

PS Jurassic Rift Architecture in the Northeastern Western Desert, Egypt*

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Abstract

During the last decade the Egyptian Western Desert has emerged as a major hydrocarbon province in North Africa. Much of the exploration success has resulted from the recognition and exploitation of the Jurassic hydrocarbon system and associated reservoirs. The Western Desert has a complex, poly-phase tectonic history starting in the Mesozoic with Jurassic rifting. The Early Jurassic extensional event occurred during the separation of the North African and European plates and resulted in a broad zone of rift basins cross cutting the Precambrian basement and, in some areas, pre-existing Paleozoic basins on the Neotethyan continental margin of North Africa. Conventional wisdom based upon interpretations of gravity and magnetic data suggested that the overall orientation of the Jurassic rift-bounding faults trend in a NE-SW direction. However, recent studies based upon regional 3D and 2D seismic interpretation and well data suggest that the Jurassic rifts have more of an east-west orientation in the western portion of the Western Desert. Regional interpretations of merged 2D/3D seismic data in the northeastern portion of the Western Desert (South Alamein, South Mariut, and Tanta concessions and adjacent areas) indicate that this east-west rift trend continues into these areas. It is only along the coastal areas, where the structure fabric is dominated by the Rosetta fault, that the NE-SW trend is dominant. Furthermore, these data indicate that in this region asymmetrical half-grabens are separated by stable basement blocks.

Apatite fission track data from recent wells that were drilled to basement indicate that the Sheiba High and Shaltut-Mekdam basement blocks formed during the Early Jurassic and were not significantly affected by subsequent tectonic events. Basinal areas of various

depths and sizes are separated and isolated by these high blocks by a complex set of rift transform zones and breached relay ramps. Accurately mapping and understanding the geometries and distribution of these rifts and associated high blocks is crucial for modeling hydrocarbon systems and predicting hydrocarbon occurrences in this region of the Western Desert as the Jurassic exploration play extends to the east.

ABSTRACT

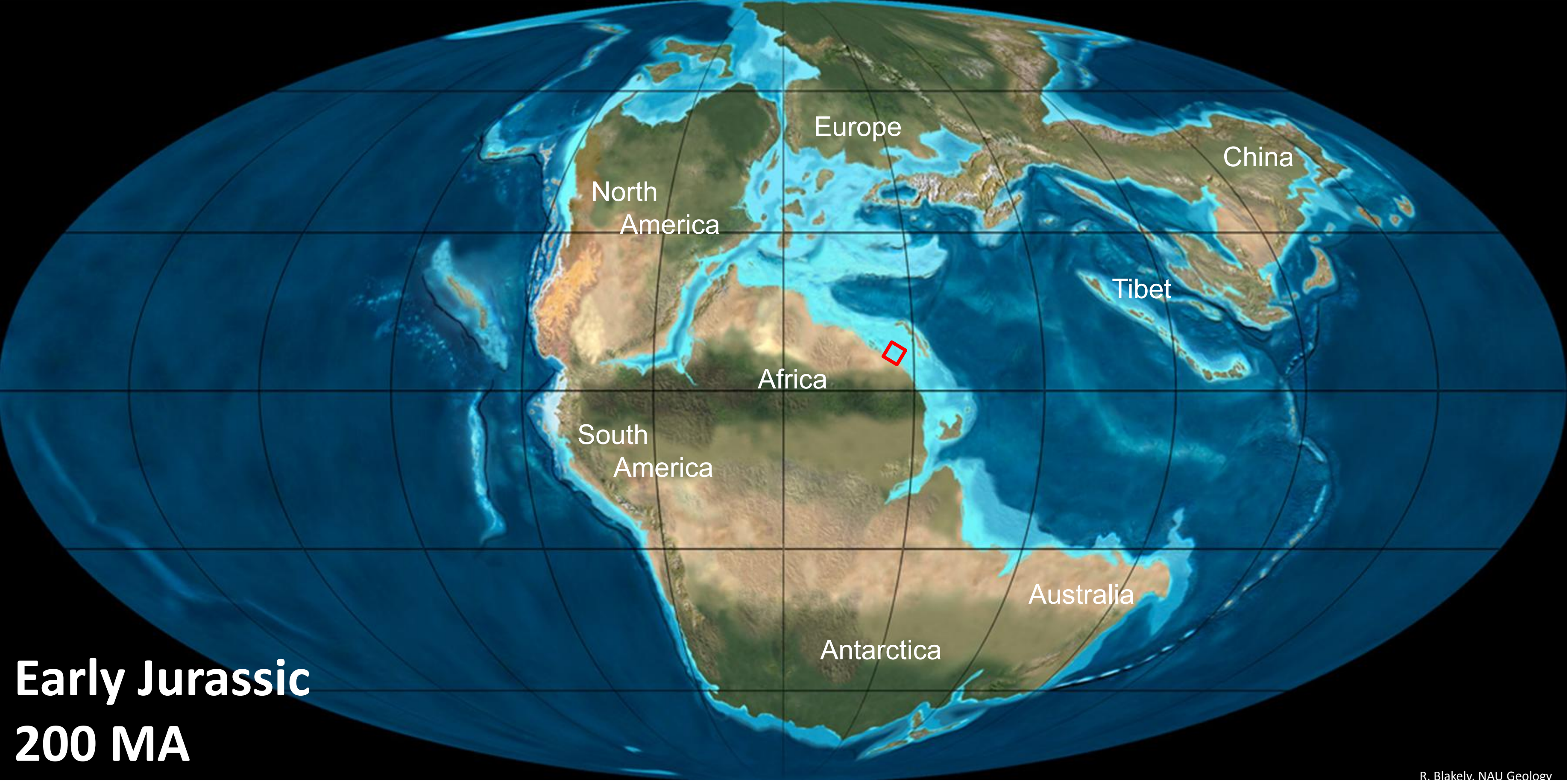
During the last decade the Egyptian Western Desert has emerged as major hydrocarbon province in North Africa. Much of the exploration success has resulted from the recognition and exploitation of the Jurassic hydrocarbon system and associated reservoirs. The Western Desert has a complex, poly-phase tectonic history starting in the Mesozoic with Jurassic rifting. The Early Jurassic extensional event occurred during the separation of the North African and European plates and resulted in a broad zone of rift basins cross cutting the Precambrian basement and, in some areas, pre-existing Paleozoic basins on the Neotethyan continental margin of North Africa. Conventional wisdom based upon interpretations of gravity and magnetic data suggested that the overall orientation of the Jurassic rift-bounding faults trend in a NE-SW direction. However, recent studies based upon regional 3-D and 2-D seismic interpretation and well data suggest that the Jurassic rifts have more of an East-West orientation in the western portion of the Western Desert. Regional interpretations of merged 2-D/3-D seismic data in the northeastern portion of the Western Desert (South Alamein, South Mariut, and Tanta concessions and adjacent areas) indicate that this east-west rift trend continues into these areas. It is only along the coastal areas, where the structure fabric is dominated by the Rosetta fault that the NE-SW trend is dominant. Furthermore, these data indicate that in this region asymmetrical half-grabens are separated by stable basement blocks. Apatite fission track data from recent wells that were drilled to basement indicate that the Sheiba High and Shaltut-Mekdam basement blocks formed during the Early Jurassic and were not significantly affected by subsequent tectonic events. Basinal areas of various depths and sizes are separated and isolated by these high blocks by a complex set of rift transform zones and breached relay ramps. Accurately mapping and understanding the geometries and distribution of these rifts and associated high blocks is crucial for modeling hydrocarbon systems and predicting hydrocarbon occurrences in this region of the Western Desert as the Jurassic exploration play extends to the east.

