[PS]Impact of Taconic Unconformity on the Depositional Geometries of the Lower Paleozoic Clastic Successions in Murzuq Basin, a Case from SW Libya*

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Abstract

The "Taconic Unconformity" is a regional polyphase event that occurred during the Late Ordovician in North Africa. This major unconformity event coincided with regional glaciation episodes that controlled the current configuration of the Lower Paleozoic clastic successions. A case study has been carried out utilizing subsurface data represented by 3D seismic lines and well log data (i.e. geological imaging, element capture spectropscopy, lithology, and facies logs) to understand the impact of the regional unconformity in the Murzuq Basin, southwest Libya. The basin is considered the second largest profitable hydrocarbon potential in Libya, one of the largest in North African, and were developed during Late Precambrian-Early Paleozoic. The main reservoirs in the basin are comprised of clastic sandstones, which were deposited during Middle to Late Ordovician. A series of pre-Ordovician basement faults mapped in the study area trending northwest-southeast have dominantly controlled the trend of the unconformity as well as the post-depositional sedimentation processes.

Based on the interpreted data, the unconformity has clearly impacted the geometries of the whole Lower Paleozoic sandstone successions especially the Ordovician deposits (i.e. Hawaz and Mamuniyat Formations). It has been observed the unconformity surface concurred with a severe erosion which have removed the clastic strata from Middle Ordovician deeper into the Cambrian deposits. It is estimated with more than 900 feet (270 meters) have been eroded by the means of glacial incisions along the strike direction of the preexisted basement faults. This mega cycle of erosion has created large scale paleo-lows of more than seven kilometers wide in the study area. These paleo-topographic geometries have controlled the depositional patterns of both Upper Ordovician clastic reservoirs and Silurian source rock in the basin. This study realized the overall clastic successions in the Early Paleozoic have been deposited under multifaceted events of tecto-stratigraphic throughout the tectonic evolution record of the basin. In this poster, an integrated work was accomplished using the subsurface data to illustrate the complexity of reservoir and source rock geometries of the Lower Paleozoic sandstones.

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1. ABSTRACT

The "taconic unconformity" is a regional polyphase event occurred during Late Ordovician in North Africa. This major unconformity event is coincided with regional glaciation episodes that controlled the current configuration of the Lower Paleozoic clastic successions. A case study has been carried out utilizing subsurface data represented by 3D seismic lines and well log data (i.e. geological imaging, element capture spectroscopy, lithology and facies logs) to understand the impact of the regional unconformity in Murzuq basin, southwest of Libya. The basin is considered as the second largest profitable hydrocarbon potential in Libya and one of the largest in North African; those were developed during Late Precambrian-Early Paleozoic. The main reservoirs in the basin are mainly comprised of clastic sandstones, which deposited during Middle to Late Ordovician. Series of pre-Ordovician basement faults mapped in the area of study trending northwest-southeast have dominantly controlled the trend of the unconformity as well as the post-depositional sedimentation processes.

Based on the interpreted data, the unconformity has clearly impacted the geometries of the whole Lower Paleozoic sandstone successions especially the Ordovician deposits (i.e. Hawaz and Mamuniyat Formations). It has been observed that the unconformity surface concurred with a severe erosion which have expurgated the clastic strata from Middle Ordovician and deeper into the Cambrian deposits. It is estimated with more than 900 feet (270 meters) have been eroded by the means of glacial incisions along the strike direction of the preexisted basement faults. This mega cycle of erosion has created a large scale of paleo-lows of more than seven kilometers wide in the area of study. These paleo-topographic geometries have controlled the depositional patterns of both Upper Ordovician clastic reservoirs and Silurian source rock in the basin. This study realized that; the overall clastic successions aged in Early Paleozoic have been deposited under multifaceted events of tecto-stratigraphic throughout the tectonic evolution record of the basin. In this poster, an integrated work was accomplished using the subsurface data to illustrate the complexity of reservoir and source rocks geometries of the Lower Paleozoic sandstones.

2. INTRODUCTION

Case study from one of the largest Libyan basins, known as Murzuq basin, has been carried out to identify the impact of the Taconic Unconformity on the Lower Paleozoic successions. Using different data scales from borehole to seismic could identify and correlate regional scale features within the area of study.

2.1. Location of the Area of Study

The area of the current study is located in the southwestern part of Libya within Murzuq basin at the northern edge within Awbari trough (Figure-1). The nearest exposures to the area of present study are the Messak escarpment of Cretaceous age to the south and the Qargaf Arch to the north.

