Sudan University of Science and Technology
College of Petroleum Engineering and Mining
Exploration Engineering Department

Title :

CONSTRUCTION OF SYNTHETIC SEISMOGRAM IN ABU SUFYAN OIL FIELD

إنشاء مخطط زلزالي اصطناعي في حقل أبو سفيان النفطي

Graduation project Submitted in Partial Fulfillment for the degree of
B.Tech Degree in Exploration Engineering

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الإستـهلال

قال تعالى :

(اللَّهُ لَا إِلَٰهَ إِلَّا هُوَ الْحَيُّ الْقَيُّومُ ۚ لَا تَأْخُذُهُ سِنَةٌ وَلَا نَوْمٌ ۚ لَّهُ مَا فِي السَّمَاوَاتِ وَمَا فِي الْأَرْضِ ۗ مَن ذَا الَّذِي يَشْفَعُ عِندَهُ إِلَّا بِإِذْنِهِ ۚ يَعْلَمُ مَا بَيْنَ أَيْدِيهِمْ وَمَا خَلْفَهُمْ ۖ وَلَا يُحِيطُونَ بِشَيْءٍ مِّنْ عِلْمِهِ إِلَّا بِمَا شَاءَ ۚ وَسِعَ كُرْسِيُّهُ السَّمَاوَاتِ وَالْأَرْضَ ۖ وَلَا يَئُودُهُ حِفْظُهُمَا ۚ وَهُوَ الْعَلِيُّ الْعَظِيمُ)

سورة البقرة – الاية (255)

صدق الله العظيم

Dedication

It’s my second home where I belong.

I thank you for everything I learned inside you and what I’ve become.

Sudan University of science and technology

She is precious in every way.

The source of

kindness. The

sunshine’s in my day.

The joy in my soul and the love of my life.

Mother

He’s a role model and a source of strength and inspiration.

He’s the greatest man I’ve ever known and I’m so proud to be addressed with him.

Father

They are ones who share me my childhood and stand beside me while no one left aside.

Brothers and sisters

To whom I appreciate.

To whom I love and

care.

To whom I won’t ever forget.

To whom I do respect.

My friends and classmates

For your patience, caring, supporting and kind words

sharing. I just want to say thank you for everything along

this period.

Dear teachers

Acknowledgement

First and foremost, we would like to thank our supervisor, Dr. Abbas Musa for his support, outstanding guidance and encouragement throughout our project. We would like to thank our families, especially our parents, for their encouragement, patience, and assistance over the years. We are forever indebted to our parents, who have always kept me in their prayers. Especial thank for Abu baker Mohamed Shoaib Hussein for help us in this project.

Abstract

The used data in this project consists of 2D seismic line and well data, this data of a good quality. The method of analysis applies (PETREL.2015 software) Tying the seismic data to well data is a major task in interpretation, It is used to correlate the well information (logs) to seismic.

Well-seismic ties allow well data measured in units of depth, to be compared to seismic data, measured in units of time, this allows us to relate horizon tops identified in a well with specific reflectors on the seismic section, we have used sonic and density well logs to generate a synthetic seismic trace by extracting the velocity and density from the logs measurements and multiply them to give acoustic impedance, the software compute reflectivity for boundaries and then convolve this reflectivity with the wavelet which extracted from the seismic line, then the synthetic trace is compared to the real seismic data collected near the well location for identifying the reflectors on the seismic line from horizons in the well.

This job used to transfer the well information to seismic line (the line in this study is line 2, and the well is Abu sufyan n-3) and then make loops around through the whole area of interest by using this line.

The work done in this study is to generate a synthetic seismogram form this data.

المستلخص

تتكون بيانات هذا المشروع من خط زلزالي ثنائي الأبعاد وبيانات بئر ذات نوعية جيدة. تم تحليل البيانات ببرنامج (PETREL.2015) يعد ربط البيانات الزلزالية ببيانات الآبار مهمة رئيسية في التفسير ، حيث يتم استخدامها لربط معلومات البئر (السجلات) بالبيانات الزلزالية.

الزلزالية تسمح بتقييد بيانات الآبار المقاسة بوحدات العمق ، ويتم مقارنتها بالبيانات الزلزالية المقاسة بوحدات زمنية ، وهذا يسمح لنا بربط قمم العرضية المحددة في البئر بعواكس محددة في المقطع الزلزالي، وقد استخدمنا الطريقة الصوتية و سجلات كثافة البئر لتوليد أثر زلزالي اصطناعي عن طريق استخلاص السرعة والكثافة من قياسات السجلات ومضاعفتها لإعطاء مقاومة صوتية انعكاسية حاسوبية للحد من التواء هذه الانعكاسية مع الموجة المستخرجة من الخط الزلزالي ، ثم تتم مقارنة الأثر التركيبي بالبيانات الزلزالية الحقيقية التي تم جمعها من موقع البئر لتحديد العواكس على الخط الزلزالي من قمة البئر.

تستخدم هذه الوظيفة لنقل معلومات البئر إلى الخط الزلزالي (الخط في هذه الدراسة هو الخط 2 ، بئر أبو سفيان n-3) تم عمل حلقات حول المنطقة بأكملها باستخدام هذا الخط.

من خلال هذا البحث تم انشاء مخطط زلازل اصطناعي من بيانات الدراسة.

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Chapter One

1.1 Introduction:

The Muglad Basin is a large rift basin in Sudan. The basin is situated within southern Sudan and South Sudan, It is oriented NW-SE (Fig 1.1).

Muglad Basin represents parts of Central Africa Rift System, which extends from North of Cameron and South Nigeria at the Atlantic Coast to western and Central Sudan. Extending southeast wards from south Darfur updated east Darfur to the Sudanese Kenyan border, The basin is oriented NW-SE and it occupies an area of about 1200 km² There is a huge amount of locally deposited Cretaceous- Neogene sediments of about 13 km in thickness (Idris, 2001).

The sedimentary basins of interior Sudan including the Muglad basin are characterized by thick non-marine clastic sequence of Late Jurassic Early-Cretaceous and Neogene age (Schull, 1988).The Muglad basin was explored by Chevron Company and partners in the early 1970s, and the first discovery was made in 1979.

In 2001, discovered 60m oil zones in Bentiu formation in Fula North-1 well,it verified Fula North is oil enrichment structure Drilled morethan 30 wells.

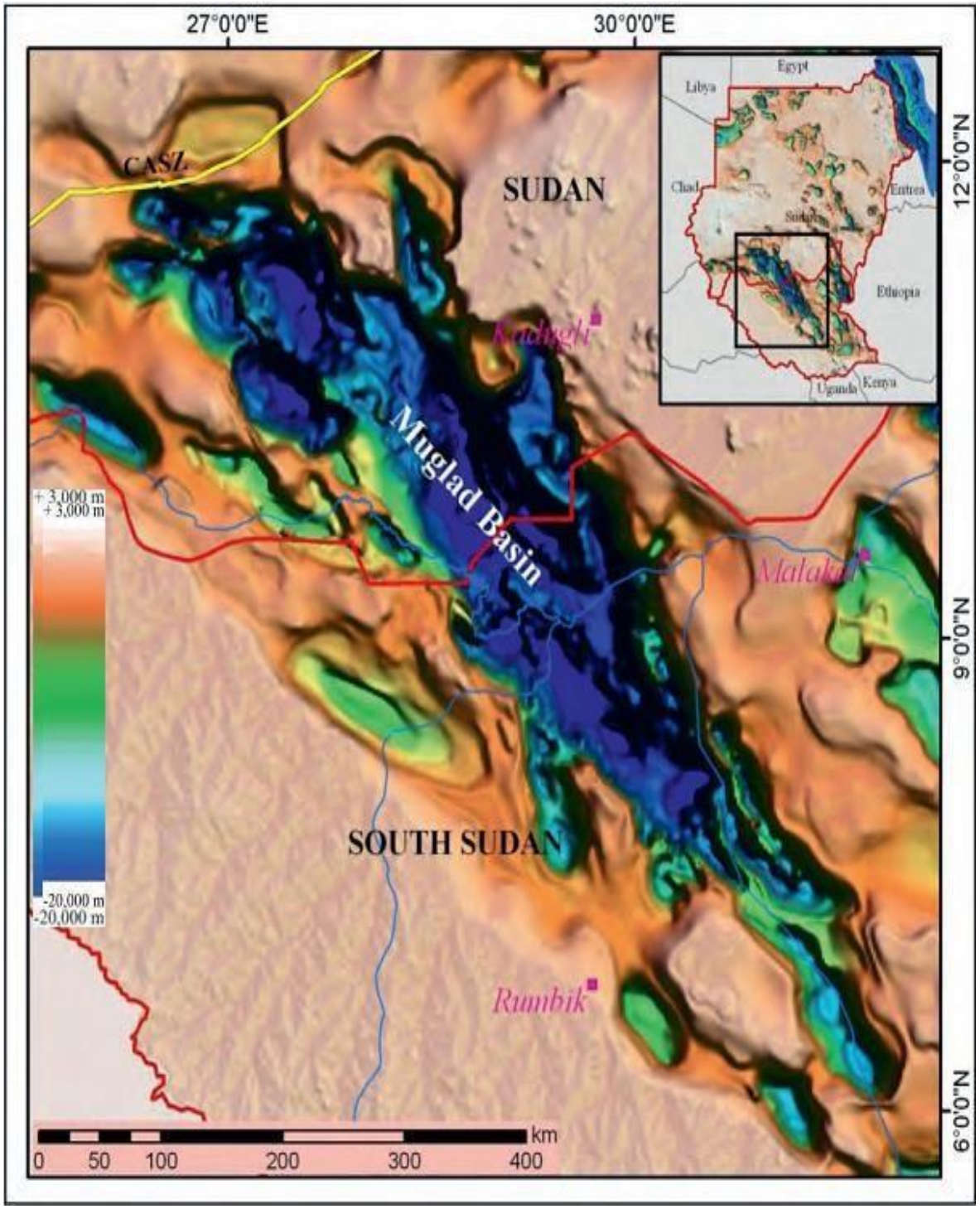
in 2001-2009, discovered hydrocarbon shows in Amal/Darfur/Bentiu/Abu Gabra, proved reserves >100 Million tons.

1.2 Study Area :

AbuSufyan Sub-basin is located in the Northwest of Muglad Basin, the Republic of Sudan, which is an intra-Craton rift basin related to the Central Africa Shear Zone. The hydrocarbon potentiality and favorable exploration trends are unclear due to complicate geological condition caused by the Central Africa Shear Zone. The area of Abu Sufyan Sub-basin is about 2800Km2.

The study area is called sufyan East ,it is located in north western part of the muglad basin, its approximately bounded by latitudes 11° 37` 45" and 11° 37` 03.6 N and longitude 26° 53` 37.98" and 26° 52` 29.6"E.

The study area width is about 0.73km, and length is about 1.69km, with total area of about 2.50km.



Figure(1.1): represents SEEBASE image of the Muglad Basin and its vicinity (after Blevin et al., 2009).

The Muglad Basin is accessible by railway,roads, air port of Heglig and air port of baleela . The country is a cross roads linking the states of kordofan, and Darfur to the rest of Sudan.

The railway runs from Khartoum through kosti at the Whit Nile to Muglad the main town in the study area, unpaved road which path through El-Obied to Muglad and other towns in the area under consideration like for example Babanusa , al fola, andadila.

1.3 Problem Statement:

The precision of reflection coefficient sequence need to correcting ,in sonic log we need to do sonic calibration , The theory wavelet differences between the practical, Log data resampling precision is not enough, The environmental impact and the information.

1.4 Physiography:

The Muglad rift basin is characterized by low relief flat plain area, except for sparse isolated outcrops in the northern part of the Basin. Therefore, this area is considered flat and surrounded by the Nuba Mountains, which represent the uplifted composed of basement terrain main igneous and metamorphic rocks.

The superficial deposits of black cotton soils cover the area and some isolated sandstone outcrops east of Muglad town, laterite deposits, (Abu Zeid, 2005).

Alluvial deposits and loss sand are common and widespread in abu sufyan oil field.

1.5 Climate and Vegetation:

The southern Central Sudan is generally considered to have Savannah-type climate where the average annual precipitation ranges between 120 and 800 mm.

East Darfur state has two different climates and is dominated by BWh according to the koppen-Geiger climate classification : hot desert climate and hot semi-arid climates: minimum temperature in January average 23°c. and maximum temperature in May

average 31.5°c.

and the rainfall fluctuates between 500mm to700mm .which start usually in May and ended on October (EN.CLIMATE -DATA.org).

The vegetation belongs to the poor savanna in the east and hot desert in the west.

The khors and the small rivers drain the area towards the White Nile to the southern east and towards Bahr El Arab to the south (Idriss, 2001).

Considerable parts of the area are covered by the hashab tree which included economic resources like Arabic gum, and tabaldi tree also economic resources .

1.6 Drainage System:

The drainage system of the area is mostly to the southeast towards the White Nile.

The country has rich agricultural land, abundantmineral, oil, livestockand grazing resources that attract pastoralists from areas such as north kordofan in the west and latina in central sudan, are making them important in term of food security and trade.

1.7 Population:

The study area is generally characterized by low populations but since the area has started the activity of the oil exploration (especially in 1996, CNPC China National Petroleum company BLOCK6 later named petro energy E&P 2002.(ministry of oil and gas) consortium was established).

The area is becoming more attractive for the settings, which is well distributed throughout the area (Abu Zeid, 2005).

Population is grazing cattle, most of them concentrated in the Arabian sea region, where grazing is an important economic activity in the country, As well as agriculture characterized by high productivity of the various crops.

The most important Elements of the population mandate are three: Rezeigat, Malian, Baraq, and Rizigat al Da'ayn .other population groups live with the three main components in the different regions of the country.

The main activity of the population is animal breeding. However, some people grow sorghum (dura), millet, Sudanesebean, sesame, groundnut, Gum Arabic, besides some vegetables and fruits.

All crops are grown depending on episodic rainfalls (Mohammed, 2003).

1.8 Previous Work:

Muglad basin is recognized to be a major part of Sudanese interior rift basins. It is the major basin of oil revenue in Sudan; consequently, there are many companies of oil exploration and development working in this basin. Most of the exploration works in the Muglad rift basin were conducted by a group of scientists from Chevron, an overseas company, between1974 and 1988.

