2.5).

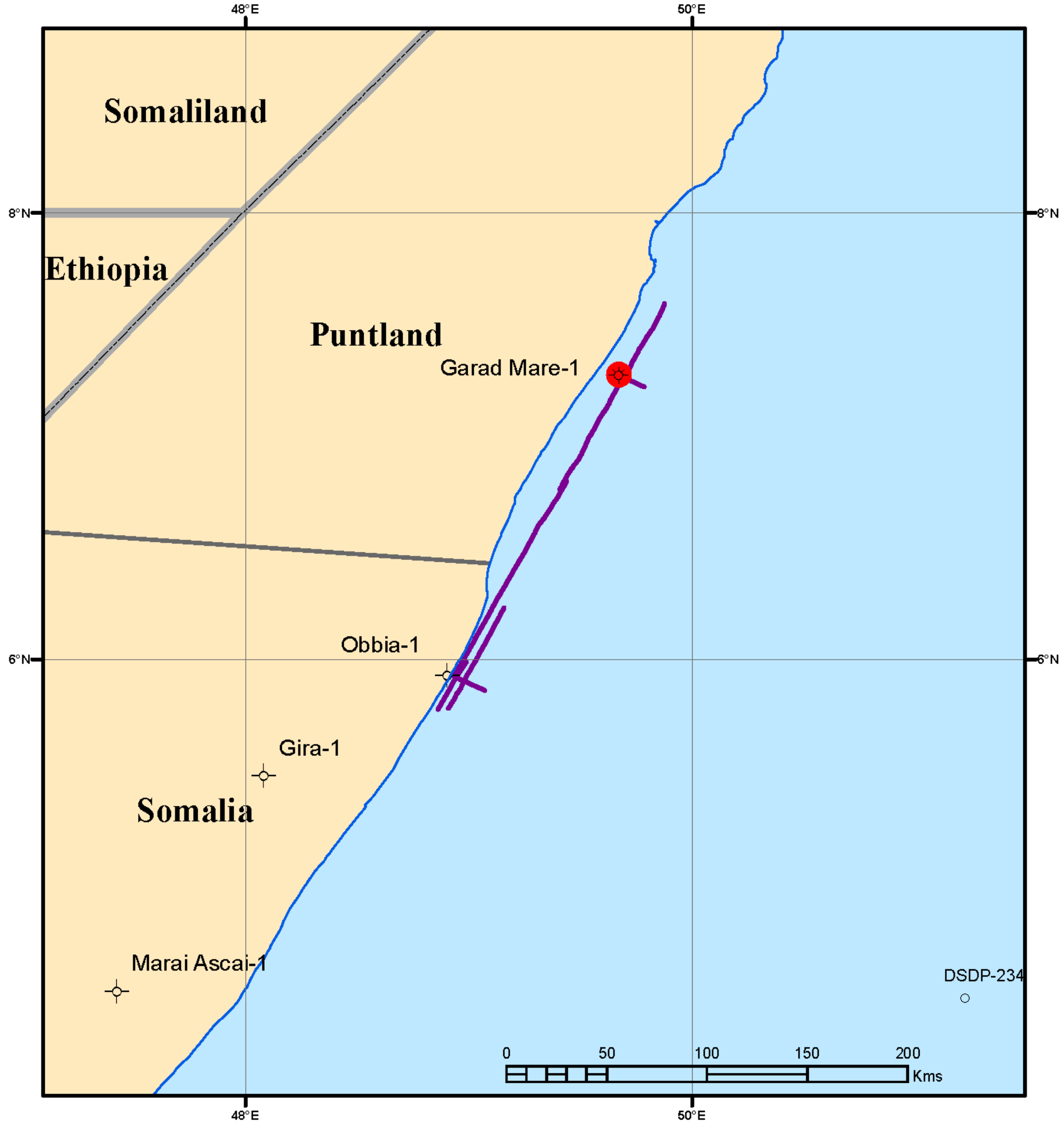


Figure 3.20: Conoco-AGIP-Pecten Offshore (1973-1977)

Conoco later, with Agip and Pecten, explored a 42,000 sq km area north of Obbia (see Figure 3.19) This included part of the offshore. After the Pecten and Conoco dropped out of the licence, Agip drilled one well **Garad Mare-1** between January and April 1977(Figure 3.20).

This well was drilled to a total depth of 3921m and reached into the Lower Jurassic/Triassic Adigrat Formation. The primary objective of the well was to test a structure targeting Mesozoic limestones within the Upper Cretaceous Gira Formation and the Middle Jurassic Hamanlei Formation.

Secondary targets were Paleogene limestones and sands. The objectives were found to be water bearing with minor gas shows in the Hamanlei and Adigrat Formations.

The well was plugged and abandoned as dry. The only available seismic line from the 1974/1975 seismic surveys which traverses the well location is O-116. A later seismic survey acquired by Pecten in 1989 included this area (see Figure 3.29).

Between 1973 and 1978, Elf and Total held a licence offshore southern Somalia adjacent to the Kenyan border. There is no record of any seismic acquired or work done.

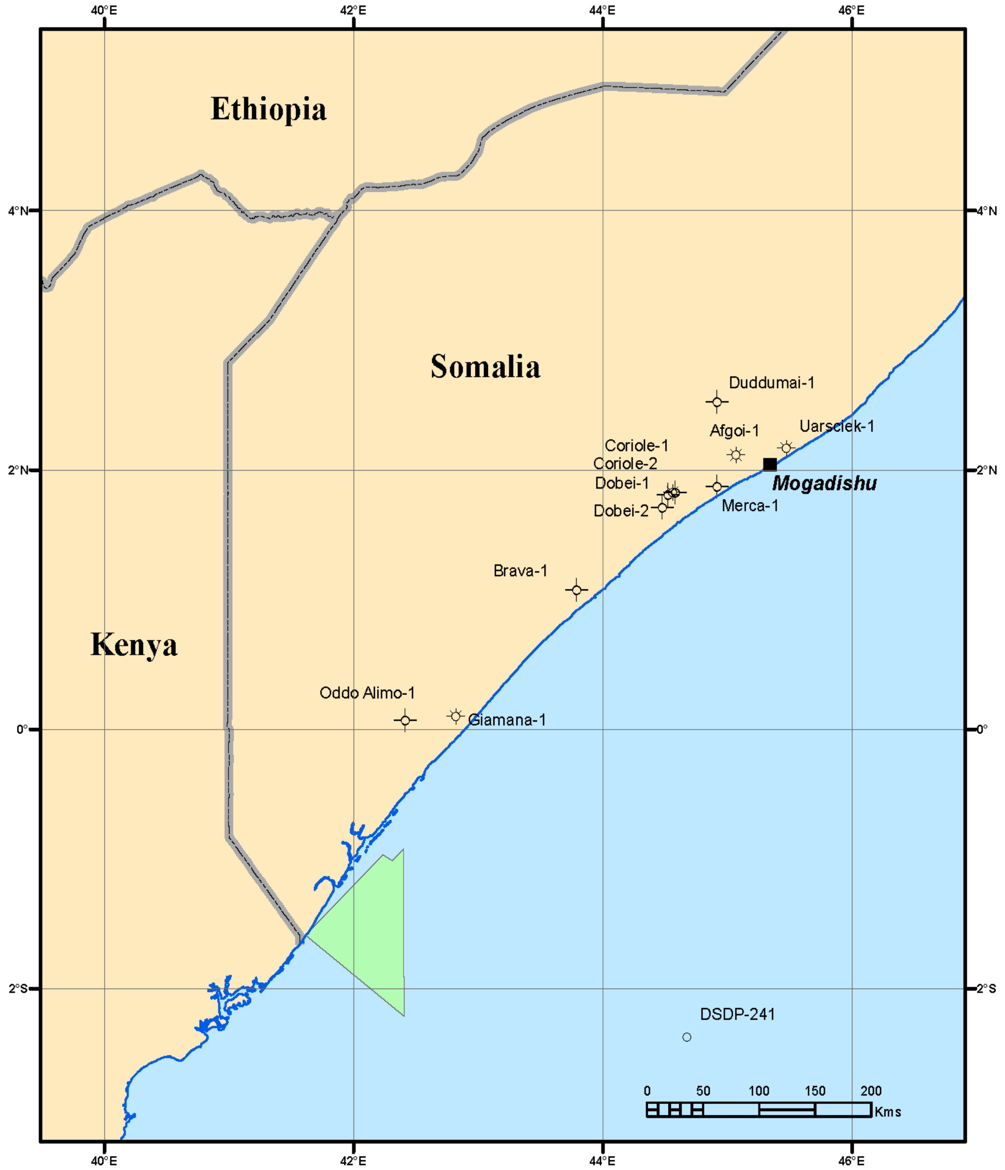


Figure 3.21: ELF-Total 1973-1978

Arco (Sinclair) returned to Somalia between 1979 and 1984 to explore a 120,000 sq km area covering both the onshore and part of the offshore (Figure 3.22).

From 1980 to 1981 approximately 600 km of 48 fold 2D seismic data were acquired onshore by Geosource (previously Petty-Ray Geophysical) for Arco in the El Cabobe area.

The survey was acquired using Geograph (thumper/weight drop).The survey used a variety of split, asymmetric and offend spreads, a shotpoint interval of 100m and a coverage of 2400% (Table 2.2 and Table 2.3).

The seismic survey tied into the **Marai Ascia-1** well drilled by Sinclair in 1958. These data were processed to stack by Petty-Ray Geophysical. Data quality is fair.

The **El Cabobe-1** well was drilled between June and September 1980 onshore. The objective of the well was to test a large (10 x 25 km) NE-SW trending structure bounded to the southeast by a large NE-SW trending fault defined by seismic data. The crest of the structure lay near the coastline.

This well was drilled to a total depth of 4,428m (14,528 ft) into the Lower Jurassic/Triassic Adigrat Formation, which was the primary target with Middle Jurassic limestones of the Hamanlei Formation being a secondary target.

Minor gas shows were recorded in limestones within the Hamanlei Formation. Six RFTs and thirty six SWC were taken without any sign of hydrocarbons and the well was plugged and abandoned as dry. Seismic line S-80-G103-P1 from the Arco 1980 seismic survey and line 500-P1 from the 1970 seismic survey acquired by the German Group of Companies tie to the well.

Arco acquired 1143 km of 48 fold 2D seismic data in1980 offshore the El Cabobe and Obbia area. The data were acquired by Geco using airguns. The survey was acquired by the MVLongva II using a 2400m cable, 48 groups and a coverage of 4800%. The data was processed to migrated stack by GSI. Data quality is fair-good (Table 2.4 and Table 2.5).

Exxon farmed into the license area as operator in 1982 and as part of the agreement acquired a 2411 km 2D seismic survey, which is all available. These data were 48 fold 2D seismic data acquired by GSI for Exxon using airguns offshore El Cabobe The survey was acquired by the RC Dunlap with a cable length of 8656ft (2638m) a source interval of 82ft (25m) using 96 groups with a coverage of 4800%. These data were processed to stack by GSI. Data quality is fair-good **(Tables 2-4 & 2-5)**.

On the results of this seismic survey, the **Meregh-1** well was drilled offshore in between August and November 1982. The objective of the well was to test Jurassic carbonates and dolomites of the Hamanlei Formation. The well was located on the edge of an uplifted Jurassic fault block. The well was drilled to a total depth of 4,298m (14,100 ft) into the Middle Jurassic Meregh Formation.

No shows were recorded and no tests were run. The well was plugged and abandoned as dry. Line SO2A32 from the 1982 Exxon offshore seismic survey and Line SOM-80-A1-P1 from the Arco 1980 seismic survey are located within 600m of the well location.

The Exxon-Arco licence was relinquished in 1984.

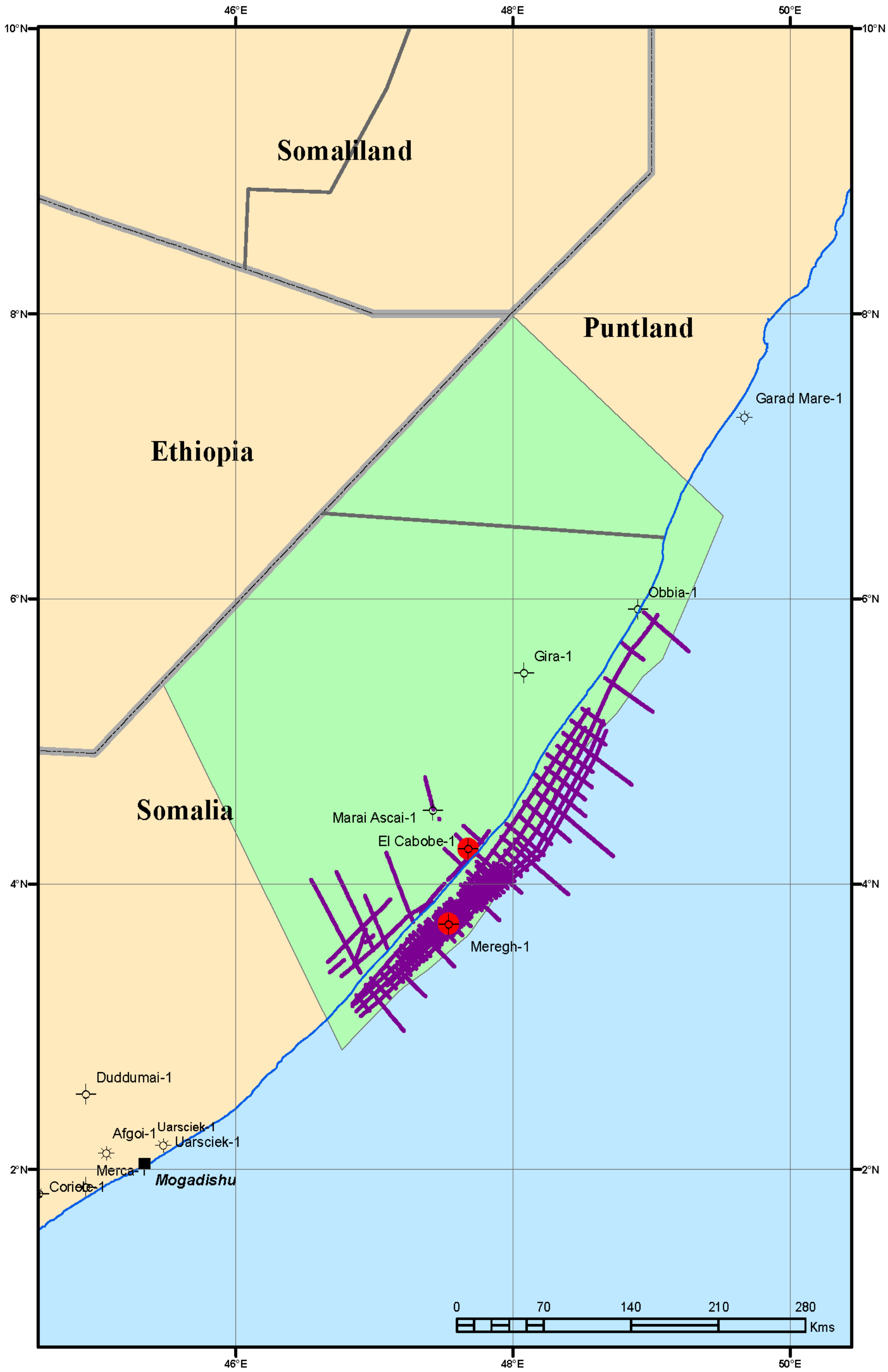


Figure 3.22: ARCO-EXXON (1979-1984)

Deutsche Texaco operated a licence (Oil exploration Permit) in the South Juba area onshore in southern Somalia between December 1979 and December 1984. The concession area covered 13500 sq km. After the initial term of two years, the concession was extended three times for one year each until December 1984 This was an area previously licensed to Texaco in 1973 and 1974.

Between 1980 and 1981, 1041 km of new 48 fold 2D seismic data were acquired by Geosource (previously Petty-Ray Geophysical). The 1980/81 seismic survey tied into the Giamana-1 and Oddo Alimo-1 wells drilled by Sinclair in 1964/65 and also the previous seismic acquired by Texaco in 1973 and 1974 (Figure 3.18).

The seismic data was acquired using vibroseis source, an offend spread of 2625m, 48 groups and 1200% coverage. This data were processed to stack by Petty-Ray Geophysical. Data quality is fair to poor (Table 2.2 and Table 2.3).

On the results of the seismic surveys, Deutsche-Texaco drilled the **Kudha-1** between July 1981 and February 1982 to a total depth of 4971m (16310 ft) in the Upper Cretaceous.

The target was a small rollover anticline at the base of a northeast trending fault block. The objectives were sandstone bodies in the Tertiary and Upper Cretaceous. Minor gas shows were recorded and four DSTs run. No coring was carried out and the well had drilling problems below 3600m caused by overpressure in caving shales.

The poor gas results and lack of petrophysical data meant that the well was plugged and abandoned as dry.

The Kudha-1 well is located on the intersection of lines 80-18-P1 and 80-07.

Deutsche Texaco drilled a second well, **Obbe-1**, between April and September 1982 to a total depth of 4865m (15960 ft) in the Upper Jurassic as then described. The TD formation would now be reclassified as Lower Cretaceous based on the change in benthic foraminiferal classification since 1982.

The well is located on the intersection of lines 702 and 705 from the earlier seismic surveys acquired in 1973 and 1974 by Texaco. The targets were Upper Cretaceous carbonates and deeper fault blocks.

No shows were recorded and no tests or coring carried out. The well encountered drilling problems caused by overpressuring in the Lower Cretaceous and was plugged and abandoned as dry.

After the negative results from the two wells, a comprehensive overall study was undertaken between 1983 and 1984. This incorporated an analysis of the drilling results and a reinterpretation of the existing seismic and the previous seismic acquired by Texaco in 1973 and 1974. This included reprocessing of selected 1973 seismic lines by Prakla-Seismos.

Deutsche-Texaco came to the conclusion that the Juba delta area had limited exploration potential with poor source rock and poor reservoir qualities in the Lower Tertiary, Cretaceous and Jurassic sections. They also concluded that deeper horizons were not prospective for liquid hydrocarbons due to thermal over maturation. Deutsche Texaco invested $50,000,000 over the five year period that it held the licence (Figure 3.23).

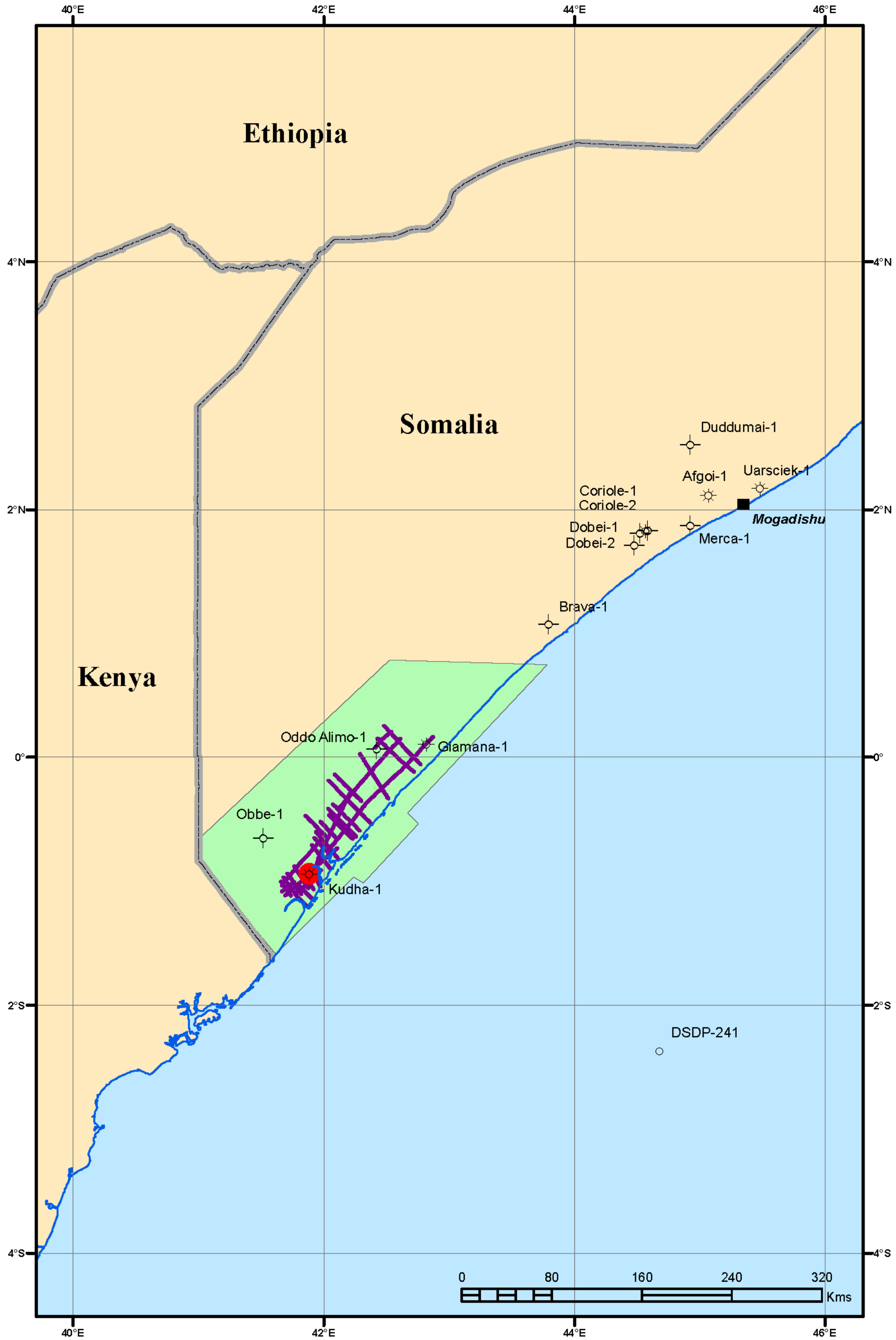


Figure 3.23: Deutsche-Texaco 1979-1984

During 1979 to 1980, 4480 line km of 2 x 24 fold 2D seismic data were acquired by Geco for the Somali Ministry of Mineral and Water Resources using airguns offshore Mogadishu Area 1.

This data was processed to stack by Geco. Data quality is fair-good (Table 2.4 and Table 2.5). Seismic grid spacing is approximately 5km x 10km This seismic survey was acquired under World Bank funding to promote the oil and gas potential of the offshore area of Somalia. This survey is not in the database (Figure 3.24).

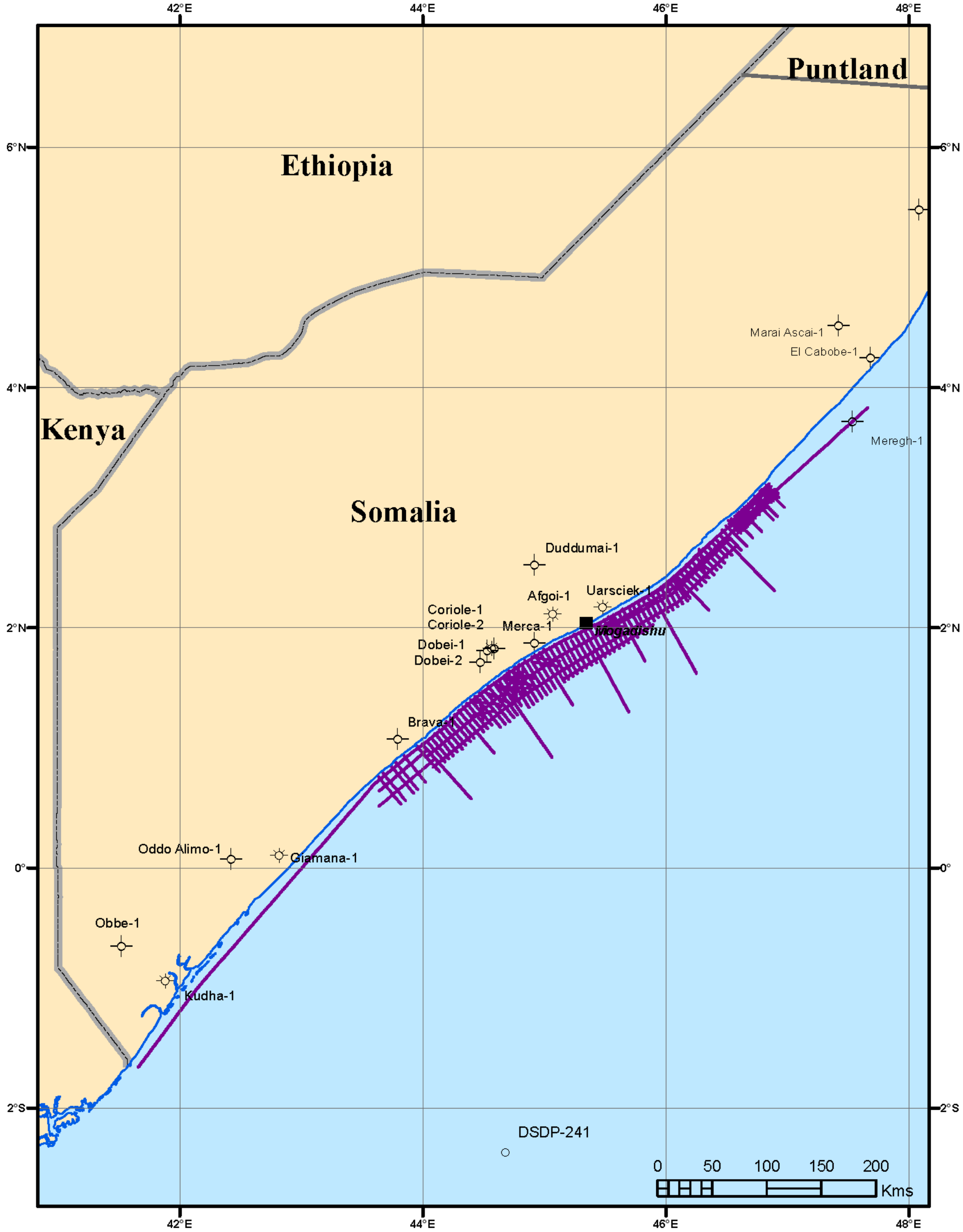


Figure 3.24: MMWR-Geco (1980)

In 1980 the Lamon-Doherty Earth Observatory of Columbia University acquired seismic data as part of a program to investigate deep earth events offshore East Africa.

The seismic data was recorded to 12 seconds and is 12 fold. Data quality is fair. 1349 km were reprocessed by Robertson Geospec International (CGG) in 2004 (Table 2.4 and Table 2.5).

These lines intersect the DSDP 241 well (Figure 3.25).

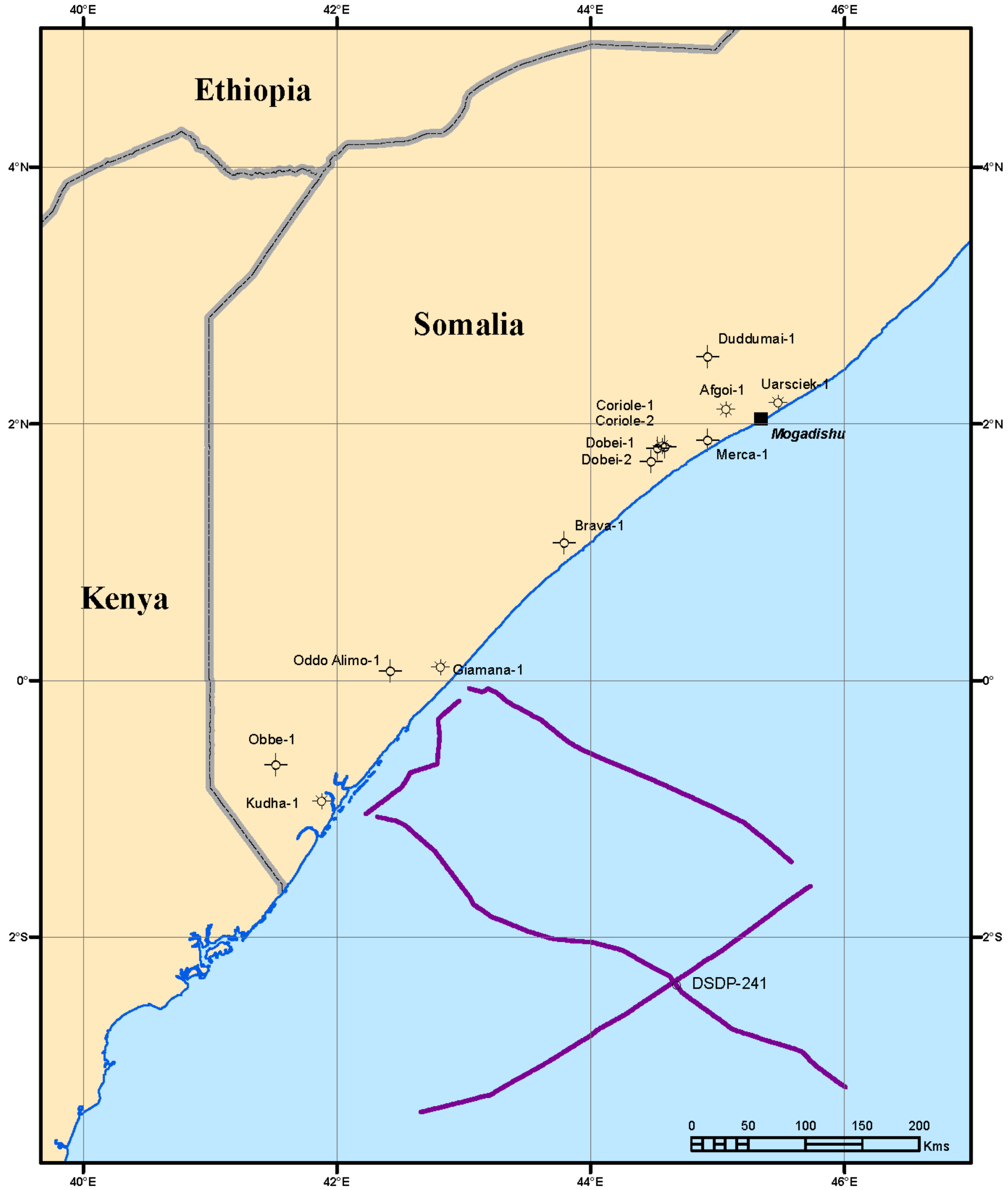


Figure 3.25: Lamon-Doherty Observatory (1980)

In 1983 a 670 line km 2D seismic survey was acquired by Geosource (previously Petty-Ray Geophysical) for the Somali Ministry of Mineral and Water Resources using vibroseis over the onshore Afgoi area.

The seismic survey was acquired as part a World Bank funded project. This project aimed to fund the development of the Afgoi-1 non-commercial gas discovery made by Sinclair in 1965 in the Upper Cretaceous Jessoma Formation. This would be achieved by the acquisition of new seismic and the drilling of 2 wells.

The seismic data was acquired using a 2600m split spread, 96 groups with a coverage of 2400% (Table 2.2 and Table 2.3).

The data were processed to migrated stack by Petty-Ray Geophysical.Data quality is fair.

On the results of the seismic data, two wells **Afgoi-2** and **Afgoi-3**, were drilled in 1984 and 1985 respectively.

Afgoi-2 was drilled between December 1984 and March 1985 to a total depth of 4194m (13761 ft) approximately 3.1 kms to the south of the Afgoi-1 well. The well location is within 200m of the intersection of lines TUS-10 and TUS-03-P1.

The objective was to target the Paleocene Sagaleh Formation within the Afgoi structure, a large faulted anticline affecting the Lower Miocene. The well reached the Upper Cretaceous. The well recorded minor gas shows in the Eocene and traces of gas in the Paleocene.

No hydrocarbons were observed in the seven DSTs and 5 RFTs carried out. Basaltic intrusions were noted in the Paleocene. The well was plugged and abandoned as dry.

The **Afgoi-3** well was drilled immediately after the Afgoi-2 well between April and June 1985 to a total depth of 4359m (14302 ft) in the Upper Cretaceous.

The well was to target the Paleocene Sagaleh Formation on the north western flank of the Afgoi structure. The well is located approximately 100m north of seismic line TUS-04 East and 400m east of seismic line TUS-27.

No significant shows were recorded in Afgoi-3 and no tests were run. The well was plugged and abandoned as dry.

The Afgoi-Coriole licence area remains as 51% owned by the government (Figure 3.26).

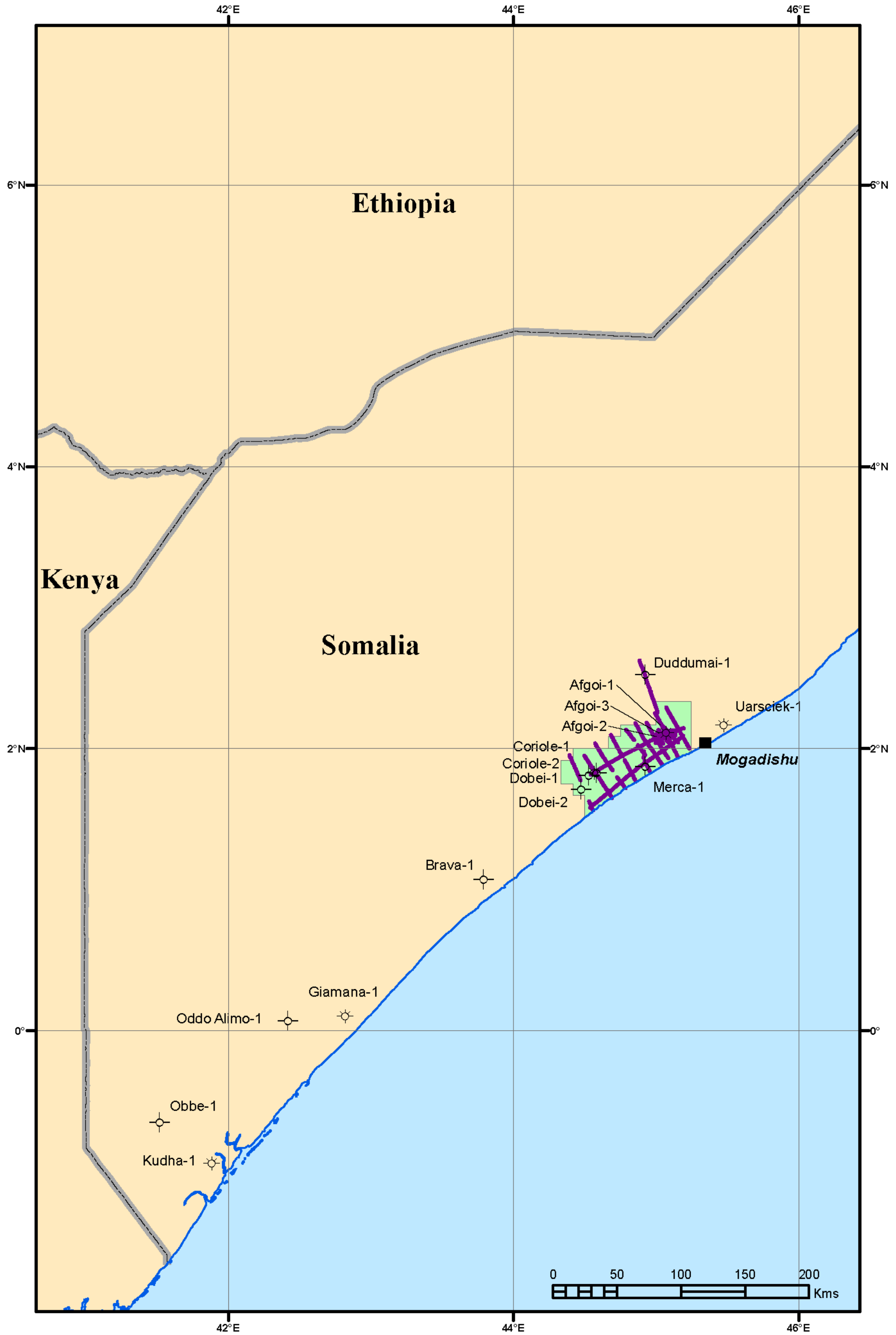


Figure 3.26: MMWR Afgoi 1983-Present

Elf-Aquitaine operated offshore Block 13 in the 1980's. In 1985 496 km of 48 fold 2D seismic data were acquired by the MV SV Explorer of Prakla-Seismos using airguns.

The survey was acquired using a 2400m cable with 120 groups and a 2400% coverage). These data were processed to migrated stack by Prakla-Seismos. Data quality is fair-good (Table 2.4 and Table 2.5).

No wells were drilled and Agip relinquished the acreage (Figure 3.27).

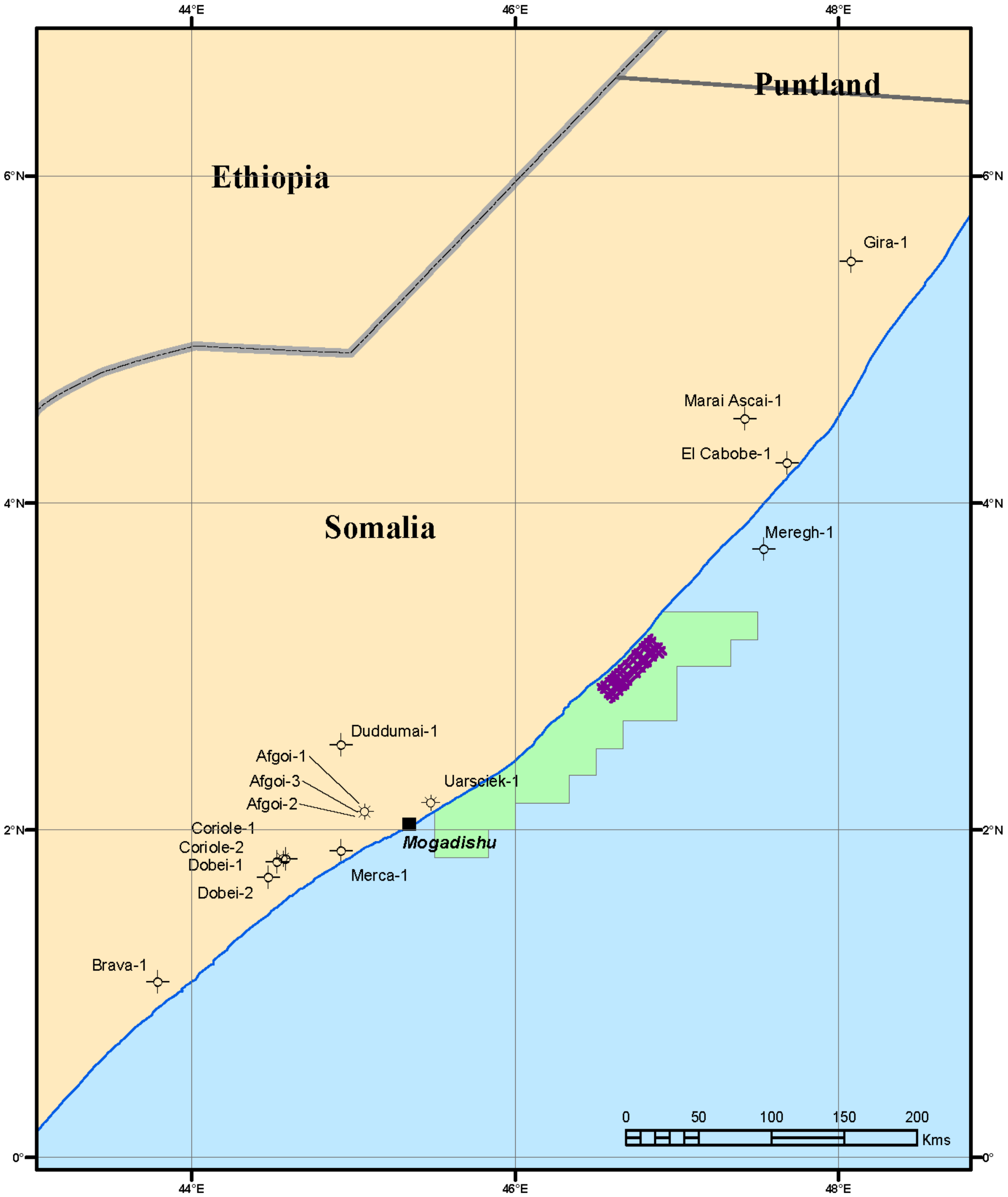


Figure 3.27: Elf-Aquitaine Block 13 1985

Amoco licensed onshore Blocks 6, 9 and 12 in 1987.

In 1988. 1687 km of 2D seismic data were acquired by Western Geophysical Company using vibroseis as a source. The survey was acquired using a 2987.5m split spread with 240 groups, shotpoint and group intervals of 25m with a resultant 12000% coverage. These data were processed to migrated stack by SSC. The seismic datum on this survey is +200m amsl. Data quality is fair-good (Table 2.2 and Table 2.3). This was the last survey acquired onshore Somalia.

The seismic survey tied into the Duddumai-1 and Brava-1 wells drilled by Sinclair in1959 and 1962 respectively.

On the basis of the interpretation of this seismic survey, the **Mudun-1** well was drilled between September and October 1990 to depth of 3045m (1000 ft) into the Upper Cretaceous. The well is located on VUY-16 1.7 km from the intersection with line VUY-12. The primary objectives were Lower Cretaceous sandstones in a structure defined by the seismic. The well failed to penetrate the Lower Cretaceous although sands were found in the Campanian. The well recorded minor gas shows in thin sands of the Paleocene and Upper Cretaceous. No tests were carried out and the well was plugged and abandoned as dry. This was last well drilled onshore or offshore Somalia (Figure 3.28).

No further seismic or drilling activity has been carried out as these licences are currently under force majeure.

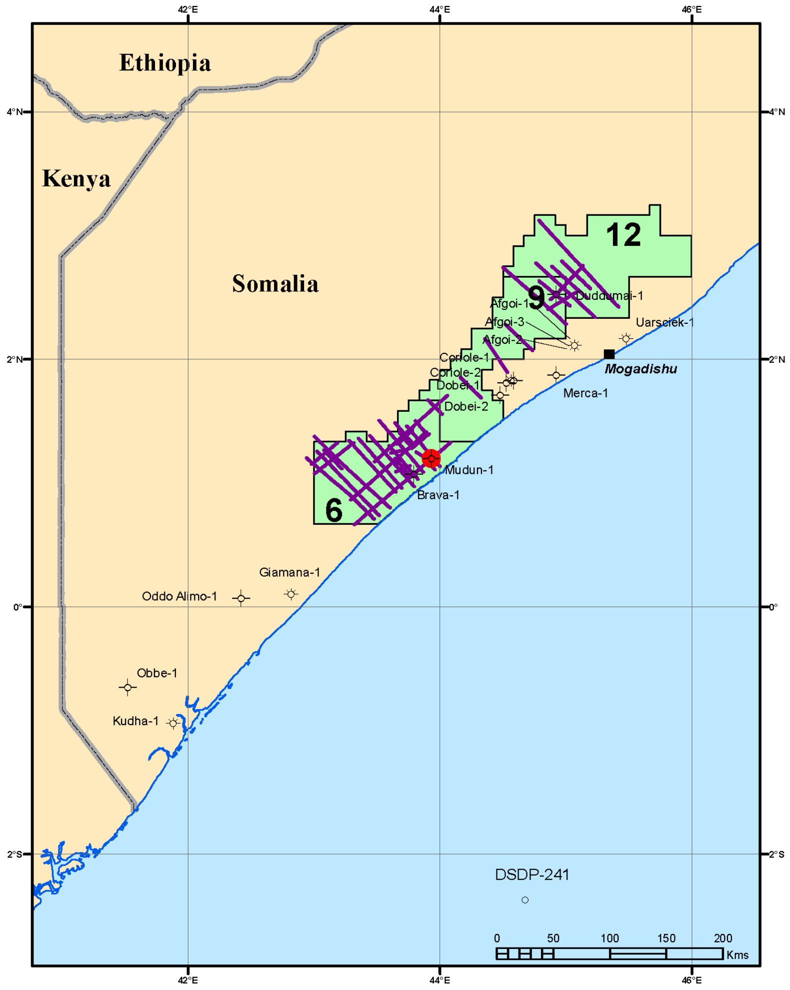


Figure 3.28: AMOCO Blocks 6, 9 & 12 1987-Present

Pecten hold the licensed offshore Blocks M-3,M-4,M-5,M-6 and M-7. In 1989. 1327 km of 2D seismic data were acquired by the MV Western Ocean of Western Geophysical. The survey was acquired with a shotpoint interval of 36.67m, a group interval of 13.33m using 300 groups on a 4000m cable. Coverage was 7500% This data were processed to migrated stack by CGG. Data quality is good (Table 2.4 and Table 2.5). This was the last seismic survey acquired offshore Somalia.

No wells have been drilled and the licences are currently under force majeure (Figure 3.29).

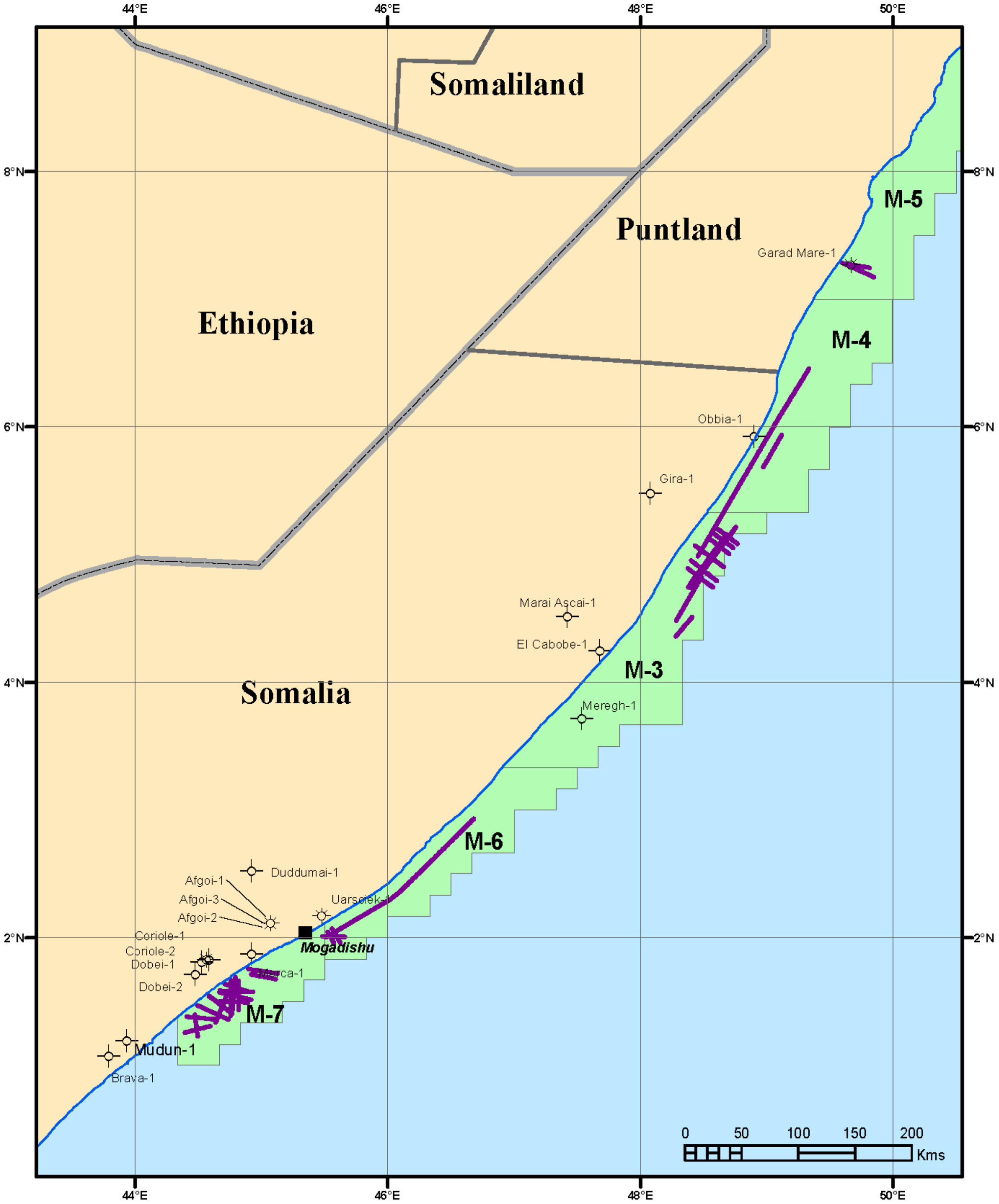


Figure 3.29: Pecten Offshore Blocks M-3, M-4, M-5, M-6 & M-7

In February 2001 Total-Fina-Elf signed a 12 month Technical Evaluation Agreement for the Jorre Basin offshore. This area covers approximately 57,000 sq km between Marka and Kismaayo in southern Somalia. The TEA was a one year contract which has now expired. (Figure 3.30).

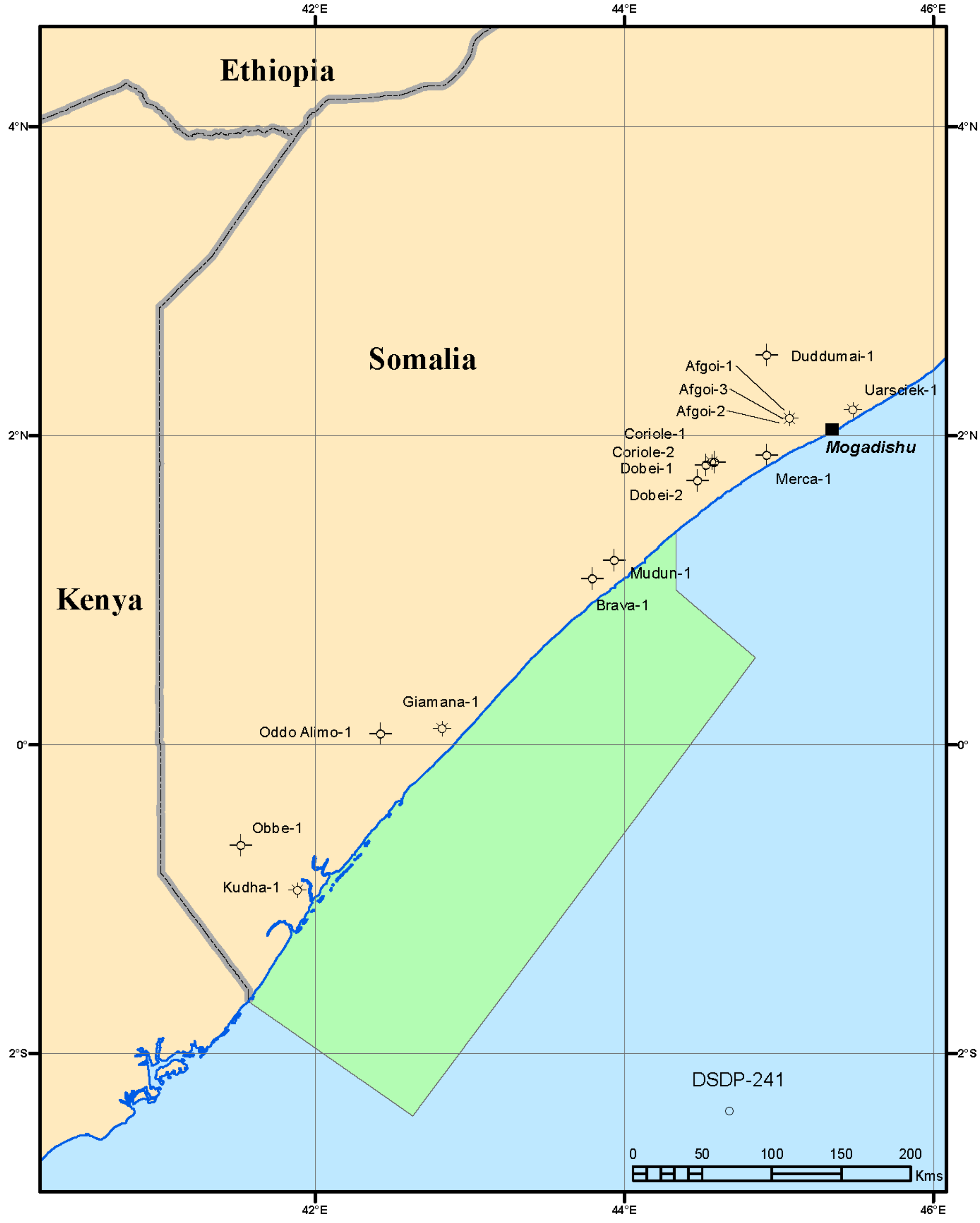


Figure 3.30: Total-Fina-Elf –TEA 2001-2002

4. REGIONAL GEOLOGY AND STRATIGRAPHY

The regional geology provides the context to evaluate the offshore Somali Basin and to predict hydrocarbon plays. With no exploration wells located in the deep offshore and only two wells drilled close to shore it is necessary to maximise information from onshore wells, the DSDP wells, and analogue basins, such as the Morondova and Majunga basins of NW Madagascar, and the along-strike Lamu Basin in north Kenya. The plate tectonic evolution of East Africa and the Indian Ocean is a fundamental part of the geological history.

4.1 Plate Tectonics

The plate tectonic history of Gondwanaland and the development of the Indian Ocean are fundamental to understanding the regional structural and stratigraphic setting of offshore Somalia. This is best explained in a series of generalised chronological events.

- Permo-Triassic: Early Karoo rifting of the Gondwana supercontinent created intra-continental rift basins in which Karoo sands, organic rich lacustrine mudstones and coals were deposited. The Permo-Triassic Sakamena Series in Madagascar are the proven source rocks for the large Bemolanga and Tsimiroro heavy oil fields of north-west Madagascar, and are evidence of this Karoo rifting episode. Most of these rifts 'failed' and did not reach the drift phase.
- Late Triassic-Early Jurassic: East Gondwana rifted from the African mainland of West Gondwana. East Gondwana comprised The Seychelles, Madagascar, India, Antarctica and Australia. The accepted plate reconstruction (Coffin and Rabinowitz, 1992, & Borsellini, 1992) places Madagascar adjacent to the Somali coast originally so that NW Madagascar and South Somalia/NE Kenya are conjugate passive rift margins (Figure 4.1). A restricted marine setting existed in the rift valleys and resulted in the development of marine shales (e.g. Meregh Fm. in Somalia), and evaporites known from Tanzania and NW Madagascar.
- Mid Jurassic-Early Cretaceous: Open marine conditions existed from Mid Jurassic. The Davie Fracture Zone was an active right-lateral transform fault from Mid Jurassic (160 Ma) to Aptian (120 Ma) as East Gondwana moved southward, relative to West Gondwana, and Madagascar reached its current position. During this period the Somali Basin continued to open and sea-floor spreading produced oceanic crust between Madagascar and mainland Africa (Figure 4.1). A major pre-Aptian regional unconformity occurred in Somalia and, according to Bosellini (1992), this Neocomian uplift was possibly caused by distal intra-plate stresses resulting from the separation of South America from Africa, and the development of the West and Central African rift systems.
- Late Cretaceous-Palaeocene: Antarctica and Australia separated from the Seychelles and India in Mid Cretaceous and drifted south and east, respectively. Later transcurrent rifting then separated the Seychelles and India from Madagascar, opening up the Mascarene Basin east of Madagascar. Rifting commenced in Mid Cretaceous (~100 Ma) and oceanic crust formation was formed from Santonian - Campanian (80-85 Ma) as India and the Seychelles drifted north-eastward. Clockwise rotation brought the Seychelles to its current orientation (Figure 4.2).
- Palaeocene: India separated from the Seychelles and the Arabian Ocean opened up. India drifted northwards and collided with the Eurasian Plate to form the Himalayas. A major left-lateral transform fault bounded the south-eastern edge of the Arabian Plate (Figure 4.2).

- Oligocene: At the end of Early Oligocene the main rift phase began in the Gulf of Aden, north of Somalia. At this time, much of onshore Somalia was affected by a period of uplift and sub-aerial erosion that caused a regional unconformity.
- Miocene: The separation and drift phase of Arabia from Africa (the Somali Plate) started in Mid Miocene in the Gulf of Aden.

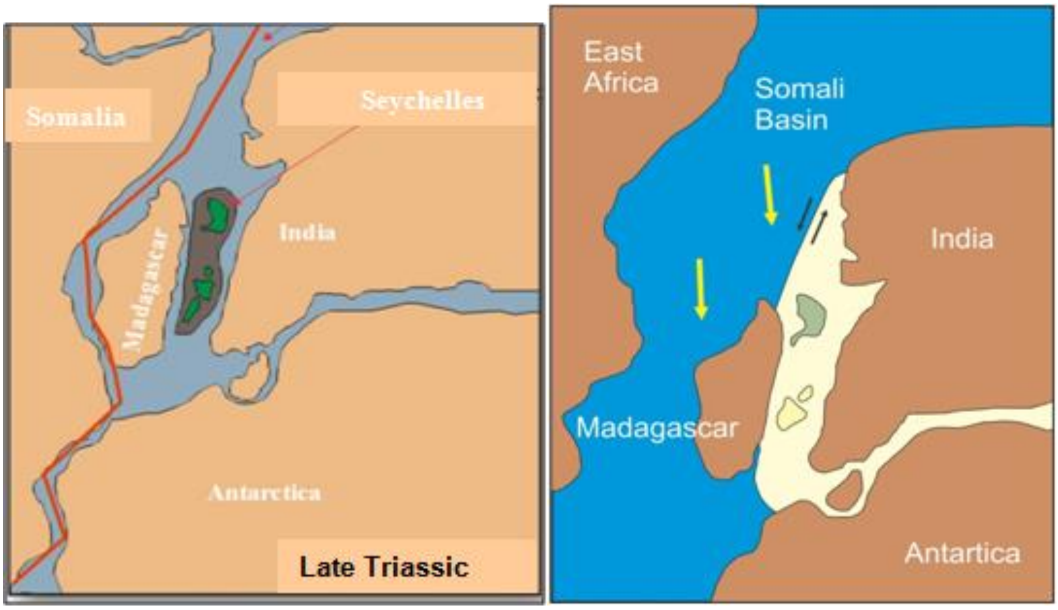


Figure 4.1: Plate Positions: Late Triassic to Early Cretaceous

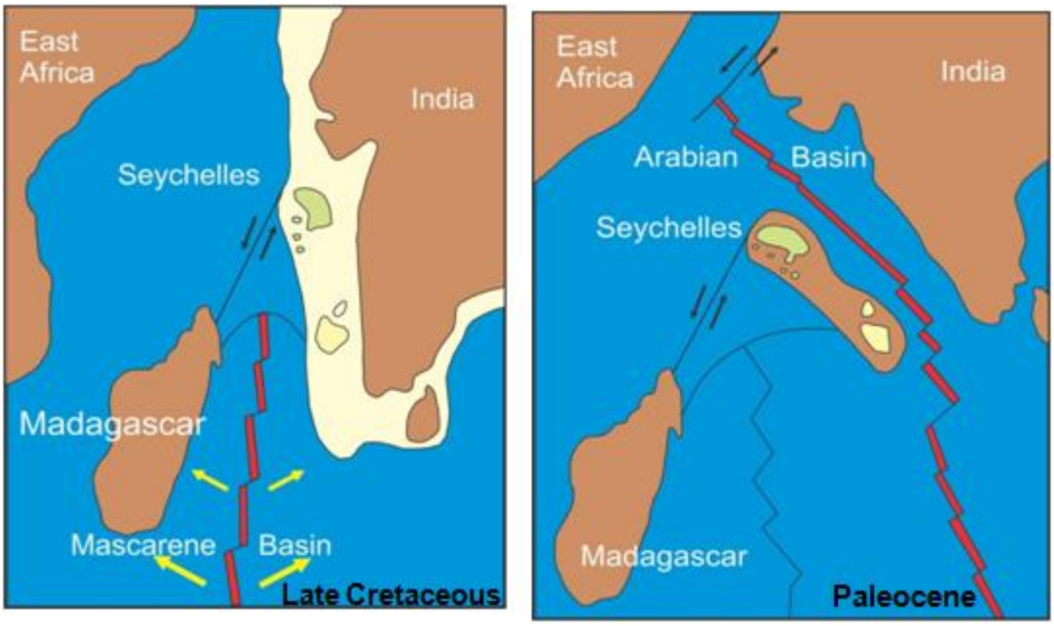


Figure 4.2: Plate Positions: Late Cretaceous – Palaeocene

4.2 Regional Structure

This plate tectonic history is reflected in the regional gravity data of the India Ocean where gravity high zones are identified (Figure 4.3). The most significant is the Davie Fracture Zone that extends from NE Kenyan coast to south west of Madagascar (Coffin and Rabinowitz, 1987). The Chain Ridge was created by the relative motion between the Indian and African plates commencing in Late Cretaceous.

Other gravity anomalies, named by Bunce and Monar (1977), are the VLCC and Dhow basement ridges that appear to be complex features rather than simple fracture zones but were caused by the separation of Madagascar and Africa. The ARS Fracture Zone appears to define the south extent of the North Somali Basin. This gravity anomaly is interpreted to curve west to intersect the north Somali coast approximately where the El Hamurre Fault is defined onshore (Cochran, 1988). Another gravity anomaly intersects the coast further south (the Mid Somali gravity anomaly?) and may merge with the ARS zone offshore. Both this anomaly and the ARS zone are probable transform fault zones analogous to the Davie FZ (Figure 4.3).

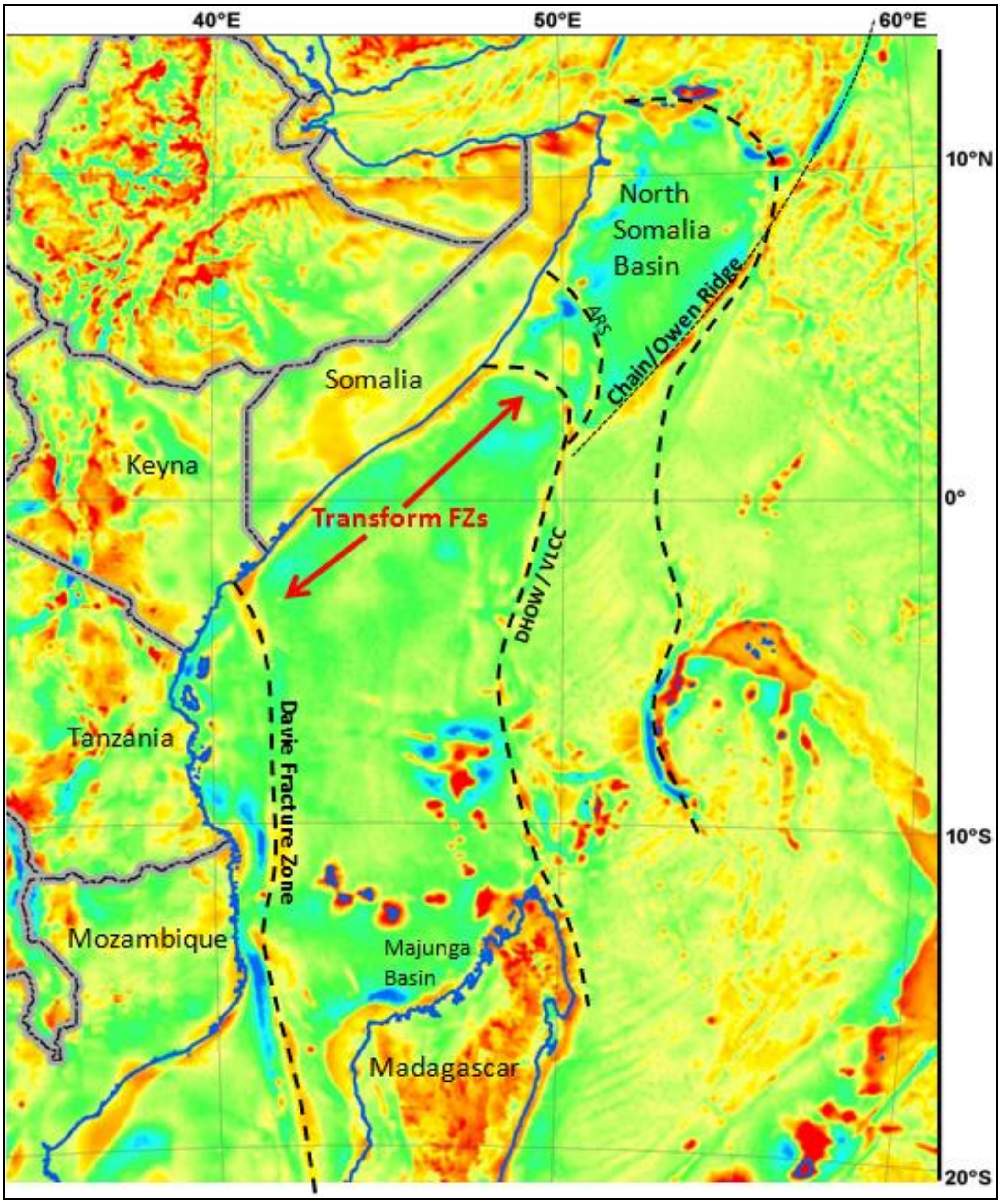


Figure 4.3: Indian Ocean Gravity Map

4.3 Somalia Structural Elements

The main structural features of the onshore Somali Basin are shown combined with bathymetric contours and gravimetric data in the offshore in **Error! Reference source not found.** Main features are the Bur Acaba High comprising basement outcrop. This high is bound to the south east by the Duddimai fault system that steps down into the thick Upper Cretaceous - Tertiary of the Coriole Basin and its seaward extension into the Mogadishu Sub-basin. The Coriole and Mogadishu sub-basins are dominated by listric faults and tilted fault blocks (Harms and Brady (1989) but also localised structural inversion in the Tertiary, as seen in well Merca-1 where there is a Late Eocene unconformity. There is also a distinct erosional Upper Oligocene-Palaeocene unconformity in well Brava-1 but whether this is due to Tertiary structural activity in the Coriole Basin or reactivation of the Brava Fault is unclear. Tertiary beds thin northward into the Obbia or Mudugh Sub-basin.

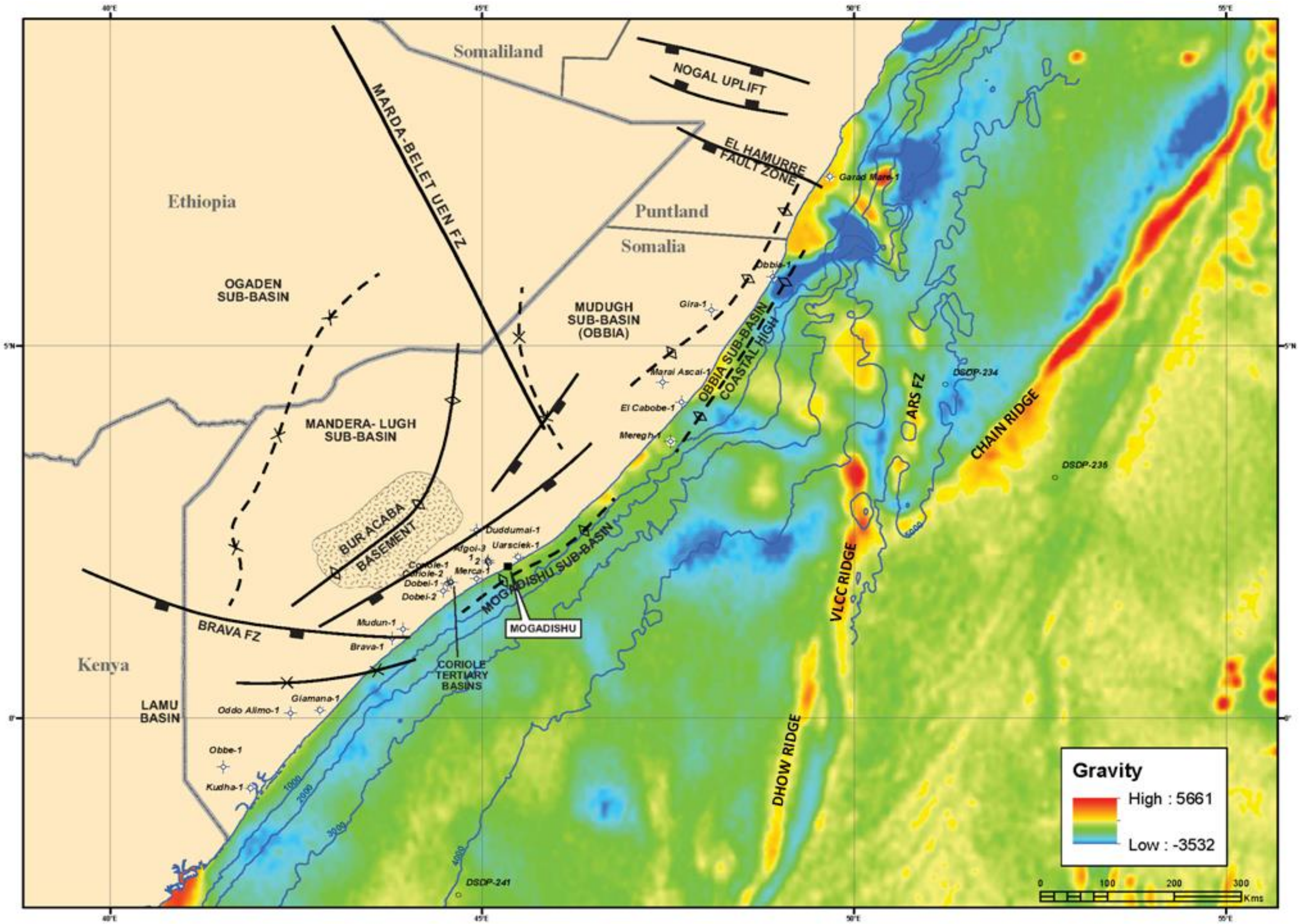


Figure 4.4: Structural Elements of Somali Basin

The Brava Fault, the Marda-Belet Uen FZ and the Mandera-Lugh Sub-basin have origins in the Karoo rift system. The Brava Fault appears to have been active from Late Palaeozoic to Tertiary, and commonly influenced depositional patterns onshore Somalia with deeper water conditions commonly prevailing south of the fault. South-west of the fault, the Juba-Lamu Sub-basin has a thicker Tertiary than the Coriole Basin.

The WNW-ESE trending El Hamurre Fault Zone bounds the Mudugh Sub-basin (aka Obbia Sub-basin) to the north-east. This fault has a structural influence on deposition patterns and often appears to separate two different lithostratigraphic provinces, NE and SW of the fault. The fault also separates the west-east trending structural style to the north, which is more affected by the interactions of the African and Arabian plates to the north, from the down-to-the-basin NE-SW fault trend to the south in the Mudugh Sub-basin. Offshore bathymetry and gravity shows that the El Hamurre FZ continues into the offshore where it is associated with a gravity high indicative of shallowing basement (Figure 4.4). It is likely that the El Hamurre Fault is a transform fault and it can be traced in the offshore to the ARS FZ.

Further south along the coast another anomaly based on gravity and bathymetric data can be inferred in the Obbia Sub-basin. Harms and Brady (1989) do not report any major NW-SE trending fault onshore at this point, located just north of well Marai Ascia-1, as might be expected. It is a point of speculation that this Mid-Somali coastal gravity trend may represent the position of another transform fault that can be extrapolated to the VLCC basement ridge in the offshore (Figure 4.4).

4.4 Stratigraphic History

The stratigraphic and tectonic history of Somalia are summarised in Figure 4.5. This gives the generalised stratigraphy for wells in the north and south coastal areas of onshore Somalia, based on well sections by Harms and Brady (1989); Bosellini (1992); and the well reports by Robertsons/CGG (2014). The lithostratigraphy nomenclature generally conforms to that of CGG, seen in Figure 4.6, although there are some name revisions from the earlier work of Harms, Brady and Borsellini, most particularly in the Upper Cretaceous and Lower Tertiary.

The nomenclature of CCG has been used for well and seismic tops in this report. However, the seminal work of Harms and Brady (1989), and the subsequent update and publication by Borsellini in 1992, largely use the nomenclature shown in Figure 4.5.

Regional tectonic events and sequence stratigraphic lowstands and transgressions shown in Figure 4.5 are adapted from Bosellini, 1992 as are the palaeogeography maps contained in this report.

The sequence stratigraphy in Figure 4.5 is simplified to infer potential deep-marine sandstone deposition on the continental slope and basin-floor at ‘lowstands’, and the potential for source-rocks during periods of transgression and highstands. The presence of these beds is also dependent on several other factors, such as sediment supply and anoxic conditions. It is recognised that reservoirs are not just confined to lowstands but may also exist in sands or carbonates in other sequence types.

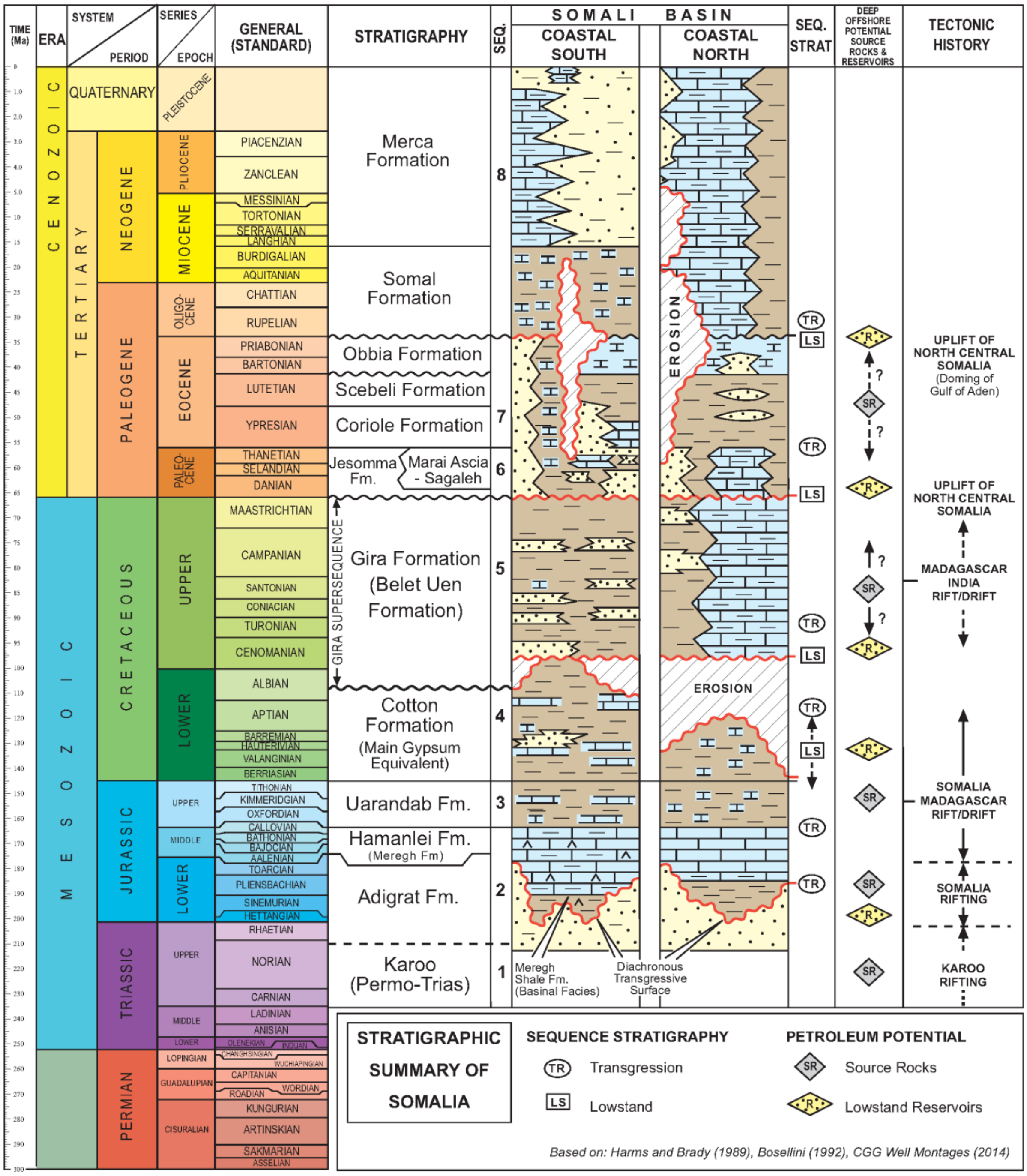


Figure 4.5: Stratigraphic Summary of Somalia

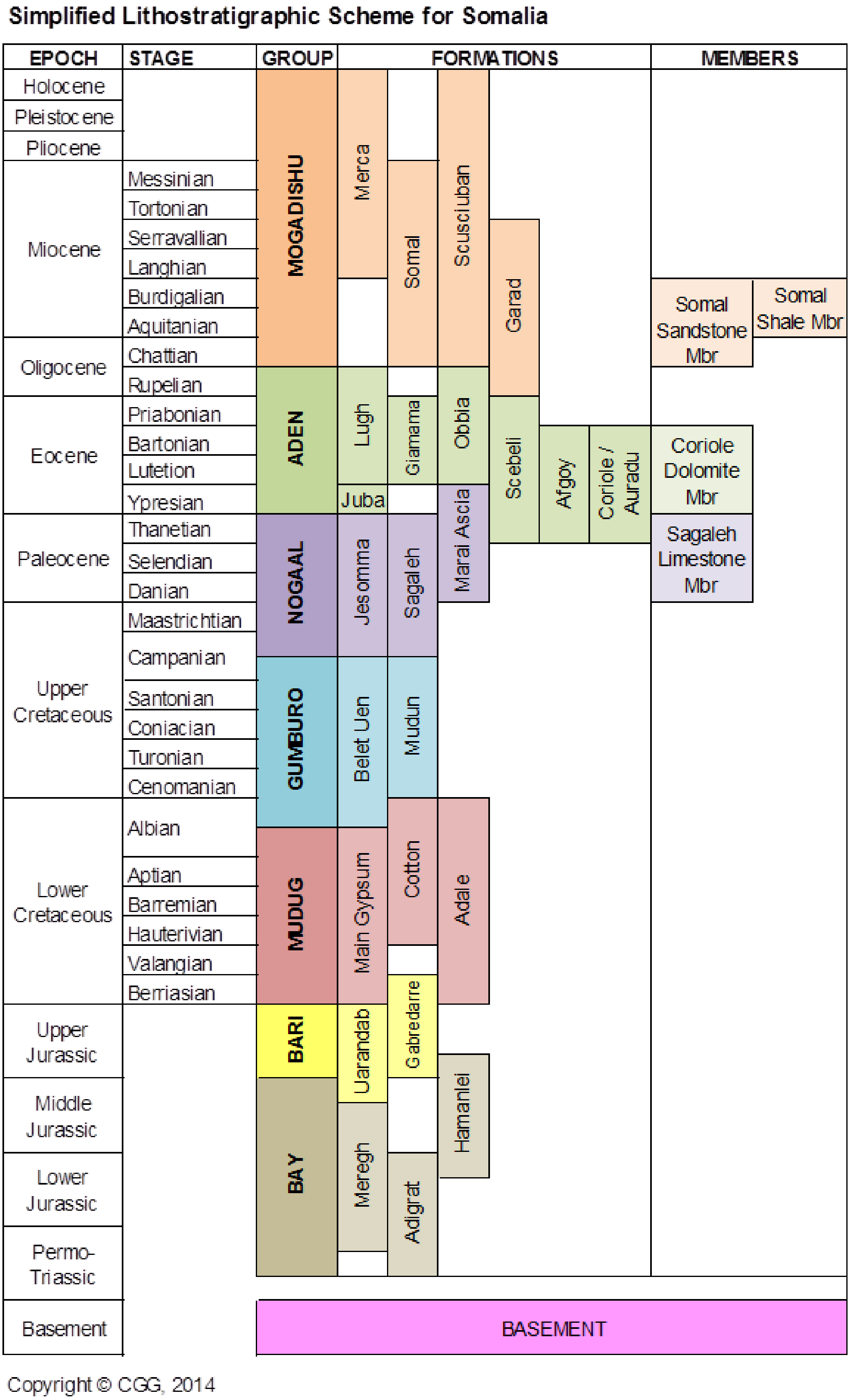


Figure 4.6: Stratigraphic Nomenclature from CGG (2014)

4.4.1 Pre- Mid Jurassic

A network of rift basins developed in Gondwanaland during Permian to Early Jurassic before the separation and drift of East Gondwana (comprising Seychelles, Madagascar, India, Antarctica and Australia) from West Gondwana (mainland Africa and South America) began in Mid Jurassic.

Late Palaeozoic to Early Jurassic Karoo continental sediments were deposited in intra-continental rift basins (Figure 4.7). Many of the basins failed to develop beyond the rift phase and are considered ‘failed arms’, such as the Mandera-Lugh Basin in Somalia. Others were later split apart by the Gondwana fragmentation and incorporated into present day continental margins, such as the Lamu Basin in south Somalia and Kenya.

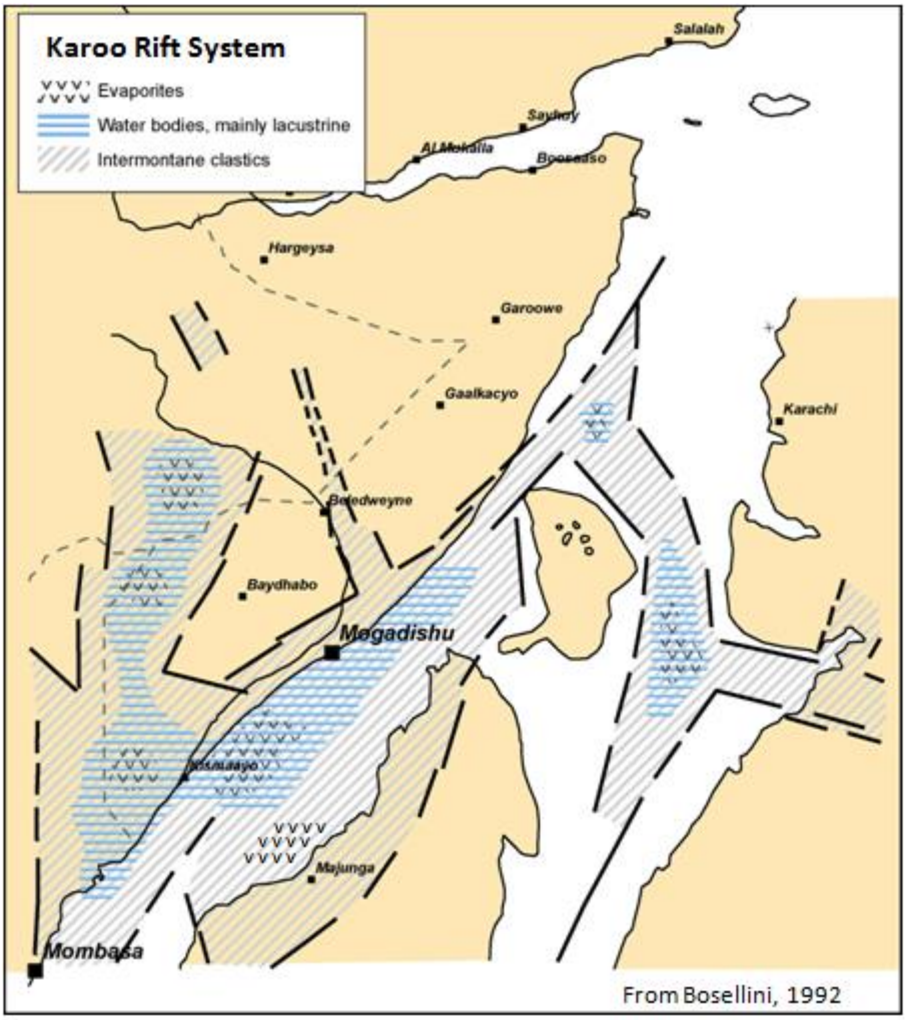


Figure 4.7: Karoo Rift Systems

According to Harms and Brady (1989) Karoo sediments lie directly on metamorphic basement and are Late Permian to Late Triassic in age. Karoo beds are fluvial and lacustrine deposits and have been drilled extensively in the Ogaden area of Ethiopia but unmetamorphosed Karoo beds have been rarely found in Somalia.

Overlying the Karoo beds are Triassic – Lower Jurassic Basal Clastics or the Adigrat Sandstone Fm. This formation consists of interbedded continental sands and shales. The sands are dominantly fluvio-lacustrine deposits, and are usually felspathic, well cemented and with poor to fair porosity, although coarse, better quality sand layers do exist. These sands are not always distinctive from underlying Karoo beds and they may be equivalent in age to the Upper Karoo. The transition from the Karoo Series to Adigrat Sandstone was diachronous and controlled by rift-affected palaeo-topography in Early Jurassic (Bosellini,1992). Time-equivalents of these sands are widespread and are found throughout East Africa, and in Madagascar, Yemen and India. All these areas were linked in Early Jurassic and largely lay under sub-aerial conditions, although some shallow marine beds have also been encountered.

Adrigrat Sandstones were reached in the base of two wells in the northern Somali coastal area; at El Cabobe-1 and Garad Mare-1 (Figure 4.4). Harms and Brady (1989) proposed that the basal 2,600 ft (793m) thick section found in the well Brava-1 was Karoo Series sands and shales. However, the well report by Robertson CGG in 2014 shows this interval as Triassic-Lower Jurassic Adigrat Sandstone Fm overlain by Lower Jurassic Meregh Fm. shales, a sequence that post-dates Karoo *sensu stricto*.

The upper boundary of the Adigrat Sandstone is diachronous and transitional with the Lower-Middle Jurassic Hamanlei Fm. shallow marine carbonate or the coeval basinal marine Meregh Shale Fm that developed in rift basins (Harms and Brady, 1989). This transgressive upper surface was the result of Early Jurassic rifting and the gradual onlap of marine sediments.

Figure 4.8 is a Late Liassic palaeogeography reconstruction based on Bosellini (1992) and revised after Harms and Brady's original work. It shows the dominant environment and facies following the major Liassic transgression of the Karoo rifts via the 'Pakistan Portal', which was the connection to the Tethyan Ocean. Terrestrial beds comprised mostly Adigrat Sandstones. Shallow water carbonates with evaporites and higher energy platform carbonates are represented by the Hamanlei Fm. Basinal marine sediments are dominantly the Meregh Shale Fm. According to Bosellini (1992) Meregh Shales are confined to the Mudugh or Obbia Basin and the Mandera-Lugh Sub-basin.

Well Hol-1 is located in the Mandera-Lugh Sub-basin (Figure 4.8). It penetrated a thick interval of Lower Jurassic anhydrites and dolomites between underlying Meregh Fm basinal mudstone and overlying shallow marine Hamanlei carbonates. Equivalent Lower Jurassic evaporites are also known in the Mandawa Basin of Tanzania. Highly mobile halites are observed on seismic from the Majunga Basin of NW Madagascar and are interpreted to be Liassic in age, although they are not yet drilled.

Coffin and Rabinowitz (1992) interpreted salt tectonics on seismic in the offshore Lamu Basin of NE Kenya and SW Somalia. But Davidson and Taylor, 2012, suggest that 'the structures previously interpreted as salt diapirs appear to be shale-cored compressional anticlines'. Thus, the presence of halites has yet to be confirmed in south Somalia although recently acquired seismic data gives provisionally positive indications of salt tectonics.

According to Coffin and Rabinowitz (1992), 'oceanic crust was created in the Western Somali Basin between Mid Jurassic and Early Cretaceous, hence no pre-Jurassic rocks should be present in the (offshore) Western Somali Basin'. It is assumed that this refers to the areas seaward of the Continent-Ocean Boundary (COB) where oceanic crust was formed. Although the position of the COB is speculated by Coffin and Rabinowitz in 1987 & 1992, it remains poorly defined offshore Somalia at this time.

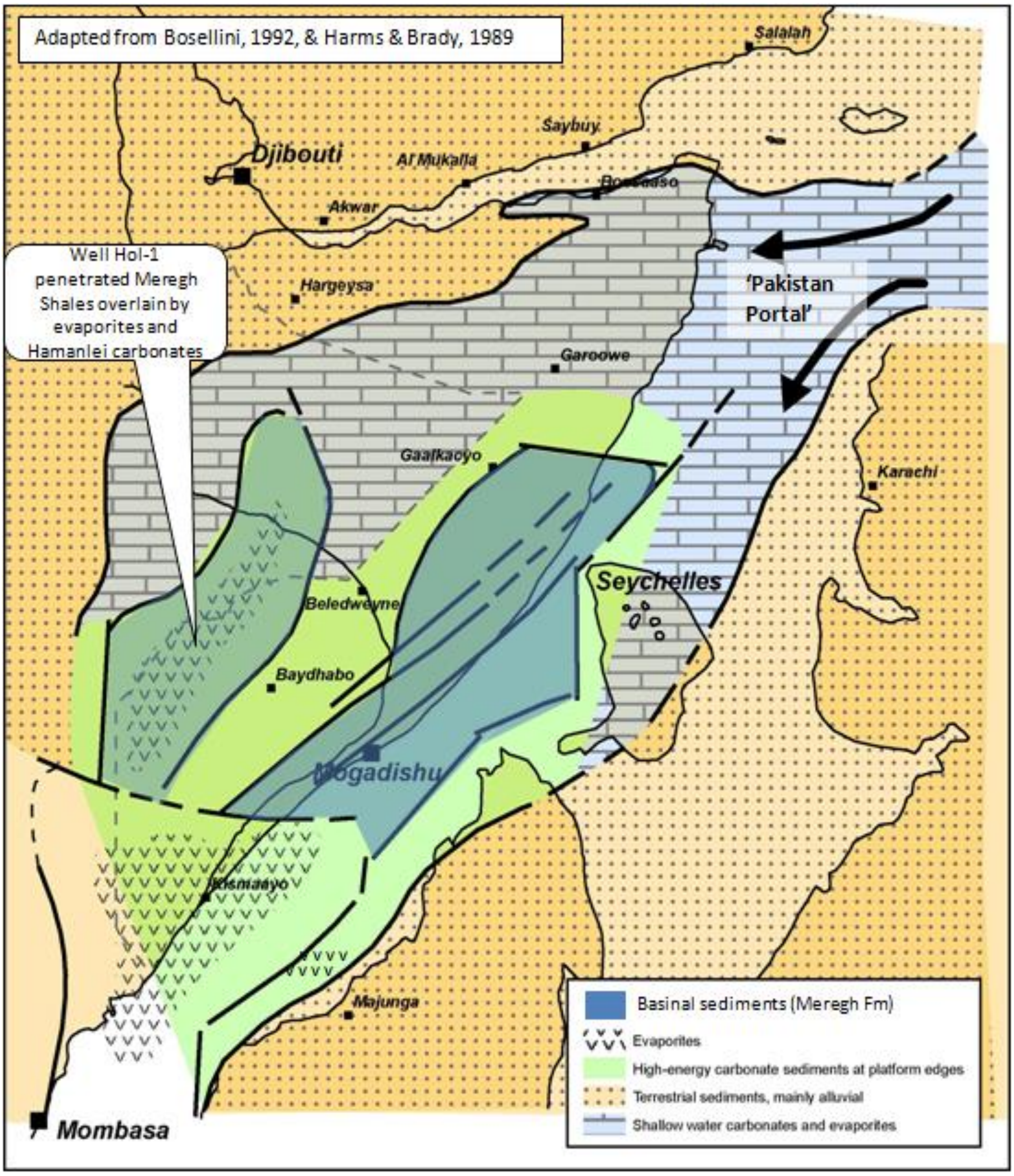


Figure 4.8: Late Liassic Palaeogeography

4.4.2 Mid to Late Jurassic

East Gondwana rifted from West Gondwana in the Early Jurassic and drifted southward through dextral shear of the Davie transform fault. Sea-floor spreading began in Middle Jurassic Callovian and ceased in Early Cretaceous Hauterivian when Madagascar reached its present position. South-east Somalia and NE Kenya, and north-west Madagascar of the Majunga Basin represent a conjugate passive rift margin pair. The Davie Fault Zone was an active transform fault for more than 30 million years until Mid Cretaceous. The onset of Madagascar/Seychelles drift to the south in the Callovian marked the beginning of a quieter period of regional subsidence, although some rifting and syn-depositional section growth persisted into Early Cretaceous, according to Bosellini (1992). As a consequence of this pre-drift plate fit, NW Madagascar is a good analogue for what is predicted in the offshore Somali Basin.

The onshore coastal wells in the Somali Basin generally contain shallow marine Lower-Middle Jurassic carbonates of the Hamanlei Fm. that were deposited in a regressive depositional sequence across the platform (Figure 4.8).

Upper Jurassic Uarandab Fm open marine muds and marly beds were then deposited in a phase of regional transgression and basin deepening. In onshore wells this formation is represented by marine mudstones overlain in places by shallower marine carbonates deposited in a regional regression (Gabredarre Fm) – see Figure 4.9.

There is little known evidence of Upper Jurassic siliciclastics in onshore wells, based on Harms and Brady (1989) and Bosellini (1992), and deepwater shales and some shallow water carbonates dominated. This indicates that there was no significant provenance to supply quartzose sands into the offshore Somali Basin, unless there were local sources in the offshore, perhaps rotated fault blocks. Therefore, Upper Jurassic sand reservoirs in the offshore may be rare and deep marine carbonate muds are likely to be the dominant facies. However, the Uarandab Fm. shales may have source rock potential.