2.2. Available Dataset & Software Used

Different scale dataset have been used in the current study to evaluate the regional unconformity, can be listed as;

- Surface 3D seismic lines cross five wells drilled in two different fields.
- Open-hole logs of five wells.
- Borehole Image data (FMI) in the five wells.

Other dataset have been also available such as surface maps of the area and satellite images, those data were utilized within the current study. The methods and techniques used to refine the structural evolution of the area of current study are believed to be covering various structural scales. Seismic data was used mainly to analyze large scale structural and stratigraphic features such as; faults and paleotopographic variations. Whereas, the FMI images were used mainly to analyze and interpret the small scale structural and stratigraphic features such as; fractures and sedimentary structures. Mainly Petrel platform software has been used to perform the seismic interpretation and well logs correlation.

3. GEOLOGICAL SETTIG OF MURZUQ BASIN

Murzuq basin is defined as an intracratonic basin that developed during the Last stage of the Pan African Orogeny (i.e. Late Neoproterozoic to Early Paleozoic) and it's considered as one of the major Paleozoic basins in North Africa (Figure-2). Murzuq basin was first developed during the Early Paleozoic time by the collision between the East Sahara and West African cratons and persist its development till the Cretaceous. During the development of the basin, cratons and terrains were remobilized crossing different latitudes and longitudes before stabilization from the late Neoproterozoic to the Early Paleozoic. This drifting is reflected in both structural features and the stratigraphic record of the basin. The main tectonic phases of the basin evolution can be listed as;

1) Precambrian (Rodinia, Pan African Orogeny and Gondwana assembly),
2) Early Paleozoic (Murzuq basin, Regional Unconformities & Glacial episodes),
3) Middle Paleozoic (Transition from Extension to Compression Episodes),
4) Late Paleozoic (Hercynian Orogeny, Assembly of Pangea),
5) Mesozoic (Breakup of Pangea, Tethyes Ocean, Austrian & Santonian Uplifting) &
6) Cenozoic (Uplifting and Inter-plate stresses during Alpine Orogeny to present day).

During all of these stages, Murzuq basin was directly or indirectly affected by multi-structural phases (compression, extension, strike-slip and/or combination) that have produced the final configuration of the present day structure of the basin. The main structural elements in Murzuq basin were mapped by Fürst and Klitzsch (1963) as Tirrine High separating Al Awaynat and Awbari troughs and Traghan High (Also named in this chapter by Barak Ben Ghanimah Arch of Klitzsch, 1963) between Awbari and Dor Al Qussah troughs (Figure-2). The present day configuration of Murzuq basin has not develop until the end of Mesozoic and prior to that the Paleozoic. The basin was mainly comprised of a serious of NW-SE directed horsts and grabens. The most important structural elements of the present study are Tirrine High, Awbari trough and Traghan High since they are confining the present area of study. The major oil discoveries in the basin are within Awbari trough as well as the area of the present study. These large scale tectonics are separated from each other by large basement faults, those faults have controlled the structural movements and the stratigraphic variation within the basin. The stratigraphic succession of the basin is represented by thick clastic deposits apart from the carboniferous which have carbonates. The Lower Paleozoic succession is dominantly comprised of clastic deposits those have been deposits within various depositional setting.

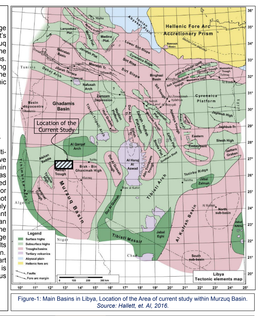
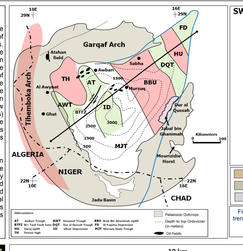


Figure-1: Main Basins in Libya, Location of the Area of current study within Murzuq Basin. *Source: Hallett, et. Al, 2016.*