Schull (1988) gave an excellent account of petroleum geology, oil discoveries in the area, and the exploration history and operation. Also he discussed the stratigraphy of

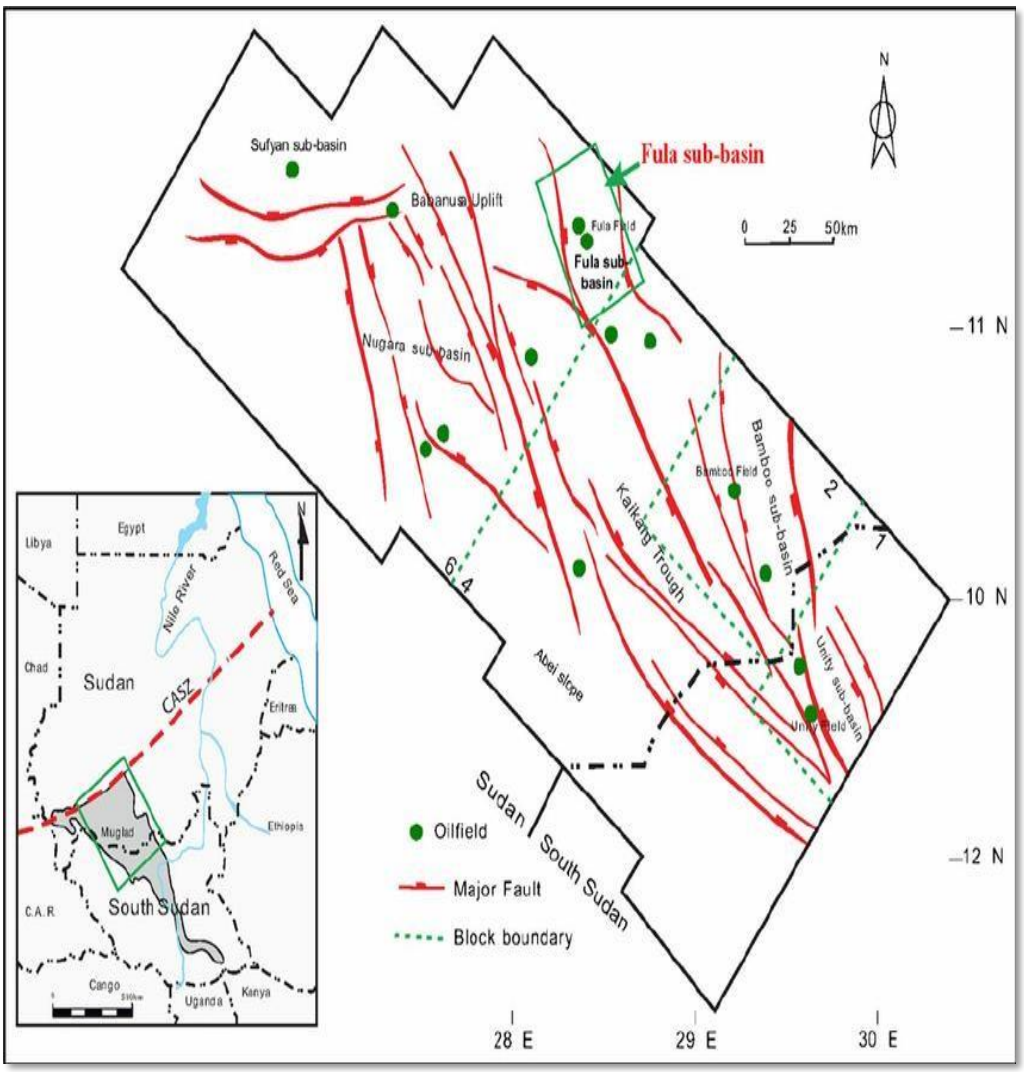
the basin, and geochemistry as well as the reservoir characteristic. There are three phase of rifting affect the stratigraphic column, each of which represent general coarsening upward cycle that began with lacustrine through shore lake deposit into fluvial deposit. This fluvial lacustrine Sequences in Central Sudan were subdivided by the means of biostratigraphy into five palynological zones, (Kaska, 1989).

Vail (1978, 1988) studied and reported the stratigraphy and regional geology of Muglad Basin and surrounded areas.

Mann (1990) studied the thick skin and thin skin structural feature of the Muglad rift baisn.

Norman (1990) studied the tectonic Influence in the fold and fault trap of the Muglad basin.

McHargue etal. (1992) studied the tectonic stratigraphy of the Muglad rift basin. Abdullatif (1992) studied the Late Jurassic /Cretaceous strata of the NW Muglad Basin with respect to paleo_environment, thermal analysis and paleo_geography of the area.



Figure(1.2): Locationmap of the fula sub basin in the muglad basin including oil field study.

1.9 Objectives:

The main objective of this study can be summarized as follows:

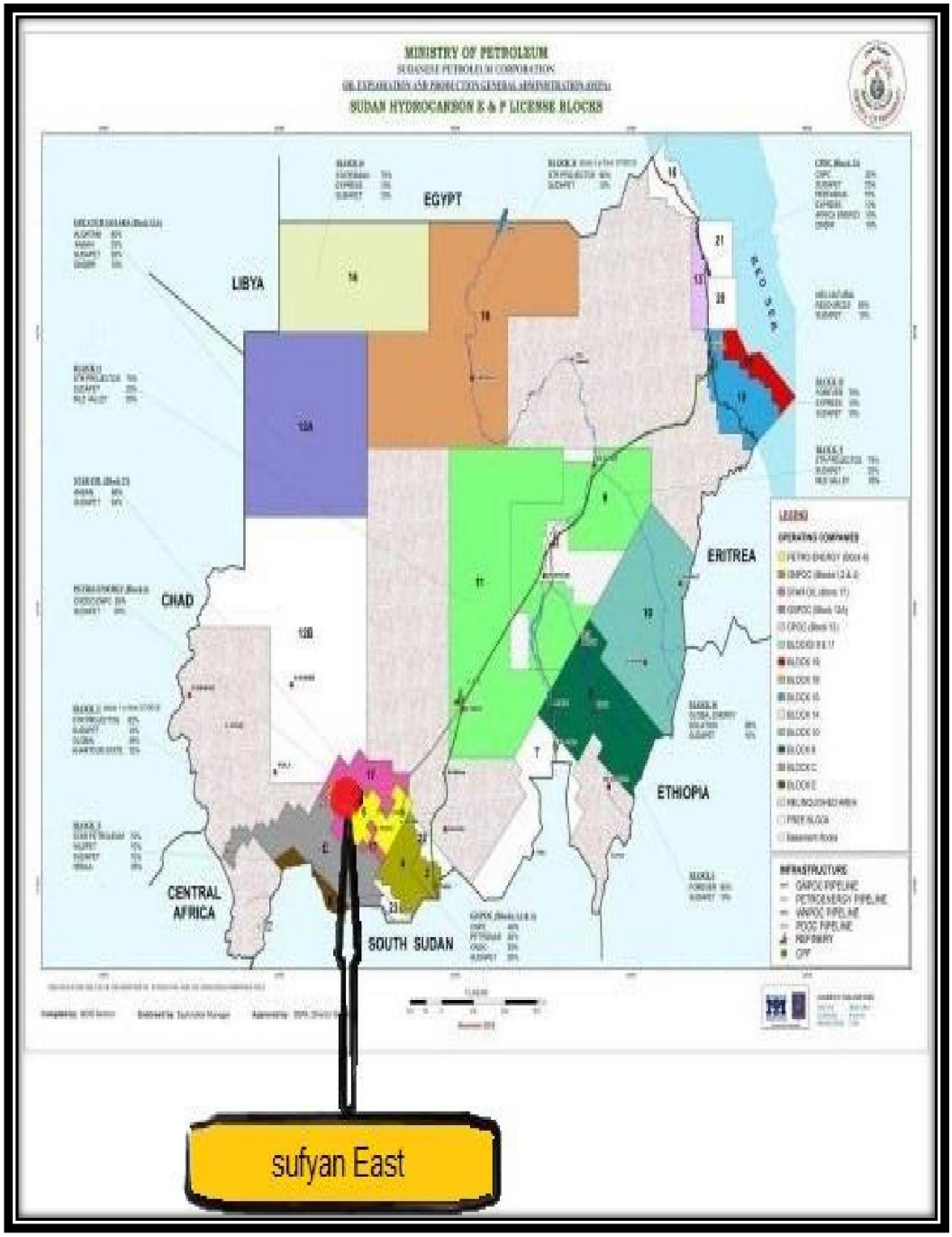
1- Correct sonic log and establish Time-Depth relation

2- Import Check shots

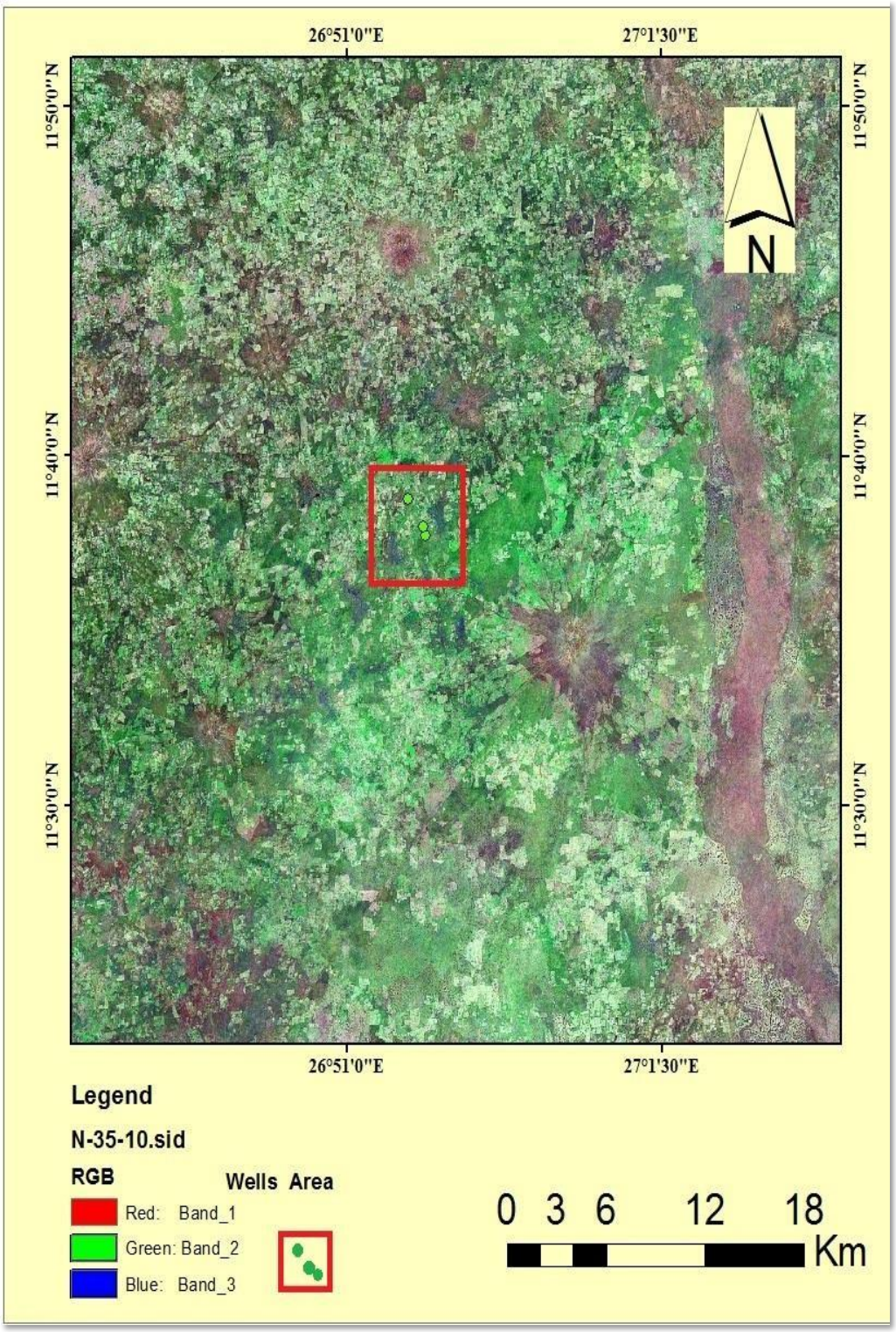
3- Make Acoustic Impedance log and Reflection Coefficient Series

4- Generate Synthetic Seismogram

5- Display of synthetic trace in 2D window



Figure(1.3) : location map of the study area in muglad basin.



Figure(1.4): well locations of study area.

Chapter Two

REGIONAL GEOLOGY AND TECTONIC SETTING

2.1 Introduction:

The Muglad basin is part of atrend of Cretaceous sedimentary basins of rift origin, which cut across north central Africa from the Benue trough in Nigeria, through Chad and the Central African Republic, into Sudan (Mohamed, and Mohammed, 2008).