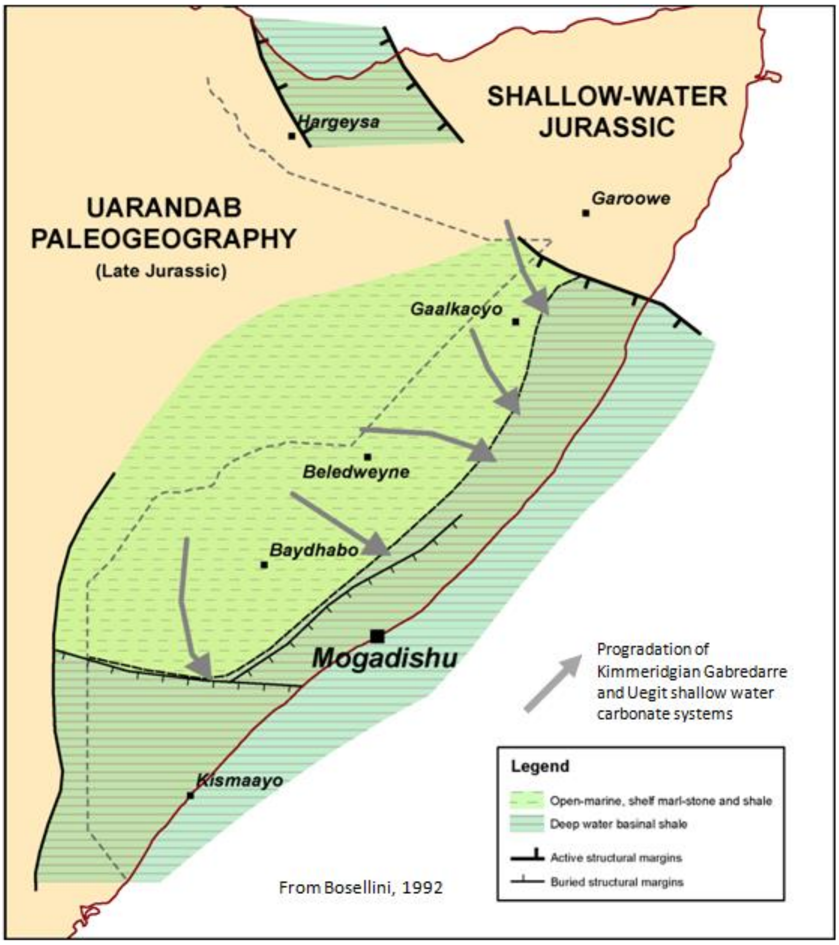


Figure 4.9: Late Jurassic Palaeogeography

4.4.3 Early Cretaceous

Early Cretaceous was a time of relative lowstand across Somalia caused by a tectonic pulse and a eustatic sea level fall. This resulted in the Pre-Aptian Unconformity, and Necomian to Barremian intervals are absent in many wells. Onshore Somalia and Ogaden was a shallow restricted marine basin at this time where the Main Gypsum beds developed in a sabkha setting. A narrow belt of high energy carbonates separated this inner basin from the continental margin to the east. East of this belt in the coastal and offshore areas basinal marine shales were dominant. These beds represent the Cotton Fm of the coastal basins (Figure 4.10).

Significant erosion of Lower Cretaceous beds was caused by a combination of tectonic uplift and a lowstand phase, which produced the Pre-Aptian Unconformity. Clastic influx occurred from local provenance areas, such as the fluvial Ambar Sandstone from SE Kenya into the Mandera-Lugh Basin, and sands may have been transported seaward into the deep offshore.

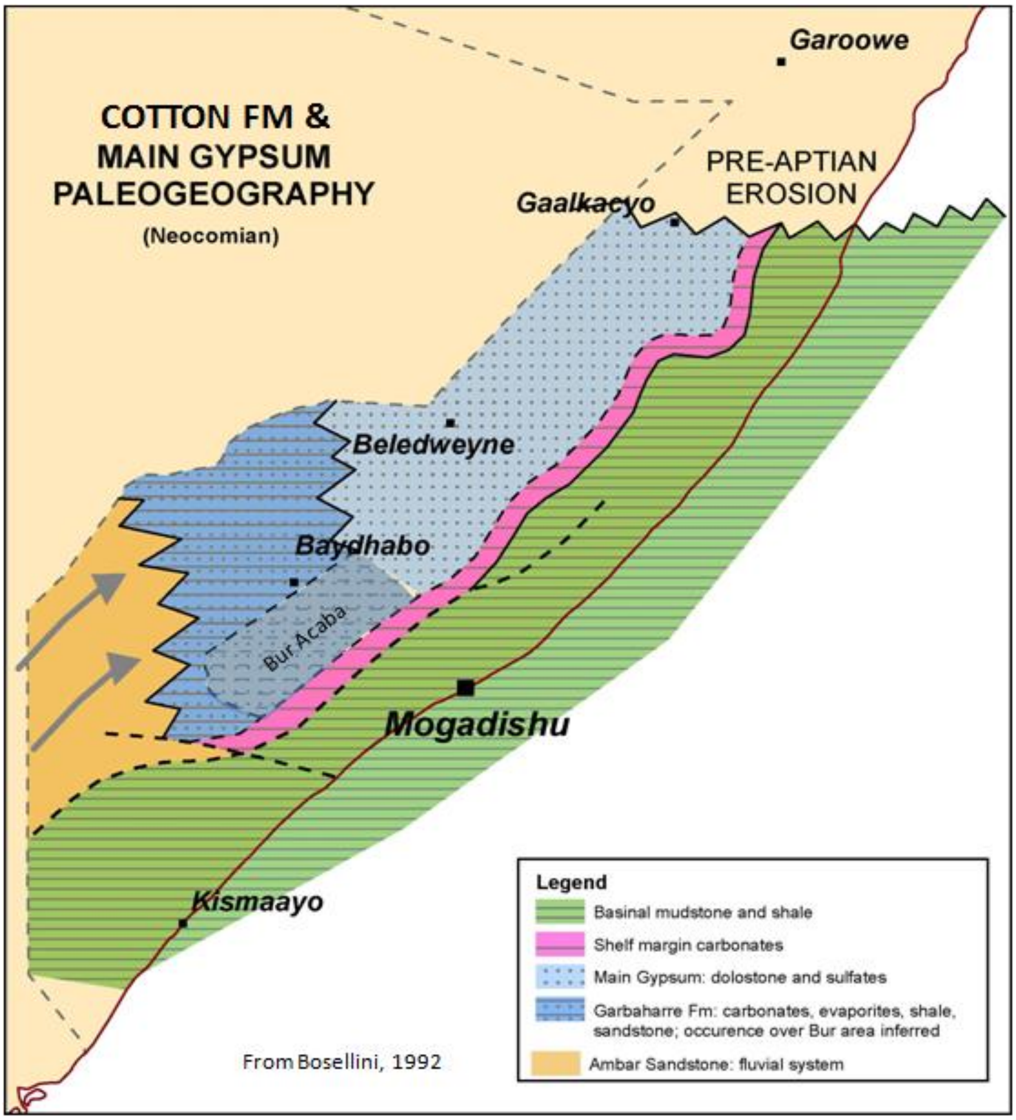


Figure 4.10: Early Cretaceous (Neocomian) Palaeogeography

4.4.4 Mid-Late Cretaceous

The Aptian transgression flooded most of Somalia and a series of shallowing-upward carbonate cycles developed with rudists and coral beds at the top of cycles in some areas during Mid to Late Cretaceous. Deeper marine conditions prevailed in Somali coastal regions south-west of the El Hamarre fault as the Gira Fm (Figure 4.11). Some Coniacian and Senonian deltaic, marginal marine and turbidite sandstones are encountered in wells in the Mogadishu Sub-basin, e.g. at Bio Addo-1 and Uarshiek-1.

The Aptian to Senonian was a relatively placid period with a vast shelf that gently dipped seaward and the facies reflected the sea-level fluctuations. Conditions in central-south

Somalia were mostly deep-water basinal with some terrigenous supply, possibly from the exposed Bur Acaba and Mandera-Lugh provenance areas. Carbonates were more prevalent in the NE coastal areas whilst sands were more common in the SW area. This indicates that sands, mostly likely as turbidite deposits, may be more probable in the offshore of the Mogadishu Sub-basin compared to the Obbia Sub-basin.

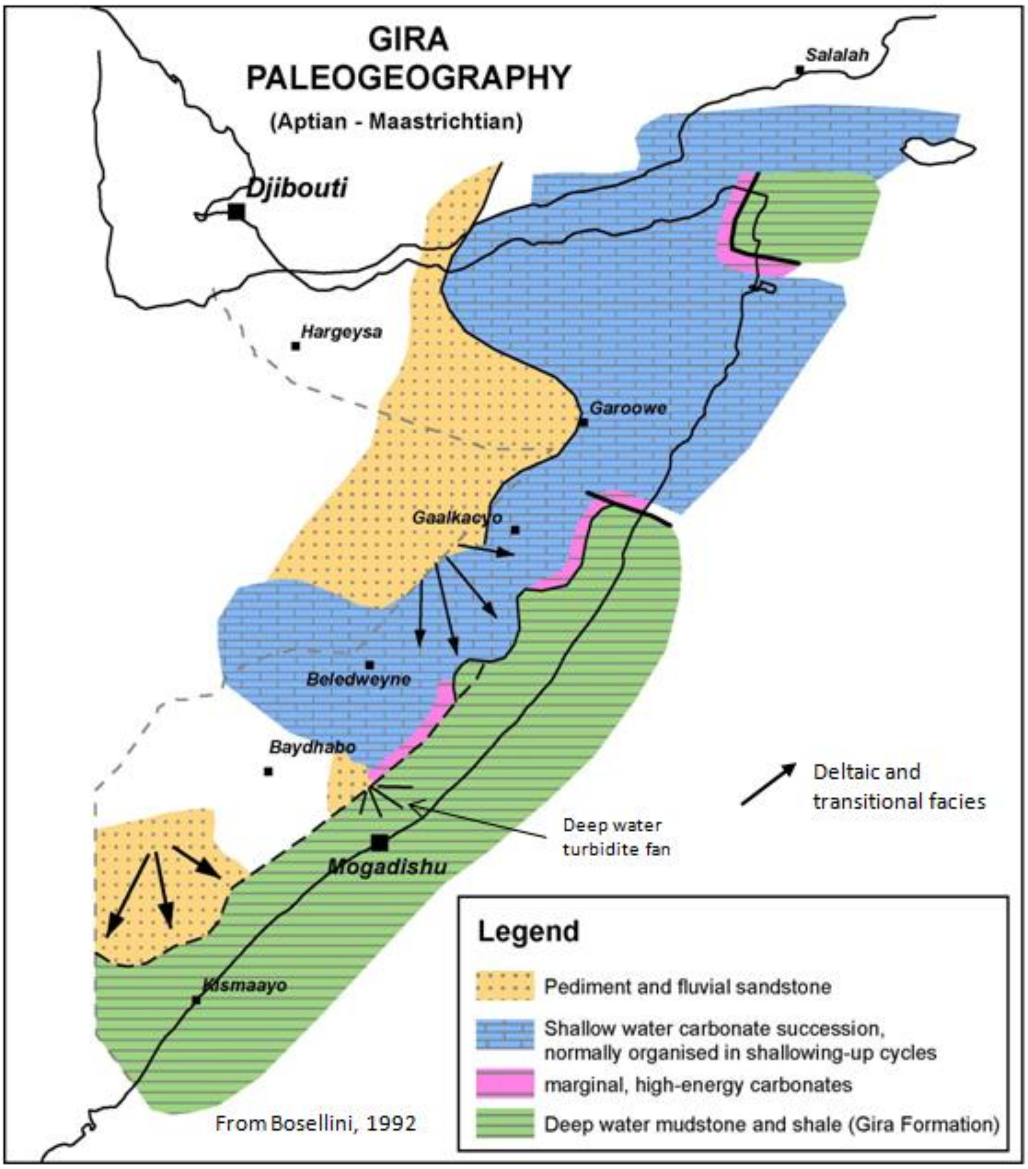


Figure 4.11: Mid-Late Cretaceous Palaeogeography

4.4.5 Maastrichtian to Palaeocene

The Maastrichtian-Palaeocene Jesomma Fm is bound by unconformities and its base marks a broad regional truncation that followed widespread uplift and block faulting. This tectonic episode may have been related to the rifting between India and the Seychelles Platform and the northward drift of the Indian Plate.

Four facies belts of the Jesomma Fm are traced from west to east across Somalia, these are: fluvial sands of the Jesomma Fm; a marginal belt of shallow marine sands, shales and carbonates; shallow water carbonates; and deep marine shales of the diachronous Sageleh Fm in the coastal and offshore area. From the Mogadishu Sub-basin southward a more deltaic setting replaced the basinal environment (Figure 4.12).

The erosional base of the sequence is a lowstand and this may have resulted in sand transportation into the deeper offshore basinal areas. From onshore palaeogeography, the probability of this occurring appears higher in the offshore Mogadishu Sub-basin area than in the Obbia Sub-basin.

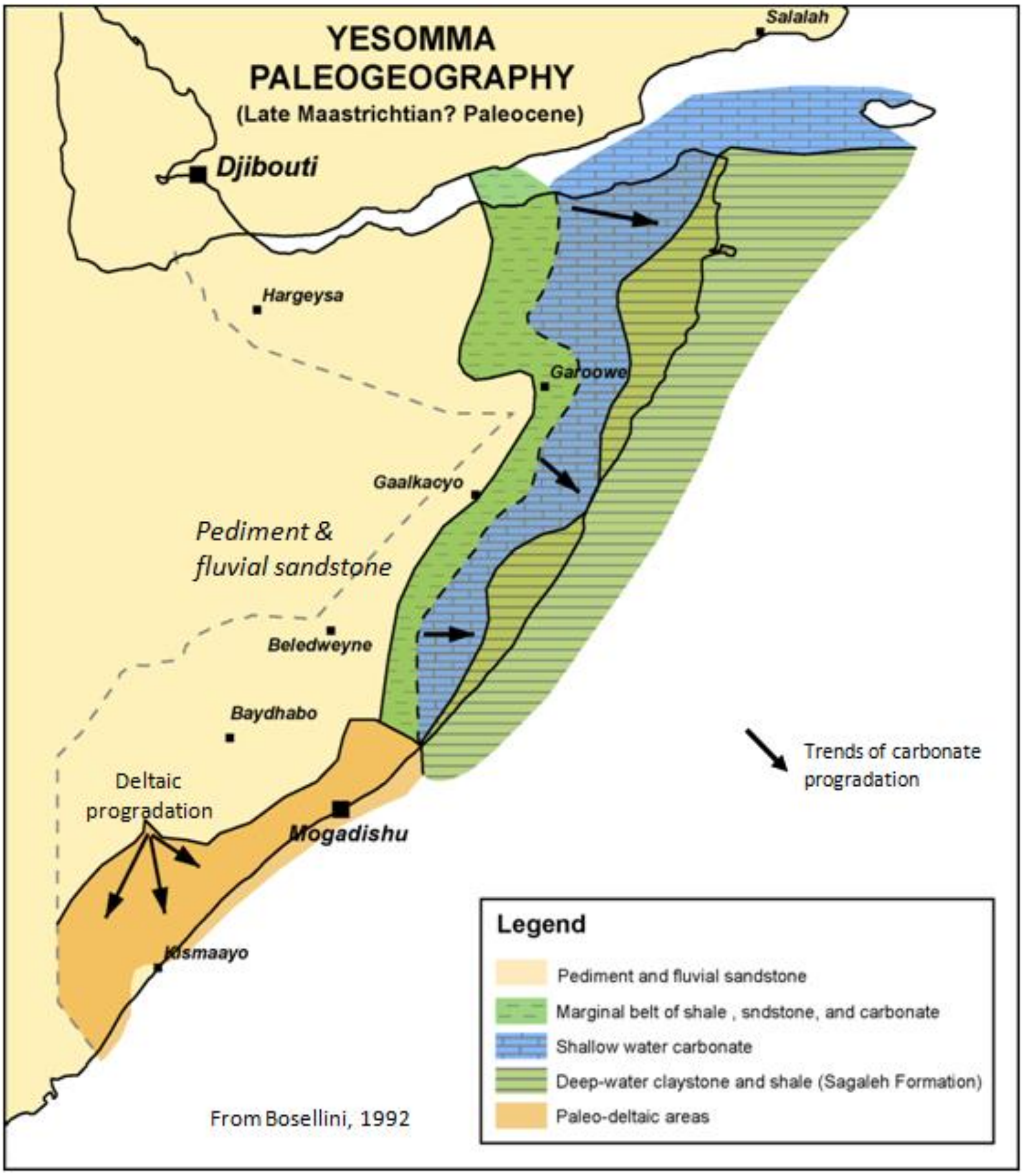


Figure 4.12: Maastrichtian - Palaeocene Palaeogeography

4.4.6 Eocene

The lithostratigraphy of the Eocene established by Harms and Brady, and Borsellini, has been revised by CGG and Robertsons more than any other stratigraphic unit. The palaeogeography according to Borsellini (1992) is shown in three palaeogeography maps in Figure 4.13 to Figure 4.15.

The lithostratigraphy of the coastal region comprised dominantly the deep marine mudstones of the Obbia Fm or Obbia Fm. Equivalents such as the Coriole and Scebeli formations (Figure 4.5).

The Late Palaeocene to Early Eocene marine 'Auradu' transgression led to predominantly shallow marine carbonate deposition in north Somalia and deep marine Obbia Fm. shales prevailed along the coastal basins (Figure 4.13).

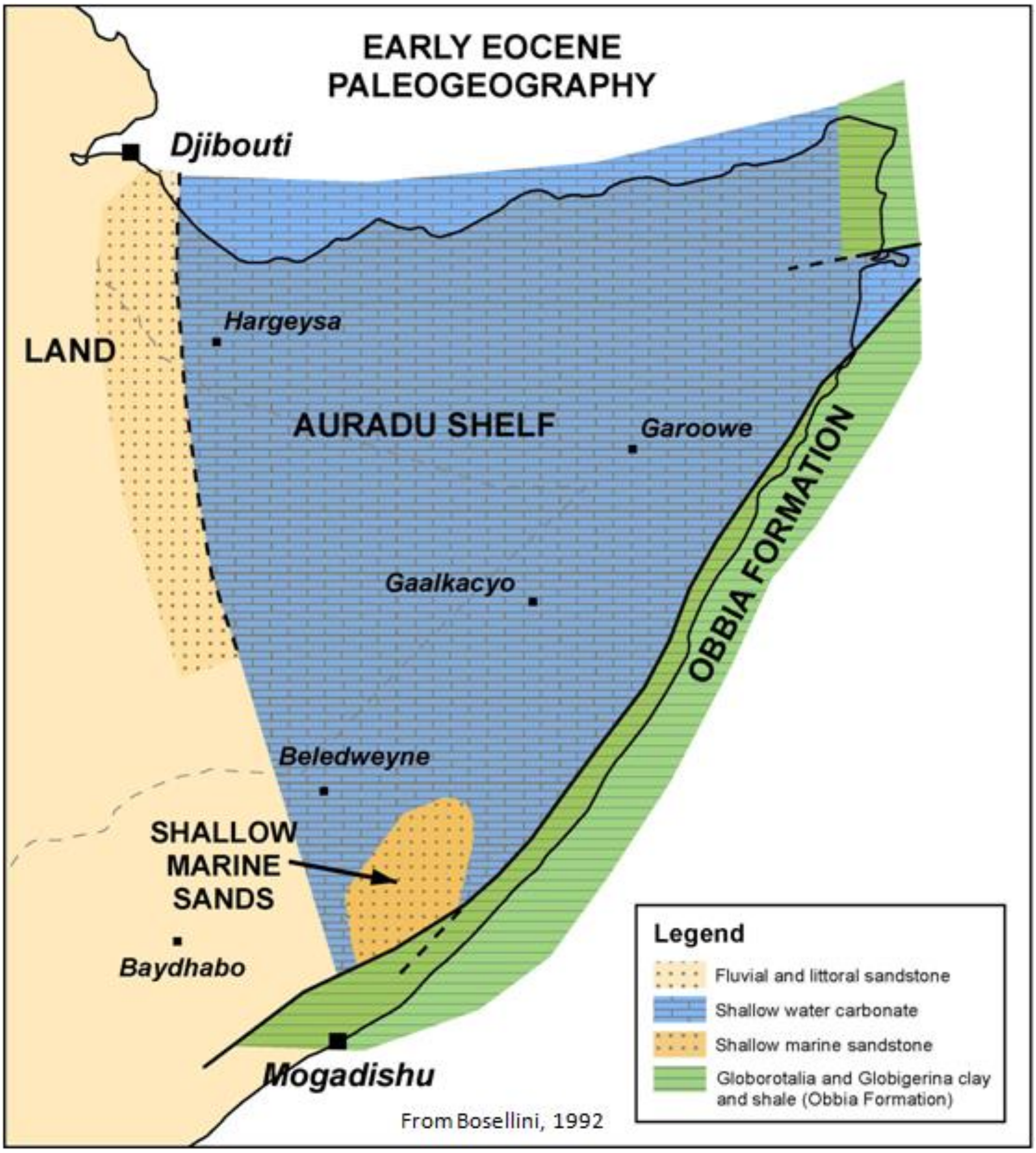


Figure 4.13: Early Eocene Palaeogeography

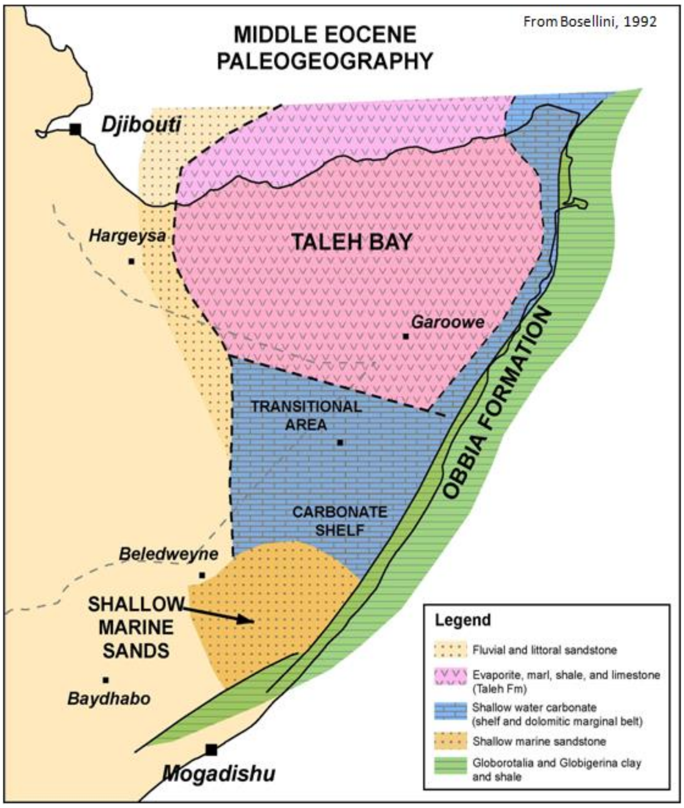


Figure 4.14: Middle Eocene Palaeogeography

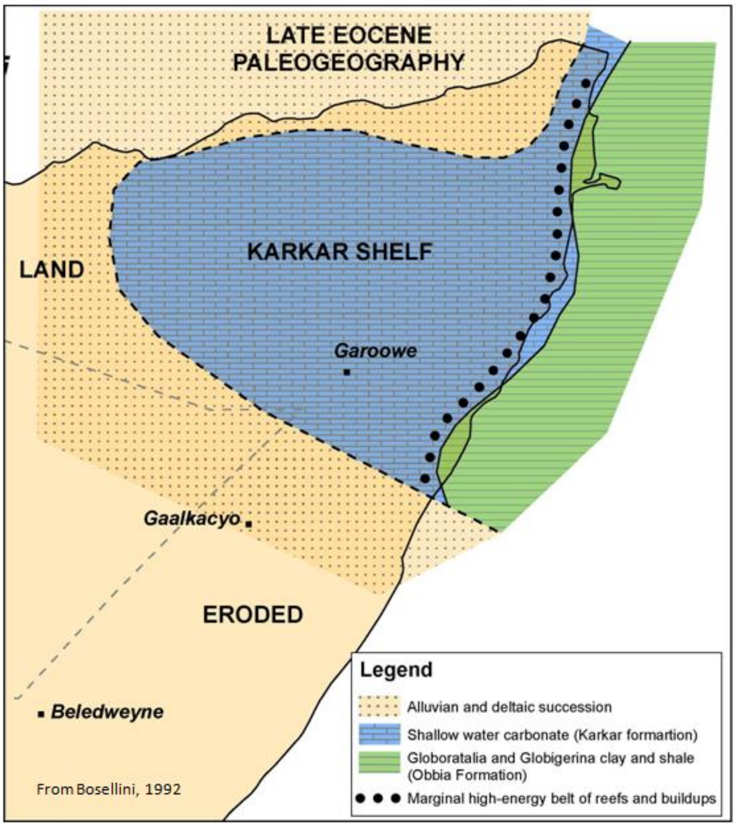


Figure 4.15: Late Eocene Palaeogeography

The settings during Middle and Late Eocene are shown in Figure 4.14 and Figure 4.15. The maps, after Borsellini (1992), show that Obbia mudstones dominate the coastal regions whilst shelf carbonates prevailed in the north and sands developed in the southern area. This is a simplified picture as the well correlations from Harms and Brady demonstrates more lithology variation through the Eocene than is indicated by the palaeogeography maps.

For example, in the south-west coastal area, in the Juba-Lamu Basin and close to the Kenya border, several wells have very thick Palaeocene to Eocene sandstones. These wells are Obbe-1, Kudha-1 and Oddo Alimo-1 (Figure 4.16). Harms and Brady's Volume I report covers the Juba-Lamu Basin where they propose that Lower Tertiary beds exceed 12,000 ft (3,657m) thickness. These Lower Tertiary sands are part of a depositional regression of the Juba delta. CCG has refined the lithostratigraphic nomenclature of the Mid Palaeocene to Upper Eocene in these wells from 'Obbia Equivalent', shown on the well correlations of Harms and Brady, to the formations shown in Figure 4.16. These revised stratigraphic units are also shown in Figure 4.6.

These Lower Tertiary sands are reduced in thickness and become less common in the wells further along the coast to the north-east. But in well Coriole-2, for example, that is located just south-west of Mogadishu a 900 ft (274m) thick sandstone is present as the Scebeli Fm (Mid Eocene?) and this is underlain by 900 feet (274m) of dolomites of the Marai Ascia Fm. (Upper Palaeocene to Lower Eocene?). These facies distributions are not shown on the palaeogeography maps after Borsellini (1992) and are not discussed in any detail by Bosellini or Harms & Brady.

The sand influx that affected much of southern Somali coastal area signifies that there may be potential for Late Palaeocene and Eocene deltaic and turbidite sand reservoirs in the adjacent deep offshore basin.

4.4.7 Oligocene - Miocene

At the end of the Eocene, central Somalia became largely sub-aerially exposed (Figure 4.15). As a result Oligocene-Miocene deposits are mostly limited to the coastal strip of the country. Base Oligocene was a major lowstand and erosional episode related to the dramatic sea-level drop 30 Ma ago and regional uplift of north-central Somalia caused by doming of the Gulf of Aden.

Along the coastal basins Oligocene to Early Miocene Somal Fm. consists mostly of shallow marine carbonates. The overlying Upper Miocene to Recent Merca Fm. is a regressive shallow marine and deltaic sequence of sands, shales and thin limestones (Figure 4.17). Miocene sands are present in wells from Obbe-1 in the south-west to Bio Addo-1, NE of Mogadishu, a distance of more than 600 km. Deep-sea fans developed in the thick Tertiary Coriole Sub-basin around Mogadishu. In Harms and Brady's Volume I report, they propose that Upper Tertiary beds exceed 8,000 ft (2,438m) thickness in the Juba-Lamu Basin, based on the thickness in the Giamama-1 well that lies just east of Oddo Alimo-1.

The Early Oligocene unconformity and sea level lowstand may represent a time when sands were transported seaward from the eroded landscape into the deep offshore where they might represent reservoir targets. Upper Tertiary sands from the thick Tertiary Juba-Lamu delta system can be expected to extend far into the offshore.

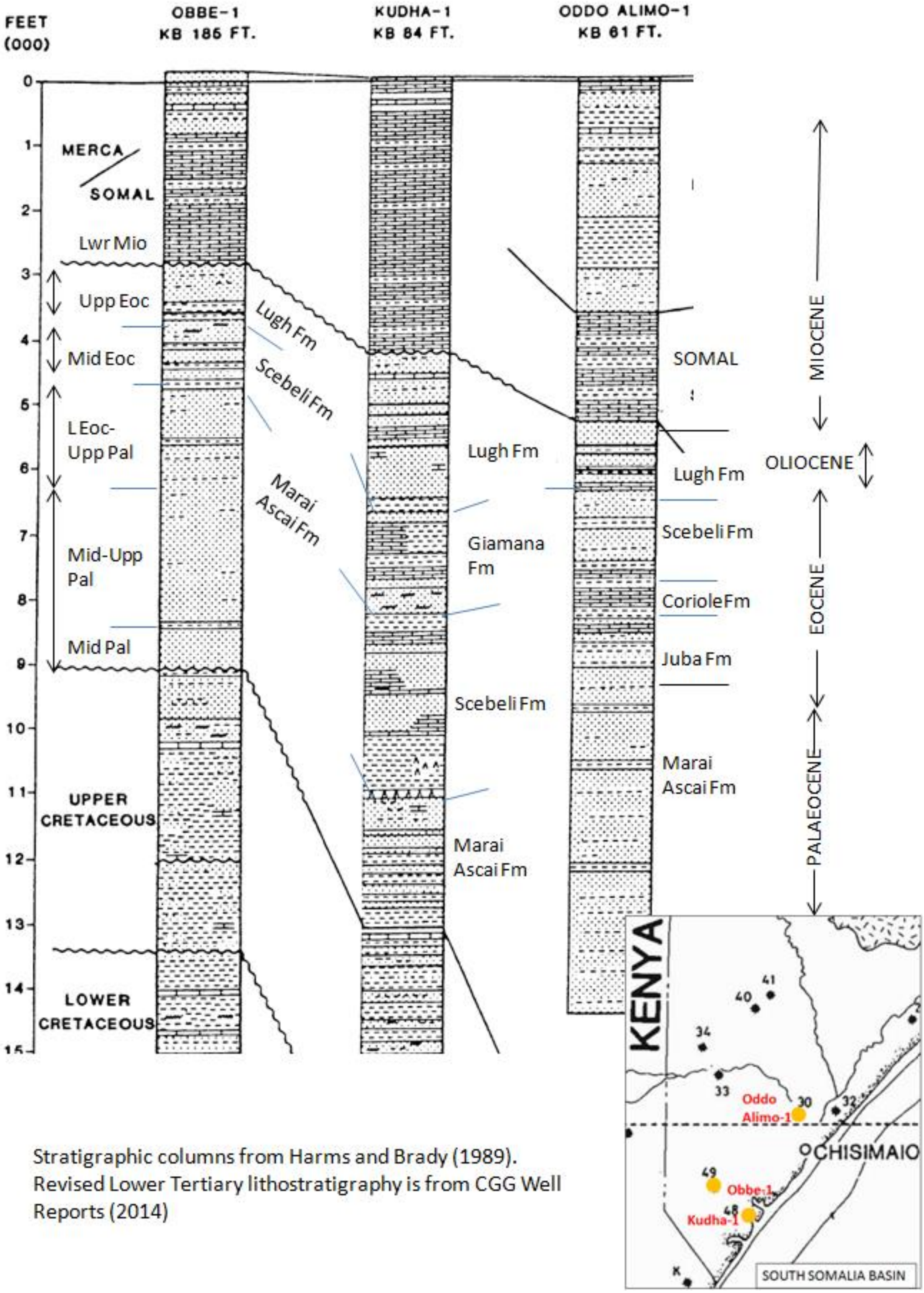


Figure 4.16: Well Correlations in Lamu Embayment

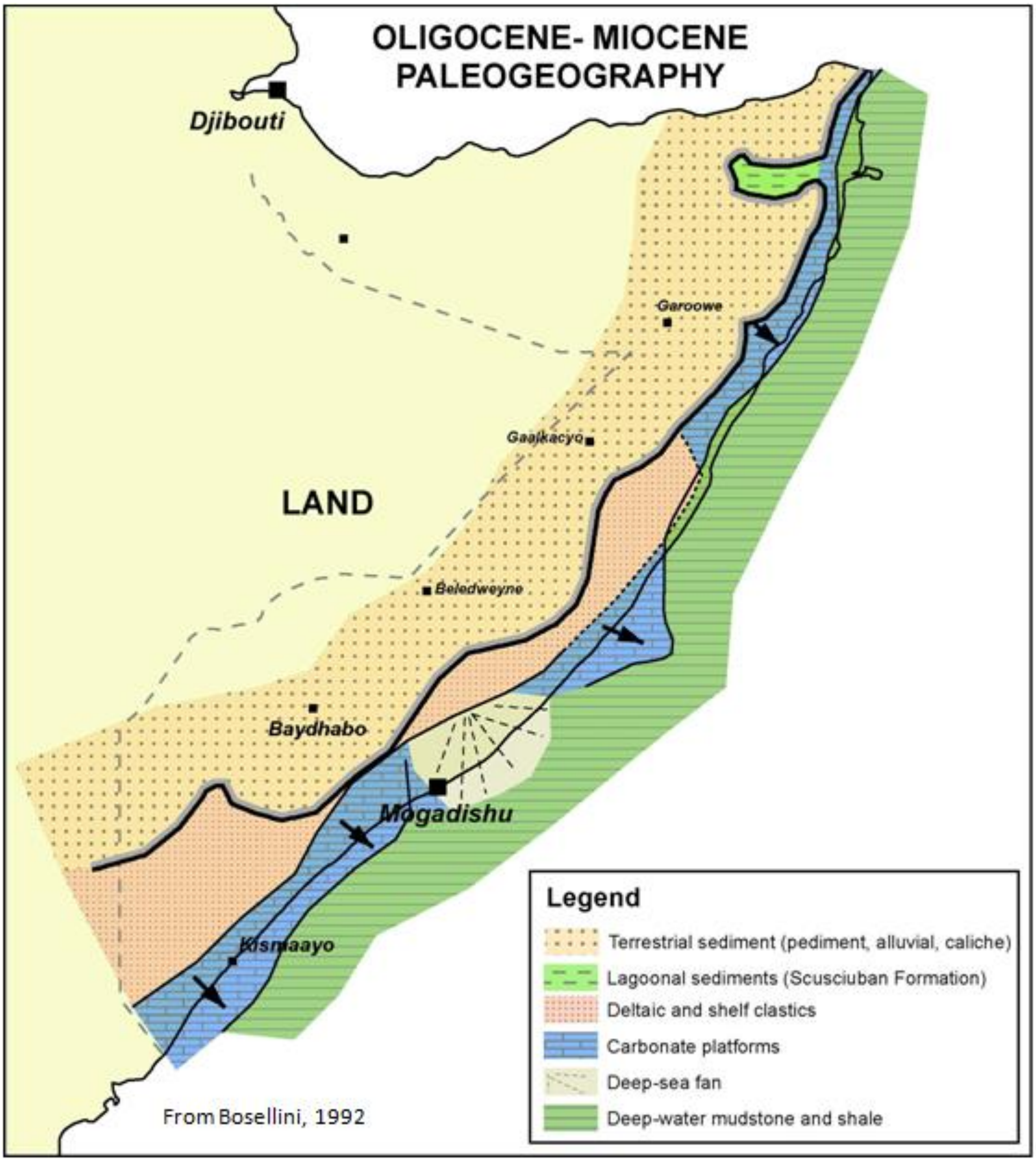


Figure 4.17: Oligo-Miocene Palaeogeography

5. EXPLORATION SUBAREA 1

5.1 Drilling Results & General Geology

Sub-area 1 is located in the most south-westerly part of Somalia. The sub-area lies in the Jabu-Lamu basin that extends into Kenya. This is a Mesozoic basin overlain unconformably by thick Tertiary sediments.

The dataset for this subarea consists of four wells and 2,116 line km of 2D seismic data.

The wells drilled in sub-area 1 are:-

Oddo Alimo-1 (Sinclair 1964)

Giamana-1 (Sinclair 1964/65)

Kudha-1 (Deutsche-Texaco 1981/82)

Obbe -1 (Deutsche-Texaco 1982)

The available seismic surveys were acquired by;

600 Texaco in 1973

700 Texaco in 1974

Deutsche-Texaco 1980-1981

None of the seismic data acquired by Sinclair in the 1960's is available.

The later seismic surveys conducted by Texaco tied into the Oddo Alimo-1 and Giamana-1 wells previously drilled by Sinclair.

The location of subarea 1 and the available well and seismic data is shown in Figure 5.1.

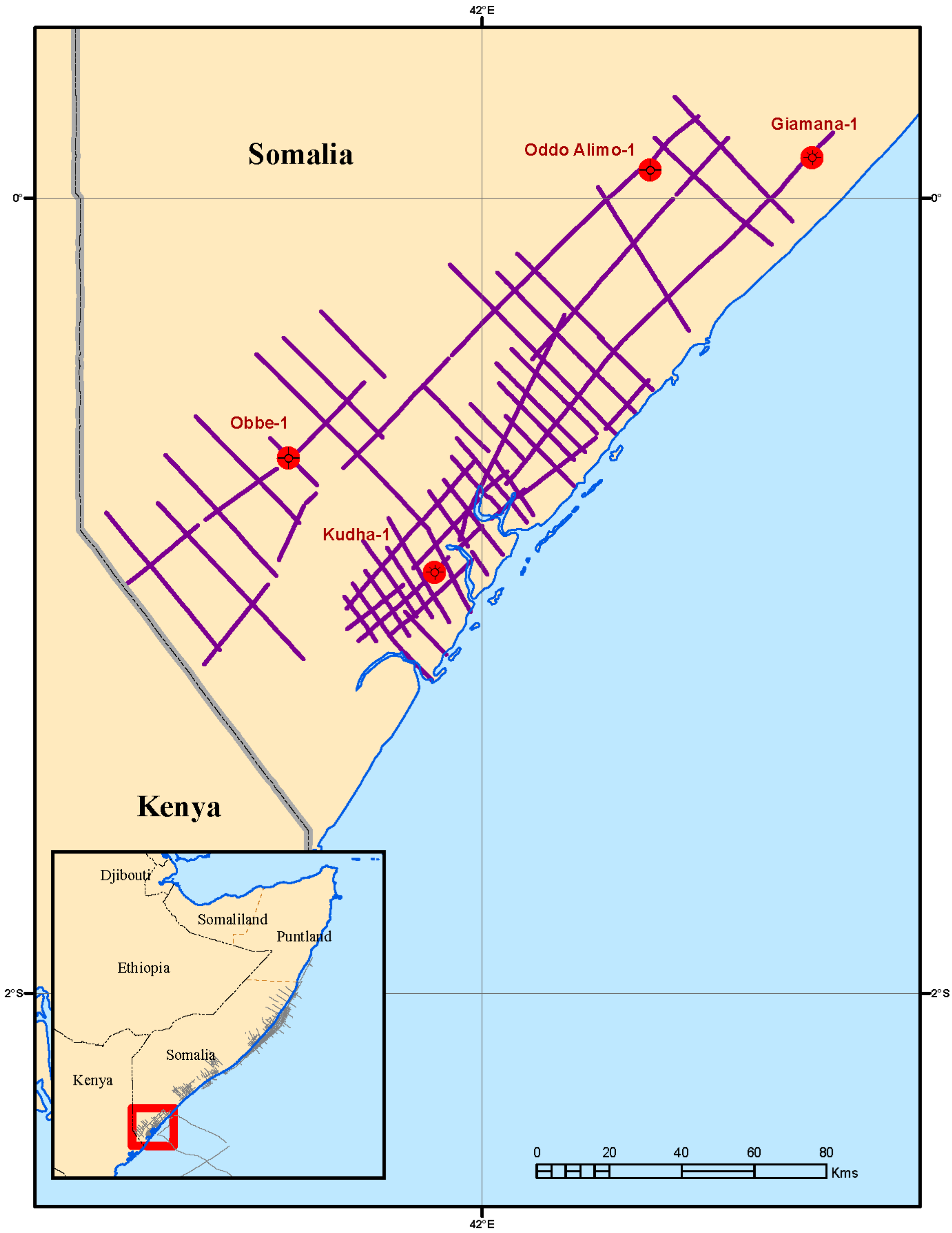


Figure 5.1: Subarea 1 Seismic and Well Database Map

Oddo Alimo-1 was drilled by Sinclair between August and November 1964 to a total depth of 4,465m (14,648ft). The well was drilled on an anticlinal structure mapped at the Top Eocene (Aden Group) on seismic that is no longer available. The well reached the Upper Cretaceous Jessoma Formation.

From 10 to 1,079.6m (30 -3,542ft) the well encountered the sands and shaly sands of the Miocene-Pliocene Merca Formation.

From 1,079.6m to 1,665.1m (3,542 – 5,463ft) the well encountered the Oligocene-Lower Miocene Somal Formation. This interval comprises shales and dolomites.

The sands and shales of the Lugh Formation between 1,665.1 and 1,908.96 (5,463 – 6,263ft) include a thick succession of organic rich material, interpreted to have been deposited in estuarine conditions.

From 1,908.65 to 2,330.2m (6,243 – 7,645ft) the Middle Eocene Scebeli Formation contains flora and fauna indicative of a shallow marine to deltaic environment.

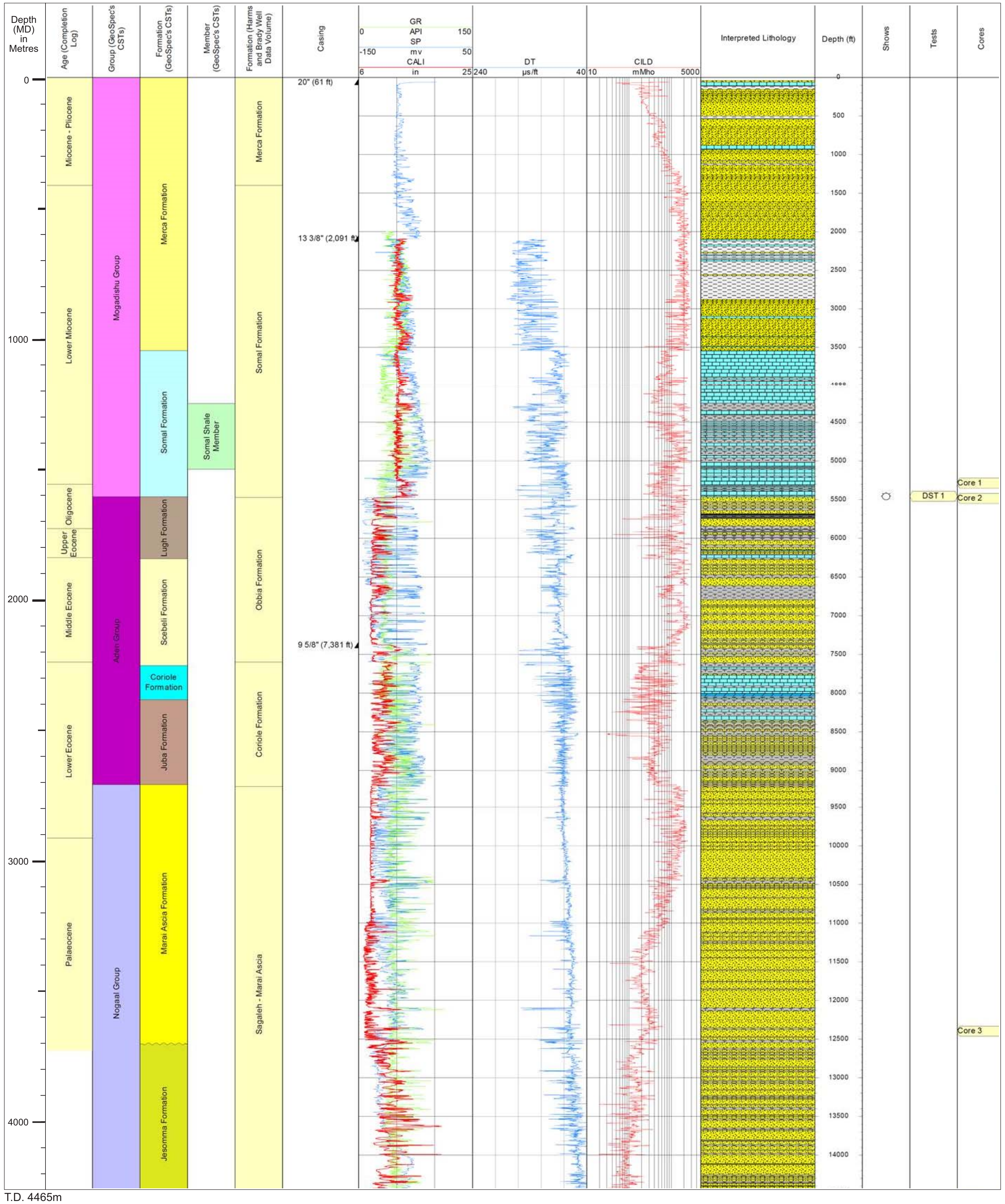
From 2,330.2 to 4,465m (7,645 – 14,648ft) the lithology is dominated by thick packages of sands with intercalated shales with the Lower Eocene Coriole carbonates near the top of the sequence. A shallow marine/lagoonal depositional environment has been interpreted for these sediments. The stratigraphic age is indeterminate from biostratigraphy as the sediments are barren towards the base of the drilled succession.

One DST and four cores were taken in the well. The DST was taken between 1,662.07 and 1,664.82m (5,453 – 5,462ft) in the Somal Formation carbonates and noted an estimated 4 mcfd recovered. Fluorescence was also noted in cuttings of the Palaeocene sands at 3,774.95m (12,385ft).

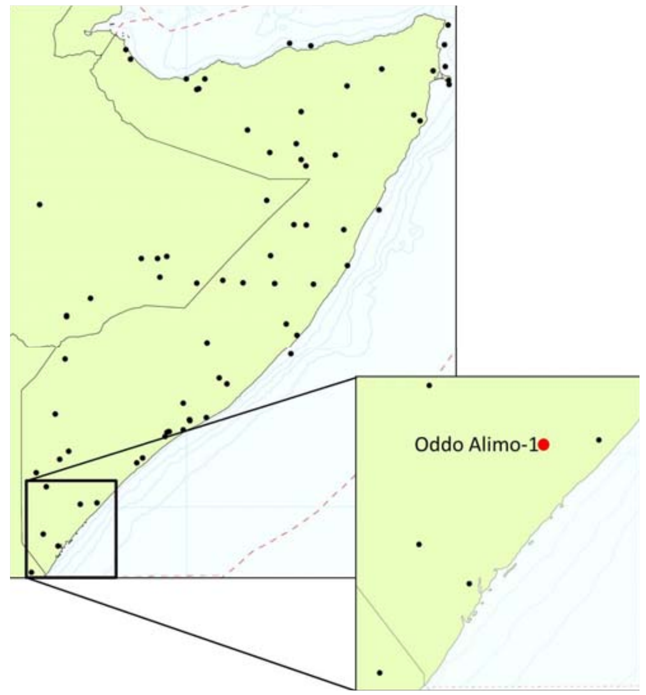
Log interpretation of the interval between 1,667.56 and 2,316.48m (5,471 – 7,600ft) in the Aden Group showed thick clean sands with porosities up to 30% and common recordings between 10% and 25%. Below 2,318.48m (7,600ft) porosities greater than 10% were rare.

The well was plugged and abandoned as dry.

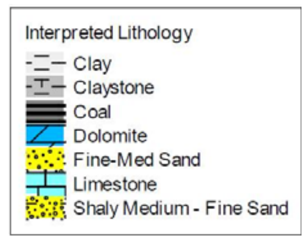
The Well Summary Chart for Oddo Alimo-1 is shown in Figure 5.2. A geoseismic line over the well location is shown in Figure 5.3.



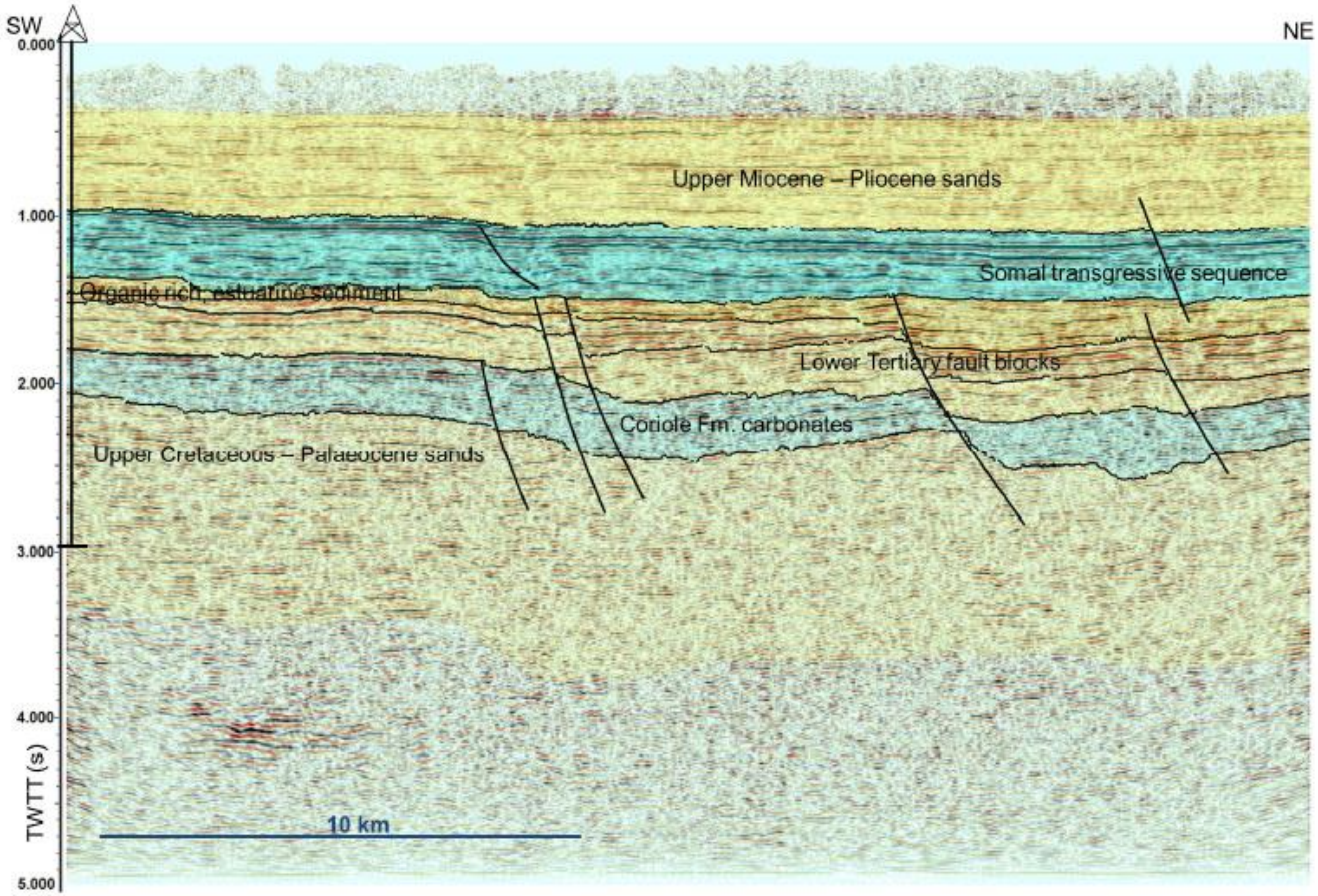
Oddo Alimo-1



Oddo Alimo-1 was drilled onshore southeast Somalia, and is located at 00° 04’ 16” N, 42° 25’ 08” E



Well Summary Chart, Oddo Alimo-1 **Figure 5.2**



The **Geoseismic Section** shows the principal stratigraphy and structure of the Oddo Alimo anticline feature at the northernmost point of the southern coastal basin. There are fault blocks trending NW - SE in the Lower Tertiary stratigraphy. The well was drilled at the crest of a broad anticlinal surface which shows at least three way dip closure (see **Chapter 3.1**) and is on the down thrown side of a bounding fault to the southwest. The key stratigraphic units to note are the Eocene sands, organic rich sediments of the Lugh Formation and the carbonates of the Somal Formation, which tested positive for gas.

Figure 5.3: Oddo Alimo-1 Geoseismic Line

Giamama-1 was drilled between November 1964 and January 1965 by Sinclair to a total depth of 4,126m (13.537ft) in the Lower Eocene Coriole Formation. The well was drilled on anticlinal feature with some evidence of Tertiary sand pinchout against the anticline identified from seismic data.

The well showed a thickening of the Middle Miocene and Lower Eocene sequences compared to the stratigraphy of the Oddo Alimo-1 well drilled previously.

Palynological analysis of samples show that the well was located in an area of high subsidence and subsequent rapid sedimentation during periods of tectonism in the Lower and Middle Miocene.

The uppermost stratigraphy of the well is the Middle to Upper Miocene Merca Formation from 0 to 1,028m (0 – 3,382ft). This is predominantly comprised of sand beds with some interbeds of shales and carbonates towards the uppermost part of the sequence. This is interpreted as an estuarine environment.

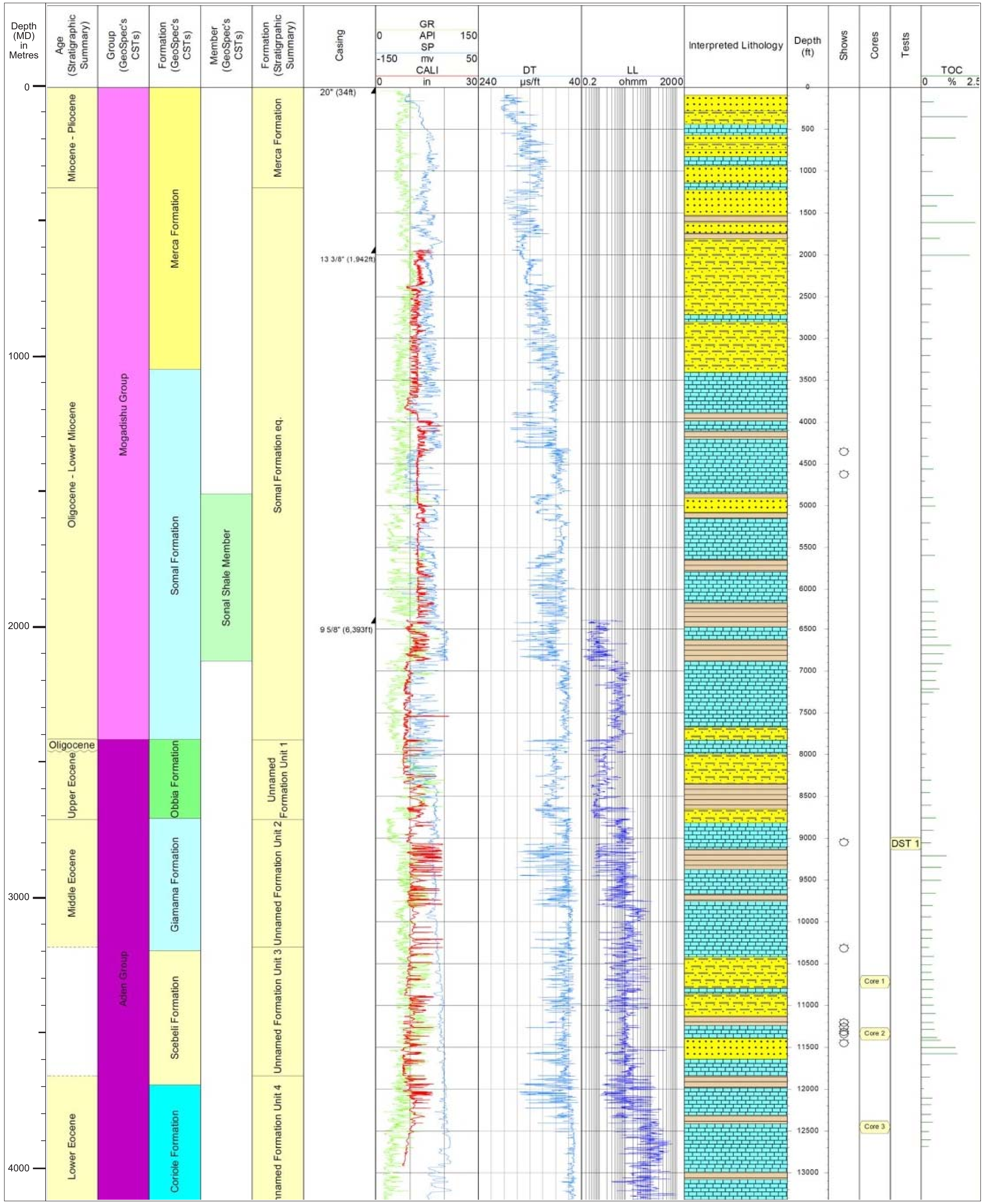
The interval from 1,028 to 2,384m (3,372 – 7,822ft) is comprised of the Oligocene to Lower-Middle Miocene Somal Formation. This is dominated by thick units of limestone with some interbeds of shale and marks a major transgression.

The interval from 2,384 to 4,126m (7,833 – 13,537ft) is comprised of the Eocene Aden Group. This is comprised predominantly of carbonates with shallow marine origins of the Coriole, Scebeli, Giamama and Obbia Formations. There is some influx of clastic sediments in the Scebeli Formation in the interval from 3,153 to 3,642m (10,344 – 11,950ft).

One DST carried out between 2743 and 2,782m (9,000 – 9,127ft) following a number of minor gas shows in limestone intervals in the Lower Miocene Somal Formation and the Middle Eocene. The DST failed due to fault in the packer seal.

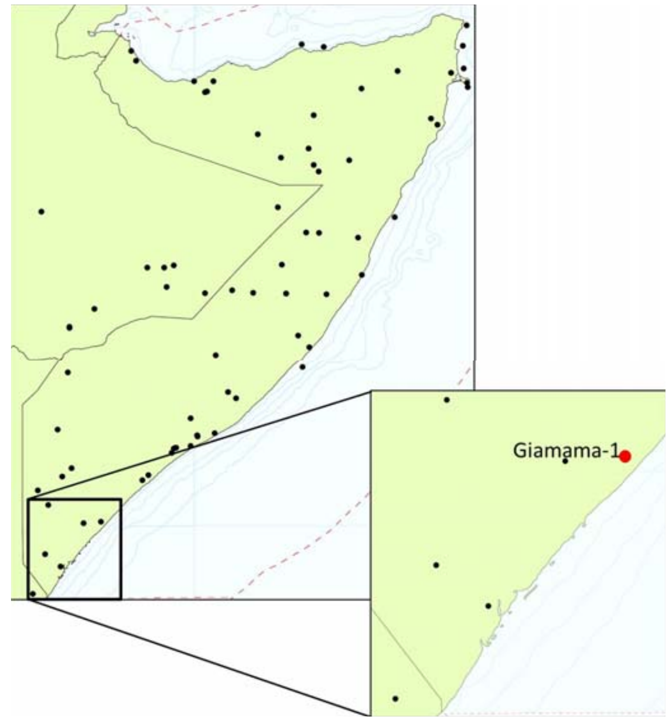
Four cores were cut. Minor fluorescence was observed in Core 2 within sandstones from the Middle Eocene Scebeli Formation between 3,455 and 3460m (11,336 – 11,353ft). Various shows of trace gas were encountered in the Lower Eocene between 3139 to TD (10,300ft – TD). Organic content in the well is generally less than 1% with peaks of 1.47% within the Middle Eocene Scebeli Formation.

The Well Summary Chart for Giamana-1 is shown in Figure 5.4. A geoseismic line over the well location is shown in Figure 5.5.

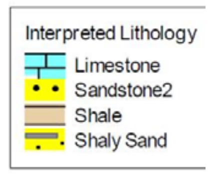


T.D. 4126m

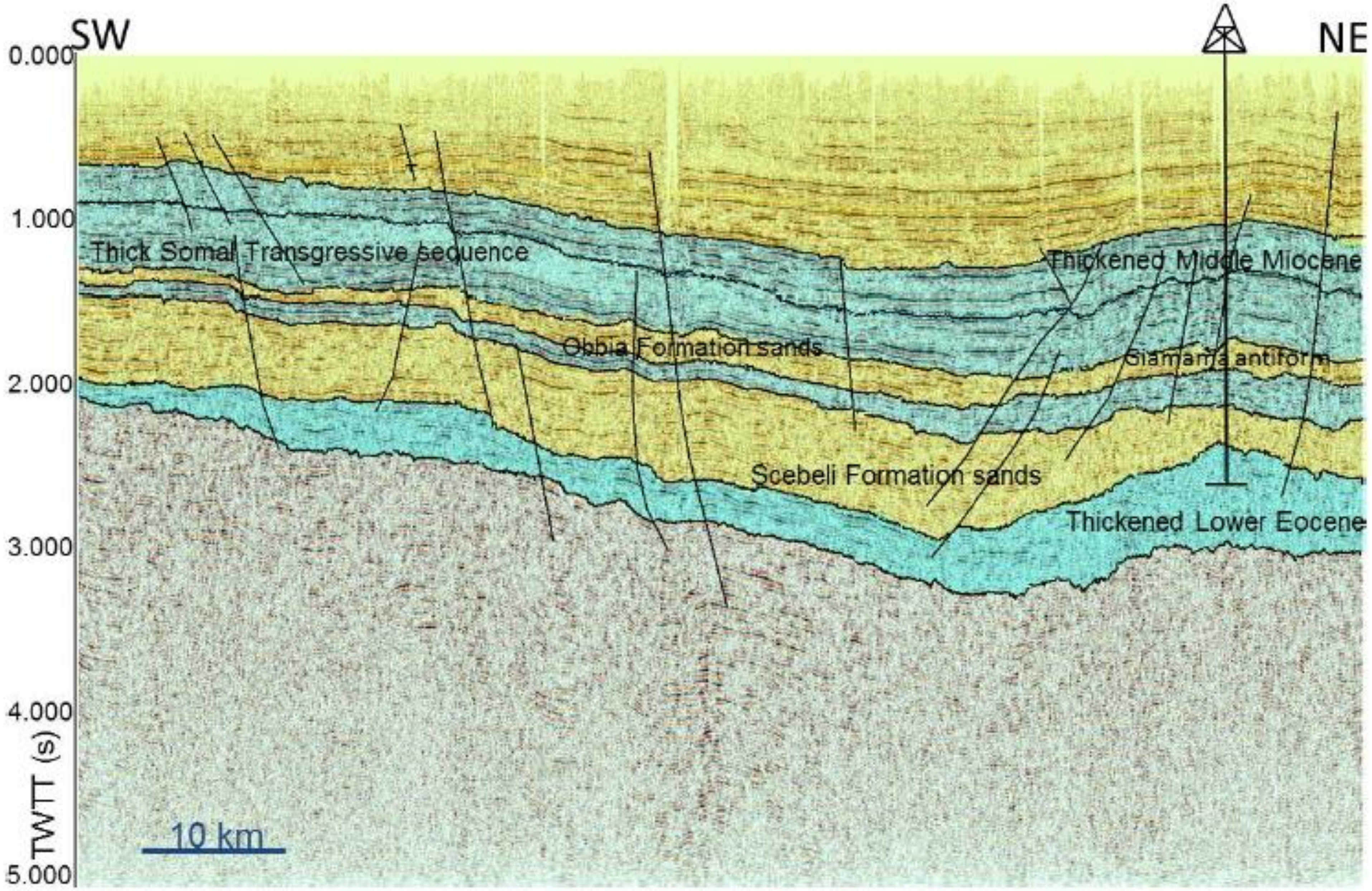
Giamama-1



Giamama-1 was drilled onshore south Somalia, and is located at 00° 06' 09" N, 42° 49' 13" E



Well Summary Chart, Giamama-1 **Figure 5.4**



The **Geoseismic Section** shows the principal structure and lithology of the Giamama-1 anticlinal feature and surrounding area. The primary structure shows good vertical closure of approximately 0.4s over 15km. There are various major fault cuts to the southwest. The stratigraphy of the area is dominated by carbonates and sands throughout the Palaeogene (Scebeli and Obbia Formations) and Lower Neogene (Upper Somal Formation). Giamama-1 is located in an area that underwent significant subsidence during the Middle Miocene and Lower Eocene. The thickened sequences during these periods are evident when compared with wells to the northwest (e.g. Oddo Alimo-1).

Figure 5.5: Giamama-1 Geoseismic Line

Kudha-1 was drilled by Deutsche Texaco between 1981 and February 1982 to a total depth of 4,971.29m (16,310ft) in the Upper Cretaceous. This was the first well to be drilled in this area since 1965. Texaco had acquired seismic data over this area in between 1973 and 1974, before returning in 1979 to acquire more seismic (**Section 3**).

The targets were Upper Cretaceous to Lower Tertiary Sagaleh Formation sandstones and Eocene Coriole and Obbia Formation sandstones. The targets were contained within a small rollover anticline at the base of a northeast trending fault block at the southern end of the Juba Basin. The objective sandstones were thought to be sealed by intraformational marine shales of the Upper Cretaceous.

The section from 0 to 1,335m (0 – 4,380ft) is comprised of carbonates of the Upper Oligocene to Middle Miocene Somal Formation.

Below this in the Middle to Upper Eocene Obbia Formation from 1,335 to 2,070m (4,380 – 6,790ft). The formation comprises deltaic sandstones and siltstones intercalated with claystones and carbonates. These are interpreted as being deposited in a shallow marine, brackish environment.

The interval from 2,070 to 2,708 (6,790 – 8,885ft) is the Middle Eocene Coriole Formation. This consists of limestones with clay interbeds and claystones. Biostratigraphic analysis of cuttings indicates a shallow to open marine environment of deposition.

From 2,708 to 3,598m (8,885 – 11,805ft) is the Eocene/Palaeocene Marai Ascai Formation. This is comprised of sandstones, siltstones and claystones.

The interval from 3,598 to TD (11,805 – 16,310ft) is comprised of numerous sands, siltstones and claystones of the Upper Cretaceous/Palaeocene Sagaleh Formation. This formation contains numerous sands up to 1.22m (4ft) thick with porosities of up to 30% which have been interpreted to have been deposited in a deltaic to middle neritic environment.

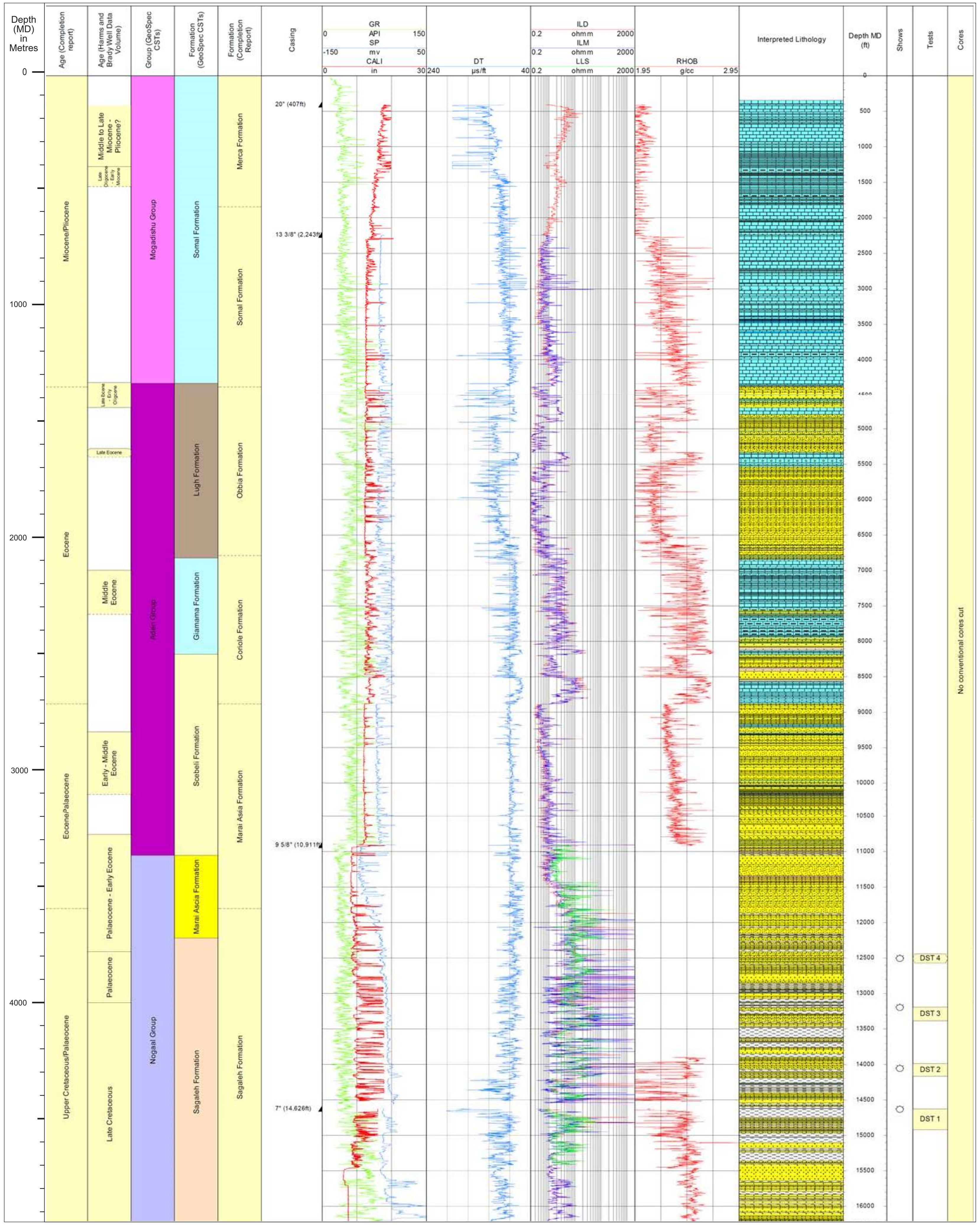
A total of four DSTs were carried out between 3,815 and 4,548m (12,516 – 14,920ft) within the Sagaleh Formation. Two of these DSTs were carried out within high porosity zones of the Sagaleh. Fresh water at 2 – 3 bbls/hr with trace gas was recovered.

Source rock analysis of the lower interval indicated marginal Type III coaly to humic kerogen, though specific TOC values were not given.

Drilling problems were encountered below 3,658m (12,000ft) due to over-pressured caving shales.

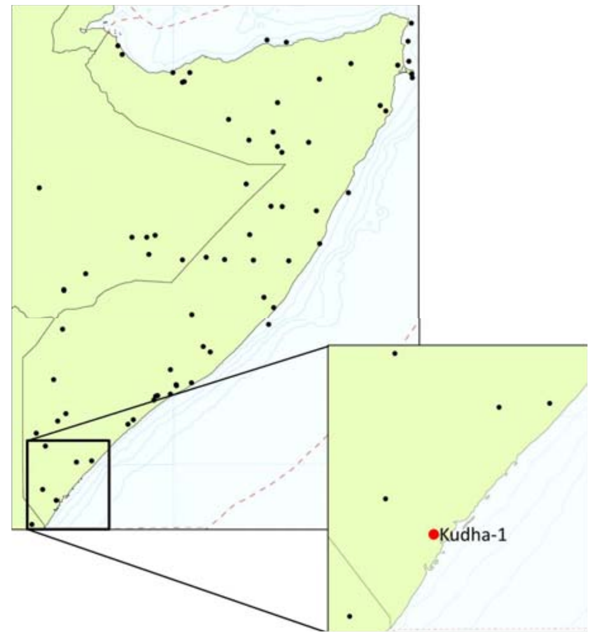
Although potential reservoir rocks were encountered in the Sagaleh Formation sandstones, the poor gas results and lack of petrophysical data meant that the well was plugged and abandoned as dry.

The Well Summary Chart for Giamana-1 is shown in Figure 5.6. A geoseismic line over the well location is shown in Figure 5.7.

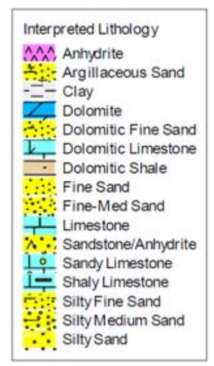


T.D. 4971m

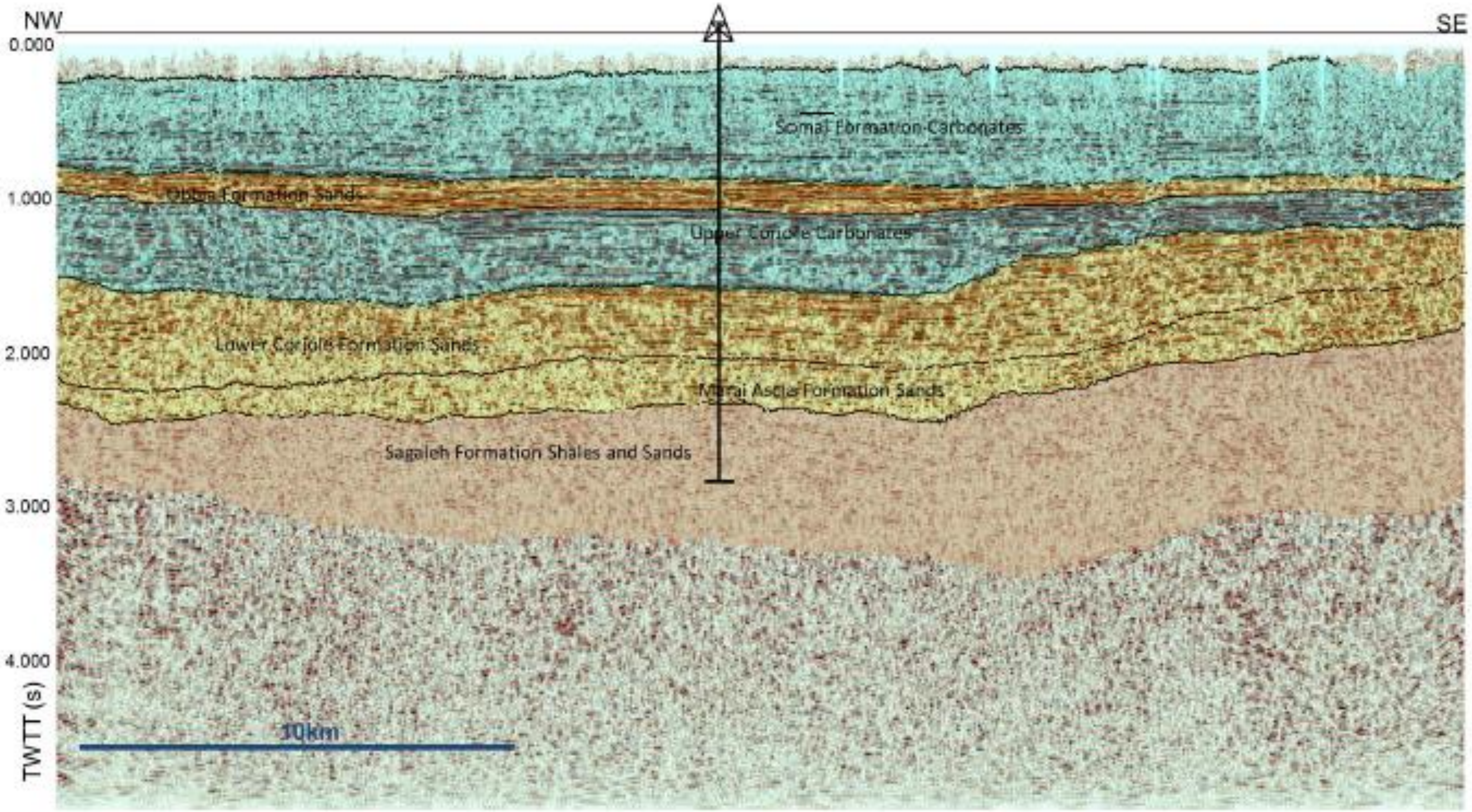
Khuda-1



Kudha-1 was drilled onshore southern Somalia, and is located at 00° 56' 27.5" S, 41° 53' 00.8" E



Well Summary Chart, Khuda-1 **Figure 5.6**



The **Geoseismic Section** summarises the well targets and the main structure and stratigraphy of the area. The lower section shows a regressive Cretaceous interval, of deltaic and middle neritic facies, coarsening up from claystones to sandstones. The Palaeocene to Eocene age sands of the Marai Ascia Formation and Coriole Formation contain anhydrite and anhydritic dolomite intervals. The Late Eocene section (Obbia/Lugh Formation) comprises intercalated, deltaic to shallow marine sandstones, shales and limestone which grade upwards into the porous, shallow marine limestone typical of the Somal transgression in southern Somalia.

Figure 5.7: Kudha-1 Geoseismic Line

The **Obbe-1** well was drilled by Deutsche-Texaco between April and September 1982 to a total depth of 4,865m (15,960ft). The Formation at TD was described in the original well report as Upper Jurassic. This would now be reclassified as Lower Cretaceous based on the change in benthic foraminiferal classification since 1982.

The primary targets were Upper Cretaceous carbonates, though deeper targets were anticipated dependent on the timing of uplift of faulted basement blocks.

The well was located on the reinterpretation of the older seismic data acquired by Texaco in 1973 and 1974.

Within the Lower Cretaceous, a zone of significant overpressure was encountered during drilling. The well was side-tracked at 3,944m (12,939ft) due to a stuck drill string and subsequent complications occurred during logging. The maximum calculated formation pressure was noted as 14.1 lbs/g (1,689 kg/m^3).

The interval from 0 to 367m (0 -1,203ft) is comprised of shaly sands of the Upper Miocene to Pliocene Merca Formation.

Below this, from 367 to 939m (1,203 – 3,081ft) is the Lower to Middle Miocene Somal Formation which is largely comprised of carbonates with thin shale intercalations.

From 939 to 1,257m (3,081 -4,124ft) is the Upper Eocene Lugh Formation which is composed of a monotonous sequence of shallow marine sandstones with siltstone and shale intercalations.

From 1,257 to 2837m (4,124 – 9,307ft) the succession is again a monotonous mixture of shallow marine sandstones with siltstone and shale intercalations. These have been assigned to the Late Palaeocene to Eocene Marai Ascia Formation.

Due to an unconformity at the Base Tertiary, there are no Early to Middle Palaeocene sediments in the well.

The sequence below the unconformity is assigned to the Upper Cretaceous Gumburo Group from 2,837 to 4,163m (9,307 – 13,659ft). This is comprised of sands near the top of the succession and then shales intercalated with limestones and clays

The interval from 4,163 to 4,865m (13,659 – 15,960ft) are now designated as the Lower Cretaceous Cotton Formation and comprise dark shales and clays and is less sandy than the Upper Cretaceous..

The Primary objective of the Upper Cretaceous limestones was encountered at 2,841m (9,320ft). These limestones were intercalated with shales and clays. Sandstones and siltstones of Campanian to Maastrichtian age were encountered down to 3,197m (10,490ft). The depositional environment inferred from the palynology suggests this to be inner/middle neritic conditions with a strong deltaic influence. This sequence was not regarded to have reservoir potential though petrophysics indicated porosities up to 14%.

Tertiary sandstones had greater reservoir potential than the Upper Cretaceous sands with log derived porosities of up to 28%. However, these were very shaly and no shows were encountered.

Two significant stratigraphic unconformities were encountered in the Cretaceous sequence at 3,746m (12,290ft) between the Late Cenomanian and Coniacian, and at 4,164m (13,660ft) in the Albian.

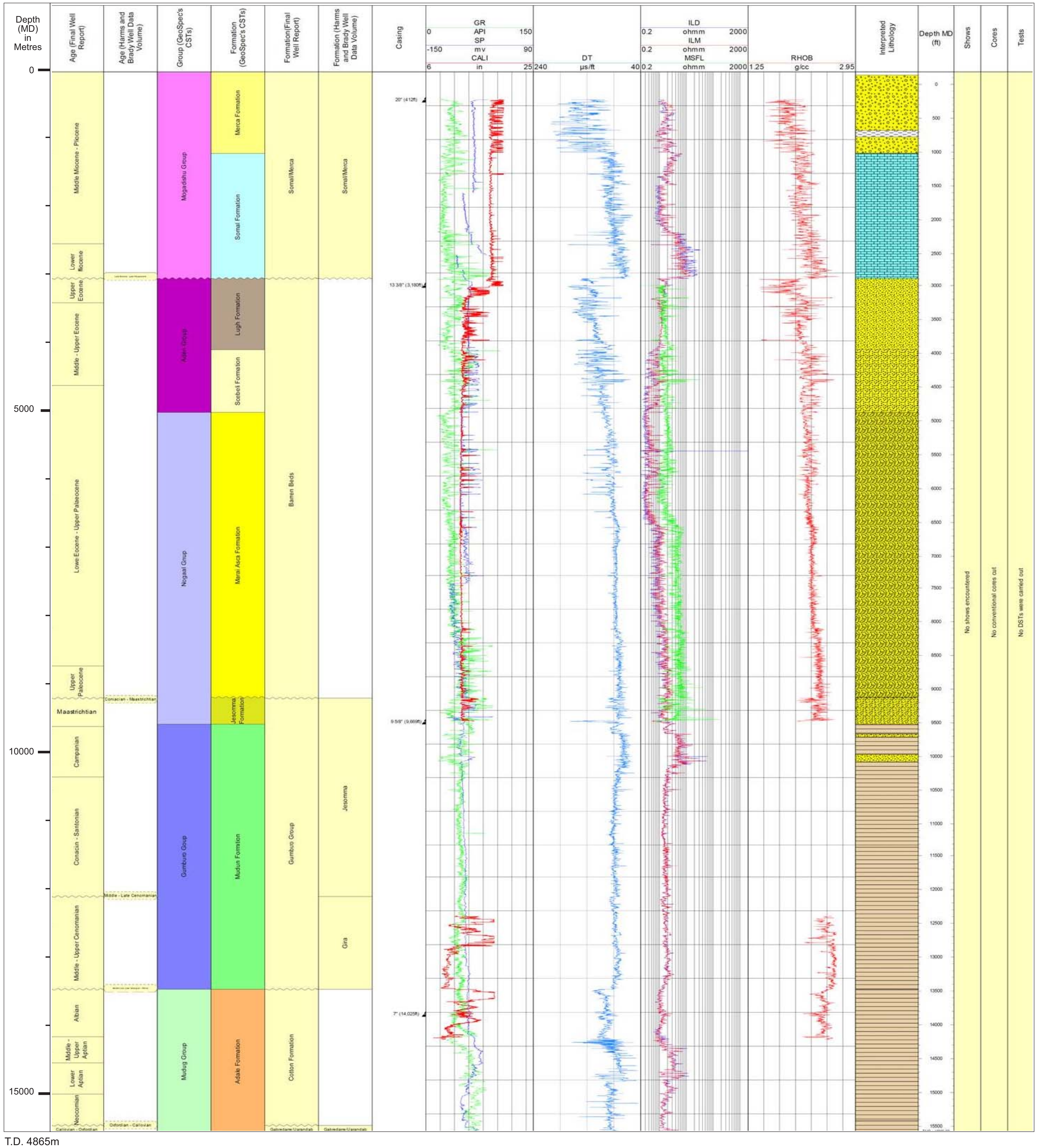
No potential reservoir was identified in Obbe-1. Thermal maturation data indicate that any Upper Cretaceous source rocks would have likely experienced a high thermal regime with a bottom hole temperature of 163ºC. Therefore they would not produce liquid hydrocarbons.

No cores or testing was carried out in Obbe-1 and no shows were recorded. The well was plugged and abandoned as a dry hole.

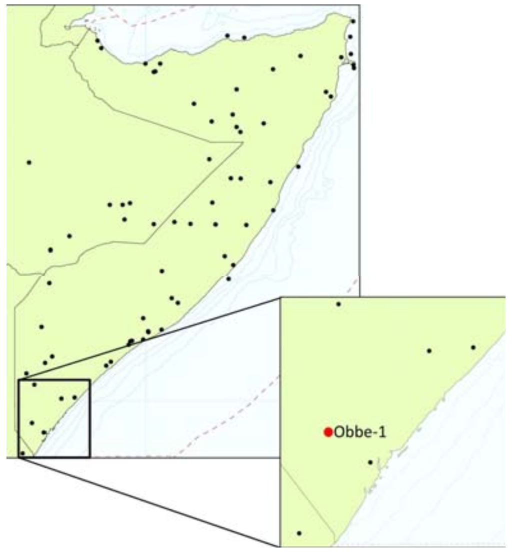
After the negative results from the two wells, a comprehensive overall study was undertaken between 1983 and 1984. This incorporated an analysis of the drilling results and a reinterpretation of the existing seismic and the previous seismic acquired by Texaco in 1973 and 1974. This included reprocessing of selected 1973 seismic lines by Prakla-Seismos.

Deutsche-Texaco came to the conclusion that the Juba delta area had limited exploration potential with poor source rock and poor reservoir qualities in the Lower Tertiary, Cretaceous and Jurassic sections. They also concluded that deeper horizons were not prospective for liquid hydrocarbons due to thermal over maturation. Deutsche Texaco invested $50,000,000 over the five year period that it held the licence

The Well Summary Chart for Obbe-1 is shown in Figure 5.8. A geoseismic line over the well location is shown in Figure 5.9.



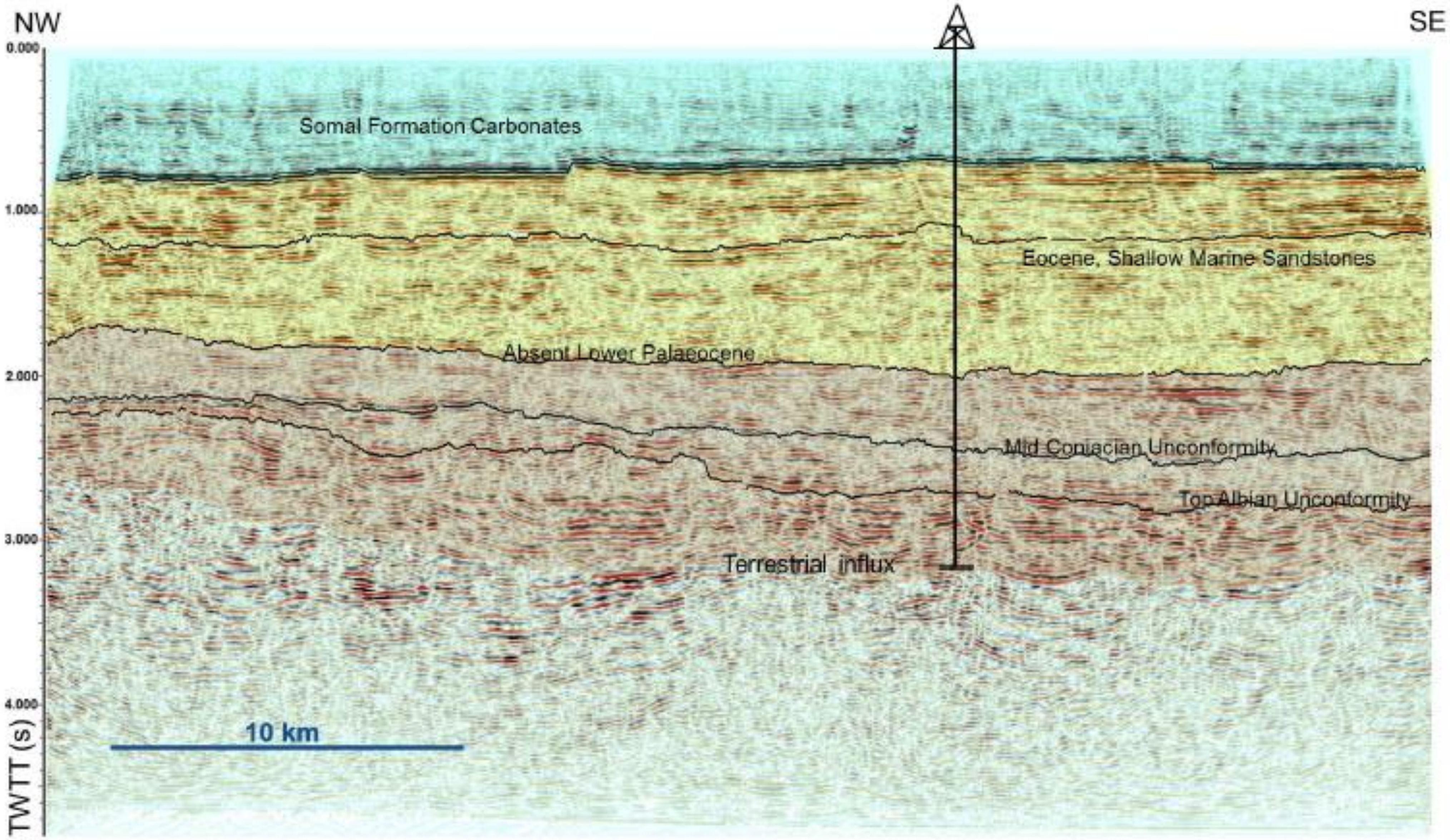
Obbe-1

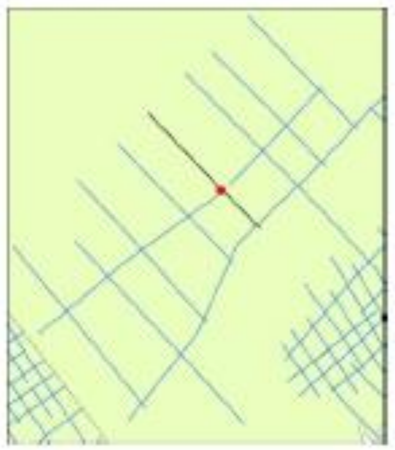


Obbe-1 was drilled onshore southeast Somalia, and is located at 00° 39' 11" S, 41° 31' 07" E

Interpreted Lithology
- Clay
- Fine-Coarse Sand
- Fine-Med Sand
- Limestone 2
- Med-Coarse Sand
- Shale
- Shaly Medium - Fine Sand
- Silty Medium Sand

Well Summary Chart, Obbe-1 **Figure 5.8**





This Geoseismic section shows the main structure and stratigraphy of the southern Juba Basin. The deepest penetrated interval of the well is the Gabredarre Formation, comprising shallow marine shales. There is also some terrestrial influx of silts and sands evident; porosities in these sediments are affected by the high overpressures encountered. The Top Albian Unconformity marks little change in lithologies though a short hiatus in open marine conditions, indicated by the Mid Coniacian unconformity, overlies a regressive sequence with deltaic sands at the top of the interval. The Lower Palaeocene is absent in this area, possibly due to uplift, though exact timing of the interval is unclear. The middle section is dominated by Palaeocene - Eocene monoclinal sand beds typical of southern Somalia. The upper sequence is marked by the Somal transgression to limestones of shallow marine environment with some anhydrites indicating restricted zones.

Figure 5.9: Obbe-1 Geoseismic Line

5.2 Seismic Examples

A selection of 2D Seismic Lines is presented within this section (Figure 5.11 to Figure 5.35). The lines show a representation of the structure and stratigraphy within Sub-area 1. The seismic is of fair to poor quality,

The locations of the following seismic examples are shown in Figure 5.10.