4. TACONIC UNCONFORMITY & ITS IMPACT IN THE AREA OF STUDY

The interpreted seismic data in the study area at the northern part of Murzuq basin have encountered one of the largest features generated as a result of the "taconic unconformity". These features are represented by paleotopographic highs and lows those occurred by deep erosion of thick clastic deposits at the end of the Ordovician. During this time, Late Ordovician, North Africa and Arabian shield were subjected to glacial episode and dominated with glaciation processes. These processes were accompanied with tectonic instabilities and generated a regional polyphase unconformity. The glacial processes have taken place in the area of study and wide U-Shape valleys have been developed with an average seven (7) kilometers wide aligned with the pre-existed basement faults system (Figures-3 to 10). The main trend of the Cambrian – Ordovician faults mapped in the study area and in the nearby areas is mainly NNW-SSE & NW-SE those have been the course of the glacial valleys at the end of the Ordovician. The glaciation processes effect were limited at the periphery of the northern part of Murzuq basin where the inner land direction was SE and the marine direction was towards the NW. From the seismic data it is indicated that; the units of the Middle Ordovician Hawaz Formation have been deposited horizontally without any lateral variations with an average thickness of 950 feet (290 meters). The depositional environment of Hawaz Formation is represented by tide dominated marginal deposits (shorefeace, estuary & tidal flat). These deposits have been preserved within the high areas and almost totally eroded at the low areas during the glacial episode that reached Cambrian deposits in some areas. The low areas shaped by the unconformity have been utilized by the Upper Ordovician deposits as favorable accommodation space and more than 900 feet (270 meters) of clastic have been deposited in the wide valleys. These deposits, known as Melaz Shuqran and Mamuniyat Formations, represent glacial deposits of marine and fluvial dominated depositional setting (Figures-3 to 10). Glacial features have been observed and described from the borehole images in three studied wells those were drilled in the incised glacial valley (i.e. paleolow area). The main glacial sedimentary features are represented by thick sequences of contorted units as a result of rapid deposition, large conglomerates floating within finer sediments, bull's eye structures, sand injectites, etc. (Figure-9).

During Early Silurian, substantial ice melting with drifting of the continents have resulted in regional marine transgression in the whole of North Africa and Arabian Shield. The large scale marine flooding invaded the basin from the north to south and crossed the Libyan boarded. This regional marine transgression have resulted in the deposition of the main source rock in North Africa which is known as Tanezzuft Shale or as Silurian Shale. Tanezzuft Formation is mainly subdivided into two main sequences as hot and cold shales with an average thickness of 800 feet (240 meters). The Hot Shale refers to the lower most unit and represents the main source rock, while the upper unit known as Cold Shale which is the thickest and represent regional seal. The Hot Shale has been deposited within the low areas of the paleotographic tectonic generated features which was deeper enough to accumulate thick sequence of glaptolitic units. This lateral distribution controls the petroleum system of the Ordovician in Murzuq basin, where both Paleohighs (Middle Ordovician Hawaz Formation) and Paleolows (Upper Ordovician Mamuniyat Formation) feed with hydrocarbon from the Hot Shale (Figures-5 &6). Tectonic cartoon built to illustrate the main tectonic episodes occurred during Lower Paleozoic and their impact on the clastic deposits and their final geometries.



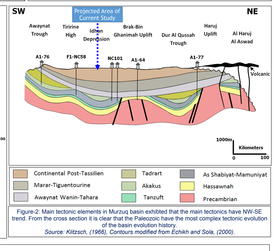


Figure-2: Main tectonic elements in Murzuq basin exhibited that the main tectonics have NW-SE trend. From the cross section it is clear that the Paleozoic have the most complex tectonic evolution of the basin evolution history.
Source: Klitzsch, (1966). Contours modified from Echikh and Sola, (2000).

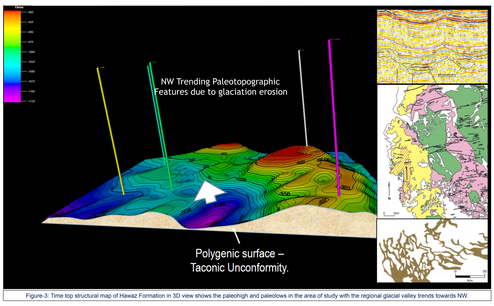
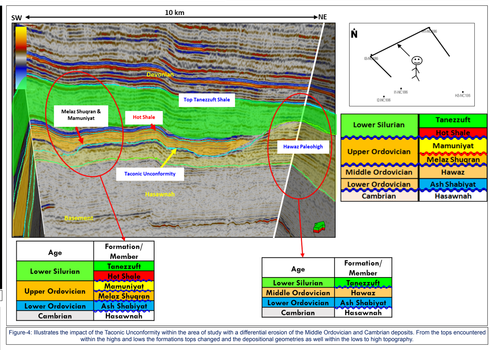


Figure-3: Time top structural map of Hawaz Formation in 3D view shows the paleohigh and paleolows in the area of study with the regional glacial valley trends towards NW.