Study Location Map & Regional Paelogeographic Setting

Study Area Location:

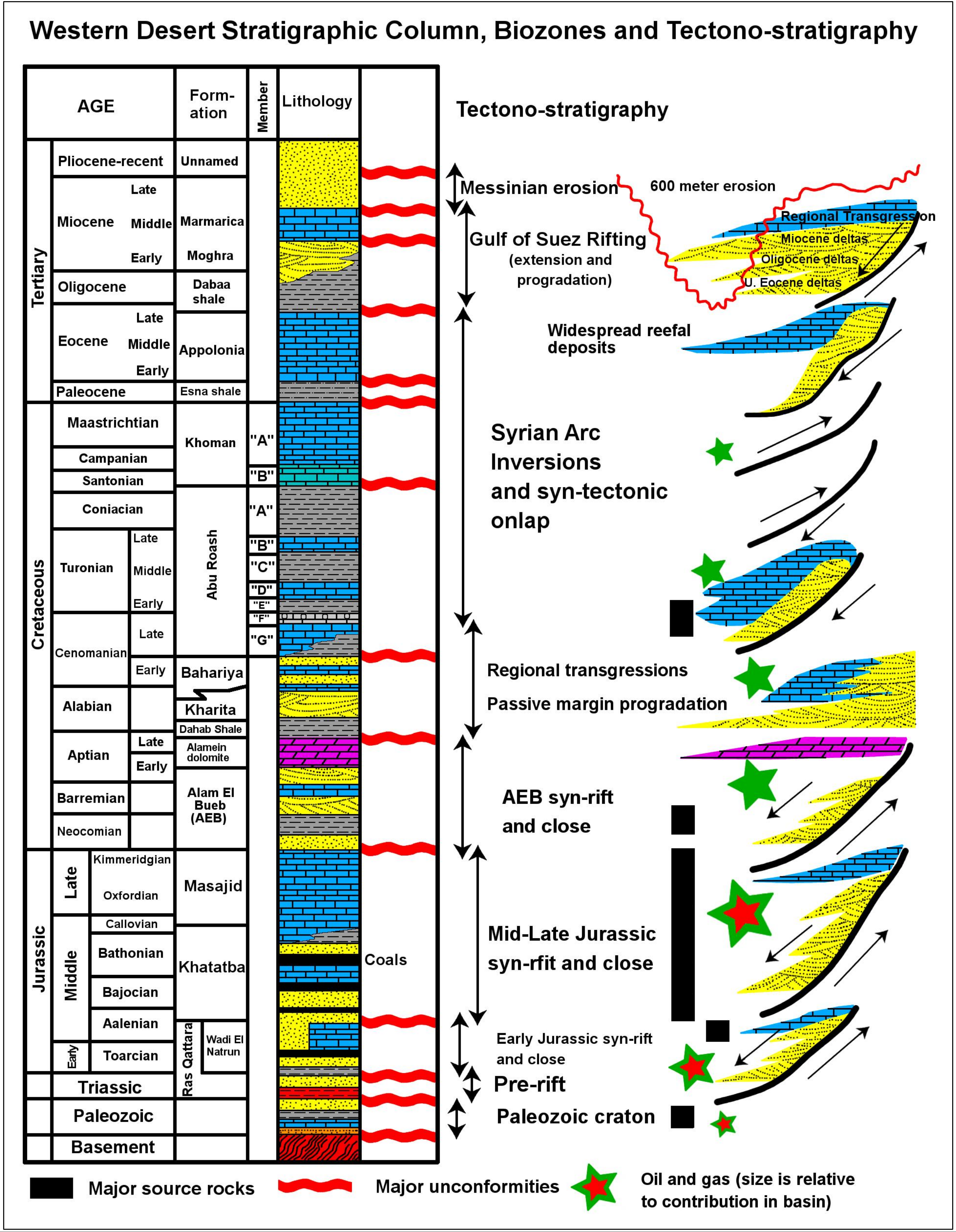


Paleogeographic Reconstruction:

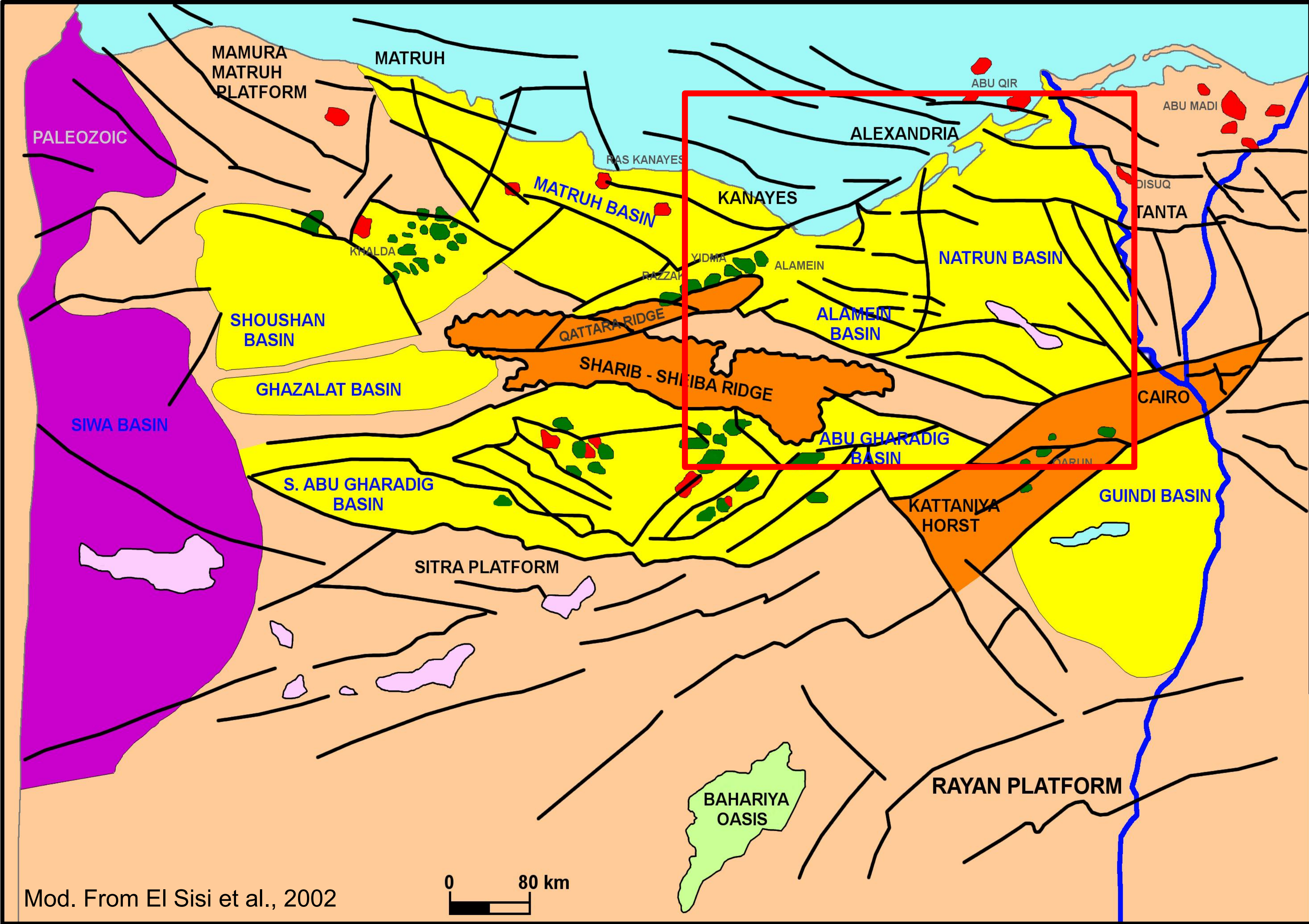


During the Jurassic Period, what is now northern Egypt was geographically located on the southern margin of the Tethyan seaway, along the equatorial coast of the massive supercontinent of Gondwana. Jurassic rifting occurred as the Atlantic Ocean began to open separating North America and Eurasia and Gondwana began to break apart. This study focuses on the transition zone between Gondwana and the Neo-Tethys, where the opening of the Tethys created a broad, diffuse, and complex rift architecture. This is a unique area where the Jurassic rift structures, and their effect on syn and post-rift sedimentation and tectonics can be studied.

Western Desert Stratigraphy & Tectonic Episodes



Previous Work of Structural Framework in the Western Desert



This published map shows the locations of the major basins and uplifts in the Western Desert is highly generalized and does not reflect the complexity of the structural architecture of the region(from El Sisi and others, 2002). This characterization is particularly true of this poster's study area, where typical Western Desert SW-NE production trends intersect the Nile Delta, at what is here described as the Natrun Basin. Natrun basin exhibits an amorphous shape, where apparent, and possibly arbitrary, boundaries include a modern day Nile River channel. The fault pattern or the Natrun Basin is somewhat chaotic with no apparent dominant trends like those see to the West and South. This poster will try to clarify the true geometries of the Mesozoic in this Western Desert-Nile Delta transitional area.