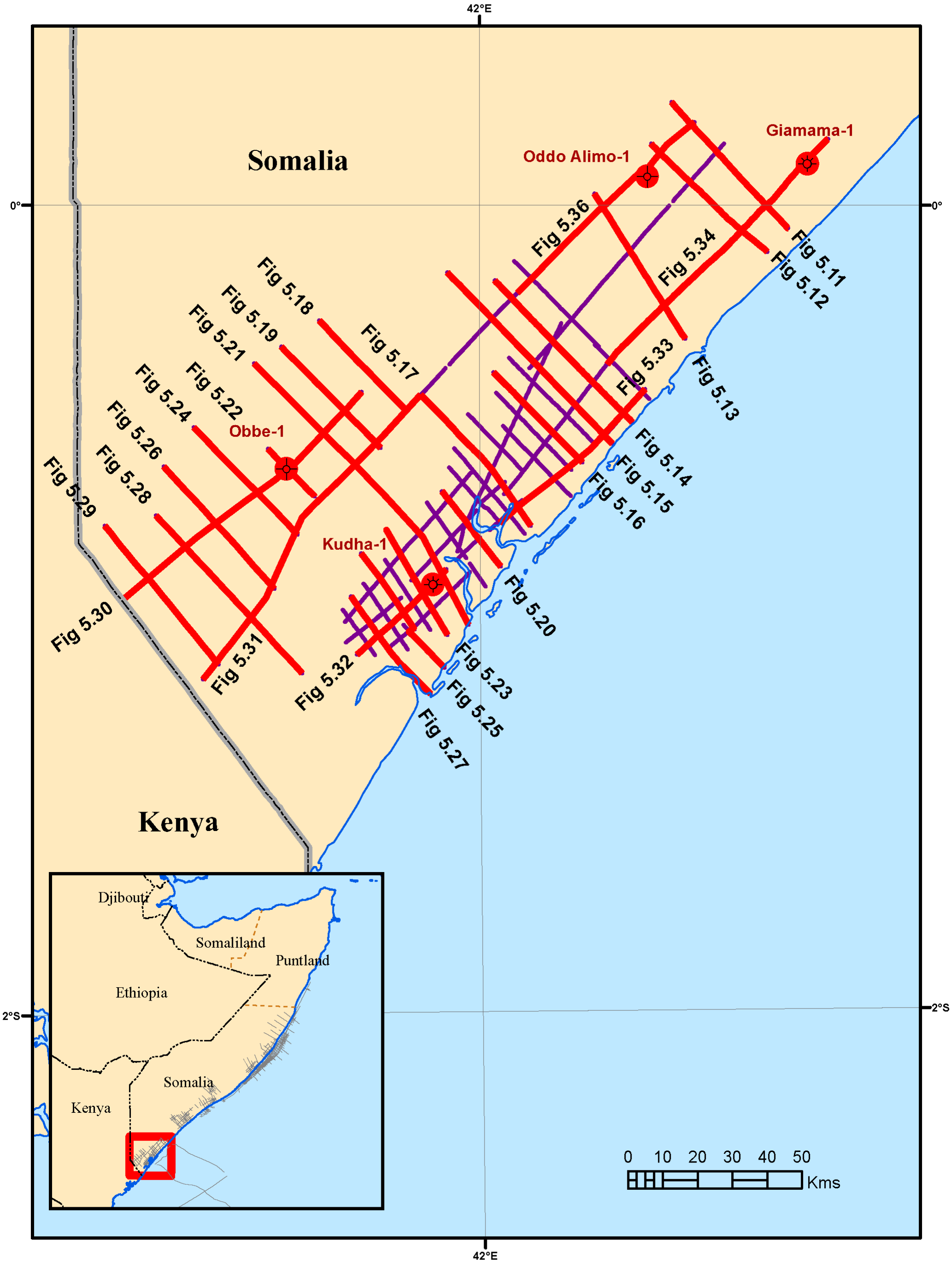


Figure 5.10: Subarea 1 Location of Seismic Displays

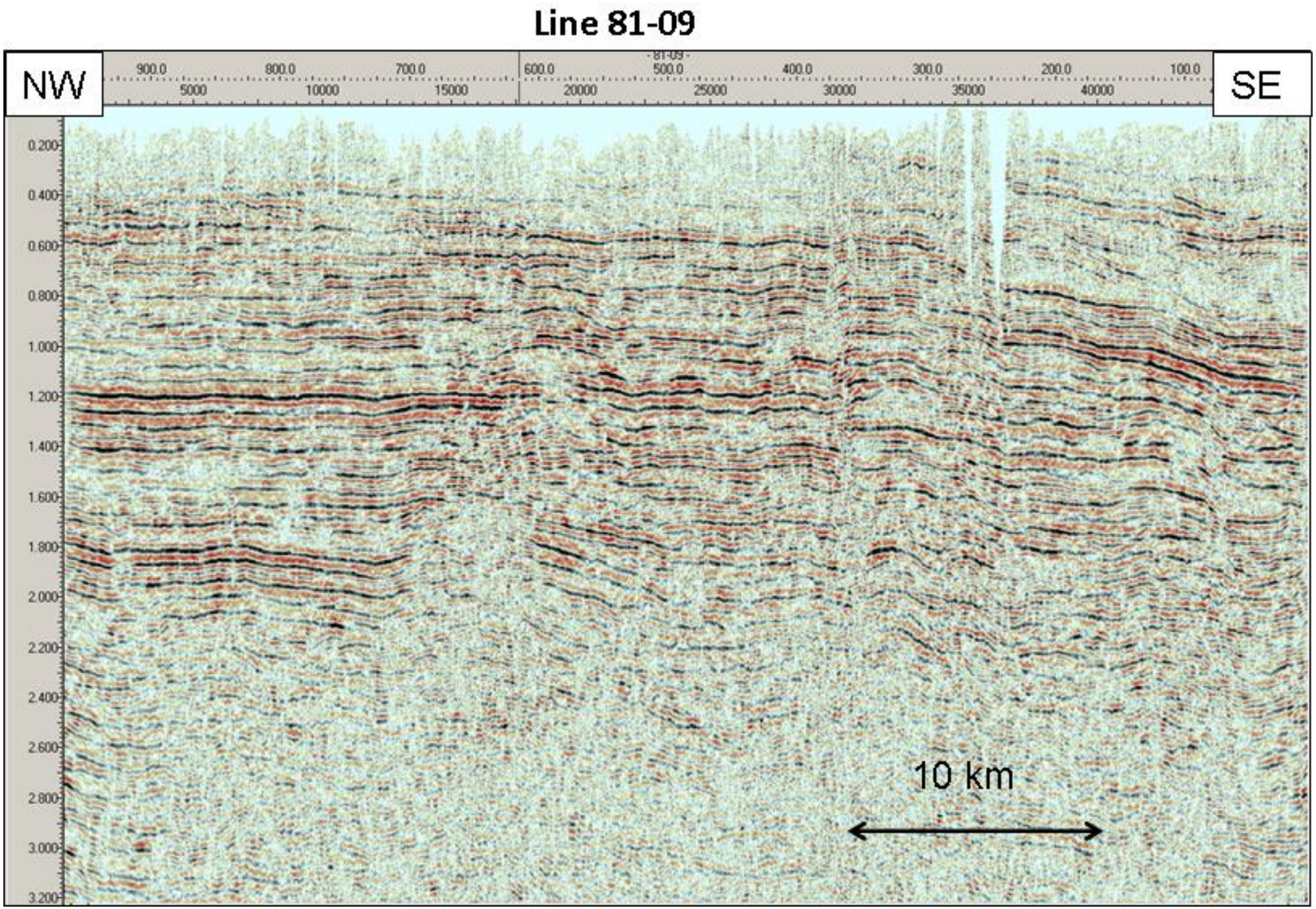


Figure 5.11: Seismic Line 81-09

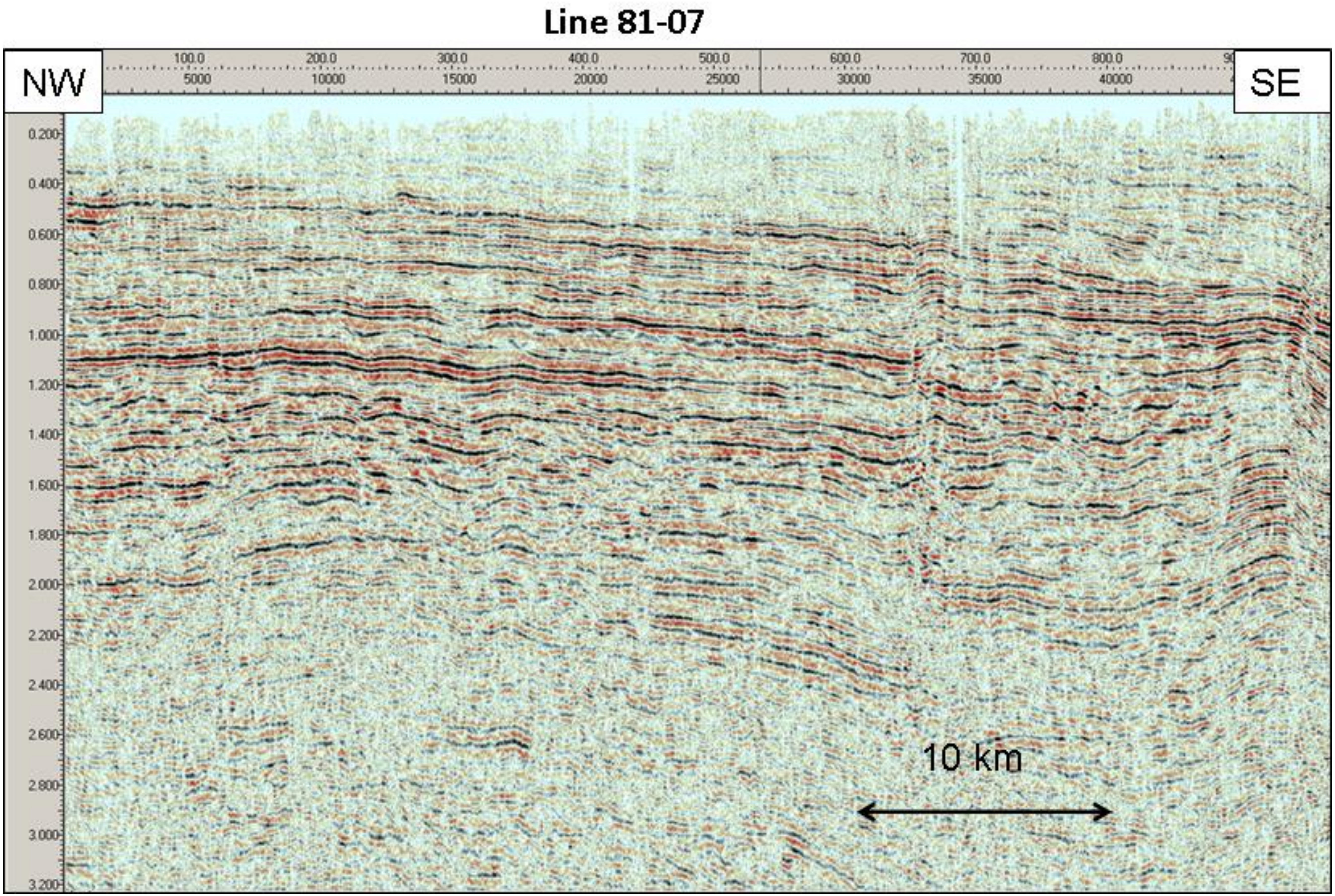


Figure 5.12: Seismic Line 81-07

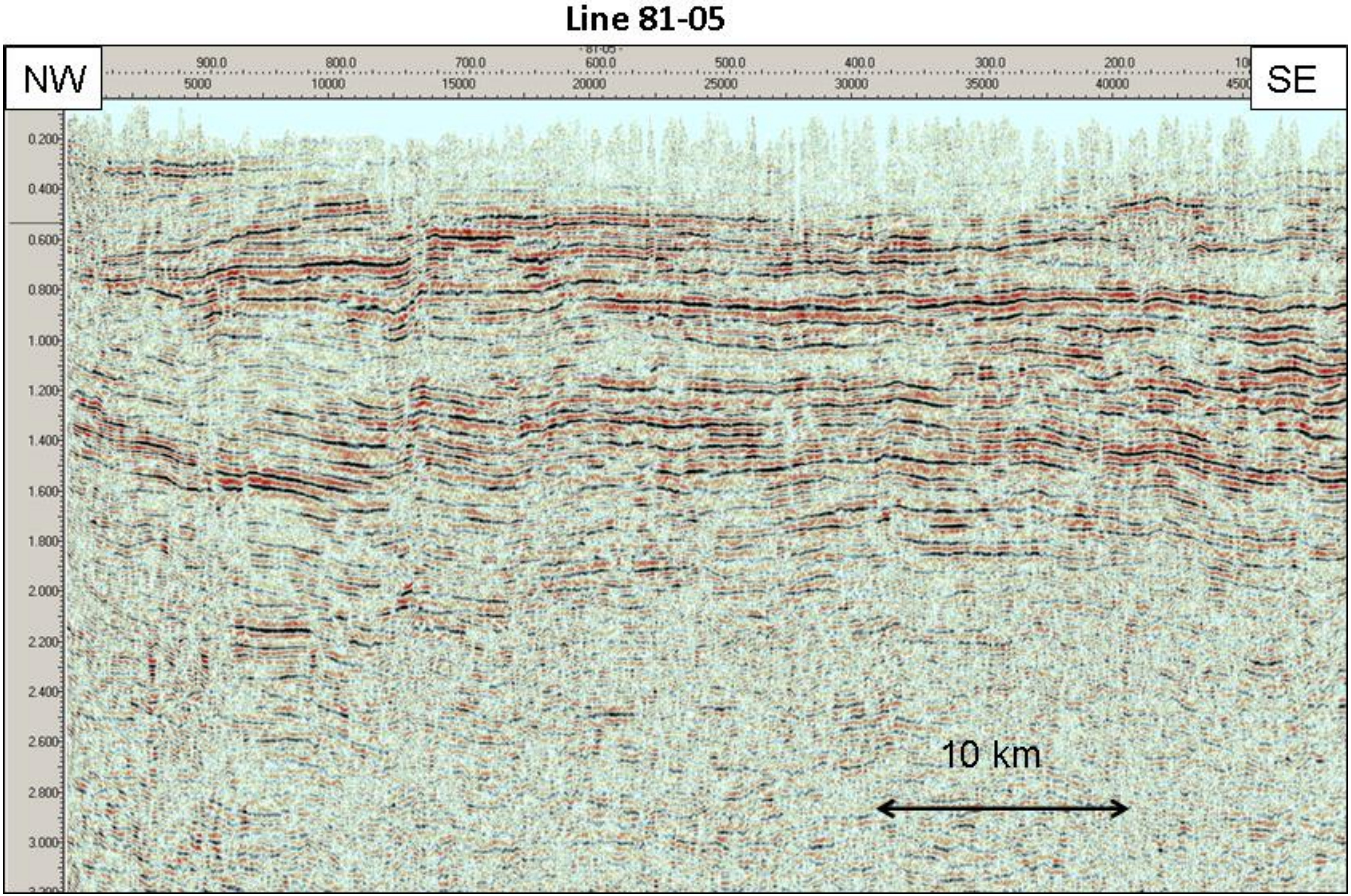


Figure 5.13: Seismic Line 81-05

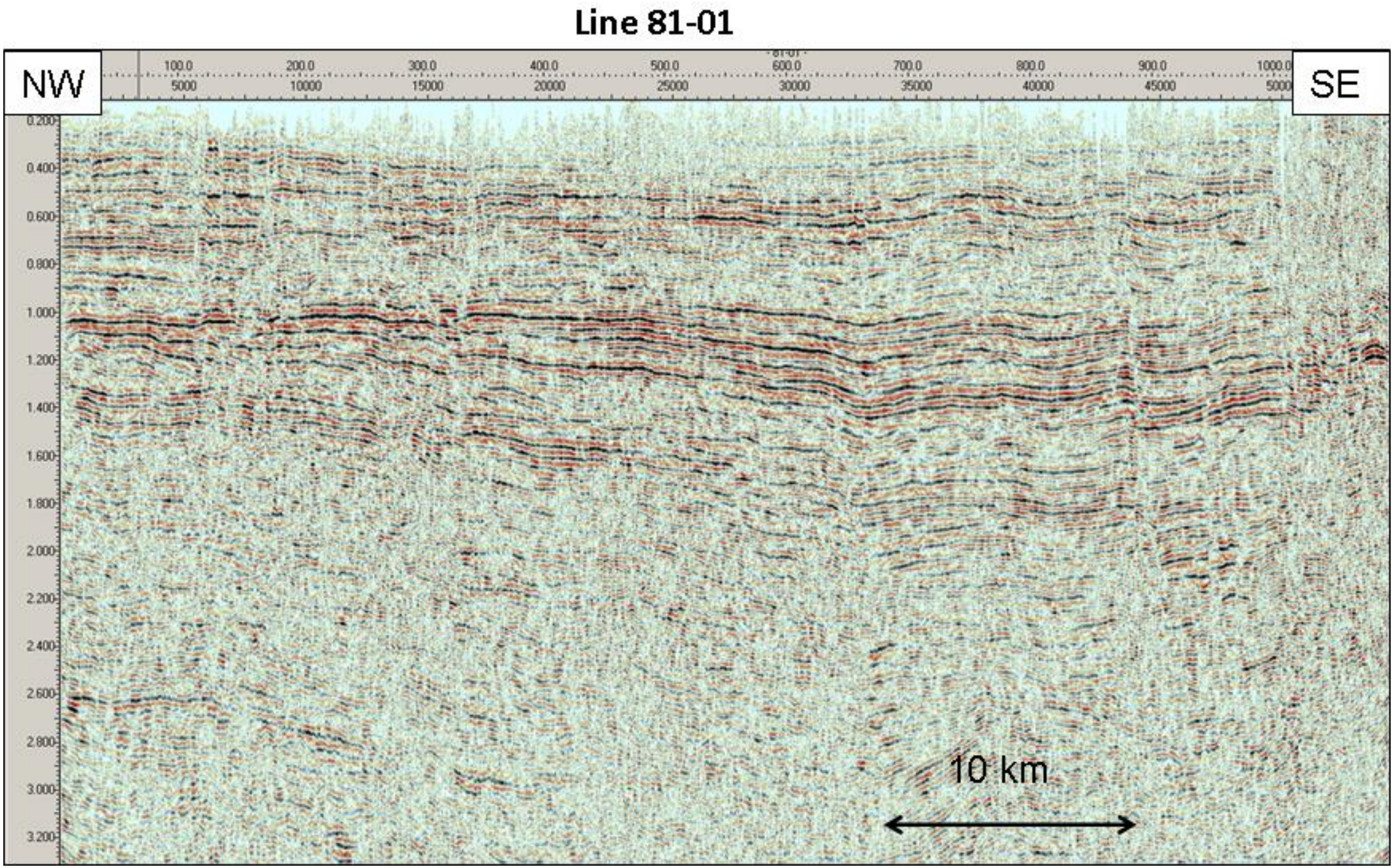


Figure 5.14: Seismic Line 81-01

Line 601

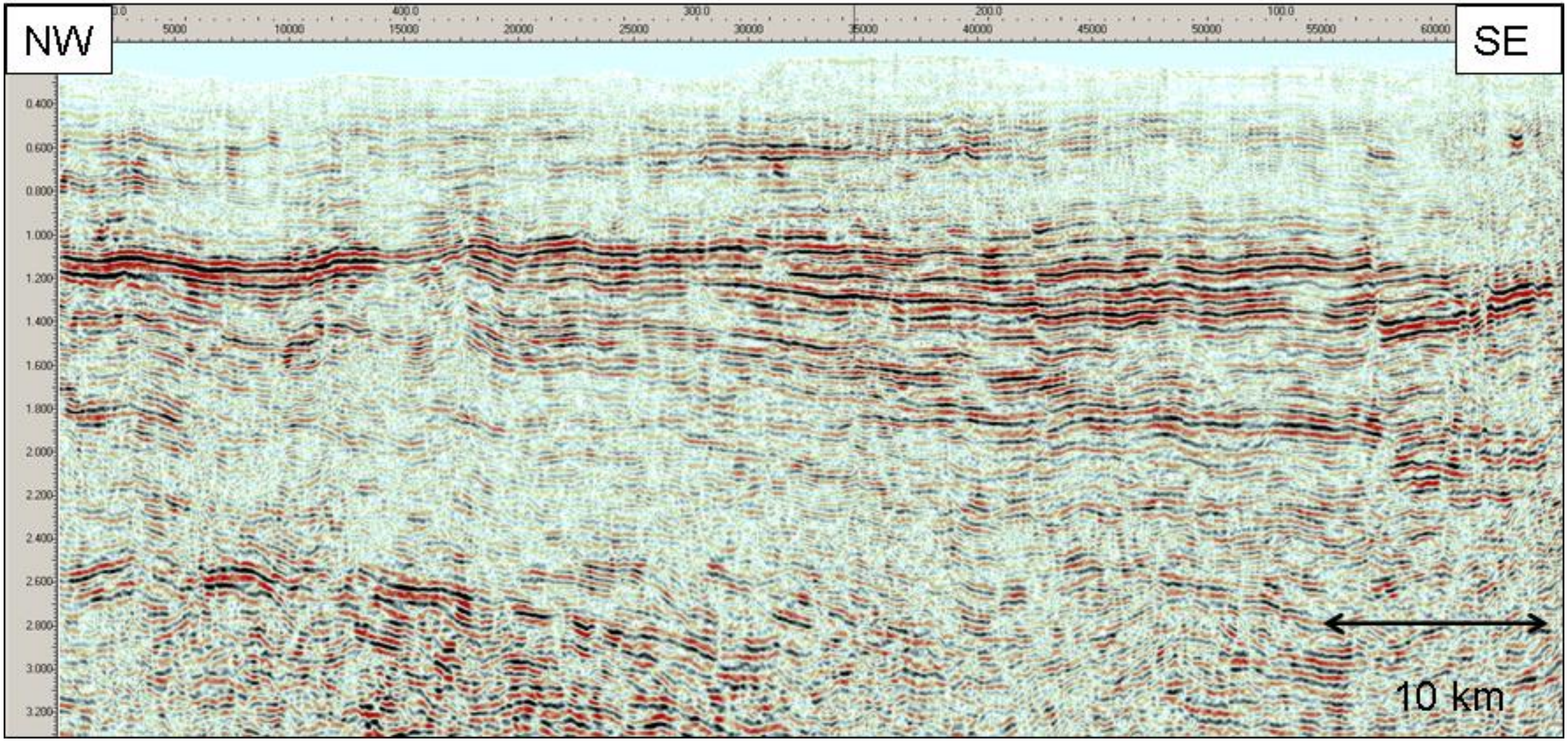


Figure 5.15: Seismic Line 601

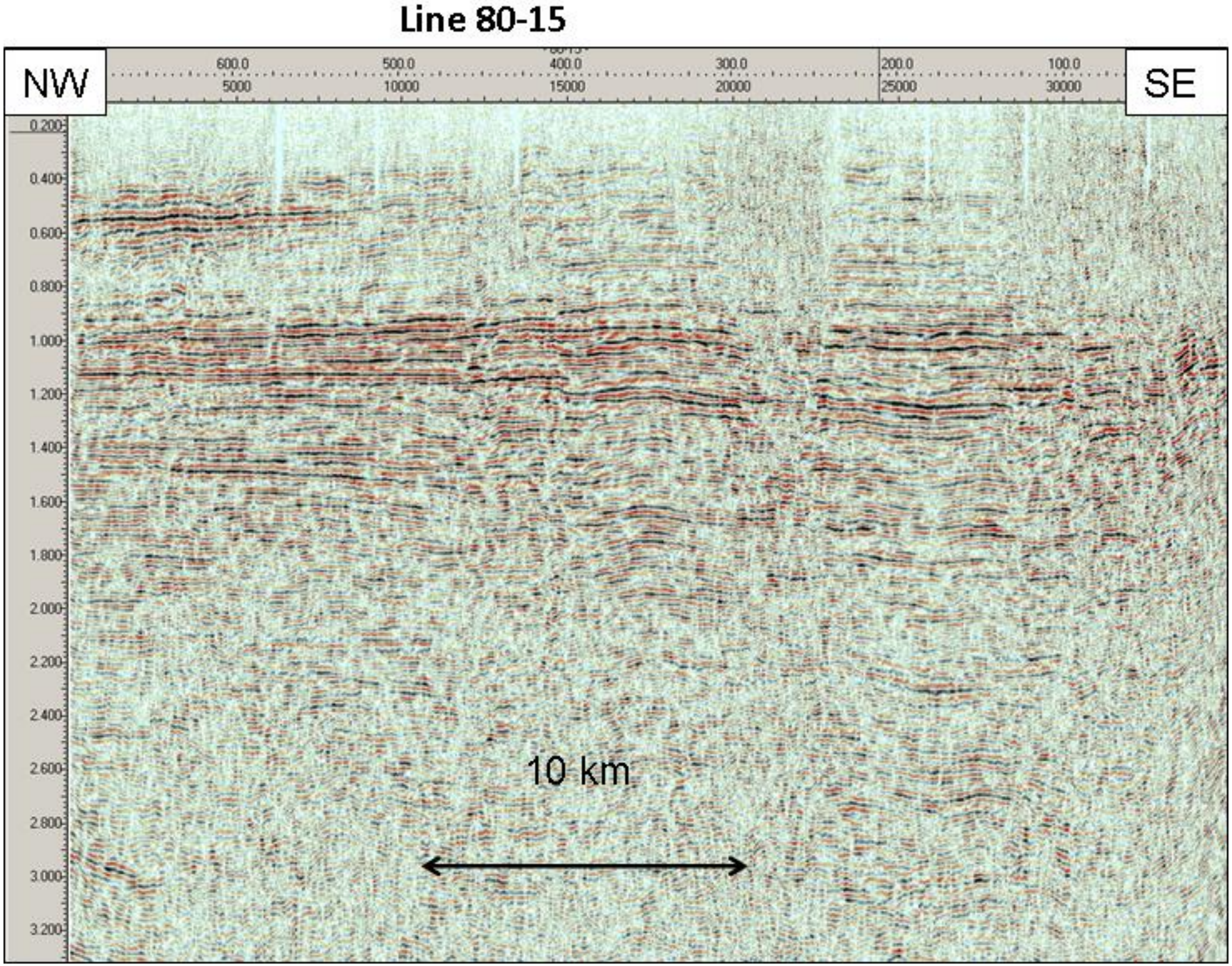


Figure 5.16: Seismic Line 80-15

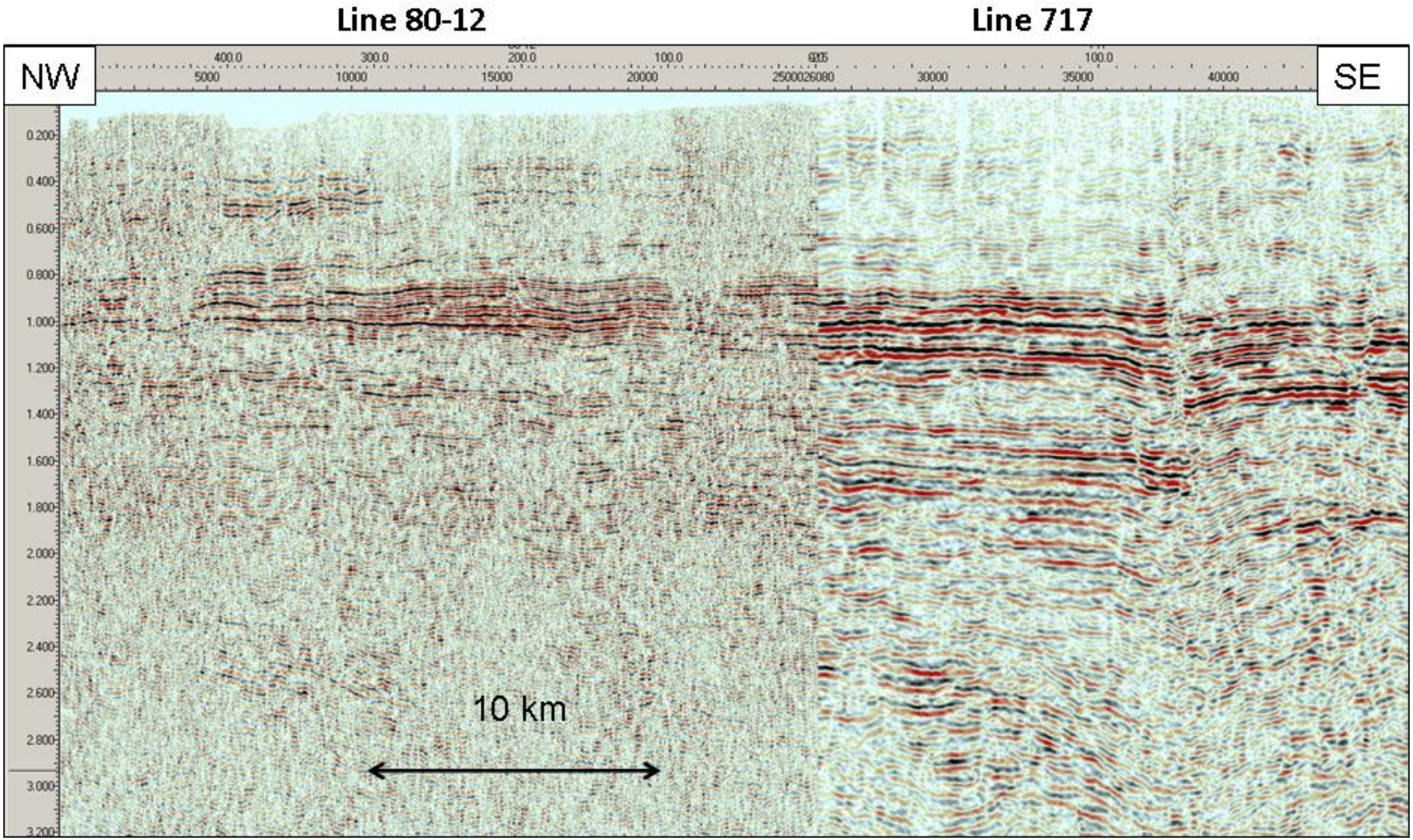


Figure 5.17: Seismic Lines 81-12 & 717

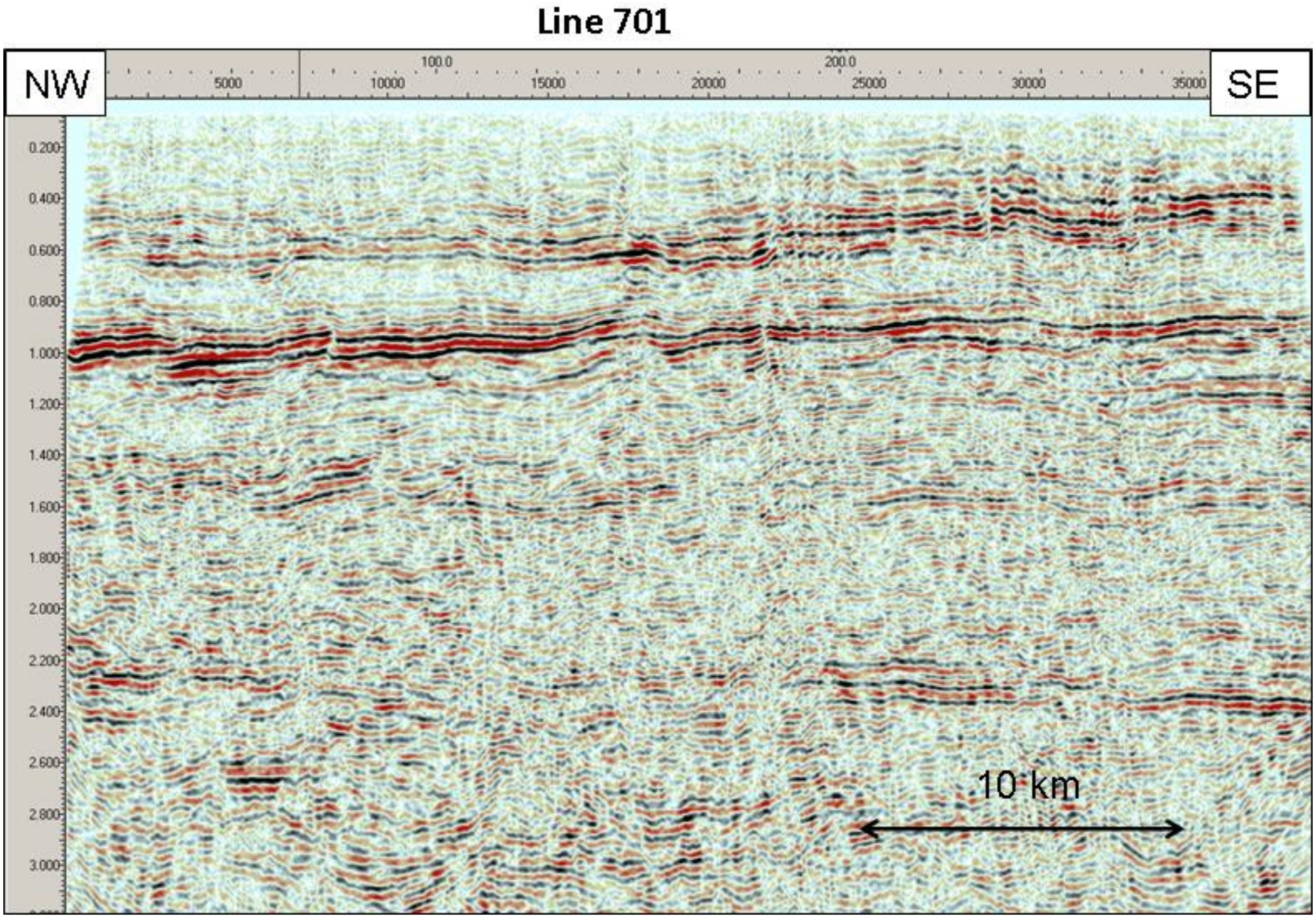


Figure 5.18: Seismic Line 701

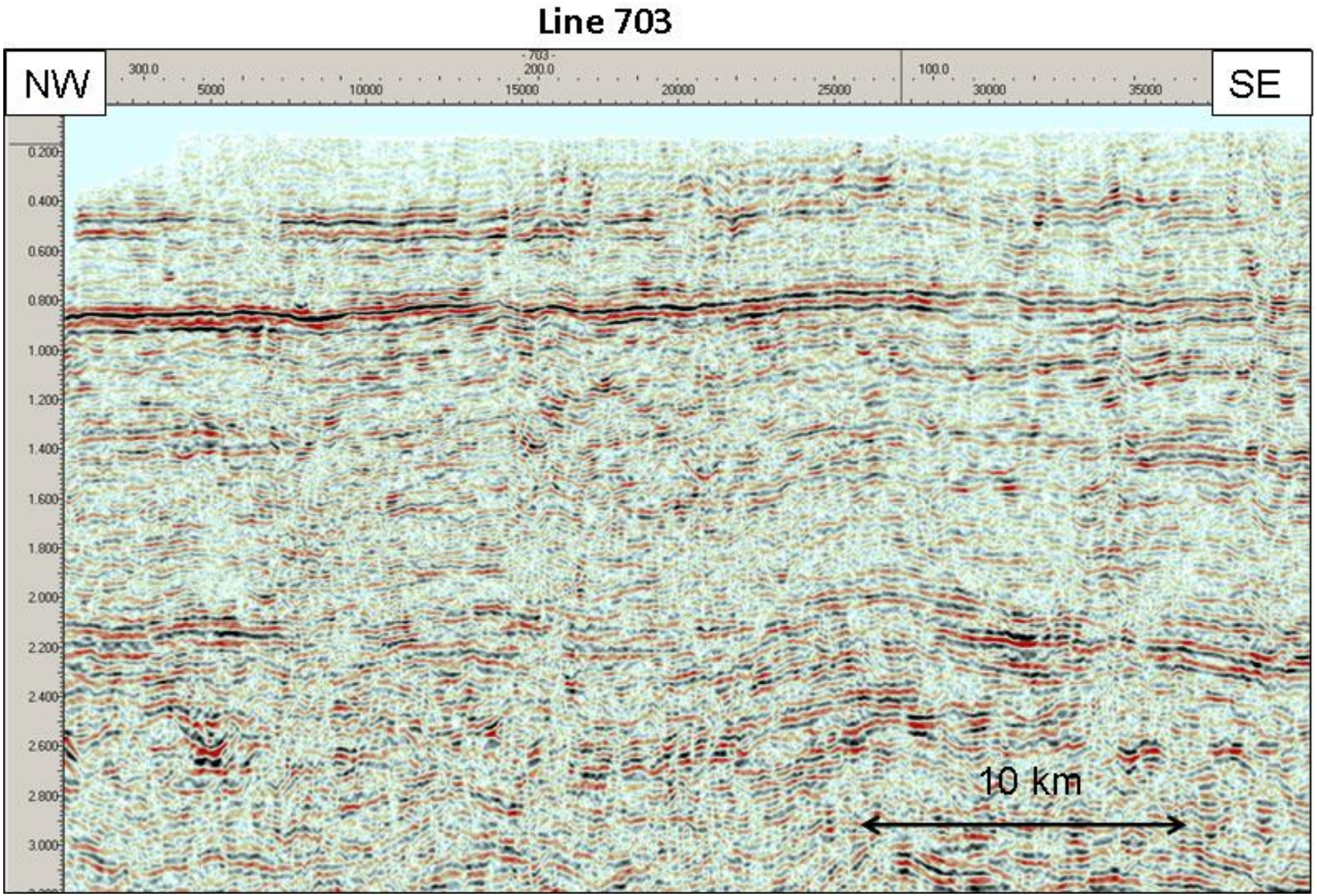


Figure 5.19: Seismic Line 703

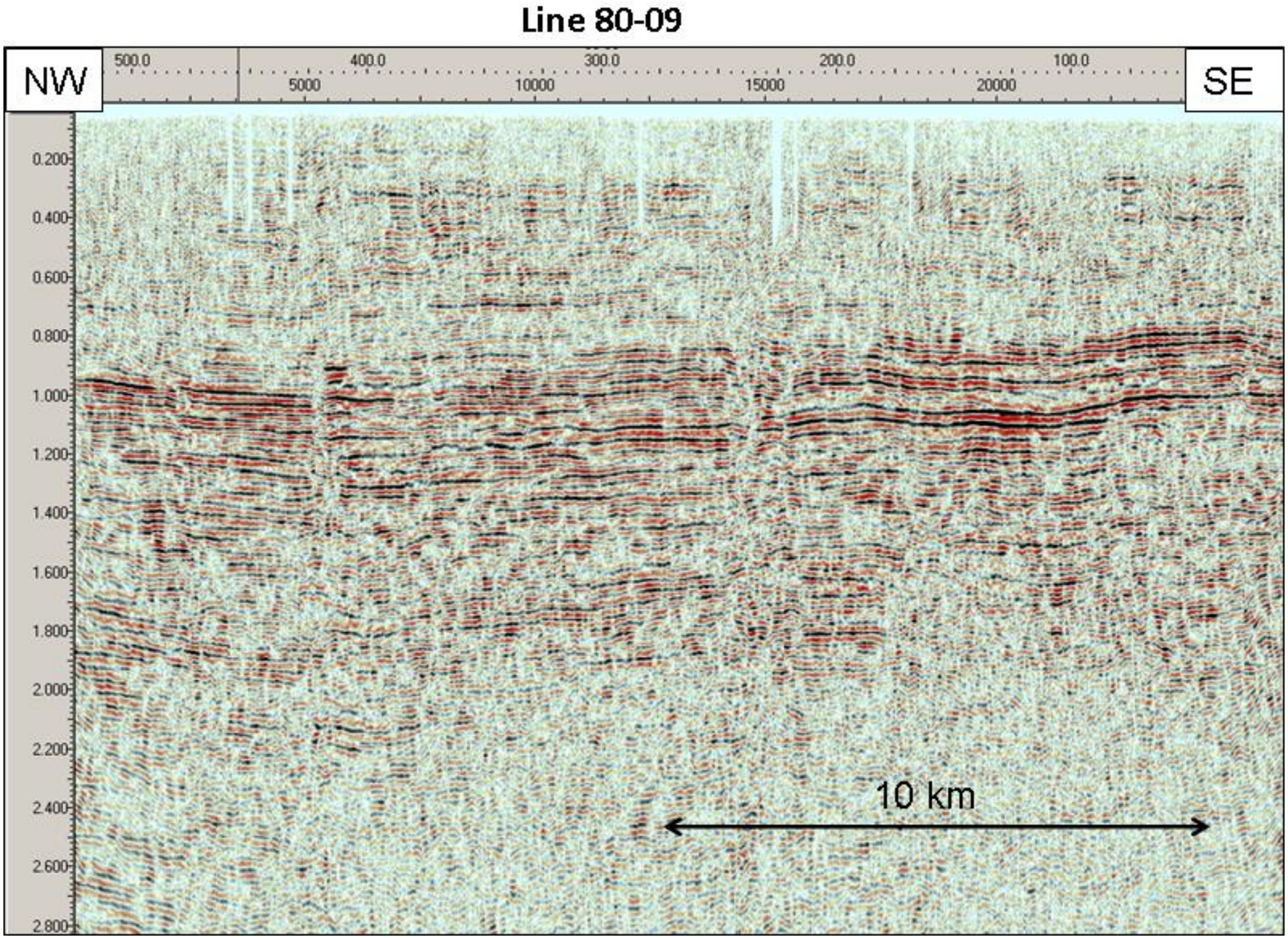


Figure 5.20: Seismic Line 80-09

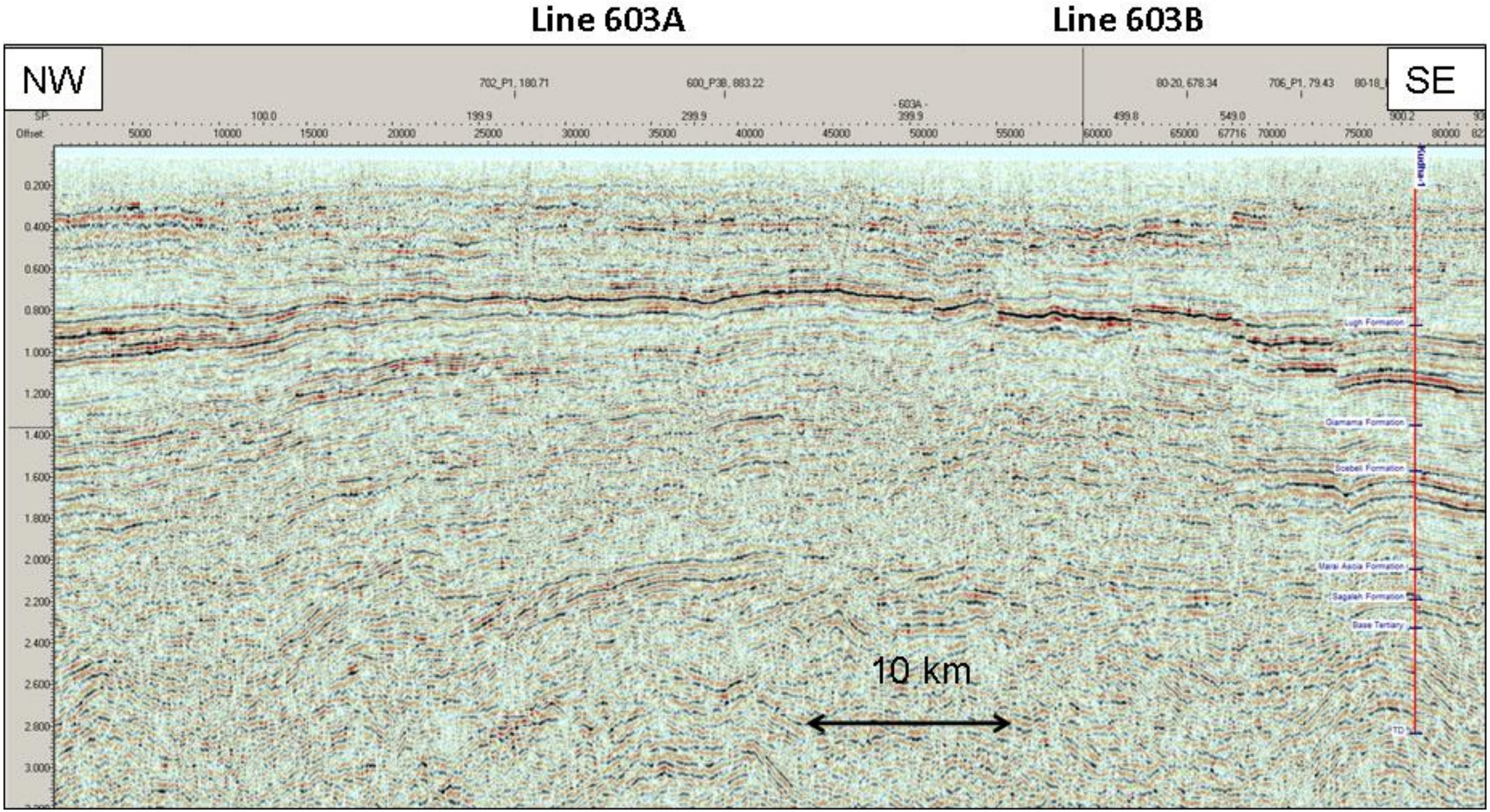


Figure 5.21: Kudha-1Seismic Lines 603A & 603B

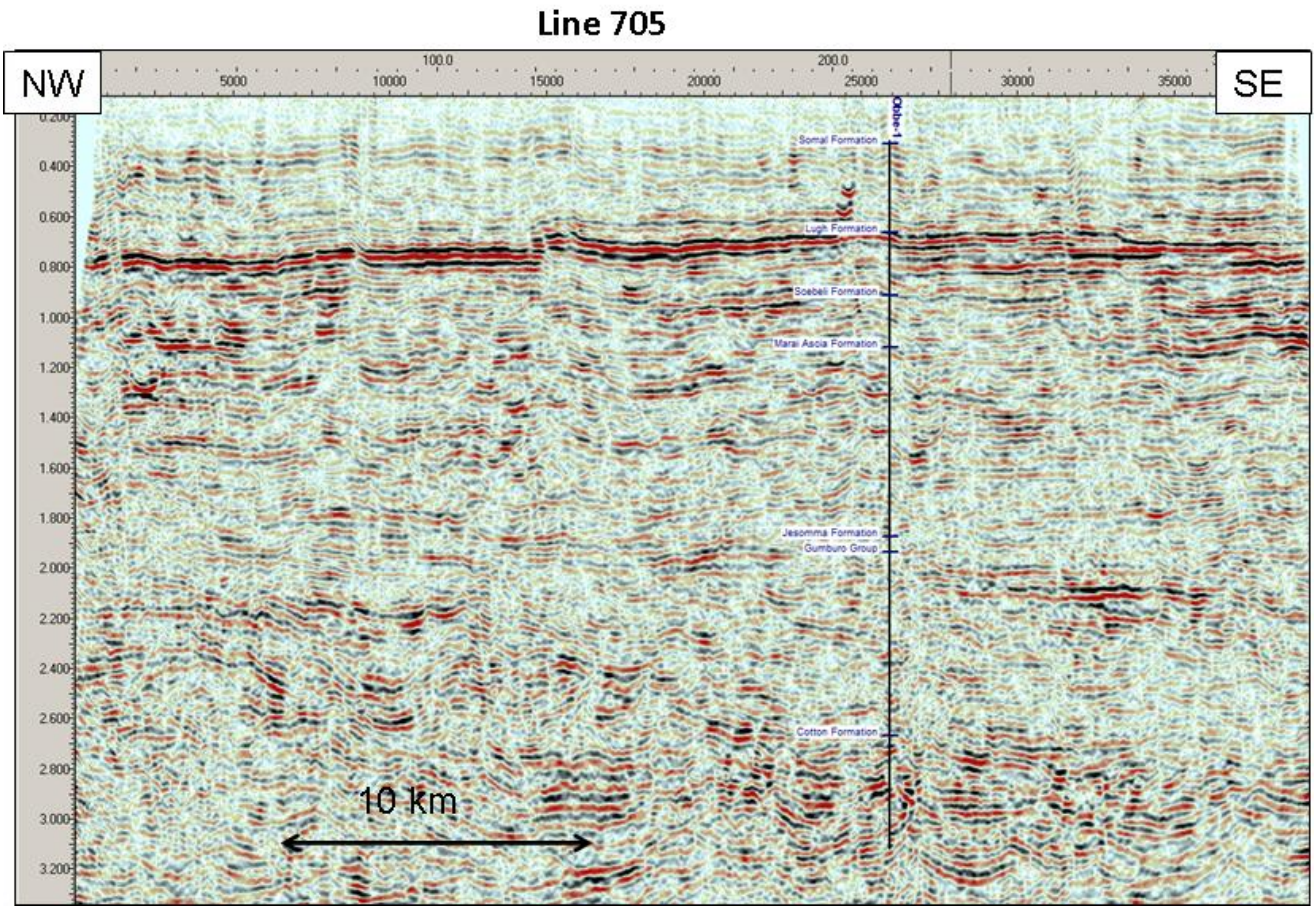


Figure 5.22: Obbe-1 Seismic Line 705

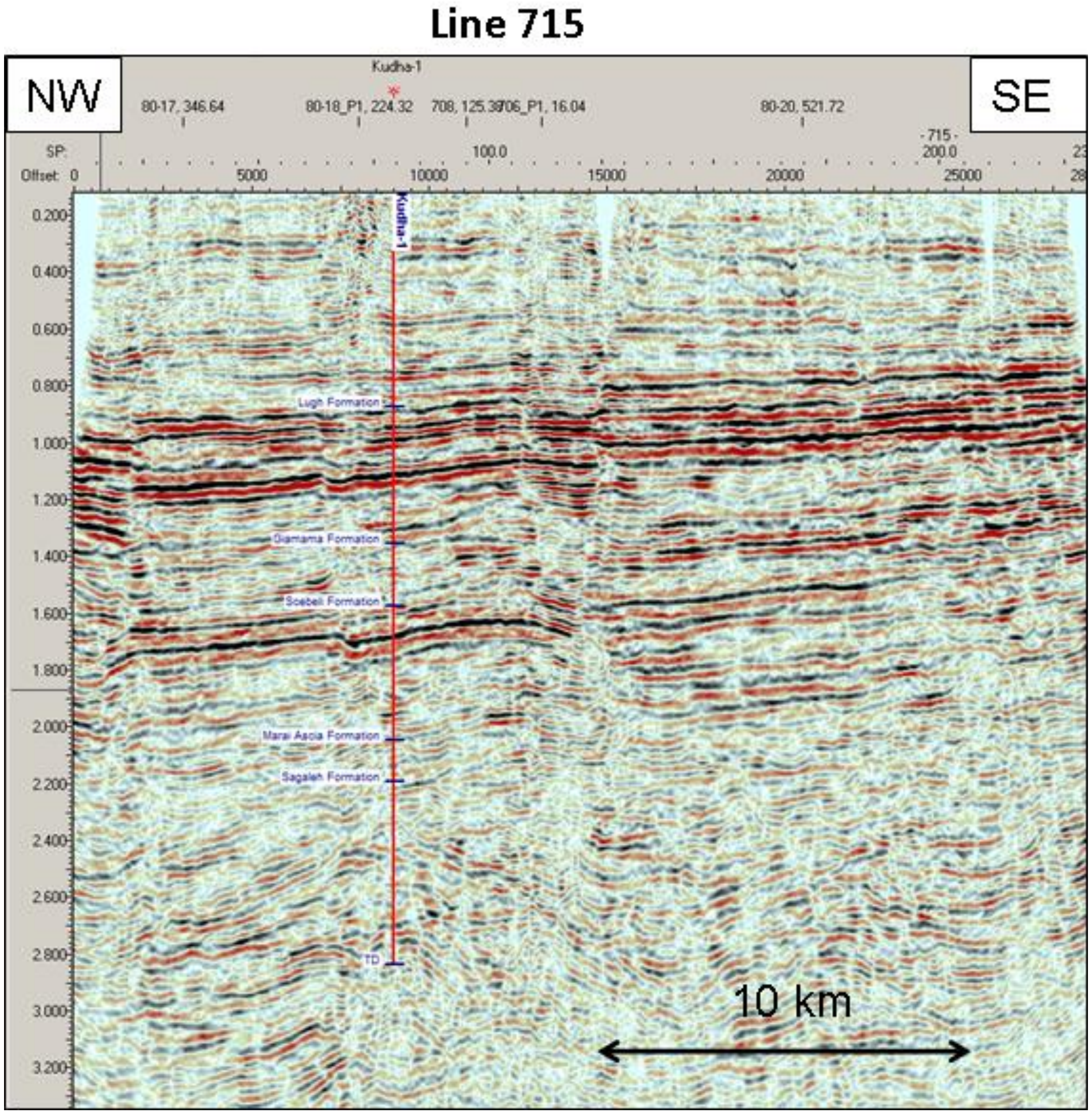


Figure 5.23: Kudha-1Seismic Line 715

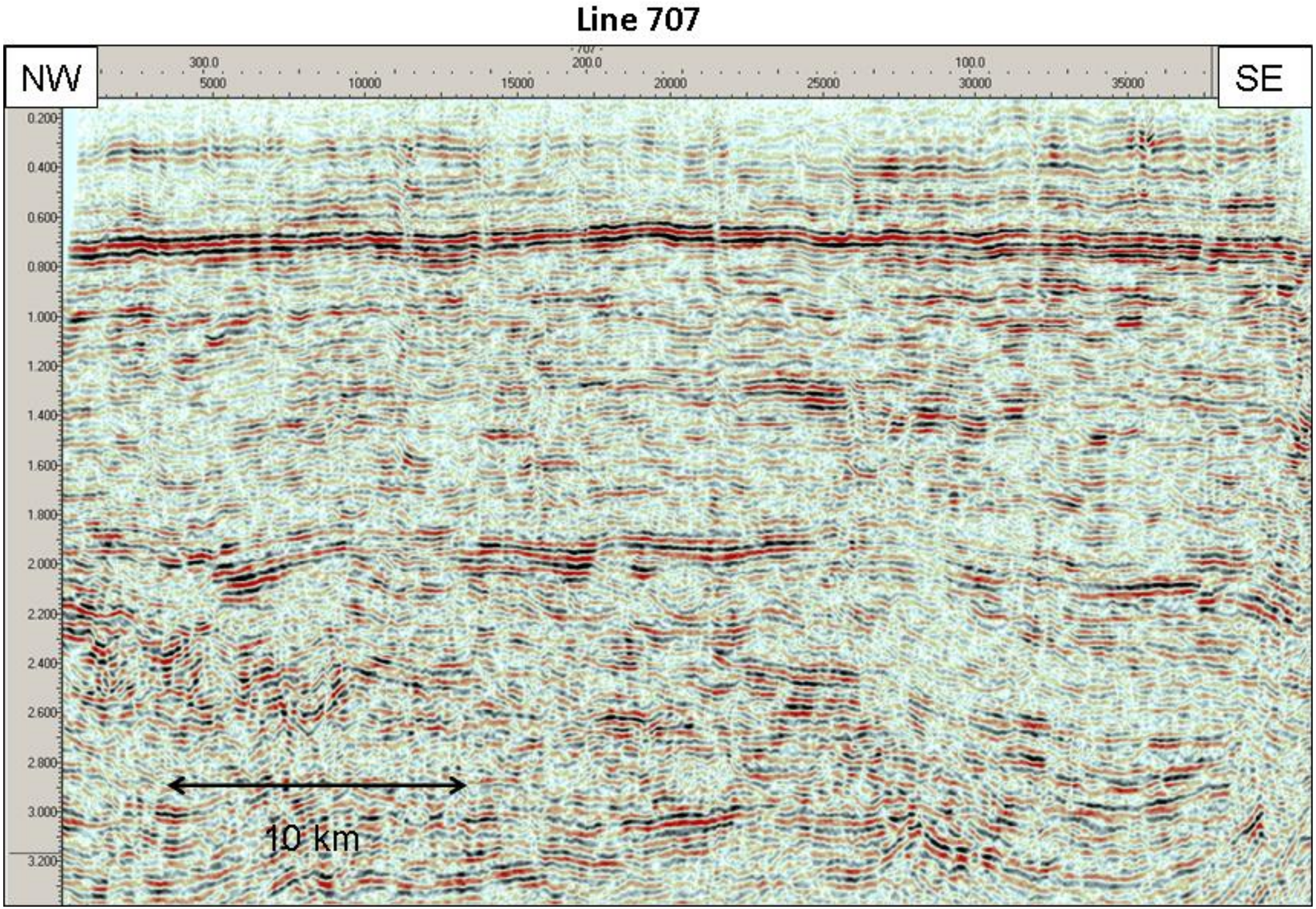


Figure 5.24: Seismic Line 707

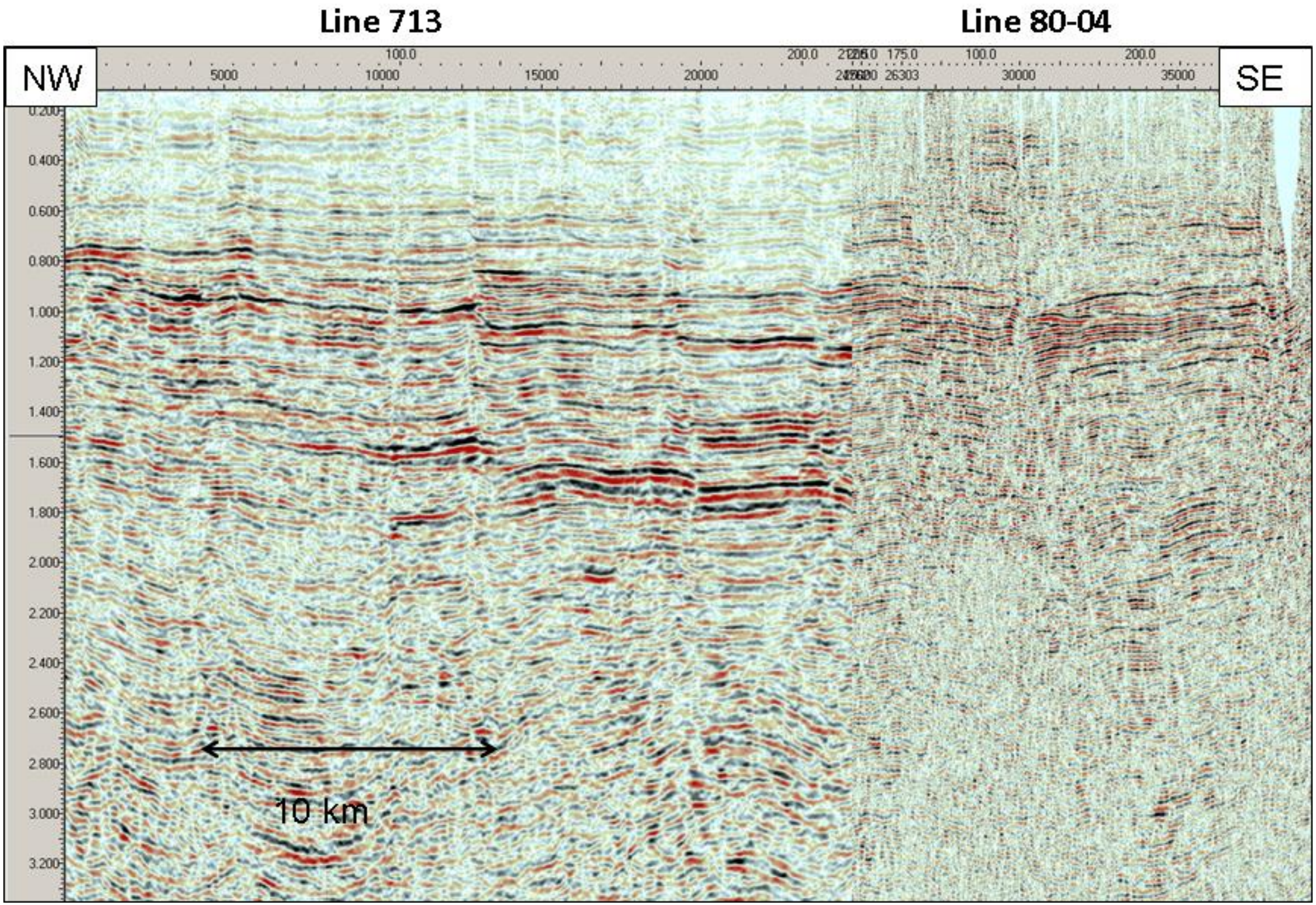


Figure 5.25: Seismic Lines 713 & 80-04

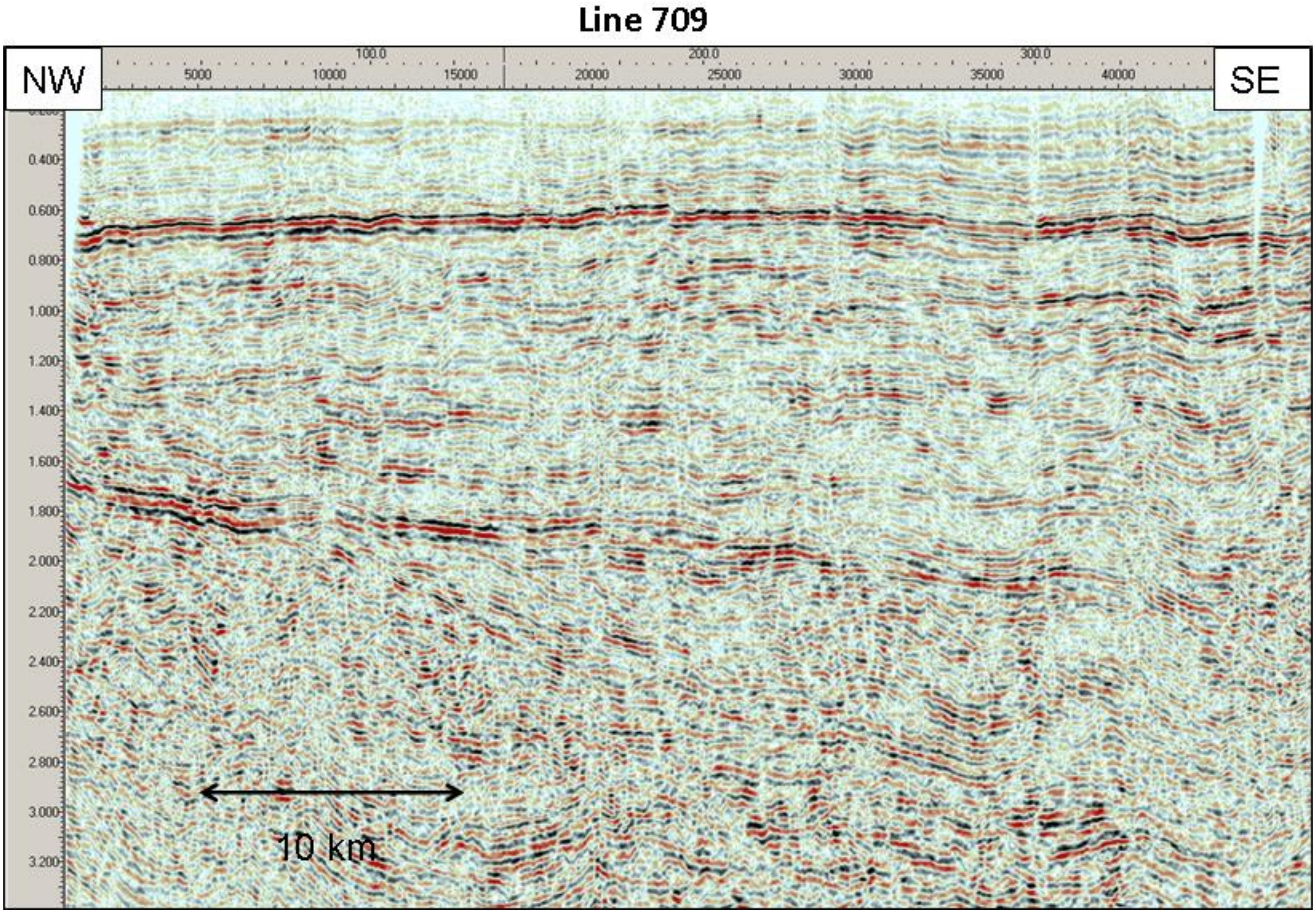


Figure 5.26: Seismic Line 709

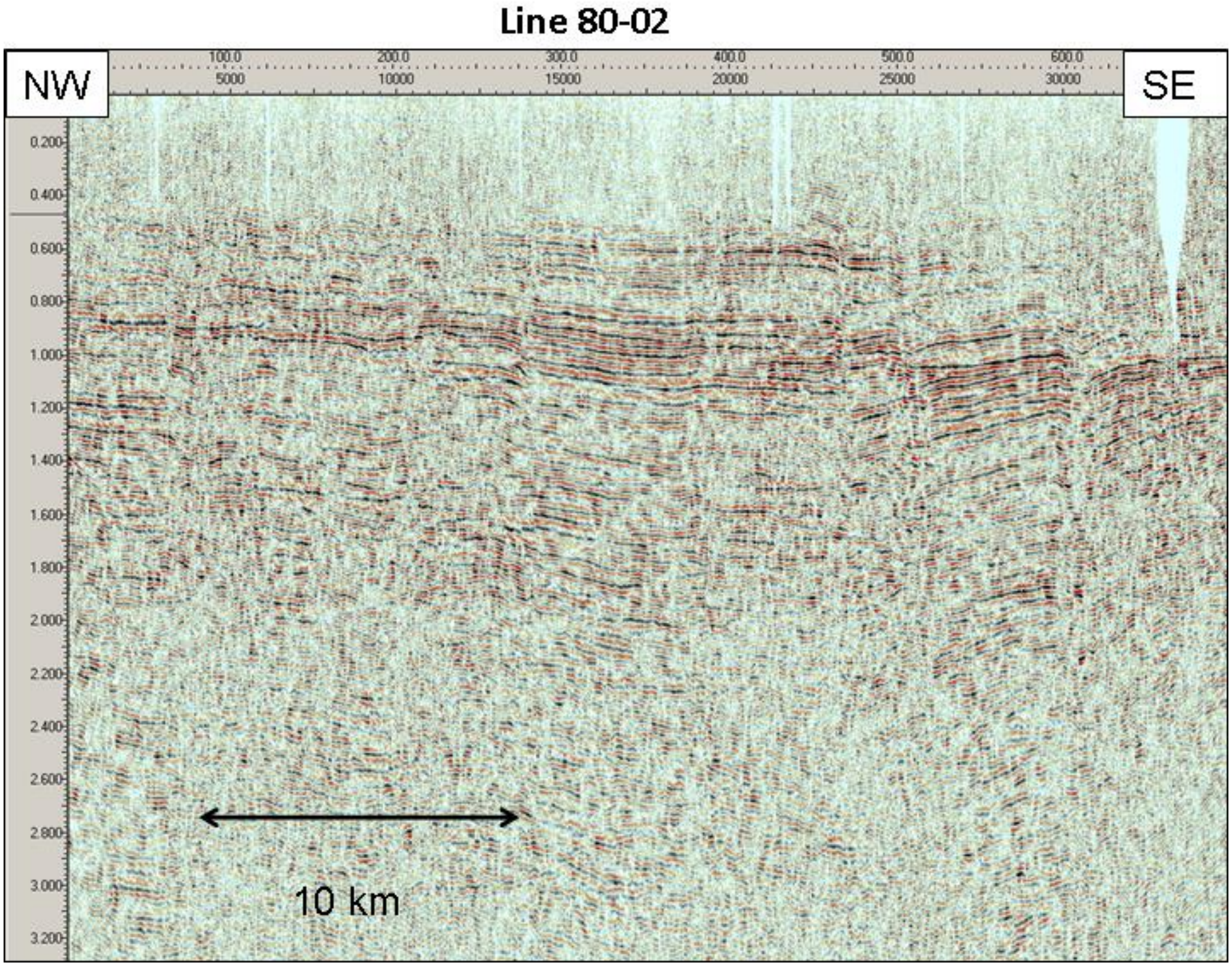


Figure 5.27: Seismic Line 80-02

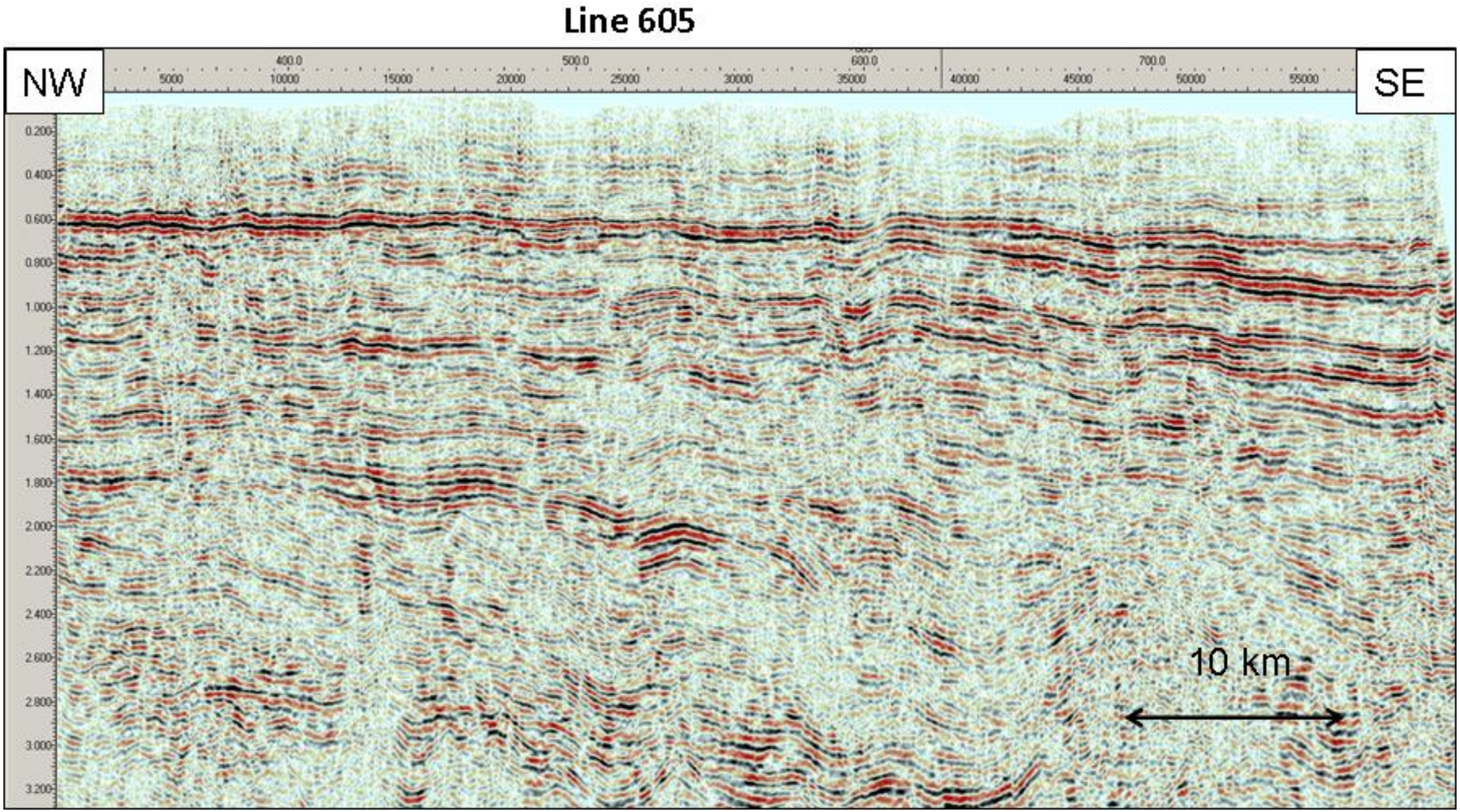


Figure 5.28: Seismic Line 605

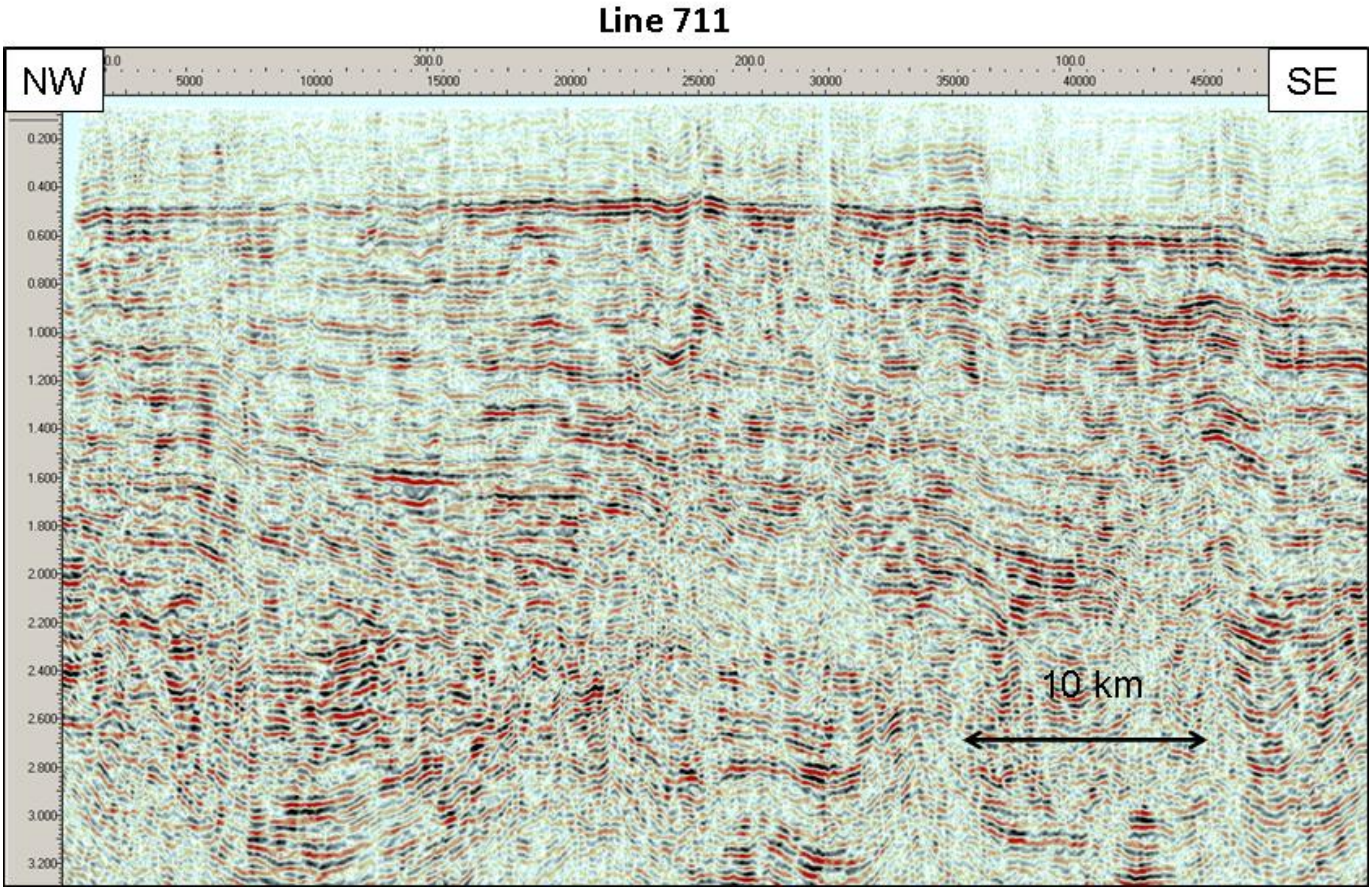


Figure 5.29: Seismic Line 711

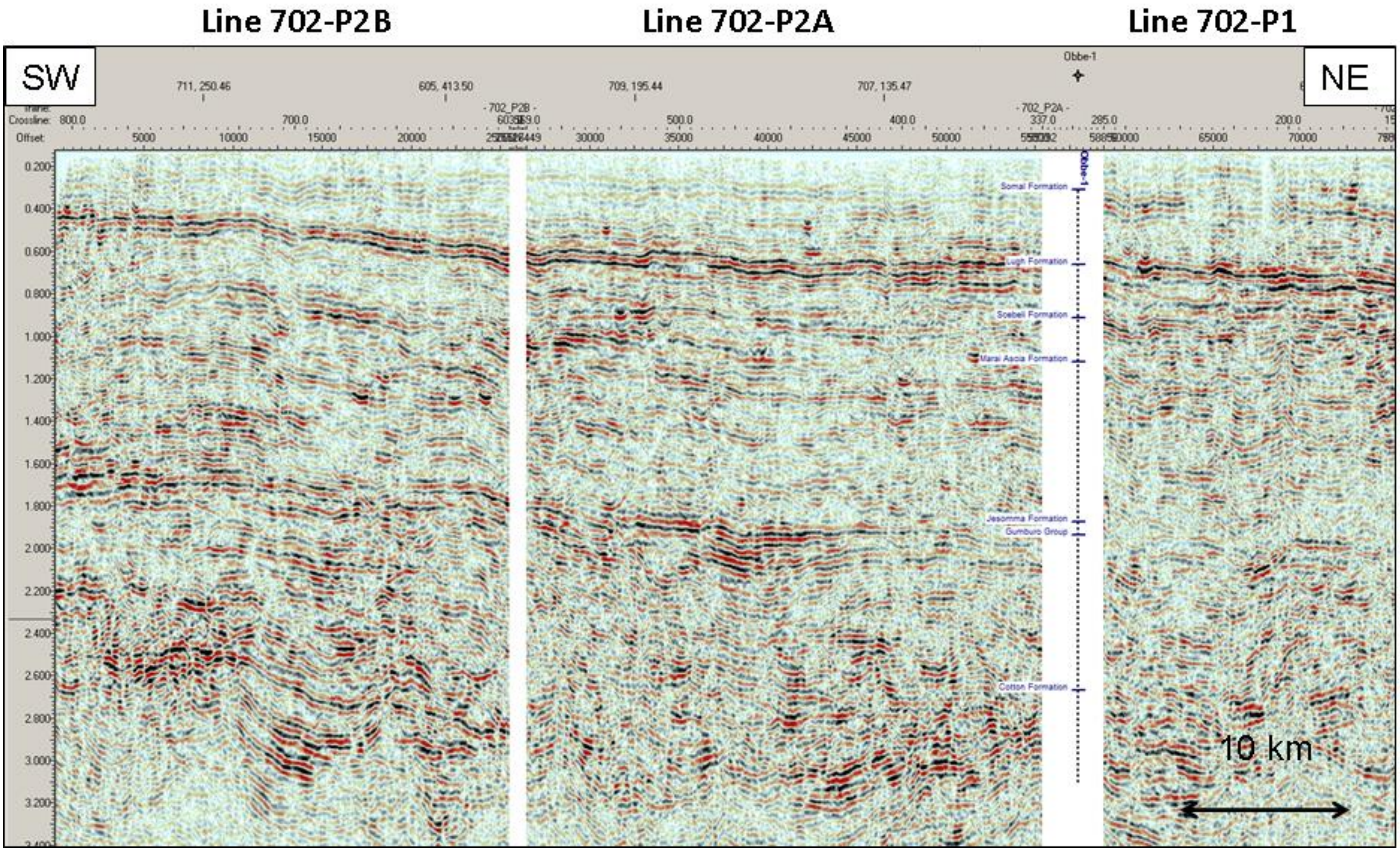


Figure 5.30: Obbe-1Seismic Lines 702-P2B, 702-P2A & 702-P1

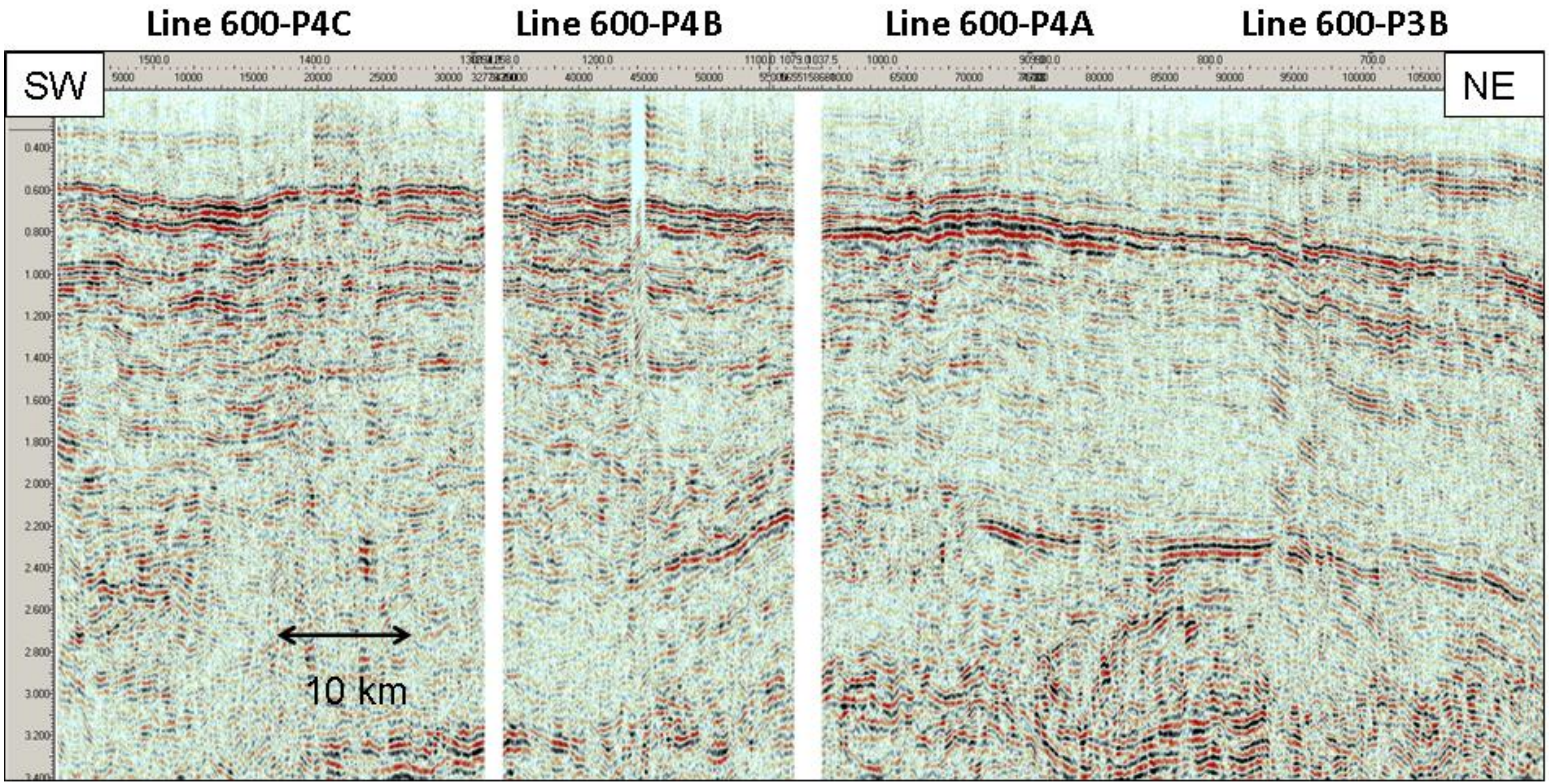


Figure 5.31: Seismic Lines 600-P4C, 600-P4B & 600-P3B

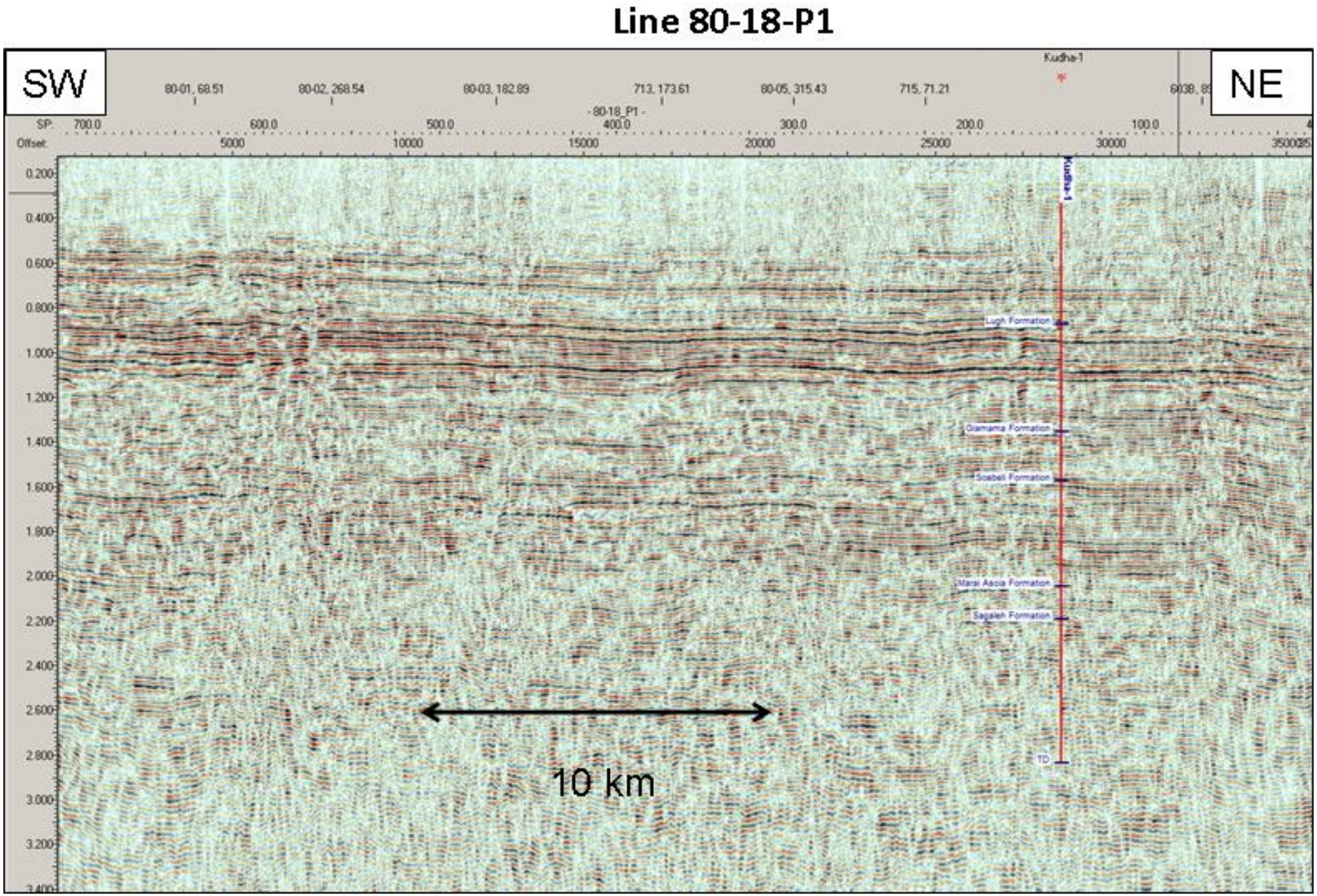


Figure 5.32: Kudha-1 Seismic Line 80-18-P1

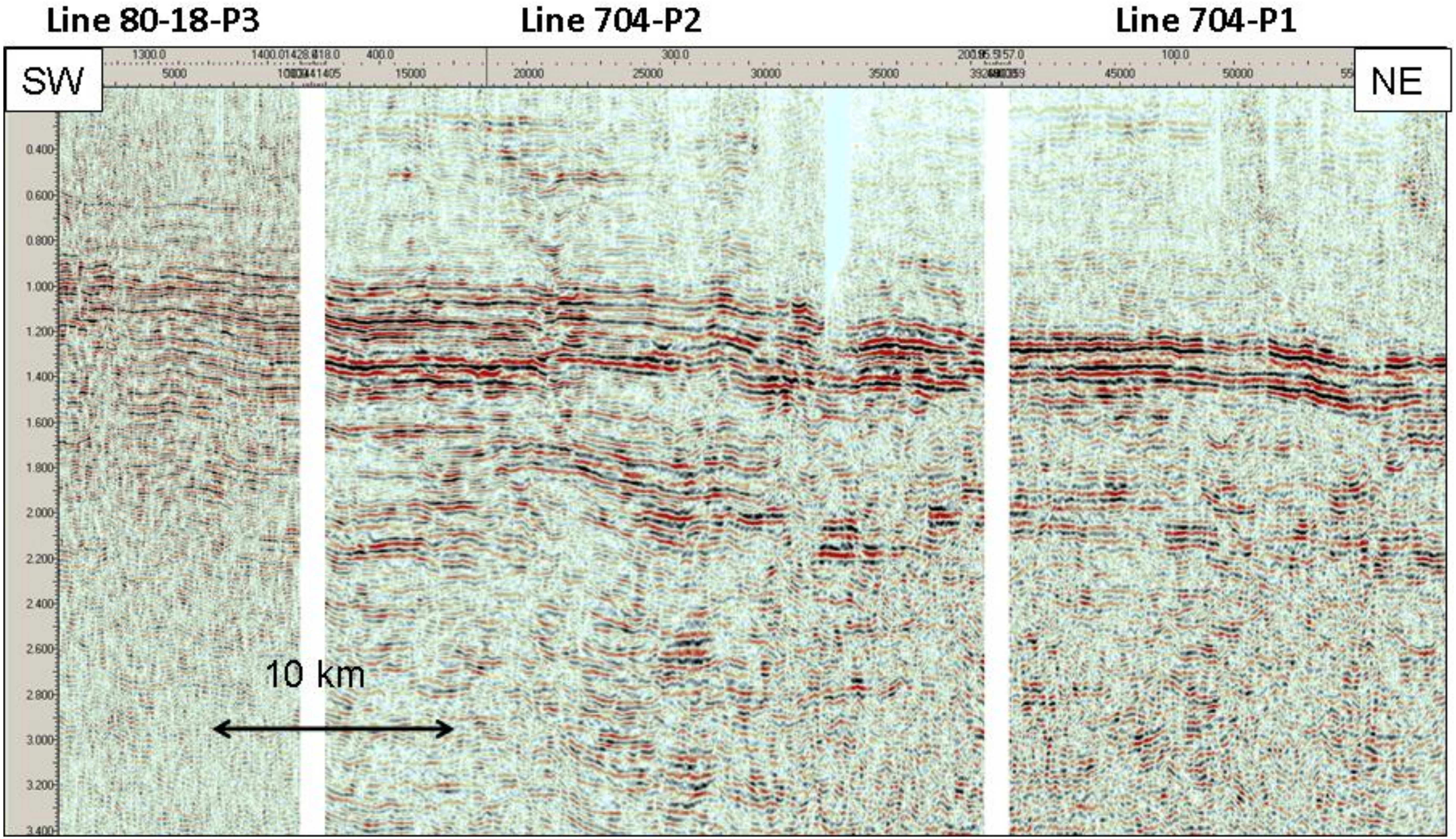


Figure 5.33: Seismic Lines 80-18-P3, 704-P2 & 704-P1

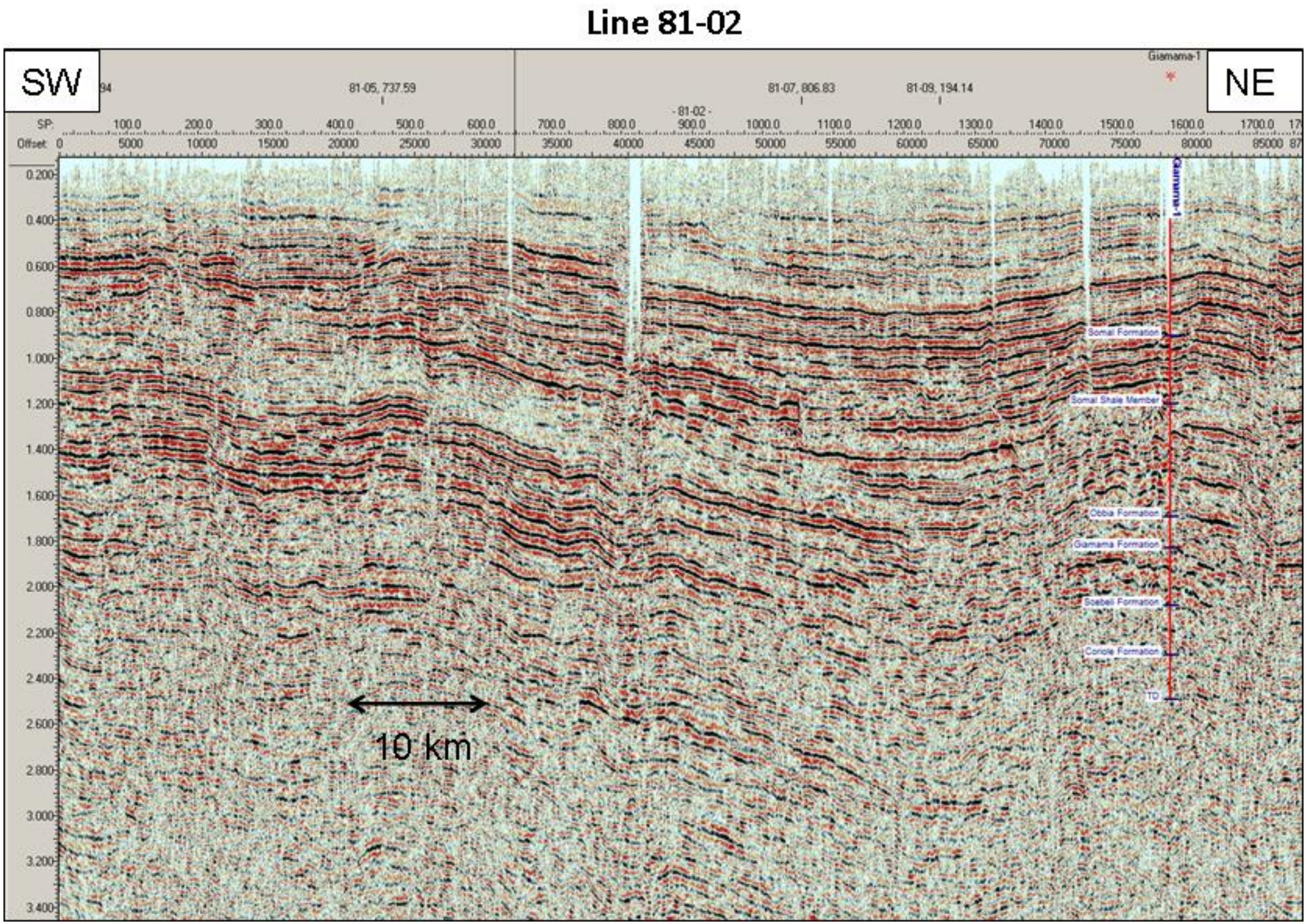


Figure 5.34: Giamama-1 Seismic Line 81-02

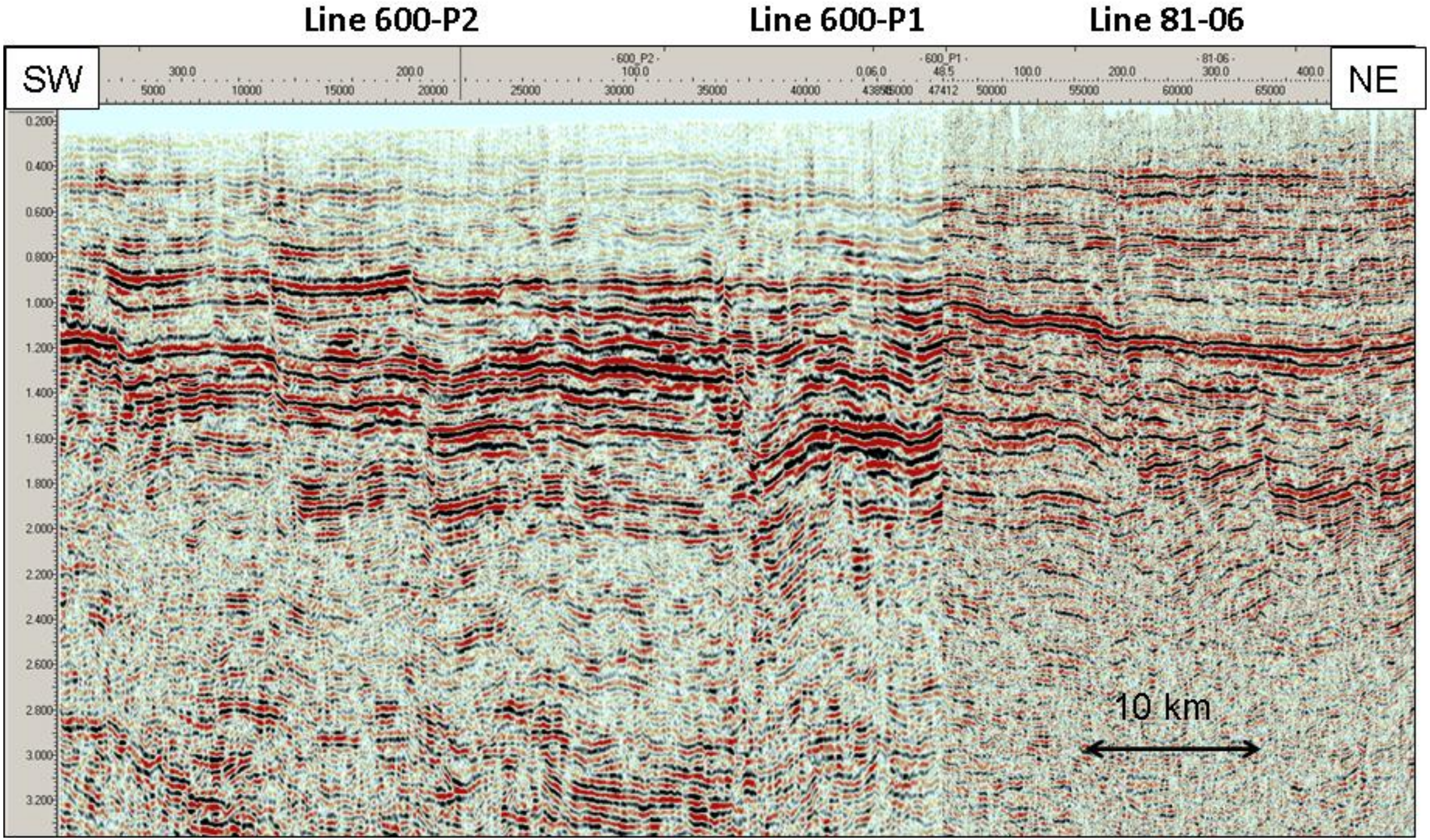


Figure 5.35: Seismic Lines 600-P2, 600-P1 & 81-06

6. EXPLORATION SUBAREA 2

6.1 Drilling Results & General Geology

Subarea 2 is located onshore approximately 200 km southwest of Mogadishu. The subarea is located adjacent to the Juba-Lamu basin and in the south of the Coriole Basin. These basins are separated by the Brava fault zone (**Section 4**).