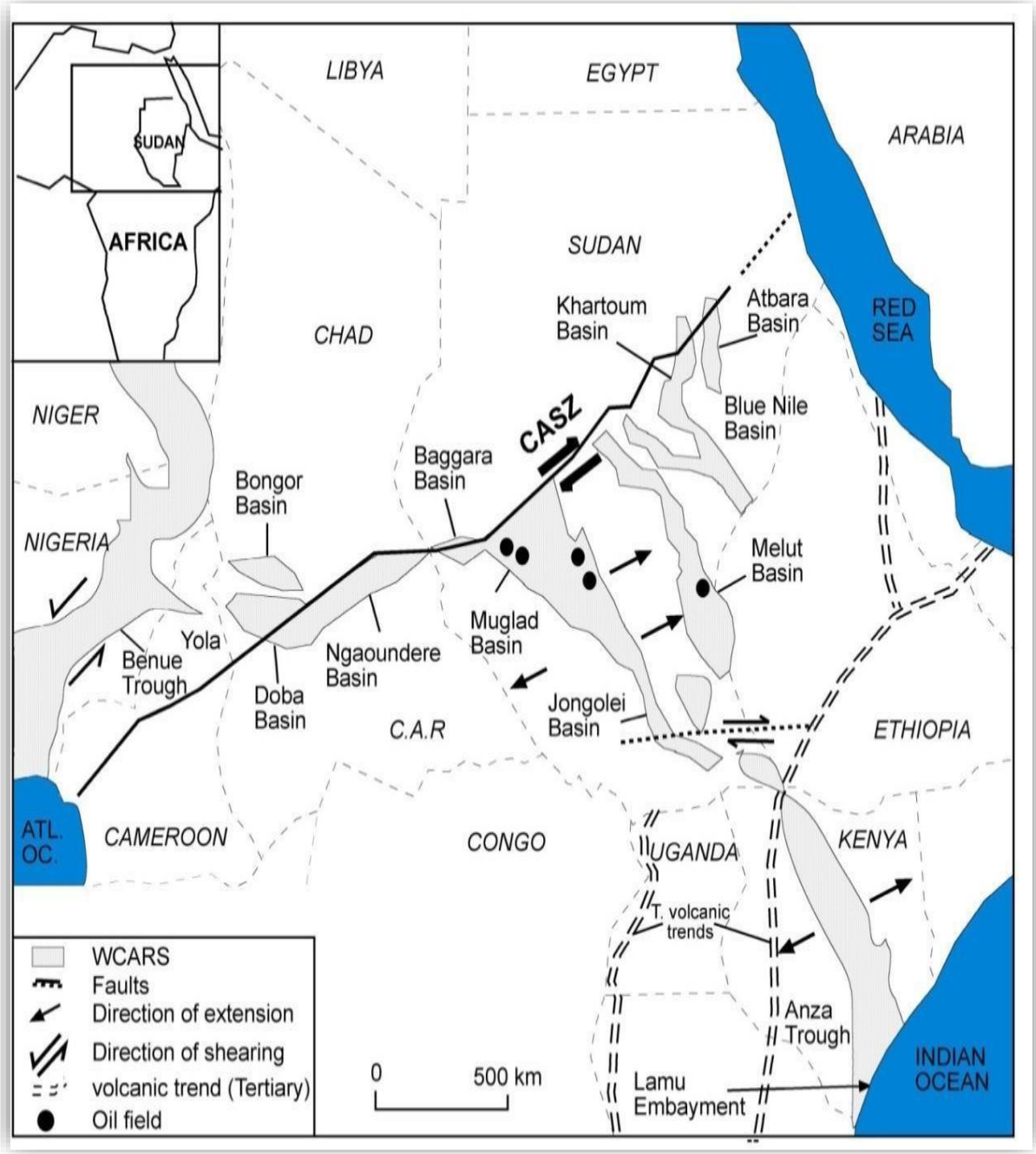
The sedimentary succession of Muglad basin is characterized by thick non marine clastic sequence of Jurassic – Cretaceous and Neogene age, that deposited in deepest trough and extensive basinal area (Schull, 1988).

The first depositional cycle (Early Cretaceous) consists mainly of suboxic organic-rich shales comprising the main lacustrine source beds ofthe Sharaf and Abu Gabra Formations, which are overlain in the sag phase by medium- to coarse-grained sandstones of the Bentiu Formation. The second depositional cycle (Late Cretaceous–Paleocene) is the Darfur Group, comprising fluvial and deltaic clay stones at the bottom (Aradeiba Formation) and thin sandstone beds (Zarga and Ghazal Formations), thickening toward the top of the section (Baraka Formation) and overlain by the coarser Amal Formation. The thin intercalating sandstones in the Darfur Group are the main reservoirs in the Unity field. The Kordofan Group (Oligocene–Late Eocene), which forms the third depositional cycle, consists of the largely shalyNayil and Tendi Formations and culminates in the coarse sandstones of the Adok Formation. The Miocene–Holocene Zeraf Formation unconformable overlies the Adok and probably represents fluvial reworking of these earlier deposits **(**Mohammed et al, 2003).

2.2 Lithostratigraphy :

Muglad Basin is covered by thick sequence of non-marine sediments, which vary in age from Cretaceous to Neogene. A generalized stratigraphic column is shown in fig 2-2 (Idris,2002).

Correlation and age assignment have been established by palynomorph assemblages from which a Five part spores/pollen zonation was created and the subsurface units have been palynologically defined for Lower ,Middle and Upper Cretaceous as well as paleogene and Eocene and Oligocene. Lower cretaceous correlations have been.



Figure(2.1): Tectonic model of the West and Central African Rift System including Muglad basin (After Fairhead, 1988).

confirmed by presence of ostracodes, and because of scarcity of Cretaceous-early.

The depositional environment of the thickest oil-prone source claystone and shale's was within large lakes distal from primary clastic influx within these area sub material deposits on the lake bottom (schull,1988).

The tectonic developmentof this area can be divided into a pre rifting phase,three rifting phases and sag phase.

The first rifting phase in muglad basin was consist of two formations which abu gabra formation and Bentiu formation (schull,1988).Three major episodes of extensional tectonism are recognized in the Muglad Basin: Fl, “Early Cretaceous”, approximately 140-95 Ma; F2, “Late Cretaceous”, 95-65 Ma; and F3, “Palaeogene”, 65-30 Ma (Fig 2-2, McHargue et al, 1992).

Exploration results have proved hydrocarbon system in bothpalaeogene, neogene cretaceous periods.

The main hydrocarbon play in cretaceous petroleum system,these petroleum system have perfect assemblage of source, reservoir and top seal (norman,1990).

Three rift-sag stages suffered in the Muglad basin since early Cretaceous, such as early Cretaceous, late cretaceous and early tertiary.

There deposited about 10,000 to 15,000m thick no-marine clastic sediments.

The source rock of the basin is lacustrine shale formed in the Early Cretaceous rifting stage.

Three reservoir-cab assemblages developed, such as Bentiu-Aradeiba of Late Cretaceous, Inner Abu Gabra of Early Cretaceous and inner Darfur group of late cretaceousNeogene-Paleogene outcrops and inferences made from seismic data and well control. A seismic stratigraphic analysis technique becomes useful in predicting stratigraphic facies and constructing depositional models (Schull, 1988).

The depositional environment (alluvial fan, fluvial-braided stream, fluvial floodplain and lacustrine)are illustrated in figure (2-3).

2.3 Used Data:

The available data as shown in fig (1.2) that was used in the current study were the following:

1. Three 2D seismic lines
2. Well information of (Abu sufyan) which include horizon tops of (Amal, Darfur group, Bentiu and AbuGabra Formations).

2.4 Precambrian- Basement complex:

rocks were reached in only few wells. The oldest penetrated sedimentary rocks are non-mThis interval is mainly represented by crystalline basement predominantly metamorphic rocks with limited igneous intrusions.

From the Cambrian to the Mesozoic, the area was an extensive continental platform which had become consolidated and stabilized by the end of the Pan-African episode (Schull, 1988). In

subsurface, basement arine Jurassic (?) Lower Cretaceous strata of the Sharaf, Abu Gabra Formations. Two wells to reach basement have been drilled on structurally high blocks over which thick pre-rift section may have been removed (Schull, 1988).

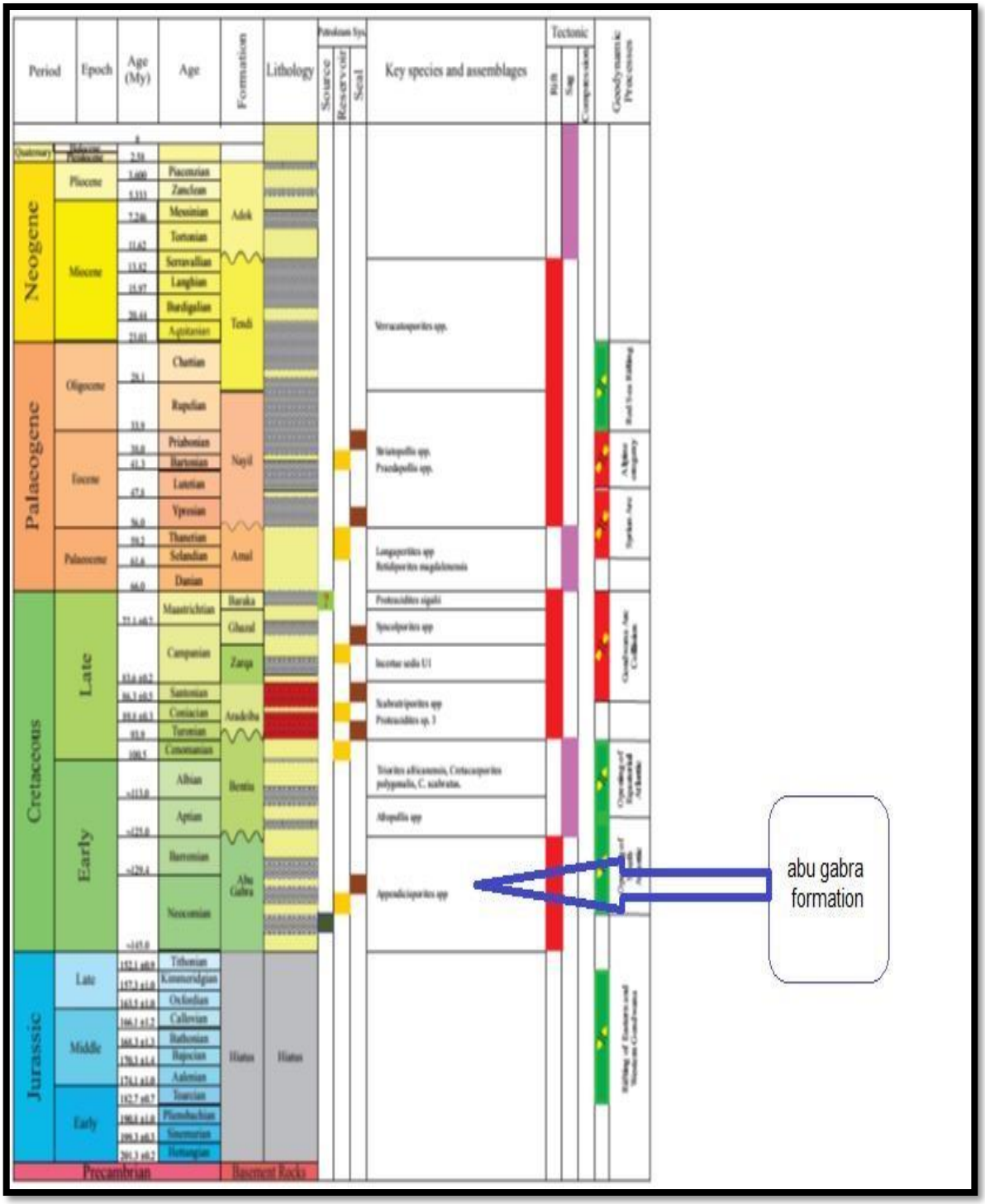


Figure (2.2): A compiled Tectono-stratigraphic subdivisions of Muglad Basin. Numerical ages are based on Cohen netal.2013; updated 2015.

The basement rocks cropping out at the NE, SW and NW margins of the Muglad basin, and the term basement complex is loosely used in the stratgraphy of Sudan to include all Precambrian and crystalline rocks found in the country (Vail 1978). In Nuba Mountains the rocks consist granites, granodiorite, gneisses, micaschists, metavolcanic and gabbroic rocks, the basement complex rocks of SW Sudan in Equatorial province consist of various type of gneisses amphibolites graphitic schist and marbles (Vail 1978) at the NW margins in Southern Darfur it consist of gneisses, quartzite (Vial 1988).

2.5 Cretaceous Strata:

A few Nubian Sandstone outcrops exist adjacent to the Muglad block, east and northeast of the town of Muglad. In the subsurface, a thick sequence of Cretaceous sediment is believed to be time equivalent to much of the Nubian outcrop. Based on seismic data and well control, Cretaceous sediment has been deposited in the deepest troughs (Schull, 1988). Cretaceous-Paleocene sediments reflect two cycles of deposition, each represented by a coarsening-upward sequence. The first cycle is represented by the Abu Gabra and Bentiu Formation. The second cycle is present in the Cretaceous Drafur Group and the Paleocene Amal Formation (Schull, 1988).

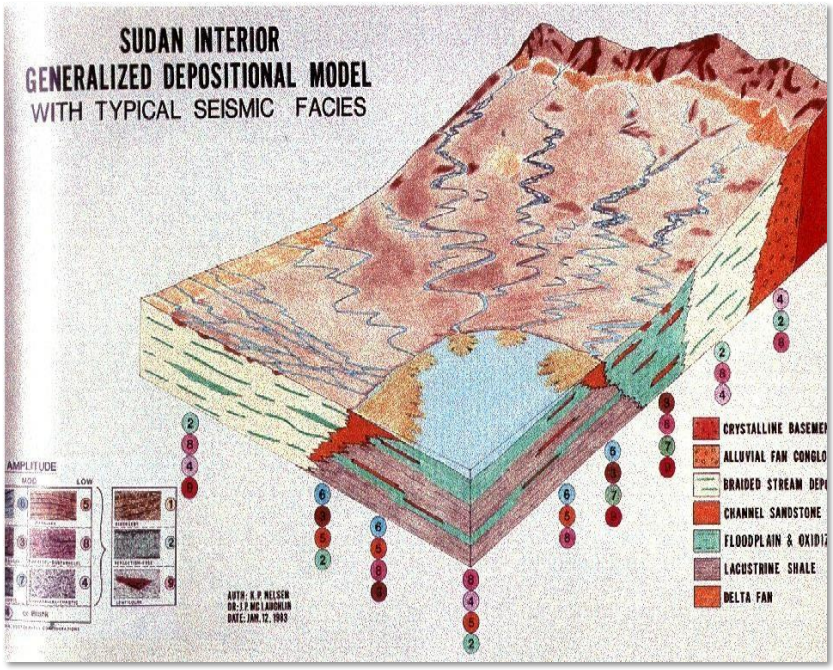


Figure (2.3): Depositional model showing non-marine environments operative during filling of southern Sudan rift basin (Schull, 1988).

This Cretaceous System Comprises Seven Formations namely: Sharaf, Abu Gabra, Bentiu, Aradeiba, Zarqa, Ghazal and Baraka.

2.6 Sharaf Formation (Neocomian-Barremian):

This unit has originally been introduced by Schull (1988) to indicate the early graben- fill clastic sediments derived from the gneissic basementcomplexduring the early phases of rifting. However, palynological evidence (Kaska, 1989) indicated a Neocomian-Barremian age.

2.7 Abu Gabra Formation (Neocmian-Barremian):

The formation was identified in the majority of well in NW muglad basin complex with thickness ranges between (1000-600feet).

Its dated palyrologicallyas Neocomian-Albian, represents the period of greatest lacustrine development and consist of several thousand feed of organic- rich lacustrine and clay stone and shale's inter bedded with fine- grained sand and silts the lower boundary of abu -gabra formation rests directly in basement complex. The lacustrine claystone and shales of this unit are primary source rock of the intror basin.abu gabra formation estimated to be up to 4500m thick (schull, 1988).