Jurassic Rift Architecture in the Northeastern Western Desert, Egypt

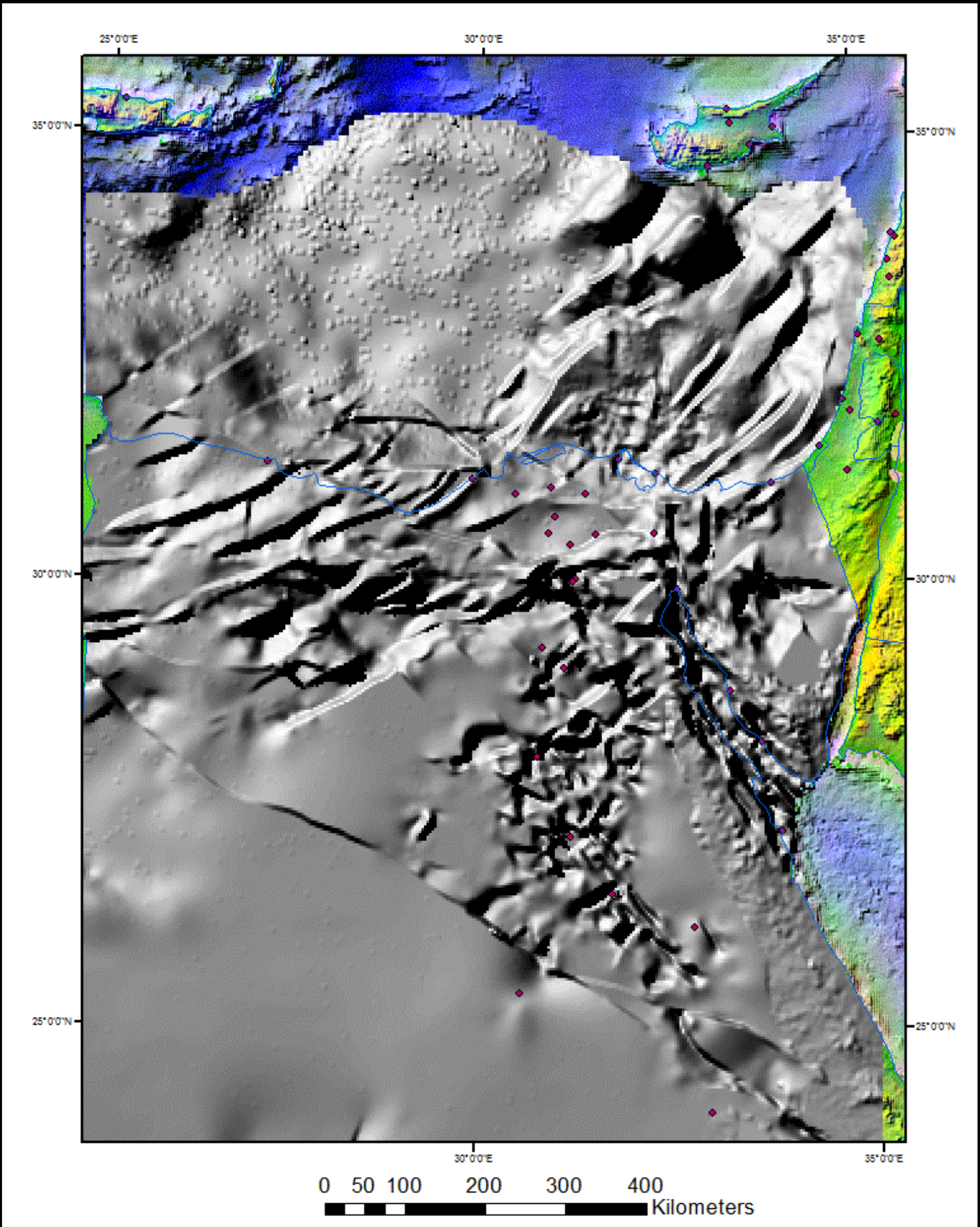
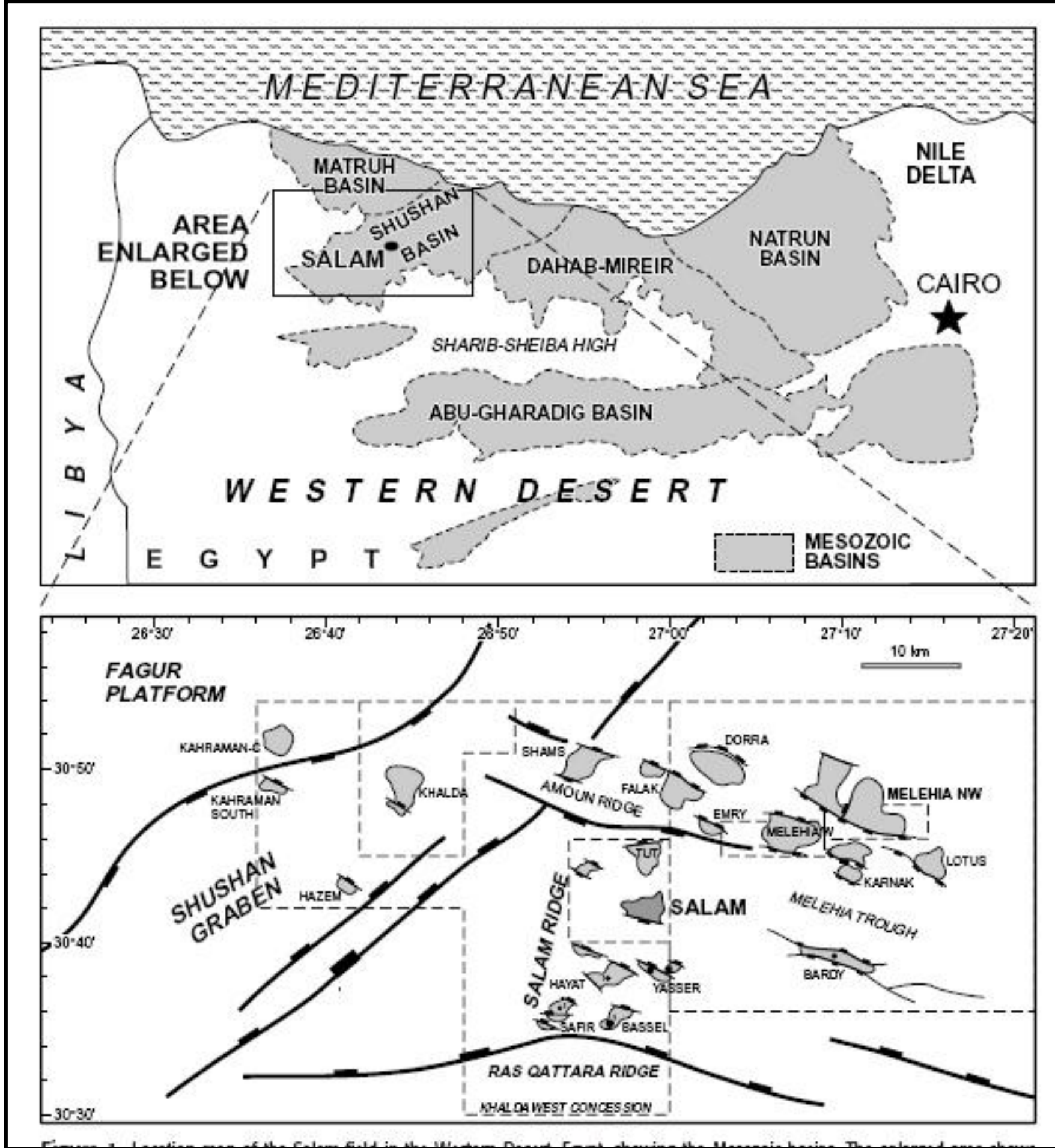
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Western Desert Basin Architecture

Previous Work:

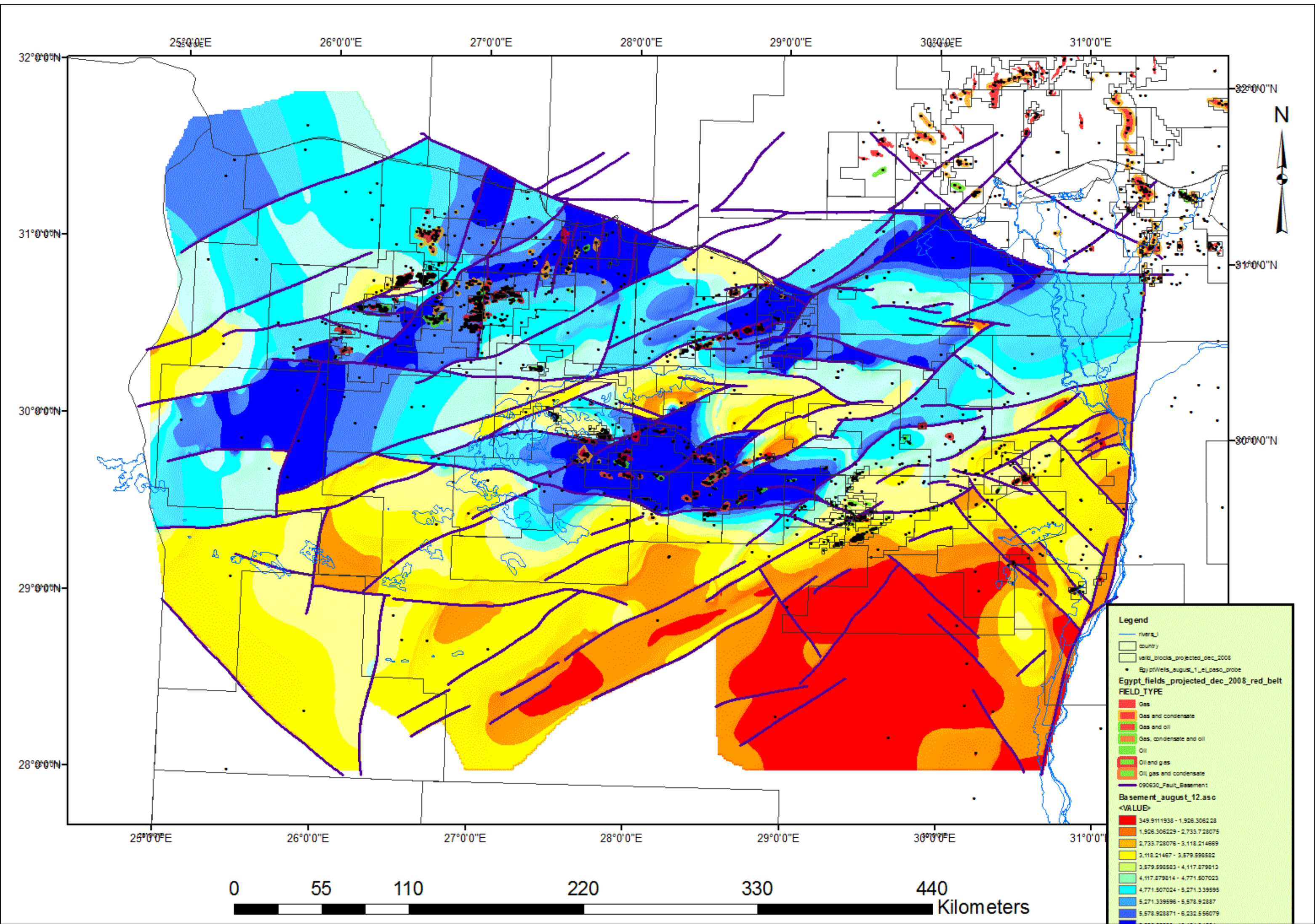
Rossi et al., (2002)

Frogtech Basement Study (2001)



Previous studies of Egypt's Western Desert show very general basin outlines and do not describe in detail the tectonic fabric. Although, there are known Paleozoic basins in the Western Desert, the prevailing tectonic architecture is dominated by Jurassic rifting caused by rifting of the African and European continents forming the Tethys Seaway. The gross structural fabric of the Western Desert is characterized by a dominant northeast-southwest trend which is consistently imaged by regional potential field studies. However, on a more local level, in many parts of the Western Desert the Jurassic rift bounding faults tend to trend in an east-west direction, as will be shown in this poster.

El Paso, Present Day:



This study incorporated data from over 100 well logs and tops from over 700 wells in the Western Desert and several hundred kilometers of 2D and 3D seismic to better define the structure of the basement and Jurassic. The northeast-southwesterly trend is inherited from the potential fields derived basement map. However, the integration of well control and seismic data has resulted in a much more detailed picture of the structural architecture including east-west trending deep areas. In particular, the transition area between the Western Desert and the Nile Delta provinces has been mapped in detail, with some unique structural features not identified in earlier studies.

Thermal History of Intra-Rift High Blocks

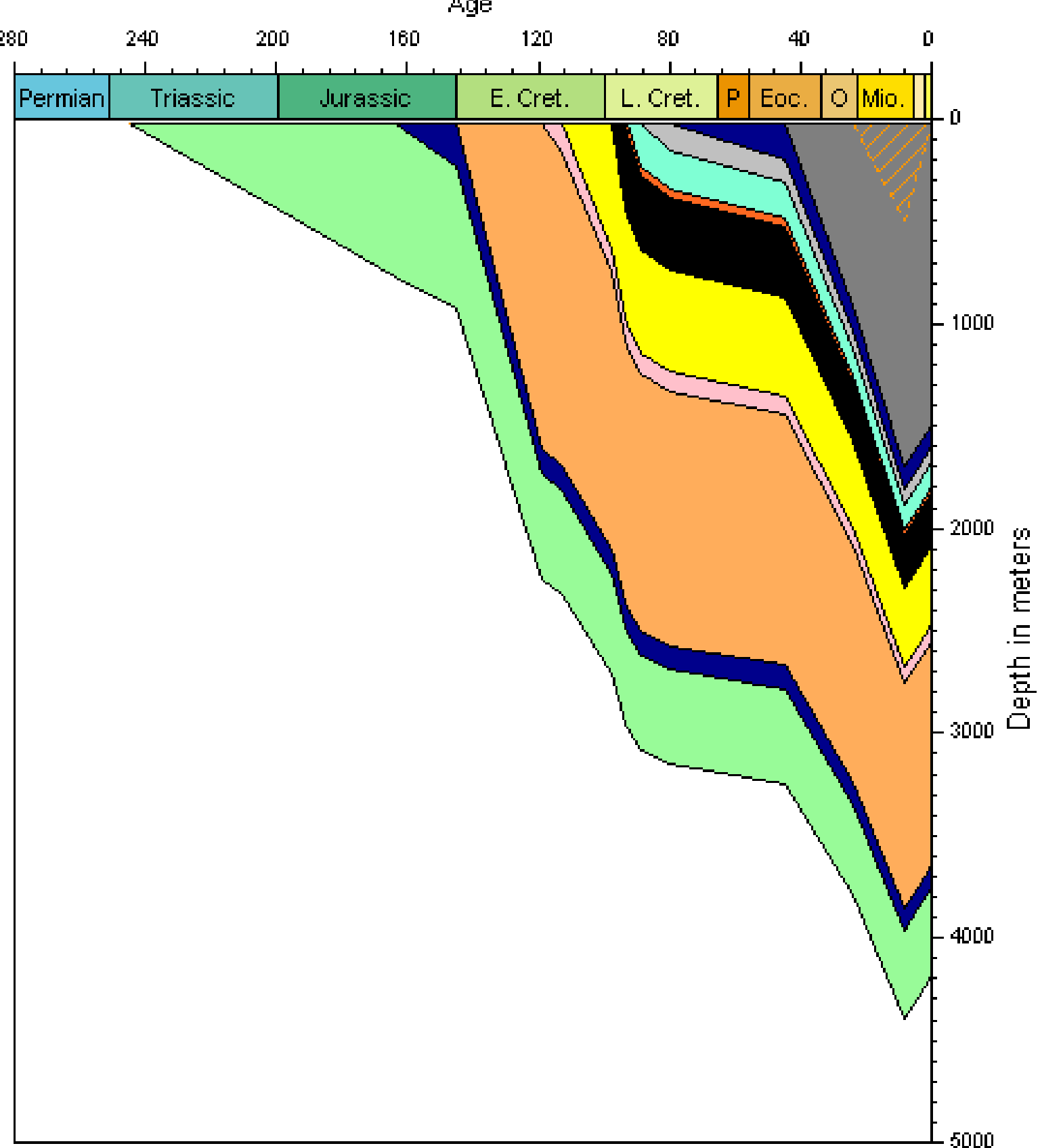
Well #1 AFT

Depth (m)	Fission Track Age (Ma)
2197-2228	200±31 Ma
2835-2868	109±17 Ma
4276-4334	12.3±4.2 Ma