The subarea area covers approximately 8,000 Km^2 and includes Block 6 currently held by Amoco (now BP) under Force Majeure (Figure 3.28).

The dataset for this area comprises of twenty three 2D Seismic Lines and two wells. The seismic lines trend either NE-SW or NW to SE. The seismic grid is sparse approximately 20 x 20km and comprises over 1,200 line km. The seismic quality varies from fair to good.

The wells drilled in subarea 2 are:-

Brava-1 (Sinclair 1962)

Mudun-1 (Amoco 1990)

The only available seismic survey was acquired by:

Amoco in 1988

The location of Subarea 2 and the available seismic and well data is shown in Figure 6.1.

The **Brava-1** well was drilled by Sinclair in 1962 on a large structure identified from seismic that is no longer available. The targets were Cretaceous and Jurassic fault blocks. The well reached the Lower Jurassic/Triassic Adigrat Formation.

The **Mudun-1** well was drilled on the results of the 1988 2D seismic survey. The primary objectives were Lower Cretaceous sandstones in an anticlinal structure defined by the seismic. The well failed to penetrate the Lower Cretaceous although sands were found in the Campanian.

The two wells did not encounter any hydrocarbons and were plugged and abandoned (P&A).

Subarea 2 lies in the southern part the Coriole Basin and is bounded to the south by the east-west trending Brava Fault Zone which downthrows towards the south. The region forms a broad structural highs perhaps initiated in the Jurassic Period. Later structural deformation occurred in Oligocene to Miocene time when faulting and uplift resulted in a significant erosional unconformity.

The oldest stratigraphy penetrated by the Brava-1 well is dated to be Triassic in age; the Adigrat Formation Sandstones, equivalent to the Karoo Series. Overlying this formation is the Meregh Formation shales which are Late Jurassic in age. Cretaceous to Eocene stratigraphy consists primarily of the Mudun Formation sandstones and shales. These formations are heavily faulted and are absent due to erosion at the Oligo-Miocene unconformity over a large proportion of the area. This unconformity is clearly visible on seismic at the Brava-1 and Mudun-1 Wells. The Middle Miocene Somal units that overly the unconformity were deposited during marine transgression. The shallowest unit in the area is the Merca Formation Sandstone and Clays.

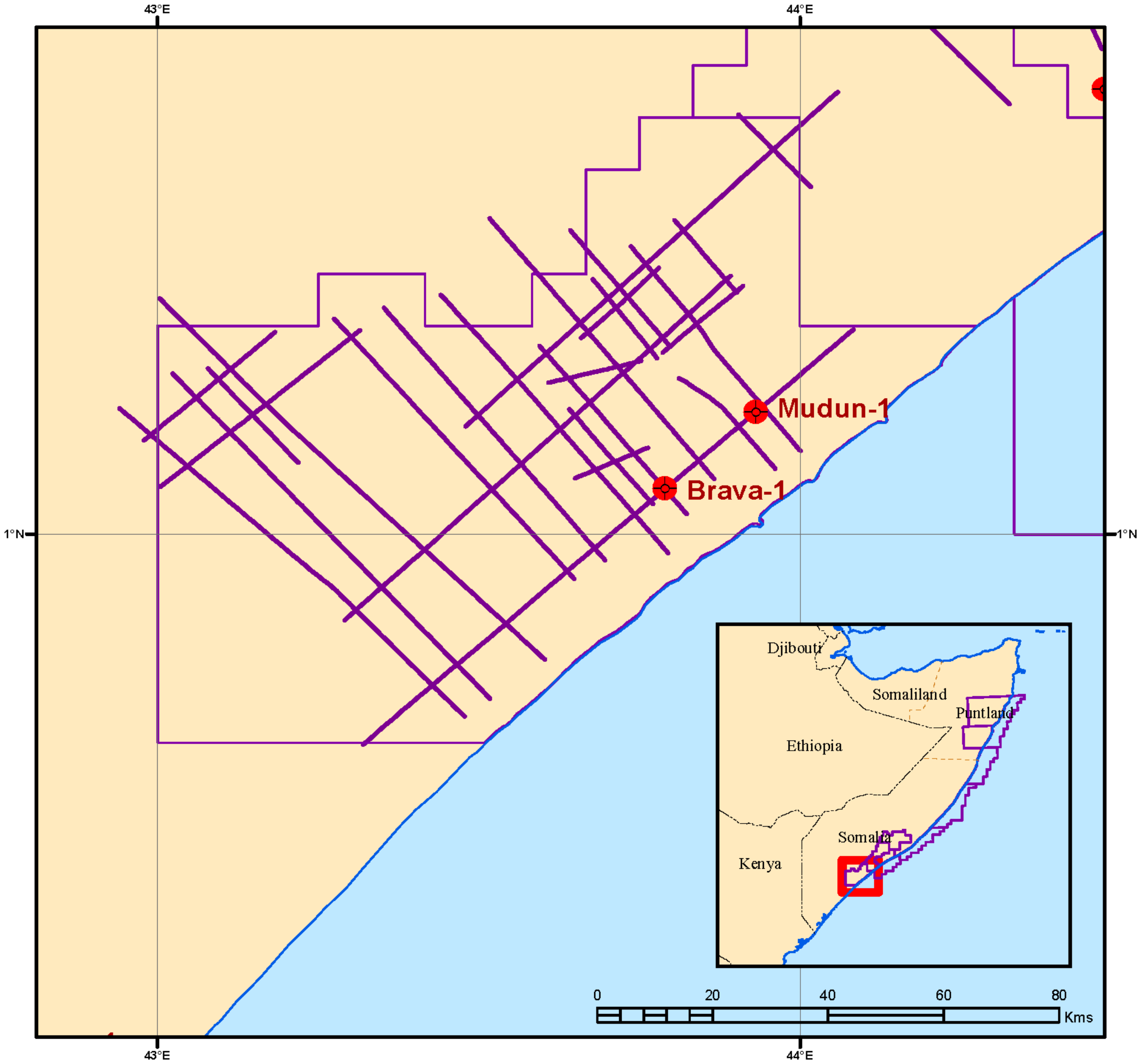


Figure 6.1: Subarea 2 Seismic and Well Database Map

Target horizons for the area were the Late Cretaceous sands of the Mudun Formation in four-way dip closures. No hydrocarbons were found in either well; the locations apparently being off-structure, and the reservoir units were either thin or absent. However some of the thin sand beds are reported to have good reservoir properties. Source potential may be present in the Upper Jurassic but data on this are sparse.

Brava-1 was drilled by Sinclair between November 1962 to June 1963 to a total depth of 3,810m (12,500ft) on a large structure with four way dip closure defined by seismic data. These data are no longer available. The structure was interpreted as large –approximately 120 sq km (30,000 acres) -and with a northeasterly trend. However the more recent seismic data available for this study (Figure 6.3) show that the well was not located on the crest of the structure.

The location of Brava-1 is shown in Figure 6.1. The well reached TD in the Lower Jurassic/Triassic Adigrat Formation.

The Adigrat Formation interval (3,700 – 3,810m (12,102 - 12,500ft) consists of sandstones regionally equivalent to the Karoo Series. Above this interval from 2,974 – 3,700m (9,757 – 12,102ft) lies the Lower Jurassic Meregh Formation. The Meregh Formation consists mainly of shales (Figure 6.2).

The Middle Jurassic Hamanlei Formation overlays the Meregh Formation from 2.582 to 2,974m (8,472 – 9,757ft). The Hamanlei Formation consists of limestones.

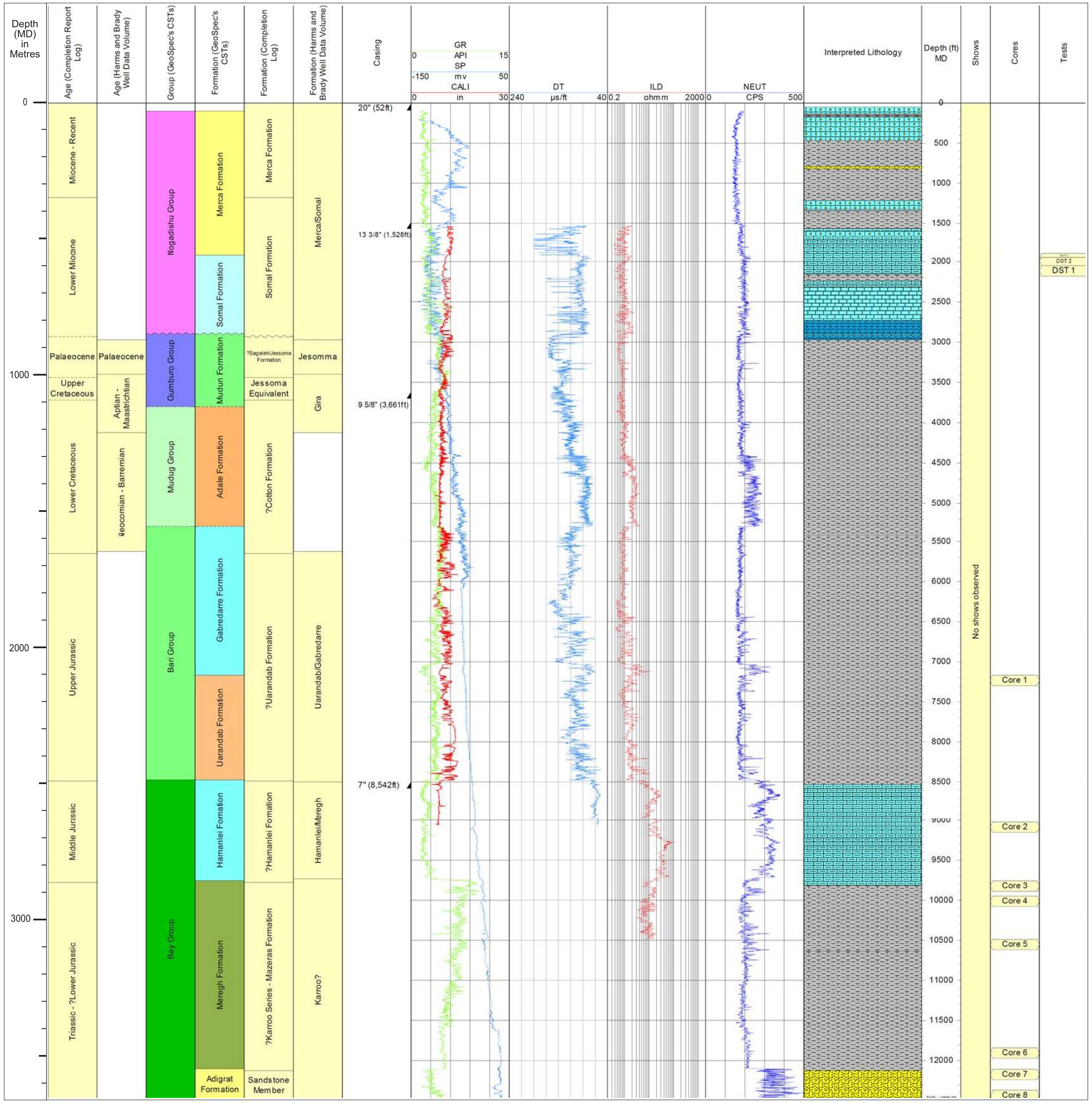
The Upper Jurassic to Cretaceous/Paleocene section in the well comprise the Uaranab, Gabredarre, Adale and Mudun Formations. These are seen between 883 and 2,582m (2,897 – 8,472ft) and are dominated by shales.

The Oligo-Miocene erosional unconformity overlies the Cretaceous and has removed a significant amount of Cretaceous and Tertiary sediments as demonstrated on the geoseismic section in Figure 6.3.

The Lower Miocene Somal Formation transgressive interval between 589 to 883m (1,932 – 2,897ft) consists mainly of carbonates. This is overlain by the Merca Formation which is dominated by sands and shale interbeds.

Three DSTs were run in the Lower Miocene and no hydrocarbons were encountered. All tests recovered salt water. Eight cores were cut in the well in the Upper Jurassic to Triassic with mixed success. No hydrocarbon indicators or visual porosity were noted. Subsequent wireline log derived porosities indicate up to 20% porosity in the Mudun Formation (Upper Cretaceous-Lower Tertiary).

The well was plugged and abandoned as dry.



T.D. 3810m

Brava-1

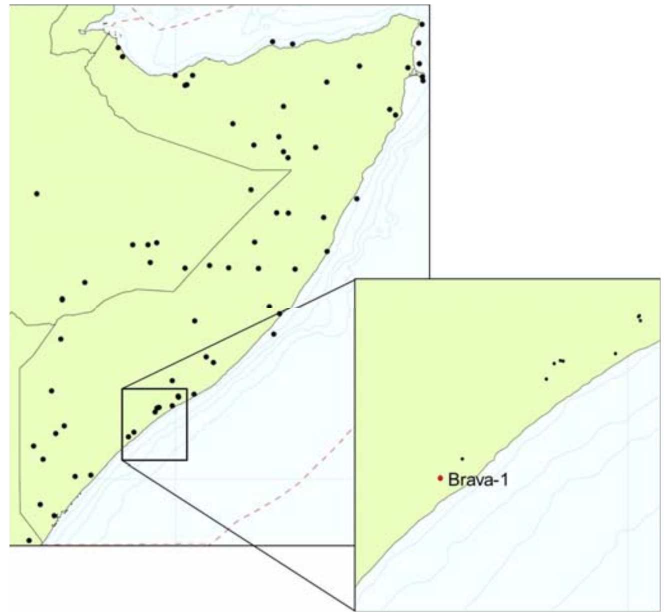
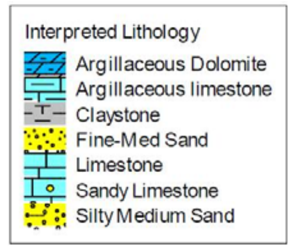
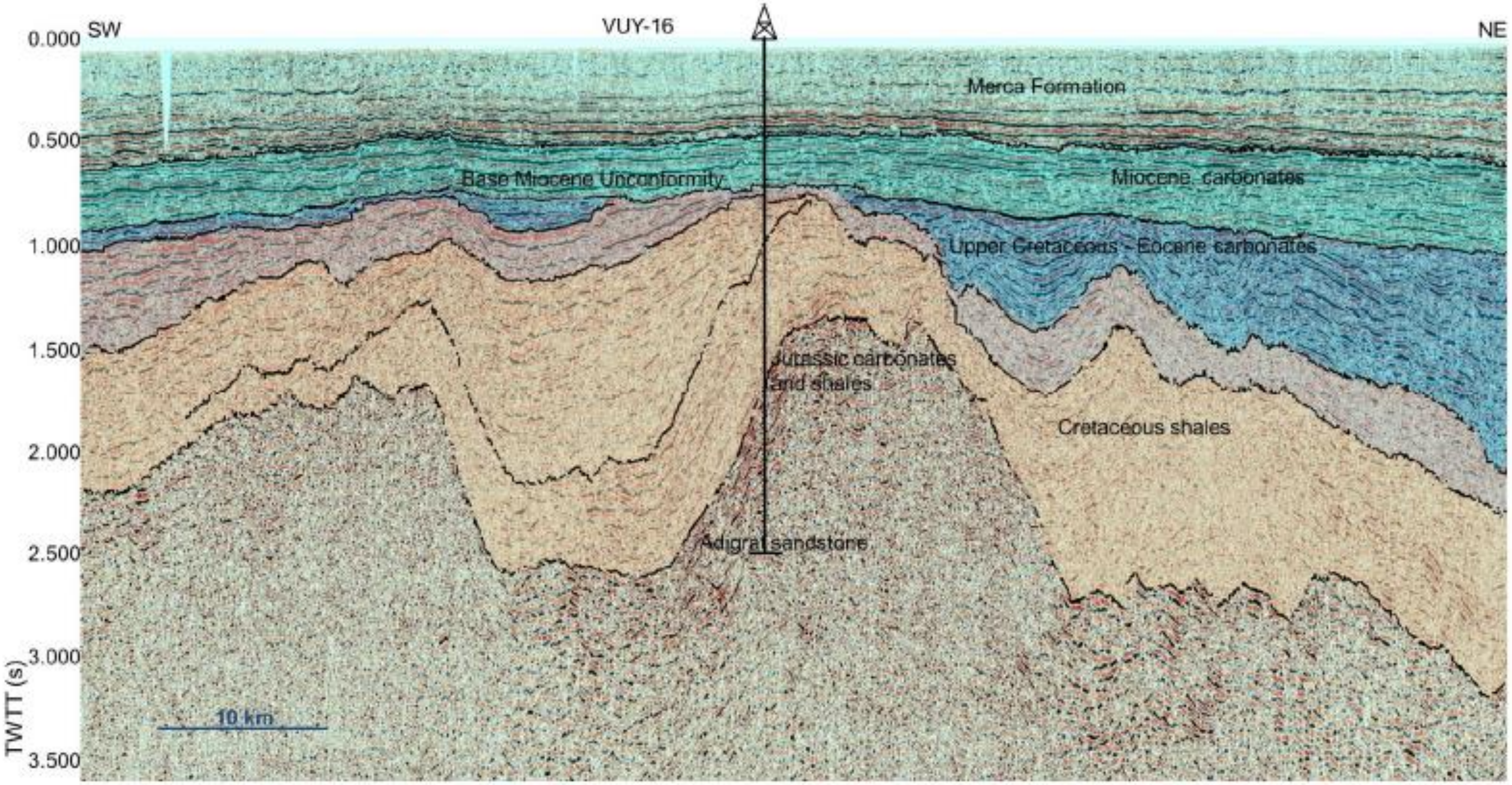


Figure 1-1: Location of Brava-1, Somalia.

Brava-1 was drilled onshore southeast Somalia, and is located at 01° 04' 25.01" N, 43° 47' 23.00" E



Well Summary Chart, Brava-1 **Figure 6.2**



The **Geoseismic Section** illustrates the key structural and stratigraphic features around Brava-1. The area is dominated by large, Jurassic half graben fault blocks. The deepest stratigraphy penetrated is the Adigrat Formation sandstones which are overlain by the Jurassic Hamanlei Carbonates. Cretaceous to Eocene stratigraphy is heavily faulted and capped by a significant unconformity which marks substantial erosion of the Upper Cretaceous Carbonates through to the Eocene Carbonates which are absent in the well section. The Middle Miocene Somal transgression overlies the unconformity in this area. The uppermost stratigraphy is dominated by sands and shale interbeds of the Merca Formation.

Figure 6.3: Brava-1 Geoseismic Line

Mudun-1 was drilled by Amoco between September and October 1990 to a total depth of 3,048m (10,000ft). The location was determined from the interpretation of the seismic survey acquired by Amoco in 1988. This survey tied into two previous wells drilled by Sinclair. These were Brava-1 in 1962 (see above) and Duddami-1 in 1959 (**Section 7**).

Primary objectives were Lower Cretaceous sandstones in a structural closure.

The well failed to penetrate the Lower Cretaceous and the deepest stratigraphy at TD was the Upper Cretaceous Mudun Formation (Figure 6.4)**.**

The Mudun Formation interval is between 2,024 and 3,048m (6,641 – 10,000ft) and consists of thin sands and shales.

The Mudun Formation is overlain by a shale sequence of Upper Cretaceous to Palaeocene age, the Sagaleh Formation from 1,556 to 2,024m (5,106 – 6,641ft).

The Tertiary section contains the Coriole Formation Carbonates at 948m to 1,556m (3,110 - 5,106ft). The folded Cretaceous sequence appears faulted on the seismic data and the uppermost Sagaleh and Coriole Formations are not present to the west in Brava-1 well.

There is a total absence of the Upper Eocene to Lower Miocene in this area due to uplift and erosion as shown in the geoseismic line in Figure 6.5.

Carbonates of the Somal Formation overlie the unconformity surface to 636 to 948m (2,078 – 3,110ft).

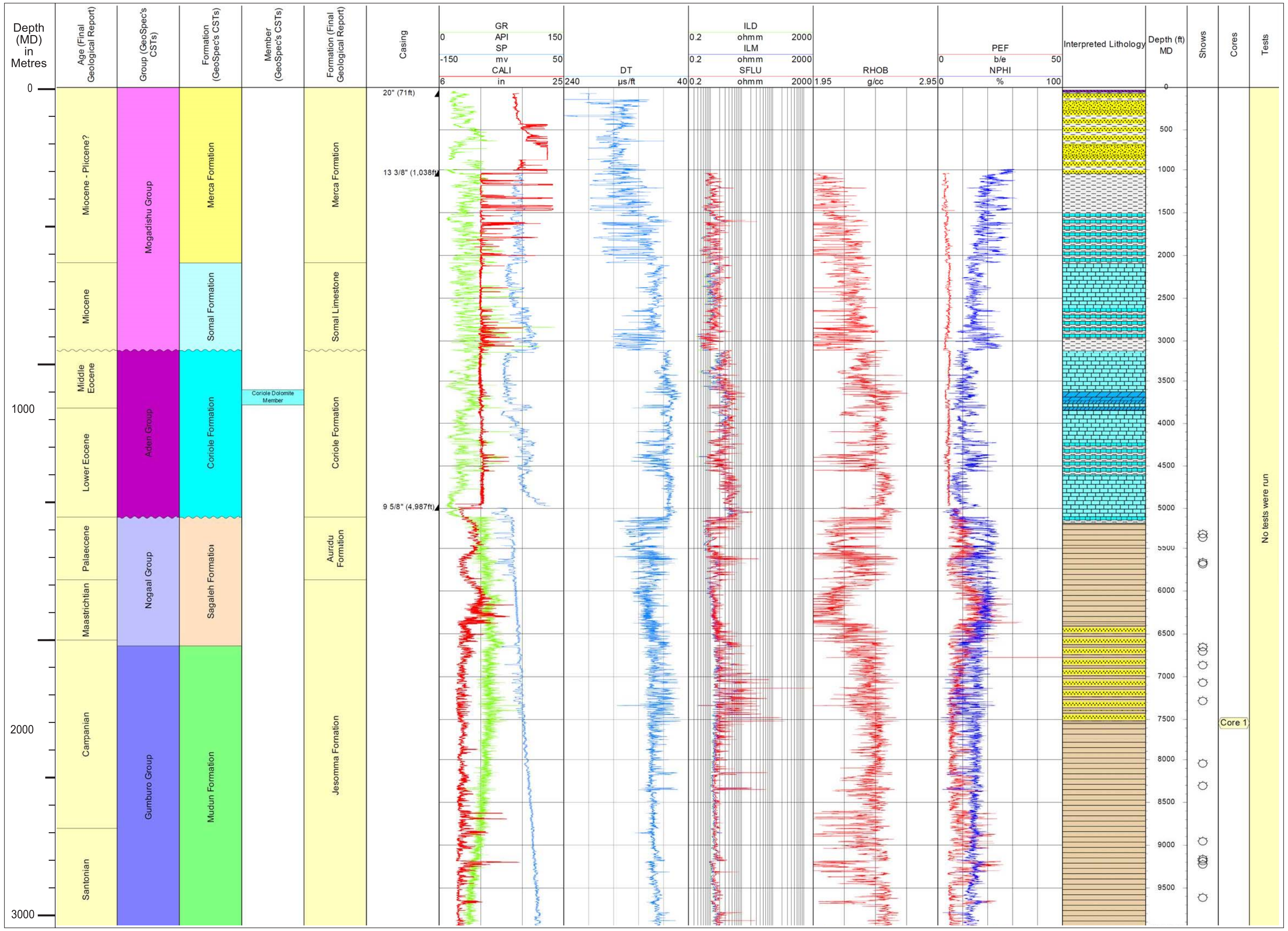
Above these lie the sandstones and interbedded shales of the Merca Formation which are thought to have been deposited in a shallow water in cyclical oxidising and reducing environments.

No DSTs were run, although trace quantities of dry gas (C_1 – C_2) are present in thin sands of the Upper Cretaceous-Paleocene section. One core was taken in the Mudun Formation.

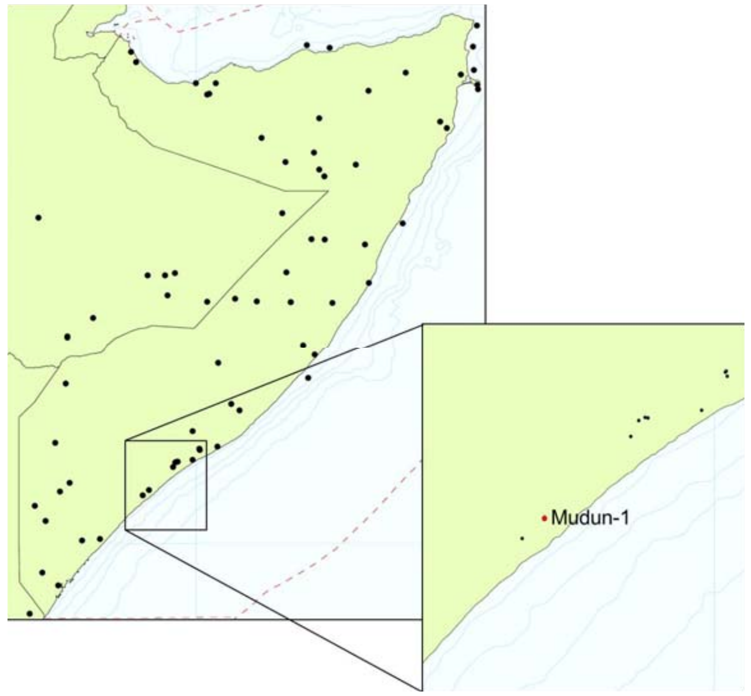
The Upper Cretaceous sands penetrated in the Mudun Formation had good reservoir properties but are thin and water bearing.

The well was plugged and abandoned as dry. This was the most recent well drilled in the study area in Somalia, either onshore or offshore.

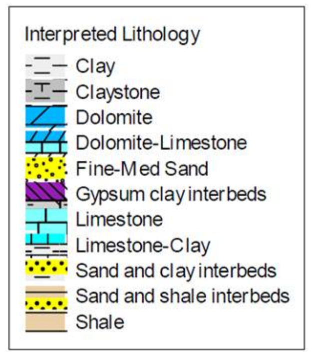
Mundun-1



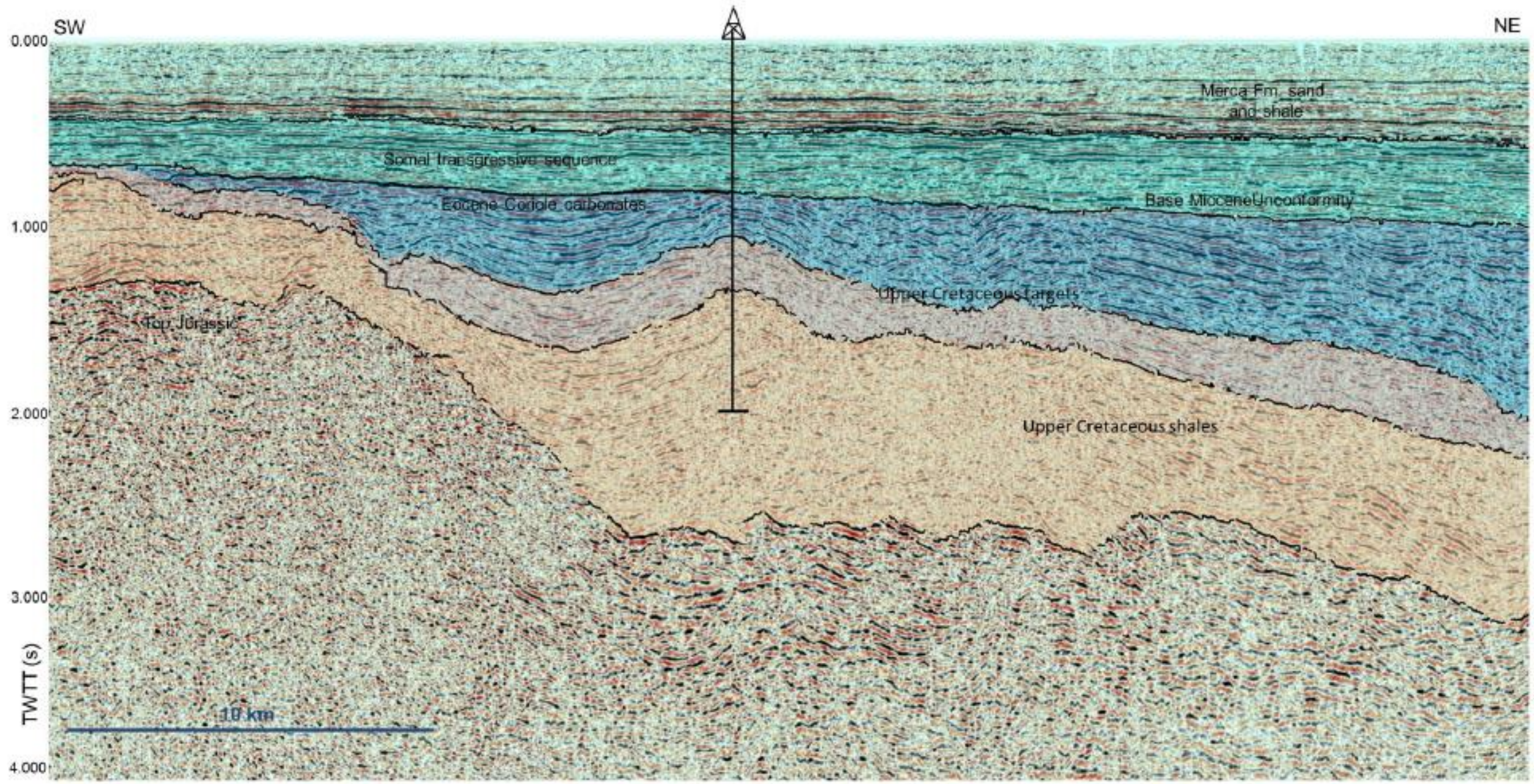
T.D. 3045m

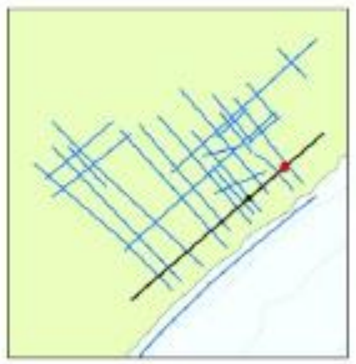


Mudun-1 was drilled onshore southeast Somalia, and is located at 01° 11' 45.62" N, 43° 55' 51.86" E



Well Summary Chart, Mundun-1 **Figure 6.4**





The **Geoseismic Section** illustrates the key structural and stratigraphic features around Mudun-1. The area is dominated by large, Jurassic, half graben fault blocks. Cretaceous and Eocene stratigraphy is heavily faulted and capped by a significant unconformity which marks substantial erosion of the Upper Cretaceous Carbonates. The Middle Miocene Somal transgression overlies the unconformity in this area. The uppermost stratigraphy is dominated by sands and shale interbeds of the Merca Formation.

Figure 6.5: Mudun-1 Geoseismic Line

6.2 Seismic Examples

A selection of 2D Seismic Lines is presented within this section (Figure 6.7 to Figure 6.19). The lines show a good representation of the structure and stratigraphy within Subarea 2. The seismic is of good quality, though some of the amplitude information has been lost through digitising the paper lines. The locations of the following seismic examples are shown in Figure 6.6.

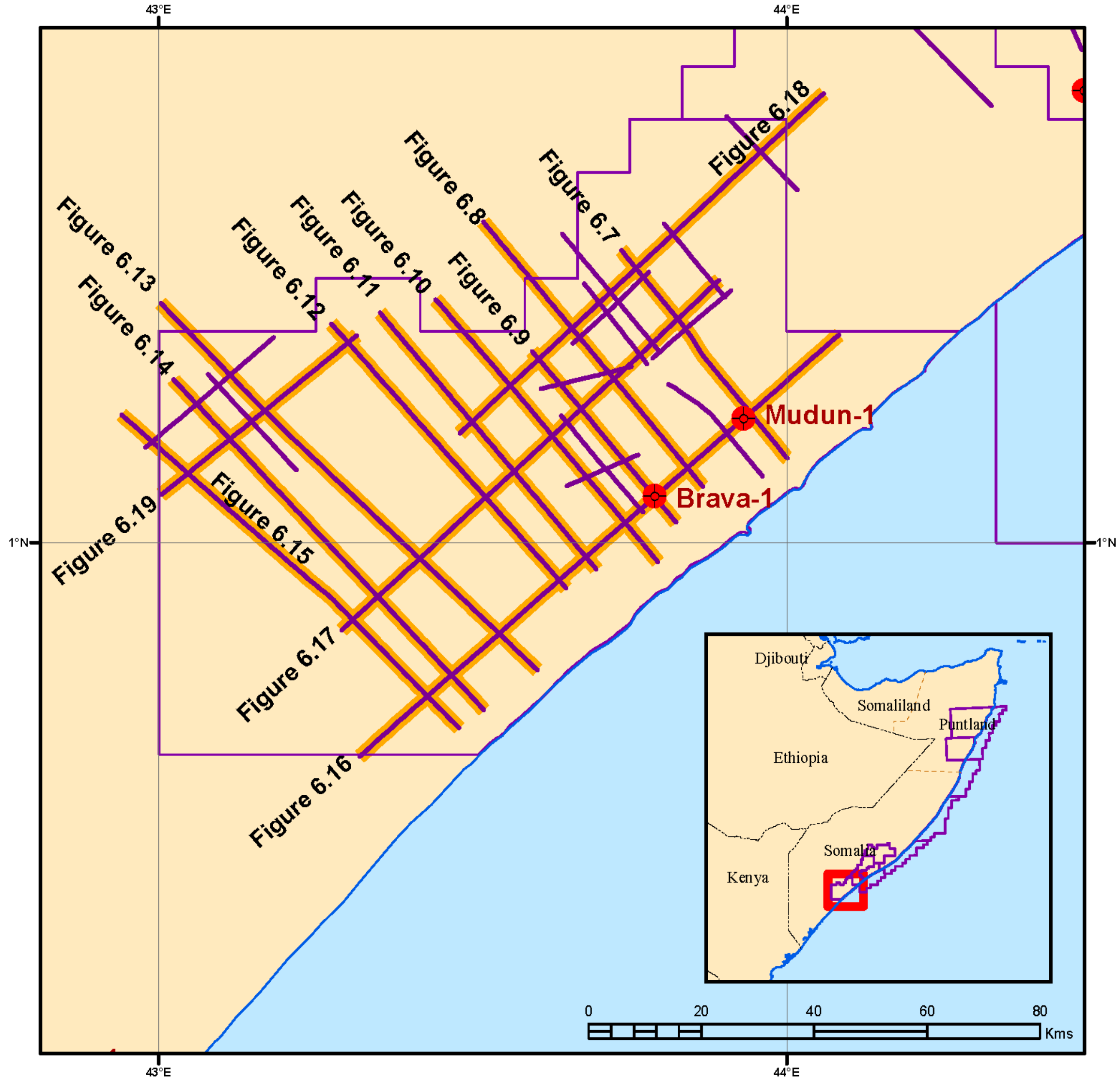


Figure 6.6: Subarea 2 Location of Seismic Displays

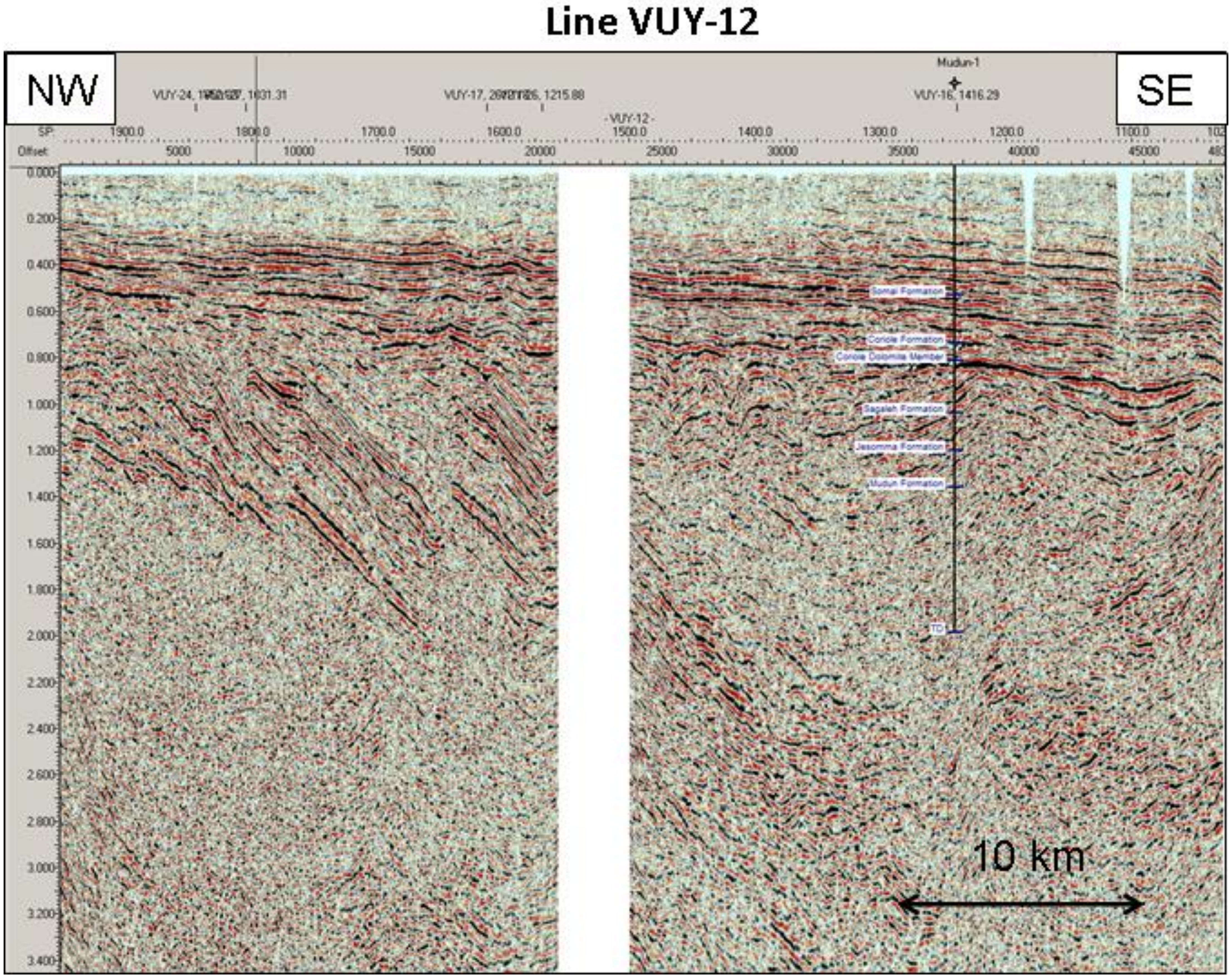


Figure 6.7: Mudun-1 Seismic Line VUY-12

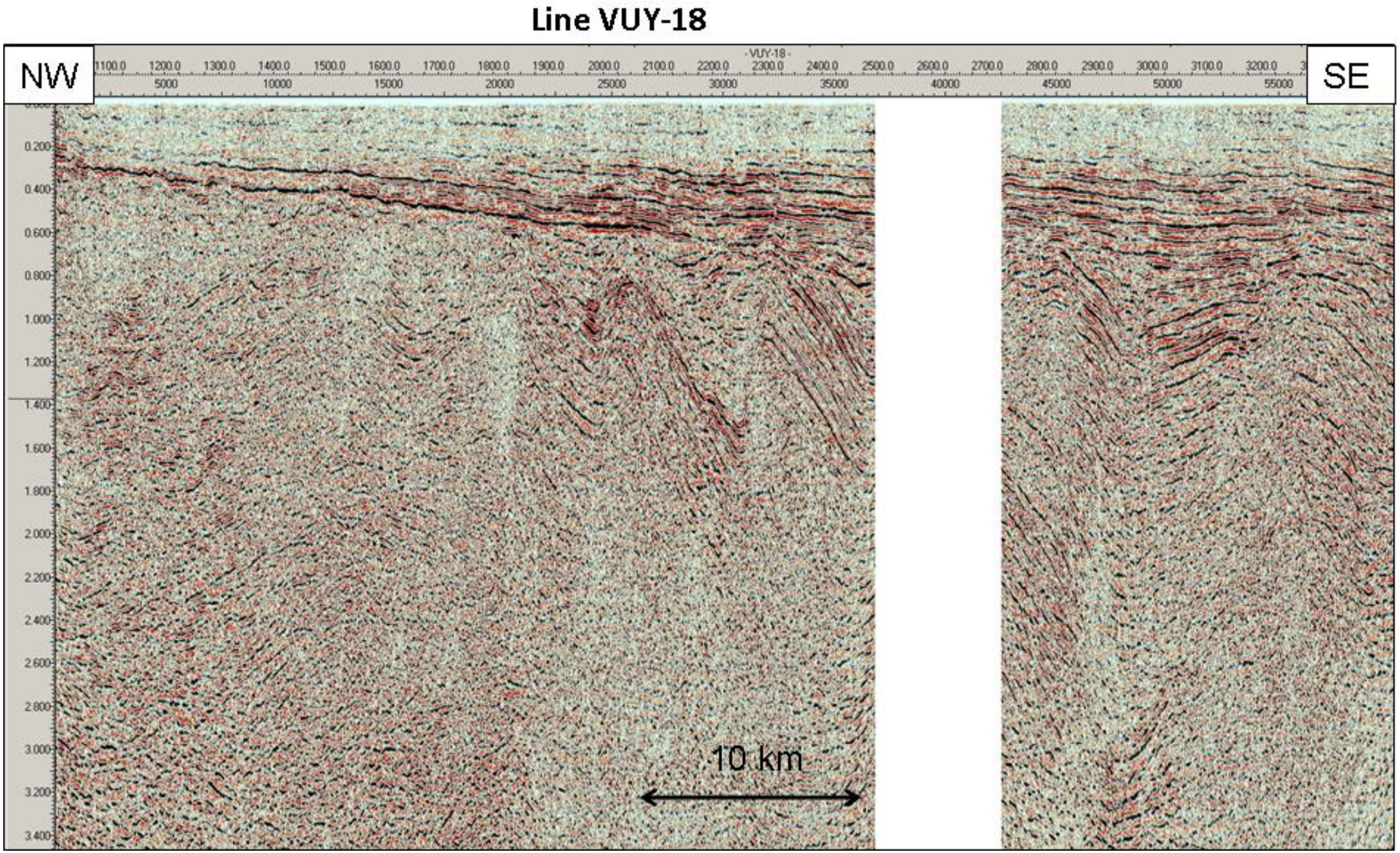


Figure 6.8: Seismic Line VUY-18

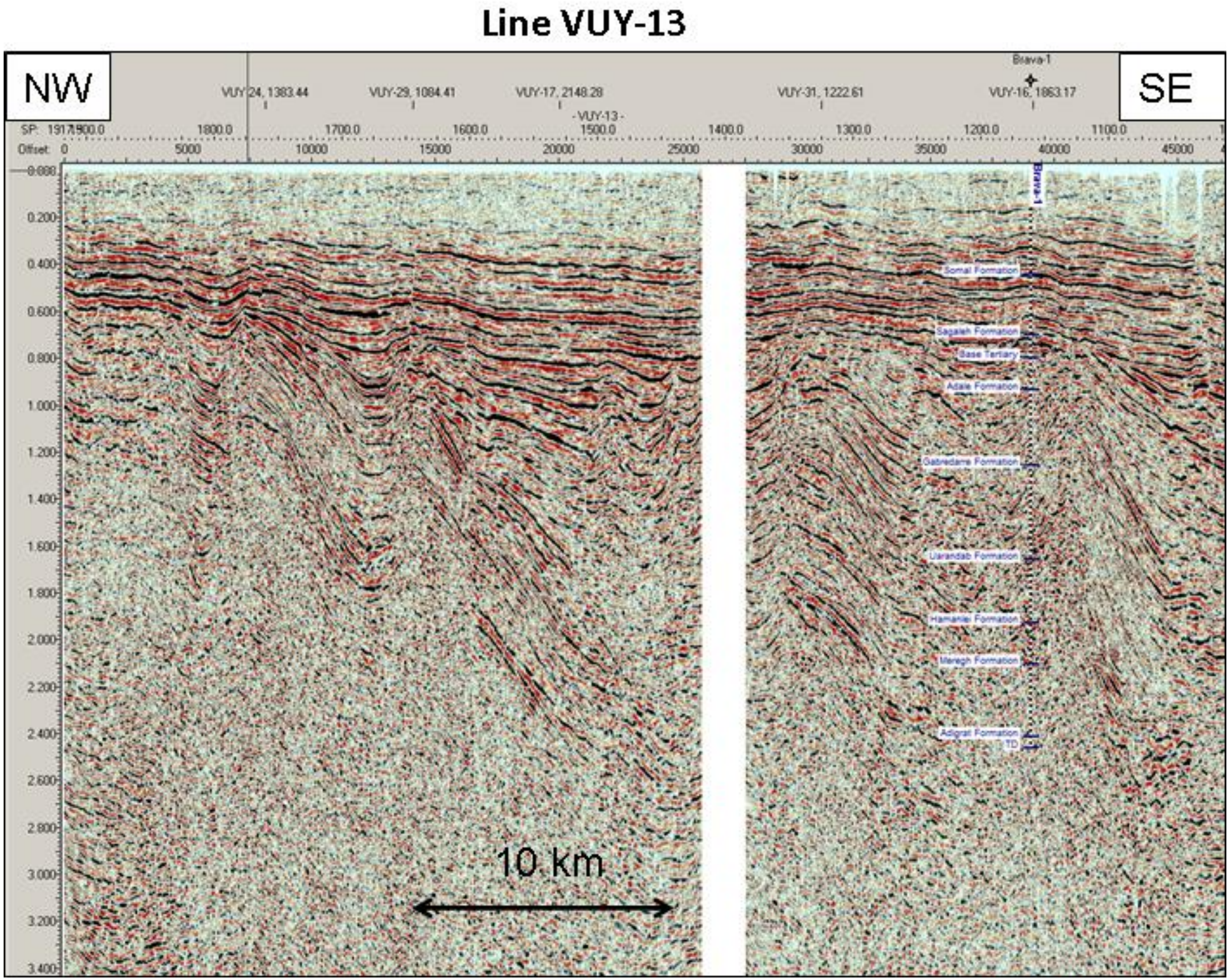


Figure 6.9: Brava-1 Seismic Line VUY-13

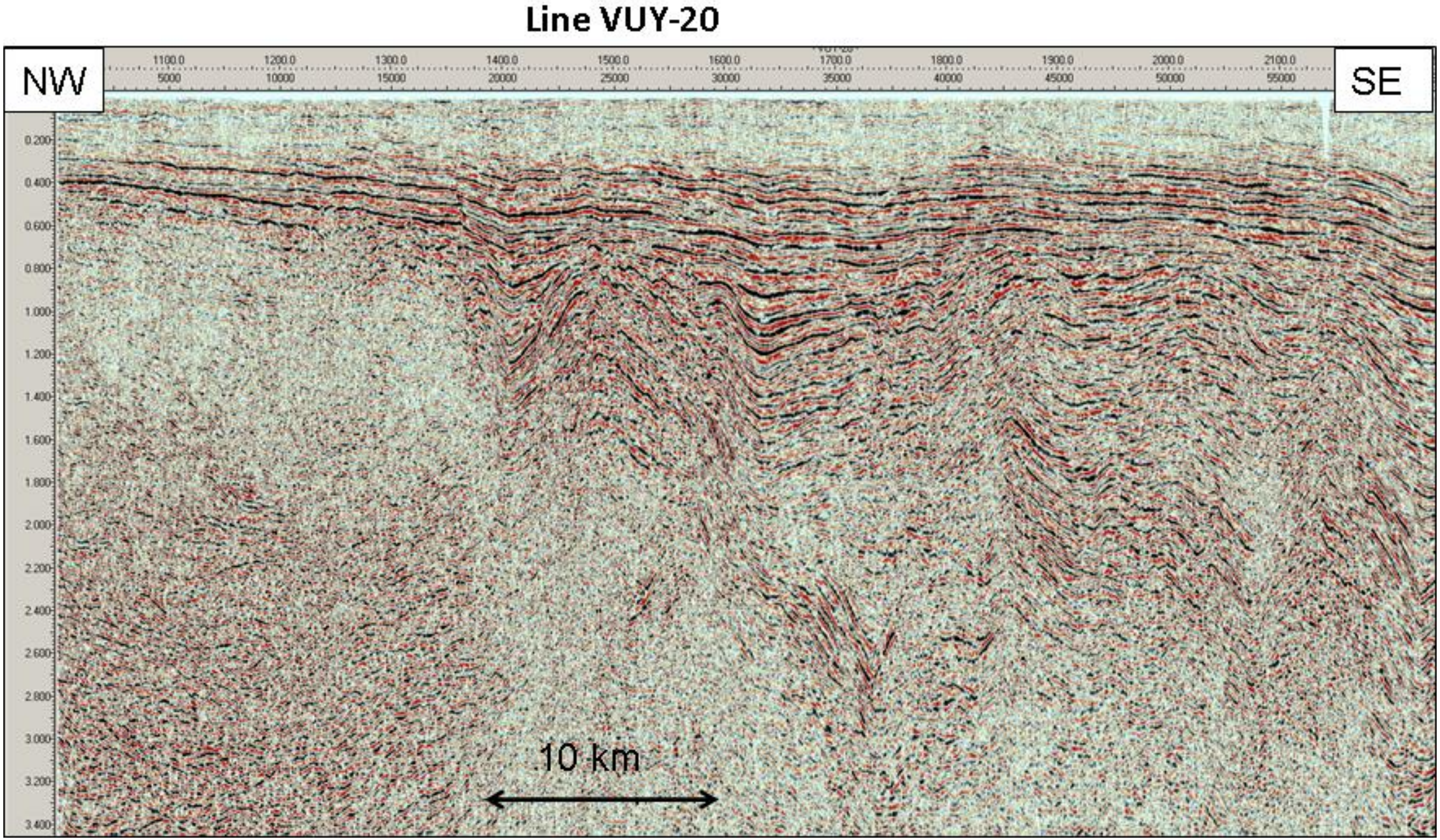


Figure 6.10: Seismic Line VUY-20

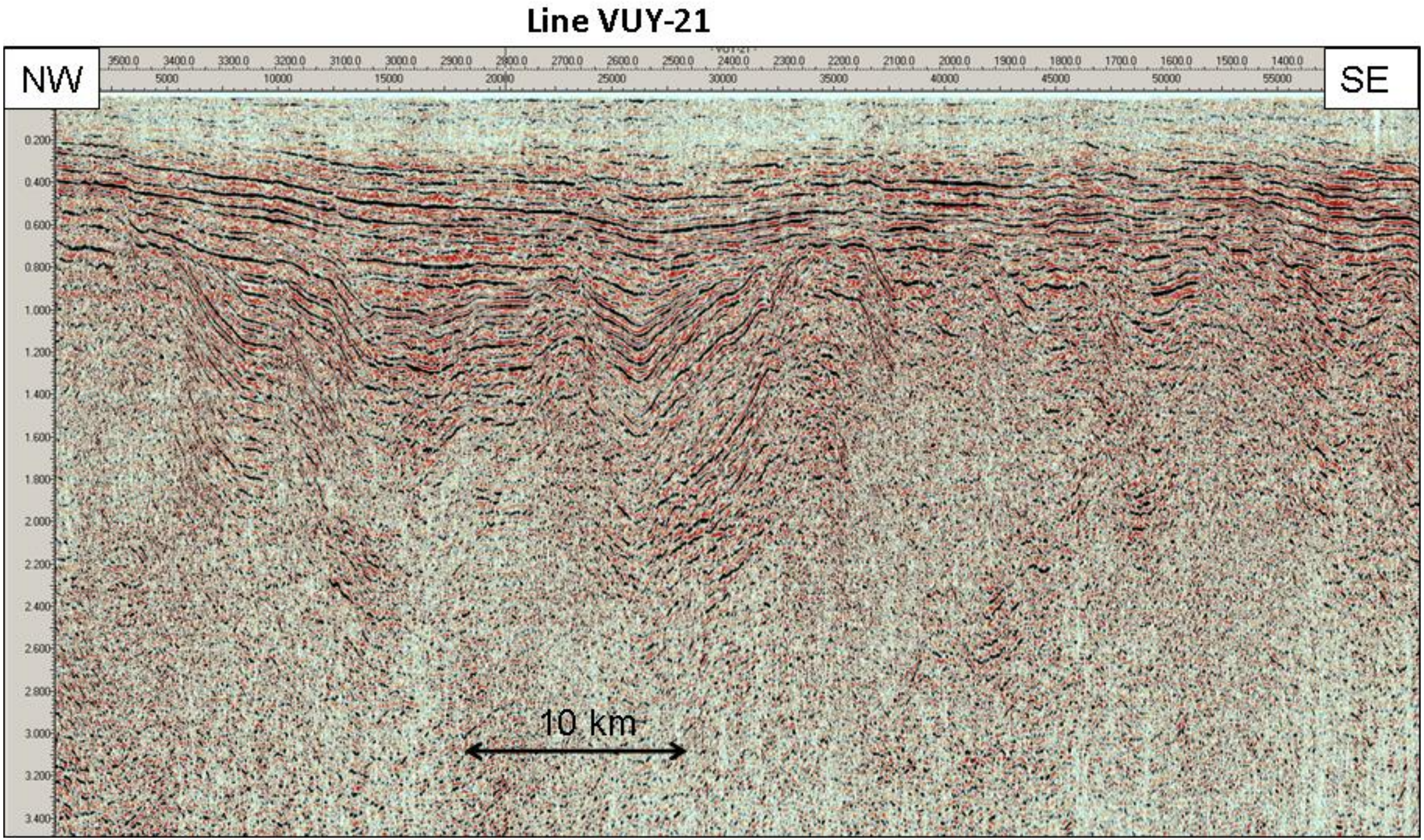


Figure 6.11: Seismic Line VUY-21

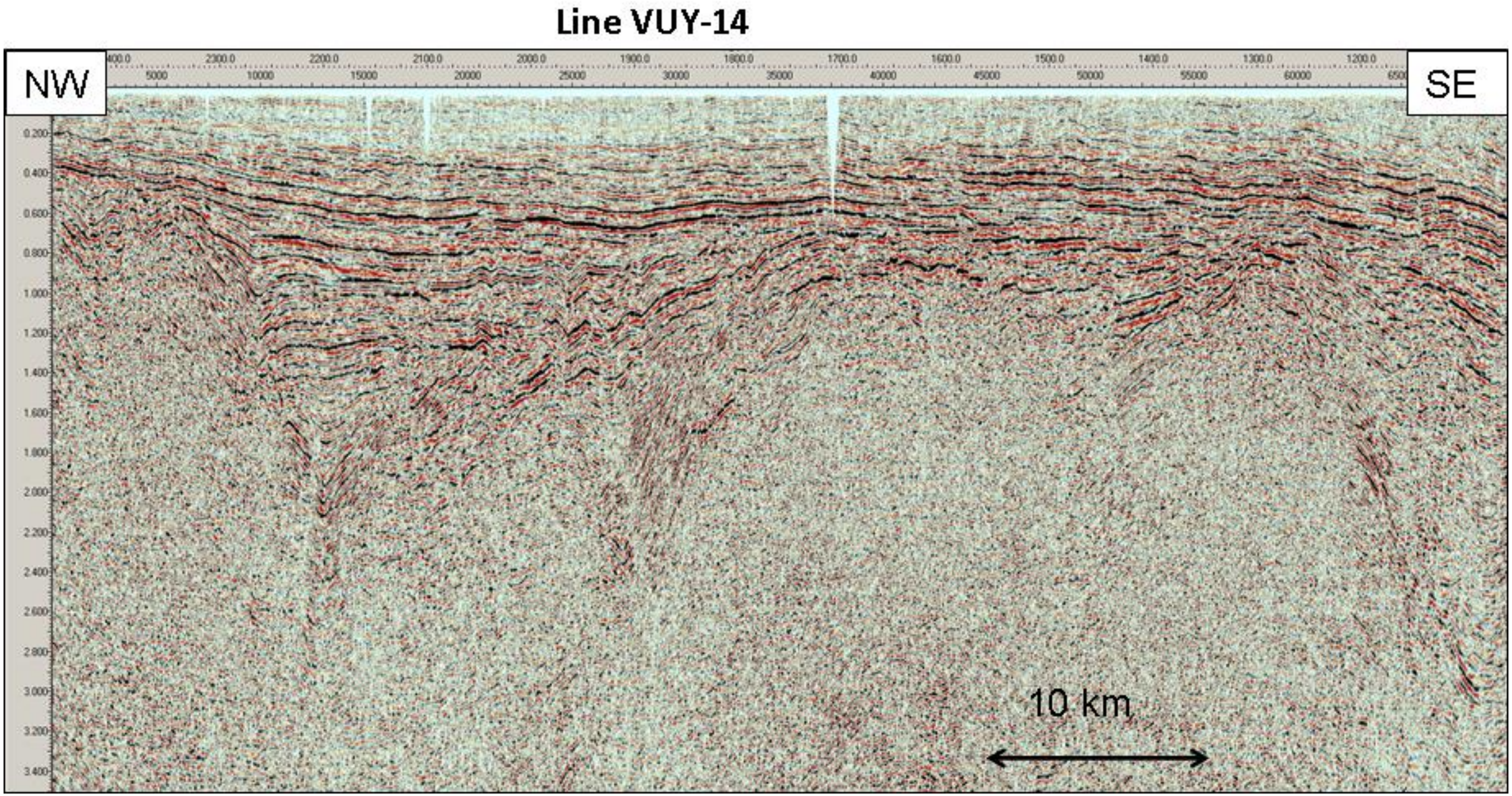


Figure 6.12: Seismic Line VUY-14

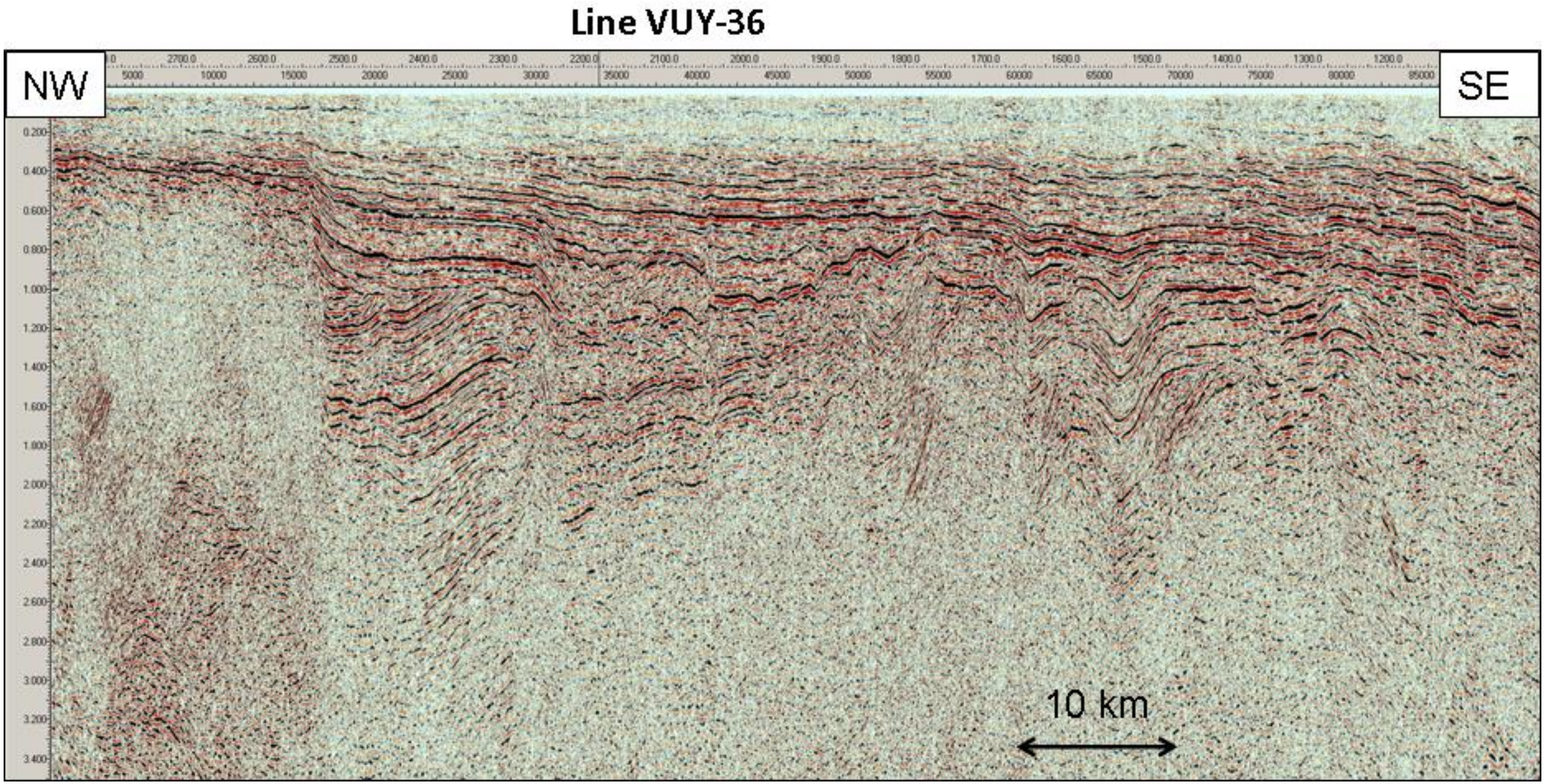


Figure 6.13: Seismic Line VUY-36

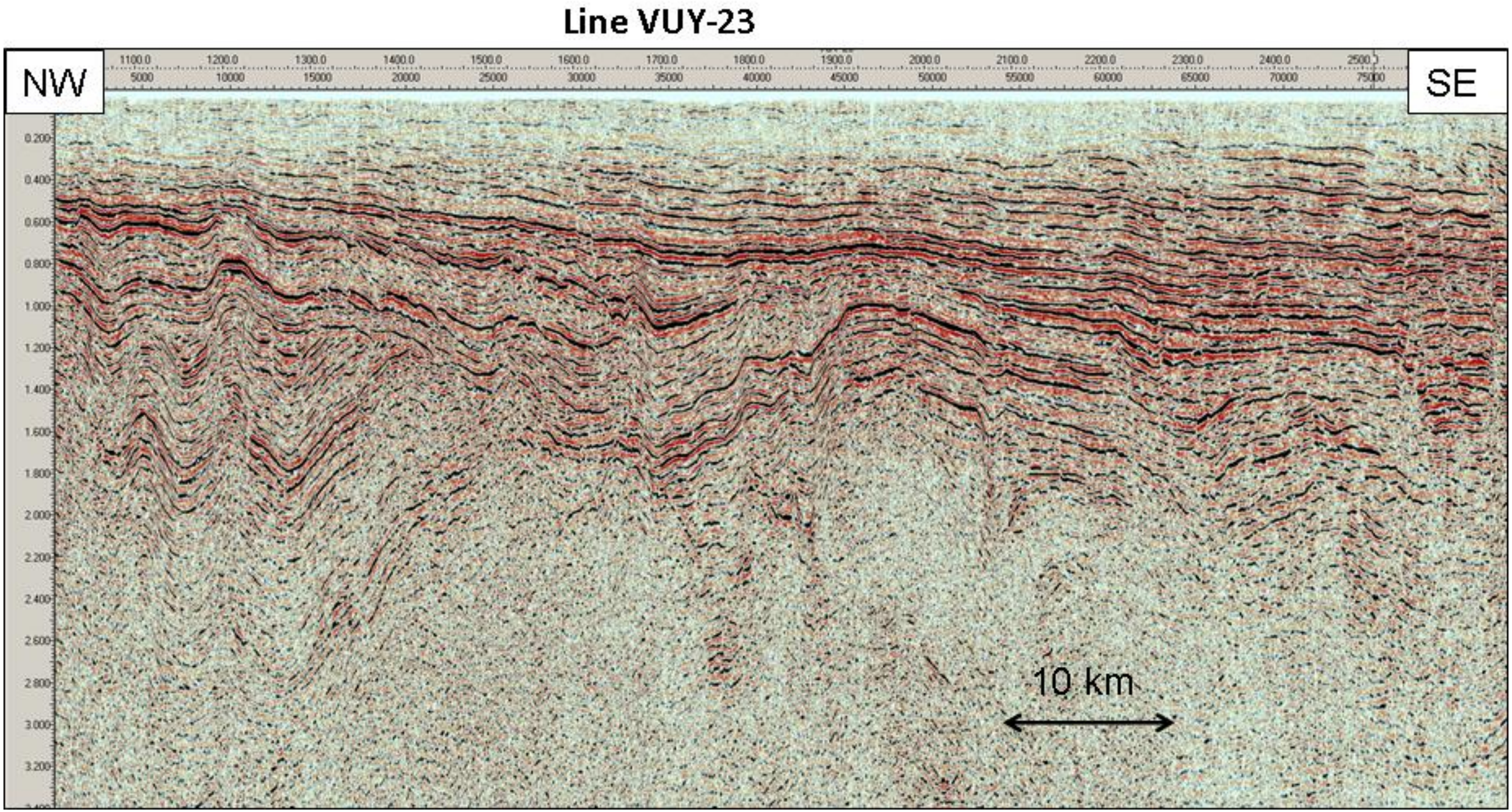


Figure 6.14: Seismic Line VUY-23

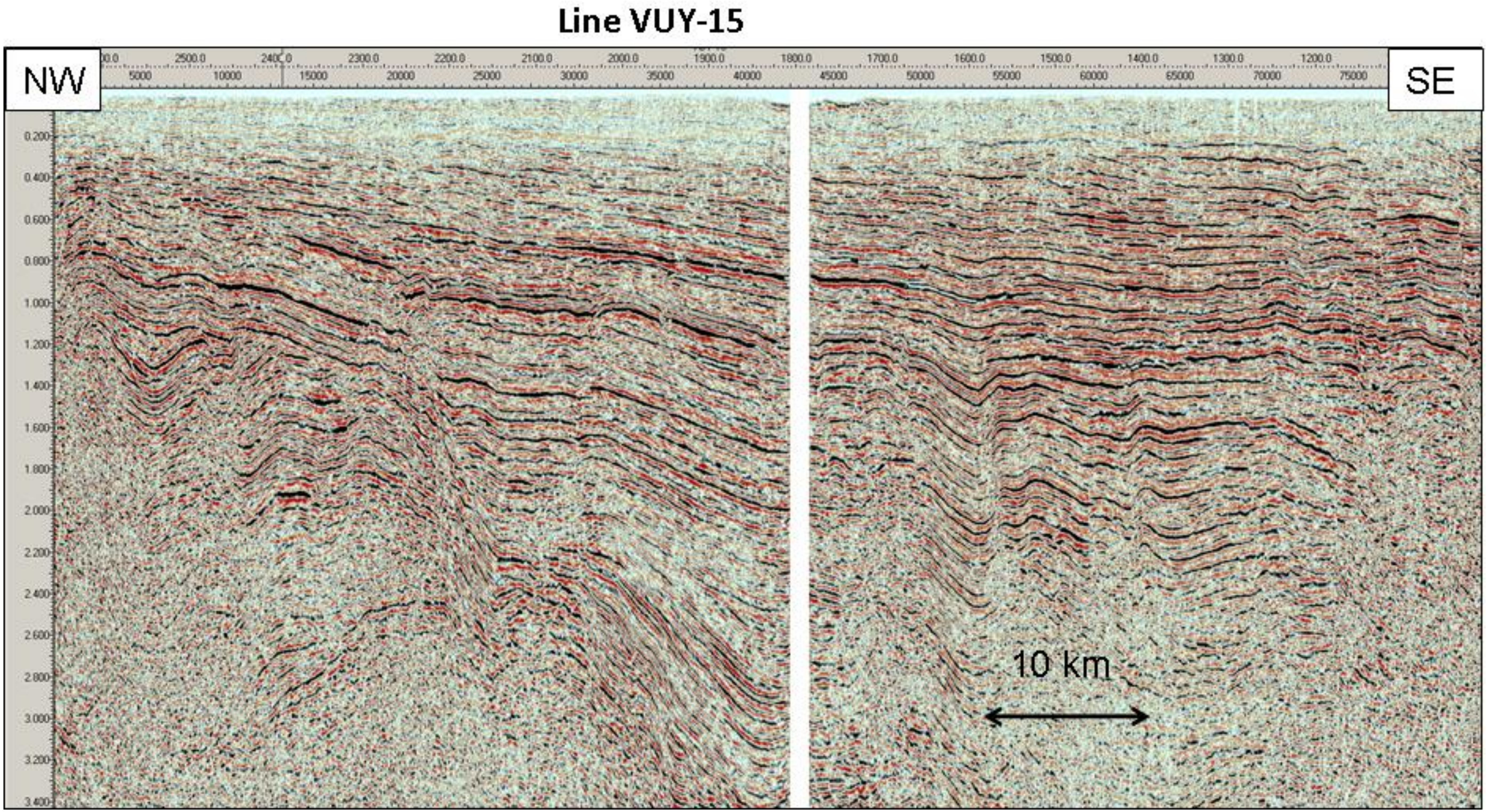


Figure 6.15: Seismic Line VUY-15

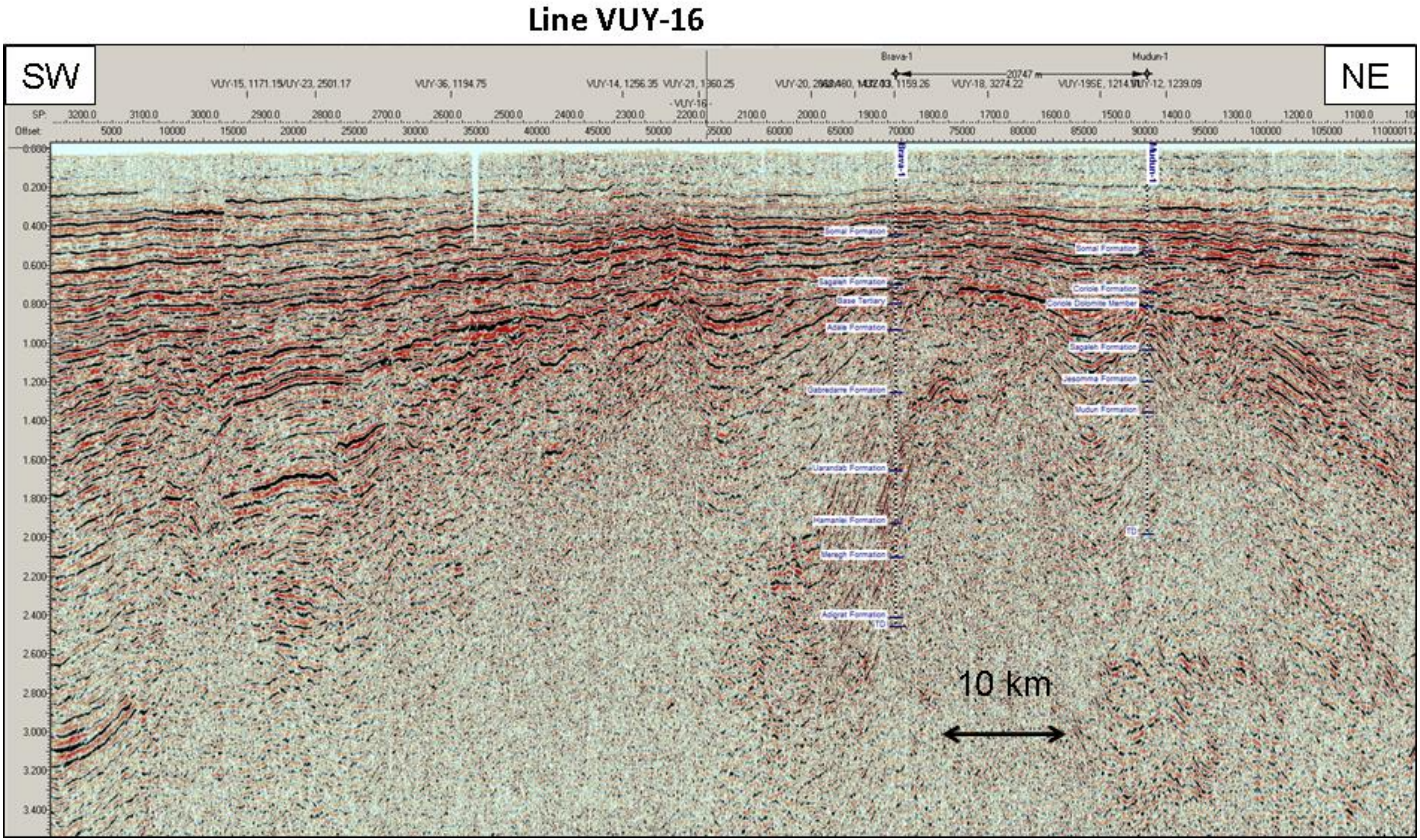


Figure 6.16: Brava-1 & Mudun-1 Seismic Line VUY-16

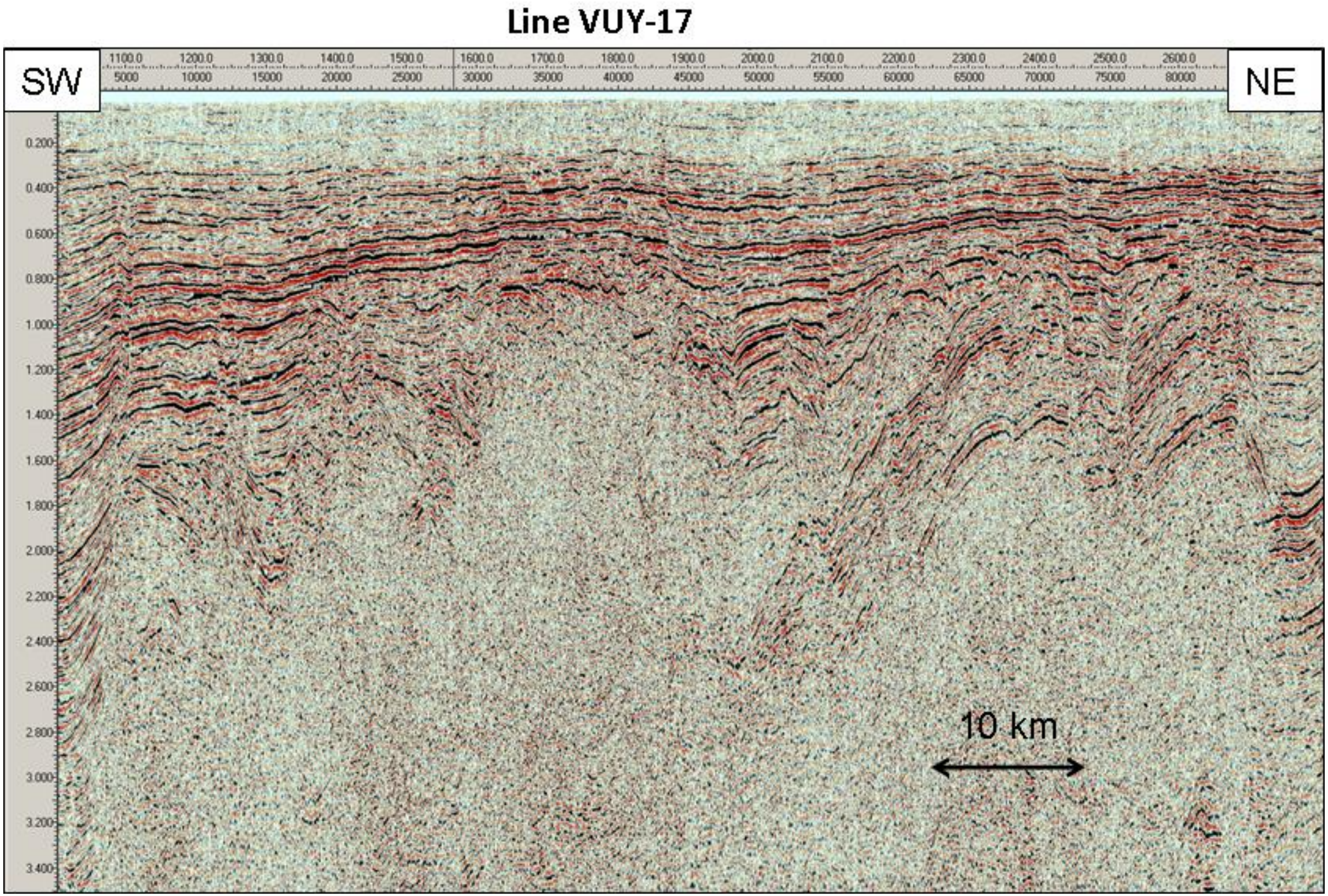


Figure 6.17: Seismic Line VUY-17

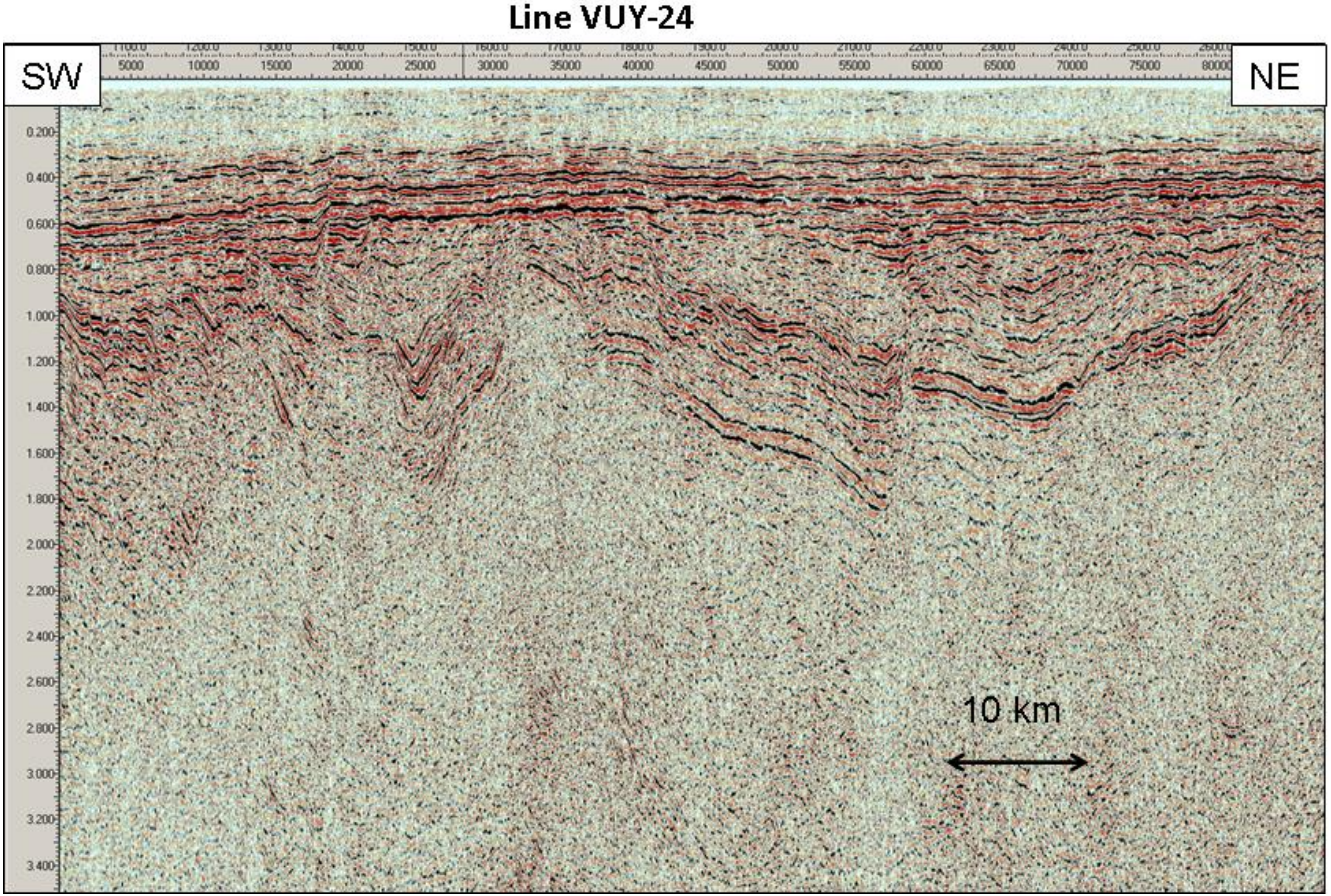


Figure 6.18: Seismic Line VUY-24

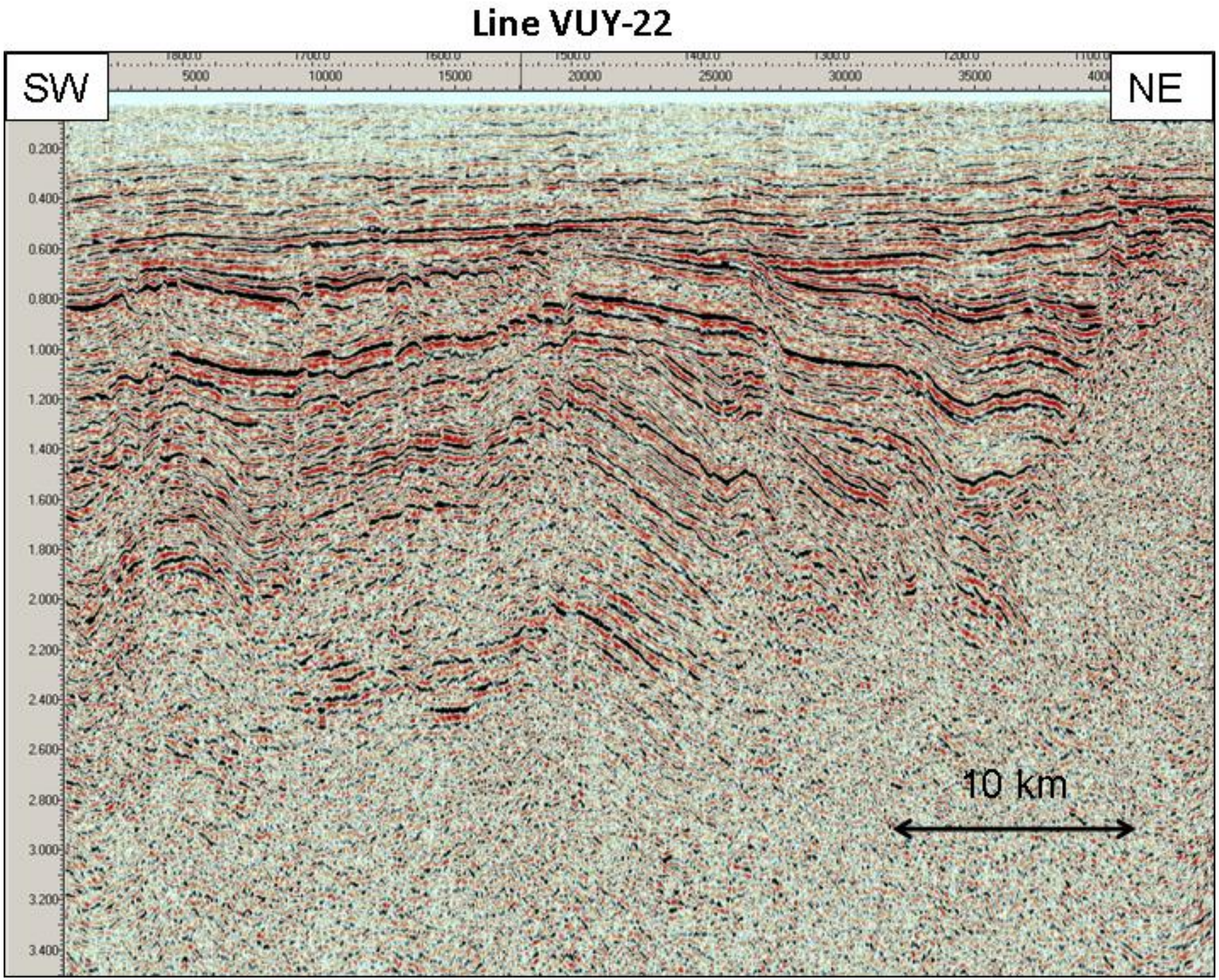


Figure 6.19: Seismic Line VUY-22

7. EXPLORATION SUBAREA 3

7.1 Drilling Results & General Geology

Subarea 3 is an onshore and part offshore region of southwest Somalia. This is located within the Coriole Basin.

The Coriole Basin is a north-east to south-west trending coastal basin comprised largely of Jurassic and Cretaceous sediments, while a Tertiary wedge is also present and thickens from the north-west to south-east across the Duddumai fault system. The basin is dominated by listric normal faults on mainly NE-SW trend that have created tilted-block closures in the central part of the basin. It is in this area where majority of the wells have been drilled.

Ten onshore wells have been drilled in Subarea 3, while a total of 1763 line km of 2D seismic has been acquired both in the onshore and offshore parts of the subarea as shown in Figure 7.1**.**

The wells drilled in this subarea are:-

Afgoi-1 (Sinclair 1965)
Afgoi-2 (Ministry of Minerals and Water Resources 1984)
Afgoi-3 (Ministry of Minerals and Water Resources 1985)
Coriole-1 (Sinclair 1960)
Coriole-2 (Sinclair 1965)
Dobei-1 (Sinclair 1961)
Dobei-2 (Sinclair 1961)
Duddumai-1 (Sinclair 1959)
Merca-1 (Sinclair 1958)
Uarsciek (Sinclair 1967)

The available seismic surveys were acquired by:-

Afgoi in 1983 for the onshore seismic database
Pecten in 1989 for the offshore seismic database

The onshore seismic in this area comprises of thirty eight (38) 2D lines onshore and covers totalling 1,237km, and the offshore has nineteen (19) lines totalling 526km. The seismic lines trend either NW-SE or SW to NE and the data quality is average to poor by modern standards. Examples of the seismic available are shown in section 7.2.

Subarea 3 lies in the Coriole Basin. The Afogia-1 well and Merca-1 well show accelerated tectonic subsidence between 80-60 Ma (Cenomanian to Late Palaeocene). Volcanics of Maastrichtian to Palaeocene age have been penetrated by Merca-1 and Uarsciek-1 well.

The Afgoi wells show that basin development took place largely during the latest Cretaceous-Early Tertiary. Subsequent periods of structural activity are recorded at Merca-1 well where there is south-eastward truncation of beds at the base of the upper Eocene. A volcanic flow is present in the Miocene section at Duddumai-1 well.

Duddumai-1 well is located on the north eastern edge of the Coriole Basin and targeted a tilted fault block structure. Merca-1 and Duddumai-1 wells exhibit characteristics of the Coriole Basin structures of deeper level faulting with sag, drape or flexure of the younger rocks. Both wells also show evidence of structural growth or fault activity during the Tertiary period.

The location of Subarea 3 and the available seismic and well data are shown in Figure 7.1**.**

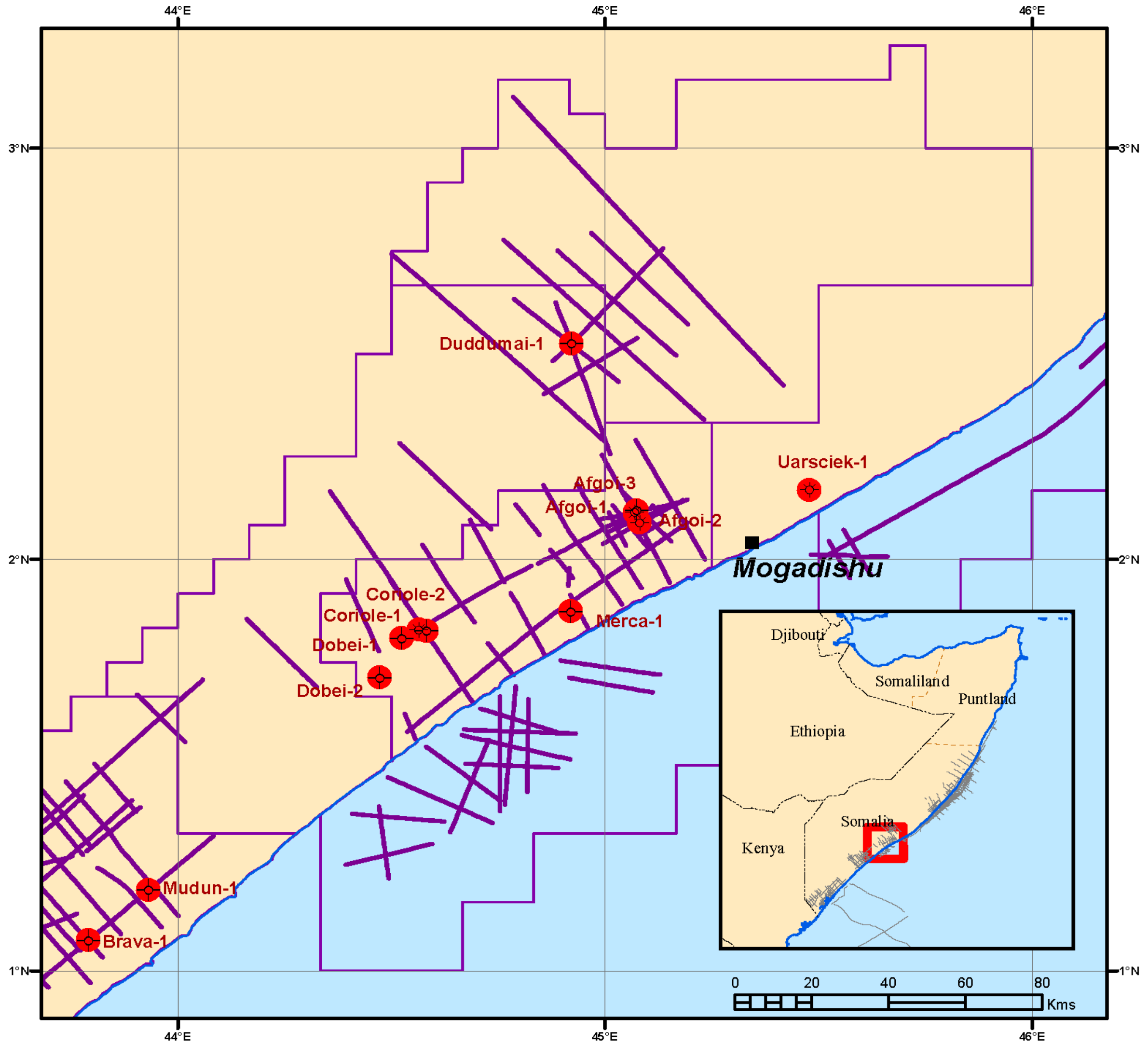


Figure 7.1: Subarea 3 Seismic and Well Database Map

Afgoi-1 was drilled onshore by Sinclair between September 1965 and January 1966 to a total depth of 4,164m (13,661 ft). The target was a faulted anticlinal structure identified in the seismic dataset. Within the vicinity of the Afgoi wells normal faults with throw ranging from 45m-189m (150ft-620ft) form NE-SW trending grabens in the Oligocene to upper Cretaceous interval. The well penetrates a number of these southeast dipping faults.

The main target for this well was the Palaeocene sands of the Sagaleh Formation. These sands were interbedded with shales which formed the prognosed seal for any potential accumulation. The lithology of Afgoi-1 is dominated by marine sands and shales, with carbonate intervals interbedded throughout the sequences.

The well found gas in the Sagaleh sands and gas was also present in the Upper Cretaceous sands. A number of Drilling Stem Tests (DST) were run on both intervals, however it was reported that neither of the gas sands was deemed to be commercially viable and thus the well was plugged and abandoned. The location of Afgoi-1 is shown in Figure 7.1**.**

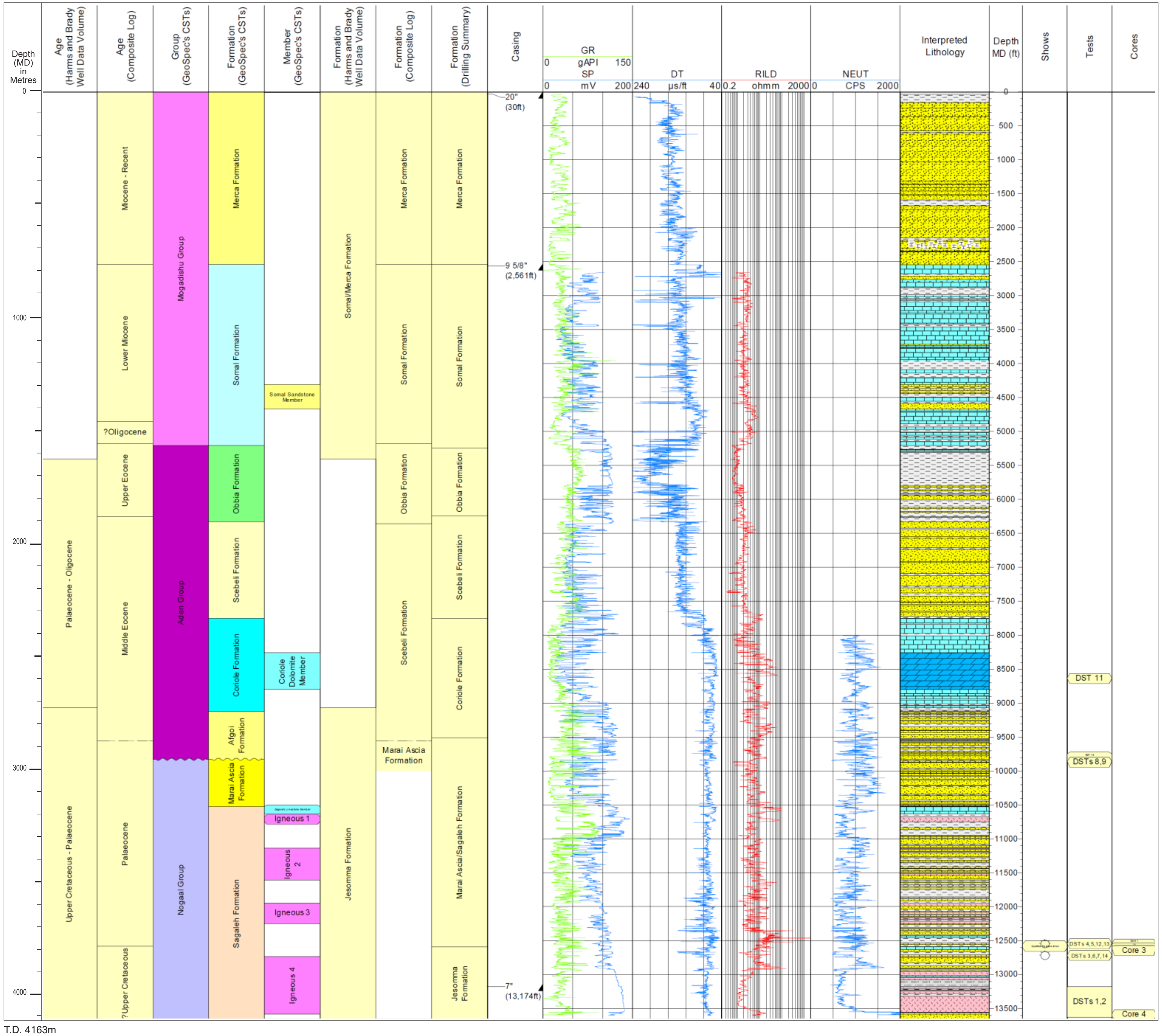
The Upper Cretaceous to Lower Palaeocene interval consists of interbedded sands, shales and carbonates of the Sagaleh Formation with basalt intrusions. The Marai Ascia and Afgoi Formation of the Lower to Middle Palaeocene are represented by thin interbedded shales. Above these formations is a carbonate dominated sequence of the Coriole Formation of Upper Palaeocene age. The Eocene age Scebeli Formation consists of marine sands with thin interbedded shales. The Somal Formation of Oligocene to Lower Miocene in age is dominated by carbonates with thin interbedded sands and shales.