Based on spore\pollen assemblage, the Abu Gabra Formation is dated as Neocomian- Aptian Paly no facies types (dominated by palynomorphs, freshwater algae and amorphous organic matter) reflect a changing environment from very near- shore in the lower part to an open lacustrine towards the upper part of the formation (Awad and Omer, 2011).

2.8 Bentiu Formation (Aptian-Cenomian):

The Abu Gabra Formation is unconformably overlain by the Bentiu Formation which comprises a massive sandstone sequence (The main reservoir rock) with some thin claystone enter beds. The thin claystone enter beds is similar to the upper most part of the Abu Gabra Formation (Awad and Omer, 2011).

it is predominantly a sand sequence deposited in alluvial-fluvial flood plain environment. The regional base level, which was created by the earlier rifting and subsidence, no longer existed when Bentiu Formation was deposited. These thick sandstone sequences were deposited in braided and . Thmeanstreamsdering is unit,

which is up to 1550 m thick. Typically shows good reservoir quality. Sandstone of the Bentiu Formation is the primary reservoirs of the Heglig area (Schull, 1988).

2.9 Sufyan Oil field:

The Sufyan Sag is one of the low-exploration areas in the Muglad Basin (Sudan), and hydrocarbon potential evaluation of source rocks is the basis for its further exploration.

Abu Sufyan Sub-basin is located in the northwest of the Muglad Basin in the Republic of Sudan, which is an interacation rift basin related to the Central Africa Shear Zone. The hydrocarbon potential and favorable exploration trends are unclear due to complicated geological conditions of the Central Africa Shear Zone

- Located in the NW of Muglad basin. Strike: W-E, different from the other sub-basins. Area: 5000km2 , the current mapping area is 3750km2

The area of Abu Sufyan Sub-basin is about 2800Km2. It is a relatively independent structural unit trending east west , which is different from the other Sub-basins in the Muglad Basin.

2.10 Darfur Group:

The Turonian-Late Senonian period was characterized by a cycle of fine to coarse- grained deposition. The lower portion of the group, Aradeiba and Zarqa formations, is characterized by the predominance of claystone, shale, and siltstone. Floodplain and lacustrine deposits were widespread. The low organic carbon content indicates deposition in shallow and well-oxygenated water.Although this unit offers little source potential to date, it may develop an organic-rich facies in areas not yet drilled. Throughout the basin, theAradeiba and Zarqa formations are an important seal (Schull, 1988).

The Cretaceous ended with the deposition of increasingly coarser grained sediment, reflected in the higher sand percentage of the Ghazal and Baraka formations. These units were deposited in sand-rich fluvial and alluvial fan environments. The Ghazal Formation is also an important reservoir unit in Unity field. The Darfur Group is up to 3200 m thick (Schull, 1988).

2.11 Neogene – Quaternary Strata Units:

Strata of this age are assigned to the lowermost units within the Kordofan Group and Amal Formations.

The Neogene is represented by sequences of unconsolidated sands, gravels, silts, and clays deposited in alluvial, fluvial, and shallow lacustrine environments (Vail, 1978). The initial deposits of the Tertiary were medium to coarse-grained clastic, followed by a single cycle of fine to coarse-grained sedimentation associated with the final rifting phase. Tertiary is up to 3450 m thick (Schull, 1988).

2.12 Amal Formation (Paleocene):

The Amal Formation consists of coarse- to medium-grained massive sandstones. Palynofacies association consists of abundant. Dark structured organic matter reflecting deposition in high energy near shore settings (Awad and Omer, 2011).

The massive sandstones of the Paleocene, which are up to 2, 500 ft (762 m) thick, are composed dominantly coarse to medium-grained quartz arenites.

This Formation represents high energy deposition in a regionally extensive alluvial- plain environment with coalescing braided streams.and alluvial fans. These sandstones are potentially excellent reservoir.Thisformation represents ahigh energy depositional environment of extensive alluvial-plain fans (Schull, 1988).

2.13 Midale and upper Kordofan Group:

These sediments represent a coarsening-upward depositional cycle that occurred from the Late Eocene to middle Miocene. The lower portion of this cycle, the Nayil and Tendi formations, is characterized by fine-grained sediment related to the final rifting phase. The deposits represent an extensive fluvial-floodplain and lacustrine environment. They offer excellent potential as a seal overlying the massive sandstone of the Amal Formation (Schull, 1988).

This unit is generally characterized by inter bedded sandstone and claystone with an increasing sand content. The fluvial-floodplain and limited lacustrine environments gave way to the increasing alluvial input reflected in the sand-rich braided streams and fan deposits of the Adok and Zeraf formations. An exception occurs in the area of the suddenly swamp where approximately 2000 ft (610 m) of Late Tertiary claystone were deposit (Schull, 1988). Dark structured organic matter reflecting deposition in high energy near shore settings (Awad and Omer, 2011).

2.14 Quaternary sediments:

The interval comprises the Zeraf and the Umm Ruwaba Formations, Zeraf formation consists of massive sands, predominantly course- to very coarse-grained. The age of this unit was inferred from its stratigraphic position above the well-dated Adok Formation. Palynological recovery from this interval is very poor, however, the majority of palynomaceral are abundant palynomorphs, structure less organic matter and Botryococcus spp. which indicates lacustrine environment (Awad and Omer, 2011).

These are unconsolidated sands, clayey sands and black clays, which vary considerably in thickness. Black clays vary in thickness from a few centimeters to over 10 meters and conformably overlie the Umm Ruwaba Formation. Wind-blown sand deposits (Qoz) , are widely spread in the northwestern part of the Muglad Basin. Fluvial deposits are found along the major drainage systems and are generally

composed of sandy and clayey sediments, which sometimes form shallow aquifers. The weathering products along the western side of the Nuba Mountains form narrow bands of washed out debris deposits around the hills (Vail, 1978).

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2.15 Tectonic Setting:

The Muglad basin is bisected by major sub-basins, which superimposed on the earlier Lower Cretaceous to early Neogenesediments. It was formed by regional rifting and divided into one pre-rifting phase and three rifting phases. Rift activity has continued through to present time. This evolutionary sequence is well documentedby geophysical data, well information andregional geology(Schull, 1988).

2.16 Prerifting Phase:

By the end of the Pan-African orageny (550 ±100 Ma), the region had become a

consolidated platform. During the remainder of the Paleozoic and up to the Late Jurassic, this platform was the site of alkaline magmatism probably caused by a long lived mantle plume (Vail 1978). The general lack of lithic fragments in the oldest rift sediments further suggests that no significant amount of sedimentary section existed in the area prior to rifting (Schull, 1988).

2.17 Rifting Phase:

The distinct periods of rifting have occurred in response to crustal extension (Fig2.3), which provided the isostatic mechanism for subsidence (Browne and Fairhead, 1983). The subsidence was accomplished by normal faulting parallel and sub-parallel to basin axes and margins.

Rifting is thought to have begun during Jurassic (?) to Early Cretaceous time (130 – 160 Ma). Three distinct periods of rifting have occurred in response to crustal extension, which provided the isostatic mechanism for subsidence.

Subsidence was accomplished by normal faulting parallel and subparallel to the basinal axes and margins (Browne and Fairhead 1983; Schull 1988). These three rifting phases can be described as follows:

The primary rifting phase had begun in the Jurassic (?) – Early Cretaceous and continued until near the end of the Albian, simultaneously with the initial opening of the South Atlantic and the subsequent extension at the Benue Trough. Consequently, several African rifts and troughs such as Benue, East Niger, Ngaoundere and Anza began to develop. Some basins developed within and in the immediate vicinity of the Cretaceous shear zones in the period from 120 – 90 Ma, due to shear movements. Moreover, Fairhead (1988) suggested that the movements of the Central African Shear Zone were translated into the extensional basins of the Sudan interior. However, no volcanism is known to be associated with this early rifting phase in Sudan. The termination of the initial rifting is stratigraphically marked by the basin wide deposition of thick sandstones of the Bentiu Formation (Schull 1988). The second rifting phase occurred during the Turonian – Late Senonian. Stratigraphically, this phase is documented in the widespread deposition of lacustrine and floodplain claystones and siltstones, which abruptly terminated the deposition of the Bentiu Formation (Schull 1988). Furthermore, Fairhead (1988) concluded that changes in the opening of the Southern Atlantic account for the Late Cretaceous period of shear movement in the West and Central African Rift System. These tectonic effects came as compressional stresses at the Benue area and as a dextral reactivation along the Central African Fault Zone during the Late Cretaceous time, and hence, gave rise to the second rifting

phase. In the ENE– WSW trending Baggara Basin, a continuation of CAFZ movement has been inferred from the compressional stresses in the seismic data, which is not proven in the adjacent NW Muglad Basin. Further to the SE, the trend appeared to have been terminated and replaced by the NW–SE trending basins, which are extensional in their development. In contrast to the primary rifting phase, this rifting phase was accompanied by minor volcanism. In wells, this phase is represented by a 300 ft (91 m) dolerite sill in the northwest Muglad Basin, dated (82 ±8 Ma) and a Senonian andesitic tuff in the central Melut Basin (Schull, 1988). These occurrences fit well with the approximate 90 Ma date cited as one of two periods of Mesozoic (?) igneous activity in central and northern Sudan (Vail, 1978). The end of this phase is marked by the deposition of an increasingly sand-rich sequence which ended with the Paleocene sandstone of the Amal Formation (Schull, 1988).

2.18 The sag phase:

The intra cratonic sag phase was first identified by Schull (1988). In the Middle Miocene, the basinal areas entered an intra cratonic sag phase of very gentle subsidence accompanied by little or no faulting. During that time the sedimentation in the Central and Southern Sudan Interior Rift Basins was essentially controlled by subsidence due to differential compaction of sediments. In Muglad and Melut Basins the Eocene-Oligocene sedimentation has continued across the Oligocene/Miocene boundary with the deposition of basin wide fluvial and floodplain sediments of the upper members of the Kordofan Group. Also in northern Sudan, the basin evolution started with the formation of intra cratonal rift basins and was followed by sag phase. In the sag phase, sedimentation was dominated by fluvial systems (Bussert, 2002).

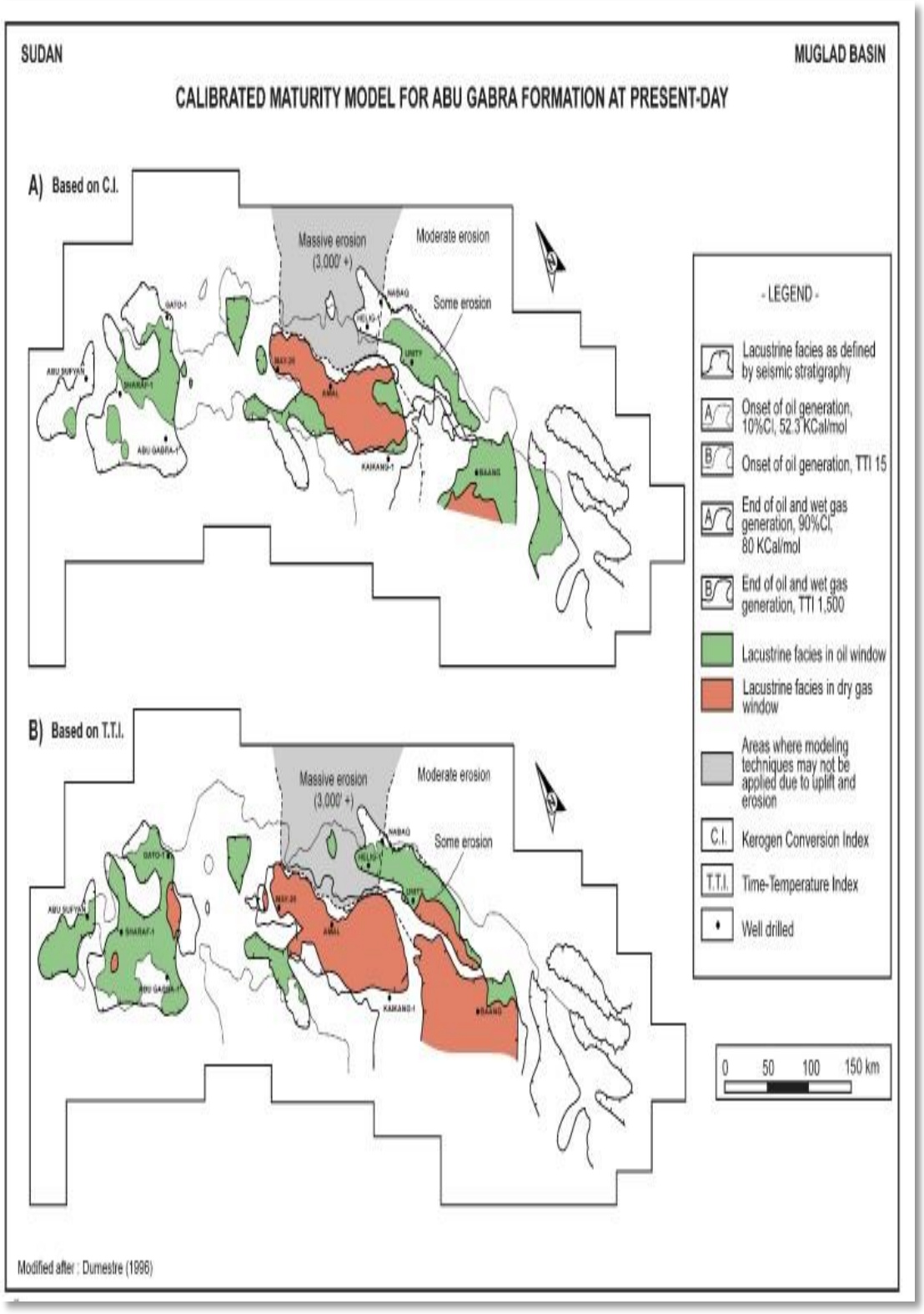


Figure (2.4): Calibrated Maturity Model for Abu Gabra Formation at Late Oligocene: 28 Ma (Muglad Basin)modified after Dumestre1996.

2.19 Petroleum Geological Elements:

The Abu Gabra/Sharaf - Cretaceous Petroleum System is by far the most important petroleum System in the Muglad Basin and accounts for the vast majority of the major accumulations.

Shales of the Lower Cretaceous Abu Gabra Formation are the main source rocks of this petroleum system, followed by the Sharaf shales to a lesser extent. They have sourced hydrocarbonaccumulations in the Lower Cretaceous Abu Gabra and Bentiu

formations, and Upper Cretaceous Darfur Group (Aradeiba,Zarqa,Ghazal and Baraka formations). In the Kaikang trough, oil hasbeen found in the Tertiary Tendi and Nayil formations. Seals are provided by shale-dominatedAradeiba Formation and other formations of the Darfur Group.