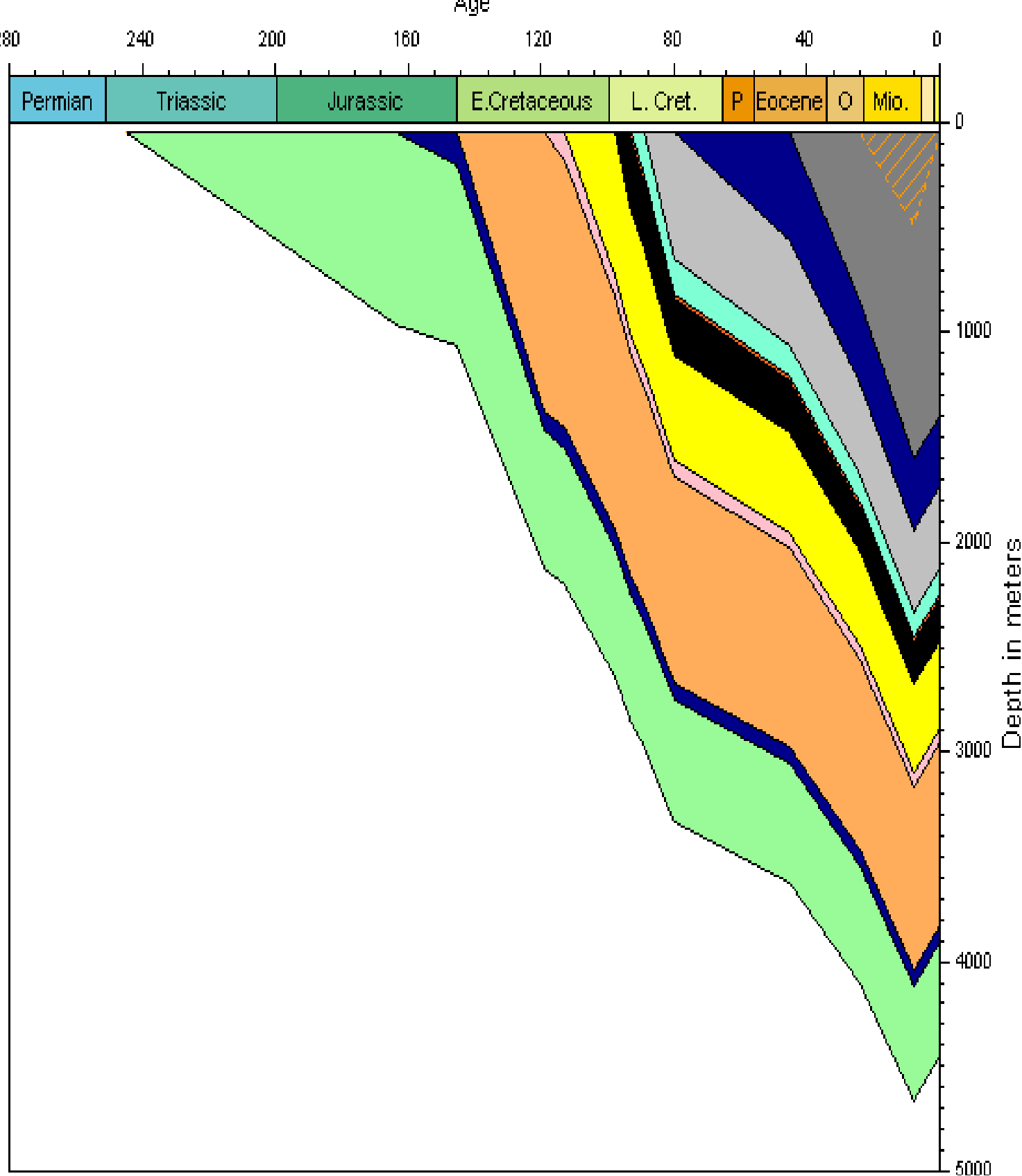
Well#2 AFT

Depth (m)	Fission Track Age (Ma)
256	152.8±24.8 Ma
690	165.4±24.0 Ma
1207	88.8±42.7 Ma
2111	136.8±92.8 Ma
2240	237.9±40.9 Ma
2423	109.6±26.4 Ma
2621	230.7±16.0 Ma