Gas shows were recorded within both the Paleocene sands 3,822m – 3,823m (12,540ft-12,544ft) and the Upper Cretaceous 3,872m – 3,877m (12,704 ft- 12,721ft) on the up thrown side of the faults. Gas was observed in the Paleocene and Upper Cretaceous with DSTs in the Paleocene and Upper Cretaceous initially flowing 9 mmcfd. This flow stabilised to 6.4 mmcfd with a small amount of liquids (8-10 bbl per mmcfd) of 50-54º API from one interval in the Lower Tertiary. However, although both intervals had good initial flow rates these quickly declined since the reservoir sands are of low permeability and may also be of limited lateral extent.

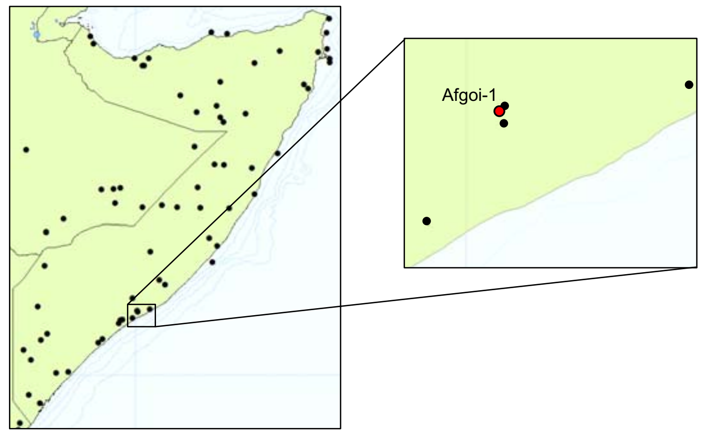
Porosity in the well is generally low seldom being higher than 5%. Spore colour indices and vitrinite reflectance values indicate that the oil maturity window probably lies between 3657m – 4267m (12,000ft – 14,000ft). However, there is a general absence of thick shales in the well, so sealing capacity may be limited. Prediction of reservoir presence and distribution will be difficult in this area due to strong digenesis, especially within the deeper sections.

The well summary chart is shown in Figure 7.2.

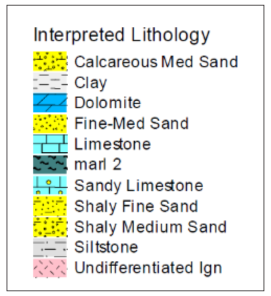
A geoseismic line over the Afgoi-1 well location is shown in Figure 7.3.



Afgoi-1



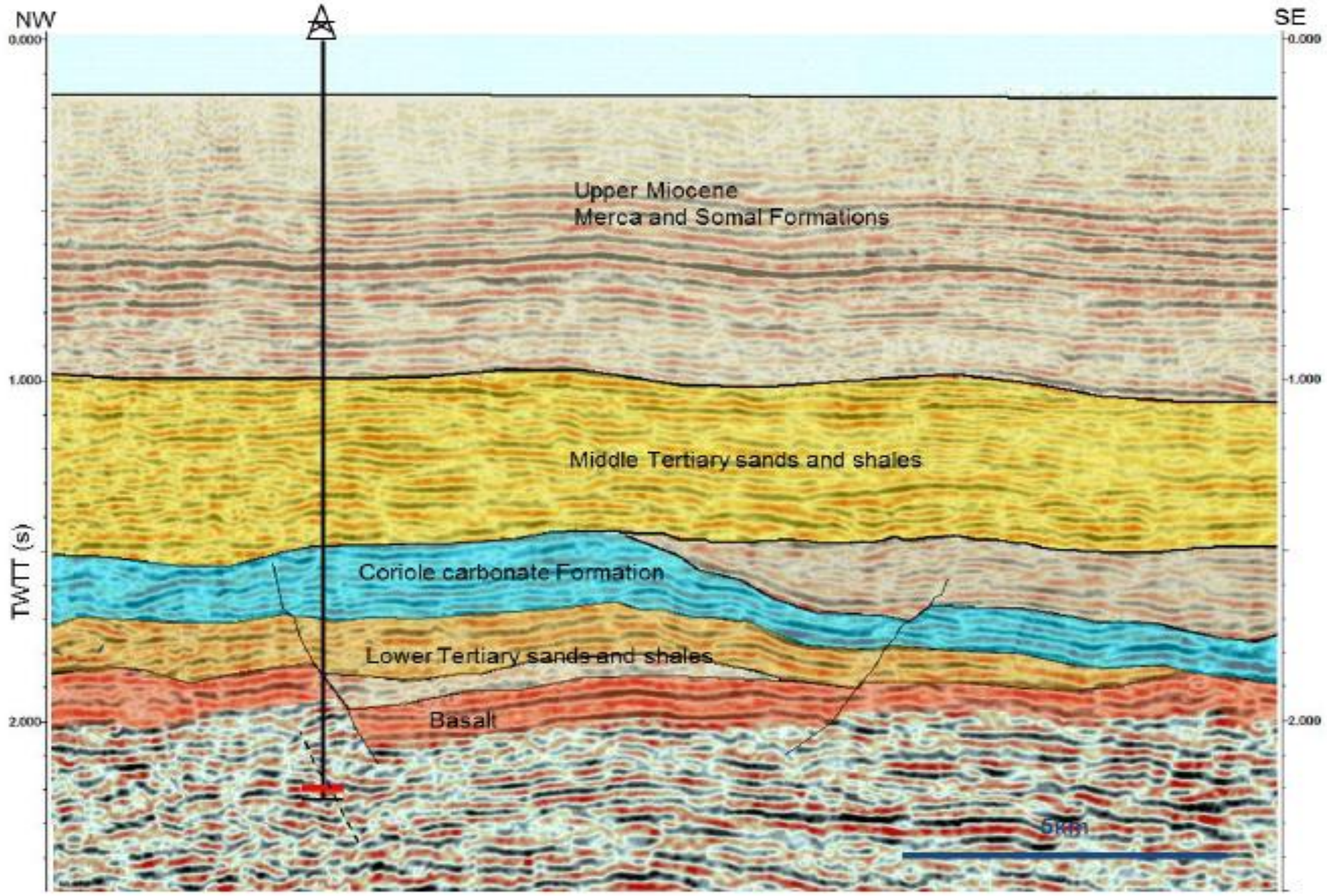
Afgoi-1 was drilled onshore Somalia, and is located at 02° 06' 52" N, 45° 04' 10" E

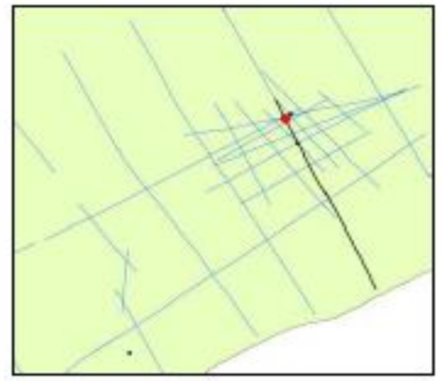


Well Summary Chart, Afgoi-1 **Figure 7.2**

Operator		
Sinclair Somal Corporation		
Coordinates		
02° 06' 52" N 45° 04' 10" E		
KB	**GL**	**TD**
105m 343ft	100.0m 328.1ft	4,164m 13,661ft

Spud Date	Completion Date
30-Sep-1965	11-Jan-1966
Shows	**Tests/Cores**
Flowed Gas on Test	14 DSTs; 4 Cores
Status	
Shut-in gas; Plugged and Abandoned	





The **Geoseismic Section**, based on interpretation by Harms and Brady, summarises the well target and the main stratigraphy of the area. It shows the general SE dipping trend of faults around the well. The gas show (red) has been indicated on the upthrown side of a fault (dashed line) towards the base of the well.

The lithology was dominated by marine sands and shales with prominent carbonate intervals in the Lower Eocene (Coriole Formation) and Lower Miocene (Somal Formation). Basaltic intrusions were observed below the Upper Palaeocene.

Figure 7.3: Afgoi-1 Geoseismic Line

Afgoi-2 was drilled onshore by the Ministry of Minerals and Water Resources between December 1984 and March 1985 to a total depth of 4,194m (13,761 ft). The target was the Sagaleh Formation within the ‘Afgoi structure’, a large faulted anticline consisting of strata of the Lower Miocene to the Eocene. At TD the well reached the Upper Cretaceous Jesomma Formation. The well location is shown on Figure 7.1**.**

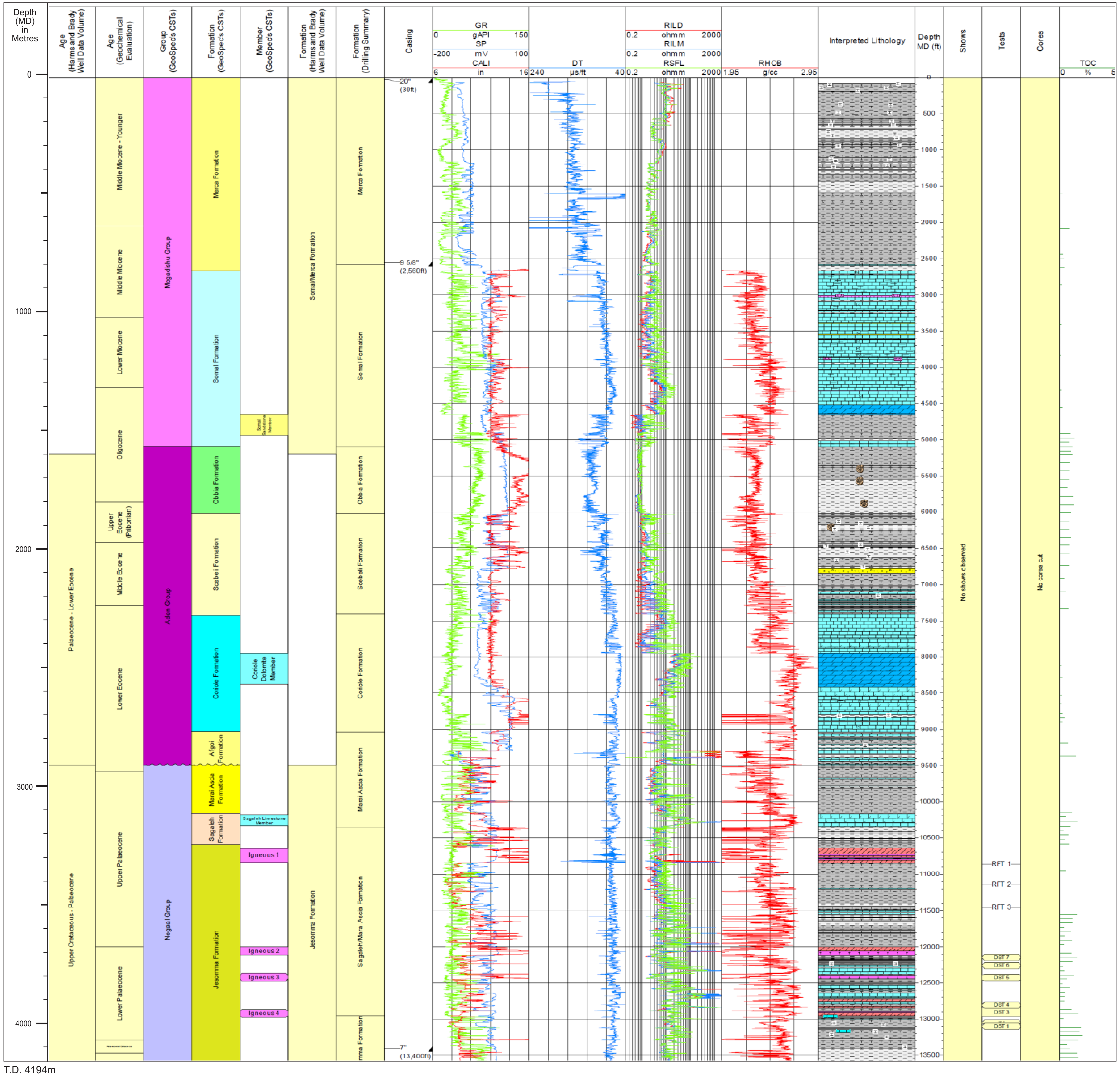
The structure was previously tested by Afgoi-1 in 1965, located 3,120m to the northwest where gas was encountered in the Palaeocene and Upper Cretaceous sands. In Afgoi-2 minor shows of C1 and C2 were observed in the Eocene, while traces of C1-C4 were noted in the Palaeocene in the mud log and completion logs. No hydrocarbons were observed in the Drill Stem Test (DST) and the well was plugged and abandoned.

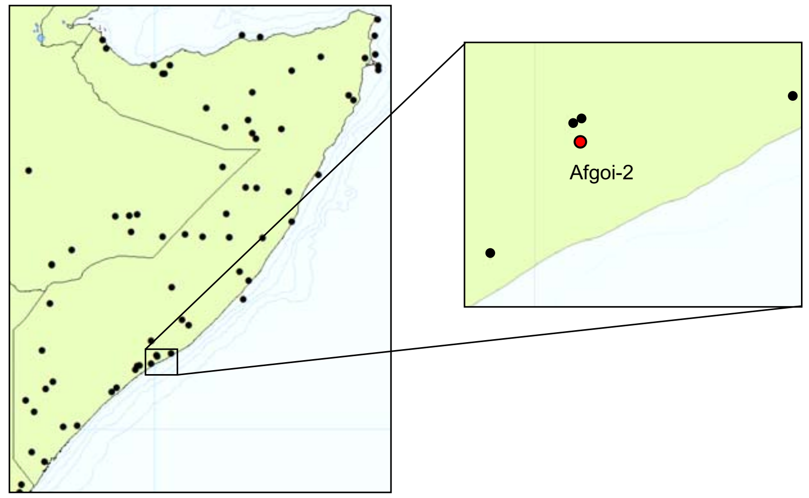
Lithologies in Afgoi-2 are dominated by marine sands and shales, with carbonate packages interbedded throughout. These carbonates intervals are prominent in the Lower Eocene (Coriole Formation) and Lower Miocene (Somal Formation). Basaltic intrusions, no younger than the Upper Palaeocene, were observed in the lower section of the well. Afgoi-2 penetrates a number of south east dipping faults. The well summary chart for Afgoi-2 is shown in Figure 7.4.

There were no significant shows in the Palaeocene sands in Afgoi-2, and this result is interpreted to be due to the sands being on the down thrown side of a fault. Possibly the reservoir sands in Afgoi-1 have been faulted out in this well. Petrophysical analysis highlighted the presence of hydrocarbons in the Jesomma Formation, consistent with traces of C1-C4 which is recorded on the mud and completion log.

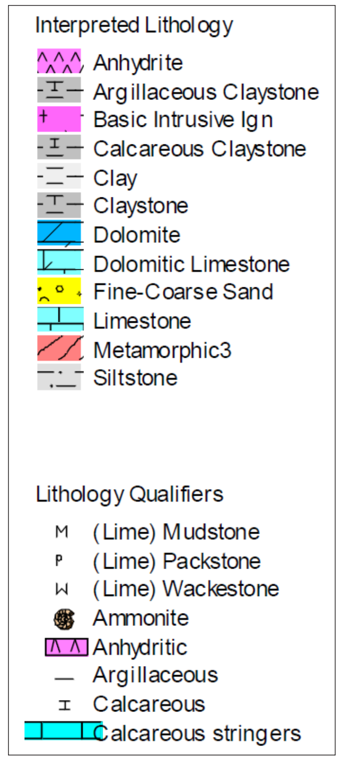
A geoseismic line over to Afgoi-2 is shown in Figure 7.5**.**

Afgoi-2



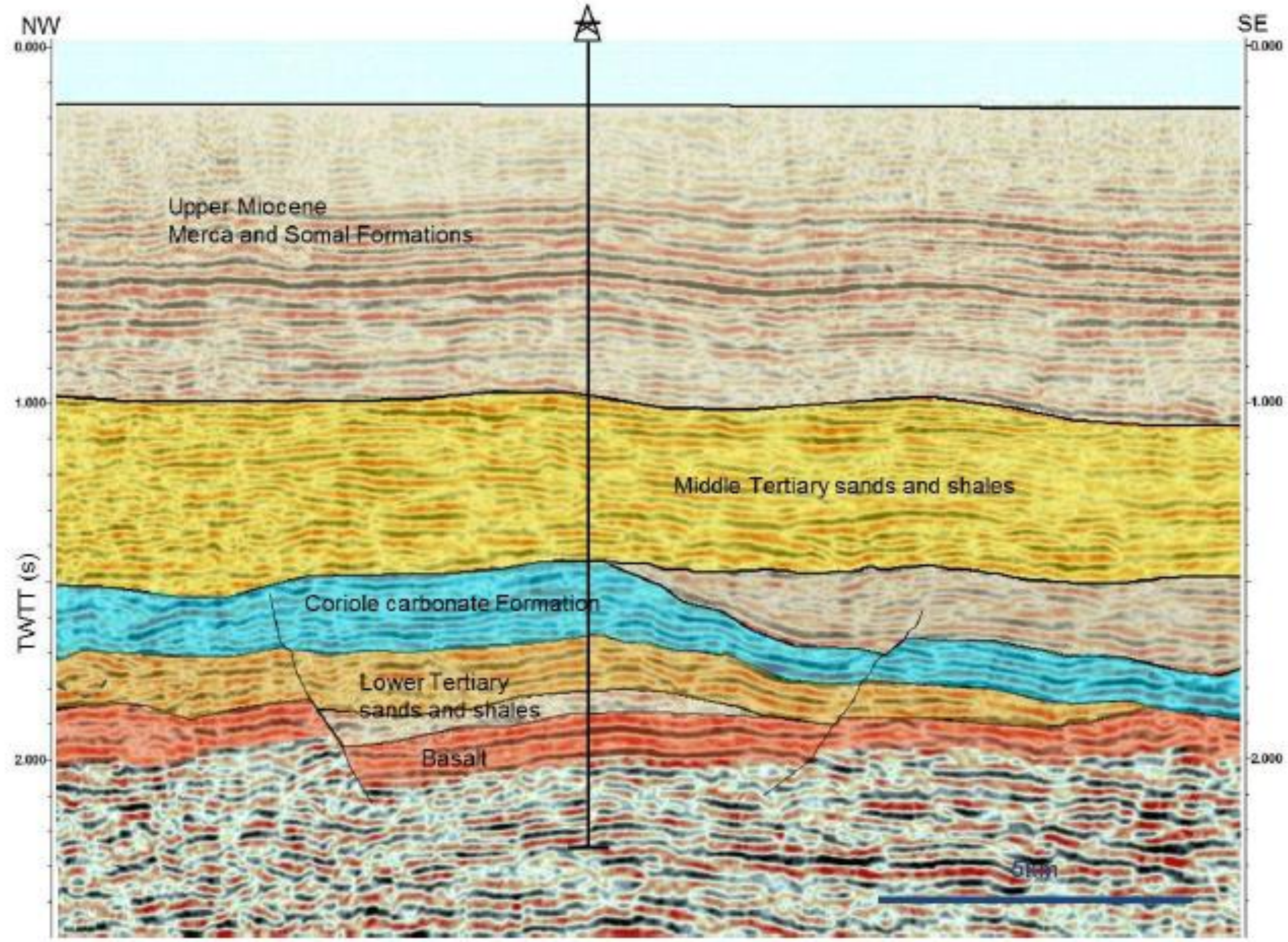


Afgoi-2 was drilled onshore Somalia, and is located at 02° 05' 20" N, 45° 04' 52" E



Well Summary Chart, Afgoi-2 **Figure 7.4**

Operator		
Ministry of Minerals and Water Resources		
Coordinates		
02° 05' 20" N 45° 04' 52" E		
KB	GL	TD
89m 293ft	82m 270ft	4,194m 13,761ft
Spud Date	Completion Date	
01-Dec-1984	19-Mar-1985	
Shows	Tests/Cores	
Trace Gas ($C_1 - C_4$)	7 DSTs; 5 RFTs; No Cores	
Status		
Dry; Plugged and Abandoned		



The **Geoseismic Section** summarises the well target and the main stratigraphy of the area. There were no significant shows in the Palaeocene in Afgoi-2. These sands were observed on the down-thrown side of the faults, this suggested that the reservoir sands in Afgoi-1 to the northwest had been cut off. The lithology was dominated by marine sands and shales with prominent carbonate intervals in the Lower Eocene (Coriole Formation) and Lower Miocene (Somal Formation). Basaltic intrusions were observed below the Upper Palaeocene.

Figure 7.5: Afgoi-2 Geoseismic Line

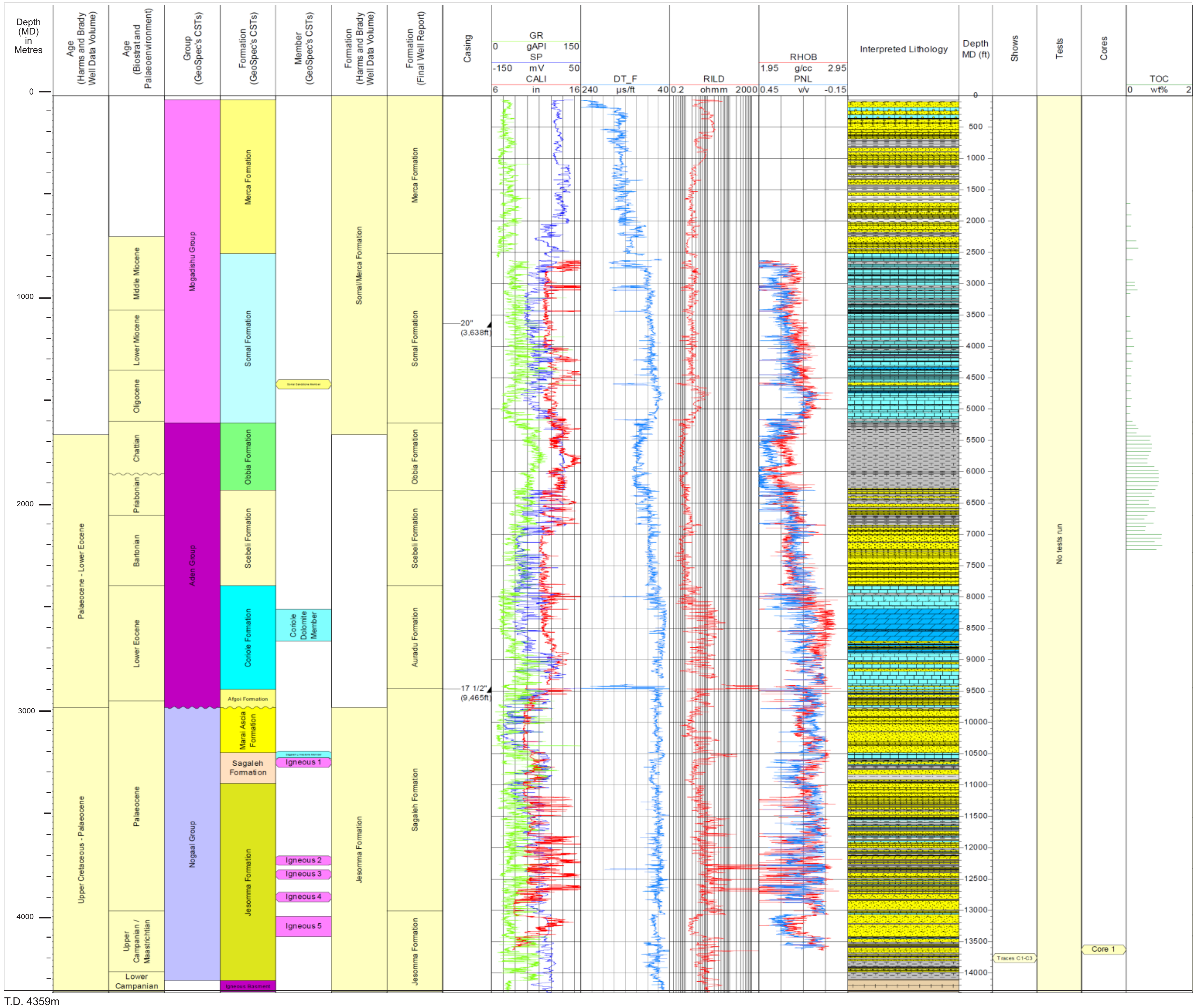
Afgoi-3 was drilled onshore by the Ministry of Minerals and Water Resources between April and and June 1985 to a total depth of 4,3594m (14,302 ft). Afgoi-3 was the final well drilled to target the Palaeocene and Upper Cretaceous sands of the 'Afgoi structure', a faulted anticline. The structural target for this well was located on the northwest flank of the anticline. However no significant shows were observed in Afgoi-3 well. The location of Afgoi-3 well is shown in Figure 7.1**.**

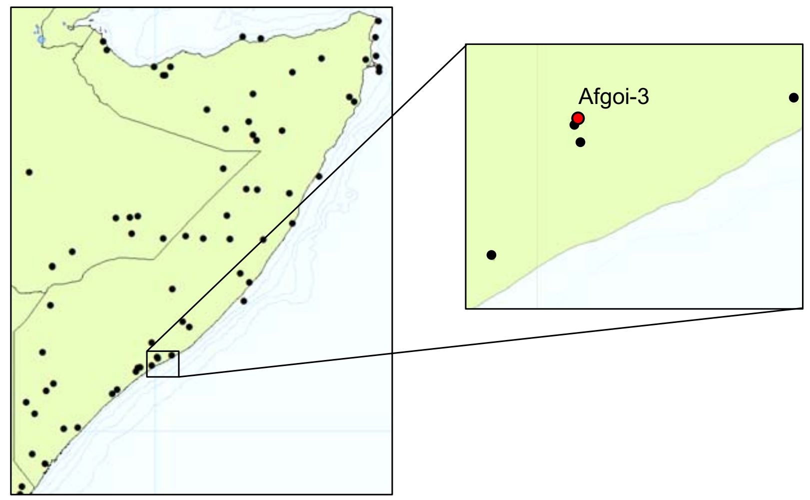
The lithology of Afgoi-3 was dominated by marine sands and shales, with carbonate packages interbedded throughout the sequence. These carbonates intervals are prominent in the Lower Eocene (Coriole Formation) and Lower Miocene (Somal Formation). Basaltic intrusions, no younger than the Upper Palaeocene, were observed in the lower section of the well. Afgoi-3 penetrates a number of south east dipping faults. The well summary Chart for Afgoi-3 is shown in Figure 7.6.

There is some source rock potential in Afgoi-3 with relatively high Hydrogen Index (HI) and free hydrocarbon (S2). However only marginal TOC (maximum (1.08%) values were recorded in the Tertiary.

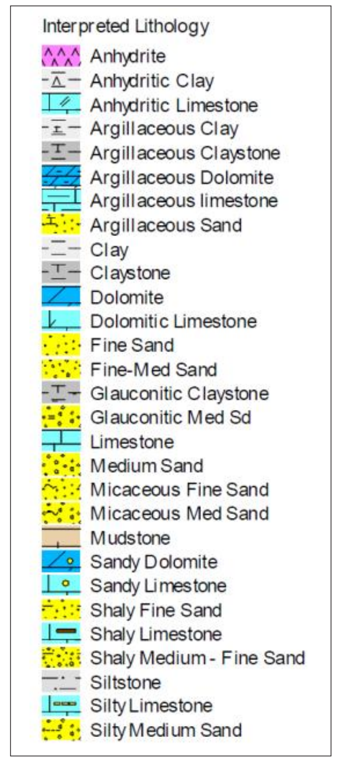
A geoseismic line over to Afgoi-3 is shown in Figure 7.7.

Afgoi-3



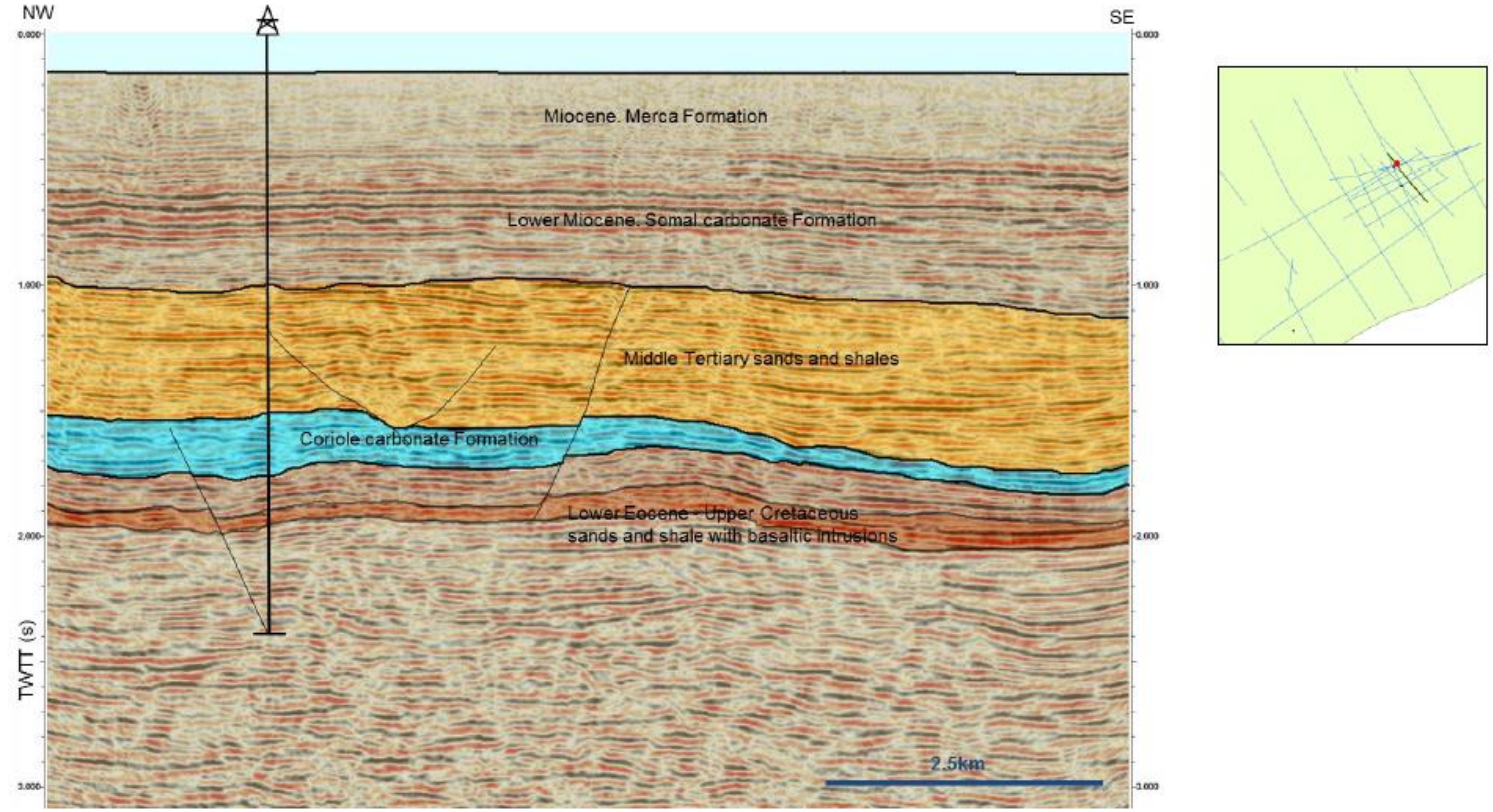


Afgoi-3 was drilled onshore Somalia, and is located at 02° 07' 10.45" N, 45° 04' 27.53" E



Well Summary Chart, Afgoi-3 **Figure 7.6**

Operator		
Ministry of Minerals and Water Resources		
Coordinates		
02° 07' 10.45" N 45° 04' 27.53" E		
KB	**GL**	**TD**
89m 293ft	82m 270ft	4,359m 14,302ft
Spud Date	**Completion Date**	
19-Apr-1985	24-Jun-1985	
Shows	**Tests/Cores**	
Trace $C_1 - C_3$	No Tests; 1 Core	
Status		
Dry; Plugged and Abandoned		



The **Geoseismic Section**, based on interpretation by Harms and Brady, summarises the well target and the main stratigraphy of the area. It shows the general SE dipping trend of faults around the well. The Palaeocene sands were observed on the down-thrown side of these faults, as shown above, this suggested that the reservoir sands in Afgoi-1 had been isolated. The lithology was dominated by marine sands and shales with prominent carbonate intervals in the Lower Eocene (Coriole Formation) and Lower Miocene (Somal Formation). Basaltic intrusions were observed below the Upper Palaeocene.

Figure 7.7: Afgoi-3 Geoseismic Line

Coriole-1 was drilled onshore by Sinclair between July 1960 and March 1961 to a total depth of 4,518m (11,543 ft). This was the first well to be drilled on the Coriole structure; reported to be a 30km long fault bounded anticline, located sub parallel to the coast. This structure was interpreted from seismic, but copies of the relevant data are no longer available. More recent seismic indicates vertical closure of several hundred feet in the Lower Cretaceous. Oil staining and gas shows were reported from core and well tests. However it is reported that the minor shows were not commercially viable and Corliole-1 well was plugged and abandoned. The well reached TD in Upper Cretaceous volcanics. The location of Coriole-1 well is shown in Figure 7.1**.**

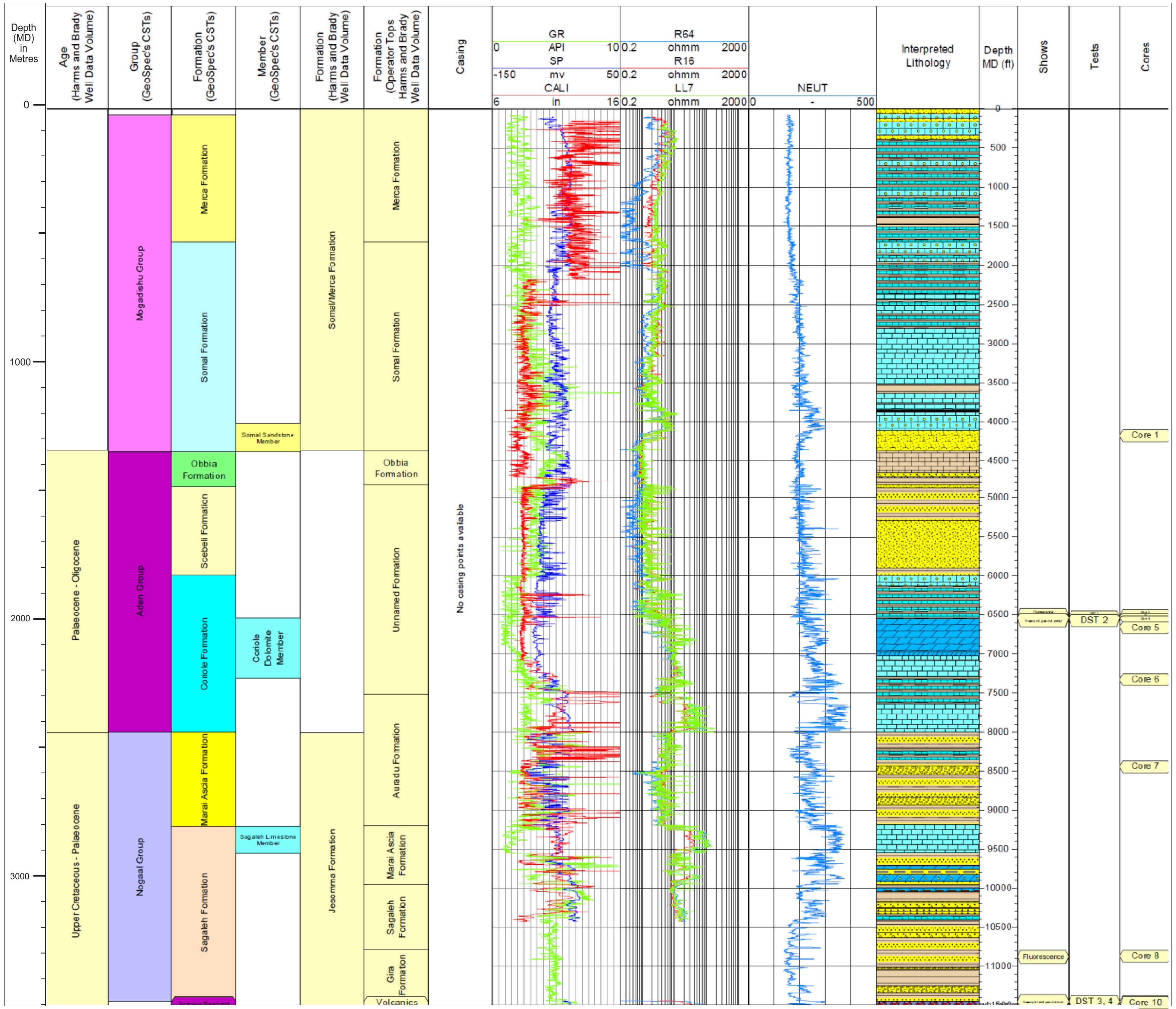
The Tertiary sequence is dominated by interbedded sands and shales, with a thick unit carbonates in the Somal Formation (Lower Miocene). A regional unconformity divides the Upper Tertiary from thick Oligocene interbedded sand and shales which lie on Lower Oligocene-Palaeocene carbonates. The Upper Cretaceous consists of thin sequences of sand, shales and carbonates, with igneous intrusions in the lower part of the Sagaleh Formation. The well summary chart for Coriole-1 is shown in Figure 7.8.

Minor shows were observed in the Eocene and Upper Cretaceous. Cores cut in these intervals indicated oil staining at depths of 1,991m–1,994m and 3487m-3492m (6,533ft-6,545ft and 11,441ft – 11,459ft). Whilst good cut and fluorescence were reported at depth of 1,982m-1,984m and 3,314m-3,316m (6,504ft-6,510ft and 10,875ft-10,880ft). Drill Stem Tests (DST) on the Eocene Coriole Formation recovered an average of 2bbls of 44° API oil and salt water. Up to 2MMcfgpd gas and minor condensate was reported in the DSTs run on the Upper Cretaceous Gira Formation, specifically within the intrusive volcanics 3487m-3492m (11,441ft-11,459ft).

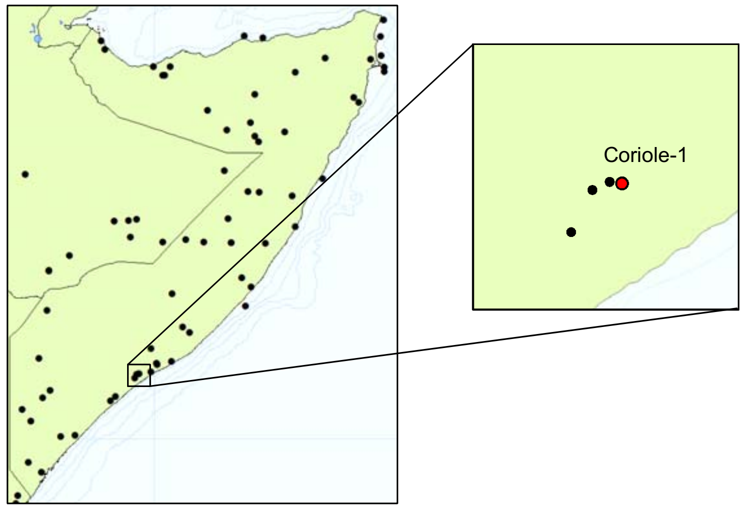
Total Organic Content (TOC) values for the samples from this well are poor to marginal, averaging 0.5%. Regional reports suggest that conditions for oil generation should be present in the deeper section of the well.

A geoseismic line over to Coriole-1 is shown in Figure 7.9**.**

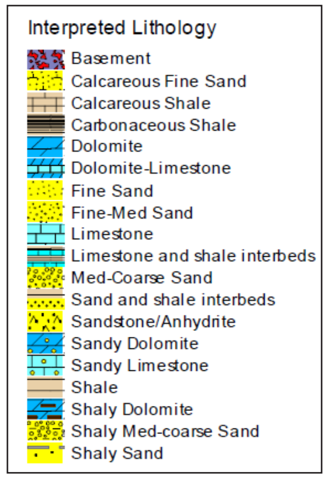
Coriole-1



T.D. 3518m



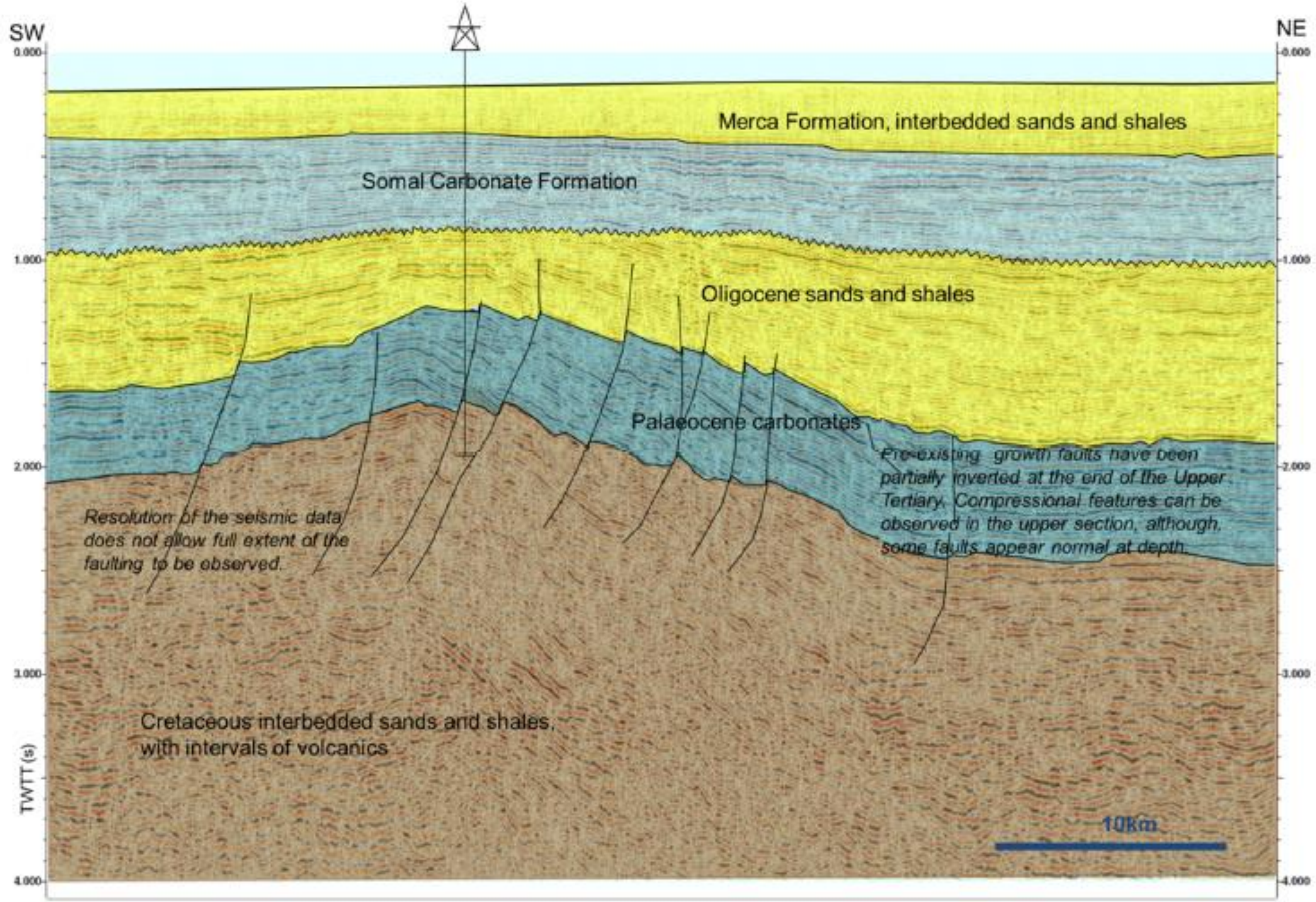
Coriole-1 was drilled onshore Somalia at 01° 49' 36.388" N, 44° 34' 54.470" E

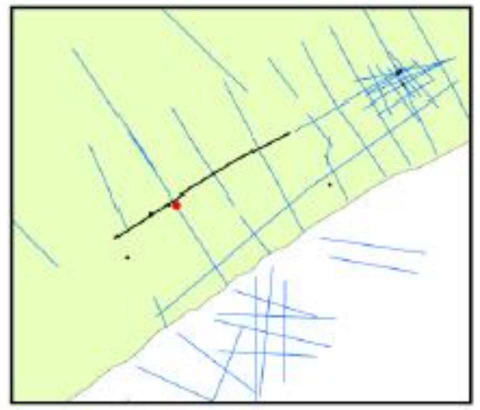


Well Summary Chart, Coriole-1

Figure 7.8

Operator		
Sinclair Somal Corporation		
Coordinates		
01° 49' 36.388" N 44° 34' 54.470" E		
KB	**GL**	**TD**
93m 305ft	88m 289ft	3,518m 11,543ft
Spud Date	**Completion Date**	
06-Jul-1960	06-Mar-1961	
Shows	**Tests/Cores**	
2bbls of 44°API oil	4 DSTs; 10 Cores	
Status		
Dry; Plugged and Abandoned		





The **Geoseismic Section** summarises the well target and the main stratigraphy of the area. The Tertiary is dominated by interbedded sands and shales, with a thick unit of carbonates in the Somal Formation (Lower Miocene). A regional unconformity divides the Upper Tertiary from thick Oligocene interbedded sands and shales which lie on Lower Oligocene – Palaeocene carbonates. The Upper Cretaceous consists of thin sequences of sands, shales and carbonates, with igneous intrusions in the lower part.

Figure 7.9: Coriole-1 Geoseismic Line

Coriole-2 was drilled onshore by Sinclair between July 1965 and September 1965 to a total depth of 4,068m (13,349 ft). Coriole-2 was the last well to be drilled on the Cariole structure, previously drilled by Coriole-1, Dobei-1 and Dobei-2 between 1960 and 1961.the structure comprises of a 30km long fault bounded anticline located sub parallel to the coast. The well was designed to extend exploration from Coriole-1 with Coriole-2 targeting the Lower Tertiary limestones and sandstones on the west side of the structural culmination.

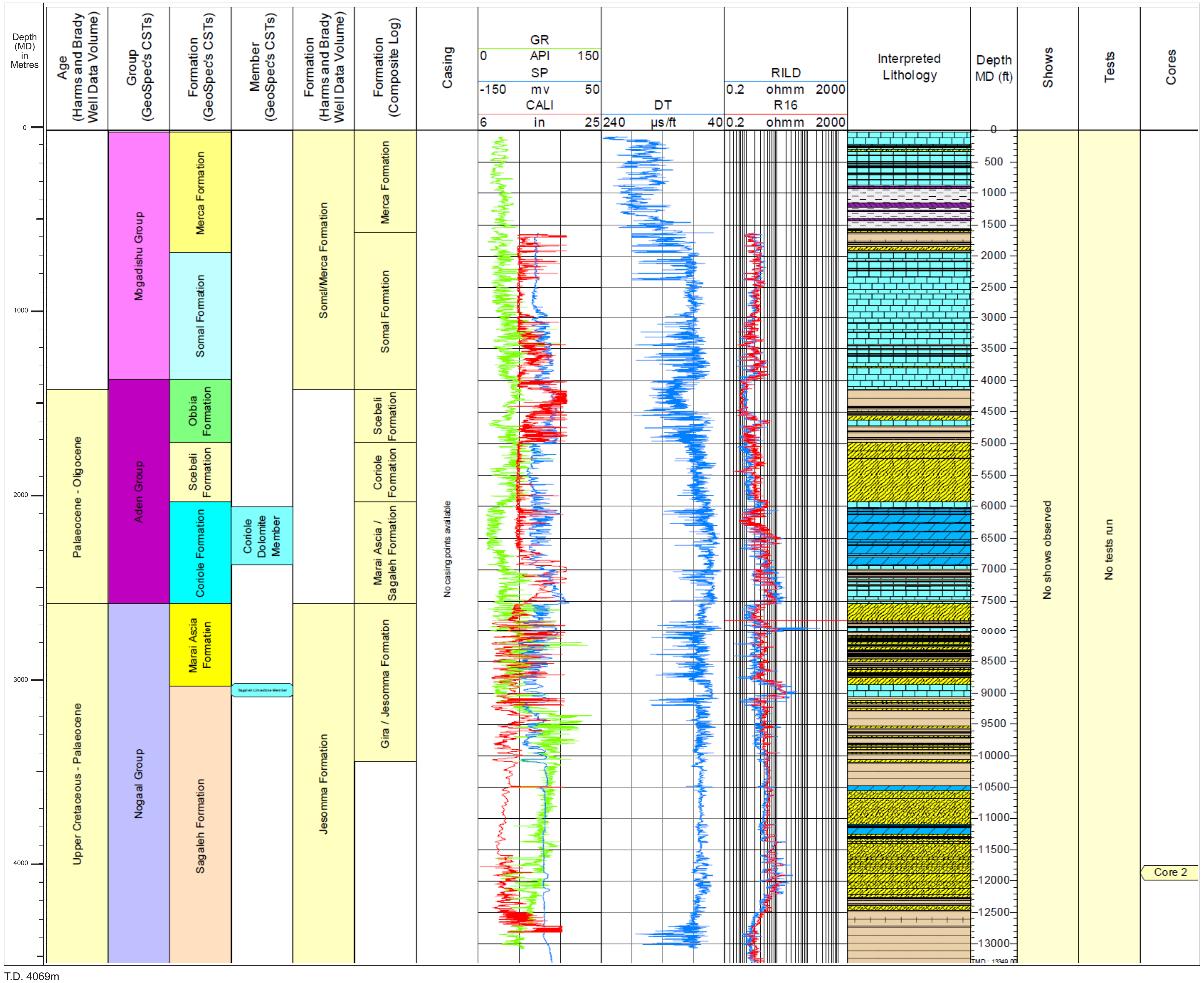
Minor gas shows were reported in the Cretaceous sands but these were not tested. The well TD was in the Upper Cretaceous Jesomma Formation. The location of Coriole-2 well is shown in Figure 7.1.

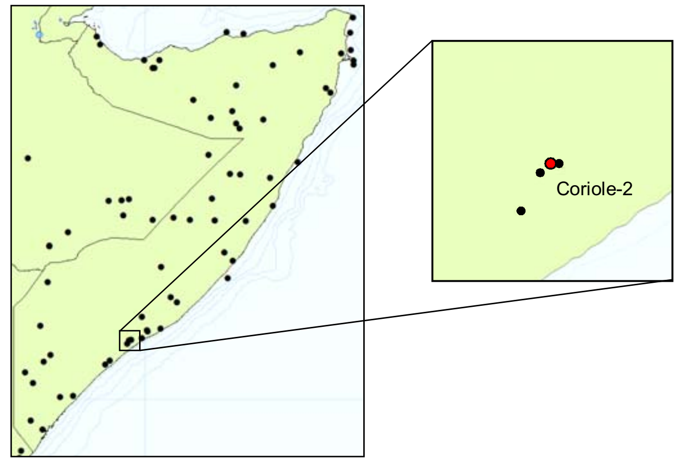
The lithology of the Tertiary sequence (down to 10,000ft) is predominately sandstone with interbedded limestones and dolomites, with a thick unit of carbonates in the Somal Formation (Lower Tertiary). A regional unconformity divides the Upper Tertiary from the thick Oligocene interbedded sands and shales which lie on the Lower Oligocene-Palaeocene carbonates. The Upper Cretaceous consists of thin sequences of sands, shales and carbonates with igneous intrusions in the lower part. The well summary Chart for Coriole-2 is shown in Figure 7.10.

Porosities in this section is range from 10%-30%, however no productive intervals were identified. From 10,000ft to TD the Upper Cretaceous consists of shale with interbedded sandstones. Porosity in this section is reduced significantly with depth. The Total Organic Content (TOC) values from the Nogaal Group (Lower Tertiary- Upper Cretaceous) average of 0.9%, indicating marginal-fair quantities of organic carbon. However, the Nogaal Group has better source rock potential in other parts of the basin, particularly in the Afgoi-1 well. Petrophysical analysis also highlighted minor shows and moderate reservoir properties in the Upper Cretaceous.

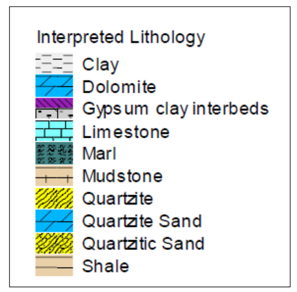
A geoseismic line over to Coriole-2 is shown in Figure 7.11**.**

Coriole-2



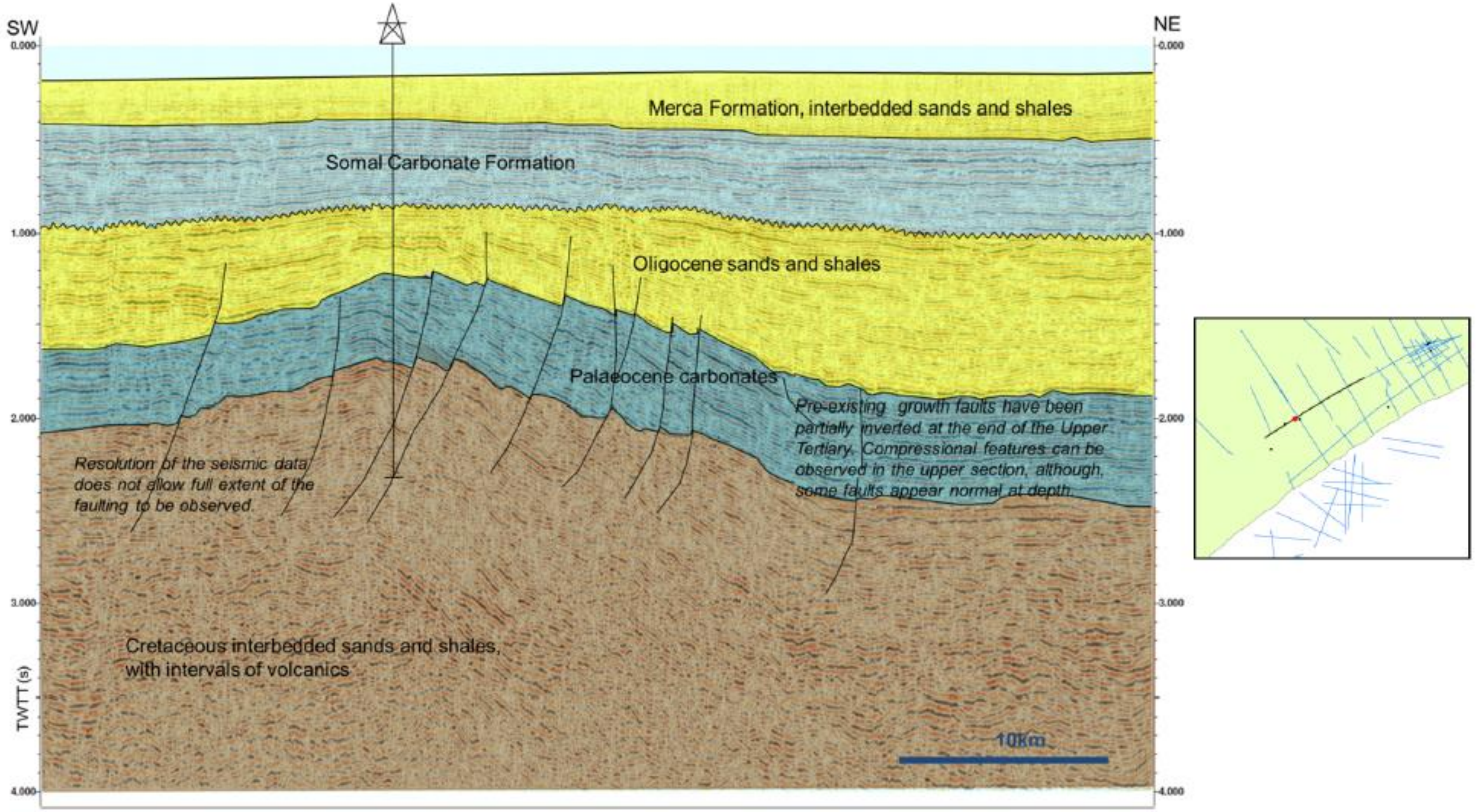


Coriole-2 was drilled onshore Somalia, and is located at 01° 49' 43" N, 44° 33' 52" E



Well Summary Chart, Coriole-2 **Figure 7.10**

Operator		
Sinclair International Oil Company		
Coordinates		
01° 49' 43" N 44° 33' 52" E		
KB	**GL**	**TD**
92m 303ft	88m 288ft	4,069m 13,349ft
Spud Date	**Completion Date**	
15-Jul-1965	18-Sep-1965	
Shows	**Tests/Cores**	
Untested Minor Gas	No Tests; 2 Cores	
Status		
Dry; Plugged and Abandoned		



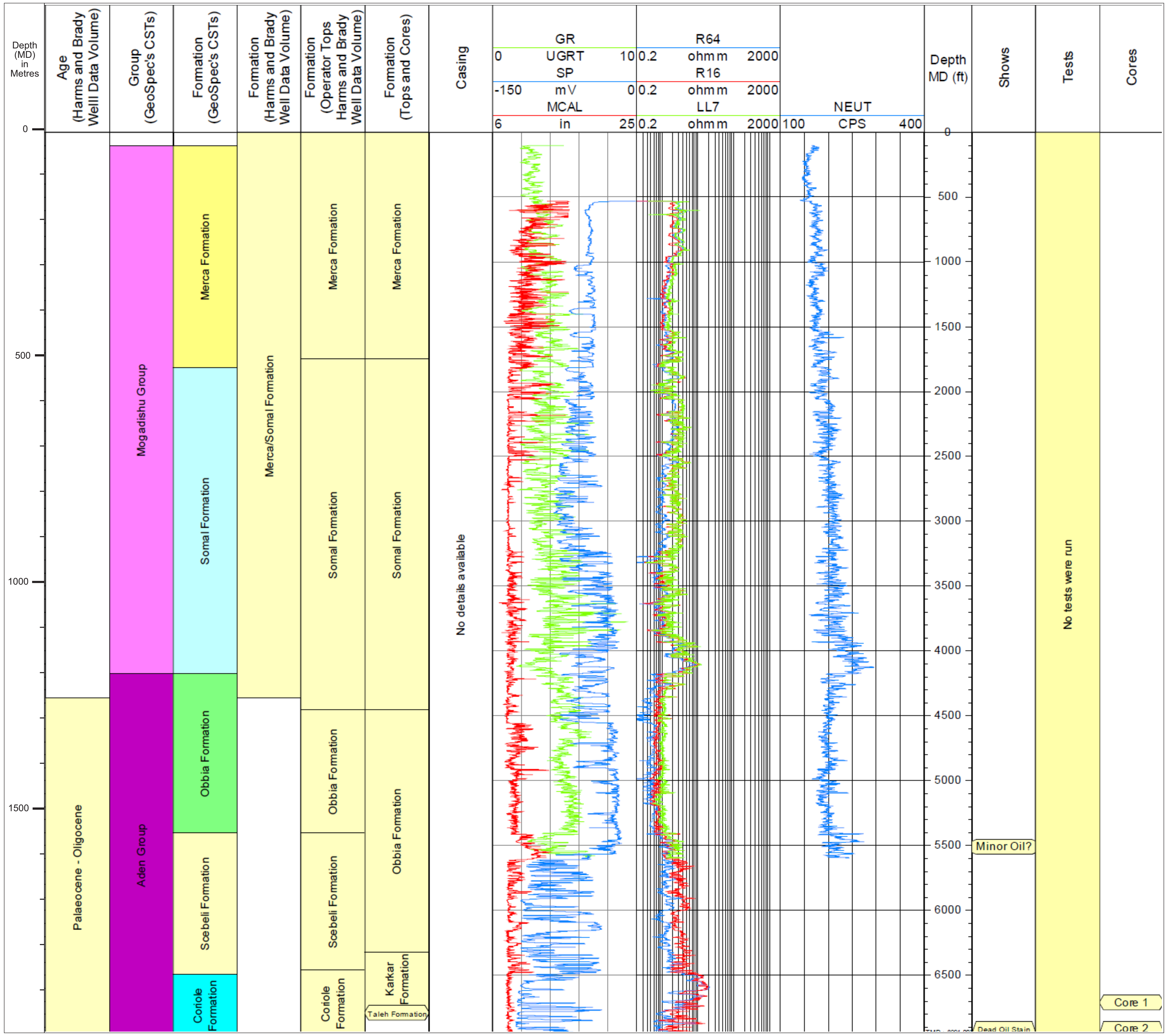
The **Geoseismic Section** summarises the well target and the main stratigraphy of the area. The Tertiary is dominated by interbedded sands and shales, with a thick unit of carbonates in the Somal Formation (Lower Miocene). A regional unconformity divides the Upper Tertiary from thick Oligocene interbedded sands and shales which lie on Lower Oligocene – Palaeocene carbonates. The Upper Cretaceous consists of thin sequences of sands, shales and carbonates, with igneous intrusions in the lower part.

Figure 7.11: Coriole-2 Geoseismic Line

Dobei-1 was drilled onshore by Sinclair between March 1961 and April 1961 to a total depth of 2,131m (6,991 ft). Dobei-1 was the second well to be drilled ion the Coriole structure, a 30km long fault bounded anticline located sub parallel to the coast. The well targeted the Eocene dolomites within the Coriole Formation (Palaeocene- Oligocene). Dead oil stains were recorded in the core at 2,116m-2,121m (6,945ft-6,961ft). Petrophysical analysis also indicated minor oil shows in the overlying sandstone Scebeli Formation (Palaeocene – Oligocene). At TD the well reached the Palaeocene-Oligocene Coriole Formation. The location of Dobei-1 well is shown in Figure 7.1**.**

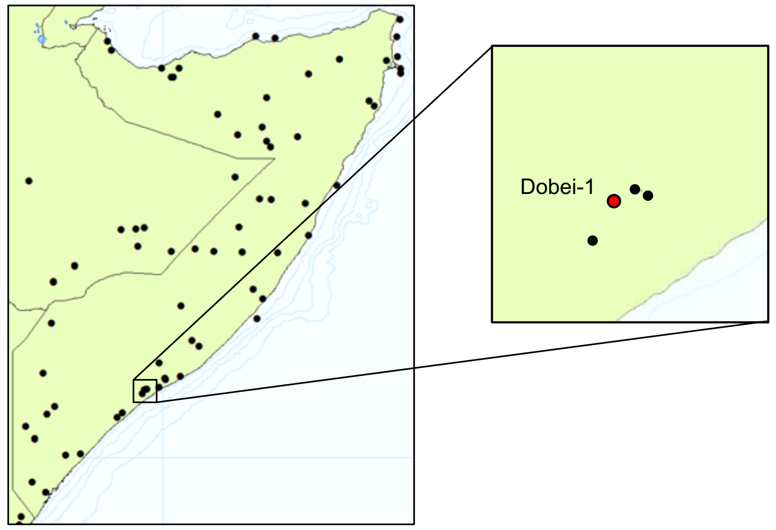
There is very little information on the lithology of Dobei-1 well. However seismic interpretation across the basin, well correlation and petrophysical analysis indicates that the lithology is dominated by interbedded sands and shales, with a thick unit of carbonates in the Somal Formation (Lower Miocene). A regional unconformity divides the Upper Tertiary from the thick Oligocene interbedded sands and shales. Dobe-1 was plugged and abandoned. The well summary chart for Dobei-1 is shown in Figure 7.12.

A geoseismic line over to Dobei-1 is shown in Figure 7.13**.**



T.D. 2131m

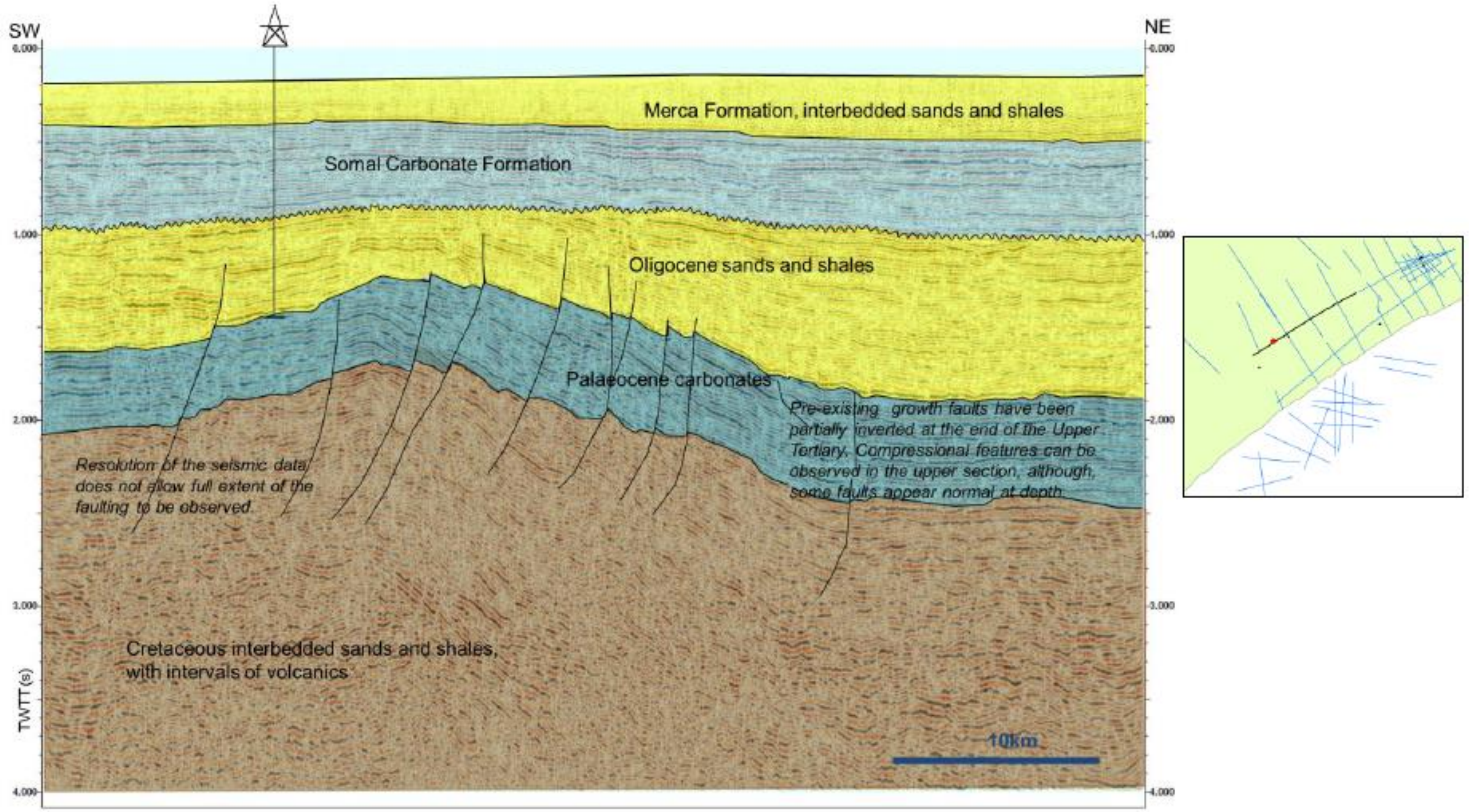
Dobei-1



Dobei-1 was drilled onshore Somalia, and is located at 01° 48' 31" N, 44° 31' 29" E

Well Summary Chart, Dobei-1 **Figure 7.12**

<table>
<tr><th colspan="6">Operator</th></tr>
<tr><td colspan="6">Sinclair Somal Corporation</td></tr>
<tr><th colspan="6">Coordinates</th></tr>
<tr><td colspan="6">01° 48' 31" N
44° 31' 29" E</td></tr>
<tr><th colspan="2">KB</th><th colspan="2">GL</th><th colspan="2">TD</th></tr>
<tr><td colspan="2">90.2m
295.9ft</td><td colspan="2">85.3m
279.9ft</td><td colspan="2">2,131m
6,991ft</td></tr>
<tr><th colspan="3">Spud Date</th><th colspan="3">Completion Date</th></tr>
<tr><td colspan="3">27-Mar-1961</td><td colspan="3">18-Apr-1961</td></tr>
<tr><th colspan="3">Shows</th><th colspan="3">Tests/Cores</th></tr>
<tr><td colspan="3">Oil stains</td><td colspan="3">No tests;
2 cores</td></tr>
<tr><th colspan="6">Status</th></tr>
<tr><td colspan="6">Dry; Plugged and Abandoned</td></tr>
</table>



The **Geoseismic Section** summarises the well target and the main stratigraphy of the area. The Tertiary is dominated by interbedded sands and shales, with a thick unit of carbonates in the Somal Formation (Lower Miocene). A regional unconformity divides the Upper Tertiary from thick Oligocene interbedded sands and shales which lie on Lower Oligocene – Palaeocene carbonates. The Upper Cretaceous consists of thin sequences of sands, shales and carbonates, with igneous intrusions in the lower part. Dobei-1 was plugged and abandoned in the Lower Tertiary Coriole Formation.

Figure 7.13: Dobei-1 Geoseismic Line

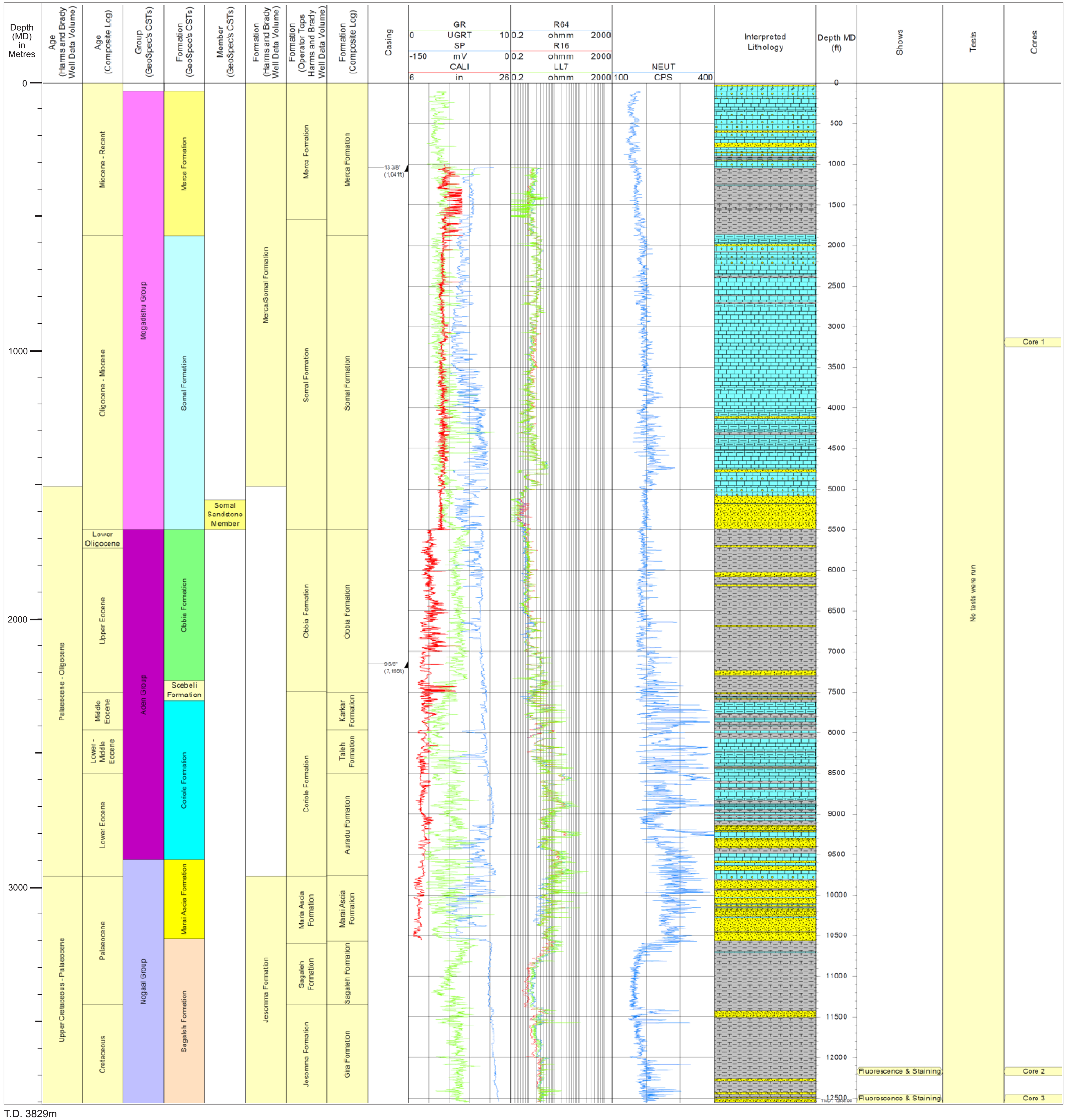
Dobei-2 was drilled onshore by Sinclair between May 1961 and September 1961 to a total depth of 3,830m (12,535 ft). This was the third well to be drilled on the Coriole structure, a 30km long fault bounded anticline north-east trending anticline. The well followed the exploration initiated by the Coriole-1 ad Dobei-1 wells, targeting the Eocene dolomites within the Coriole Formation (Palaeocene- Oligocene). No significant shows were reported, however there was some fluorescence noted in the cores at 3,707m – 3,712m and 3,826m – 3,829m (12,163 ft – 12,181 ft & 12,555 ft-12,565 ft). At TD the well reached the Upper Cretaceous Sagaleh Formation. The location of Dobei-2 well is shown in Figure 7.1**.**

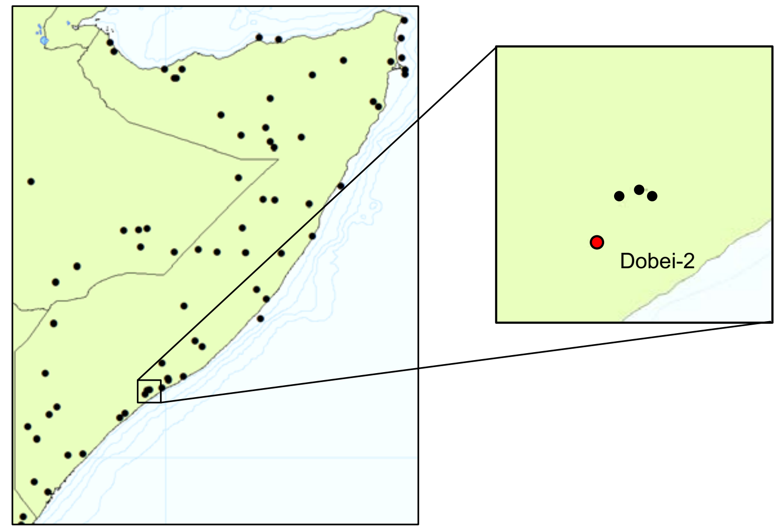
The lithology of the Cretaceous Sagaleh Formation, at the base of the well, is dominated by shales with thin interbedded sands. Above this unit is the Marai Ascia Formation consisting of a very sandy sequence. The overlying Coriole Formation consists of carbonates with interbedded sands and shales. The shale content increases towards the Scabeli Formation. The Obbia Formation (Eocene–Oligocene) is dominated by shales with few interbedded units of sands.

A large unconformity, identified by truncated reflectors, can be observed in the seismic data at the top of the Obbia Formation/Aden Group. Very little information is available on the Oligocene section. Above the unconformity, the Lower Miocene Somal Formation consists of massive limestone with a sandstone member at the base. The Upper Miocene Merca Formation was found to be shaly in the lower (305m) 1,000ft, with overlying interbedded carbonates and sands. The well summary chart for Dobei-2 is shown in Figure 7.14.

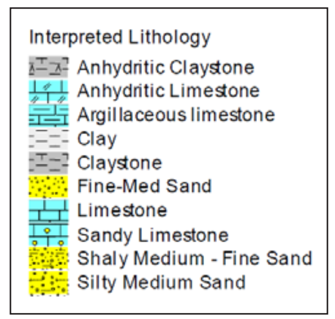
Limited geochemical data suggested that the Dobei-2 well reached oil maturity at approximately 3,291m (10,800ft), in the Sagleh Formation. With Vitrinite Reflectance (VR) values of 0.61% and Total Organic Carbon (TOC) values peaking at 1.16%. However, poor Hydrogen Indices (HI) indicate that the well is unlikely to contain any reasonable quality source rocks.

Dobei-2





Dobei-2 was drilled onshore, Somalia, and is located at 01° 42' 44" N, 44° 28' 25" E



Well Summary Chart, Dobei-2

Figure 7.14

Duddumai-1 was drilled onshore by Sinclair between December 1959 and May 1960 to a total depth of 3,380m (11,090 ft). The well was drilled on a large northeast trending 20km by 6km anticline defined by seismic reflection data. Later refraction maps by Sinclair highlighted large fault blocks steeply dipping to the southeast at the well location. Seismic data shot by the Ministry of Mineral and Water Resources (MMWR) in 1983 indicated a broad fault block at the well location and an unconformity near the Tertiary-Cretaceous boundary at approximately 0.7s.

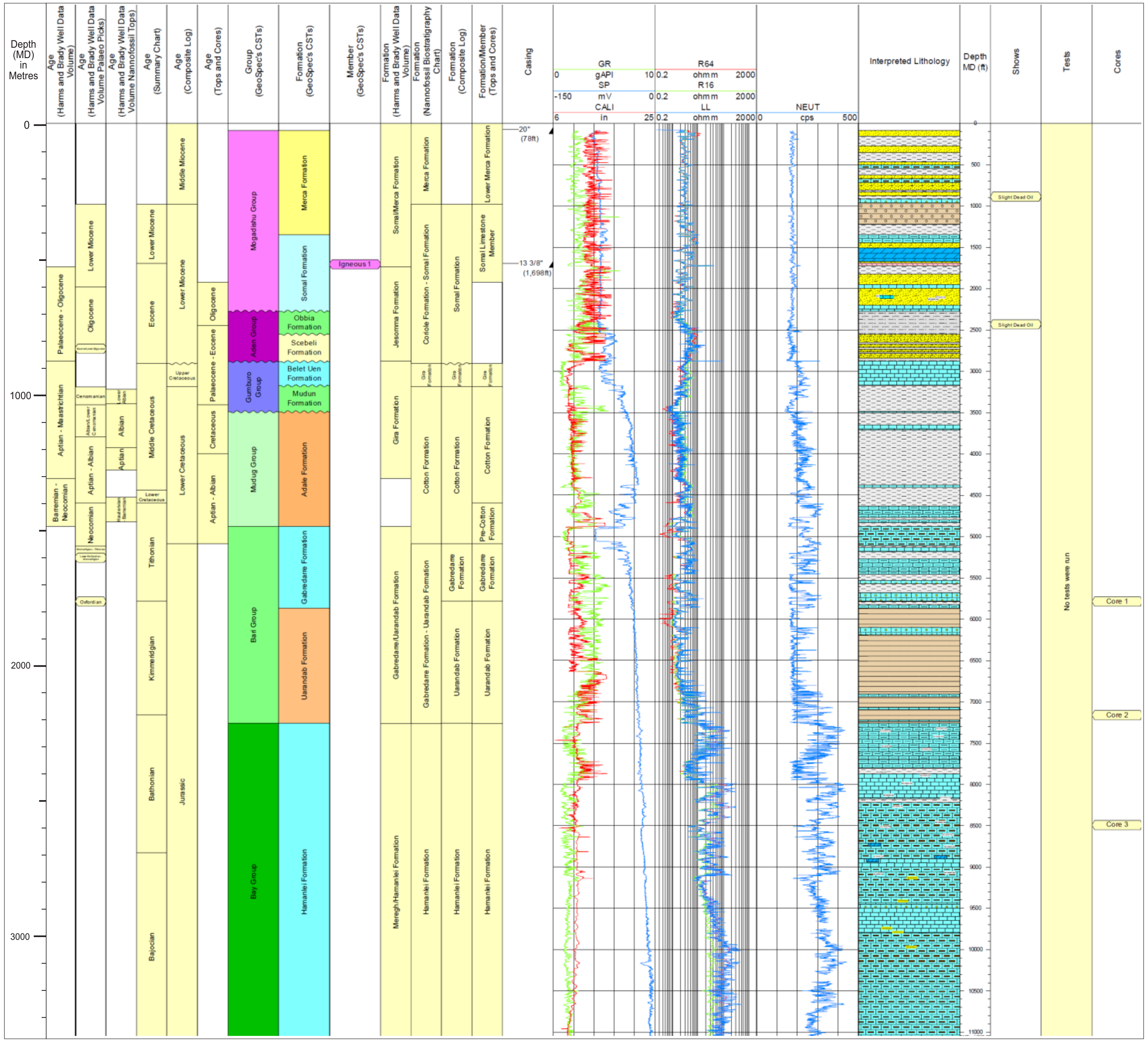
Slight dead oil staining was reported in the Tertiary shales but no producible hydrocarbons were observed. At TD the well reached the Lower to Mid Jurassic Hamanlei Formation. The location of Duddumai-1 well is shown in Figure 7.1**.**

The Jurassic section below 1,554 m (5,100ft) is dominated by tight limestones, with porosities below 10%. Above this lies interbedded Upper Jurassic-Cretaceous limestones, shales and clays. A significant erosive unconformity is observed at 886m (2,910ft) separating the Campanian age Mudun Fm. From the overlying Eocene age Coriole Fm. The overlying Tertiary is dominated by sand and shale interbeds, with occasional carbonate interval. Basalt was noted between 528m - 539m - (1,736ft - 1,770ft) within the Oligocene age Somal Fm. The well summary Chart for Duddumai-1 is shown in Figure 7.15.

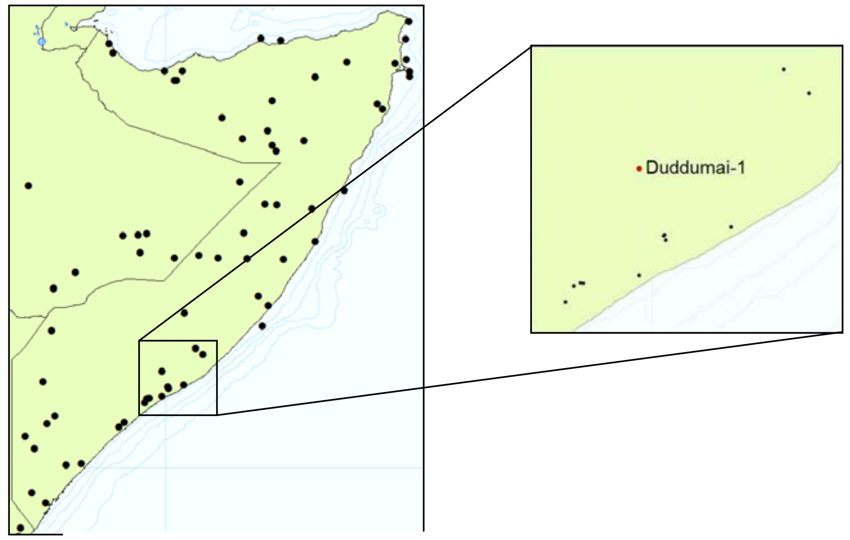
Poor TOC values no greater than 0.5% are reported suggesting that no potential source rock were penetrated. Analysis of the dip log within the Cretaceous below 975m (3,200ft) showed dips between 5-15°, which suggested that the well may have penetrated the flank of the anticline instead of the crest. Duddumai-1 was plugged and abandoned as a dry well.

A geoseismic line over to Duddumai-1 is shown in Figure 7.16**.**

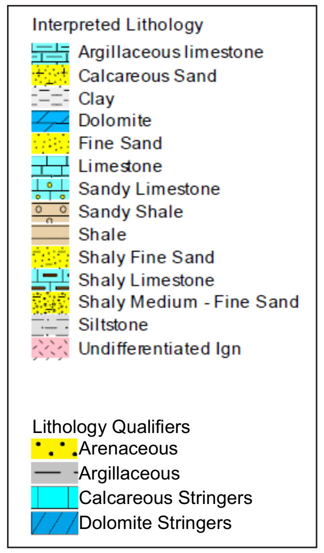
Duddumai-1



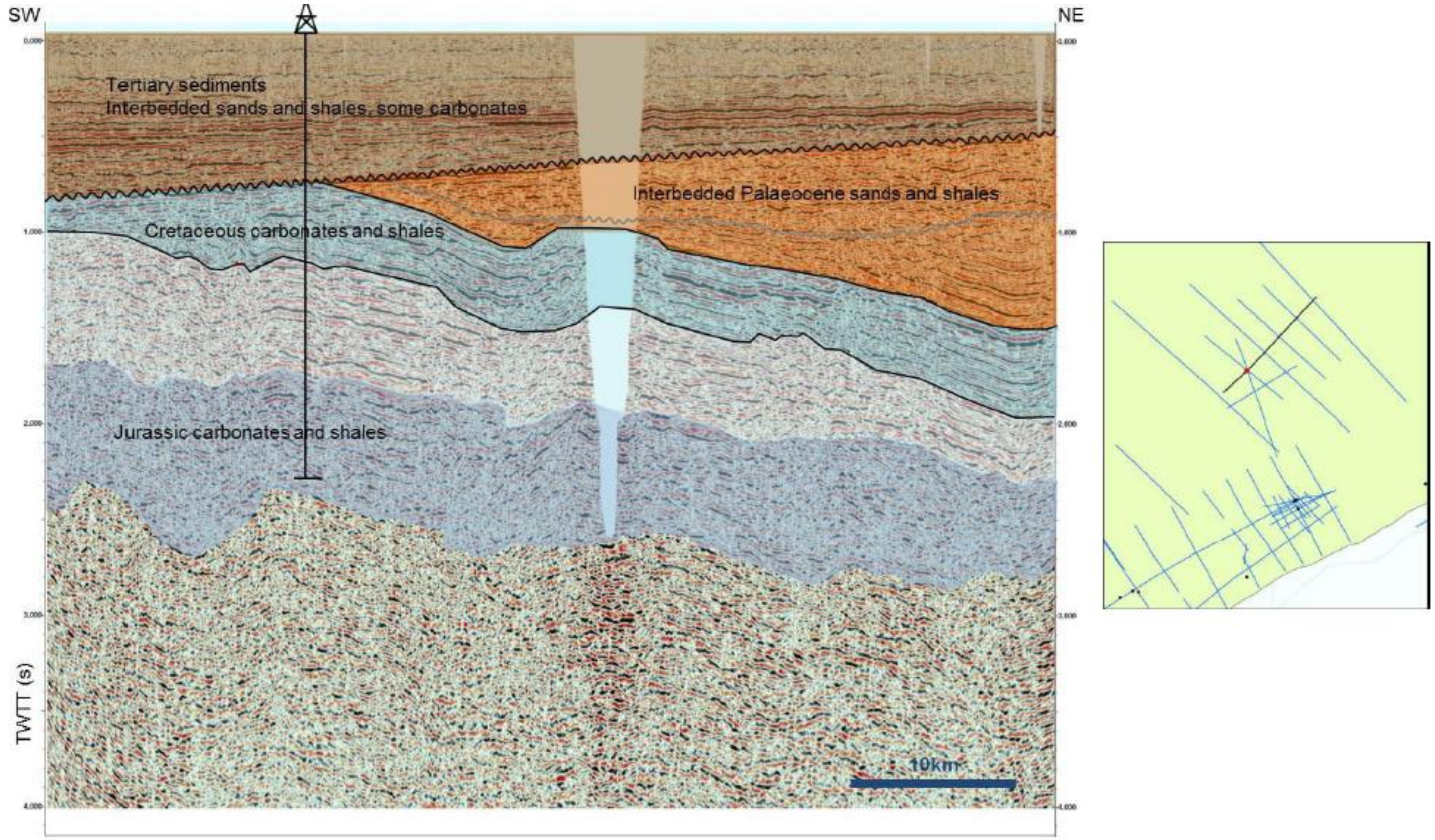
T.D. 3380m



Duddumai-1 was drilled onshore Somalia The well is located at 02° 31' 28.655" N, 44° 55' 14.702" E. The coordinates were taken from the post-well Satellite Survey Report, using the WGS72 datum. The original wireline logs for Duddumai-1 quote the well location as 02° 32' 14" N, 44° 53' 57" E.



Operator		
Sinclair Somal Corporation		
Coordinates		
02° 31' 28.655" N 44° 55' 14.702" E		
KB	**GL**	**TD**
111m 363ft	105m 344ft	3,380m 11,090ft
Spud Date	**Completion Date**	
20-Dec-1959	29-May-1960	
Shows	**Tests/Cores**	
Slight dead oil staining	No Tests; 3 Cores	
Status		
Dry; Plugged and Abandoned		



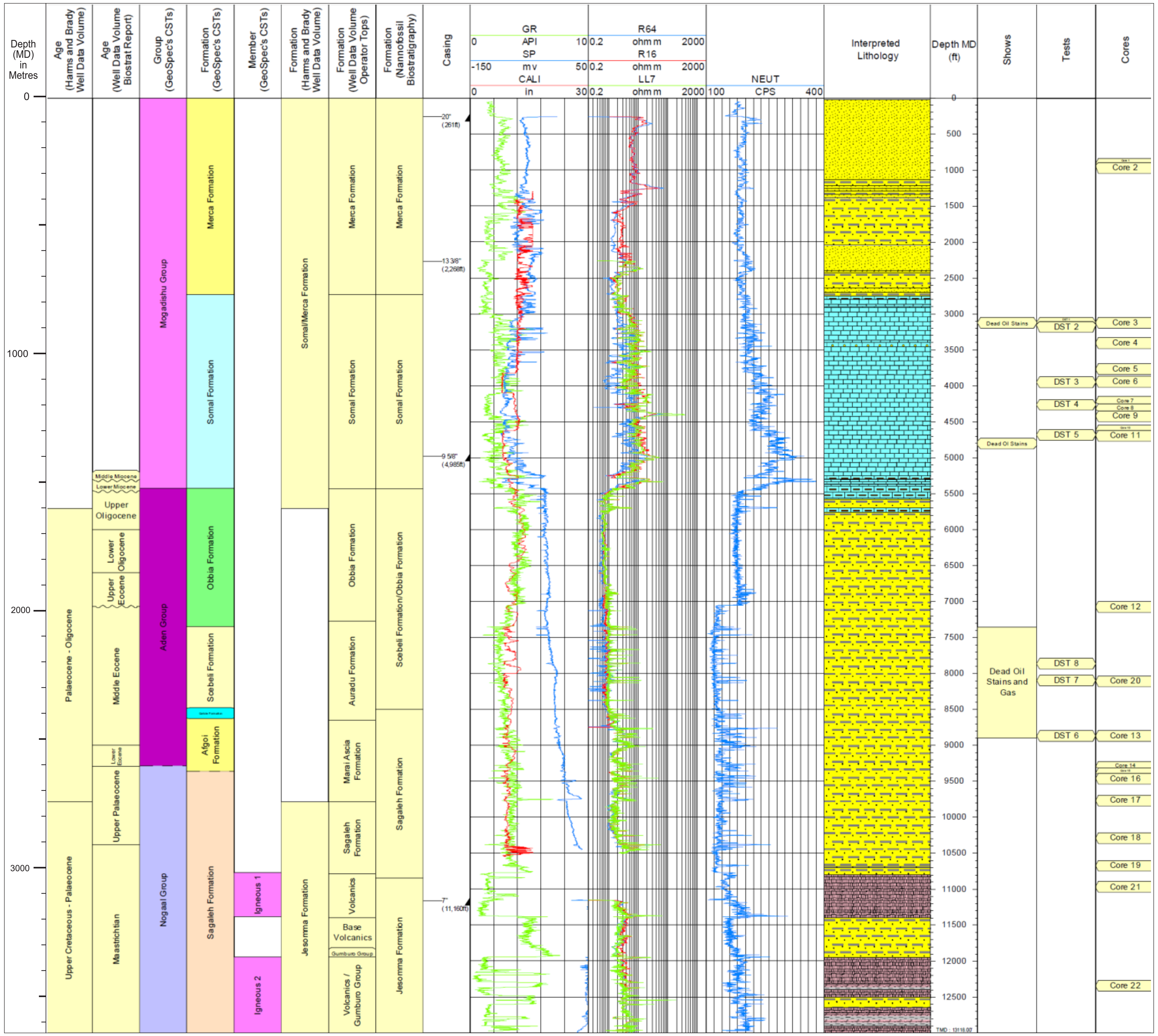
The **Geoseismic Section** summarises the well target and the main stratigraphy of the area. The Lower Jurassic section was dominated by limestones. Above this lie interbeds of Upper Jurassic – Cretaceous limestones, shales and clays. In the well, these were divided from the Tertiary sediments by a large scale unconformity (black). The Tertiary was dominated by sand and shale interbeds, with the occasional carbonate interval. Large southeast dipping fault blocks are observed in the Cretaceous – Jurassic section. A large wedge of Palaeocene sediments, not present in the well was observed to the south and east of Duddumai-1. A number of localised unconformities were observed throughout the Tertiary sediments.