Age	Formation/ Member
Lower Silurian	Tanezzuft
	Hot Shale
Upper Ordovician	Mamuniyat
	Melaz Shuqran
Lower Ordovician	Ash Shabiyat
Cambrian	Hasawnah

Age	Formation/ Member
Lower Silurian	Tanezzuft
Middle Ordovician	Hawaz
Lower Ordovician	Ash Shabiyat
Cambrian	Hasawnah

Figure-4: Illustrates the impact of the Taconic Unconformity within the area of study with a differential erosion of the Middle Ordovician and Cambrian deposits. From the tops encountered within the highs and lows the formations tops changed and the depositional geometries as well within the lows to high topography.

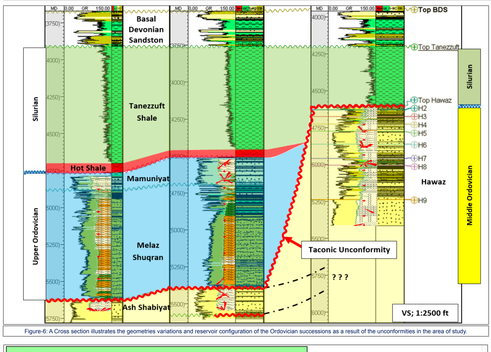


Figure-6: A Cross section illustrates the geometries variations and reservoir configuration of the Ordovician successions as a result of the unconformities in the area of study.

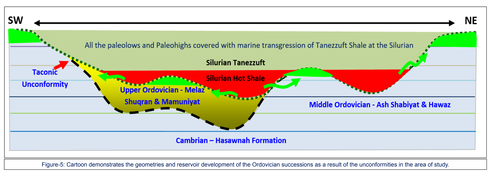


Figure-5: Cartoon demonstrates the geometries and reservoir development of the Ordovician successions as a result of the unconformities in the area of study.

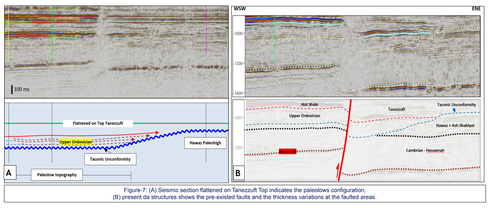


Figure-7: (A) Saismic section flattened on Tanezzuft Top indicates the paleolows configuration, (B) present da structures shows the pre-existed faults and the thickness variations at the faulted areas.

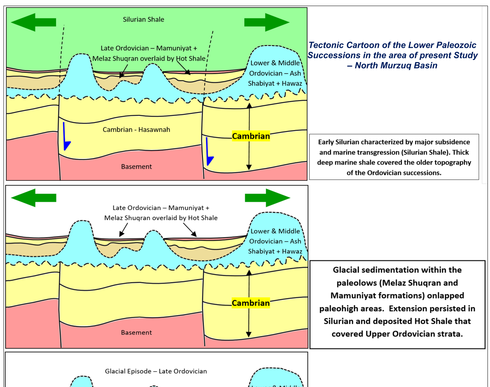


Figure-10: Cartoon demonstrated the tectonic evolution of the Lower Paleozoic successions in the area of present study – Northern Murzuq Basin.

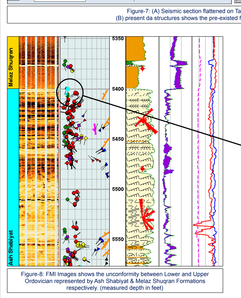
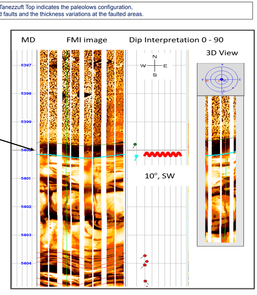


Figure-8: FMI Images shows the unconformity between Lower and Upper Ordovician represented by Ash Shabiyat & Melaz Shuqran Formations respectively. (measured depth in feet)



FMI Glacial Features Examples from Melaz Shuqran and Mamuniyat Formations

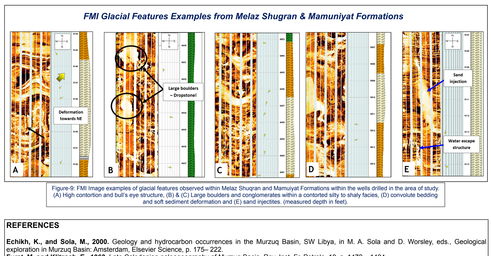


Figure-9: FMI Image examples of glacial features observed within Melaz Shuqran and Mamuniyat Formations within the wells drilled in the area of study. (A) High contortion and bull's eye structure, (B) & (C) Large boulders and conglomerates within a contorted silty to shaly facies, (D) convolute bedding and soft sediment deformation and (E) sand injectites. (measured depth in feet).

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