Shaltut-Mekdam Horst Burial History



Sheiba High Burial History

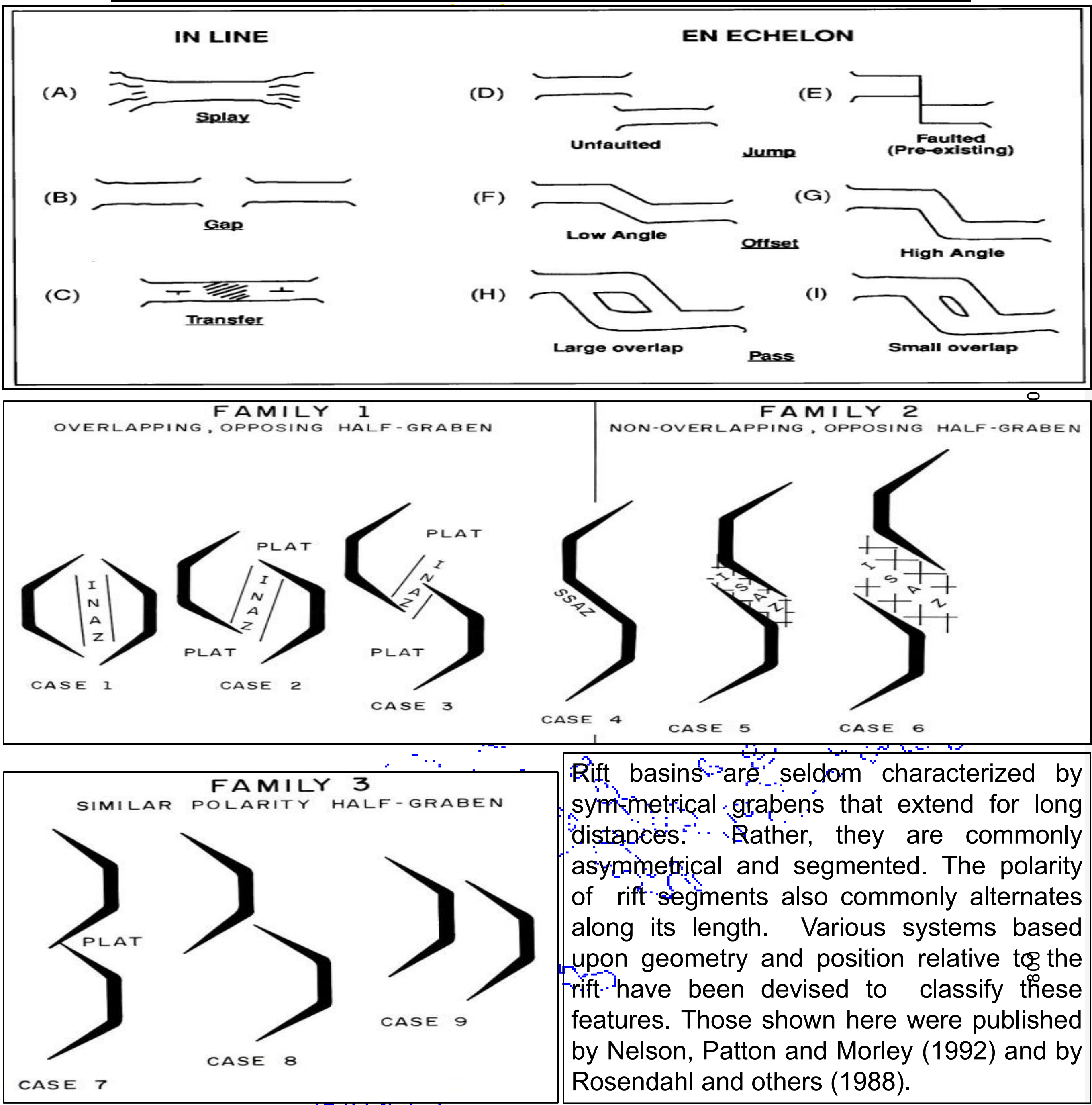


Well#3 AFT

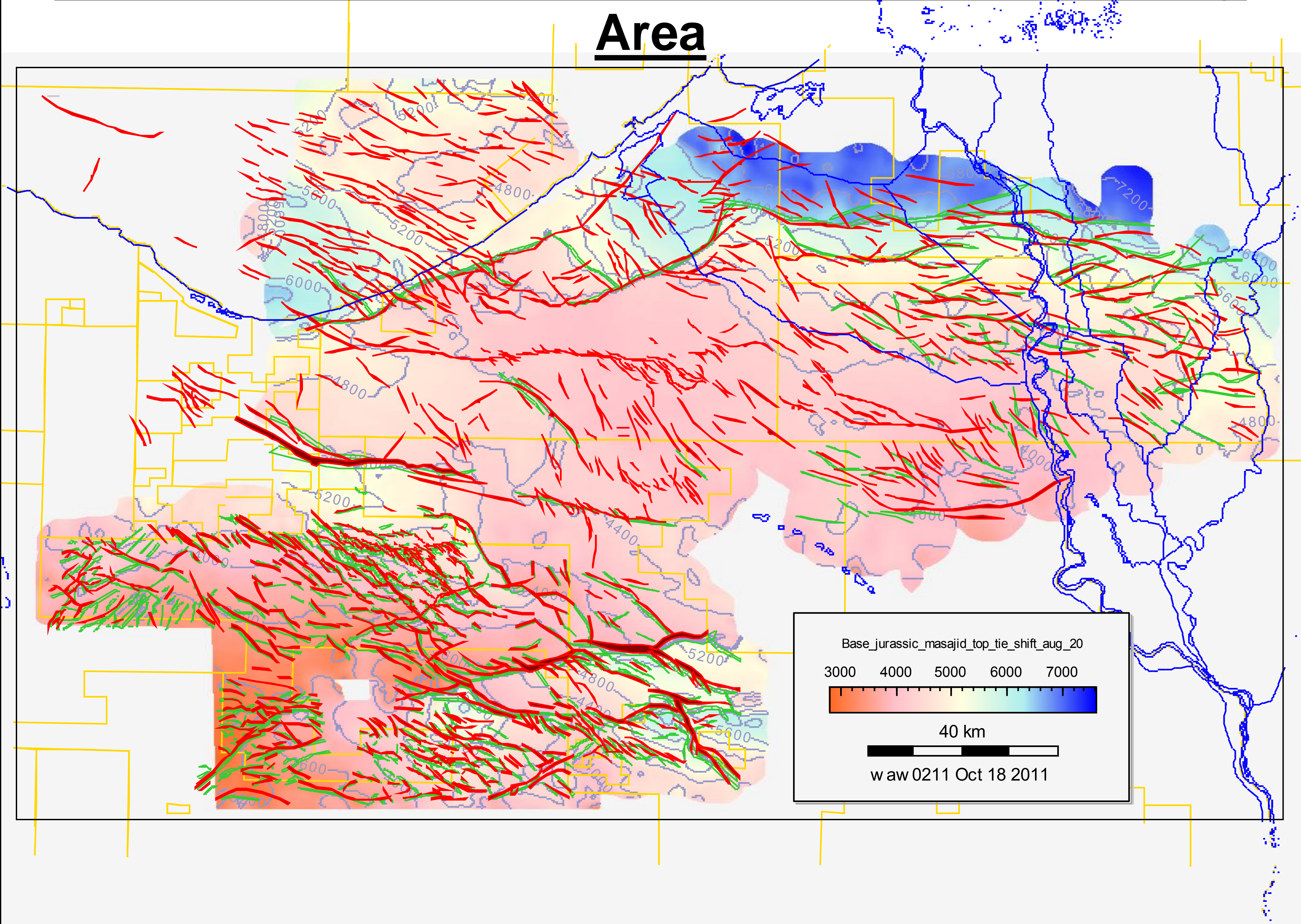
Depth (m)	Fission Track Age (Ma)
630	167.0±32.9 Ma
985	115.9±17.0 Ma
2765	19.2±10.6 Ma
2863	24.7±6.2 Ma
2980	28.1±5.1 Ma
3195	27.3±3.0 Ma
3450	28.1±4.4 Ma

The thermal history of the Shaltut-Mekdam and Sheiba highs, as determined by apatite fission track analysis of samples from the Mekdam-1, Washeik-1, and Boraq-1 wells, suggests the following geological history. The samples fit a model with a thermal history that includes heating (burial?) during the Late Cretaceous followed by recent cooling (unroofing?) leading up to the Miocene/Pliocene and very recent reheating (burial?) to reach present-day temperatures. Therefore it is reasonable to assume that these high blocks formed in the Jurassic and were relatively stable throughout the Cretaceous (that is no uplift only burial); followed by the Miocene-Pliocene un-roofing during the Oligo-Miocene and subsequent post-Messinian reburial. Consequently, the apatite fission track analysis suggests that all of the stratigraphic units encountered in these wells are currently at their maximum post-depositional temperatures. Considering the synrift age of formation and structural position of the Shaltut-Mekdam high between two half grabens with opposing polarities, this feature is interpreted as a rift transfer or accommodation zone .