Figure 7.16: Duddumai-1 Geoseismic Line

Merca-1 was drilled onshore by Sinclair between November 1958 and November 1959 to a total depth of 3,998m (13,118 ft). The well drilled on a northeast trending anticline defined by seismic data but seismic indicates that the well did not penetrate the crest of the structure. Only minor gas and dead oil were reported and the well was plugged and abandoned. At TD the well reached the Upper Cretaceous volcanics. . The location of Merca-1 well is shown in Figure 7.1**.**

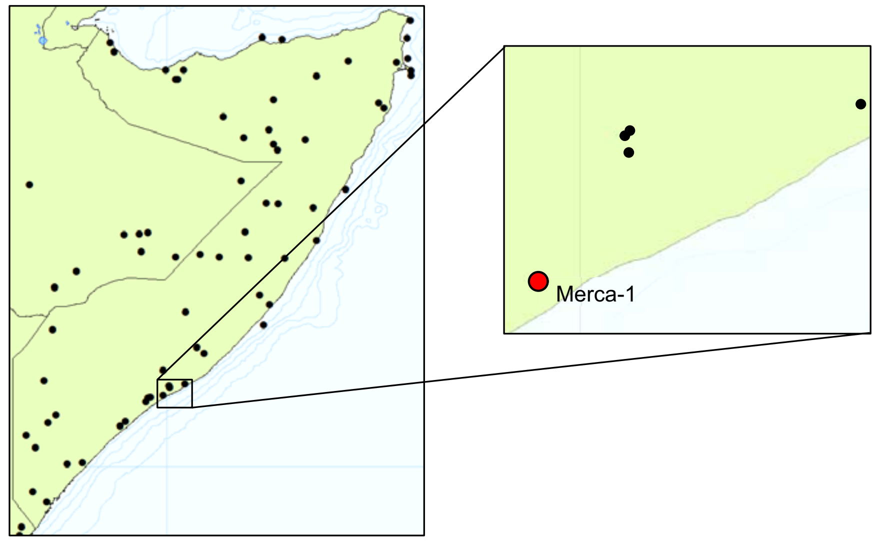
At the base of the well, the Sagaleh Formation 2,829m-3,998m (9,284ft-13,118ft) is dominated by interbedded shales and sands. This sequence is also interrupted by two thick (greater than 485m) units of volcanics at depths of 3,281m-3,640m (10,766ft-11,943ft). Above the volcanics the lithology of the Lower Tertiary is dominated by interbeds of sands and shales. In the Lower-Middle Miocene, thick sand units have been reported by log derived porosities of 20-30%, but only minor gas and dead oil staines were noted in this interval. The Somal Formation (Lower Miocene) consists of carbonates with a log derived porosities of 25%-30% and dead oil stains in this interval. The well summary Chart for Merca-1-1 is shown in Figure 7.17.

Good Total Organic Carbon (TOC) values were observed in sample of Obbia Formation (Oligocene) and Sagaleh Formation (Cretaceous) sands, averaging 2.47%. Hydrogen Indices (HI) for these samples suggest that these are mainly gas prone. A geoseismic line over to Marai-Ascia1 is shown in Figure 7.18**.**

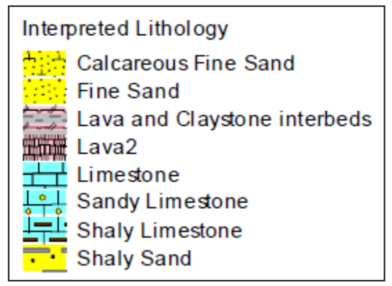


T.D. 3998m

Merca-1



Merca-1 was drilled onshore Somalia, and is located at 01° 52' 26" N, 44° 55' 12" E



Well Summary Chart, Merca-1 **Figure 7.17**

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<tr><td colspan="6">Sinclair Somal Corporation</td></tr>
<tr><th colspan="6">Coordinates</th></tr>
<tr><td colspan="6">01° 52' 26" N
44° 55' 12" E</td></tr>
<tr><th colspan="2">KB</th><th colspan="2">GL</th><th colspan="2">TD</th></tr>
<tr><td colspan="2">137.63m
451.55ft</td><td colspan="2">133.0m
436.3ft</td><td colspan="2">3,998m
13,118ft</td></tr>
<tr><th colspan="3">Spud Date</th><th colspan="3">Completion Date</th></tr>
<tr><td colspan="3">19-Nov-1958</td><td colspan="3">26-Nov-1959</td></tr>
<tr><th colspan="3">Shows</th><th colspan="3">Tests/Cores</th></tr>
<tr><td colspan="3">Dead oil stains;
Minor gas shows</td><td colspan="3">8 DSTs;
23 Cores</td></tr>
<tr><th colspan="6">Status</th></tr>
<tr><td colspan="6">Dry; Plugged and Abandoned</td></tr>
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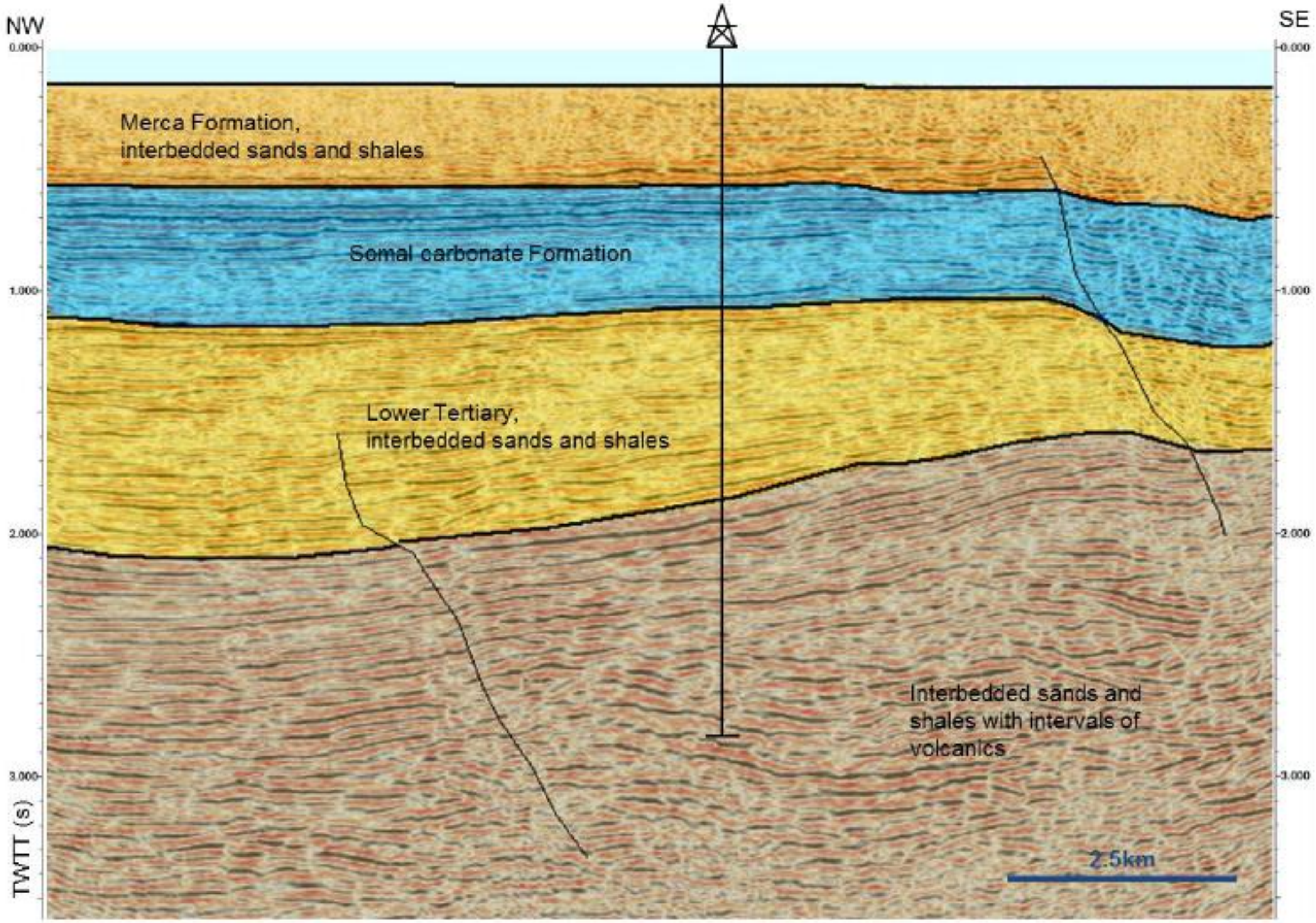


The **Geoseismic Section**, based on interpretation by Harms and Brady, summarises the well target and the main stratigraphy of the area. It shows the interbedded sands and shales of the Tertiary, with the massive carbonate Somal Formation. Intervals of volcanics are observed in the Upper Cretaceous. The well appears to have been drilled down-dip of the prognosed structural closure.

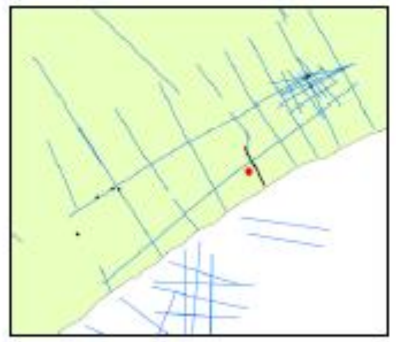


Figure 7.18: Merca-1-1 Geoseismic Line

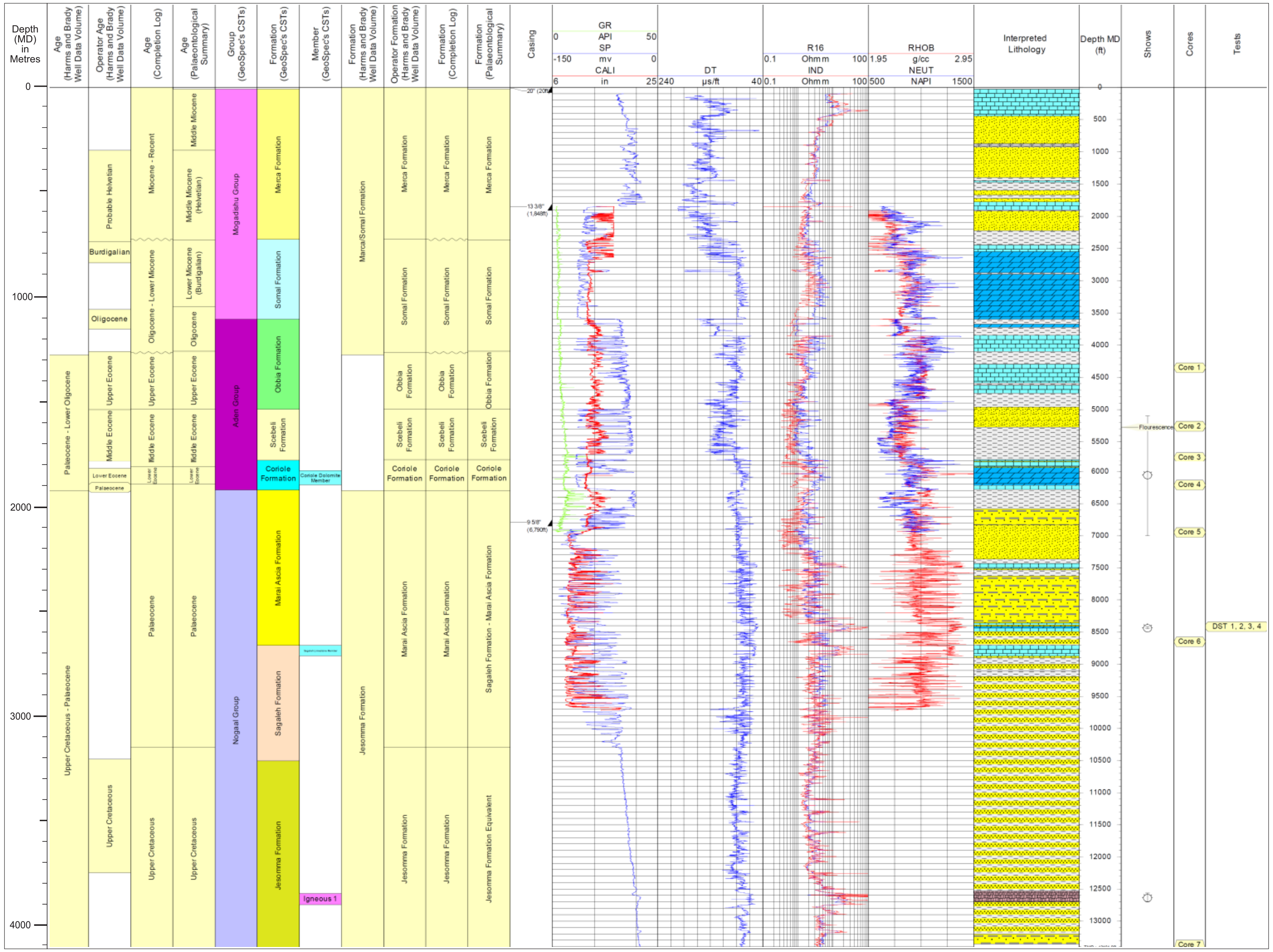
Uarsciek-1 was drilled onshore by Sinclair between November 1967 and March 1958 to a total depth of 4,103m (13,464 ft). The well was drilled on a northeast trending anticline with a reported areal closure of 200km^2. However the seismic data used to map this structure is not available and no more recent seismic data has been acquired in the vicinity of the well. Dipmeter readings and cores suggest that the well was drilled into the flank of the anticlinal structure.

Despite minor gas shows (C1) and fluorescence the well was plugged and abandoned as a dry hole. At TD the well reached the Upper Cretaceous Jesomma Formation. The location of Uarsciek-1 well is shown in Figure 7.1**.**

The Lithology of the Upper Cretaceous–Palaeocene (Jesomma, Sagleh & Marai Ascia Formations) consists of predominately sands with intercalations of basalt, clays, limestones and dolomites. Middle Miocene – Palaeocene (Coriole Formation & Merca Formation) contains thick units of clays, sands and limestones, dolomites. Whilst the Eocene Scebeli Formation was exposed as almost entirely of dolomite. The well summary Chart for Uarsciek-1 is shown in Figure 7.19.

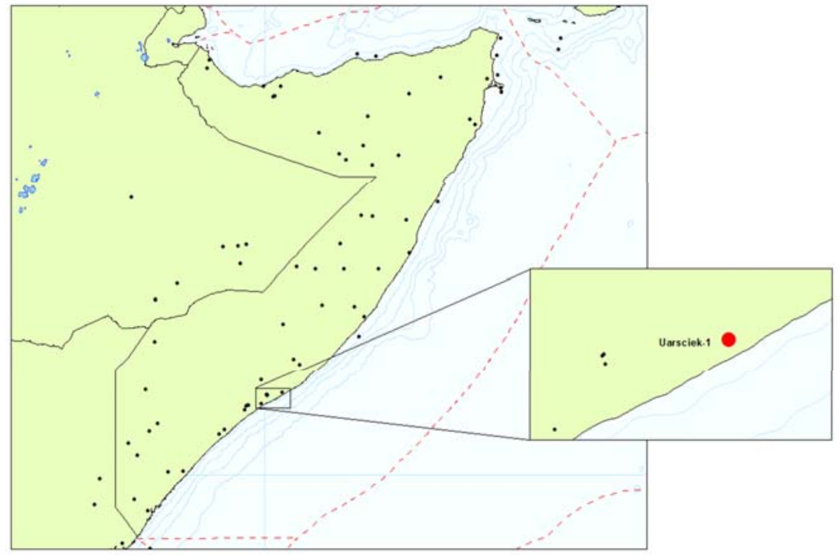
Four Drill Stem Tests (DST) were run between 2,550m-2,575m (8,367ft-8,450ft) within the Marai Ascia Formation. Minor gas and salt water were recovered between 2,565m-2,575m (8,417ft-8,450ft). A gas kick was also recorded in the basalts 3,830m- 3,871m (12,565ft-12,702ft) within the shale an-siltstone deposits of the Upper Cretaceous Jesomma Formation 3,202m-4,103m (10,505ft-13,464ft).

Minor gas was noted in the Middle Eocene-Palaeocene interval 1,554m-2,133m (5,100-7,000ft) with patchy blue fluorescent observed in the Scabeli Formation sands at 1,607m (5,275ft). No porosity or permeability data was available from petrophysical analysis of the Uarsciek-1 well.

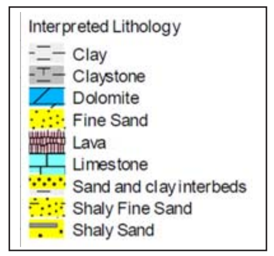


T.D. 4103m

Uarsciek-1



Uarsciek-1 was drilled onshore Somalia, and is located at 02° 10' 10" N, 45° 28' 41" E



7.2 Seismic Examples

The following section contains examples of seismic data within Subarea 3 (Figure 7.21 to Figure 7.43).

The locations of these seismic lines are shown in Figure 7.20 below.

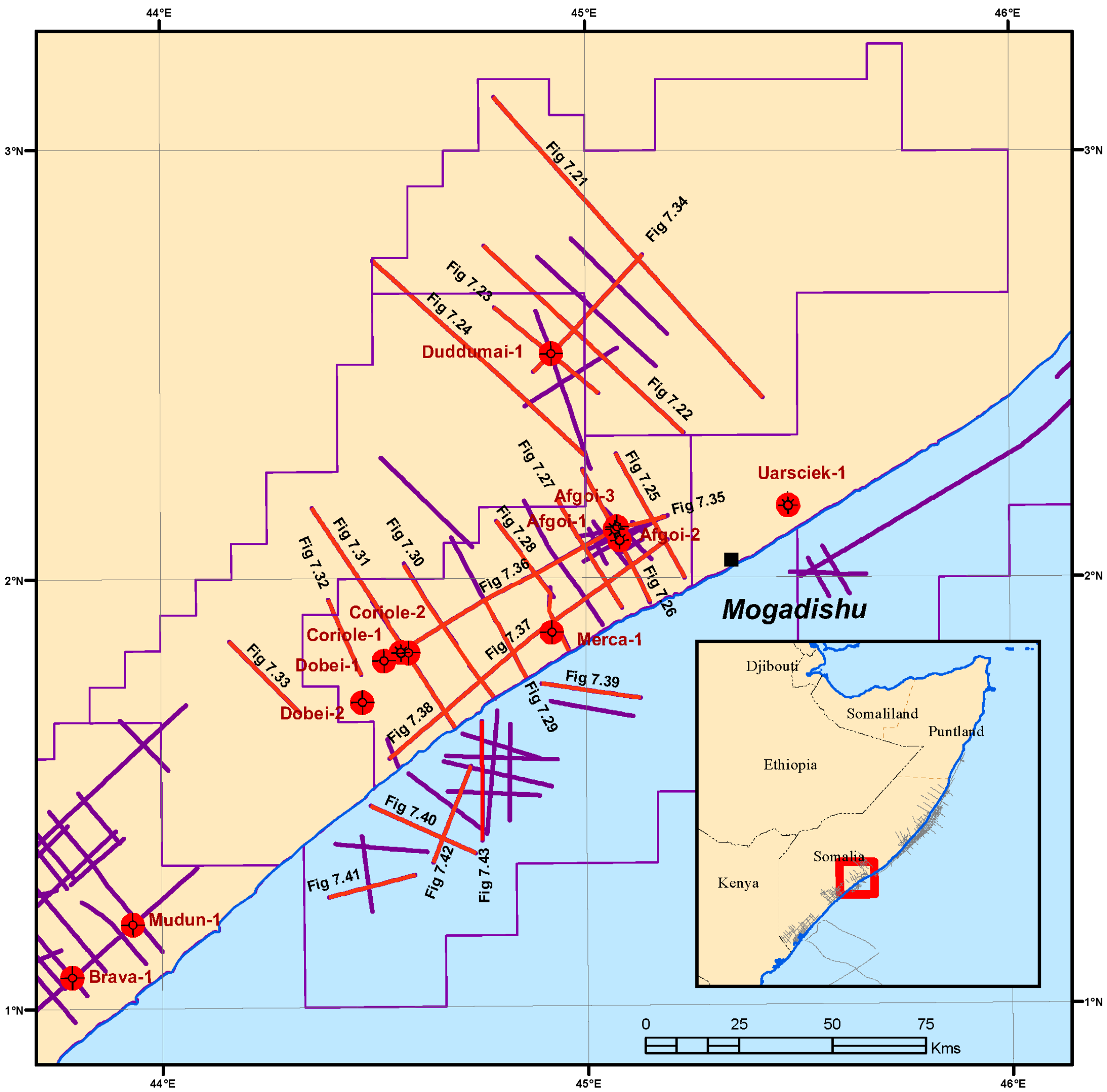


Figure 7.20: Subarea 3 Location of Seismic Displays

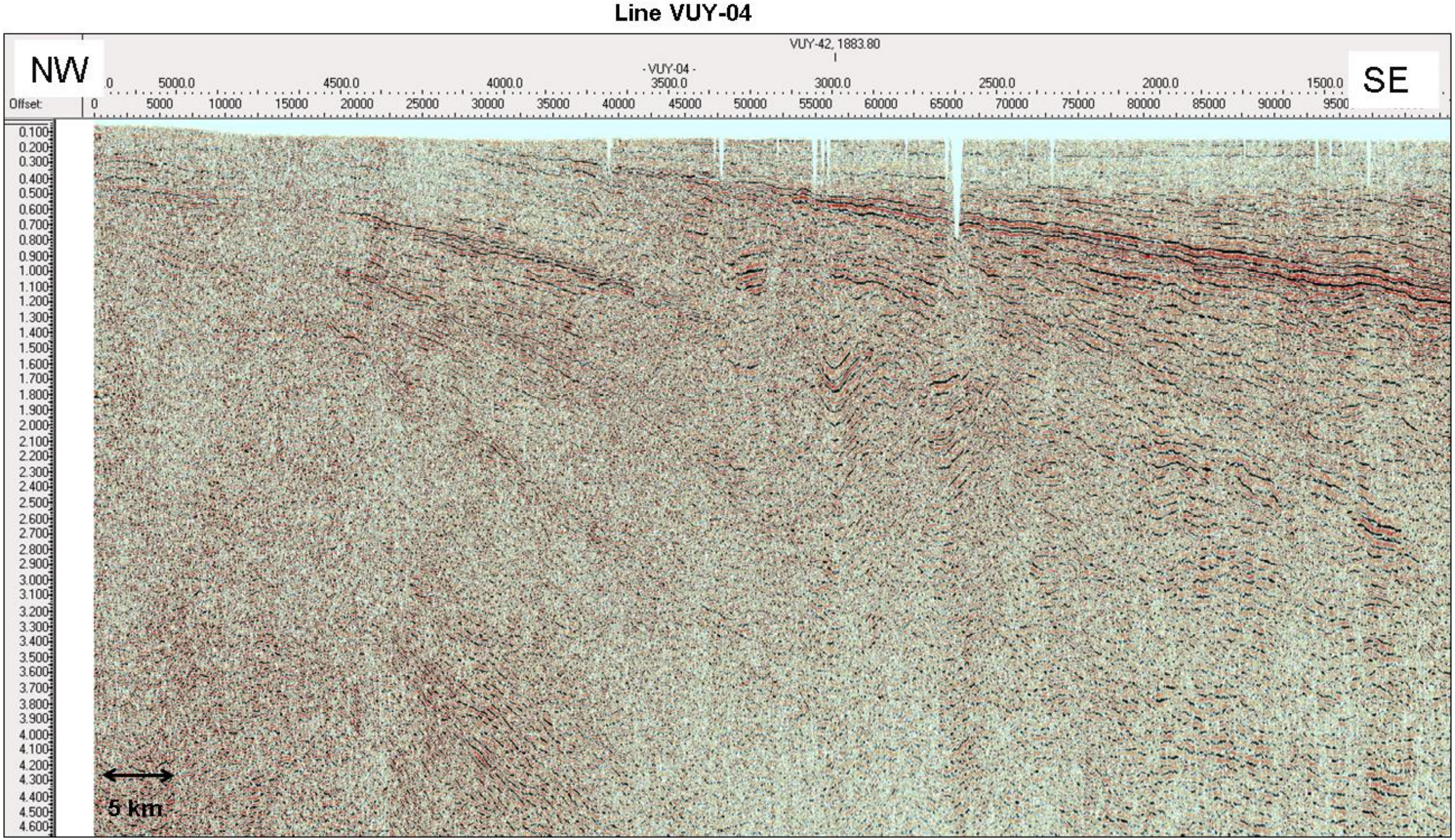


Figure 7.21: Seismic Line VUY-04

Line VUY-06

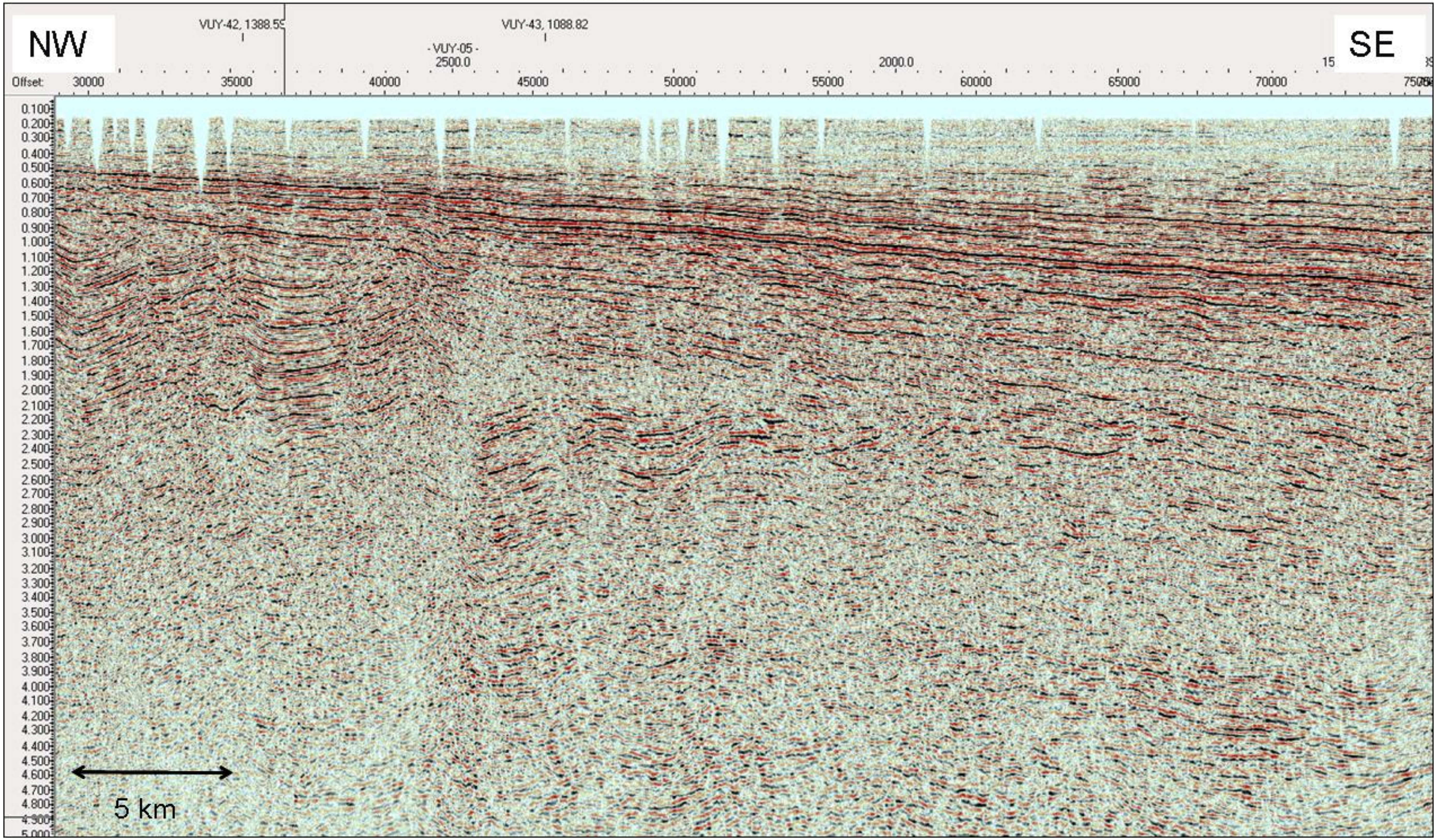


Figure 7.22: Seismic Line VUY-06

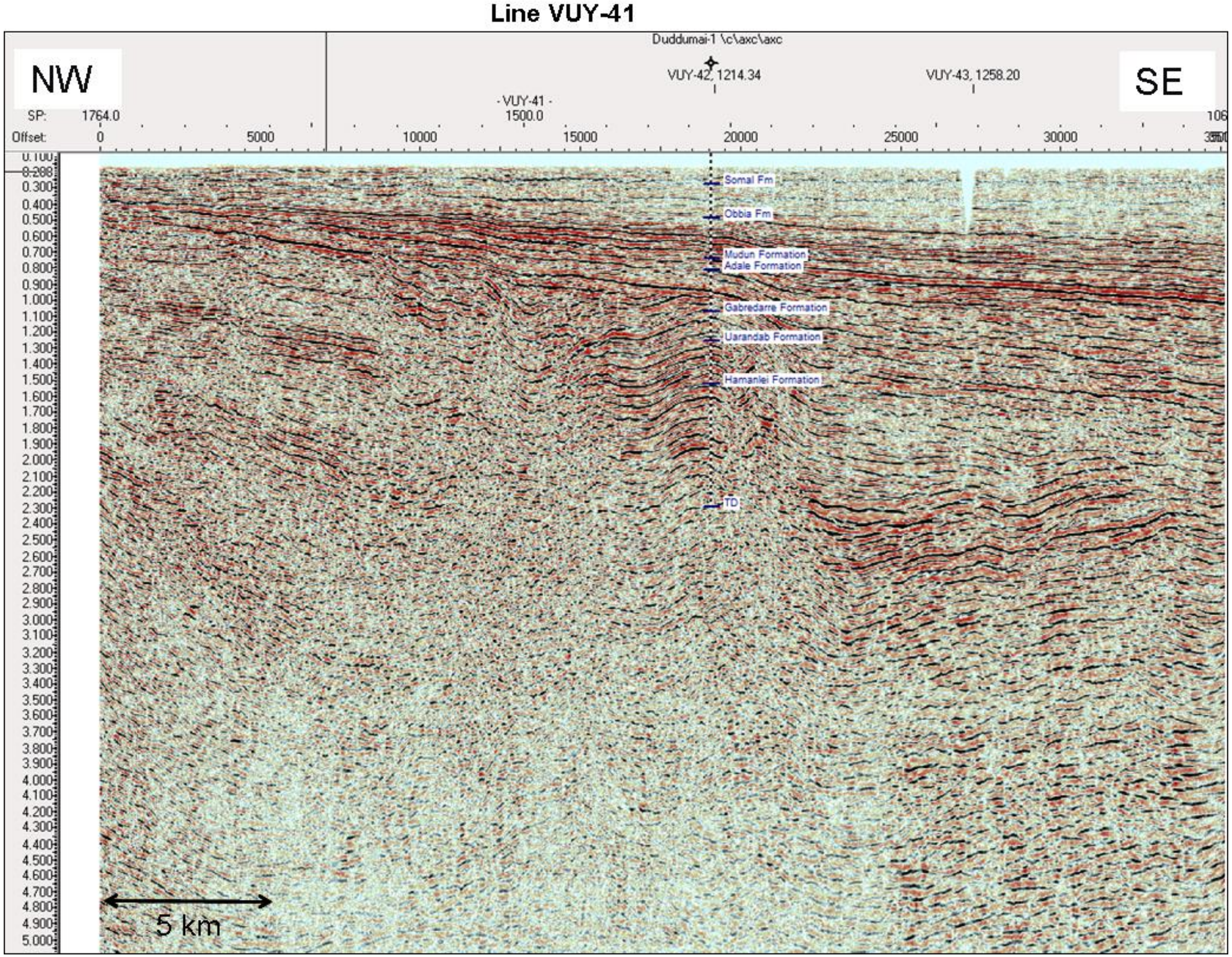


Figure 7.23: Duddumai-1 Seismic Line VUY-41

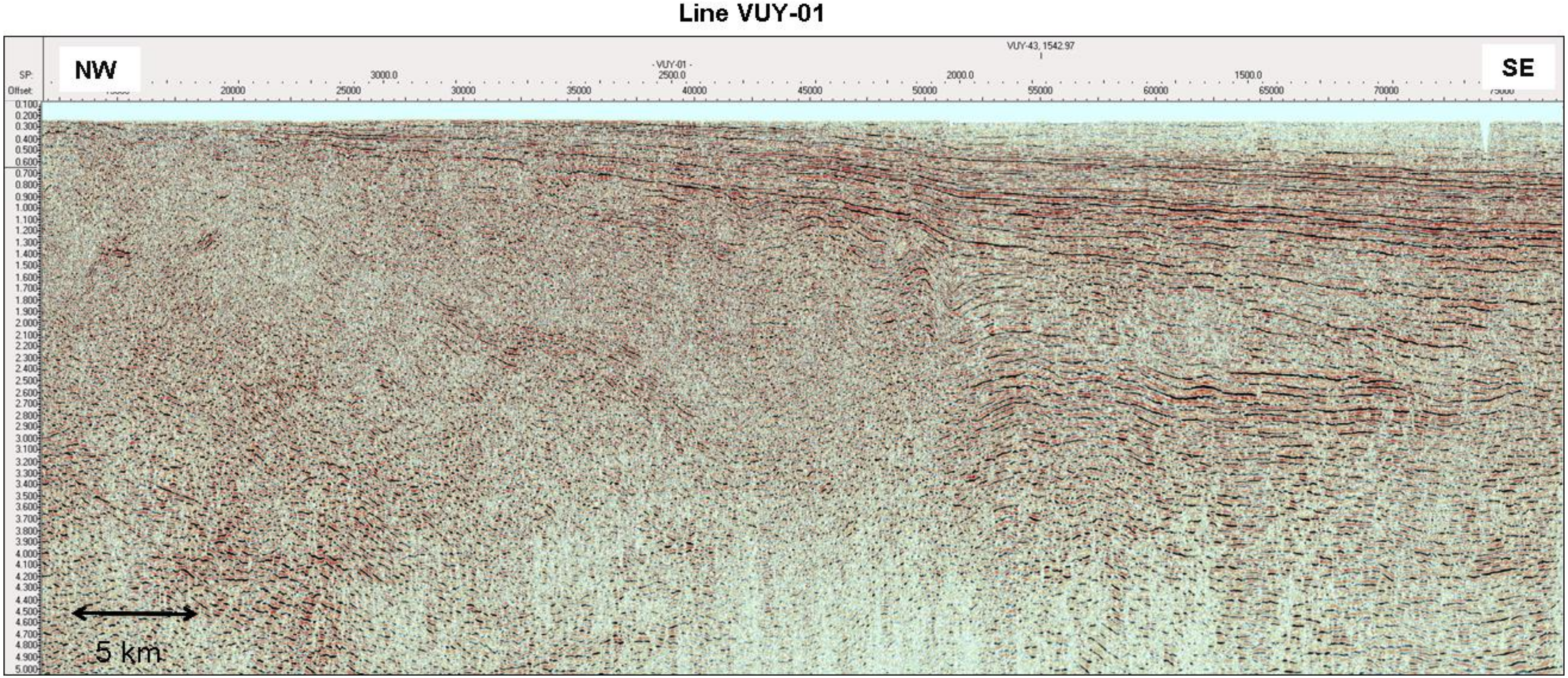


Figure 7.24: Seismic Line VUY-01

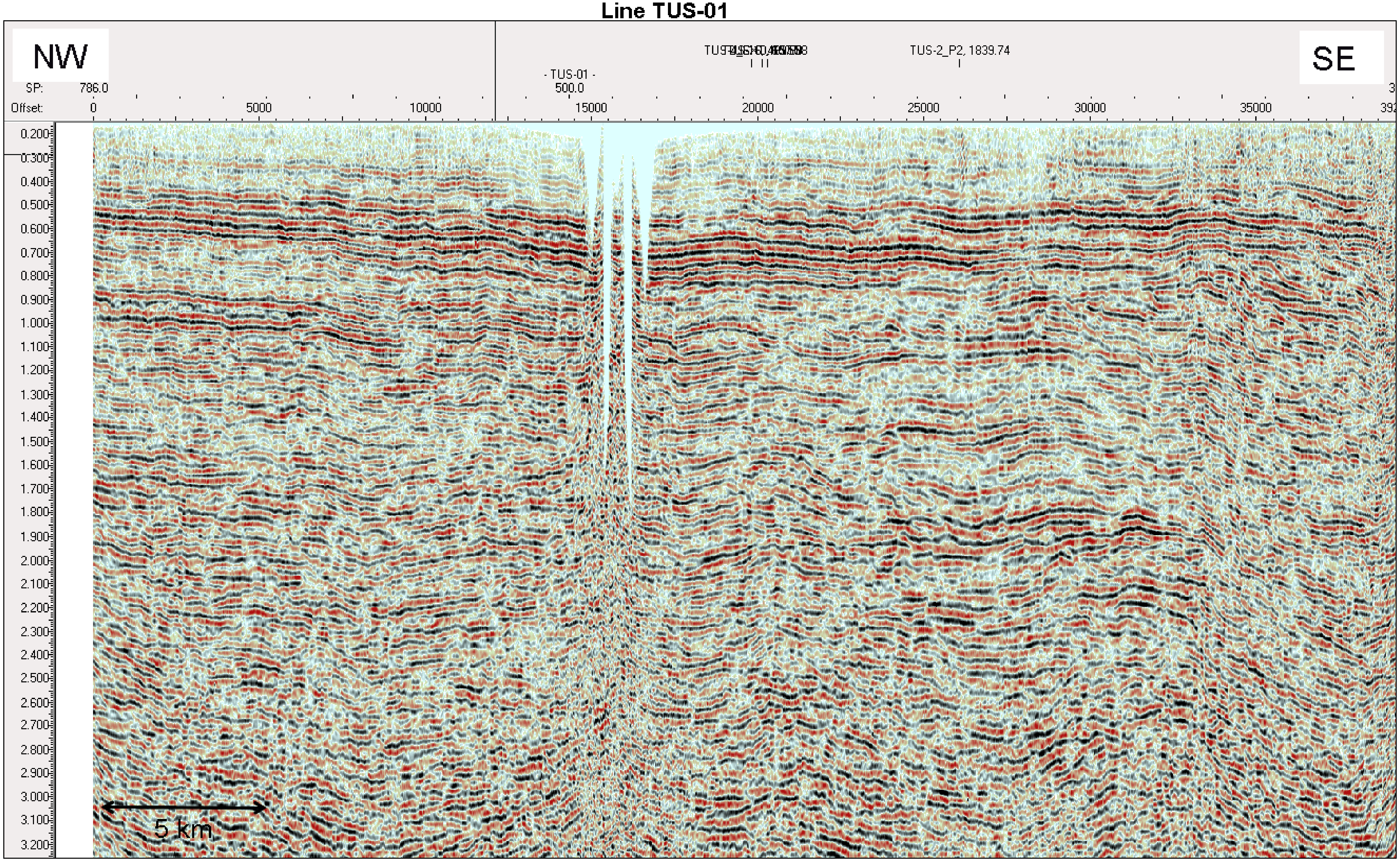


Figure 7.25: Seismic Line TUS-01

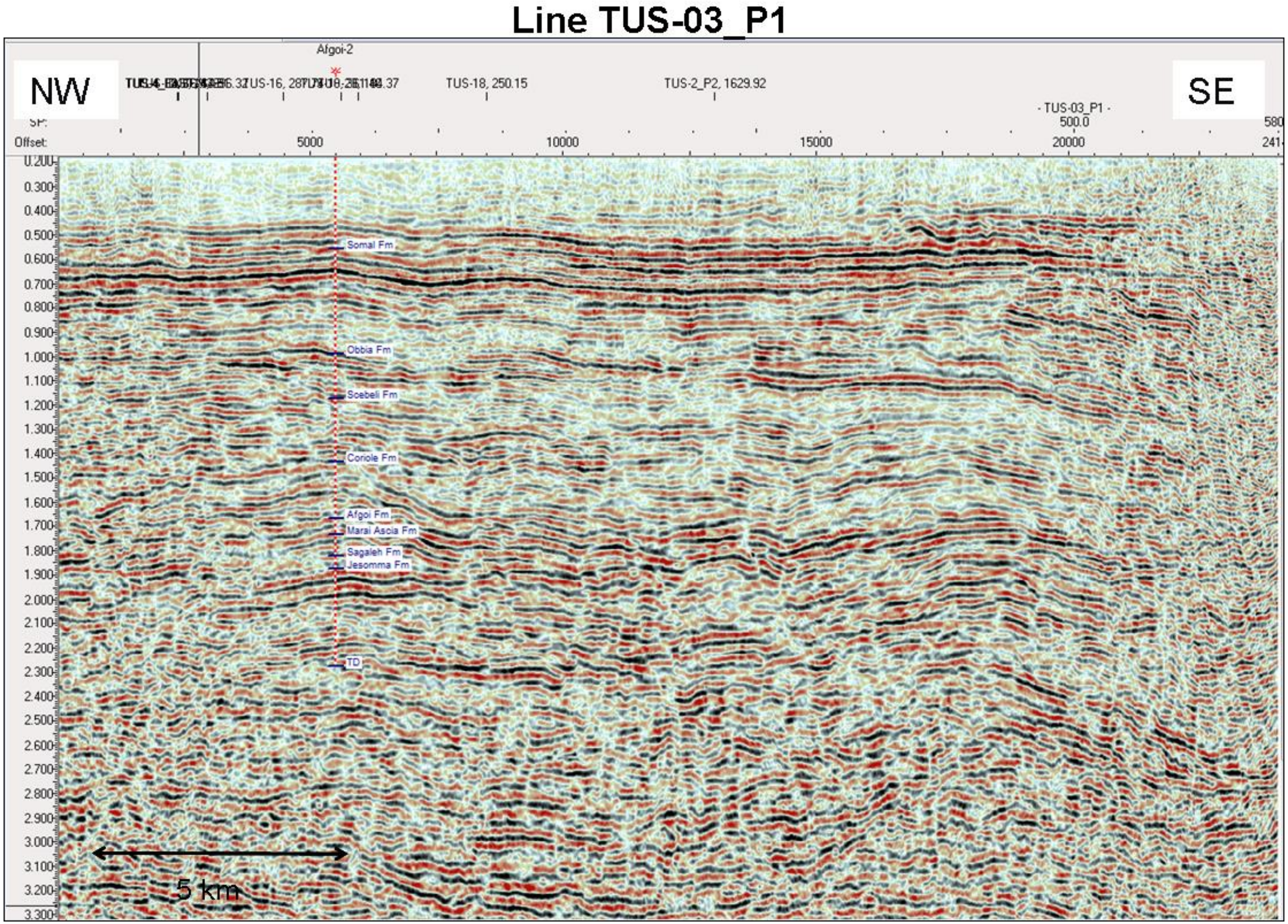


Figure 7.26: Afgoi-2 Seismic Line TUS-03_P1

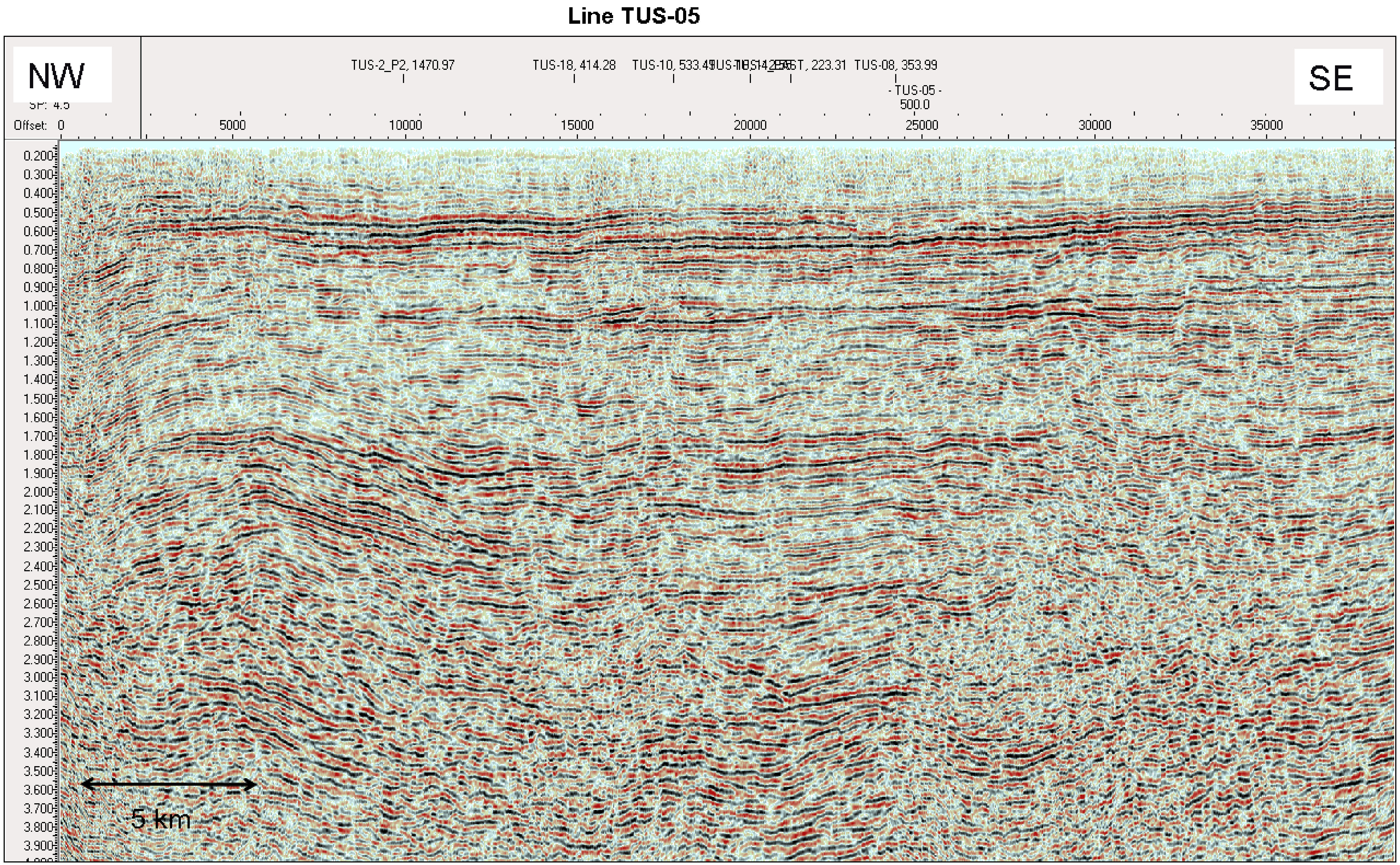


Figure 7.27: Seismic Line TUS-05

Line TUS-09C_P2

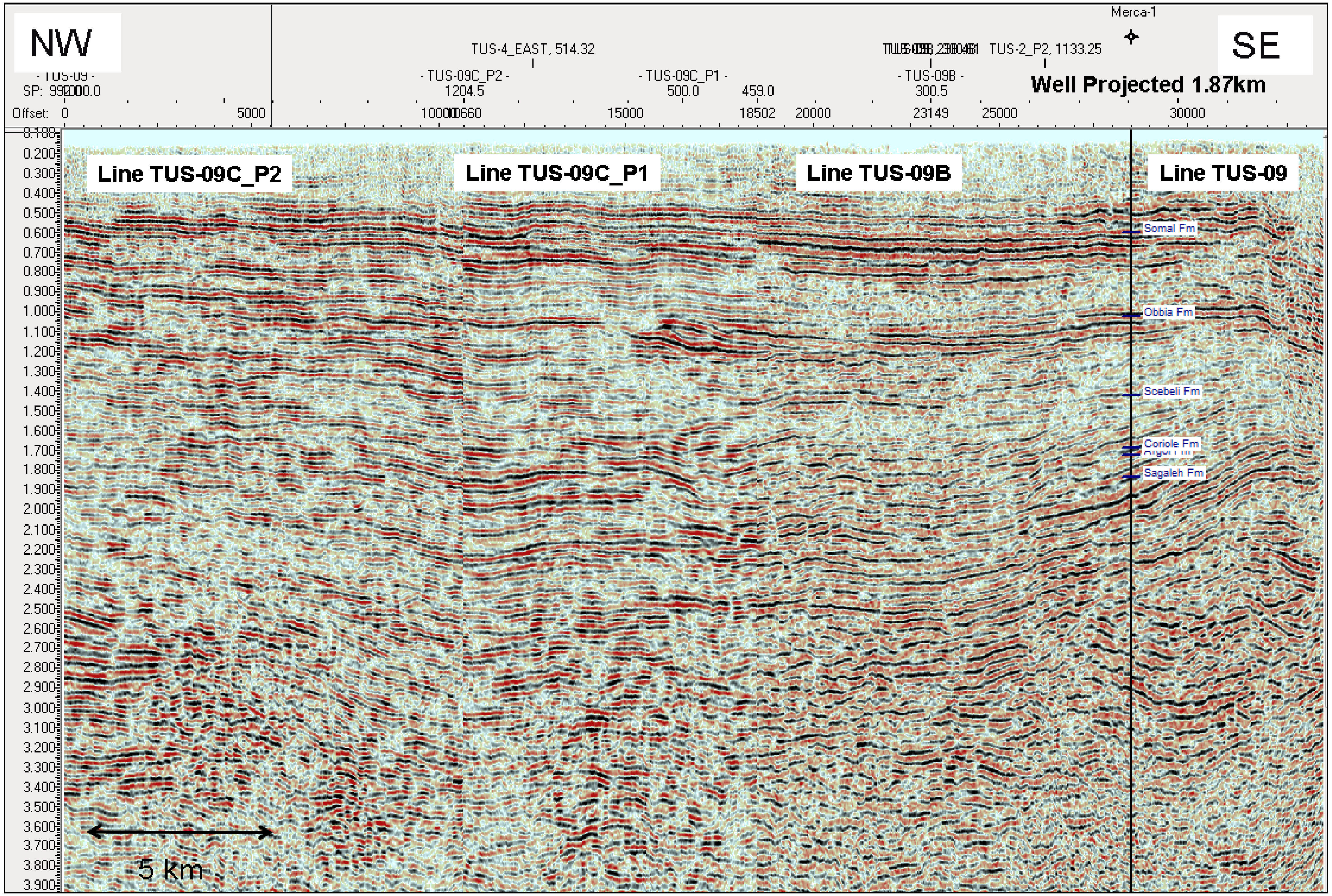


Figure 7.28: Seismic Line TUS-09C_P2, TUS-09C_P1, TUS-09B & TUS-09

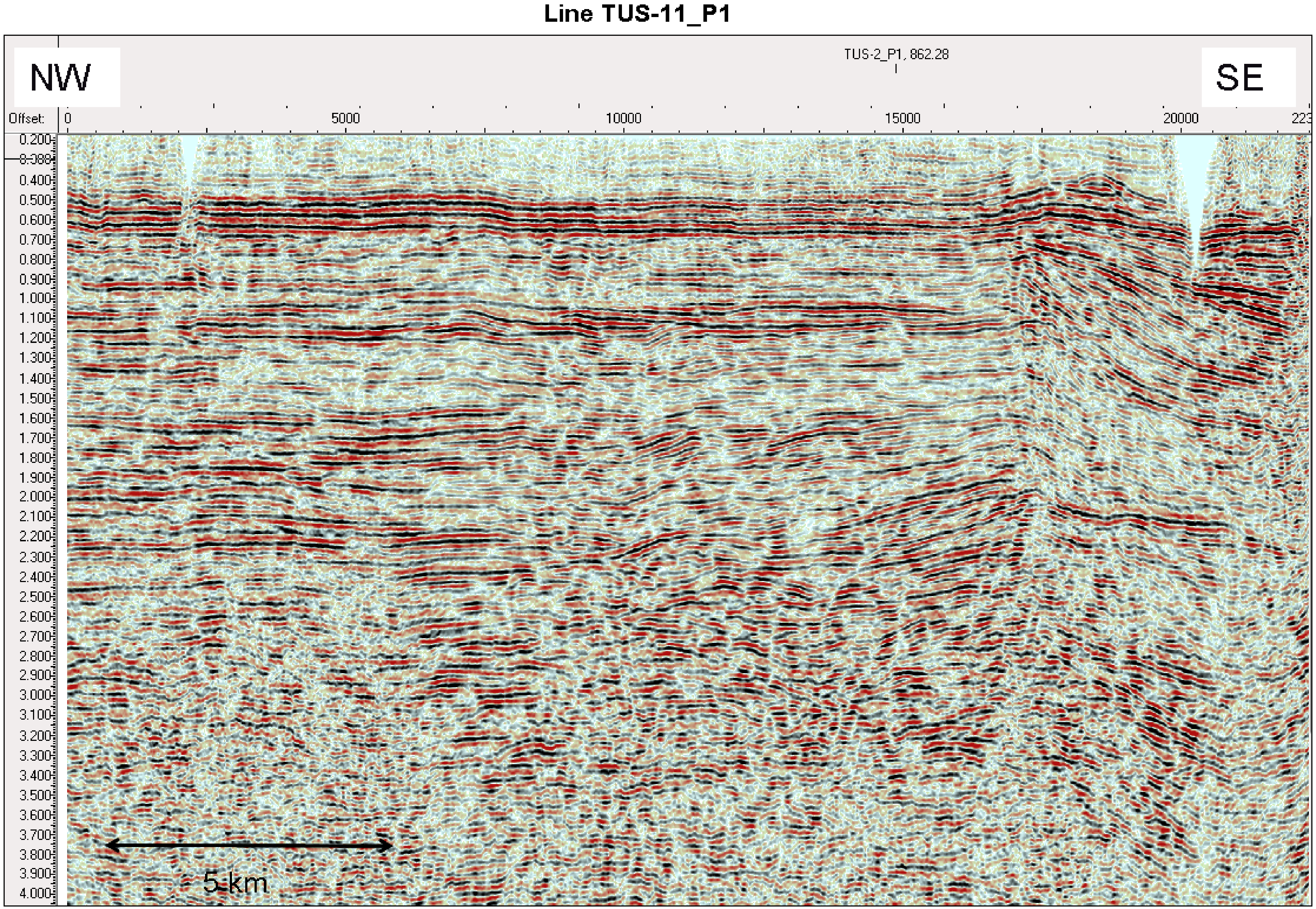


Figure 7.29: Seismic Line TUS-11_P1

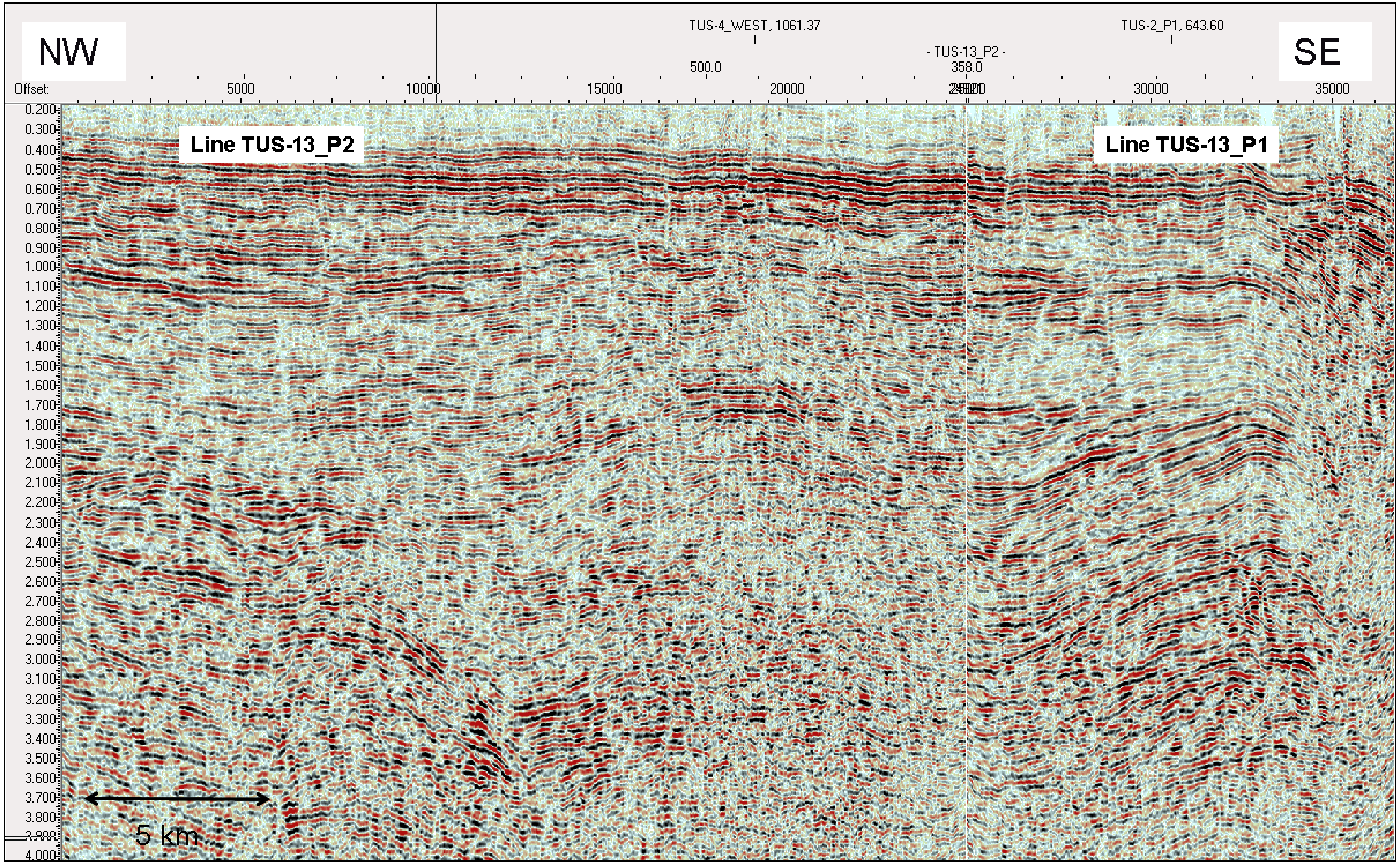


Figure 7.30: Seismic Line TUS-13_P2 and Line TU-13_P1

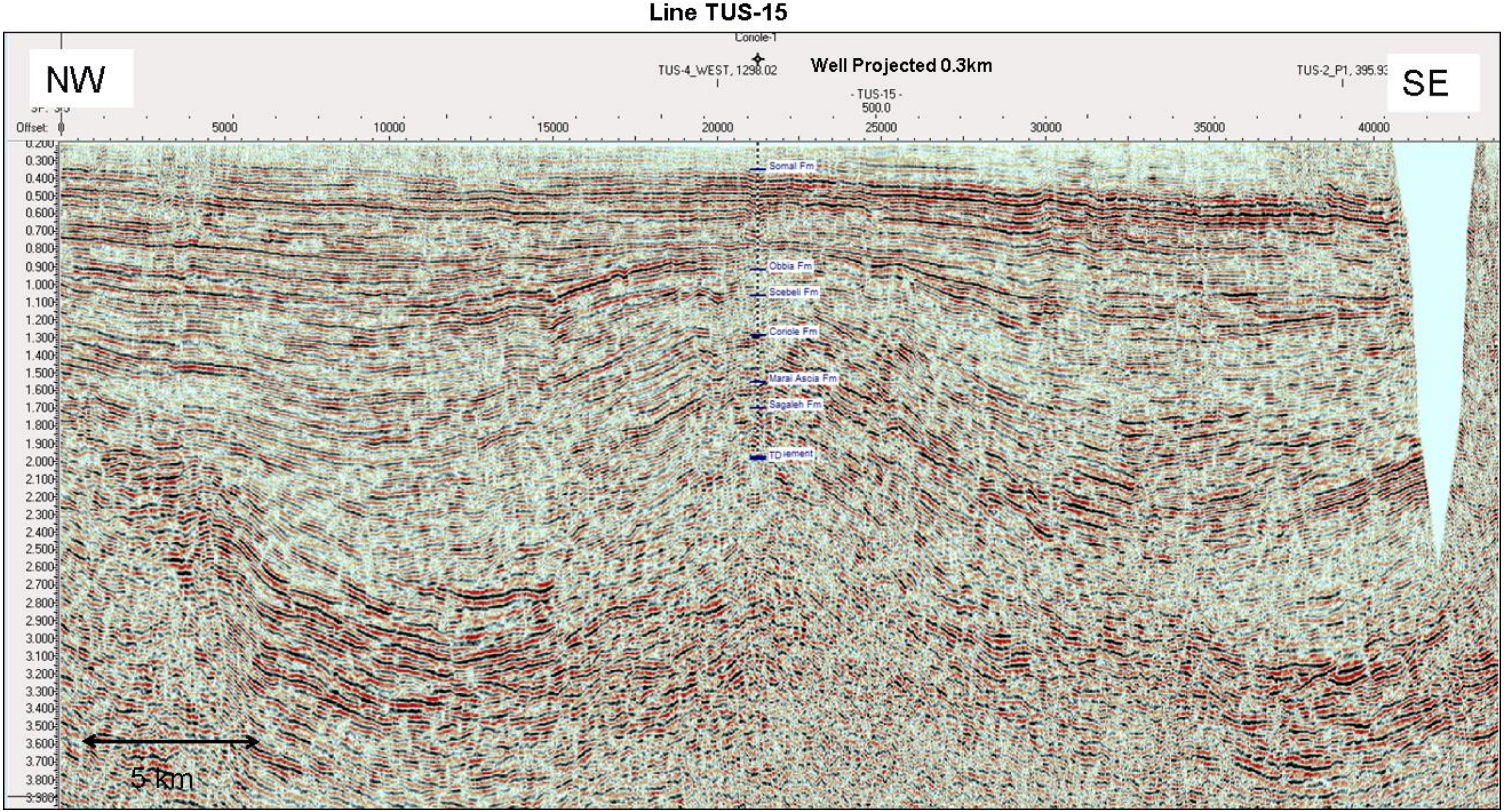


Figure 7.31: Seismic Line TUS-15

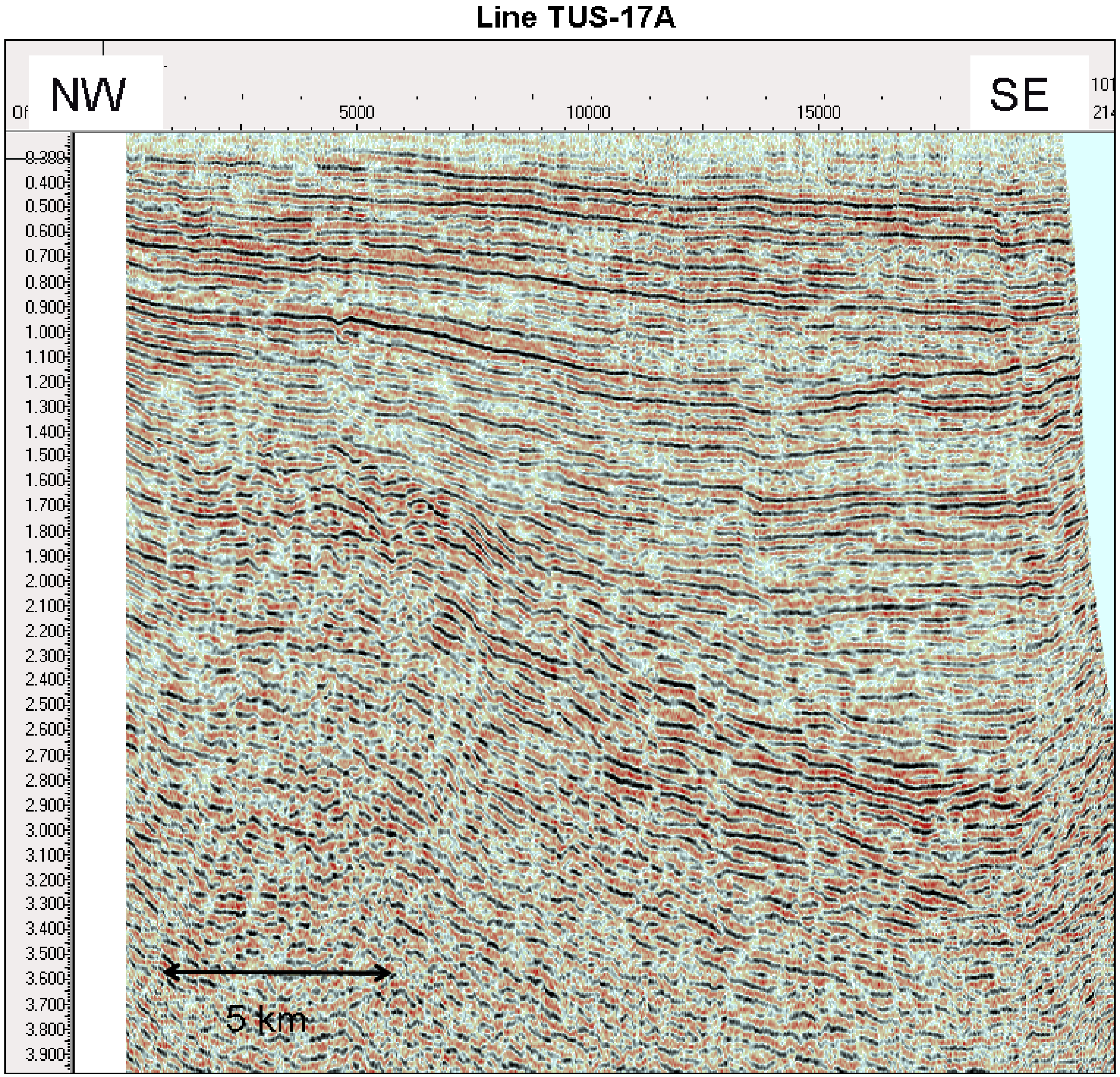


Figure 7.32: Seismic Line TUS-17A

Line VUY-10

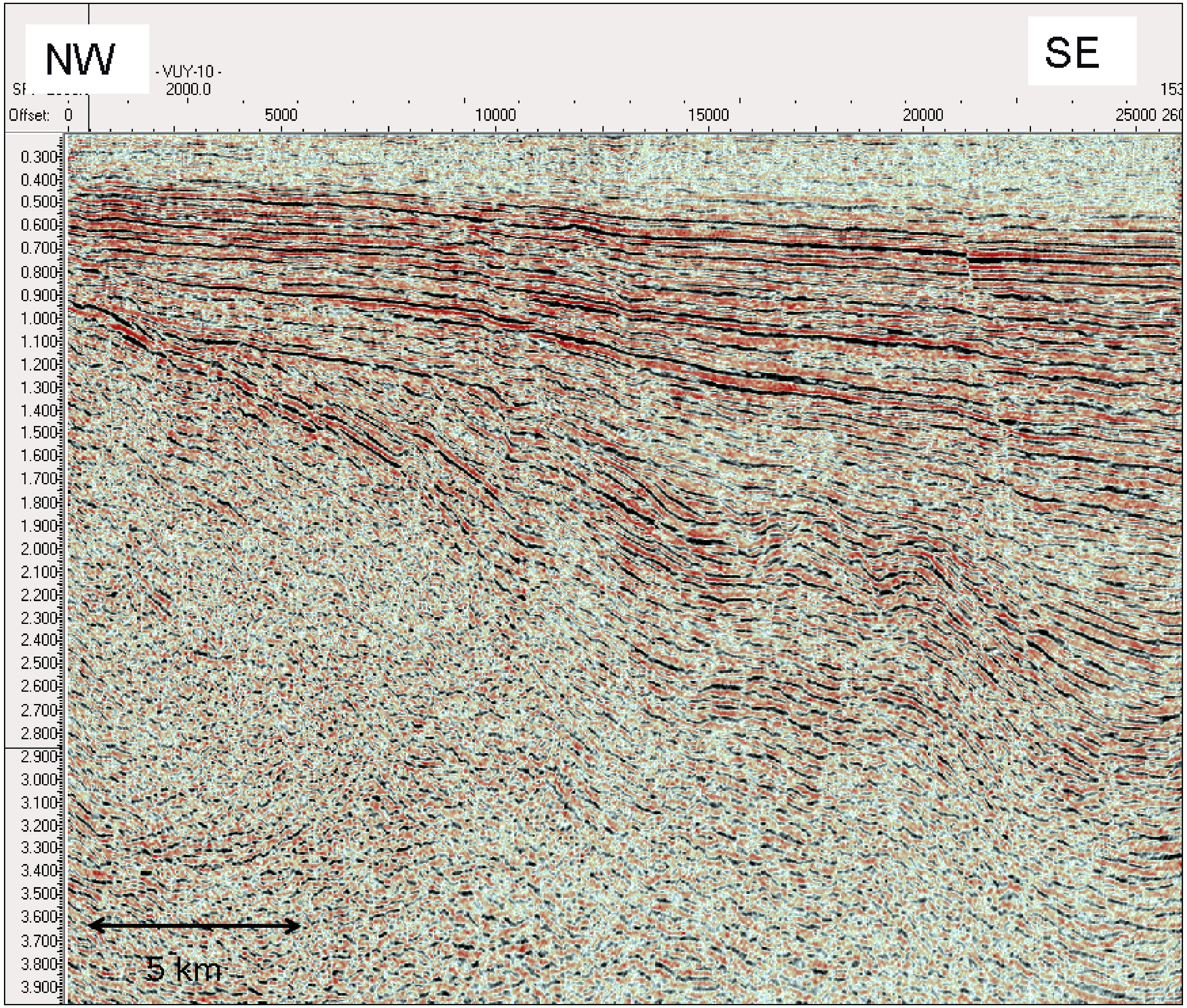


Figure 7.33: Seismic Line VUY-10

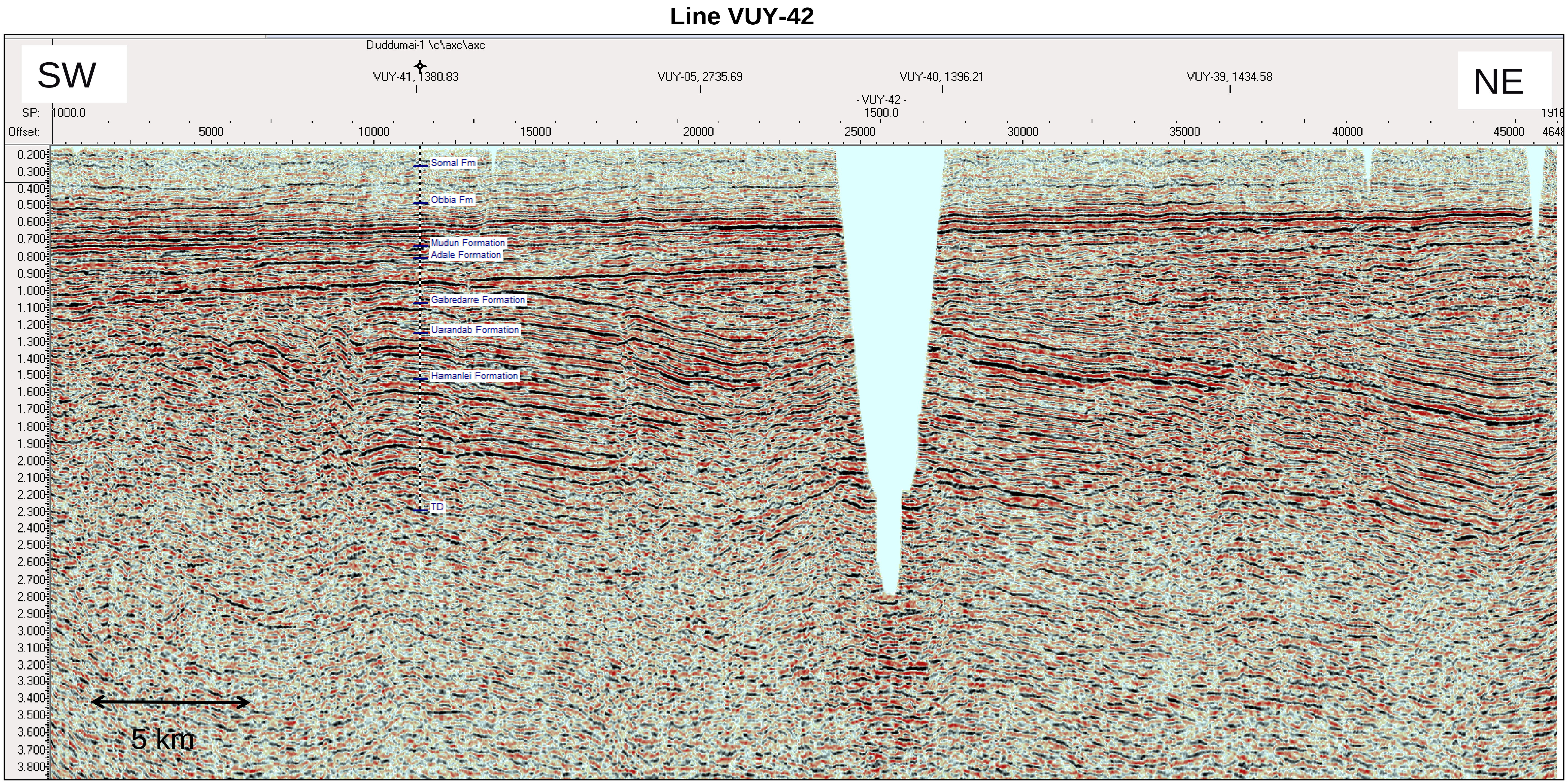


Figure 7.34: Duddumai Seismic Line VUY-42

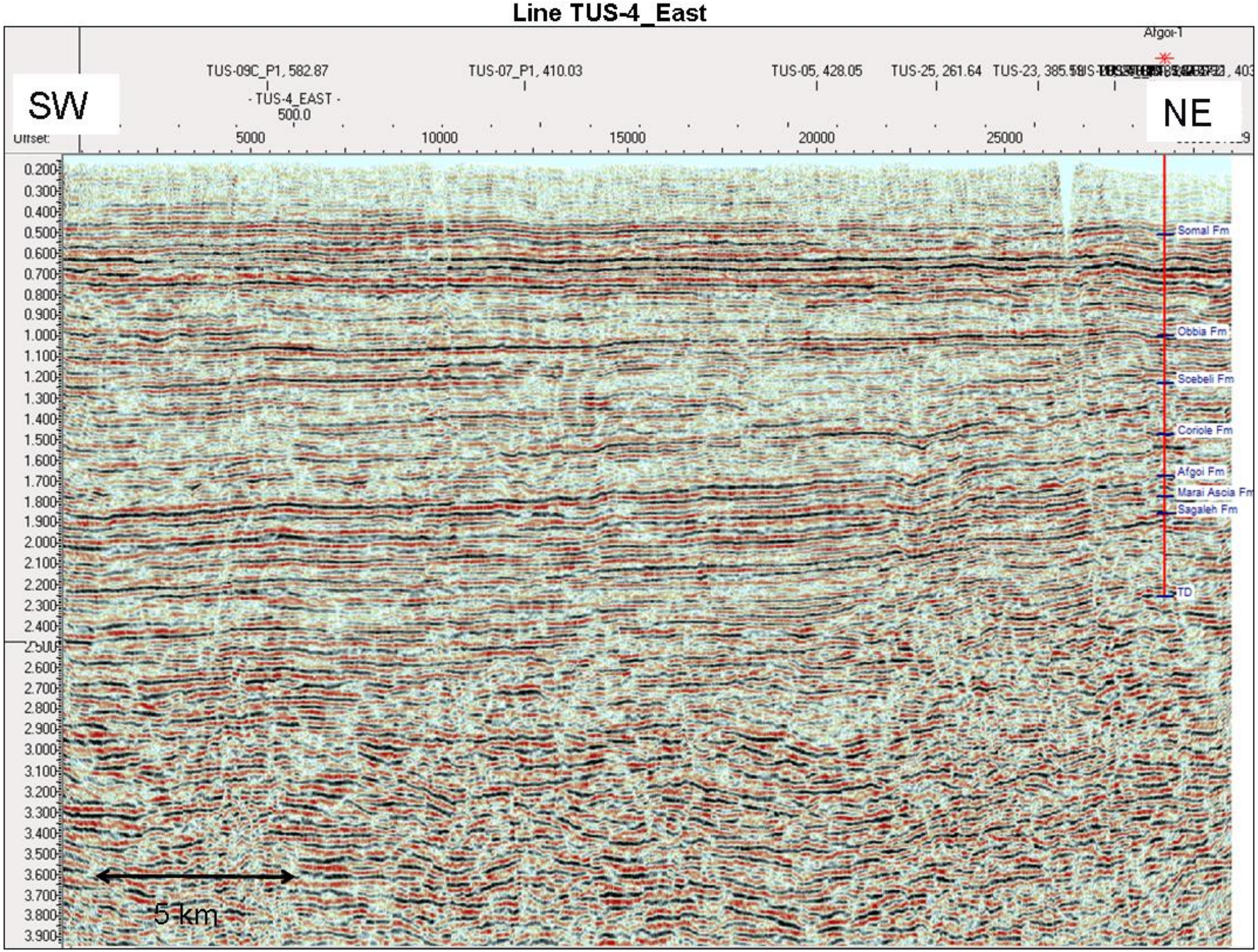


Figure 7.35: Afgoi-1 Seismic Line TUS-4_East

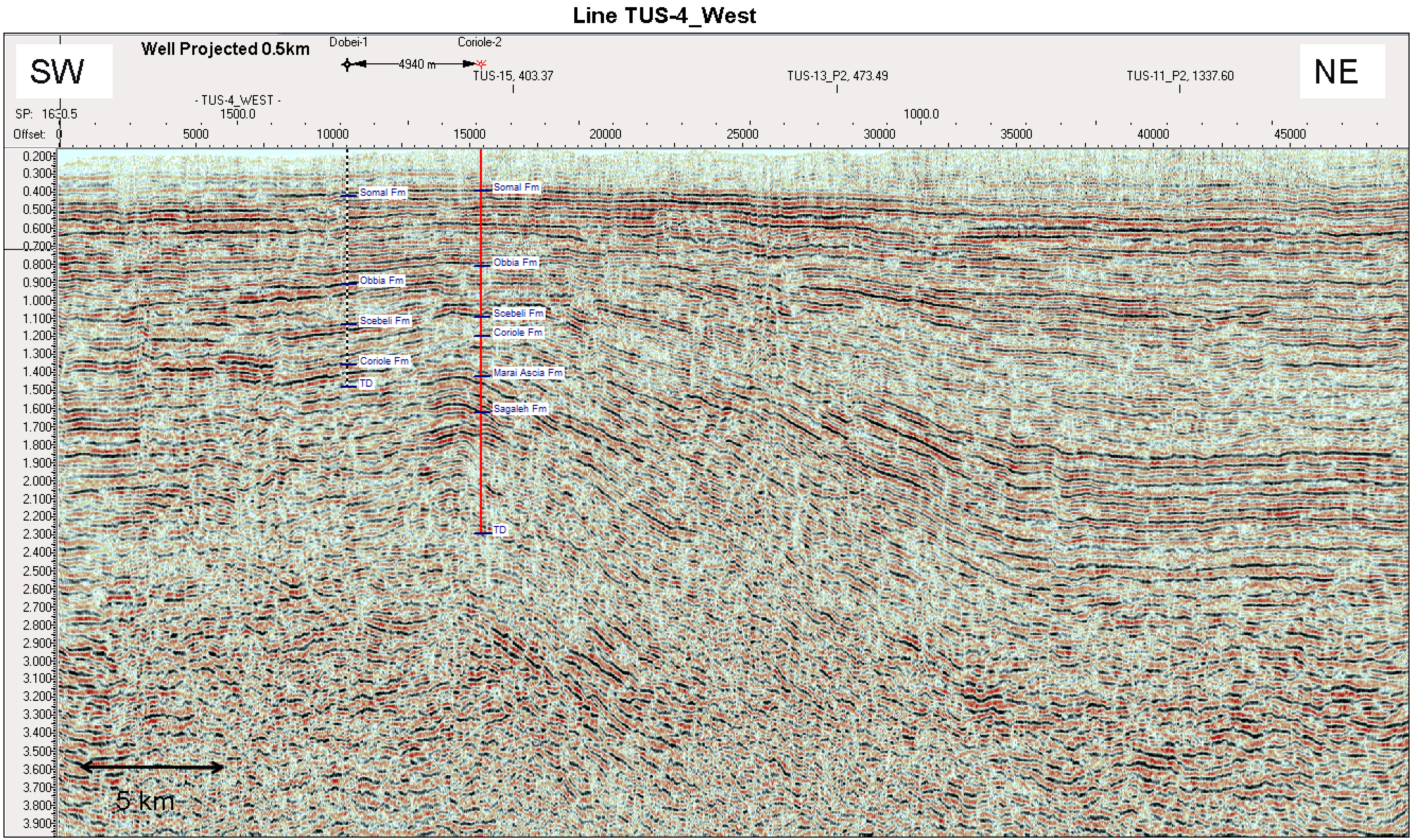


Figure 7.36: Coriole-1 & Dobei-1 Seismic Line TUS-4_East

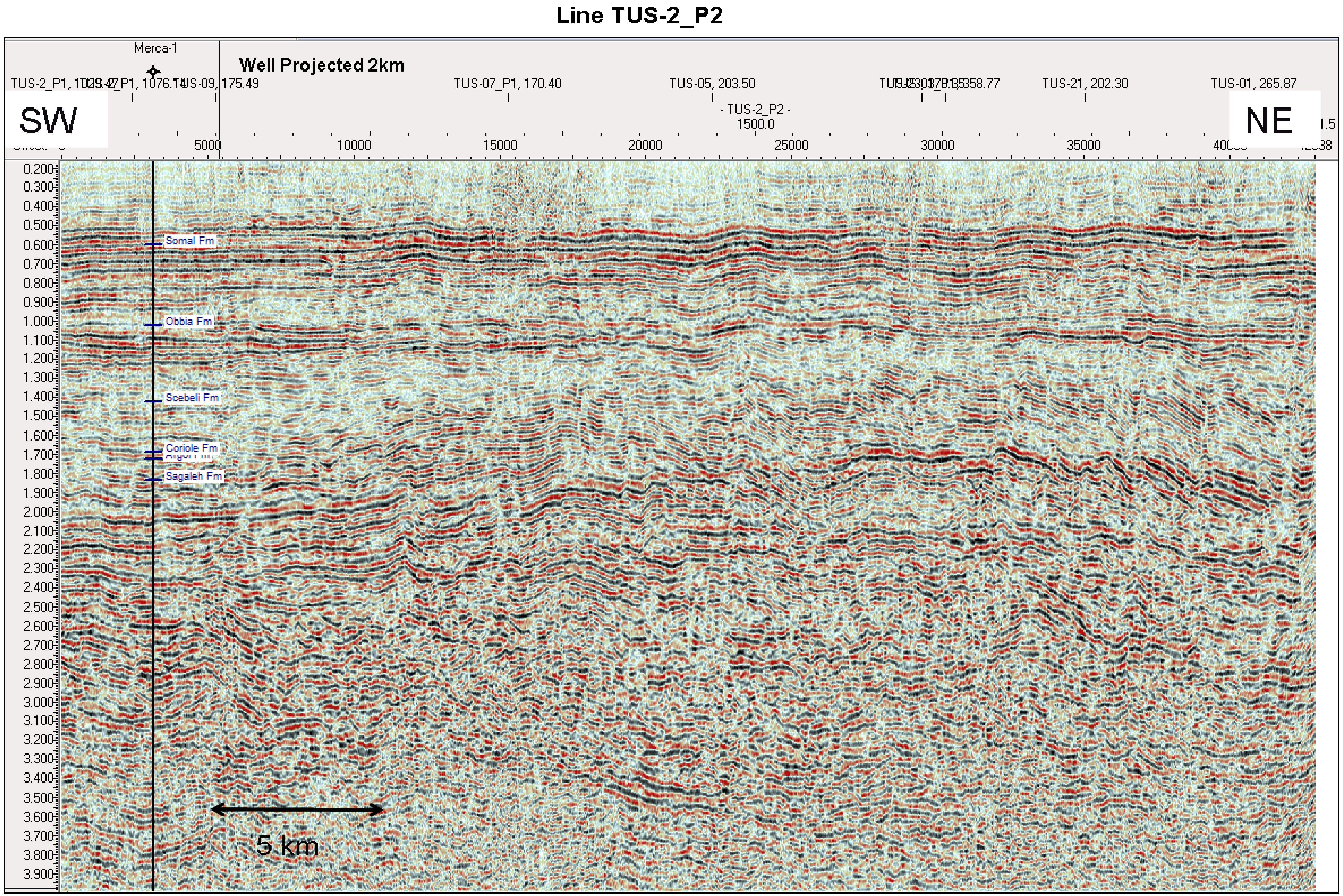


Figure 7.37: Merca-1 Seismic Line TUS-2_P2

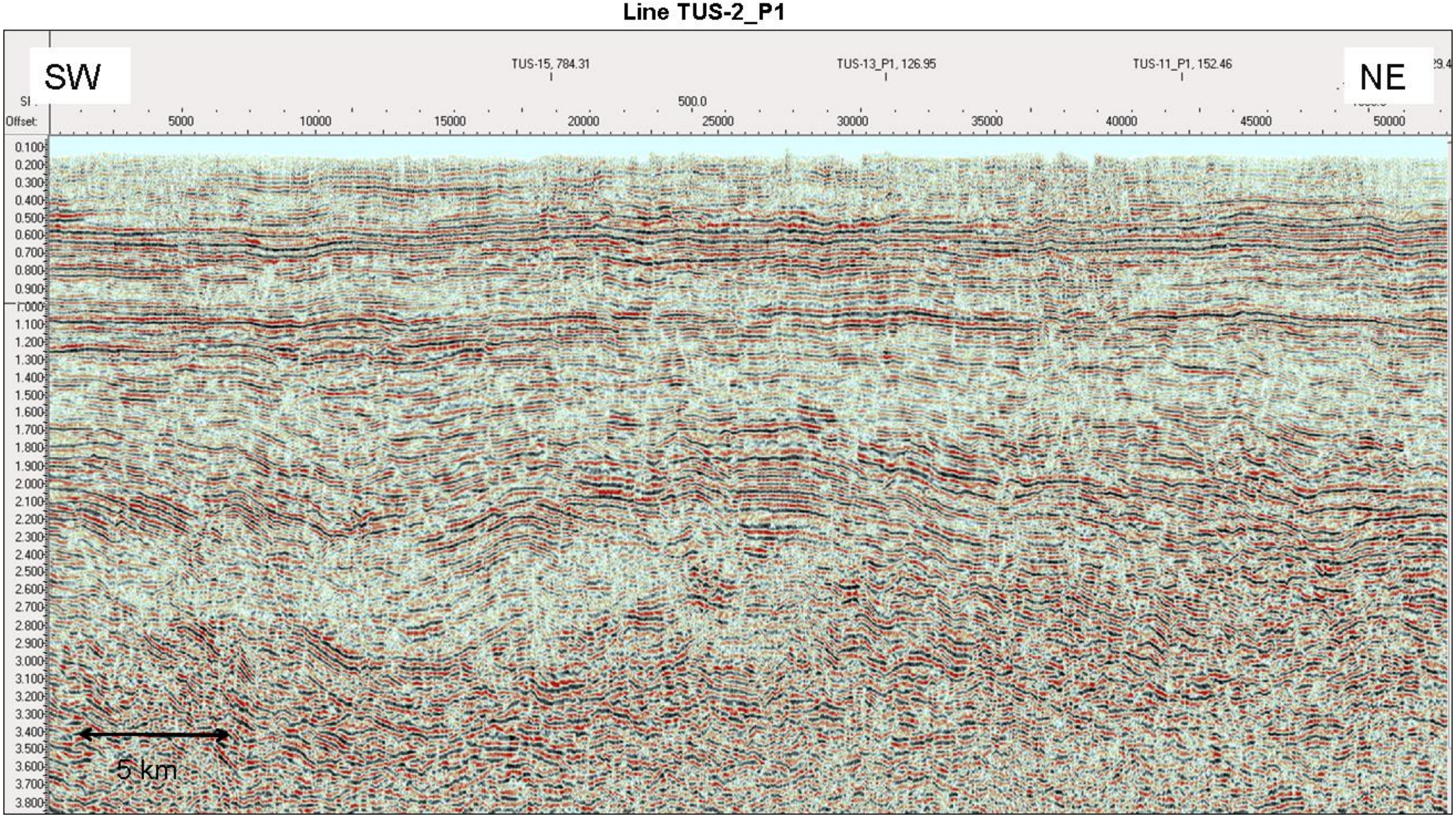


Figure 7.38: Seismic Line TUS-2_P1

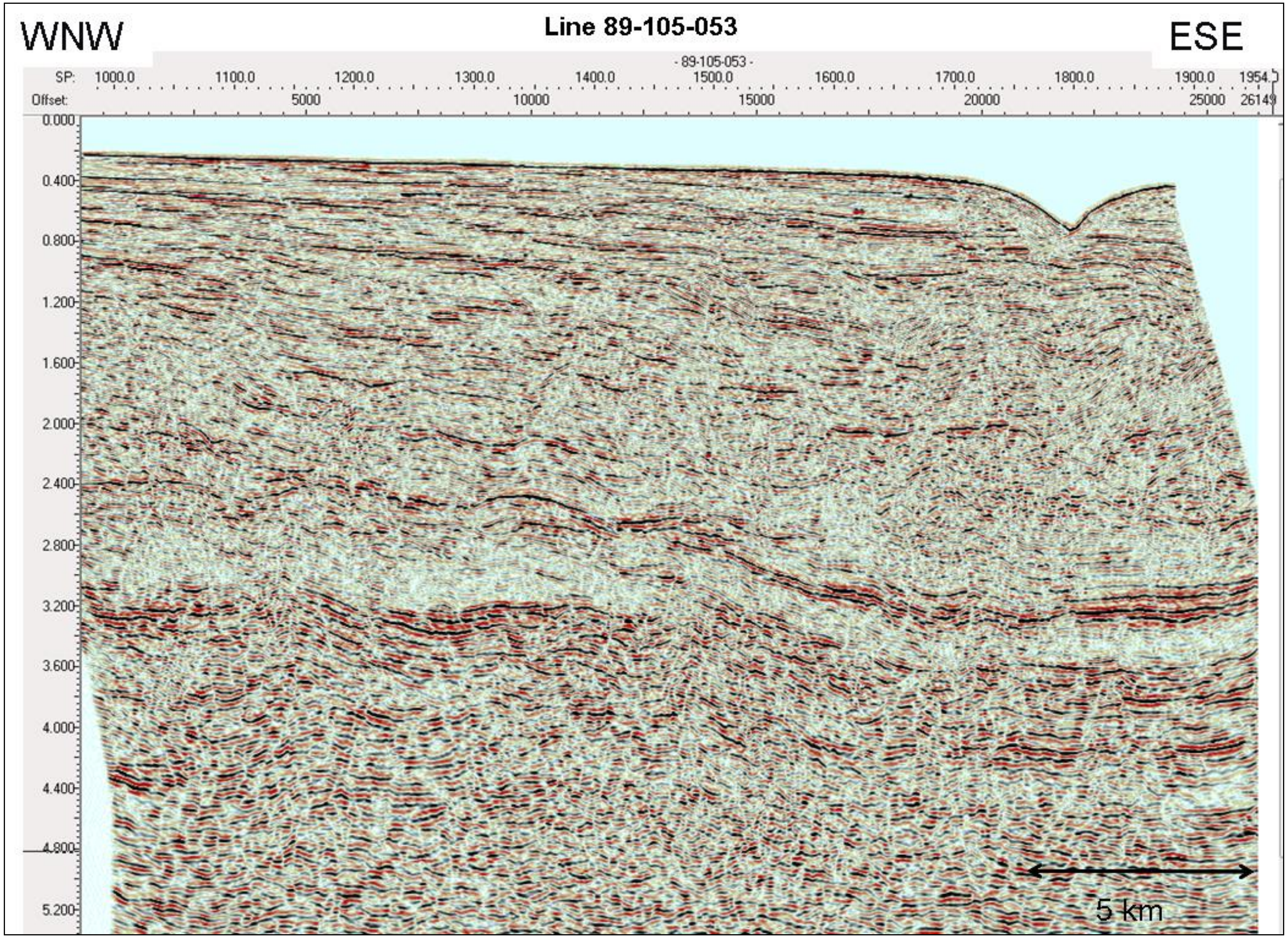


Figure 7.39: Seismic Line 89-105-053

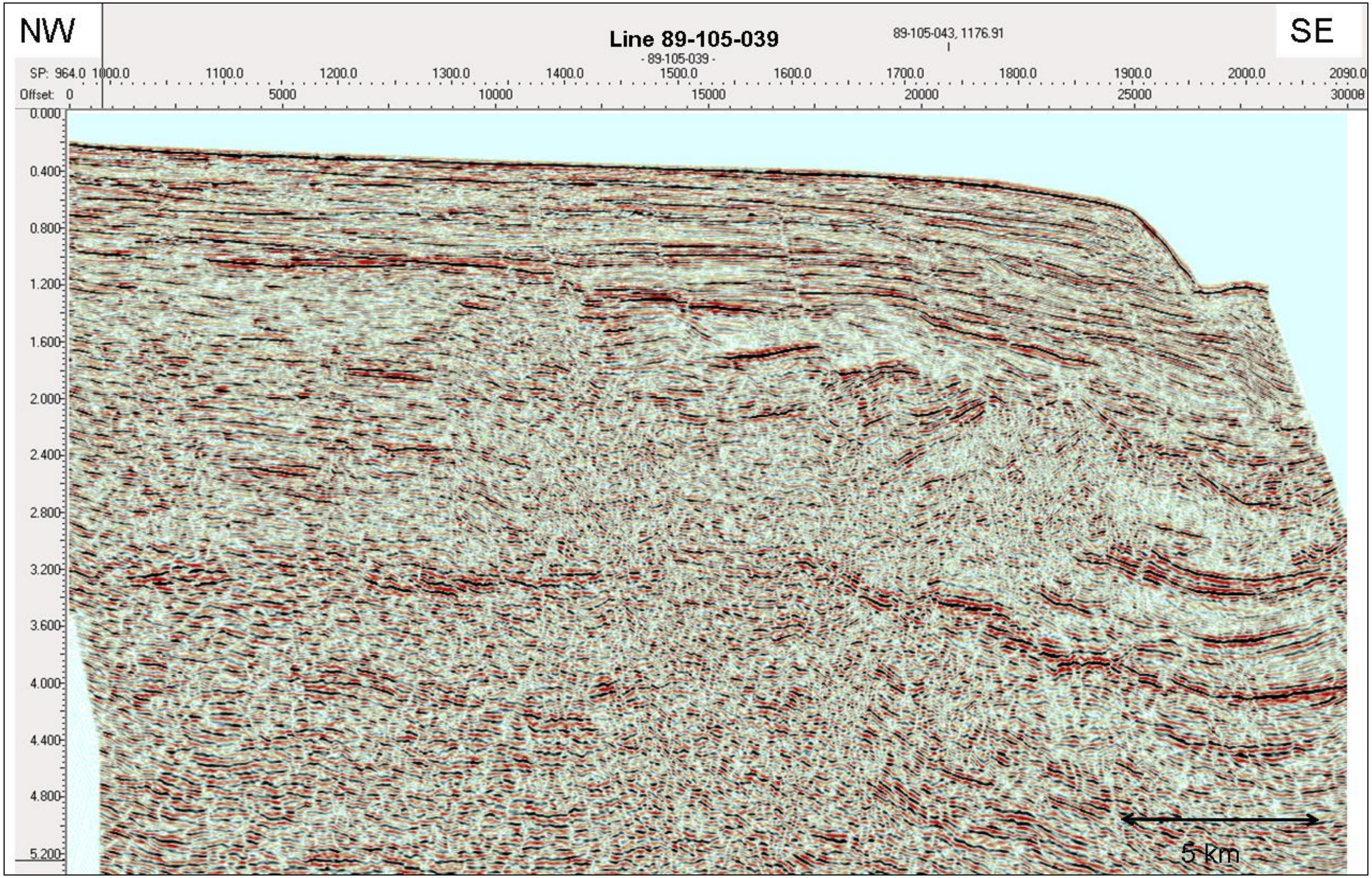


Figure 7.40: Seismic Line 89-105-039

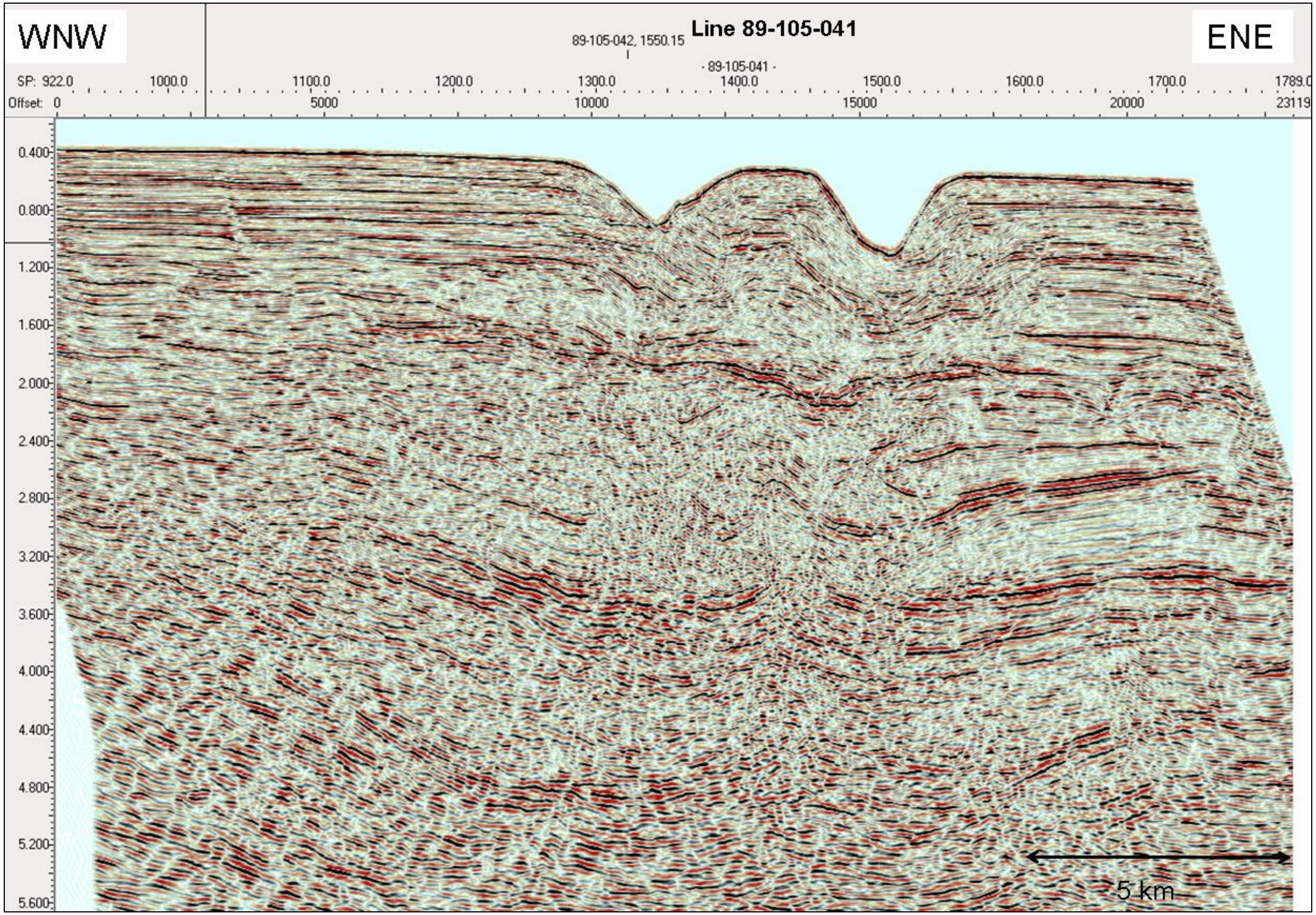


Figure 7.41: Seismic Line 89-105-041

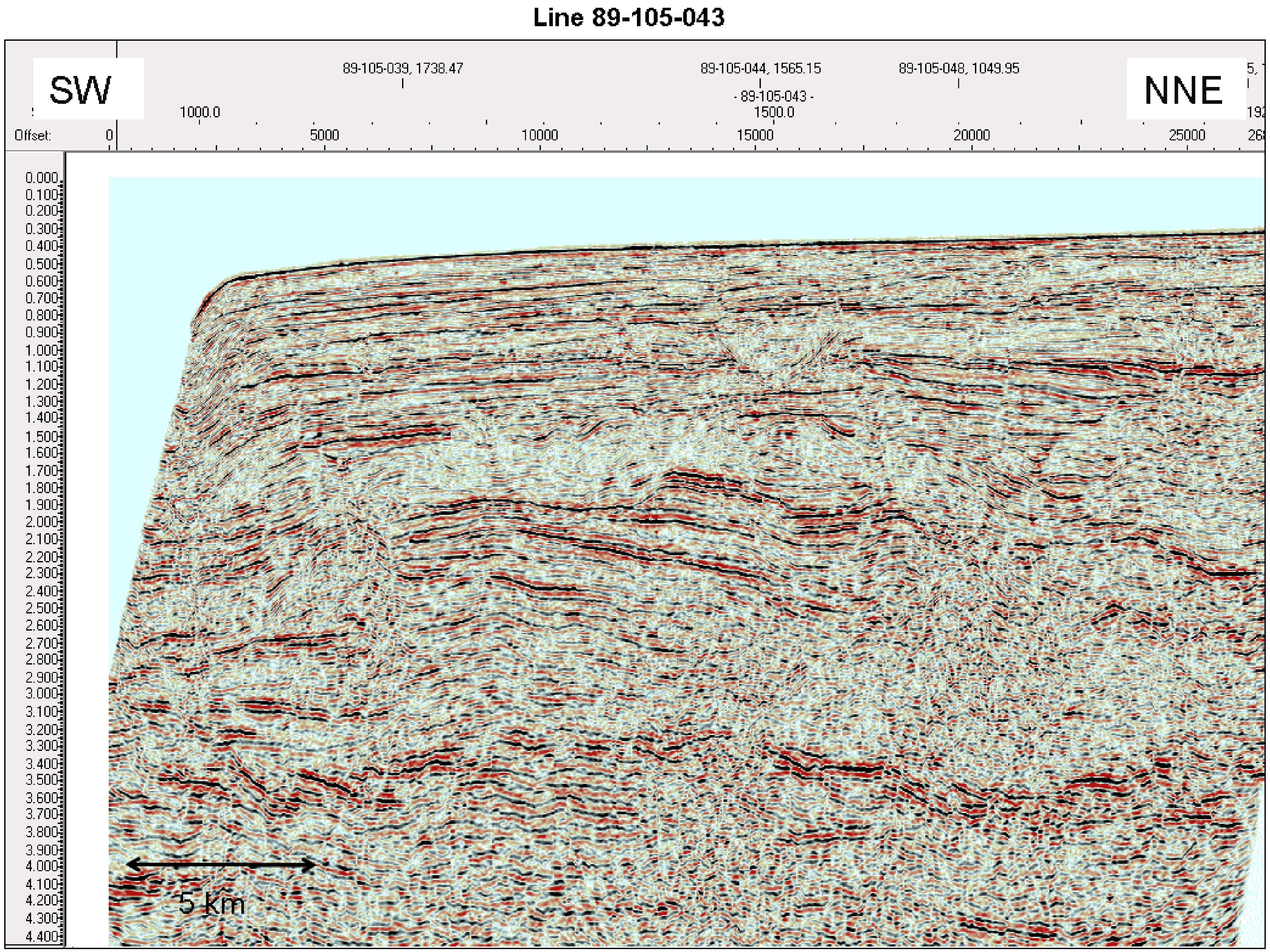


Figure 7.42: Seismic Line 89-105-043

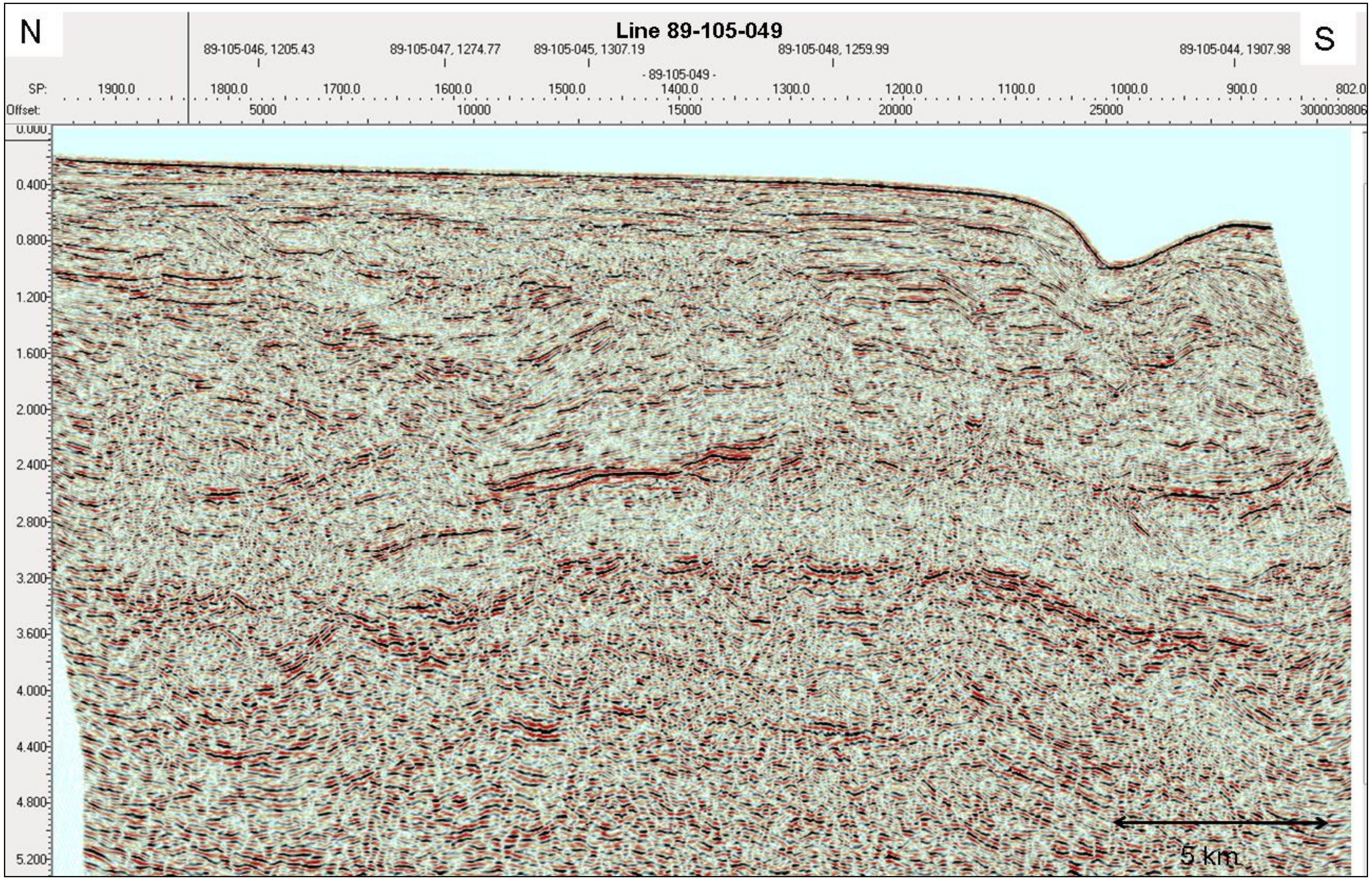


Figure 7.43: Seismic Line 89-105-049

8. EXPLORATION SUBAREA 4

8.1 Drilling Results & General Geology

Subarea 4 is the most northerly onshore subarea. This is located within the Obbia Basin.