The Neocomian-Barremian Sharaf and Aptian-Lower Albian Abu Gabra source rocks areargillaceous units deposited in half-grabens during the first rifting phase in the Muglad Basin.

Schull (1988) described these sediments as moderately rich and reported mean Total OrganicCarbon (TOC) values of 1.3%, and a range of 1-5%. Giedt (1990) noted that TOC values mayreach 7.5% in the Abu Gabra Formation in the northwestern part of the basin. The kerogen ismainly of Type I, but Type III kerogen is also present in the Abu Gabra source rocks. Thenonmarine oils derived from these source rocks are typically paraffinic and of low sulfur content.

2.20 Source rock:

The source rocks of the Muglad basin are organic-rich shale of Abu Gabra Formation that were deposit in stratified lake during Neocomian to Barremian time the abu gabra formation consist of three member (AG3,AG2,AG1) From bottom to top is main source rocks. Total organic carbon in the penetrated Abu Gabra section averages 1.3 but exceeds 7 in places in the north western part of the basin.

characterized by the rich lacustrine clay stones and shales were deposited with inter bedded fine grained sands and silts, besides Baraka, Nayil and Tendi formations (Schull, 1988).The regional Muglad structural-stratigraphic cross section indicates the position of these clay stones and shales as well as turonian- late senonian and late Eocene- Oligocene intervals (shull 1988).

The depositional environment of the thickest oil- prone source clay stone and shale's was within large lake distal from the primary plastic influx within these area sub- material deposits on the lake bottoum(shull, 1988).

2.21 Reservoir:

The reservoir rocks of interior Sudan range from quartz arenites and wackestones to arkosicarenites and wackestones. Generally, the better reservoirs were deposited in the more proximal alluvial and fluvial environments. The more distal lacustrine environment generally lacked the energy necessary to rework and clean up the potential reservoir sands (Schull, 1988). Typically, sandstone of the Bentiu Formation is the primary reservoir of the Muglad basin, and the Ghazal Formation is also an important reservoir, and the sandstone of the Amal Formation are potentially excellent reservoirs (Schull, 1988).

Most of the unity reservoir sandstone generally are characterized by good porosity and permeability. Porosity range from 8 and 38 .averaging 27 permabilites range from 40 to over 10.000 md, averaging 1600 md. These sandstone, exhibit good reservoir quality at depth at which the typical Cretaceous reservoirs are un attractive. The following conclusion can be drawn from the reservoir data compiled from the study of 3,200 ft (975 m) of conventional core taken from 30 wells (Schull, 1988).

2.22 Cap Rock (Seal):

Throughout the basin, the Aradeiba and Zarga formations are an important seal for Bentiu Formation, the Nayil and Tendi formations offer excellent potential as a seal overlying the massive sandstone of the Amal Formation (Schull, 1988).

2.23 Lateral Seal :

Lateral seal depends on the thickness and the lithology of the Aradeiba shale and the amount of fault throw. The Aradeiba Formation is highly variable in thickness and sand/shale ratio. Thickest Aradeiba Formation penetration to date is in excess of 1000 m in the central part of the basin, decreasing to less than 20 m along the basin edges. Most of the perfect lateral seals are due to direct juxtaposition of Bentiu sandstone reservoirs against Aradeiba shale.

In some cases clay smear and shale gouge ratio play an important role in lateral seal integrity. The shale gouge ratio seems to depend on shale thickness and amount of displacement along the fault plane. Shale gouge will, of course, also depend on clay mineralogy, but this aspect has not been fully investigated.

2.24 Structural Style Analysis of Muglad Basin:

According to Browne and Fairhead (1983), Schull (1988) and Fairhead (1988), the rift basins of Sudan belong to a much larger regional structural system that extends across Central Africa to the west, to link up with the Atlantic coast via the Benue Trough in Nigeria and embraces the Red Sea-Gulf of Aden plate boundary to the east. Within the Sudan Republic, and from east to

west, they include the Blue Nile Rift Basin, the White Nile Rift Basin, Muglad Rift Basin and Baggara Basin (fig 2.1).

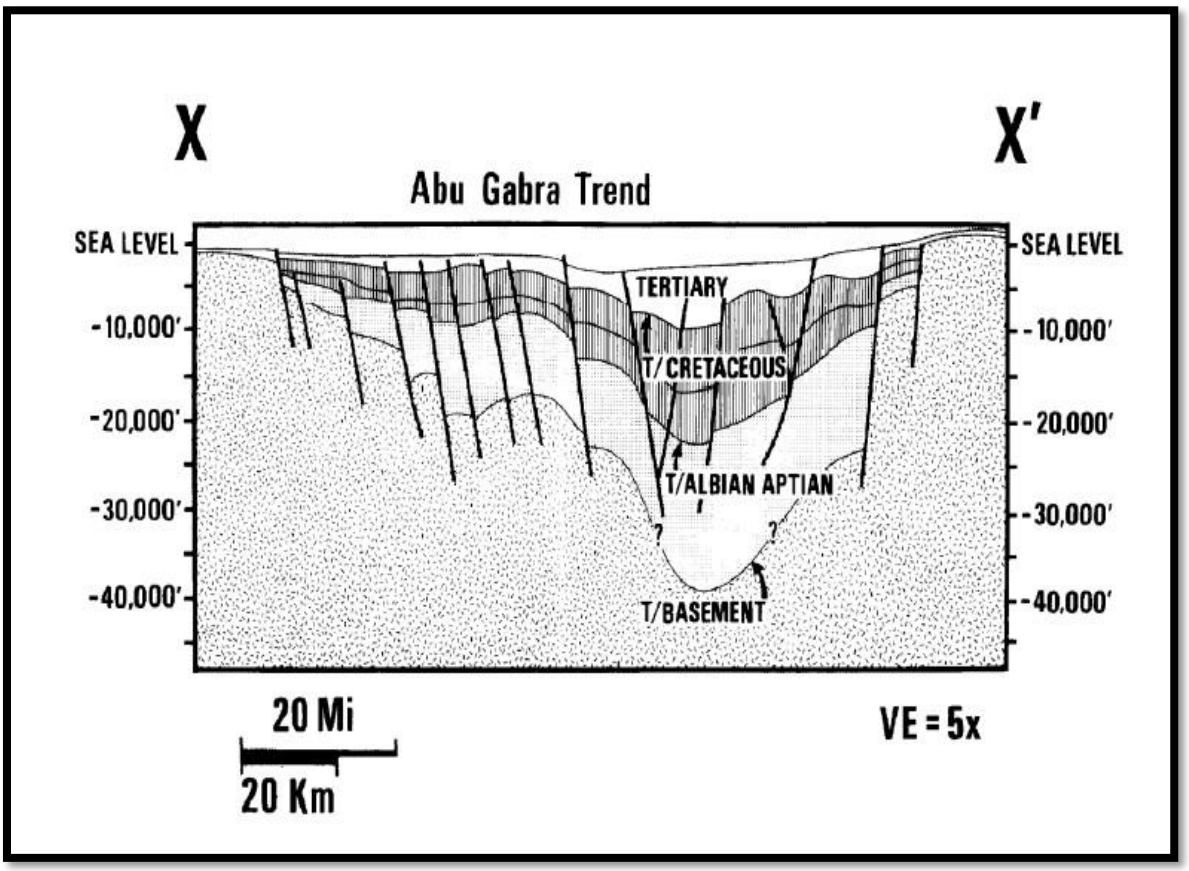
2.25 Extensional movement:

Structurally, the area is dominated by dip-slip normal faults. The three rifting phases resulted in along complex history of horst and graben development and formation of highly complicated fault system. The predominant fault orientation is parallel or sub- parallel to the strike of primary graben and basin margins. The general structure of the Muglad basin is shown in Fig (2.4).The faulting exhibits great variety in displacement, geometry, and growth history. Representative the structural profiles XX' and YY' reflect (Fig2-5 and Fig2-6) this variety and provide a cross-sectional view of the structural style of Muglad basin. Along the basin flanks the faults clearly involve basement. The productive and prospective structures resulting from this complex extensional history have been categorized as rotated fault blocks, drape folds and reverse drag folds (Schull,1988).

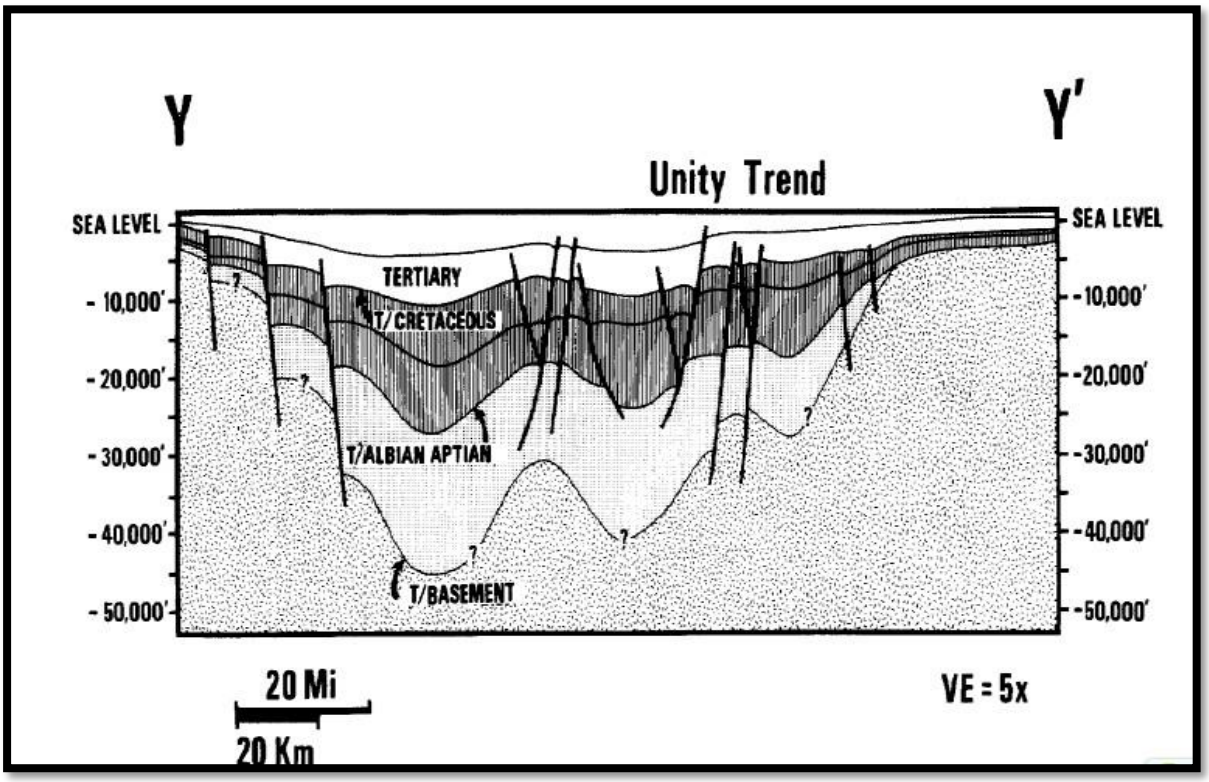
2.26 Productive and Prospective Structure:

Productive and Prospective Structure resulting from this complex extensional history have been categorized as rotated fault block, drape fold and reverse drag fold (Schull, 1988).

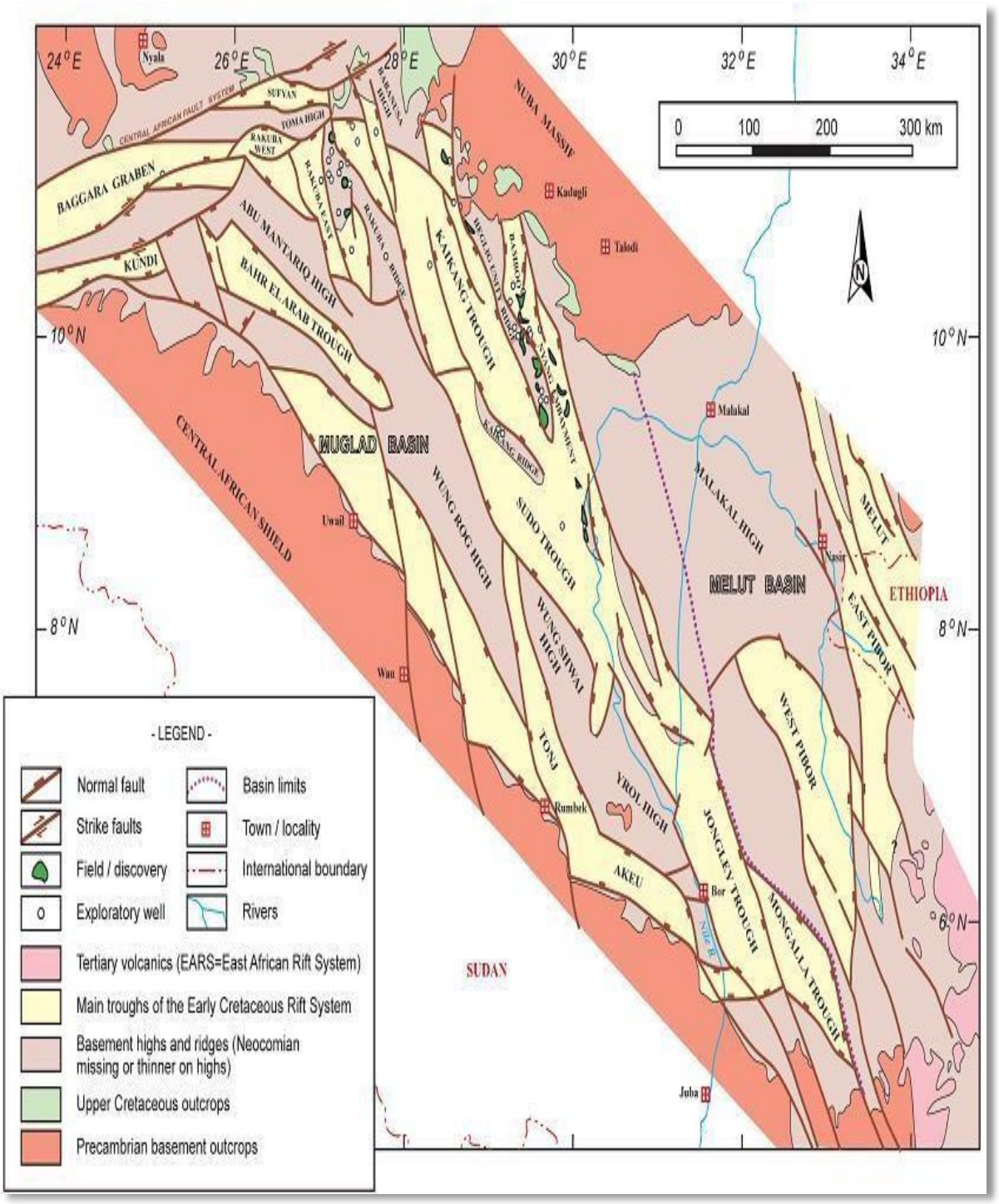
Rotated fault blocks are formed by simple block rotation along normal fault plane. These structures are important producing traps, but entrapment depends upon a seal or cross faults for closure. This type of structure is common throughout the basins and can be seen on seismic line BB' (Fig.2.4 Schull, 1988). Drape folds are formed in the sediments overlying the up thrown side of deeper normal faults. This type of closure has been found in areas where faults formed during the early rifting phase where not rejuvenated. Closures of this type have trapped oil in Heglig area. In some locations, down-thrown rollover anticlines have resulted from rotation into listric faults. These listric faults are often accompanied by antithetic.