The Obbia Basin trends northeast – southwest from the El Hamurra trend to the northeast to the Oddur Arch and Coriole Basin to the southwest (**see Section 4**). The Obbia basin is a coastal basin with a seaward expanded section. The Obbia Basin is primarily a Mesozoic basin with a relatively thin Tertiary cover. Most structures within the coastal part of the basin are NW-SE trending tilted fault blocks. However, there is a lack of seismic control and the available seismic is old vintage and generally poor quality by modern standards.

Four wells have been drilled and over 1800 line km of seismic data is available in Subarea 4.

The wells drilled in this subarea are:-

Gira-1 (Sinclair 1957)

Obbia-1 (Sinclair 1957)

Marai Ascia-1 (Sinclair 1958)

El Cabobe-1 (Arco 1980)

The available seismic surveys were acquired by:-

The German Group of Oil Companies in 1970

Texaco in 1975

Arco in 1980-1981

The Gira-1, Obbia-1 and Marai Ascia-1 wells were drilled by Sinclair in the late 1950's on large anticlinal structures identified from seismic refraction and reflection surveys. The targets were of Cretaceous and Jurassic age as the Tertiary forms only a thin cover.

The most modern well located in the area is El Cabobe-1 drilled by Arco on their 1980 seismic survey results. This also targeted the Mesozoic section.

Although there have been some minor hydrocarbon indications in the form of minor gas shows in El Cabobe-1, results have been disappointing and the wells have all been plugged and abandoned as dry.

The location of Subarea 4 and the available seismic and well data are shown in Figure 8.1**.**

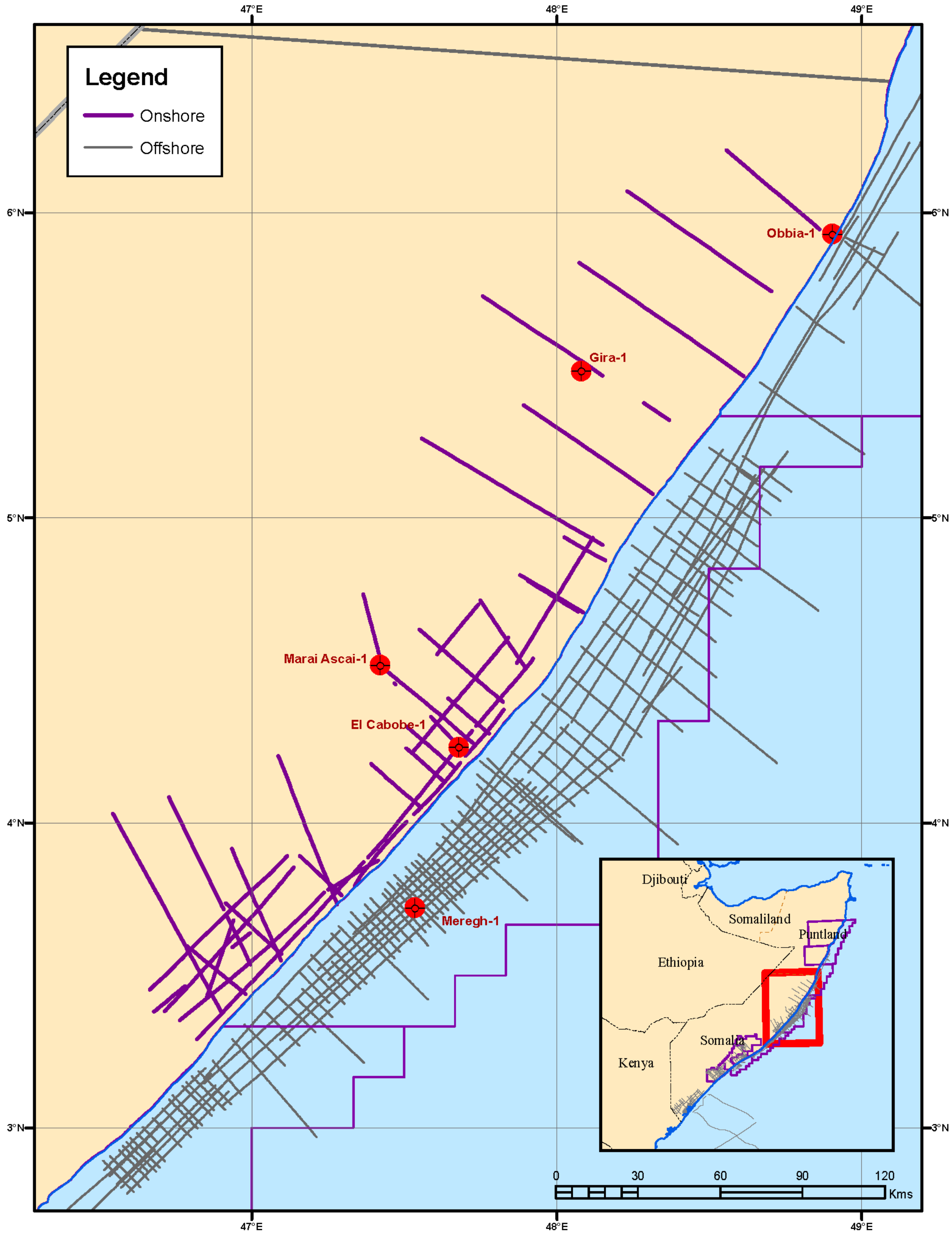


Figure 8.1: Subarea 4 Seismic and Well Database Map

Gira-1 was drilled by Sinclair between June 1956 and January 1957 to a total depth of 3,890m (12,764 ft). The target was a large NE trending anticlinal structure (60km long 15-30km wide) with a vertical closure of 100m identified from seismic refraction data. The formation reached at TD was the Lower/Middle Jurassic Hamanlei Formation. The location of Gira-1 is shown in Figure 8.1**.**

The recent to Upper Cretaceous interval 0 - 1920m (0 - 6,300 ft) is comprised of mainly of shallow water carbonates with occasional shale intervals. This sequence represents the transition from the deeper water environments of the Lower Cretaceous Adale Formation (1,920 - 2,403m / 6,300 - 7,883 ft) to shallower marine conditions.

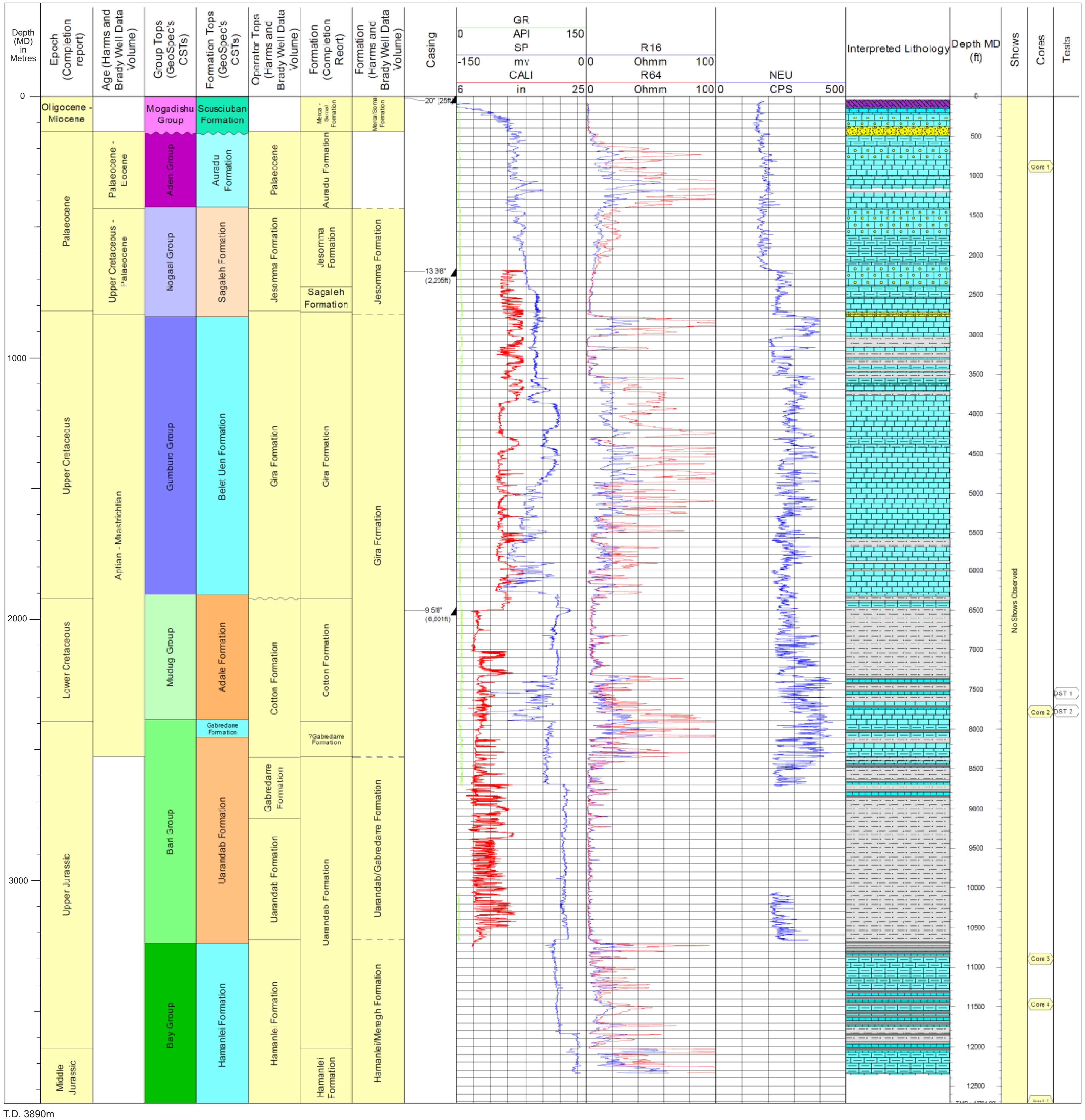
A 1341m (4,402 ft) thick shale/siltstone sequence from the Top Adale Formation to the Base Uarandab Formation at 3,262m (10,702 ft) is divided by a sequence of carbonates from 2,403 to 2,469m (7,883-8,098 ft) of the Gabredarre Formation (Upper Jurassic) suggesting a brief period of marine regression. Below 3,262m (10,702 ft) lies the predominantly carbonate Hamanlei Formation with occasional clastic interbeds.

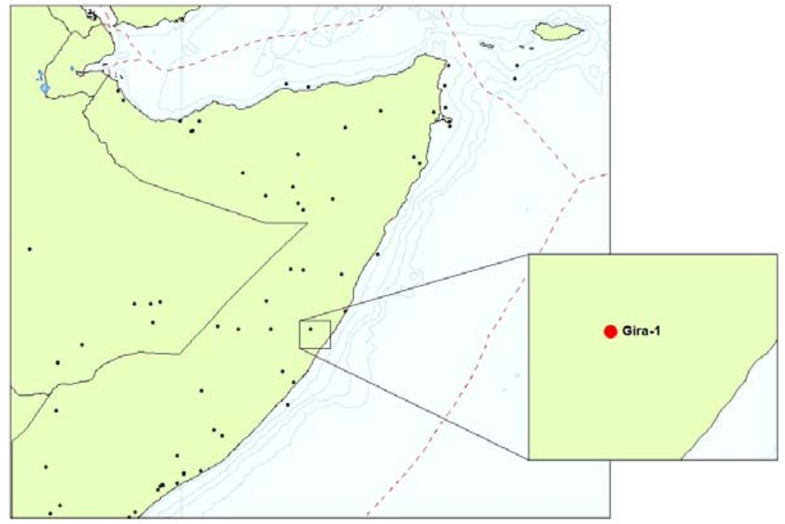
The Lower Cretaceous Adale Formation contain limestone intervals of medium to poor porosity, which if sealed by overlying shale/siltstones could form a poor reservoir. Seven cores and 2 DSTs were run in the well. Both DSTs were run within the Adale Formation. The first test produced 76m (250ft) of salt water and the second test failed due to technical difficulties. Rare oil staining was observed between 2368.8 to 2374.7m (7,771ft – 7,791ft) and very dull fluorescence was observed in core samples between 3881m to 3884m (12,734ft-12,744ft). Although some porosity in carbonate intervals was evident within the Cretaceous Belet Uen and Adale Formations, the DSTs did not produce any hydrocarbons. No oil or gas shows were observed and the Gira-1 well was plugged and abandoned as dry.

The well summary chart is shown in Figure 8.2.

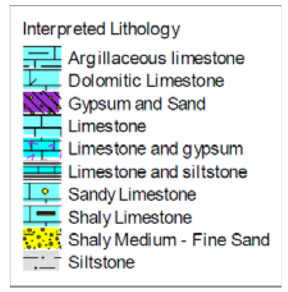
A geoseismic line over the Gira-1 well location is shown in Figure 8.3.

Gira-1



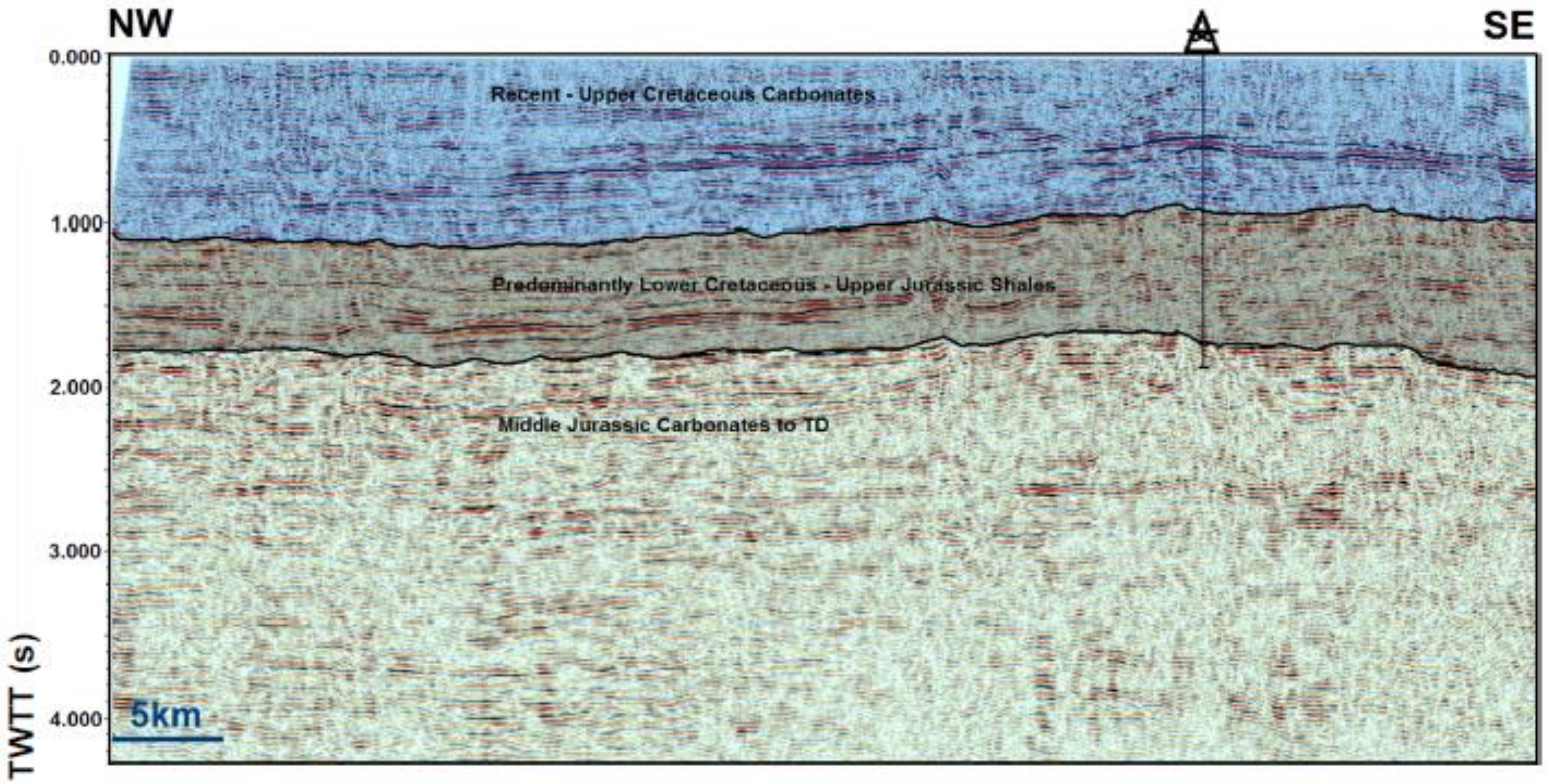


Gira-1 was drilled onshore Somalia, and is located at 05° 29' 59" N, 48° 04' 41" E



Well Summary Chart, Gira-1 **Figure 8.2**

<table>
<tr><th colspan="4">Operator</th></tr>
<tr><td colspan="4">Sinclair Somal Corporation</td></tr>
<tr><th colspan="4">Coordinates</th></tr>
<tr><td colspan="4">05° 29' 59" N
48° 04' 41" E</td></tr>
<tr><th>KB</th><th colspan="2">GL</th><th>TD</th></tr>
<tr><td>133.10m
436.58ft</td><td colspan="2">128.34m
421.06ft</td><td>3,890.47m
12,764ft</td></tr>
<tr><th colspan="2">Spud Date</th><th colspan="2">Completion Date</th></tr>
<tr><td colspan="2">18-Jun-1956</td><td colspan="2">31-Jan-1957</td></tr>
<tr><th colspan="2">Shows</th><th colspan="2">Tests/Cores</th></tr>
<tr><td colspan="2">None</td><td colspan="2">2 DSTs; 7 Cores</td></tr>
<tr><th colspan="4">Status</th></tr>
<tr><td colspan="4">Dry; Plugged and Abandoned</td></tr>
</table>



The **Geoseismic Section** shows the structure and stratigraphy surrounding Gira-1. The transition from Middle Jurassic carbonates (Hamanlei Formation) to a thick sequence of Upper Jurassic – Lower Cretaceous shales represents a change to a deep water depositional environment. Occasional carbonate sequences are visible in this interval suggesting transitions to shallower shelf conditions. A change from deep water shales to shallow marine carbonates is evident at the onset of the Upper Cretaceous (Belet Uen Formation).

Figure 8.3: Gira-1 Geoseismic Line

Obbia-1 was drilled by Sinclair between March and November 1957 to a total depth of 4,884m (16,023). The target was a large NE trending anticline approximately 30km long by 5 km wide with several hundred metres of vertical closure identified from seismic refraction data. At TD the well reached the Middle Jurassic Hamanlei Formation. The location of Obbia-1 is shown in Figure 8.1**.**

The Hamanlei Formation (3,325 – 4,884m / 10,910 -16,023 ft) is composed predominantly of limestone. These grade to shaly limestones and subsequent sands within the Upper Jurassic Uarandab Formation suggesting a general marine transgression. The top of the Uarandab at 2,301m (7,550 ft) shows a rapid change from sands to carbonates indicative of a transgressive period.

The Cretaceous (1,286– 2,301m / 4,220 -7,550 ft) comprises the Belet Uen and Main Gypsum Formations and are shallow marine carbonates.

The Tertiary and Recent section (0 -1286m / 0- 4220ft) are composed of the Sagaleh Formation (1,104 – 1,337m / 3,622 -4,388ft), the Scebeli Formation (866- 1,104m/3,662 - 2,842ft) and the Obbia Formation (748 – 866m / 2,454-2,841ft). These are comprised of sands and silty sands with a sandy limestone interval from 1,027 to 1,051m (3,368 – 3,447ft).

Above the Obbia Formation is the sandy Scuscubian Formation, but the top of this is indeterminate as there is negligible lithological information for the interval above 641m (2,104ft).

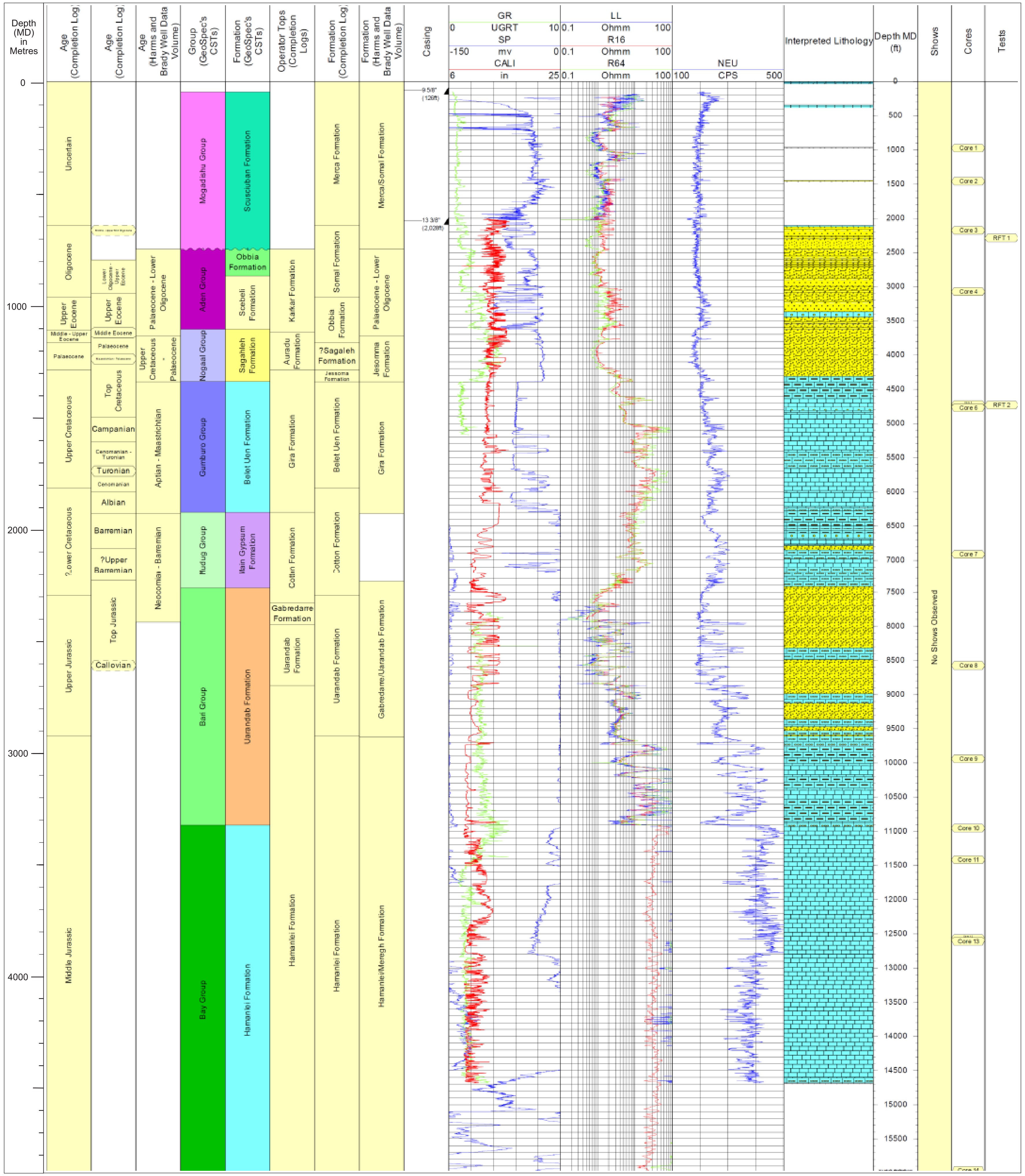
Two DSTs were run on Obbia-1. DST-1 was run between 694.94 and 701.04m (2,280 - 2,300ft) in the Scusciuban Formation. This recovered 3m (10ft) salt water from porous sandstone. DST-2 was run between 1,438.96 and 1,444.14m (4,721 – 4,738ft) in the Belet Uen Formation. This recovered 1,027m (3,370ft) of salt water from porous limestone. Neither of the tests produced any hydrocarbons.

Fourteen cores were cut between 296.57m and 4883.81m (973 -16,023ft). Minor fluorescence was observed between 1,445.97 to 1452.07m (4,744 – 4,764ft) and 2,105.25 to 2,109.83m (6,907 – 6,922ft) without any staining or hydrocarbon shows. Petrophysical analysis conducted between 3 – 4,873.6m (10 -15,989.5ft) showed good porosity between 3 to 783.34m (10 -2,570ft) in the Merca (Scusciuban) Formation and between 1,286.26 to 1,920.24m (4,220 – 6,300ft) in the Gira (Belet Uen) Formations. These were shown to be water bearing. Hydrocarbon shows were computed in the Hamanlei Formation between 3,498.19 and 4,450.08m (11,477 - 14,600ft).

The Obbia-1 Well Summary Chart is shown in Figure 8.4.

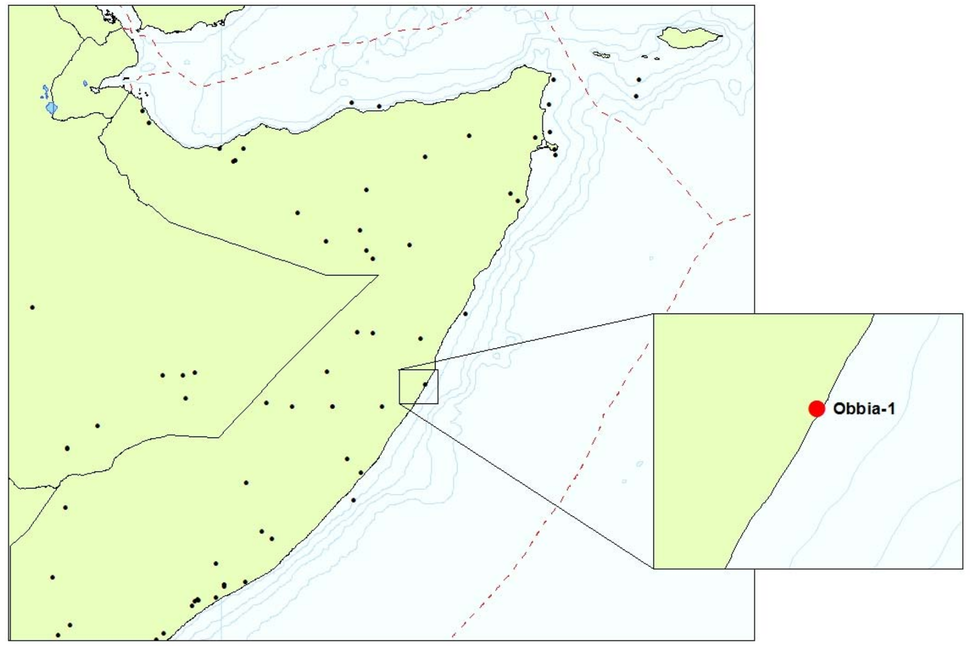
Obbia-1 was plugged abandoned as dry.

A geoseismic line near to Obbia-1 is shown in Figure 8.5.

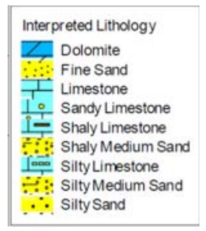


T.D. 4884m

Obbia-1



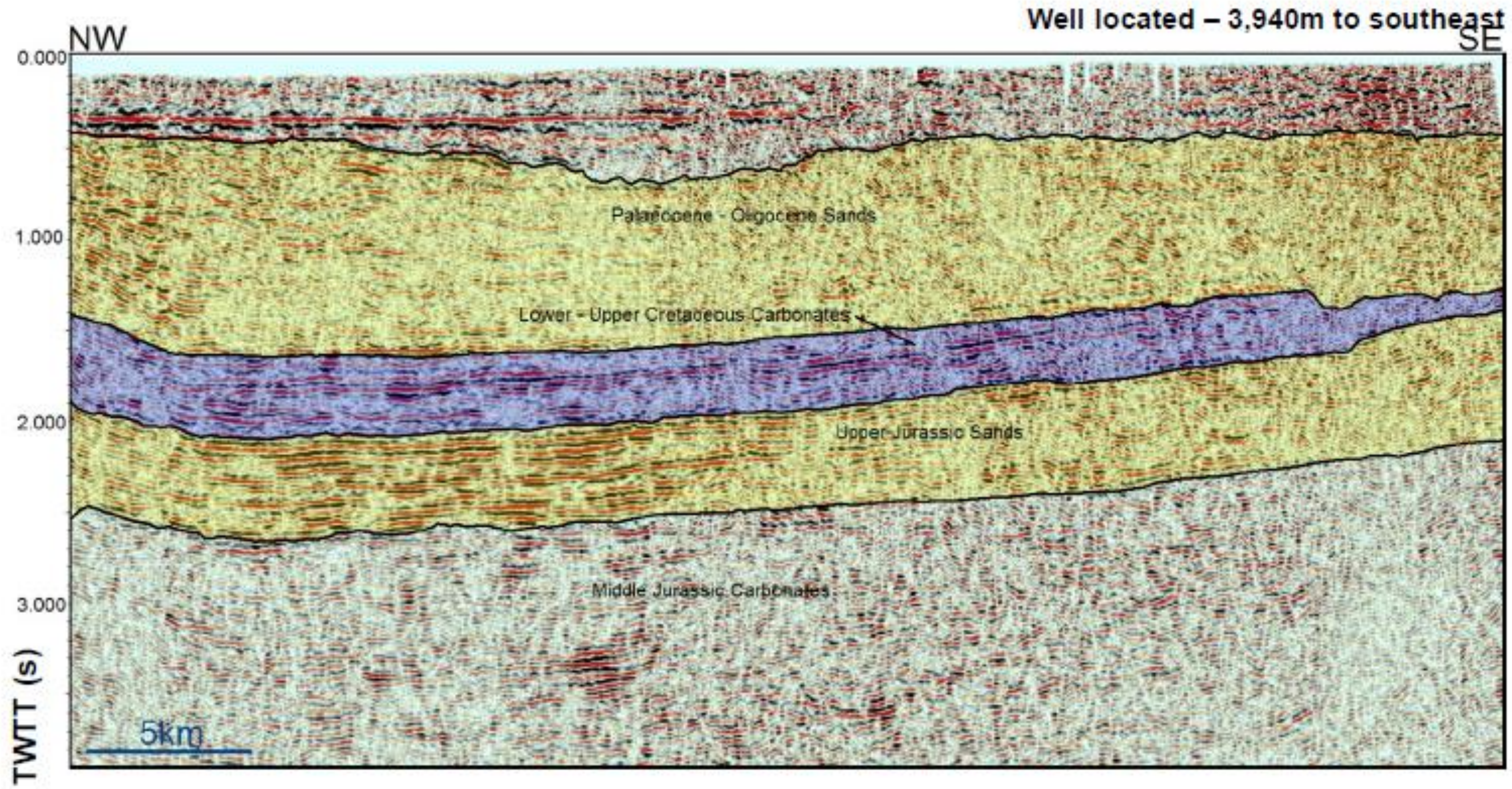
Obbia-1 was drilled onshore Somalia, and is located at 05° 55' 48" N, 48° 54' 11" E



Well Summary Chart, Obbia-1

Figure 8.4

Operator		
Sinclair Somal Corporation		
Coordinates		
05° 55' 48" N 48° 54' 11" E		
KB	**GL**	**TD**
43.89m 144ft	39.16m 128.48ft	4,883.81m 16,023ft
Spud Date	**Completion Date**	
04-Mar-1957	12-Nov-1957	
Shows	**Tests/Cores**	
None	2 DSTs; 14 Cores	
Status		
Dry; Plugged and Abandoned		



The **Geoseismic Section** summarises the main stratigraphy and lithology of the area. The shallow marine Middle Jurassic carbonates (Hamanlei Formation) are overlain by Upper Jurassic sands (Uarandab Formation). The Lower – Upper Cretaceous (Belet Uen and Main Gypsum Formations) are predominantly shallow marine carbonates, which thin towards the southeast. The Sagaleh, Scebeli and Obbia Formations (Palaeocene – Oligocene) are dominated by fine silty sands. The strata dip to the northwest, suggesting the well is located at the crest of the anticlinal structure. No lithology data was available for the uppermost formations.

Figure 8.5: Obbia-1 Geoseismic Line

Marai Ascia-1 was drilled onshore between January and September 1958 to a total depth of 4,115m (13,500 ft). The target was a large NE trending anticline approximately 150 km long and up to 80 km wide with 600m of vertical closure defined by seismic refraction data. At TD the well reached the Middle Jurassic Hamanlei Formation. The location of Marai Ascia-1 is shown in Figure 8.1**.**

No formation tests were run and the cores cut showed no hydrocarbon indications. The well was plugged and abandoned as dry. Although no seismic data is available from this era, Line S-80-G103-P2, acquired later by Arco in 1980, traverses the Obbia-1 well location.

The well penetrated the Middle Jurassic Hamnalei Formation from 2704.8 to 4111m (8,874 – 13,486ft). This formation was comprised of argillaceous and dolomitic limestones with occasional interbeds of siltstones and shales. This indicates a shallow marine carbonate environment.

The Hamanlei Formation is overlain by the Upper Jurassic Uarandab Formation between 2051.3 to 2704.8m (6,730 -8,874ft). This was composed primarily of siltstones and shales.

The Upper Jurassic to Upper Cretaceous interval between 1,417 and 2051.3m (4,649-6,730ft) is comprised of the predominately carbonate Gabredarre, Adale and Belet Uen Formations.

Above the Belet Uen Formation lies the Sagaleh Formation which is composed of siltstones with limestone intervals.

The well summary Chart for Marai Ascai-1 is shown in Figure 8.6.

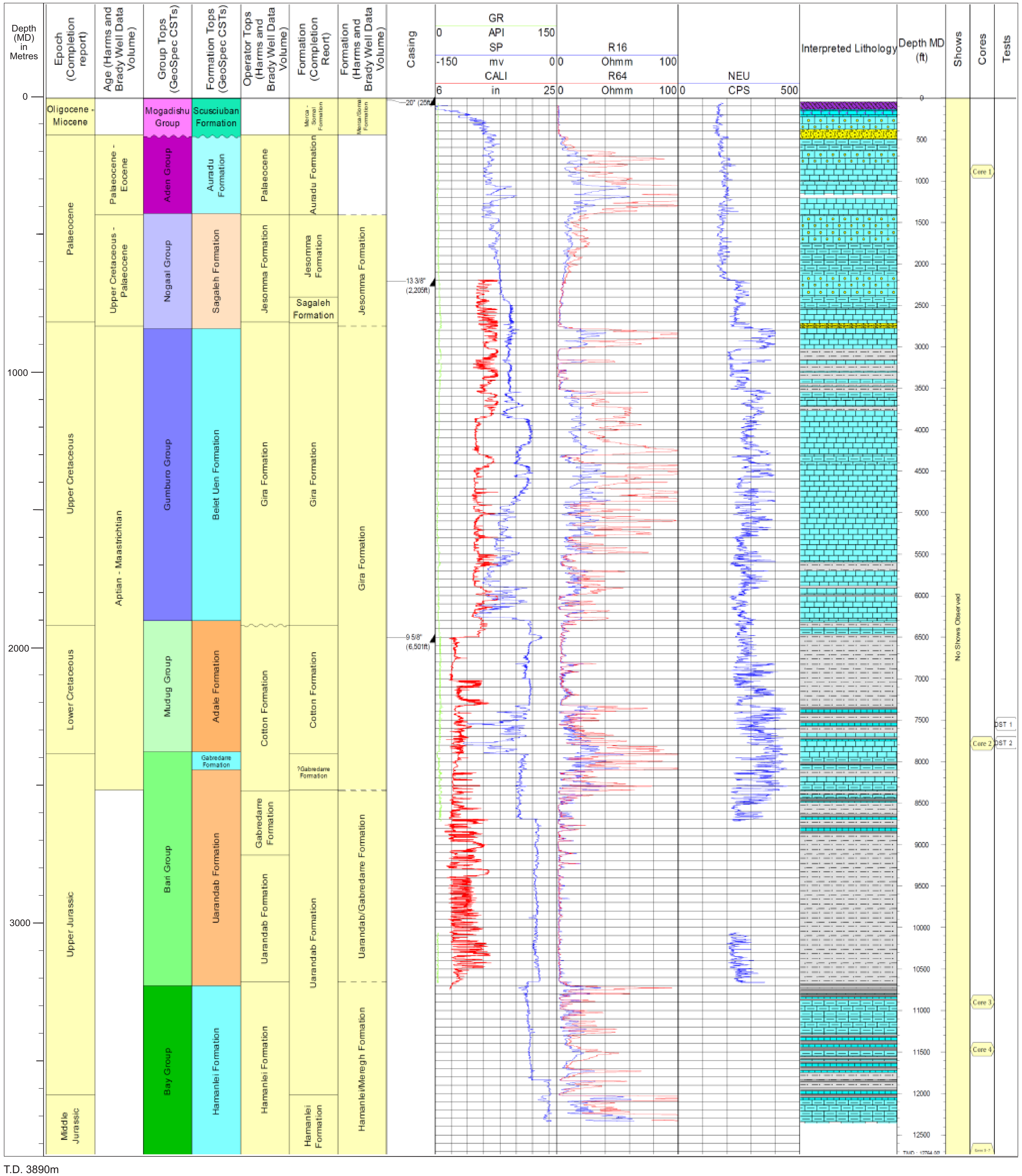
No DSTs were run on this well. Seven cores were cut. One core was cut from the Middle Jurassic Hamanlei between 3,009.9 and 3,016.91m (9,875 – 9,898ft). This did not indicate any shows, porosity or permeability. Similarly a core cut in the Upper Cretaceous Belet Uen Formation between 1,559.36 and 1,564.23m (5,116 – 5,132ft) also did not indicate any shows, porosity or permeability.

Five cores were cut in limestone/siltstone intervals of the Upper Cretaceous-Paleocene Sagaleh Formation.The core cut between 1,062.23 and 1,068.32m (3,485 – 3,505ft) showed an average of 24.9% porosity and 1.9% permeability. The core cut between 1,068.32 and 1,074.42m (3,505 3,525ft) showed negligible porosity and 7.7% permeability.

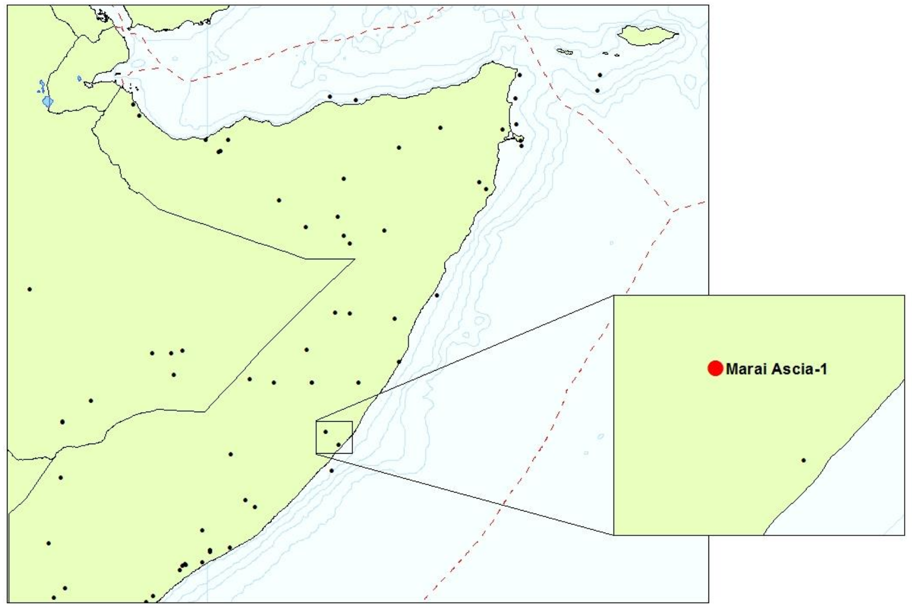
Petrophysical analysis computed hydrocarbons between 832.1 and 1,895.19m (2,730 - 6,185ft). This correlated with excellent porosities recorded by core 4. Although this indicated reservoir potential, none of the cores had hydrocarbon shows.

Due to the general lack of porosity and shows within the cores, no formation testes were run and the well was plugged and abandoned as dry.

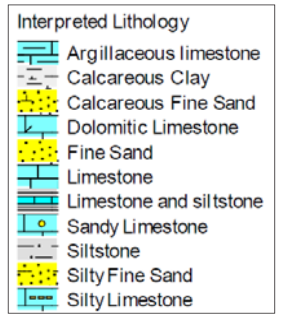
A geoseismic line over to Marai Ascia-1 is shown in Figure 8.7**.**



Marai Ascia-1



Marai Ascia-1 was drilled onshore Somalia, and is located at 04° 30' 59" N, 47° 25' 18" E



Well Summary Chart, Marai Ascia-1 **Figure 8.6**

Operator
Sinclair Somal Corporation

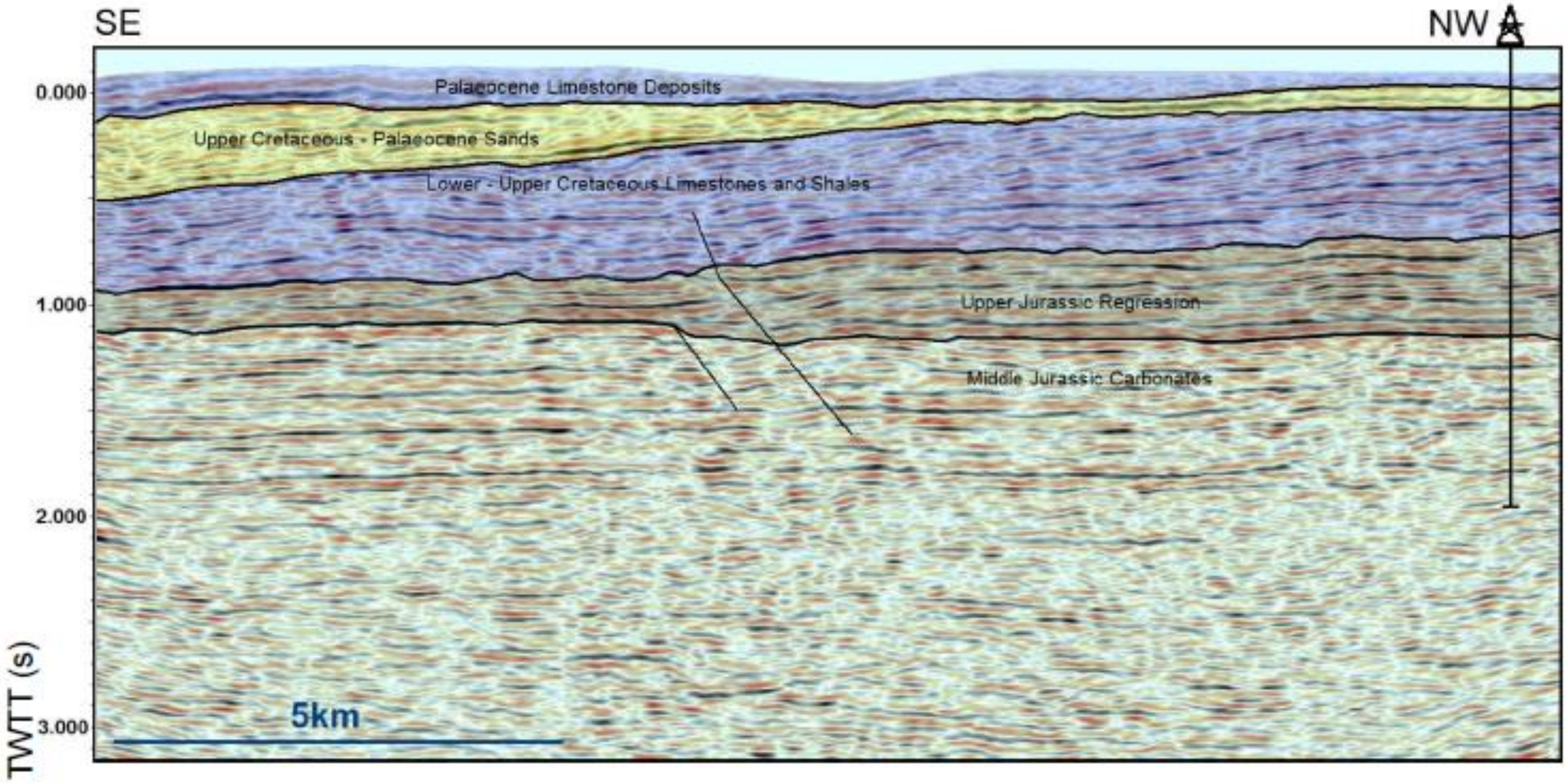
Coordinates
04° 30' 59" N 47° 25' 18" E

KB	GL	TD
357.79m 1,173.85ft	353.19m 1,158.75ft	4,114.80m 13,500ft

Spud Date	Completion Date
10-Jan-1958	03-Sep-1958

Shows	Tests/Cores
None	None; 7 Cores

Status
Dry; Plugged and Abandoned



The **Geoseismic Section** summarises the well target and main stratigraphy of the area. The Middle Jurassic carbonates (Hamanlei Formation) are overlain by Upper Jurassic (Uarandab, Gabredarre and Adale Formations) shales and limestones; indicating a marine regression. The Lower – Upper Cretaceous Belet Uen and Sagaleh Formations comprise of alternating carbonate and shale intervals. They are overlain by the Marai Ascia Formation (Upper Cretaceous – Palaeocene) sands and limestones, which thicken towards the southeast, and the Palaeocene limestone deposits of the Auradu Formation.

Figure 8.7: Marai Ascai-1 Geoseismic Line

The **El Cabobe-1** well was drilled by Arco between June and September 1980 onshore. The objective of the well was to test a large (10 x 25 km) NE-SW trending structure bounded to the southeast by a large NE-SW trending fault defined by seismic data. The crest of the structure lay near the coastline.

This well was drilled to a total depth of 4,428m (14,528 ft) into the Lower Jurassic/Triassic Adigrat Formation, which was the primary target with Middle Jurassic limestones of the Hamanlei Formation being a secondary target.

The well location is shown in Figure 8.1.

The top of the Lower Jurassic/Triassic Adigrat Formation is at 4,095.6m (13,437ft).

The Adigrat Formation consists of interbeds of pyritic shale and limestones transitioning into interbeds of slightly porous (5%) calcareous sandstones and shales with rare interbeds of bituminous coal. The petrophysical analysis computed thin pockets of porosity with very minor gas shows. Wireline log analysis suggested 100% water saturation in porous zones. The saturation combined with the low organic carbon content of the coal interbeds excludes the Adigrat as a potential source rock here. This is further compounded by the high geothermal gradient of up to 38.8º C/km, which minimises the hydrocarbon and source rock potential of the coal interbeds within the Formation.

The secondary objective of the Middle Jurassic Hamanlei Formation was encountered between 2,089.1 and 4,095.6m (6,854 – 13,437ft).

This consists primarily of limestones and shaly limestones indicative of shallow marine environments. There is an interval of fine sands between 2,503.63 – 2,520.7 (8,214 – 8,270ft). Between 3,456.13 and 3,572.26m (11,339 – 11,720ft) there is an interval of dolomites. Porosities of between 3% and 4% were recorded during drilling with very occasional increases up to between 8% and 10%. Minor gas shows of C_1 – C_4 were recorded between 2,505.5 and 2,734.06m (8,220 – 8,970ft) but were determined to be insignificant. Petrophysical analysis confirmed low porosities of up to 5% and only computed minor hydrocarbon shows. Six RFTs were run between 3,387.24 and 3,694.48m (11,113 – 12.121ft). Three of these were successful but with no fluid recovery. The first three RFTs run between 3,.387.24 and 3,477.77m (11,113 – 11,410ft) had seal failures.

The interval from 1,082.35 to 2,089m (3,551 - 6,854ft) has been assigned to the Cretaceous. The lithologies are interbeds of siltstones/shales and limestones intercalated with coals. The base of the Upper Cretaceous Belet Uen Formation at 1,125.6m (3,693ft) lies unconformably on the Lower to Upper Cretaceous Adale Formation. This is indicative of a brief period of shallow marine conditions.

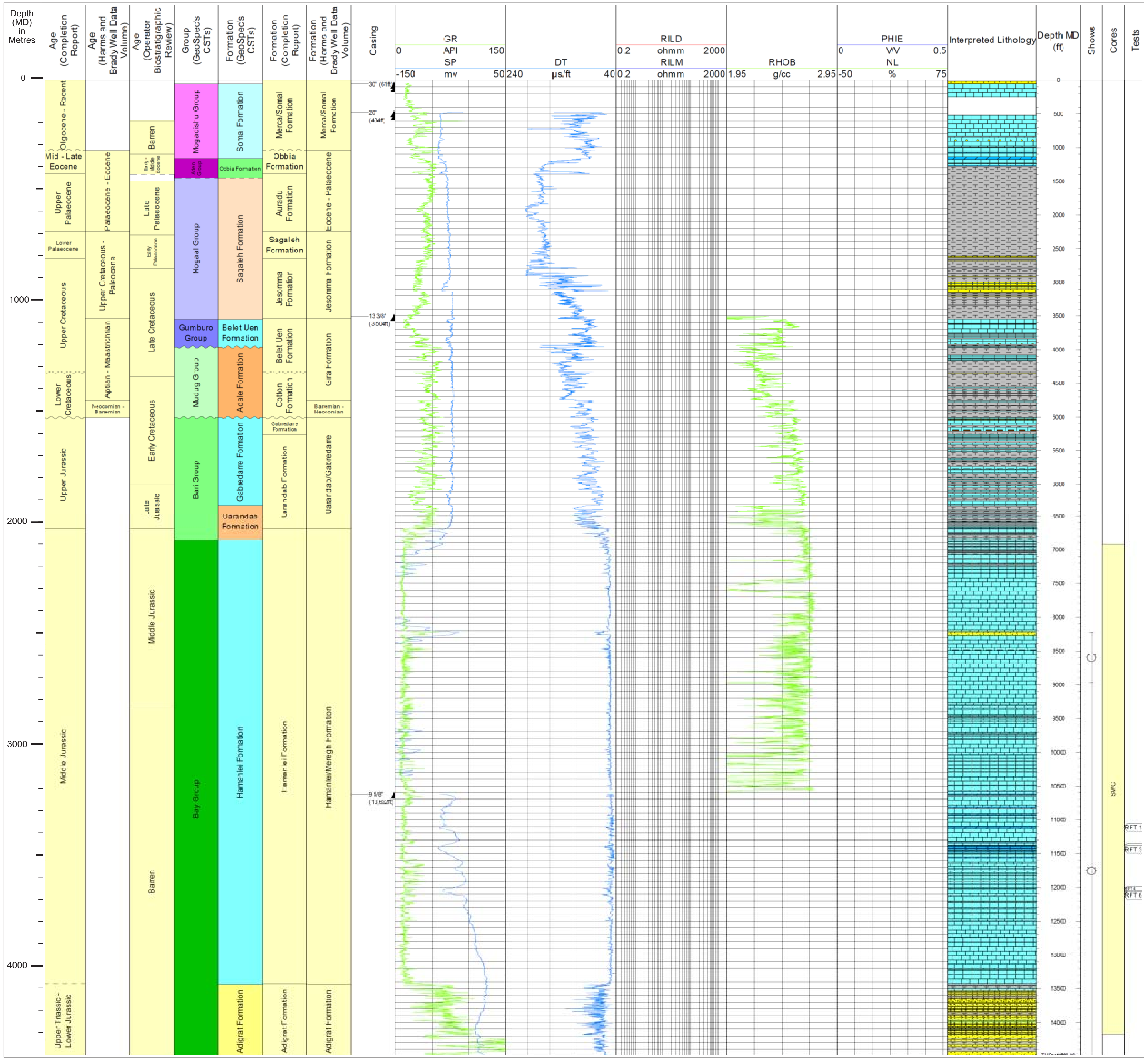
The overlying interval from 0 to 1,082.35m (0 – 3,551ft) shows a general marine regression with lithologies changing from deep marine clastics to shallow marine carbonates of Upper Cretaceous to Recent age.

No conventional coring was undertaken but thirty six Side Wall Cores were taken between 2,109.22 to 4,319.02m (6,920 – 14,170ft).

The El Cabobe-1 well did not show any significant hydrocarbon shows and the formation testing did not yield any hydrocarbon production. The well was plugged and abandoned as dry.

The well summary chart for El Cabobe-1 is shown in Figure 8.8.

A geoseismic line over El Cabobe-1 is shown in Figure 8.9**.**



T.D. 4482m

El Cabobe-1

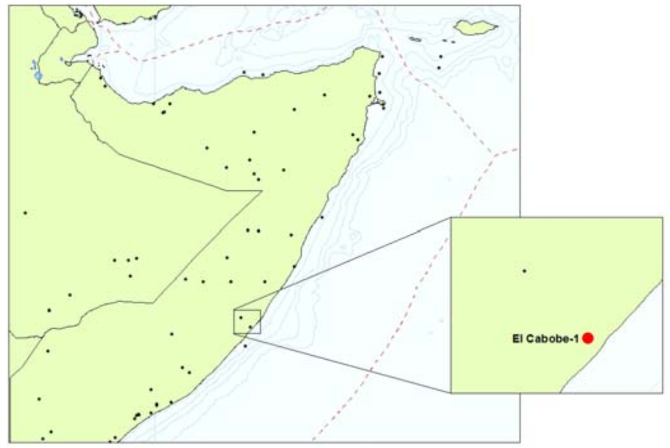


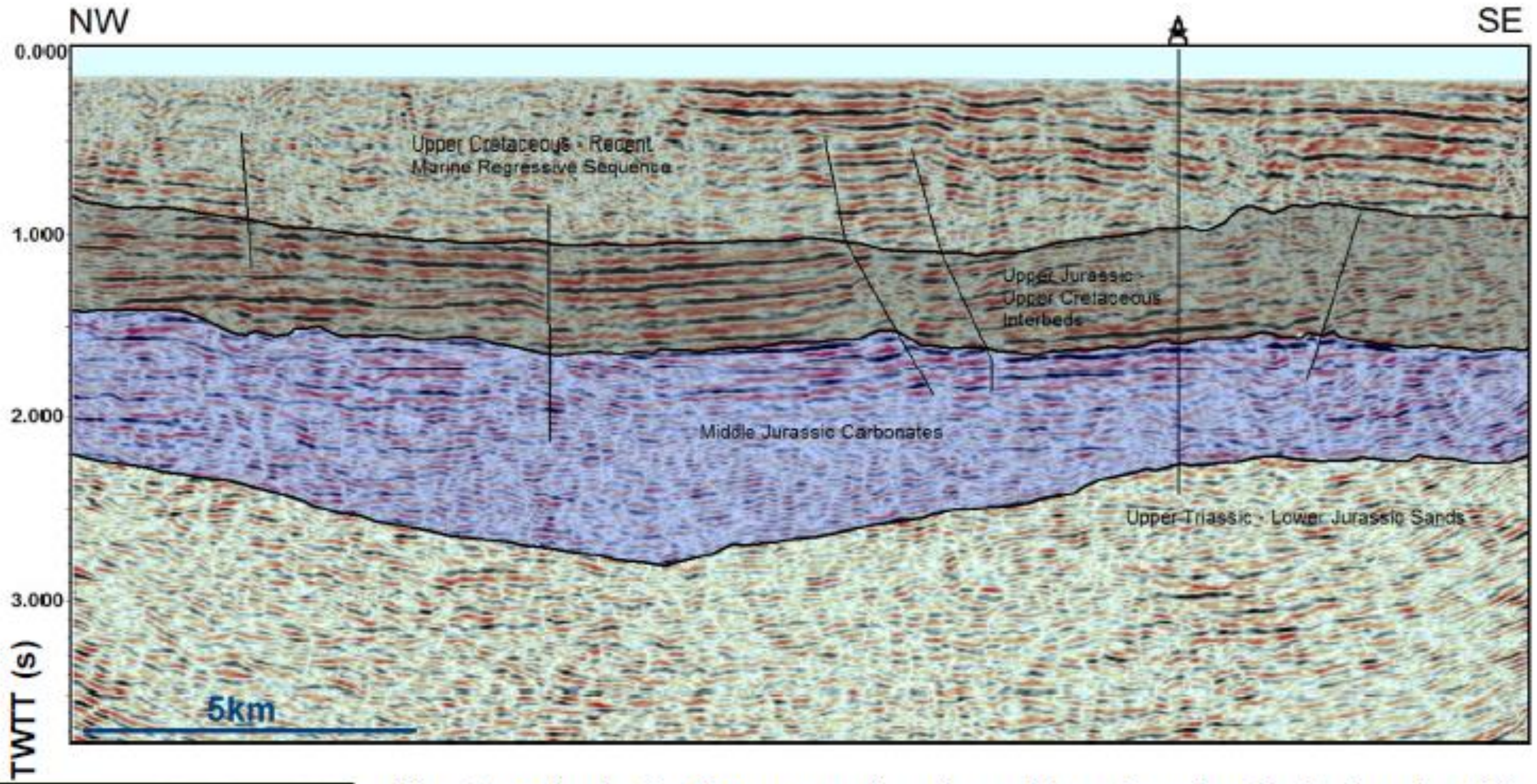
Figure 1-1: Location of El Cabobe-1, Somalia.

El Cabobe-1 was drilled onshore east Somalia, and is located at 4° 14' 48" N, 47° 40' 42" E

Interpreted Lithology
- Calcareous Fine Sand
- Clay
- Claystone
- Coal
- Dolomite
- Dolomitic Fine Sand
- Fine Sand
- Limestone
- Sandy Limestone
- Shaly Limestone
- Shaly Medium - Fine Sand
- Shaly Medium Sand
- Silty Limestone

Well Summary Chart, El Cabobe-1 Figure 8.8

Operator		
ARCO Somalia Incorporated		
Coordinates		
04° 14' 48" N 47° 40' 42" E		
RKB	**GL**	**TD**
27.6m 90.41ft	20.2m 66.41ft	4,428.1m 14,528ft
Spud Date	**Completion Date**	
03-Jun-1980	24-Sep-1980	
Shows	**Tests/Cores**	
Minor Gas (C_1 – C_4)	6 RFTs; 36 SWCs	
Status		
Dry; Plugged and Abandoned		



The **Geoseismic Section** summarises the well targets and main stratigraphy of the area. The secondary objective of the shallow marine Middle Jurassic Carbonates (Hamanlei Formation) overlies the primary objective Upper Triassic – Lower Jurassic continental sands of the Adigrat Formation. This sequence is overlain by a 3,304ft Upper Jurassic – Upper Cretaceous sequence of limestone and siltstone interbeds with occurrences of coal. At the top of this interval a marine regressive sequence of Upper Cretaceous – Recent age was interpreted as a transition from deep water shales/siltstones to shallow marine carbonates.

Figure 8.9: Marai Ascai-1 Geoseismic Line

8.2 Seismic Examples

The following section contains examples of seismic data within Subarea 4 (Figure 8.11 to Figure 8.21).

The locations of these are shown in Figure 8.10.

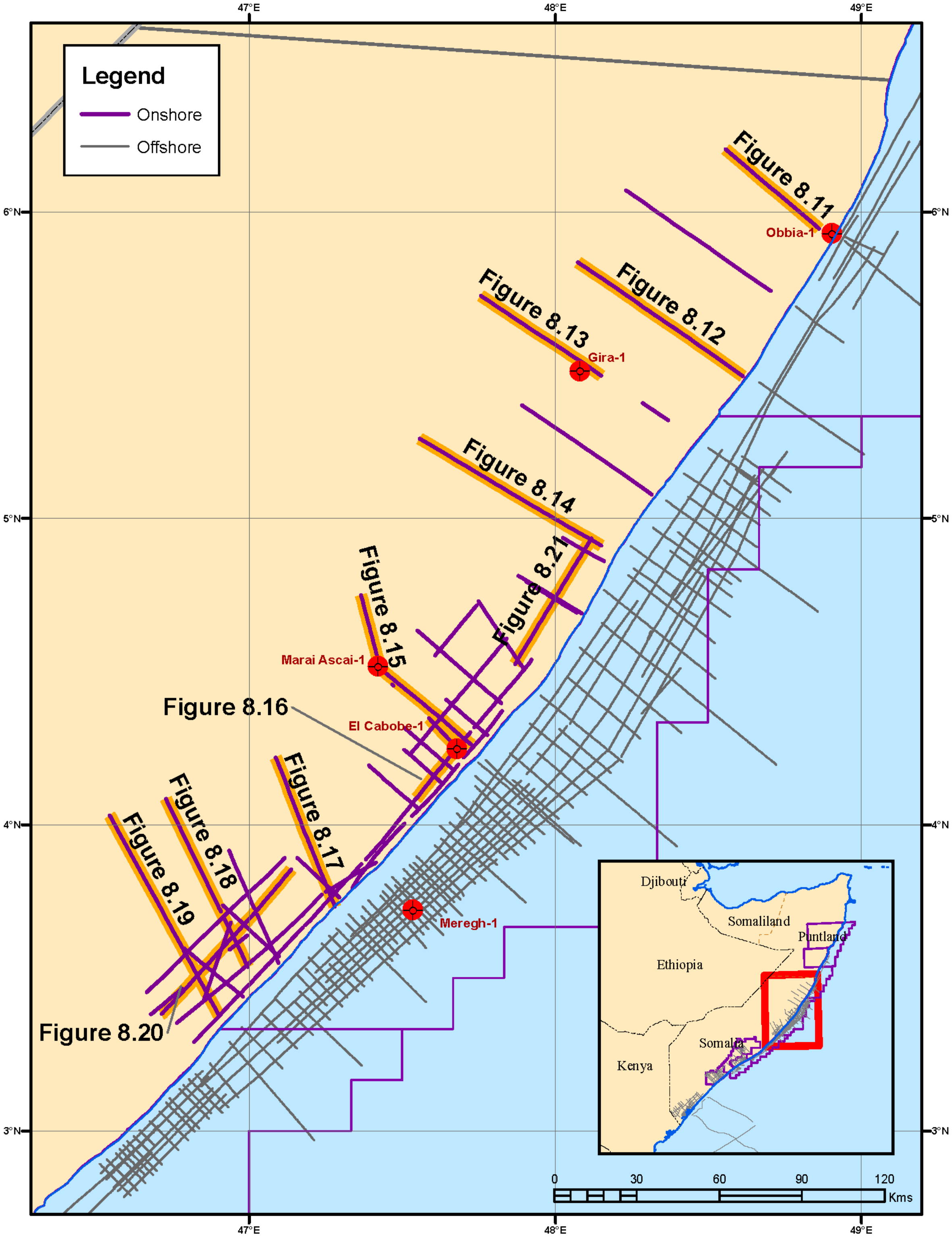


Figure 8.10: Subarea 4 Location of Seismic Displays

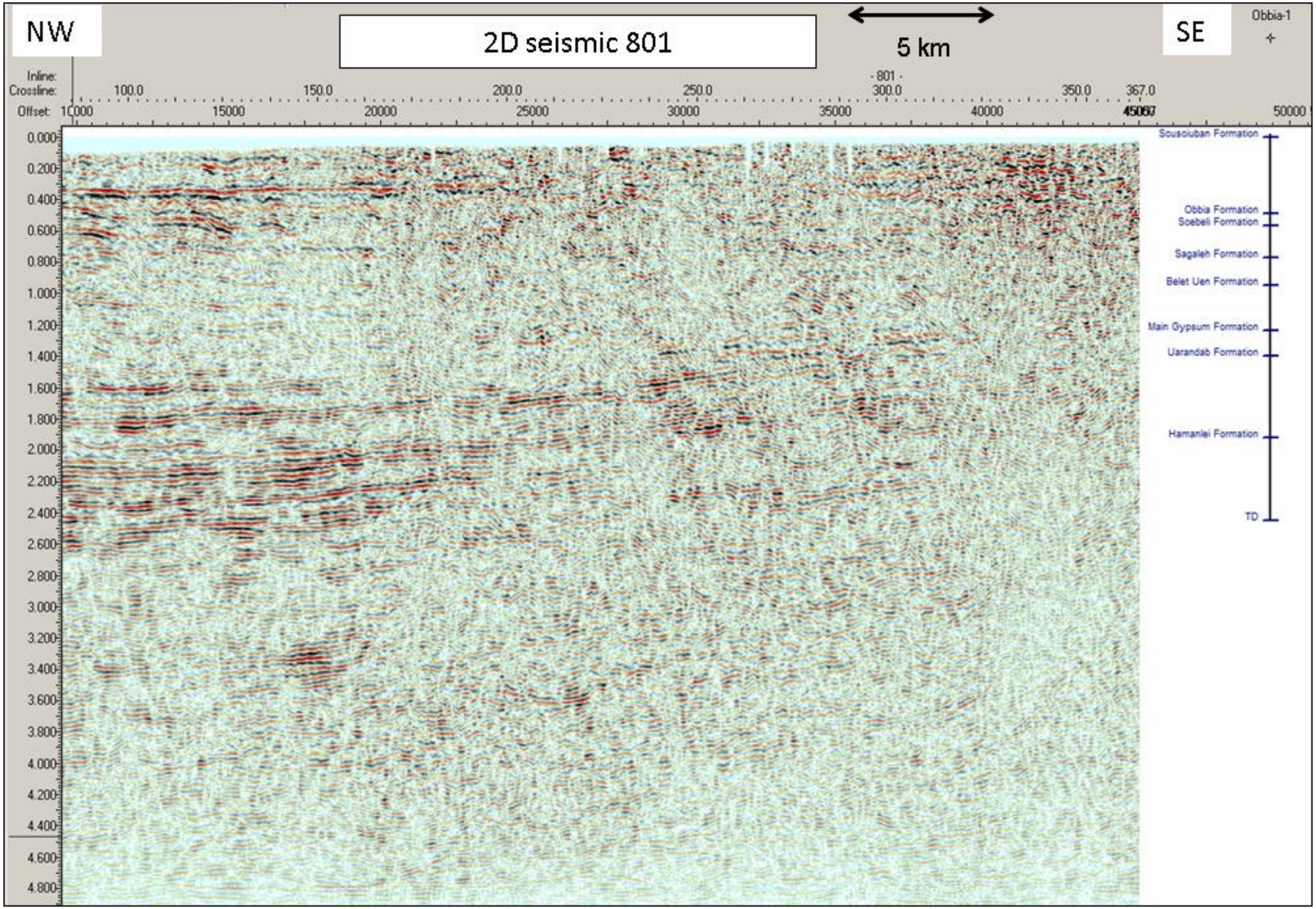


Figure 8.11: Obbia-1 Seismic Line 801

Line 805

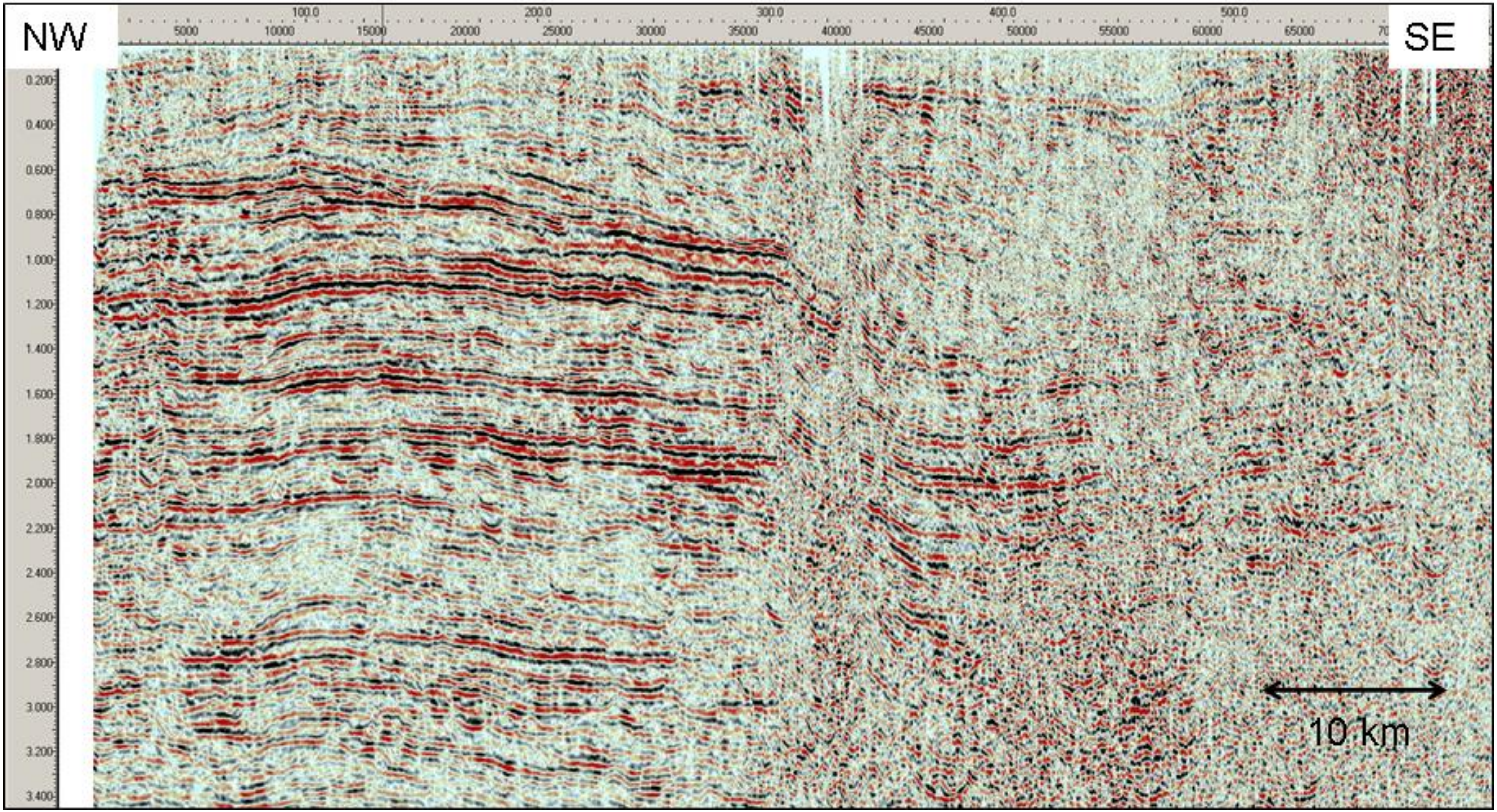


Figure 8.12: Seismic Line 805

Line 807-P1

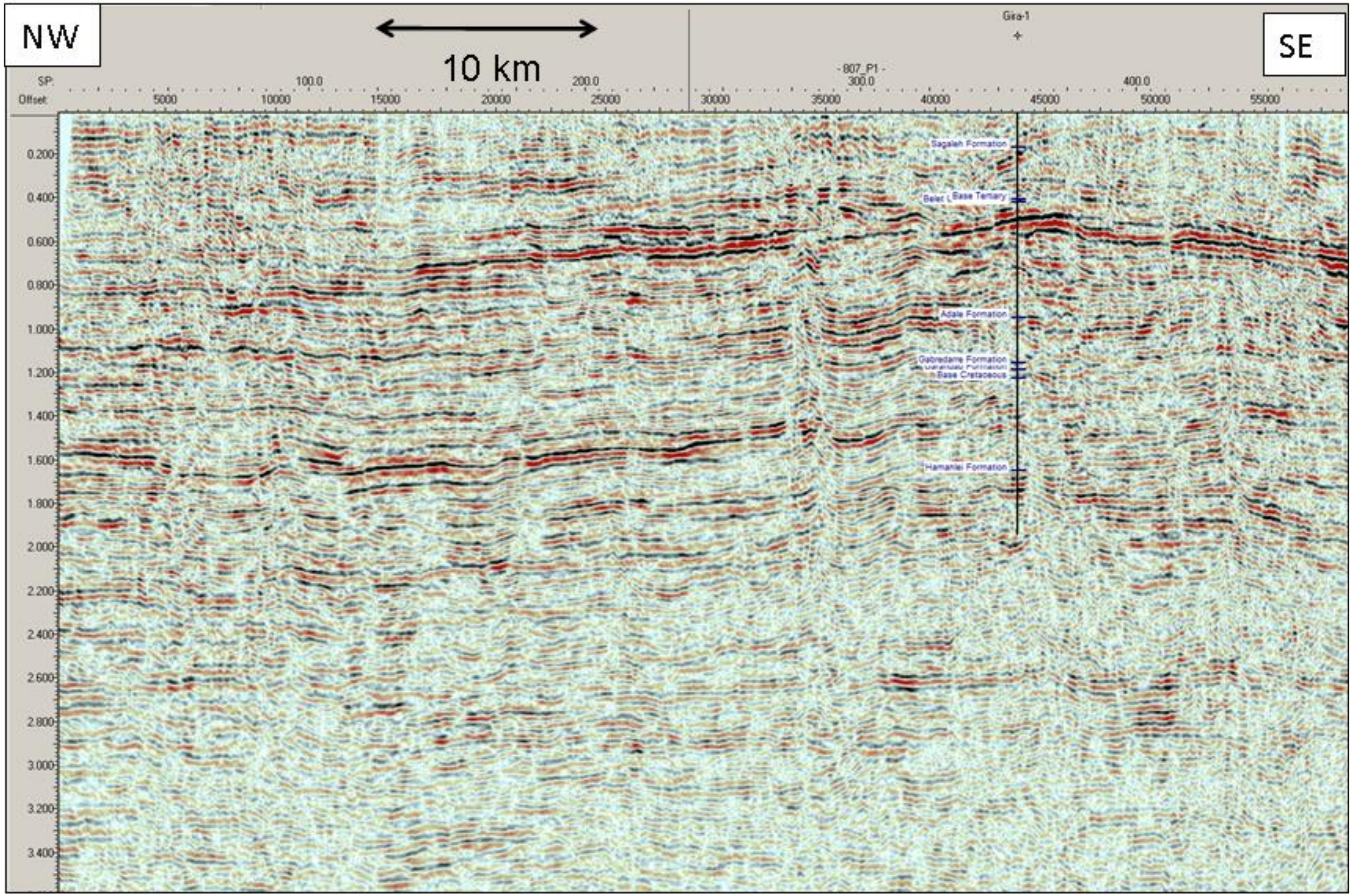


Figure 8.13: Gira-1 Seismic Line 807 P1

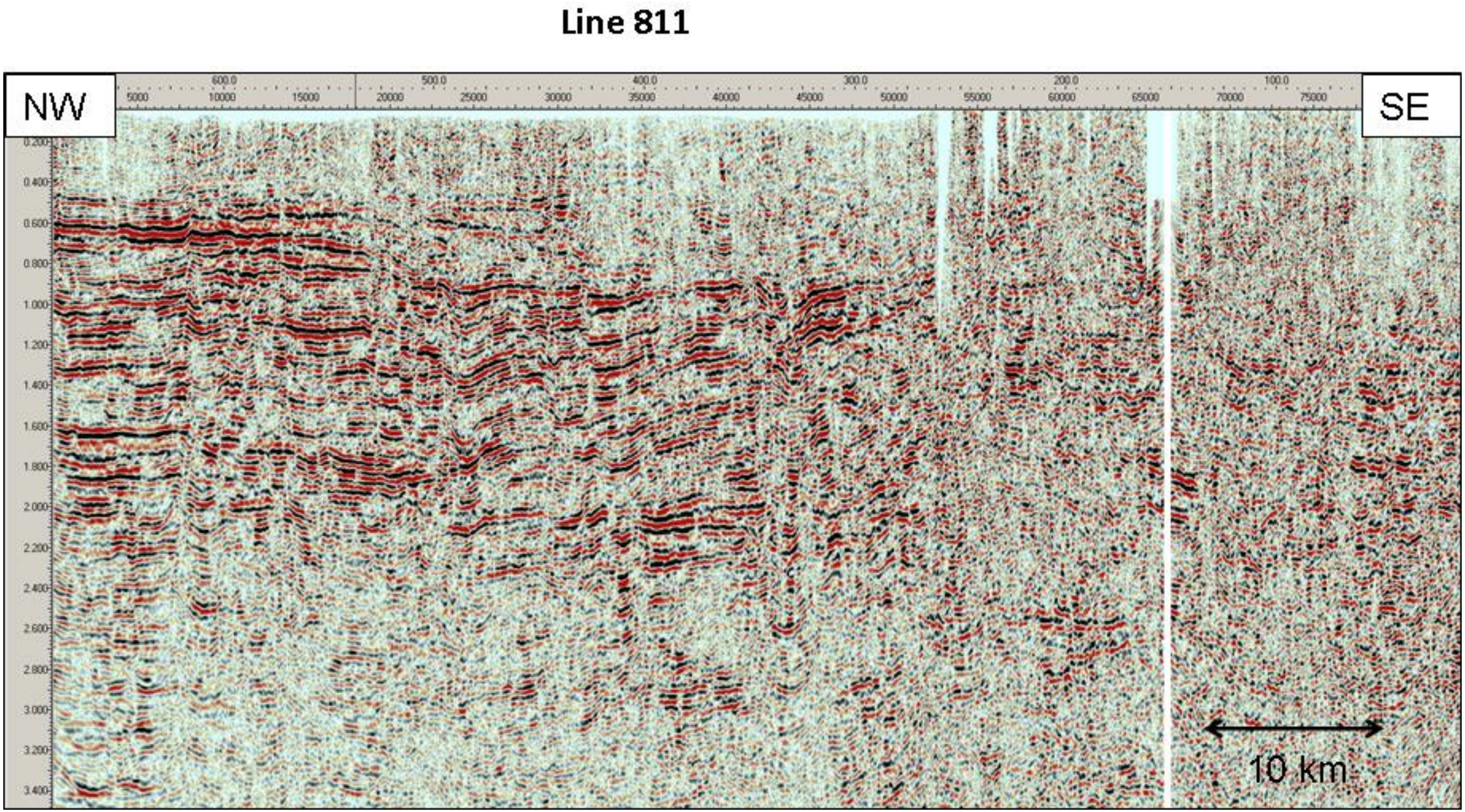


Figure 8.14: Seismic Line 811

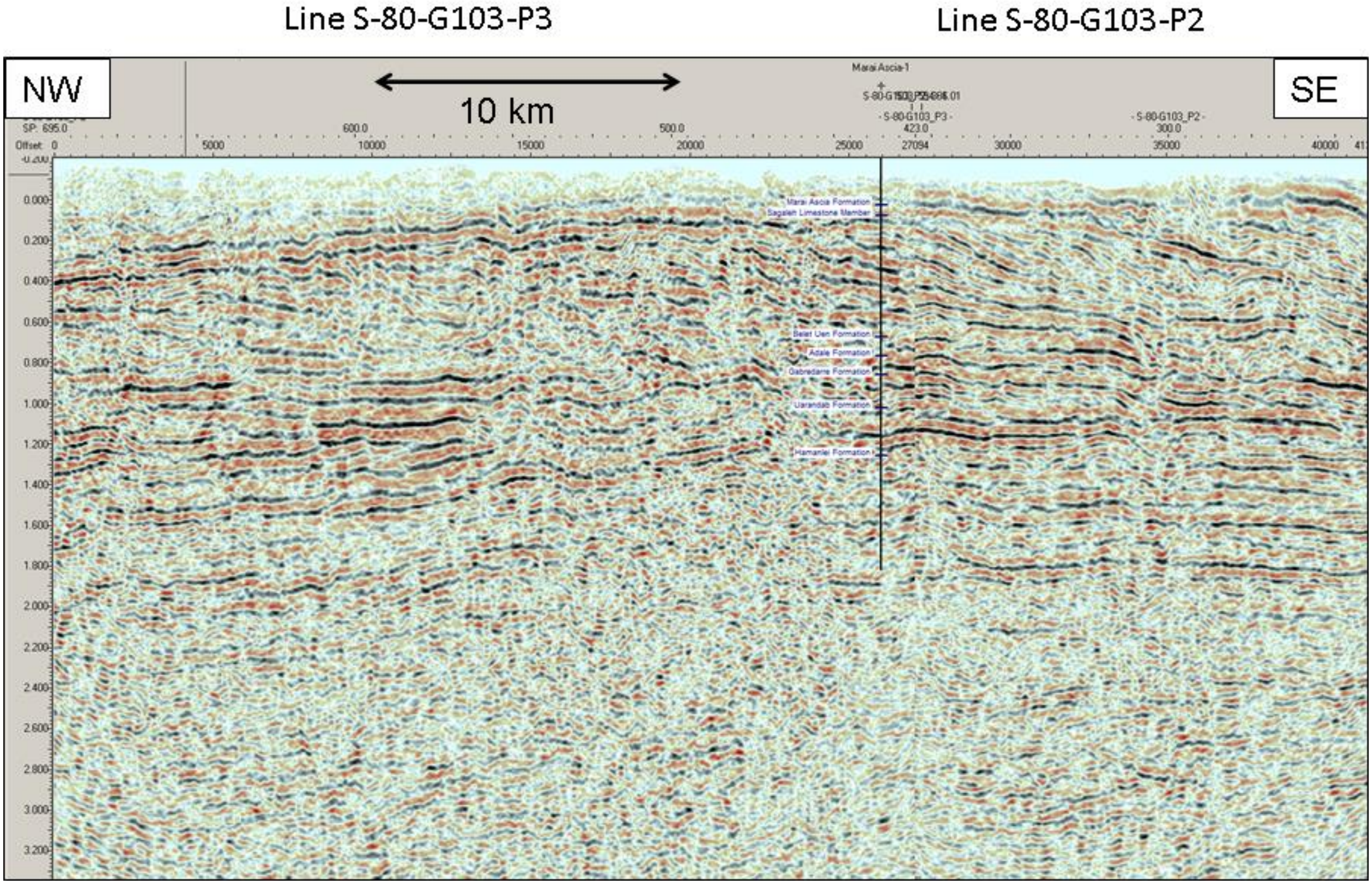


Figure 8.15: Marai Ascia-1 Seismic Lines

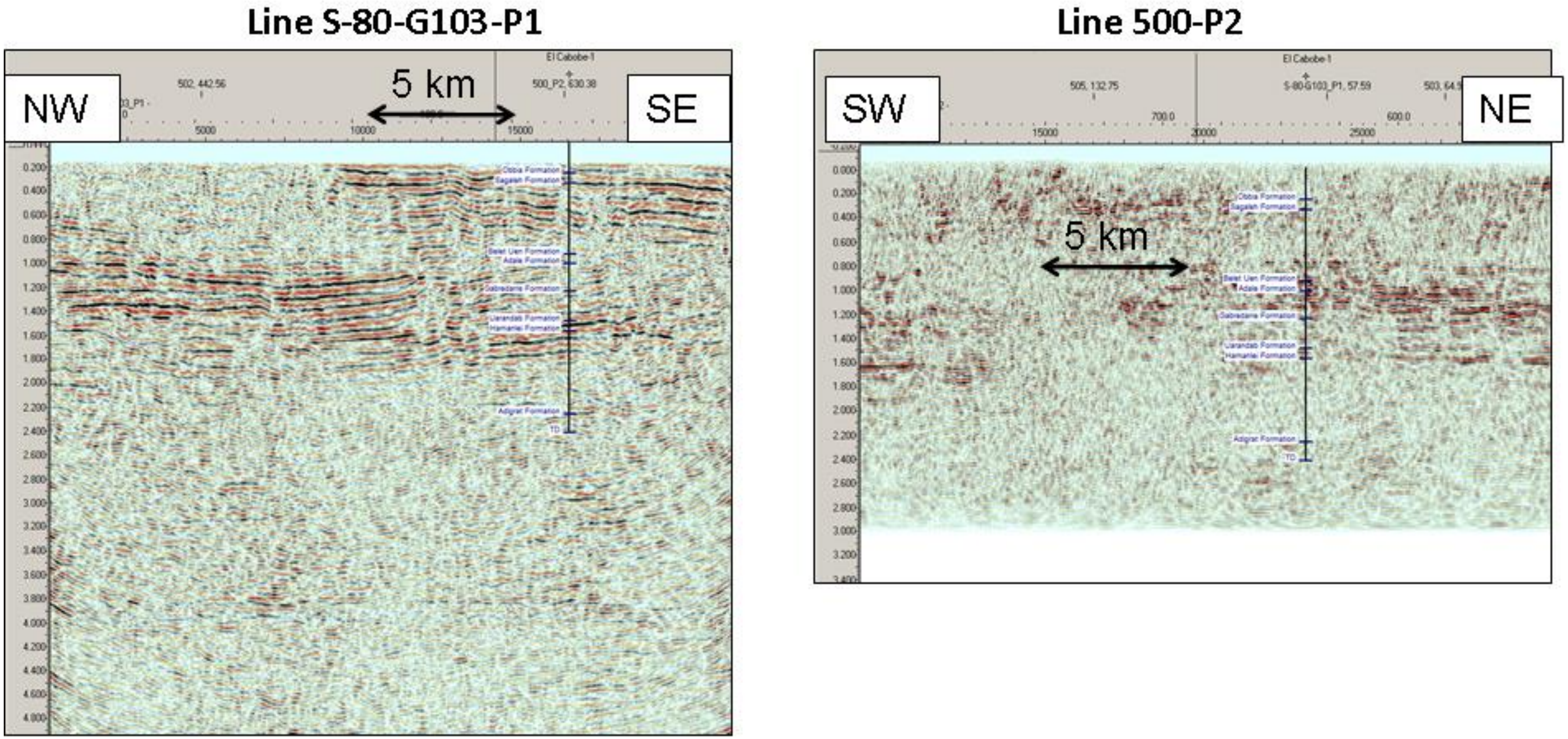


Figure 8.16: El Cabobe-1 Seismic Lines

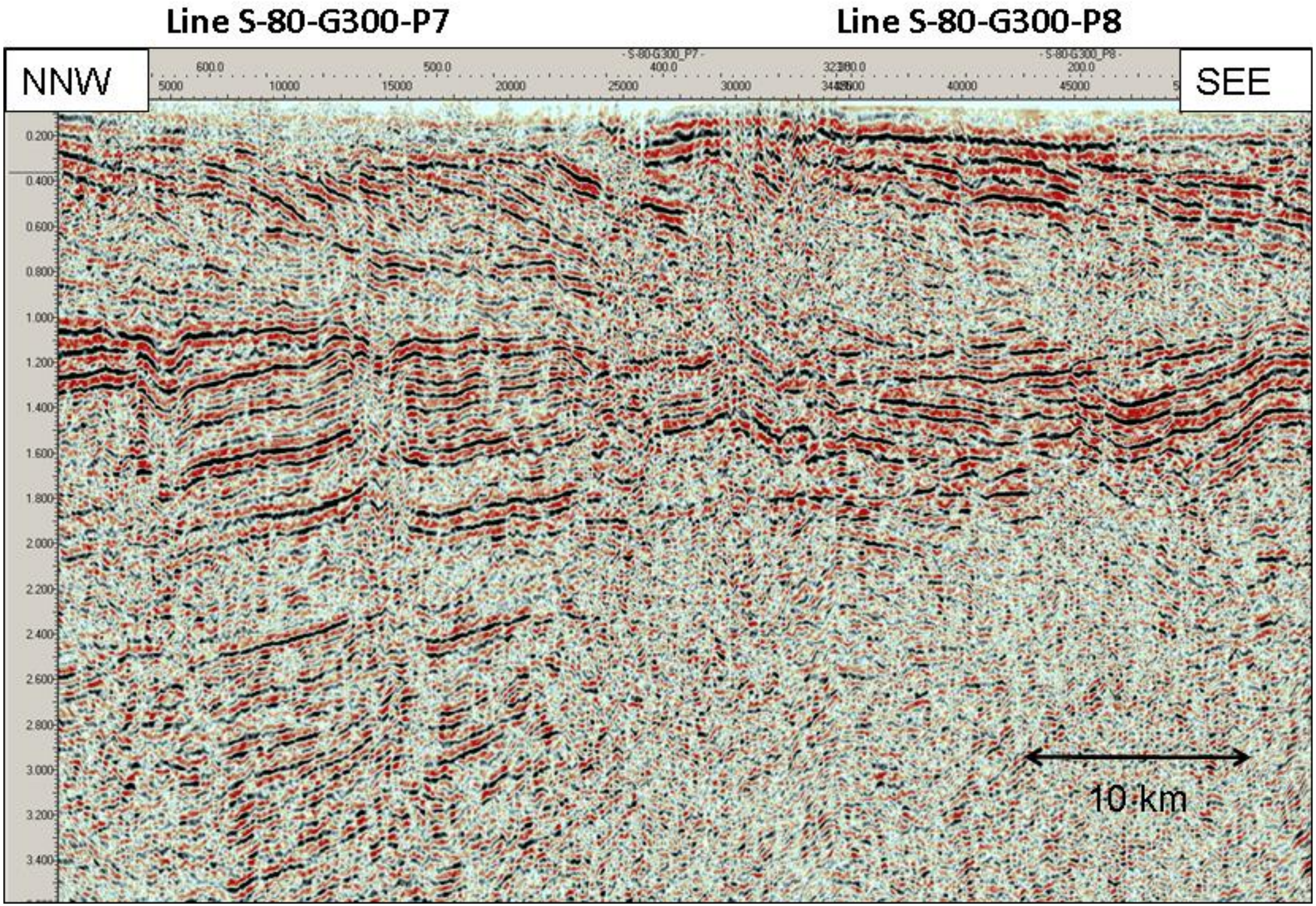


Figure 8.17: Seismic Lines S-80-G300 P7 & P8

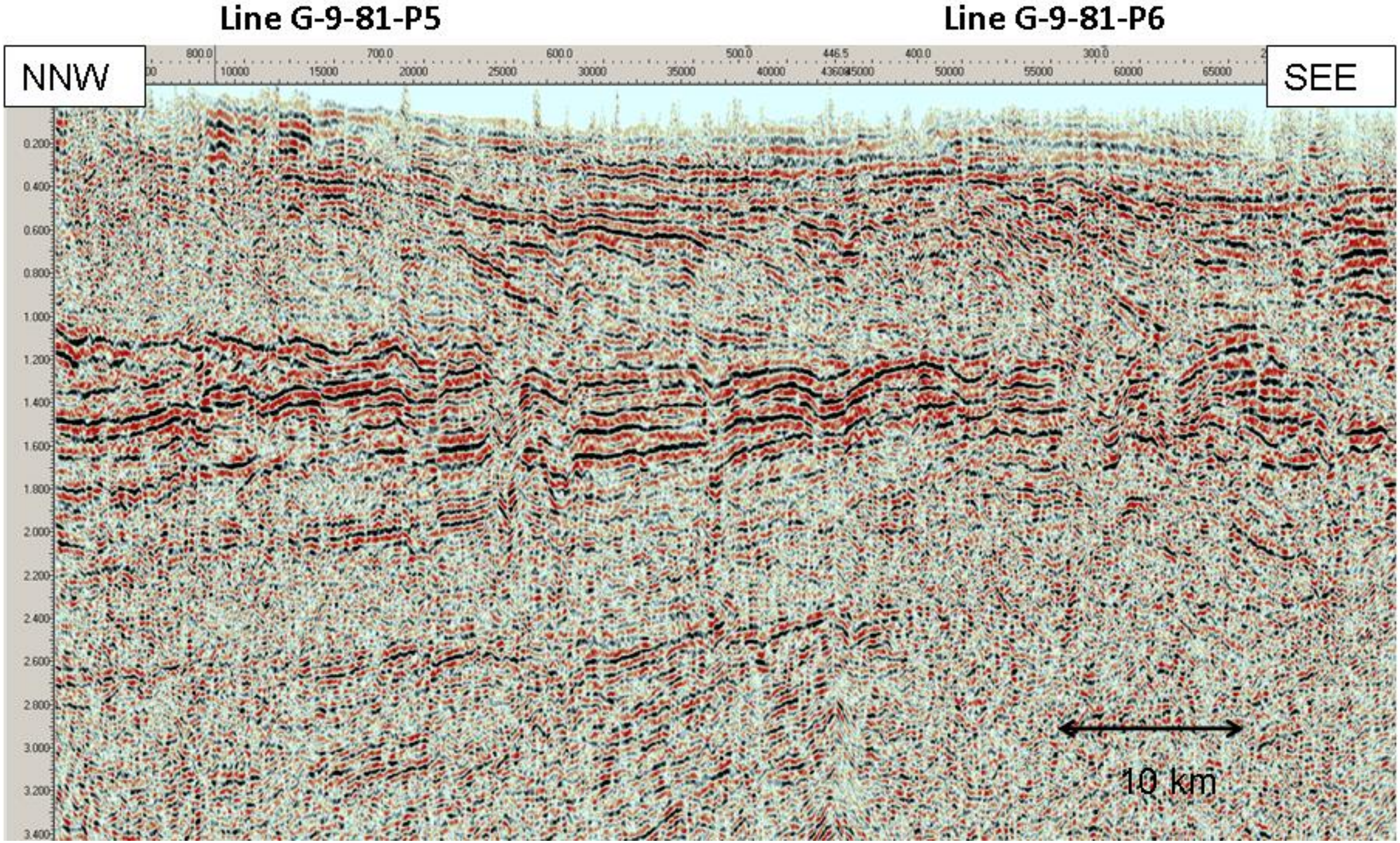


Figure 8.18: Seismic Lines G-9-81 P5 & P6

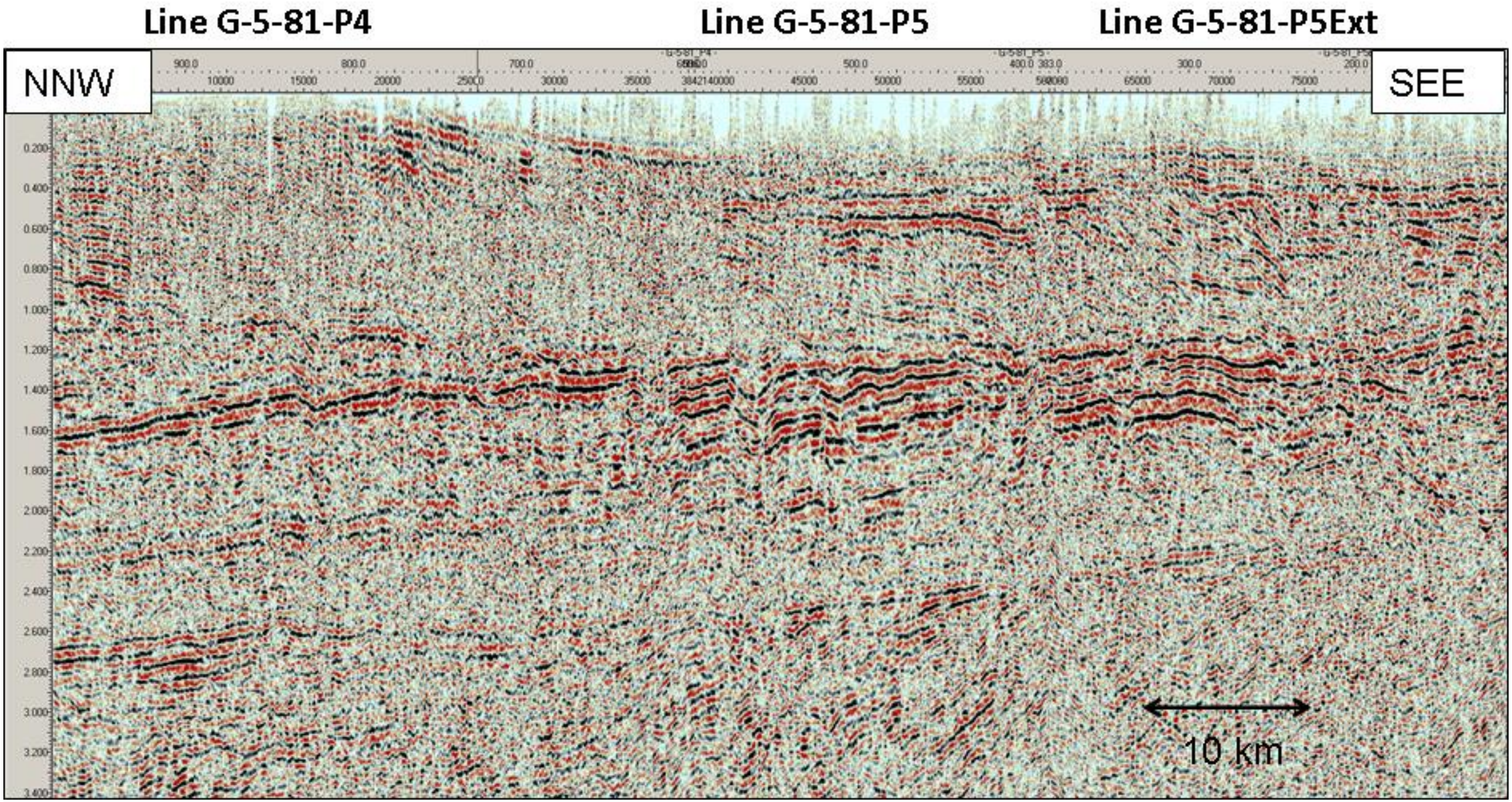


Figure 8.19: Seismic Lines G-5-81 P4,P5 & P5Ext

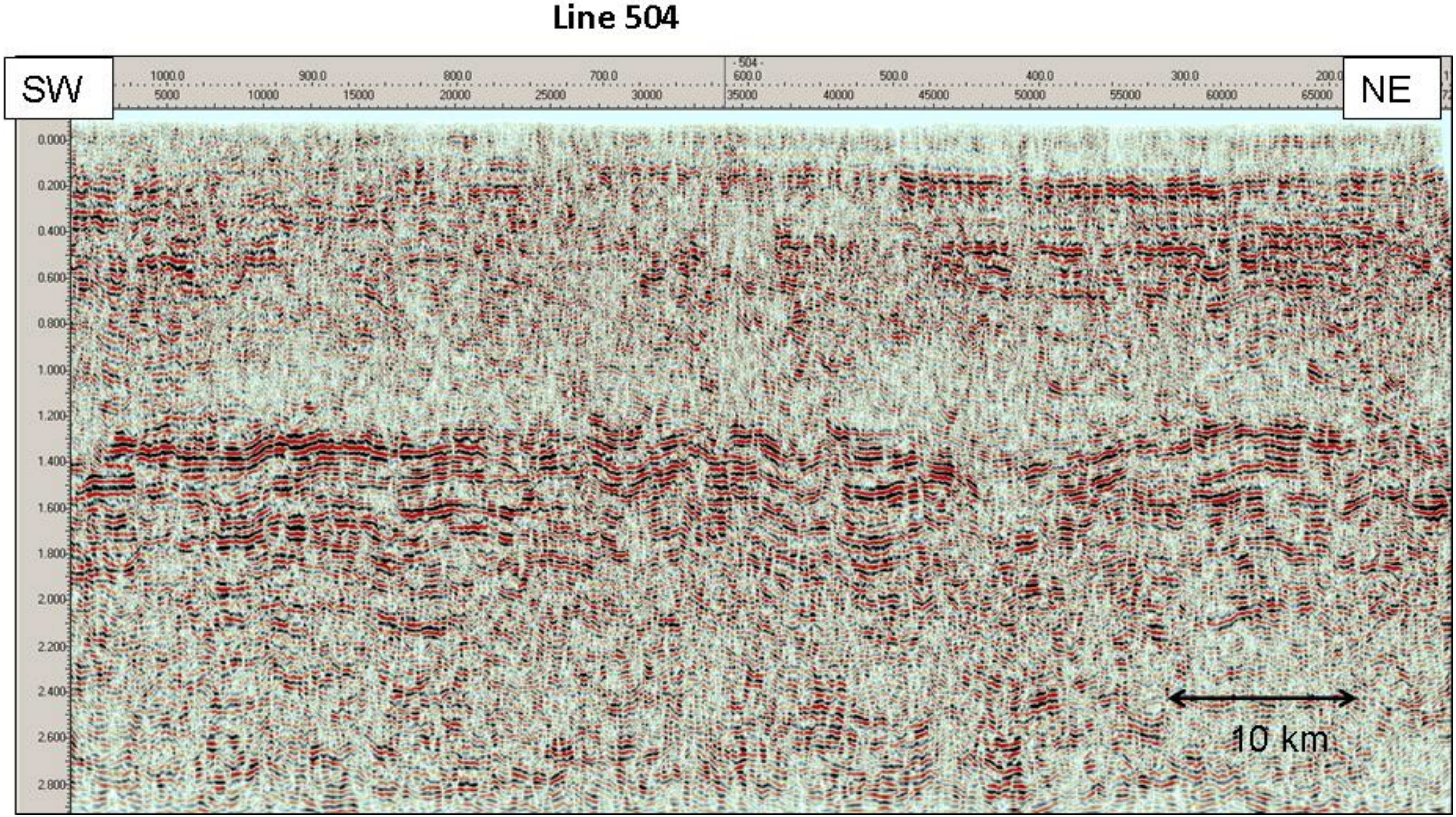


Figure 8.20: Seismic Line 504

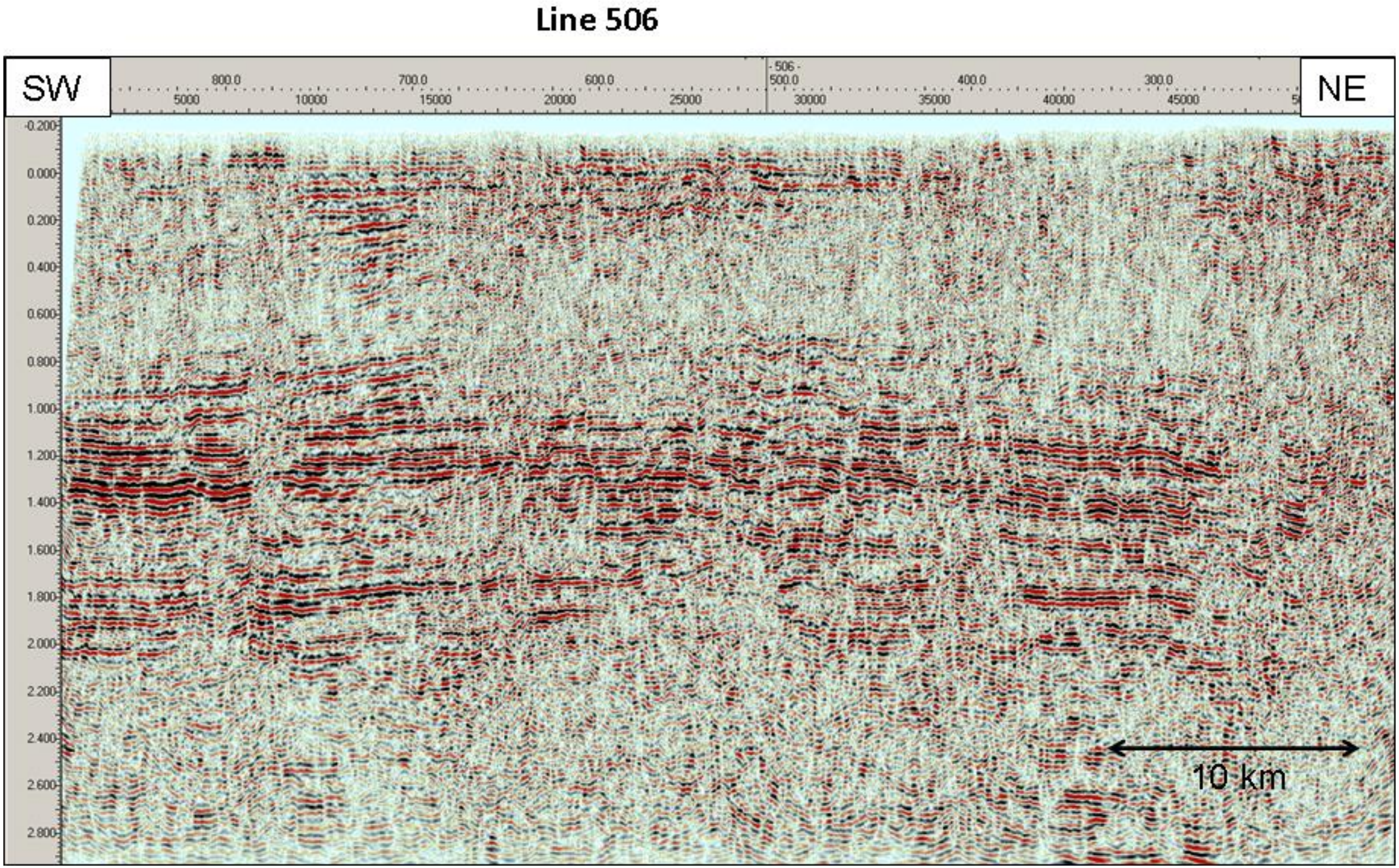


Figure 8.21: Seismic Line 506

9. EXPLORATION SUBAREA 5

9.1 Drilling Results & General Geology

Subarea 5 lies offshore along the northern coast of Somalia stretching from and into waters of Puntland. This area is within the Obbia Basin encompassing the Coastal High.

The data set for this area consists of two wells and over 6,000 line km of 2D seismic data.

The wells drilled in subarea 5 are:-

Garad Mare-1 (AGIP 1977)

Meregh-1 (Esso 1982)

These two wells are the only commercial wells drilled offshore.

The Garad Mere-1 well is offshore Puntland but is a useful tie to the Meregh-1 well.

The available seismic surveys were acquired by several companies:-

Deutsche Ergo in 1969

Conoco in1974 and 1975

Arco in 1980:

Esso in 1982

Elf Aquitaine in 1985

Pecten in 1989

The location of subarea 5 and the available well and seismic data is shown in Figure 9.1

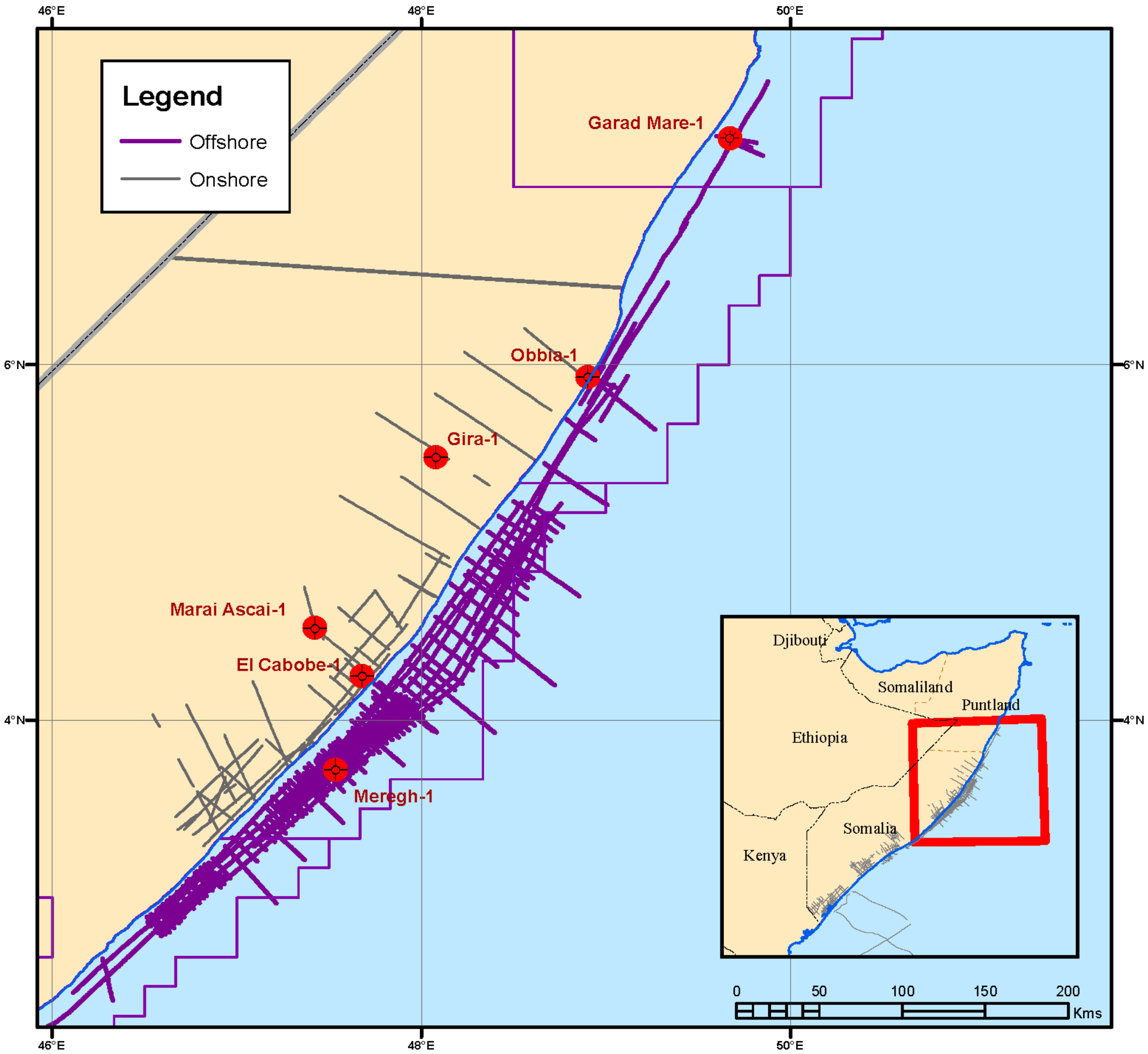


Figure 9.1: Subarea 5 Well and Seismic Database Map

Garad Mare-1 was drilled offshore by AGIP between January and April 1977 to a total depth of 3,921m (12,864ft).

The well was drilled to test a structure and primarily target Mesozoic limestones within the Upper Cretaceous Gira Formation and the Middle Jurassic Hamanlei Formation.

The secondary target was to test possible Palaeogene limestones and sands.

The formation reached at total depth was the Lower Jurassic/Triassic Adigrat Formation.

Stratigraphically the Lower Miocene to Palaeocene shales with minor argillaceous limestones lie unconformably above the Upper Cretaceous Gira Formation down to

1,477.06m (4,846ft). The Gira Formation is also identified as the regional Belet Uen and Cotton Formations. The formation consists of predominantly of limestones with some minor shales.

The Cretaceous lies unconformably at 2,702.05m (8,865ft) on Jurassic sediments of the Uarandab and Hamanlei Formations. The Uarandab Formation is predominantly marly.

The Hamanlei Formation sediments are dominated by oolitic packstones/grainstones before becoming dolomitic towards the base. Interbedded marls and silty mudstones are common throughout the Jurassic section. The well terminates in the continental sands and shales of the Lower Jurassic/Triassic Adigrat Formation.

Reasonable porosity exists in the limestones of the Upper Cretaceous Gira Formation. However the reservoirs were water bearing.

Minor gas shows (C_1 – C_4) were observed towards the base of the Hamanlei Formation, but the limestones were tight.

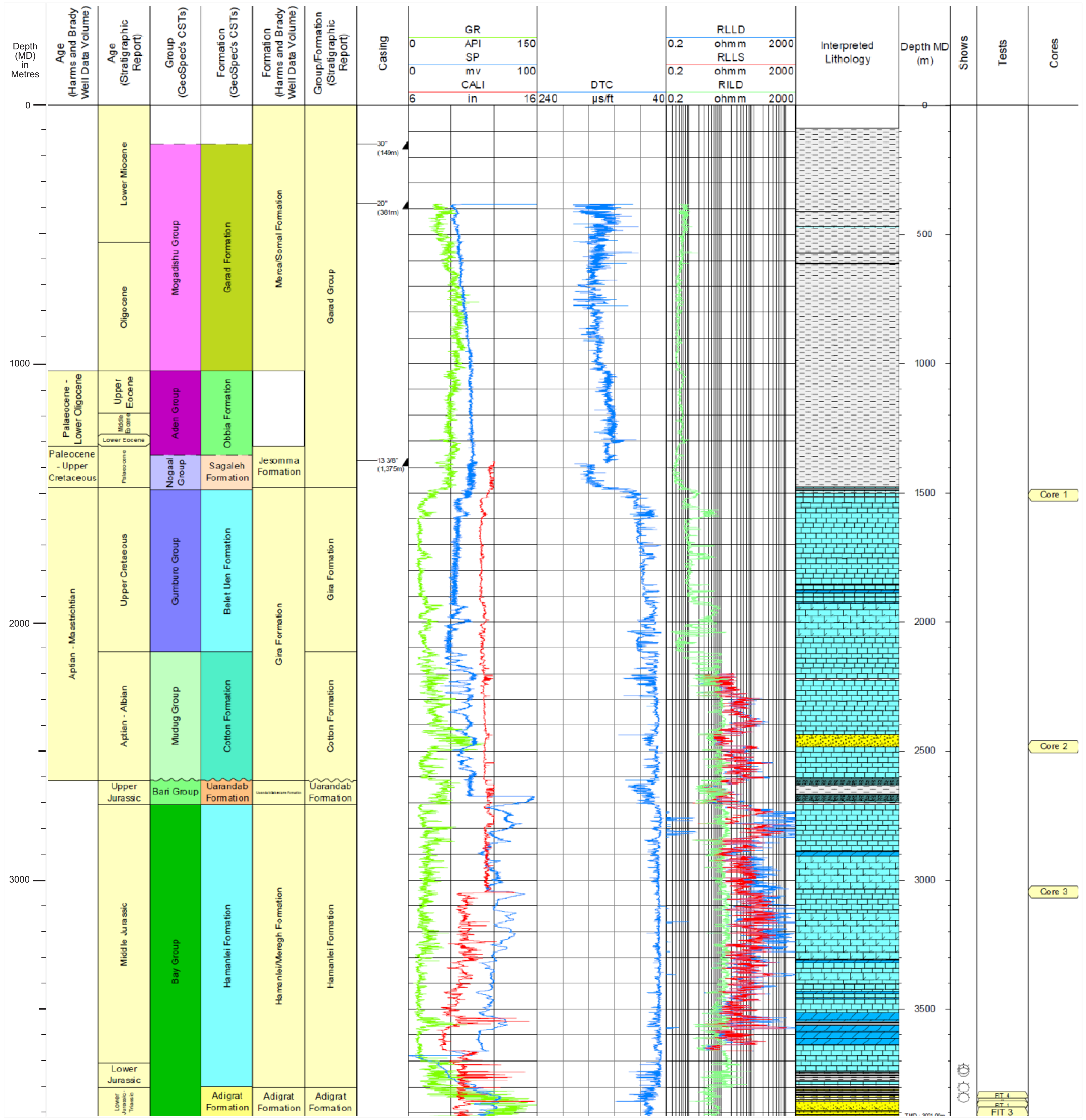
The sands of the Adigrat Formation had low porosity and permeability.

Three cores were taken. Core-1 near the top of the Gira Formation, Core-2 in marly sands near the base of the Gira Formation and Core-3 within the Hamanlei Formation. Four FITs were carried out in the Adigrat Formation.

The well proved the potential of Mesozoic reservoirs and provided evidence of thermogenic source rock. The area is heavily faulted and structures are probably small.

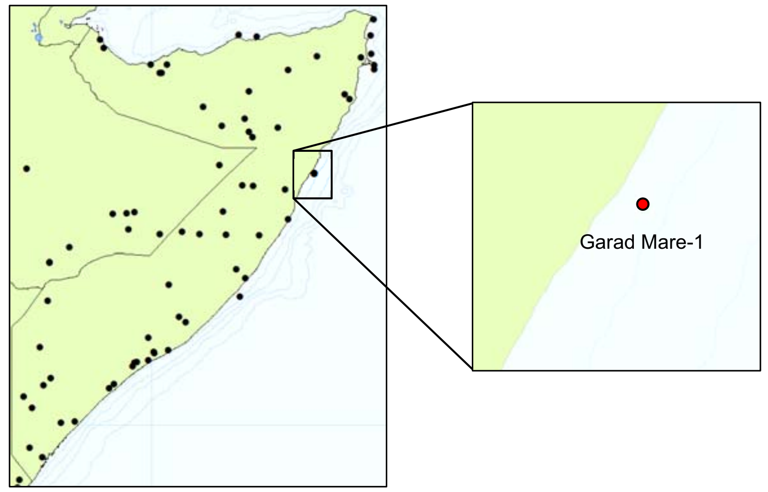
The well was plugged and abandoned as dry with gas shows.

The well summary chart for Garad Mare-1 is shown in Figure 9.2 and a geoseismic line over the well is shown in Figure 9.3.



T.D. 3921m

Garad Mare-1



Garad Mare-1 was drilled offshore East Somalia

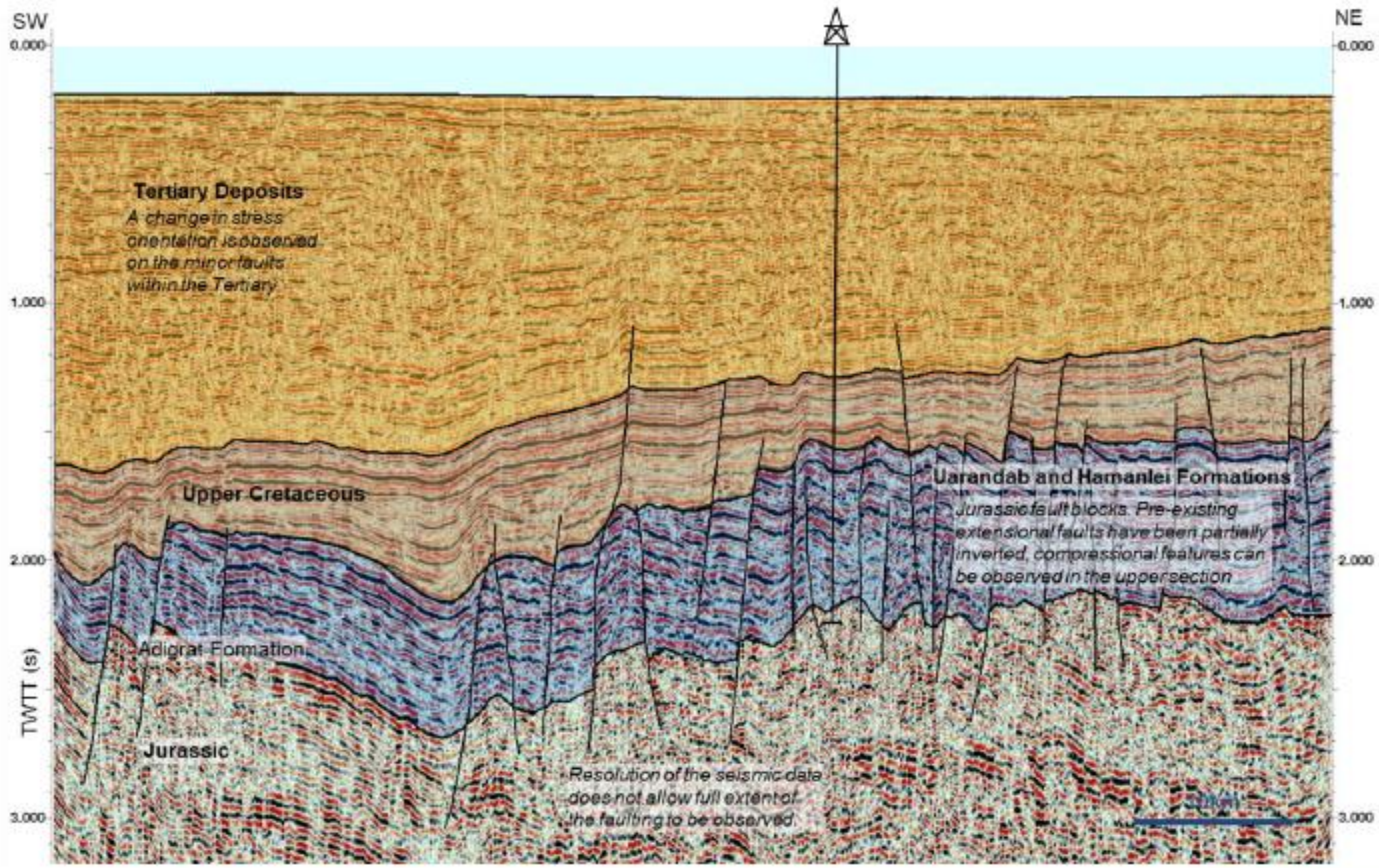
The coordinates for the well are 07° 16' 27.552" N, 49° 40' 17.084"N

Interpreted Lithology

- Argillaceous Sand
- Calcareous Med Sand
- Clay
- Dolomite
- Dolomitic Limestone
- Limestone
- Marl
- Marly Sand

Well Summary Chart, Garad Mare-1 **Figure 9.2**

Operator		
AGIP		
Coordinates		
07° 16' 27.552" N 49° 40' 17.084" E		
RT	**WD**	**TD**
13.35m 44ft	74.65m 245ft	3,921m 12,864ft
Spud Date	**Completion Date**	
16-Jan-1977	03-Apr-1977	
Shows	**Tests/Cores**	
Minor gas (C_1 - C_3)	4 FITs; 3 Cores	
Status		
Dry; Plugged and Abandoned		



The **Geoseismic Section** summarises the well targets and the main stratigraphy of the area. It shows large scale faulting that affects the Cretaceous and Jurassic sections. The Tertiary section is predominantly shale with some argillaceous limestone. This lies unconformably on top of the Cretaceous limestone, the well's primary objective. The secondary objective, the carbonates of the Hamanlei Formation, sit at the top of Jurassic section and are sealed by the Upper Jurassic Uarandab Formation. Beneath this, shales and interbedded sands dominate the Adigrat Formatipn.

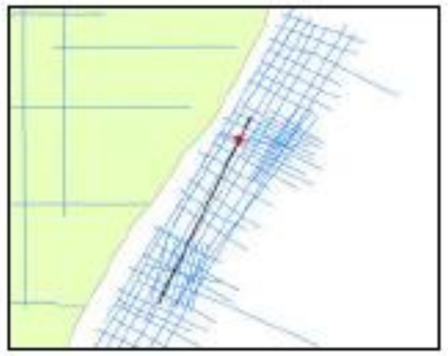


Figure 9.3: Garad Mare-1 Geoseismic Line

Meregh-1 was drilled by Esso between August and November 1982 to a total depth of 4,298m (14,100ft). This was drilled on a tilted fault block defined by recently acquired seismic data. The objective was to test the potential of Jurassic carbonates and dolomites of the Hamanlei Formation. These were expected to be reefal or deposited on the edge of a high energy bank. The seal was to be provided by the interbedded shales of the Upper Jurassic Uarandab Formation.

The well reached the Meregh Facies of the Middle/Upper Jurassic Hamanlei Formation at TD.

The Upper Tertiary sequence from 0 to 329.79m (0 – 1,082ft) consisted of limestones assigned to the Miocene Somal Formation. These lie unconformably on the shallow water carbonates, clays and shales of the Middle Eocene Obbia Formation from 329.79 to 604.72m (1,082 – 1,984ft).

Underlying the Obbia Formation is the deep water Palaeocene facies deposited upon Upper Cretaceous shales and clays of the Sagaleh Formation from 604.72 to 914.1m (1,984 – 2,999ft).

These shales and clays become more calcareous in the Upper Cretaceous.

By the Lower Cretaceous, reached at 1,172.26m (3,846ft), these shales dominate the sequence with interbeds of carbonates, marls and claystones.

The Cretaceous lies unconformably on the Upper Jurassic Uarandab Formation shales at 1,411.53m (4,631ft).

The Jurassic Hamanlei Formation was reached at 1,554.48m (5,100ft). This was comprised of outer shelf to bathyal micritic limestone.

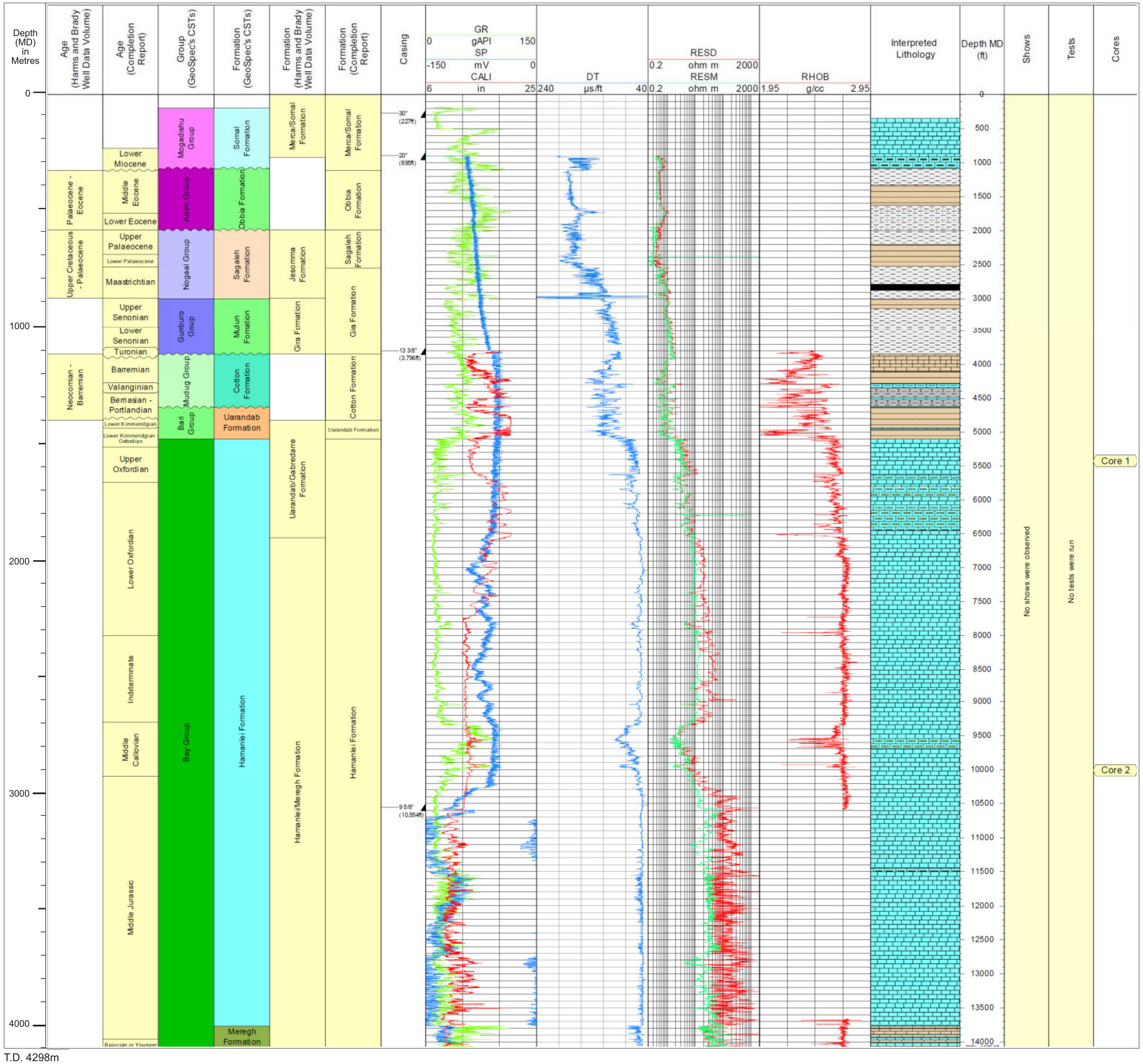
The Hamanlei Formation had very low porosities, decreasing from 2% - 4% to 0% 1% at depth. Good levels of porosity (less than 25%) were observed in Tertiary and Cretaceous sands though these were water bearing.

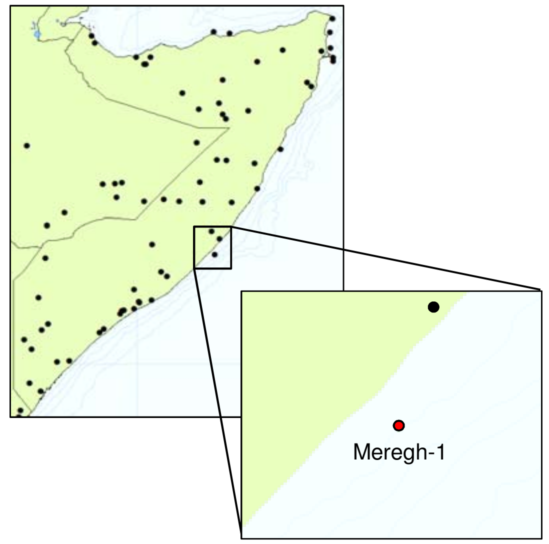
No shows were encountered in the well and DSTs were run. Two cores were cut within the Hamanlei Formation.

The well was plugged and abandoned as dry.

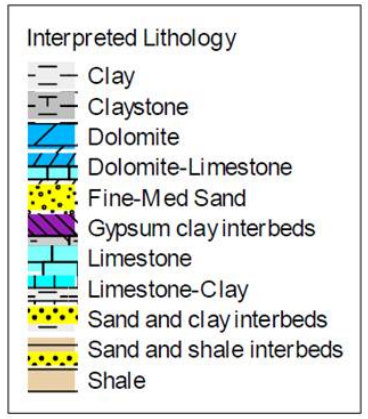
The well summary chart for Meregh-1 is shown in Figure 9.4 and a geoseismic line over the well is shown in Figure 9.5.

Meregh-1

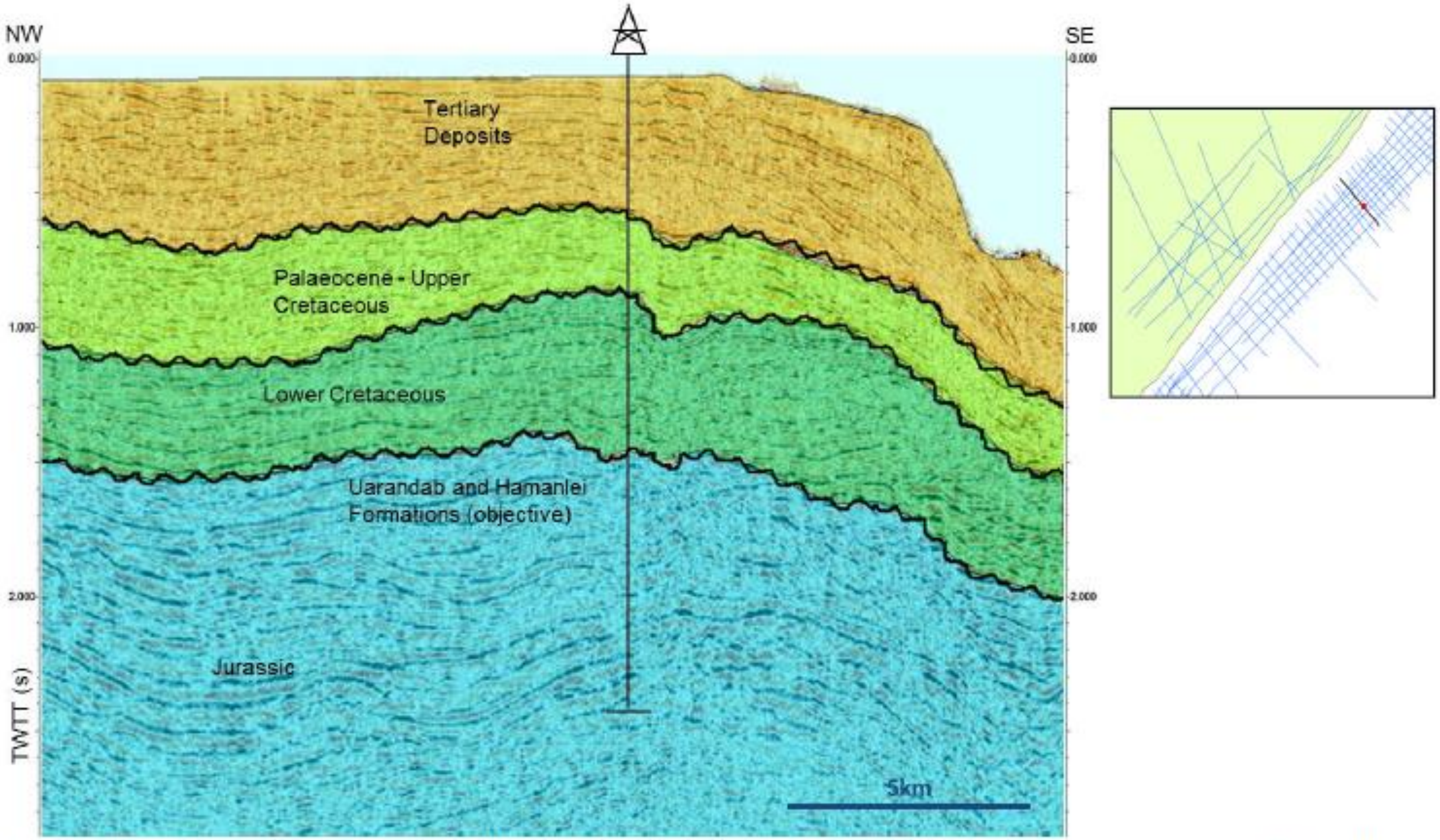




Meregh-1 was drilled offshore east Somalia, and is located at 03° 43' 12.239'' N, 47° 32' 03.661'' E



Well Summary Chart, Meregh-1 **Figure 9.4**



The **Geoseismic Section** summarises the well target and the main stratigraphy of the area. It clearly shows three main regional unconformities dividing the stratigraphic sequences. The Tertiary consisted of limestones lying on shallow water clays and shales. These sediments became more calcareous with depth; by the Lower Cretaceous shales were dominant. The Hamanlei Formation and the overlying Uarandab Formation, consisting of limestone and shales, were found at the top of the Jurassic section.

Figure 9.5: Meregh-1 Geoseismic Line

9.2 Seismic Examples

A selection of 2D Seismic Lines is presented within this section (Figure 9.7 to Figure 9.16). The lines show a good representation of the structure and stratigraphy within Subarea 5. The seismic is of good quality. The locations of the following seismic examples are shown in Figure 9.6.

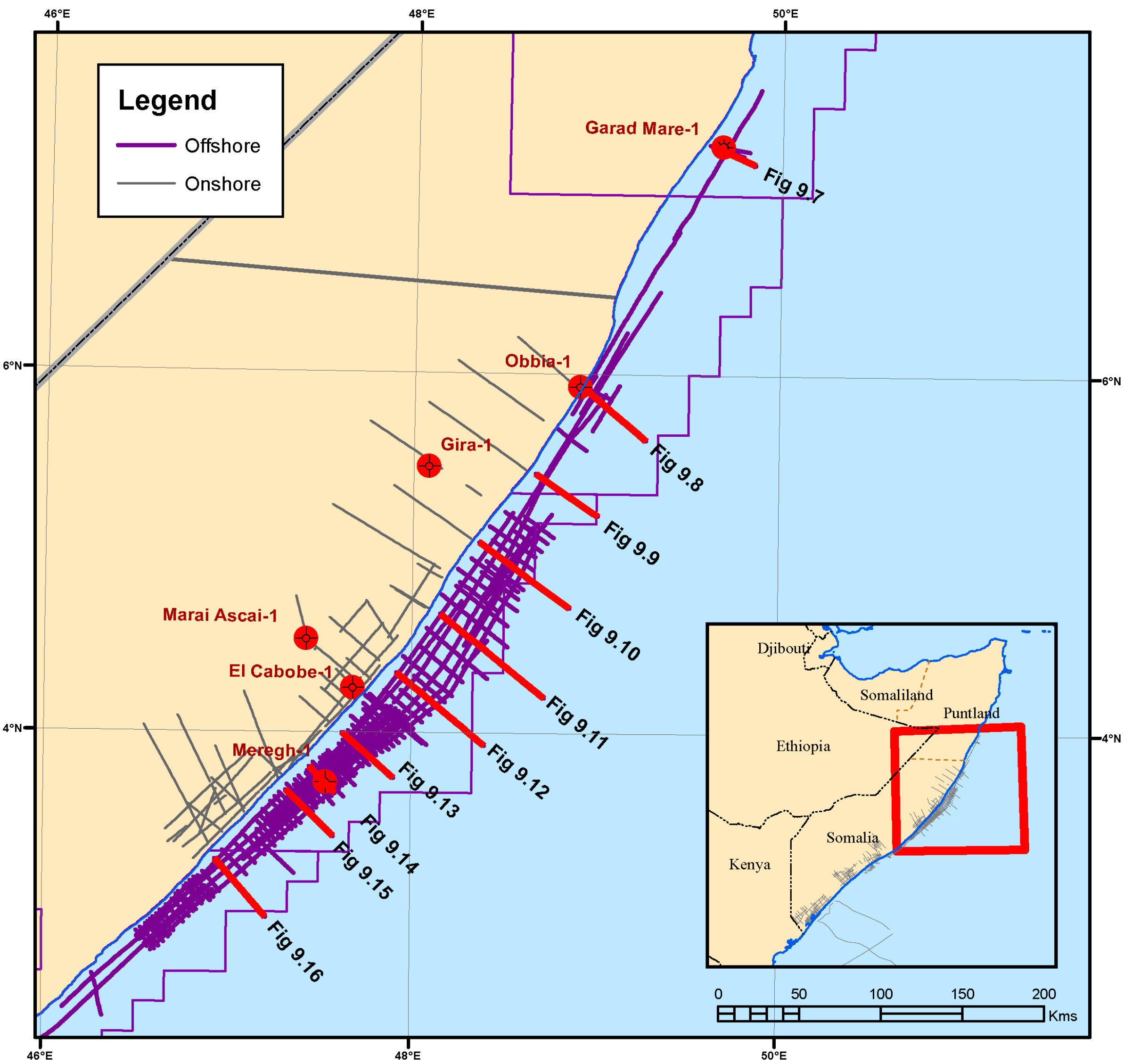


Figure 9.6: Subarea 5 Location of seismic lines

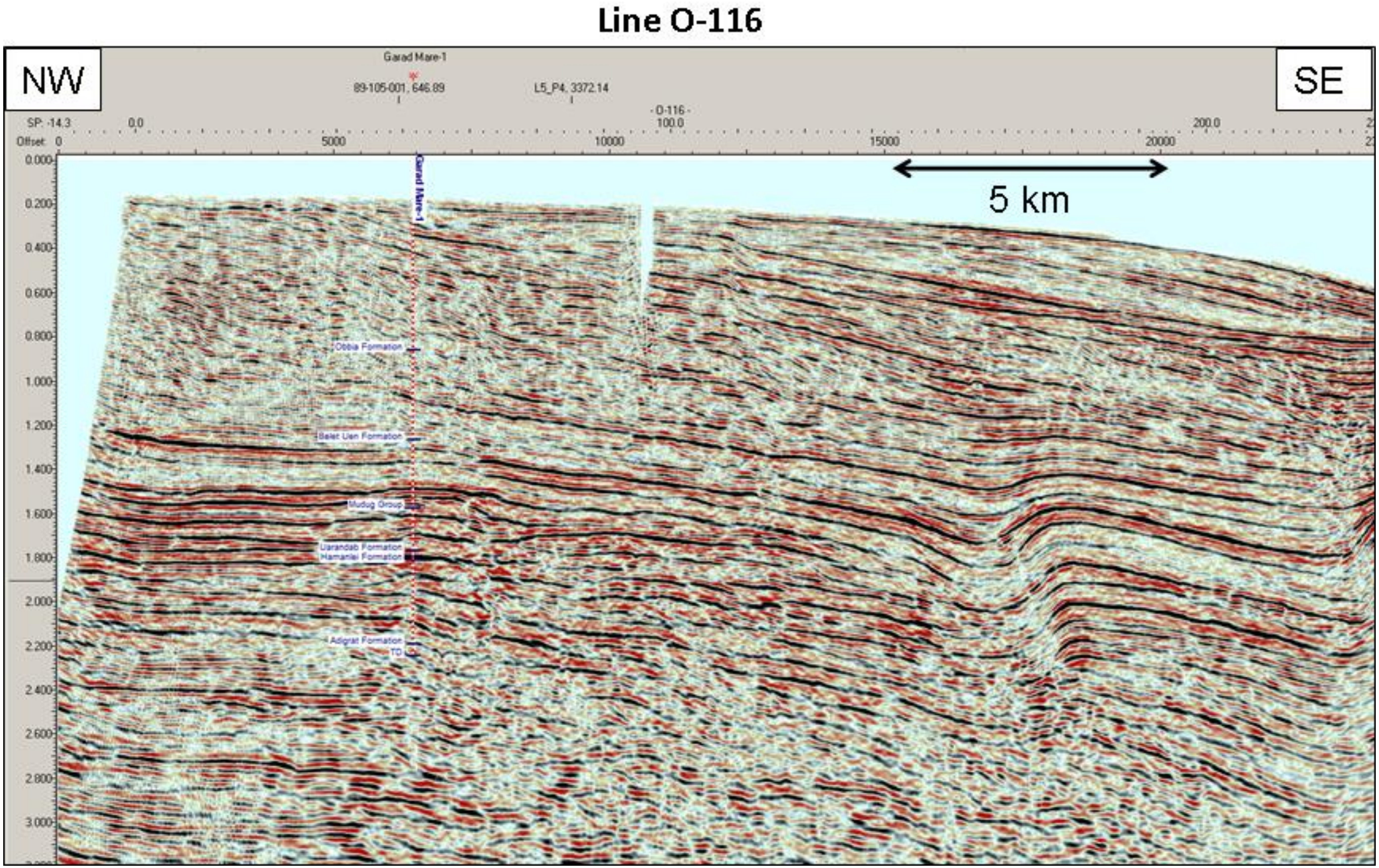


Figure 9.7: Garad Mare-1 Seismic Line O-116

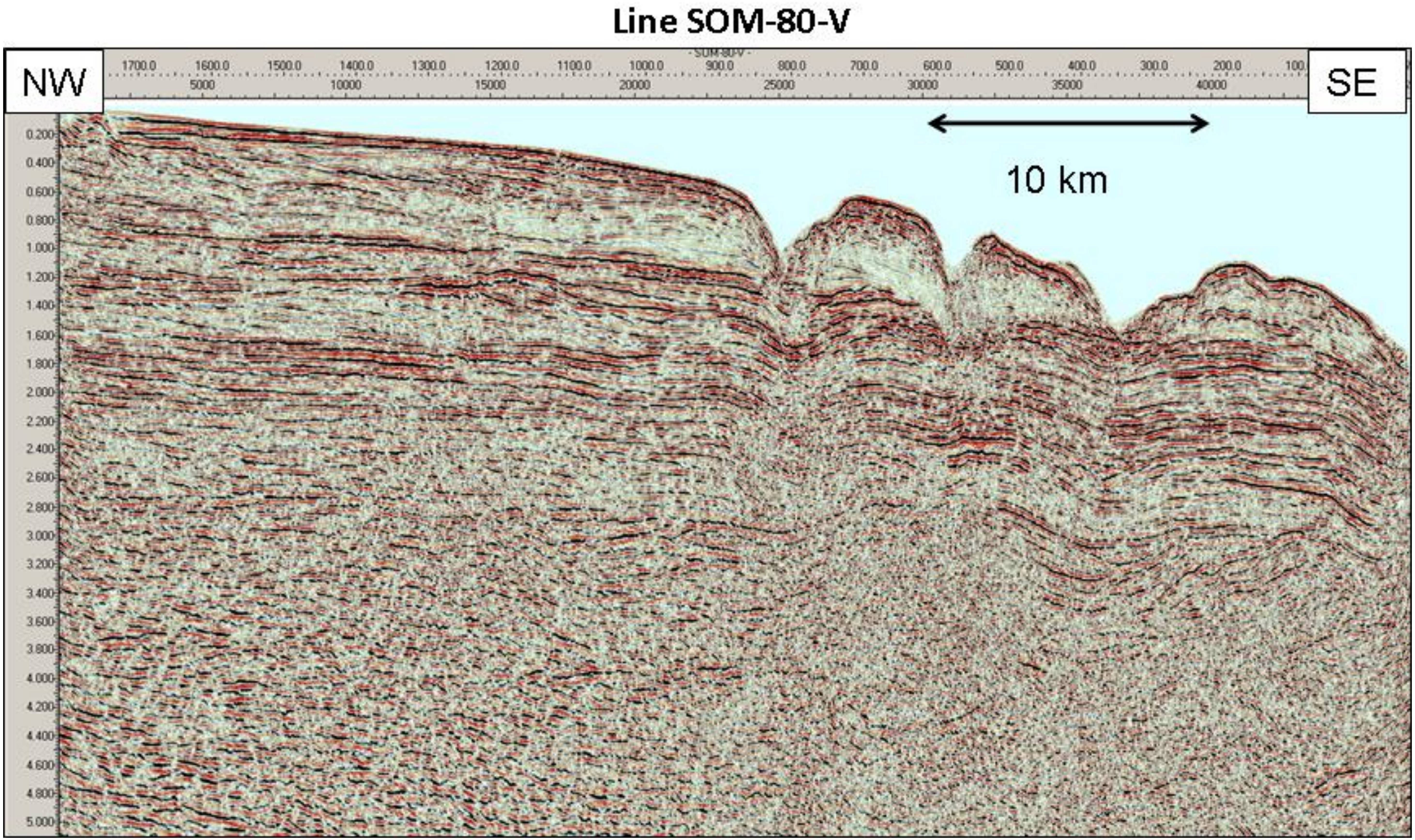


Figure 9.8: Seismic Line SOM-80-V

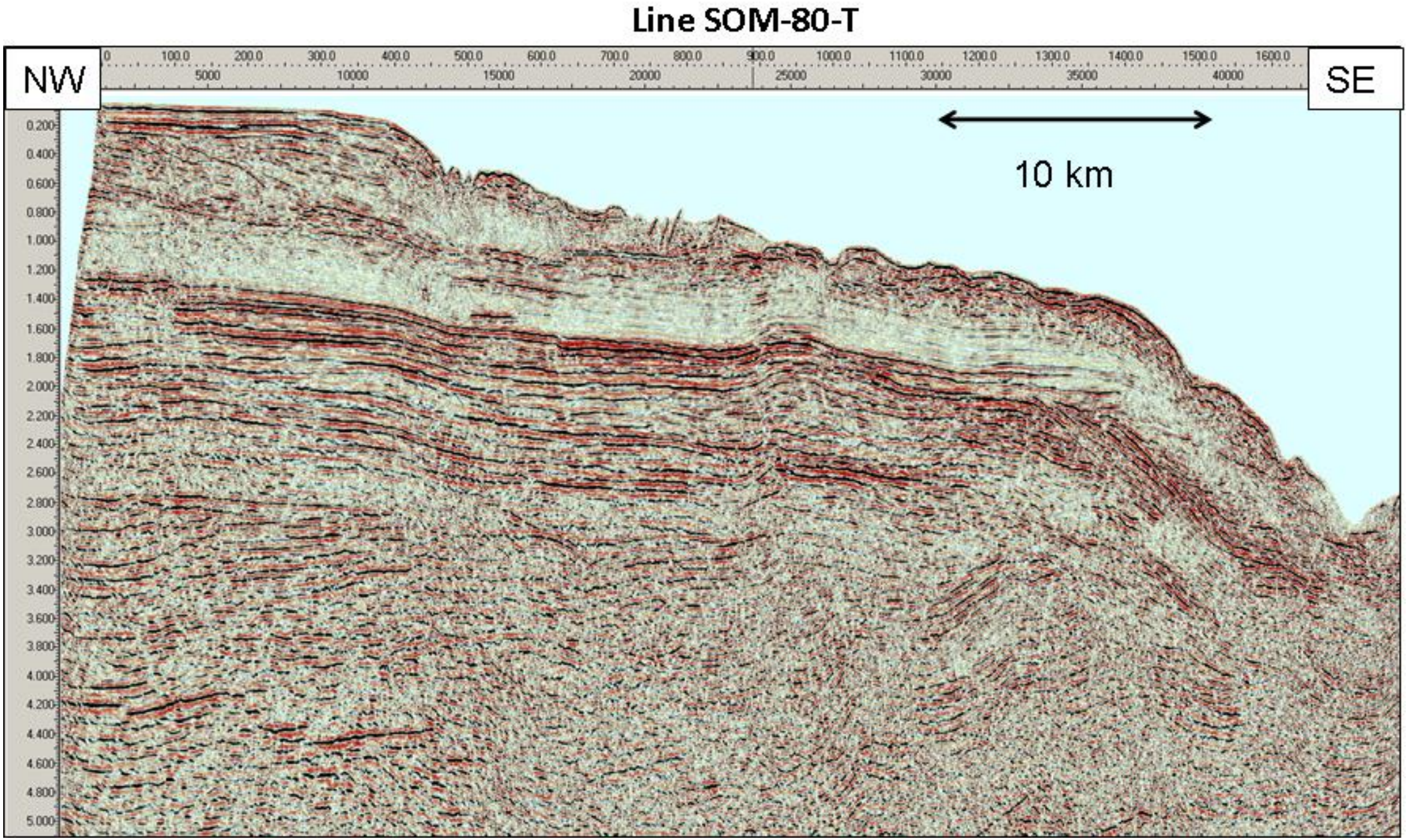


Figure 9.9: Seismic Line SOM-80-T

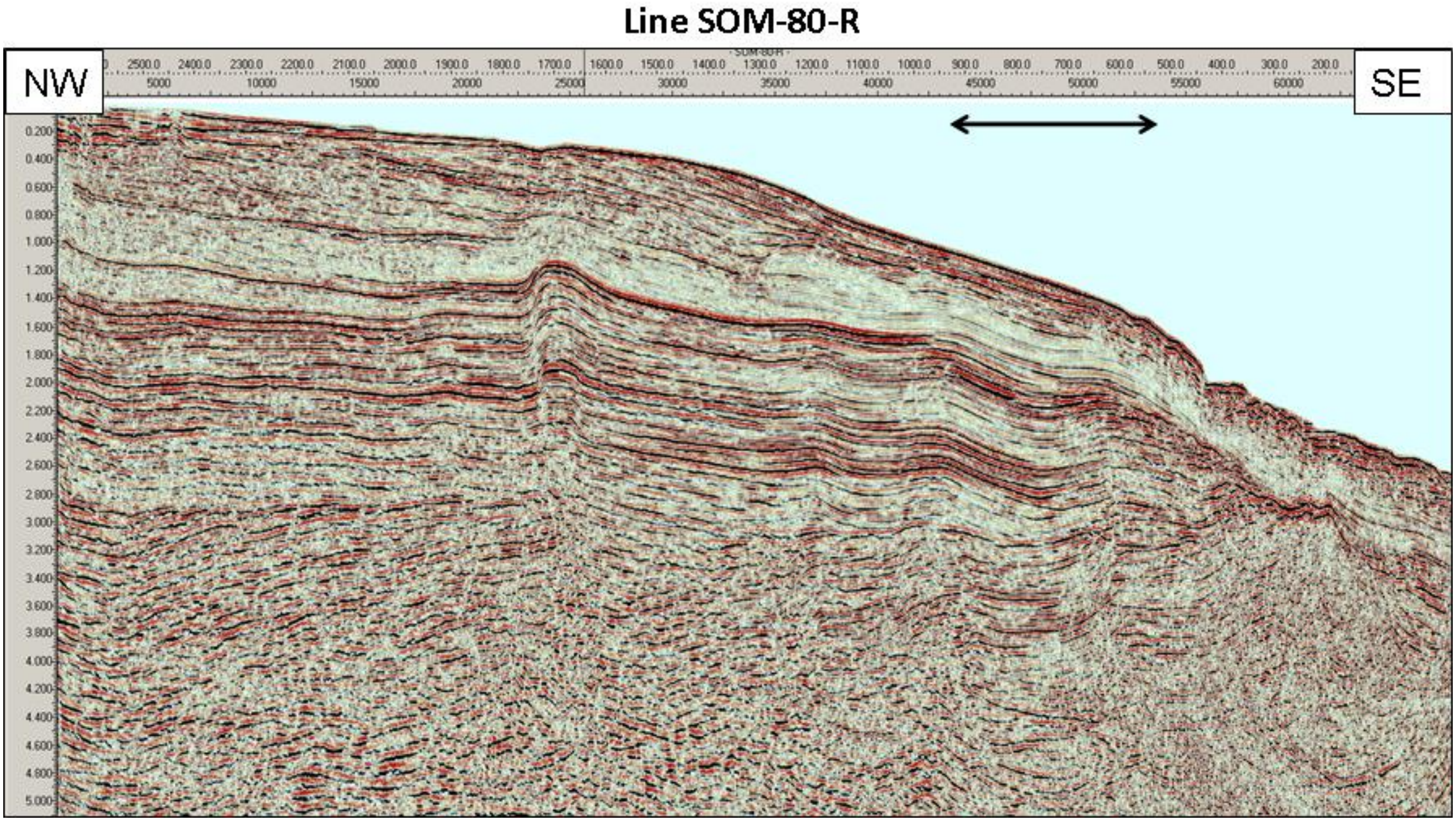


Figure 9.10: Seismic Line SOM-80-R

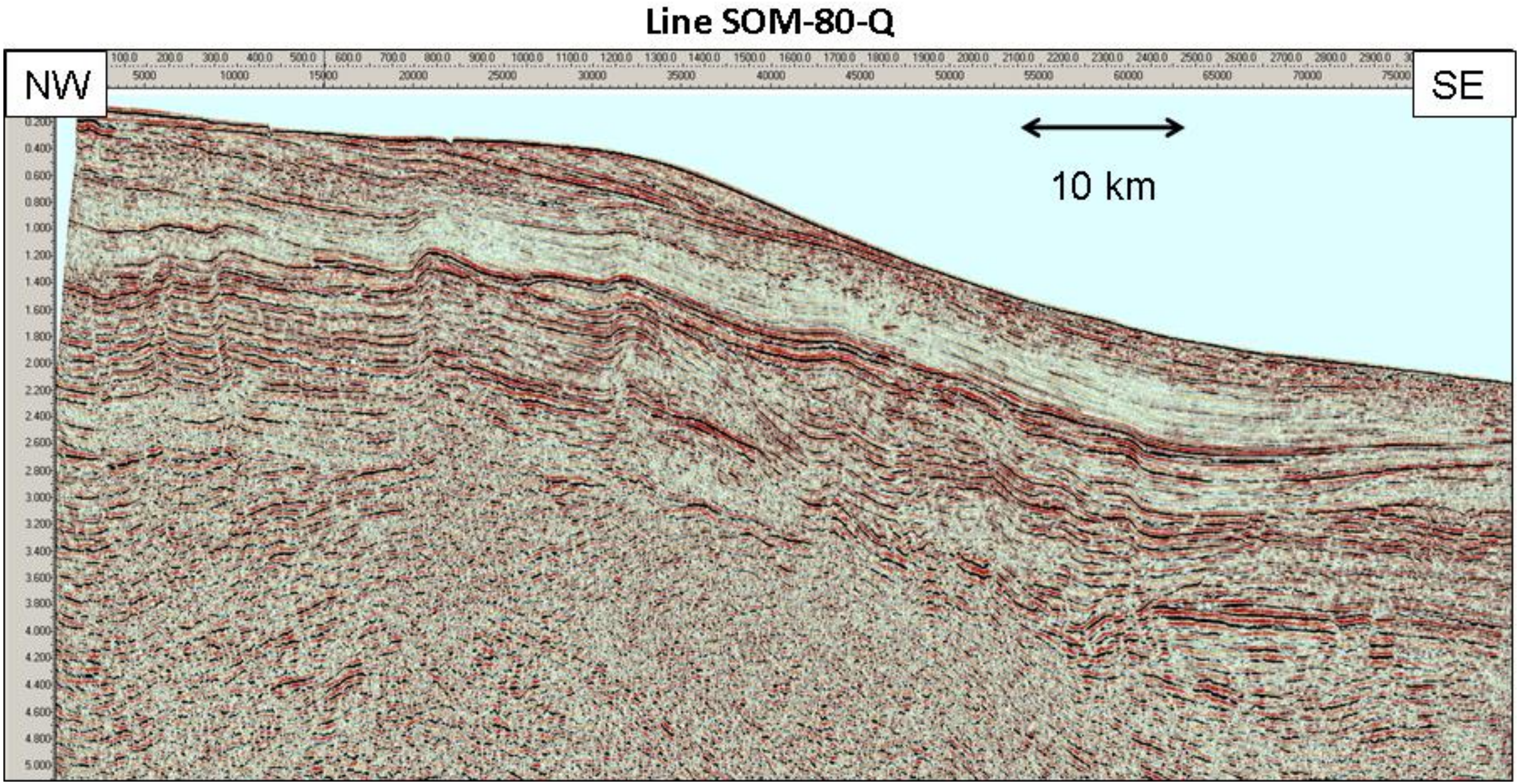


Figure 9.11: Seismic Line SOM-80-Q

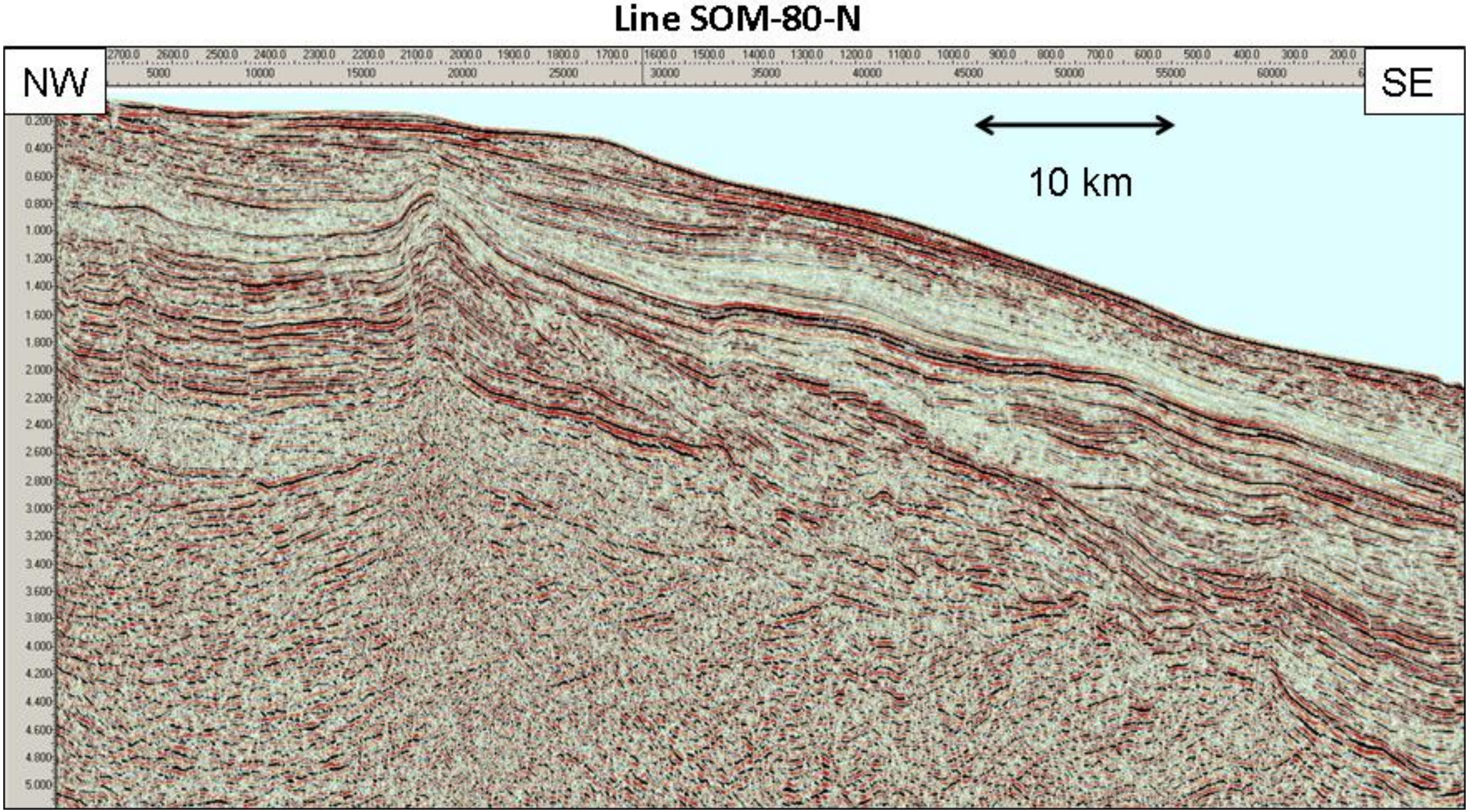


Figure 9.12: Seismic Line SOM-80-N

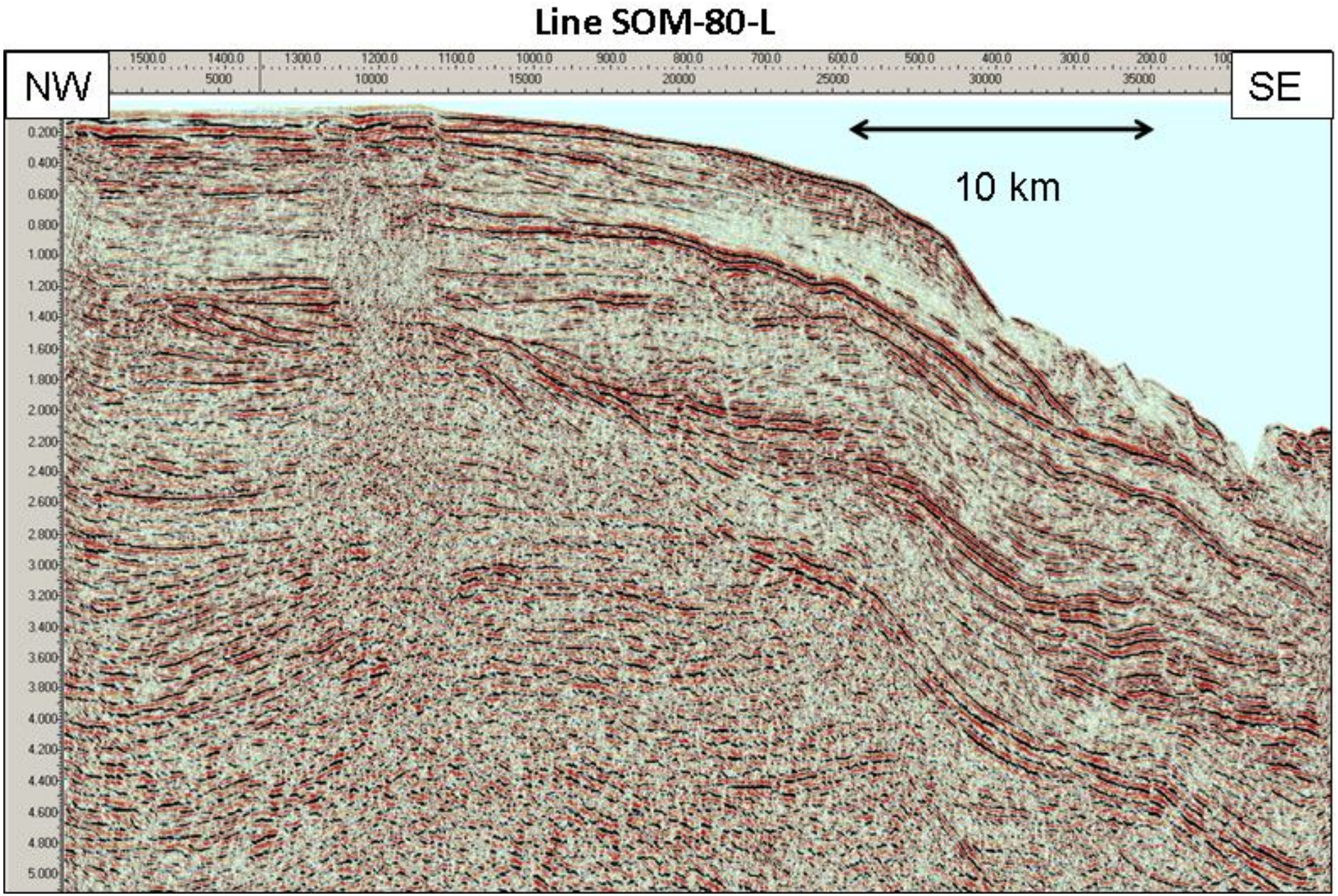


Figure 9.13: Seismic Line SOM-80-L

Line SOM-80-J

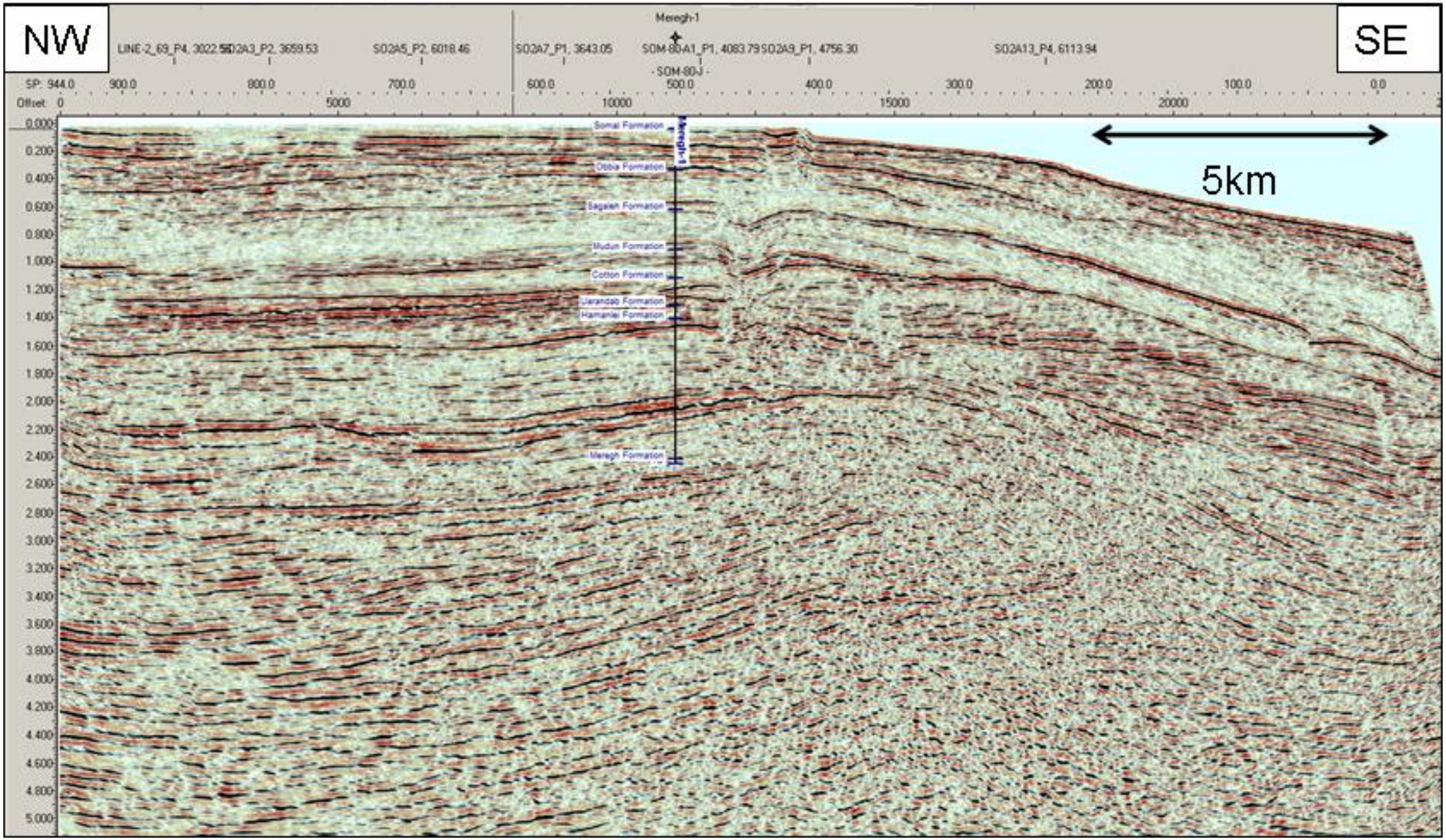


Figure 9.14: Meregh-1 Seismic Line SOM-80-J

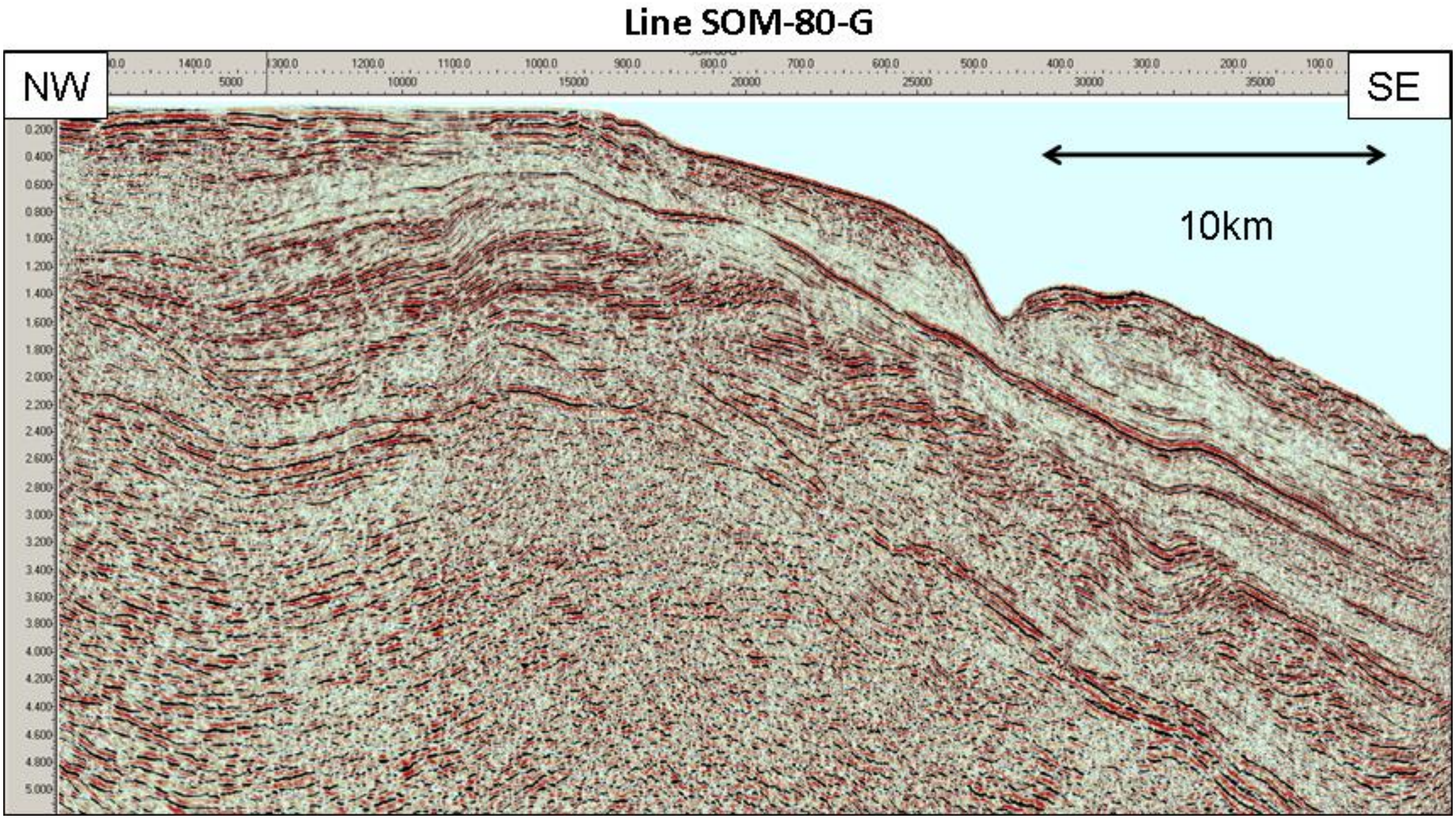


Figure 9.15: Seismic Line SOM-80-G

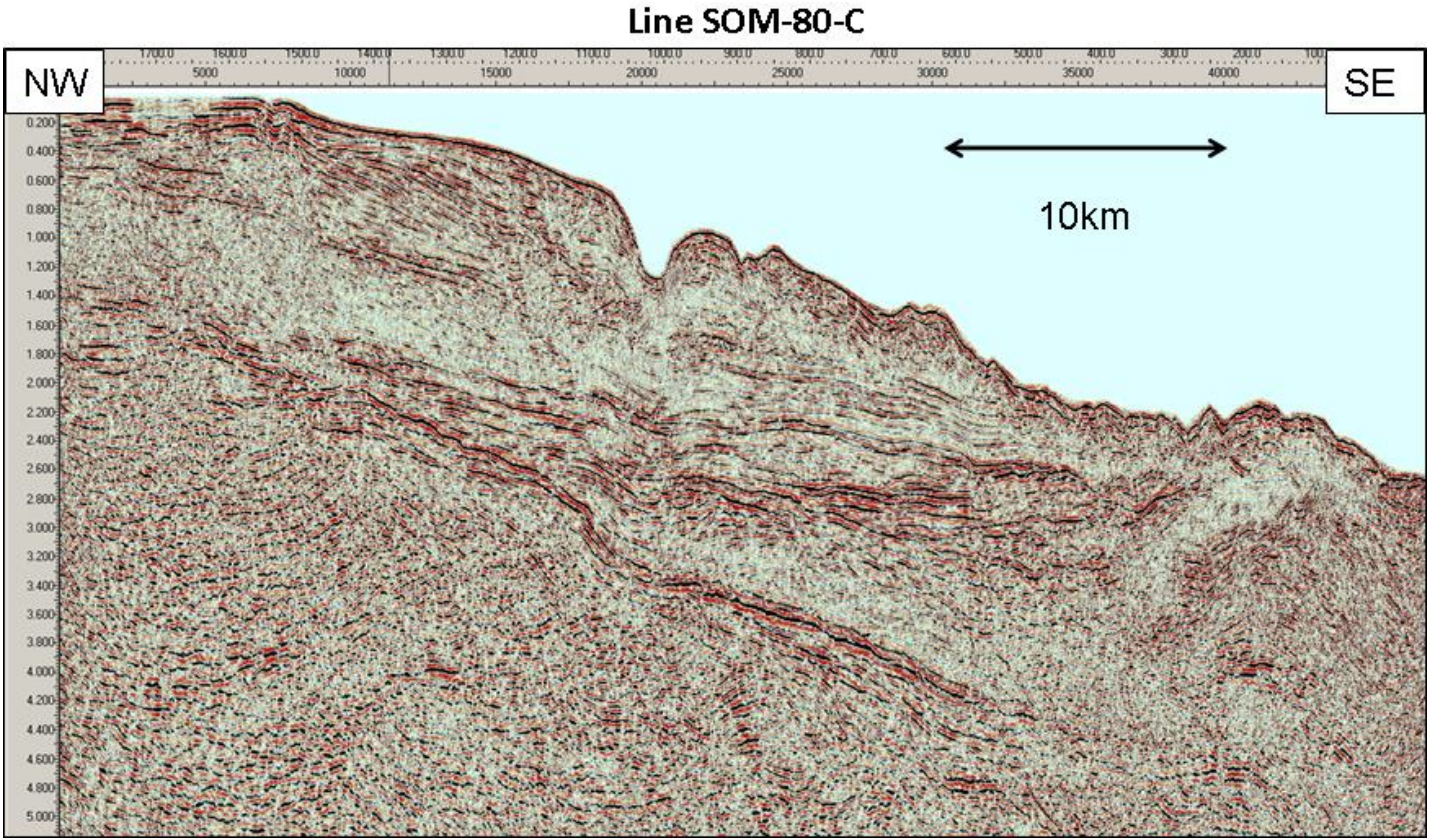


Figure 9.16: Seismic Line SOM-80-C

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