Figure(2.5) : structural profile across abu gabra trend of north muglad basin.



Figure(2.6):structural profile across unity trend of southern muglad basin.



Figure(2.7): Generalized structural Framework Map (Muglad Basin).Modified after (Dumestre1996).

Chapter Three

3.1 concept of synthetic seismogram:-

The result of one of many forms of forward modeling to predict the seismic response of the Earth, a more narrow definition used by seismic interpreters is that a synthetic seismogram, commonly called a synthetic, is a direct one-dimensional model of acoustic energy traveling through the layers of the Earth. The synthetic seismogram is generated by convolving the reflectivity derived from digitized acoustic and density logs with the wavelet derived from seismic data. By comparing marker beds or other correlation points picked on well logs with major reflections on the seismic section, interpretations of the data can be improved.The quality of the match between a synthetic seismogram depends on well log quality,seismic data processing quality, and the ability to extract a representative wavelet from seismic data, among other factors. The acoustic log is generally calibrated with check- shot or vertical seismic profile (VSP) first-arrival information before combining with the density log to produce acoustic impedance.

3.2 significance of synthetic seismogram:-

Synthetic seismograms provide a crucial link between lithological variations within a drill hole and reflectors on seismic profiles crossing the site. In essence, they provide a ground-truth for the interpretation of seismic data.

They are useful tools for linking drill hole geology to seismic sections in offshore/onshore because they can provide a direct link between observed marine/land lithology's and seismic reflection patterns. Reflection profiles are sensitive to changes in sediment impedance, the product of compressional wave velocity and density. Changes in these two physical parameters do not always correspond to observed changes in lithology. By creating a synthetic seismogram based on sediment petrophysics, it is possible to identify the origin of seismic reflectors and trace them laterally along the seismic line.

The synthetic seismograms allow for the accurate interpretation of the overall seismic section by tying observed recovered lithology's to reflectors in the seismic profiles. These results provide a foundation for seismic-based regional lithological and facies interpretation.

3.3 Basics of the Synthetic Seismogram: -

A synthetic seismogram is created to simulate seismic data acquisition in your computer.The unknown physical properties of the earth beneath a seismic survey are known properties at a wellbore-P-wave acoustic velocity and bulk density. In acquiring seismic data, at the simplest,a seismic compressional wave (P-wave) is generated with a surface source; the wave travels at the acoustic velocity of the rock,which varies with lithology; the wave bounces off surfaces across which the impedance - the product of velocity and density -varies. The strength of the reflection is measured with a reflection coefficient,which is the difference in impedance over the sum of the impedance. The wave then returns to the surface,where geophones detect the P-waves returning vertically.The time from generation of energy to its recovery at a geophone is the travel time; it depends on the velocities of the units traversed.The amplitude of the recovered energy is governed by the contrasts in velocity and density across the interfaces.All the various geophone groups are recorded;data are processed,and an output section is generated. The interpreter then tries to identify target reflectors in time,analyze the seismic response to geology and fluids,convert time to depth, and drill. In other words,a source wave is sent through a velocity field and a series of reflectors which yield seismic data,or

(Source Wave)(Velocity Field)**(Reflection Series)=Data* …… *(3.1)*

Geology and hydrocarbons control both velocities and reflections. The objective is to resolve the reflection series using the data,knowing the source wave and estimating the velocity field:

(Reflection Series)=Data((Source Wave)*(Velocity Field)**)-1* …… *(3.2)*

This is an “Inverse Problem."There are direct and useful ways to do this (called “seismic inversion”) if the phase of the data is known, and the very low-frequency components of velocity and density that are not captured in seismic data can be added back. One of the simplest ways to work the inverse problem is to take sonic velocity and density data from wells, run the seismic experiment with the sonic-derived velocity field and the sonic- and density-derived reflection series, assume a source wave similar to the seismic data, and compare the result to the data.The well data can be varied to match what might exist away from the wellbore--but within the seismic survey. This can be done before the survey is acquired to answer a question such as: “Is a likely target visible?

3.4 well logging:-

Well logging, also known as borehole logging is the practice of making a detailed record (a well log) of the geologic formations penetrated by a borehole. The log may be based either on visual inspection of samples brought to the surface (geological logs) or on physical measurements made by instruments lowered into the hole (geophysical logs). Well logging can be done during any phase of a well's history; drilling,completing,producing and abandoning. In this research we interest with sonic, density, gamma ray and resistivity logs, as describe below.

Sonic log : The sonic logging tool measures the transit time of an acoustic waveform between an emitter and receiver,spaced several feet apart. The recorded transit time (AT) is a slowness measured in usec/feet.It is easily converted in a velocity log. The penetration depth of the sonic log depends on the wavelength is in the order of a few inches (one wavelength, Vasquez et al. 2004). The full waveform tool (dipole sonic imager or DSITM of Schlumberger)measures the P-as well as the S-wave velocities.This information is needed in more sophisticated reservoir modeling and gives an accurate view of the rock physical parameters directly around the borehole (De Beukelaar et al. in press). The acoustic waves recorded by sonic logging tool depend on the energy source, the path they take and the properties of the formation and borehole. A velocity log can be computed from the sonic log.

which measures transit times (DT). The sonic velocity is given by:

$$Sonic\ velocity = (1/DT)\ 304800. \qquad \ldots\ldots\ldots \quad (3.3)$$

The velocity is multiplied by the density to generate an acoustic impedance log. The AI contrast at each sampling point is computed reflectivity trace is subsequently convolved with a seismic wavelet and a synthetic trace is and a spikey reflectivity trace is obtained. The created.

Density log: The density of the rocks is registered by lowering a radioactive source in the borehole. The emitted radiation encounters electrons and is back scattered by the Compten Effect. The amount of back scatter is counted by the specially shielded detector The pumber of electrons is proportional to the bulk density. The measurements are usually done with a compensated density tool, correcting automatically for mud cake and bore irregularities. Together with the velocity response from the sonic log, the acoustic impedance curve can be calculated and hence the reflectivity behavior is analyzed.

Gamma ray log: The gamma ray tool measures the natural radiation from the formation In shale a lot of radioactive elements are incorporated in the clay mineral structure and a high gamma ray reading is the result. The radiation level in carbonates and sands is normally much less. The gamma ray is convenient for discrimination of the shale intervals. Several types of radiation can be analyzed, which help to subdivide the sedimentary succession. These are:

Potassium (40K), uranium (230U) and thorium (232TH).The gamma ray log is measured in API

units that have been defined by the American Petroleum Institute and are calibrated in a quarry pit owned by the University of Houston.

Resistivity log: Electrical logs illustrate the resistivity and the Spontaneous potential (SP) of the rock sequence. The shallow resistivity reads 10 inches into the formation, while the micro resistivity reads basically the mud cake. The dip-meter tool is a micro-resistivity logging device with azimuth dependent sensors. The dip is inferred from the cross correlation of the recordings from the various pads. The heavy point corresponds to the dip value and the line segment gives the direction of the dip (azimuth). Nowadays a formation imaging device is often run, a view on the borehole and allows detecting Dips, faults, fractures and sedimentary features, when the sonic log is not available, then a velocity curves estimated from the resistivity log using the Faust relation (Faust 1951,1953):

Vp 2000 (resistivity z) 0.166666. *…….(3.4)*

A correction should be made when gas is present in the reservoir.

Subsequently the density is estimated from the velocity curve using Gardner's relation (Gardner et al. 1974):

Density = 0.31(velocity P -wave) 1/4. *…….(3.5)*

The 0.31 value is a general value for all sorts of lithologies.

This is a rather rough estimate and certainly not very accurate. All these logs will be discussed in detail in chapter two.it provides

3.5 required seismic data:-

In order to generate synthetic seismogram we only used seismic reflection data –The simplest possible seismic measurement would be a I -D point measurement with a single source (often referred to as a shot, from the days when explosive charges were the most usual sources) and receiver, both located in the same place. The results could be displayed as a seismic trace, which is just a graph of the signal amplitude against travel time, conventionally displayed with the time axis pointing vertically downwards Reflectors would be visible as trace excursions above the ambient noise level Much more useful is a 2-D measurement, with sources and receivers positioned along a straight line on the surface It would be possible to achieve this by repeating our 1-D measurement at a series of locations along the line. In practice, many receivers regularly spaced along the line are used ,all recording the signal from a series of source points .I n this case ,we can extract all the traces that have the same midpoint of the source-receive to offset. This is a common midpoint gather (CMP) the traces within such a CMP gather can be added together (stacke if the increase of travel-time with offset is first corrected for (normal move out (NMO) correction).

Seismic reflections originate from interfaces that show sufficient density-velocity (Rho- Vee) contrasts. Each seismic layer in the subsurface has it its own acoustic impedance. The acoustic

impedance is defined as:

A.I. = density x velocity …… (3.6)

The interface between layers is usually related to sedimentary bedding planes, unconformities and/or pore fill characteristics. The basic ray path geometry at an acoustic impedance interface is illustrated .

Snell's Law is applied at the interface. Also wave splitting into P-wave and S-wave energy occurs, but is ignored in this representation.

Snell's Law is applicable to the transmitted energy in medium 2.

Sin0i/VI = sinOt/V2 …….. (3.7)

terms of density and velocity of the media located on opposed sides of the interface. ¡ the angle of the incident wavefront. In anisotropic media, where wavefronts are not necessarily perpendicular to raypaths, Snell's Law holds for the angles measured between an interface and the wave fronts, using phase velocities (Sheritt 2002). The phase velocity is a directional velocity. The seismic response of a reflected wave tront is dependent on the amount of Rho- Vee changes over the interface. It is expressed in

It is normally defined in terms of reflection coefficient (2D sense) and reflectivity R (full 3D sense for the wavefront). It is expressed by the tollowing formula:

R=p2V2 -p1V1\p2V2 +p1V1 .... (3.8)

Not all energy is reflected back to the surface; a certain amount is transmitted to deeper levels, proportional to the expression:

R*trans =1-R ..... (3.9)*

This transmitted energy is important as it allows detection at the surface of deeper interfaces with the same

3.6 Seismic to well tie:-

In order to make a good seismic-to-well tie, it is also possible to apply a phase rotation to seismic. This is done because the seismic is not always zero phase over the zone of interest. For determining the phase rotation of the seismic trace, it is necessary to perform a Fourier Transform (FT) whereby the data is taken into the frequency domain. The seismic trace is decomposed into its periodic sine wave representation. Each frequency has a certain amplitude and phase assigned. The phase of cach individual sine wave is computed at the T =0 sample. The results of the FT are visualized in the amplitude and phase spectra. It is possible to apply a bulk rotation on the phase of these individual frequencies. This bulk phase rotation does not change the shape of the seismic trace, but it optimizes the match with the synthetic trace. The time position of the

reflections is respected, but their phase is altered . The phase rotation is calculated in the matching procedure between the synthetic and seismic trace via cross correlation techniques. The cross correlation Function is constructed by sliding one of the trace Well seismic-ties allow well data measured in units of depth, to be compared to seismic data measured in units of time, this allows us to relate horizon tops identified in a well with specific reflection on the seismic section. We use sonic and density well logs to generate a seismic trace. The seismic trace compared to real seismic data collected near the well location. One of the first steps in interpreting a seismic dataset 15 to establish the relationship between seismic reflections and stratigraphy. For structural mapping, it may be sufficient to establish approximate relationships it is usually necessary to be more precise and establish exactly how (for example) the top of a reservoir is expressed on the seismic section. Although some information can be obtained by relating reflectors to outcrop geology, by far the best source of stratigraphic information. Wherever it is available,
is well control. Often wells will have sonic (lie. Tormation velocity) and formation density logs, at least over the intervals of commercial interest, trom these it is possible to construct a synthetic seismogram showing the expected seismic response tor comparison with the real seismie data. In addition, some wells will have Vertical Seismic Profile (VSP) data, obtained by shooting a surface seismic source into a down hole geophone, which has the potential to give a more precise tie between well and seismic data.

3.7 Synthetic seismogram:

In order to tie-in the well results, it is customary to compile a so-called synthetic seismogram or trace Figure (3.1). The basic input is formed by:

– A sonic log.

– A density log.

– A check shot survey or VSP.

– A seismic wavelet.

The integrated sonic log, calibrated with the check shots, allows for time conversion of the well data. A T–Z graph is normally constructed for this purpose. The time axis is usually one way travel time, but also two way travel time can be applied if the right correction is made.

A velocity log can be computed from the sonic log, which measures transit times (DT). The sonic velocity is given by:

$$Sonic\ velocity = (1/DT)304800. \qquad (3.10)$$

The velocity is multiplied by the density to generate an acoustic impedance log. The AI contrast at each sampling point is computed and a spiky reflectivity trace is obtained. The reflectivity trace is subsequently convoluted with a seismic wavelet and a synthetic trace is created. This trace is compared to the seismic traces on the seismic sections through the well. For this purposes the same synthetic trace is usually repeated four or five times in the display. It is then overlaid or split-in with the seismic data at the well location. In case of deviated holes the synthetic trace is plotted along the curved well trajectory. Intersection points of the various markers are plotted along this curved trajectory.

Well logs are normally measured along hole from the Kelly Bushing (KB). The kelly is the edged drill pipe that rotates the drilling string. The kelly bushing is the box that guides the kelly on its way down the hole. It is set on the rotary table, which is the work floor where the tool pusher and rough necks manipulate the drill pipes. This is also known as the derrick floor. Below the rotary table are located the Blow-Out Preventers (BOP), which are big valves controlling the access to the bottom of the well trajectory. This tubing assembly is also known as the Xmas tree . The well location has a certain topographic elevation with respect to the main sea level or a local reference datum plane. It has a water depth if located offshore. The measured depth is usually referenced:

– Along hole depth below kelly bushing.

– Along hole depth below mean sea level.

– True vertical depth sub sea.

There is also a difference between driller's depth (the amount of steel piping screwed on top of each other) and the logger's depth (who uses a steel cable to lower his logging tool). Both are measured from the Kelly bushing. The logger's depth includes a cable stretch effect of several meters for a 3000 m deep hole. The Total Depth or TD according to the drillers and the loggers depth shows a discrepancy because:

– Cable stretch effect.

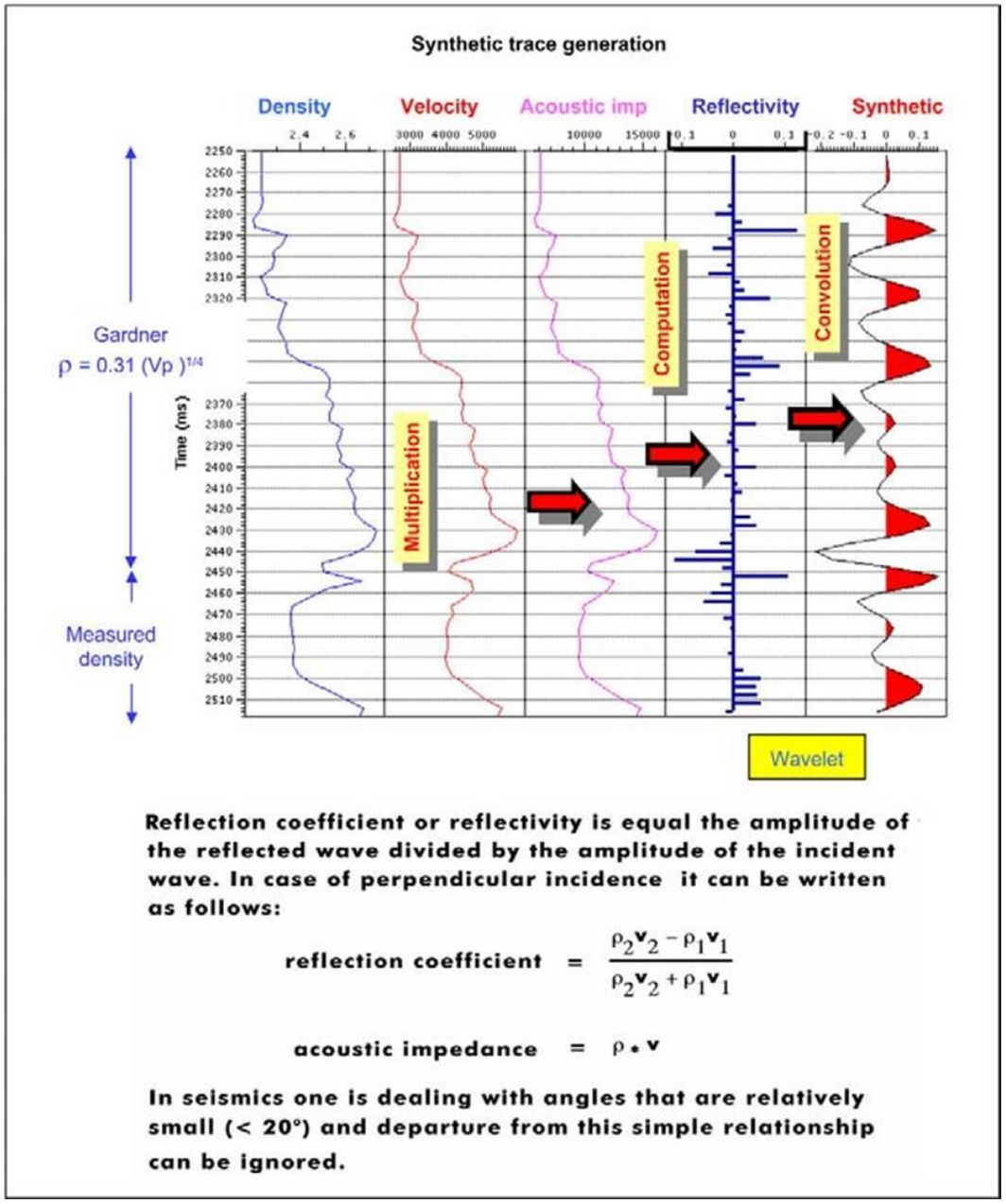
– The logging combo's have a certain length.

– The hole conditions at the bottom of the well are frequently bad.

The seismic data has usually the mean sea level reference as T-zero level. It is necessary to make the right correction for the differences in reference level before comparing the well logs and the seismic .

If this is not done, it will result in an additional bulk time shift for the synthetic trace.

On the synthetic seismogram the position of various biozones, stratigraphic markers and other relevant well information is precisely known and hence a reliable match is made. It often happens that the match is not perfect.



Figure(3.1): synthetic trace generation

3.8 Methodology:

to conduct this study in successful way, the following materials and information were made available by the oil exploration and production authority(OEPA):

wells data includes:

- Three wire line logs for three wells
- Three master logs

- Three final well reports

Software's Used:

(PETREL2015)

Chapter Four

How to generate a synthetic seismogram

4.1 source of the data:

Generation of a synthetic seismogram required to special data, both seismic data and well logging data. In this project we take the data from Abu Sufyan oil field, which locate in Muglad Basin (case study) by helping SUST, College of petroleum and mining .

4.2 contents of the data:-

In this project we take Sufyan oil field bloke 6 as a case study, so we choice 2D seismic data and one well (sufyan n-3) for that area to generate a synthetic seismogram.

2D seismic data include three lines:

- SF2010-01_migration_agc
- SF2010-02_migration_agc
- SF2010-12_migration_agc

4.3 The software used:-

To generate a synthetic seismogram we need to use the software, in this project we use Petrel 2015 software.

4.4 Data loading:-

There are many steps should be followed to generate a synthetic seismogram, the first step is data loading. The data loading has been briefly addressed in two sections. The first section will guide in loading the 2D SEG-Y data, while the second will guide in loading well data.

4.5 Seismic data loading:

seismic data loading is done with two steps, firstly, import seismic line from the computer, secondly, load and display the line on the software screen in 2D window

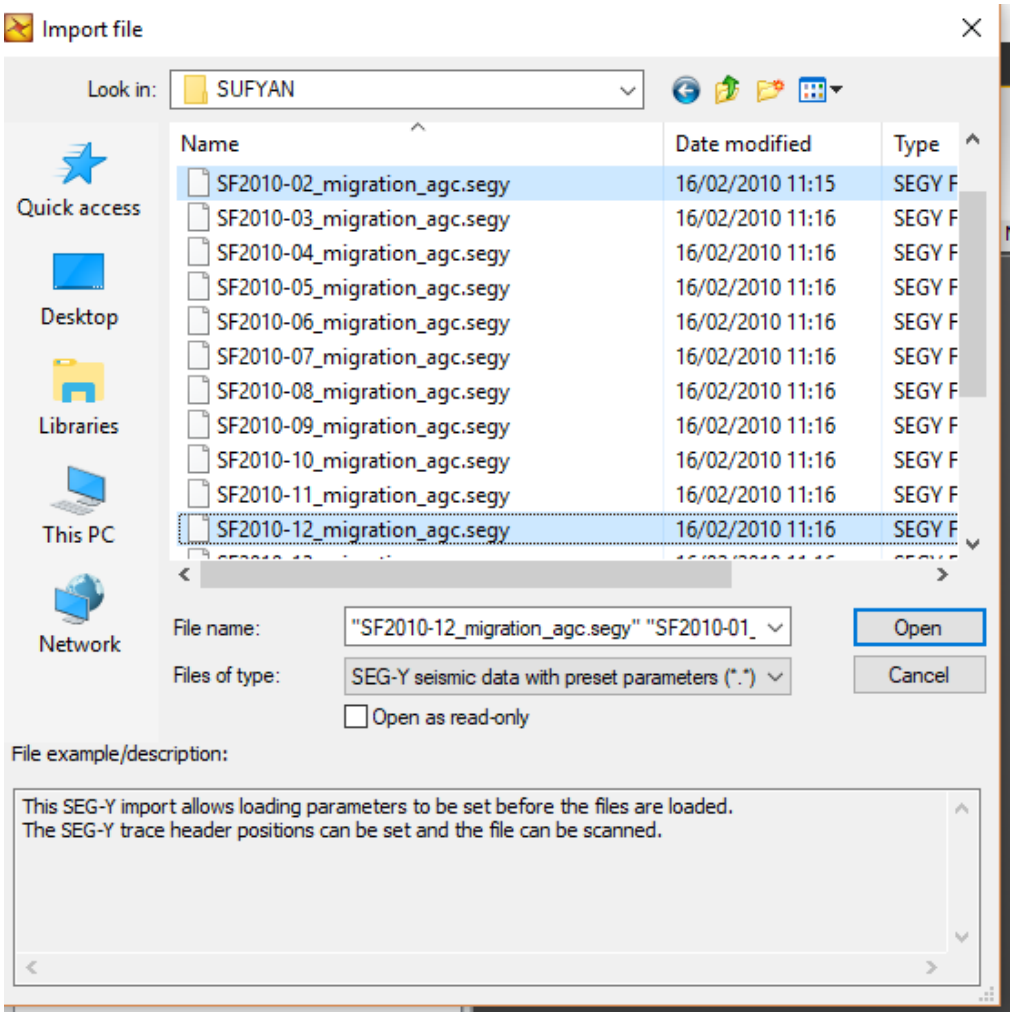


Figure (4.1) import seismic lines from data in computer (SF2010-1,SF2010-2,SF2010-12)

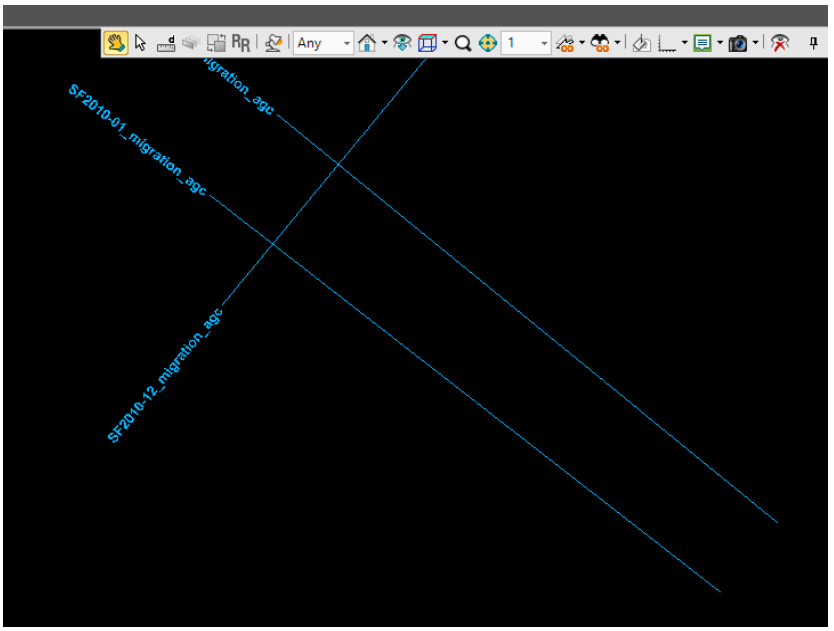


Figure (4.2) load and display the line on the software screen in 2D window

4.6 well data loading:

Well data loading is done with three steps, firstly, import new well from the computer and select the well head (x , y) as shown in Fig (4.3) and show the location of well in Fig (4.4) , secondly, import logs in load and display the well see Fig (4.6).

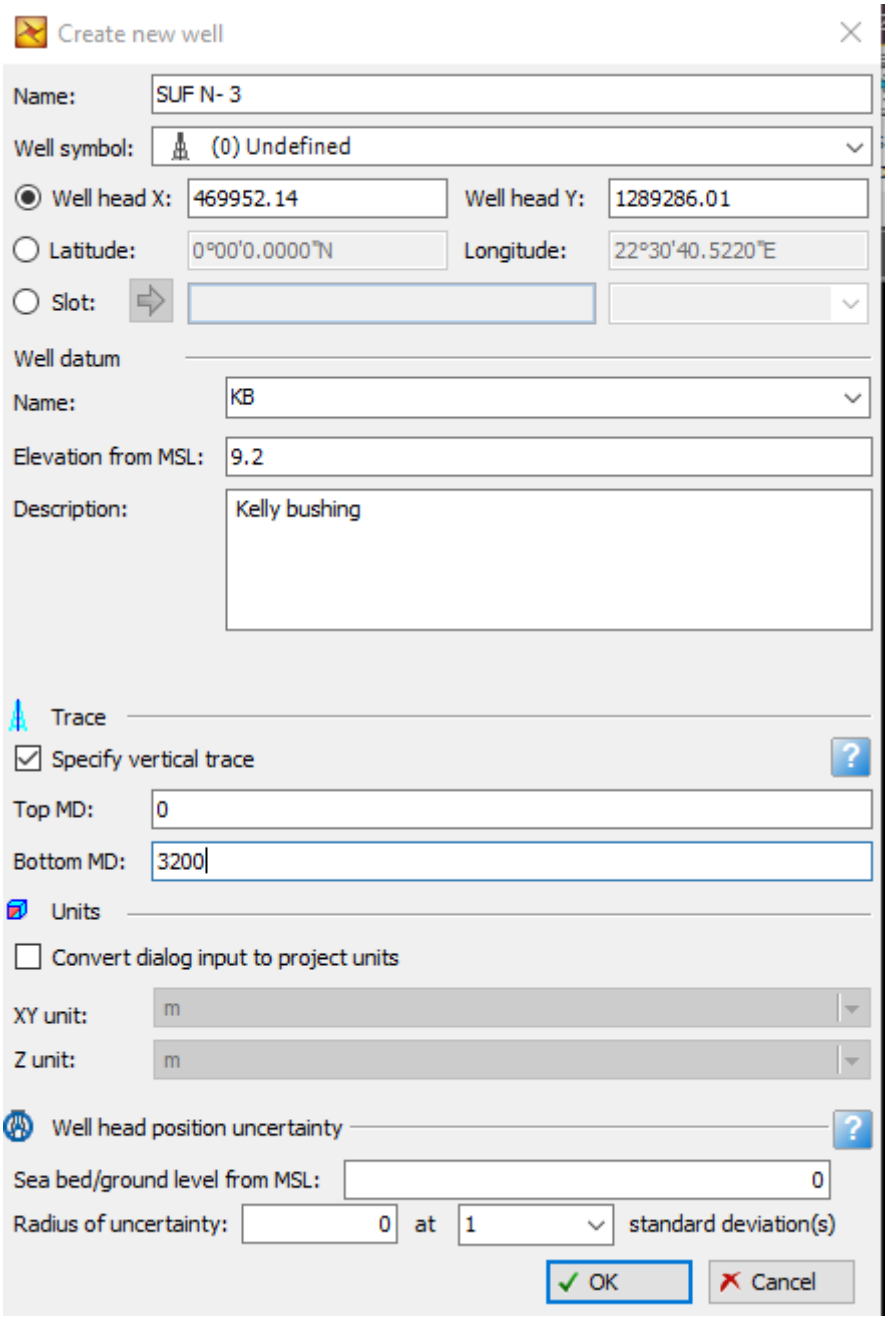


Figure (4.3) import new well from the computer and select the well head (x , y)

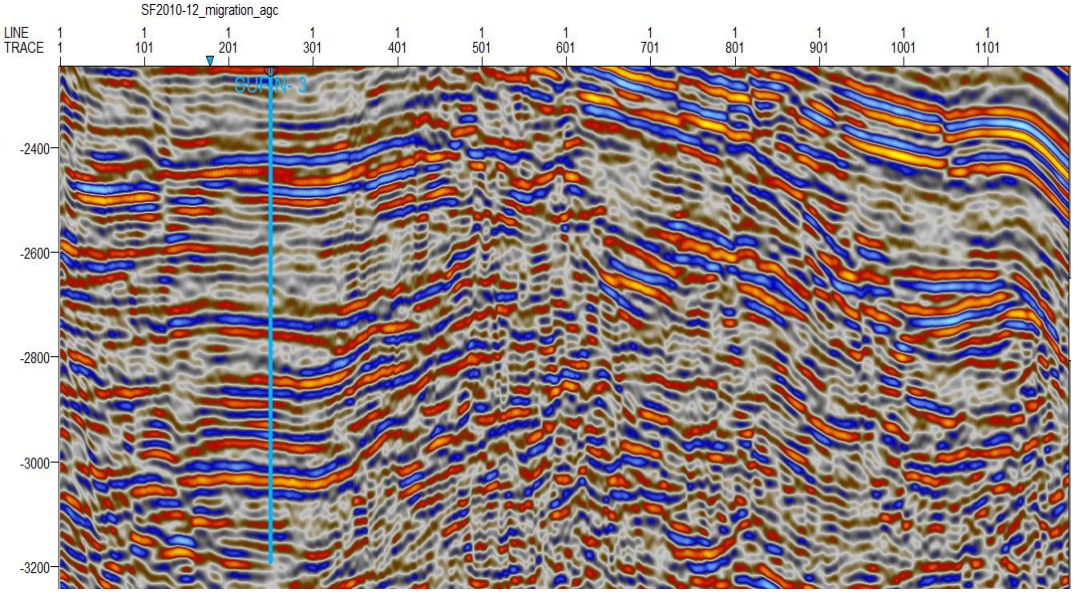


Figure (4.4) show the well location in the seismic interpretation 2D window

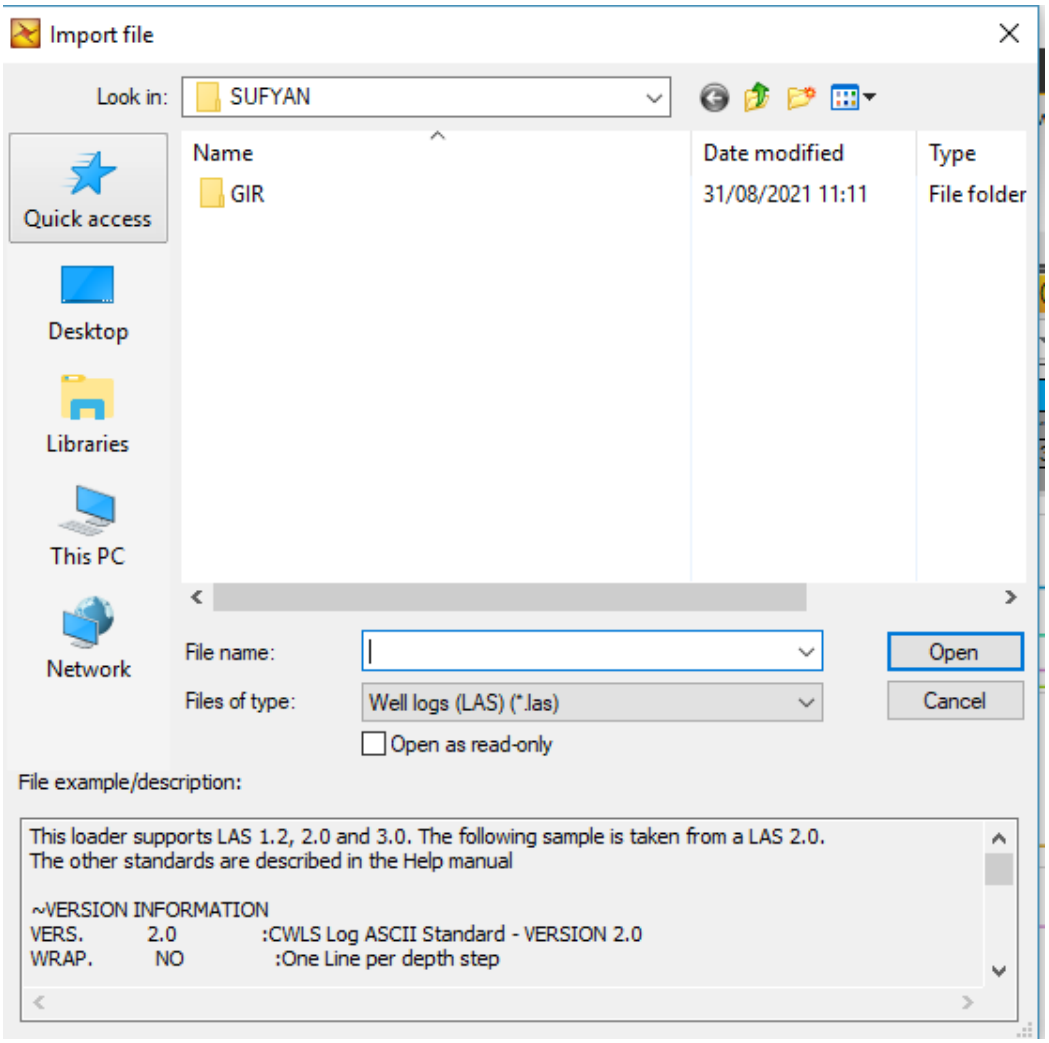


Figure (4.5) import logs with well logs (LAS)(*.las)

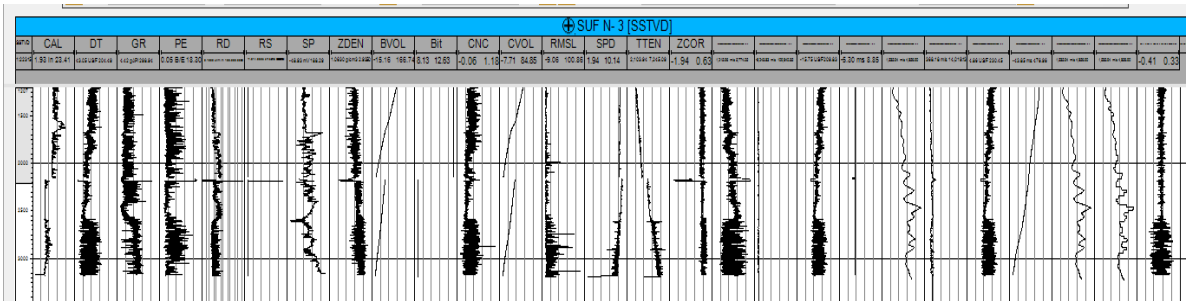


Figure (4.6) the display of the logs

4.7 Synthetic seismogram generation work flow:-

4.7.1. Data preparation:

- open the main page of the software and click in the icon perspective and chose advances geophysics.
- go to the Quantitative interpretation select seismic well tie (wavelet toolbox).
- we chose create study and write the well name ,select type of study (sonic calibration) in the output we chose the well drill land or marine.
- again we click in seismic well tie and chose and hit at study type but we chose synthetic generation in the input we have several older in (tdr we click at checkshot) in wavelet we have to choose ether analytical, statistical, deterministic, multi wavelet, multi well in this project we chose analytical.

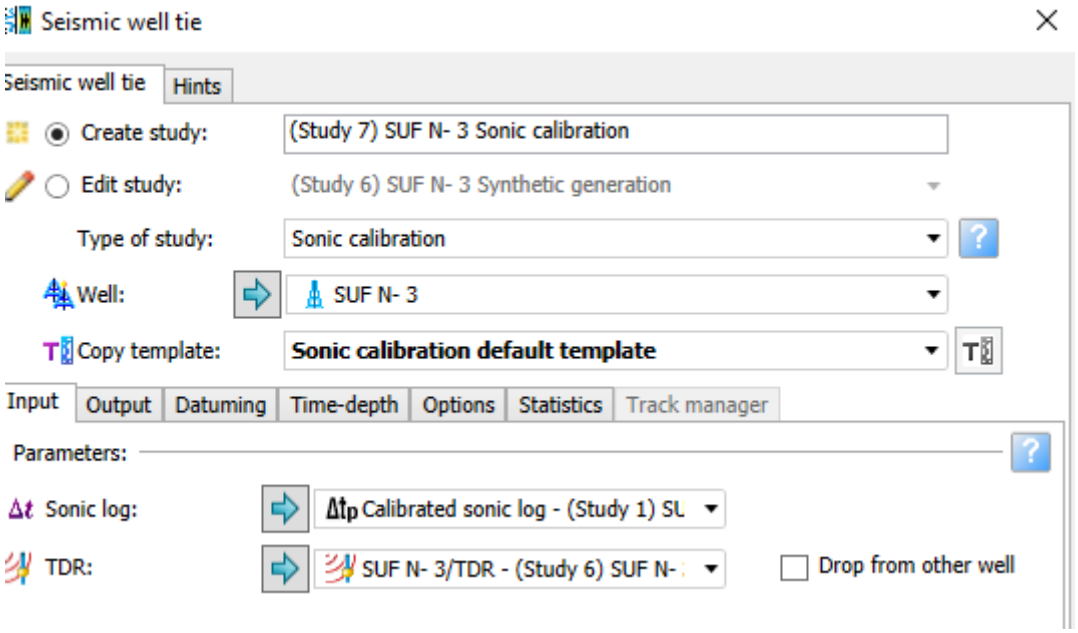


Figure (4.7) show the select of sonic study and the parameters

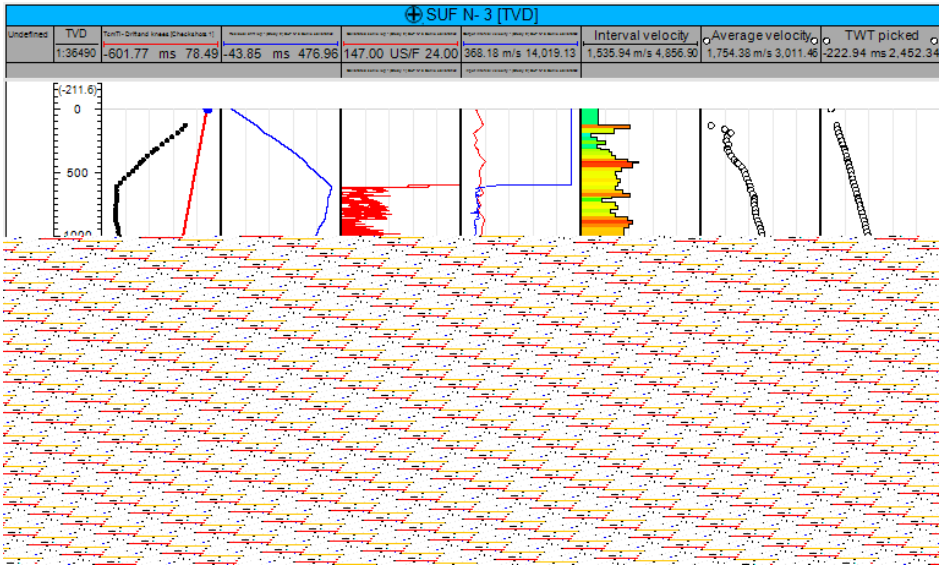


Figure (4.8) show the sonic calibration

Figure (4.9) show the select of synthetic generation

Chapter Five

5.1 Results and discussions:-

Seismic well ties is a process applied to reveal shifting in seismic sections occurs due to acquisition and processing effects, by correlating with well positioned in or near seismic line path, in addition to obtain a clear identification of horizons which had a bad appearance in seismic section as a result of noise .We have discussed how to generate a synthetic seismogram. The quality of synthetic seismograms depends on quality of seismic data, well data, and time depth relationship. In the case study we have obtained an acceptable synthetic seismogram for available data from area under study (Abu sufyan oil field).

5.2 Conclusion:-

In this project, we discussed theory and concept of synthetic seismogram, theory of seismic reflection, and well logging technology, also we discussed how to generate a synthetic seismogram. The used data in this project consists of 2D seismic line, the seismic data and well logs were of good quality. TD of the well is 3200m. The method of analysis includes using of Petrel software. To generate a synthetic seismogram the software computes the velocity from the sonic logs and density from density logs and multiply them to give acoustic impedance, the software compute reflectivity for boundaries and then convolve this reflectivity with the wavelet which extracted from the seismic line to generate synthetic seismogram.

5.3 Recommendation:

To construct a suitable synthetic seismogram must have:

1.To insure data availability and quality.

2. To use advanced seismic interpretation software's with broad technical solutions, and high capacity workstations.

3. The well log data must be of high quality, so that the process of extraction of density and velocity yield best fit synthetic seismogram.

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