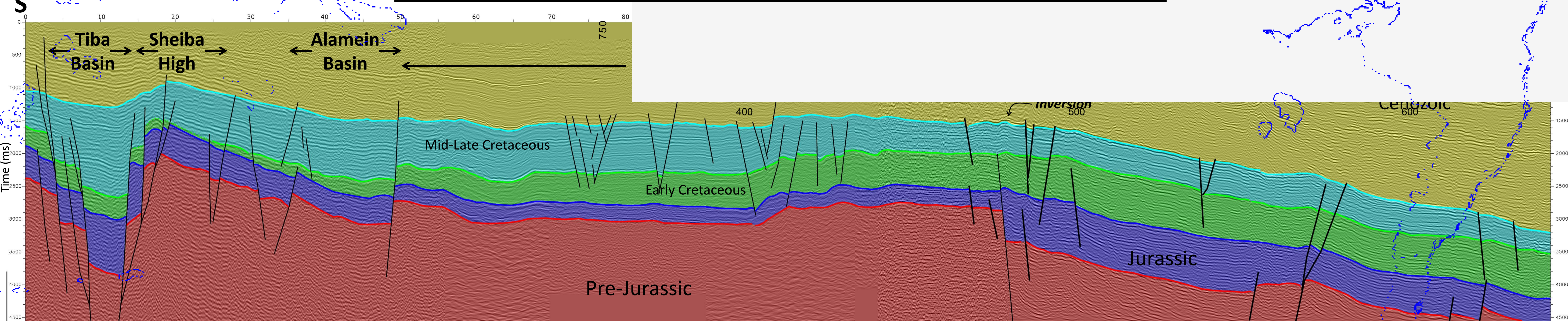
Rift Segmentation Geometries



Jurassic Fault Patterns and Structure in the Study Area

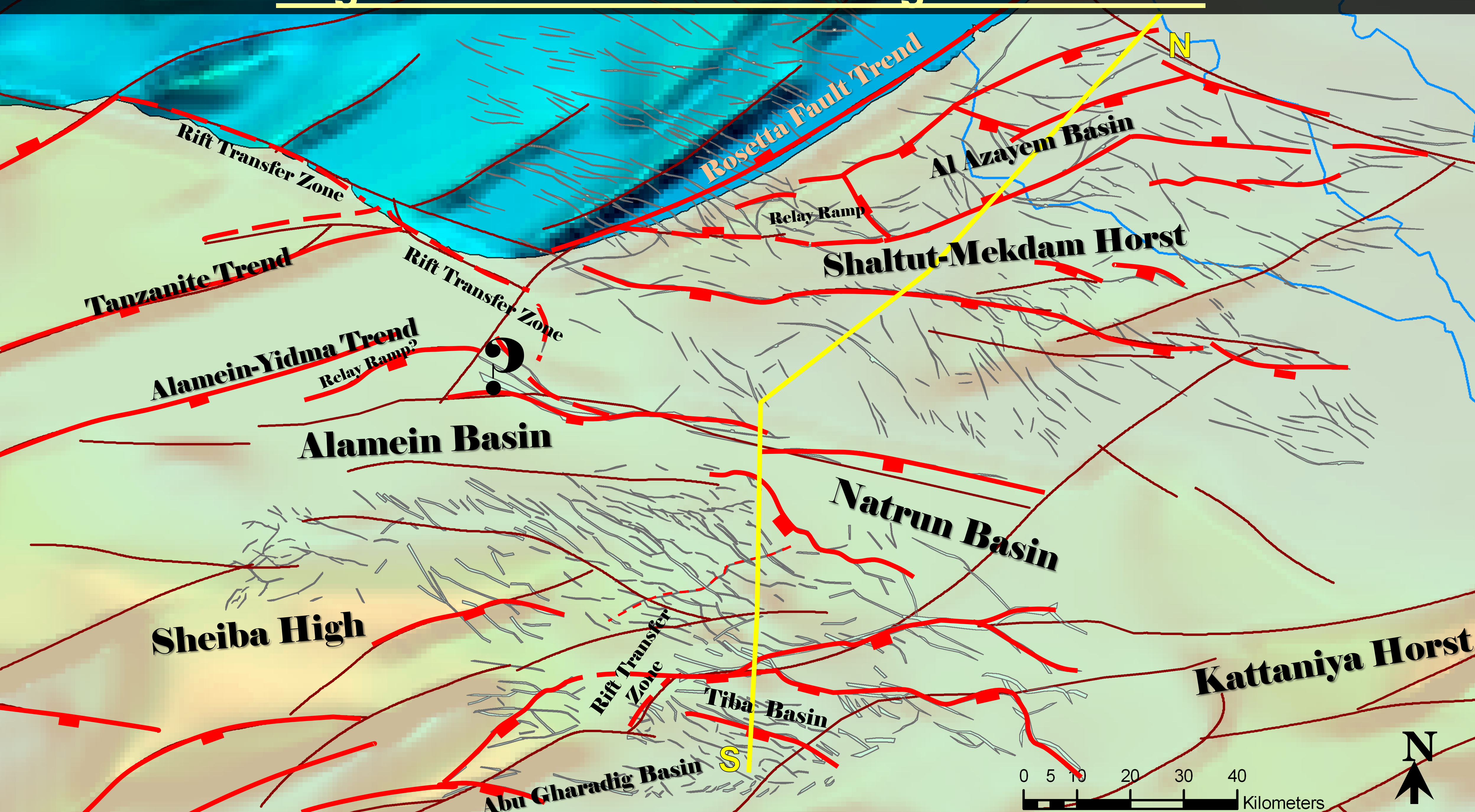


Regional Seismic Line and Structural Features



Regional seismic line showing the major structural elements of this poster's study area. The Tiba Basin to the south exhibits a thick Mesozoic section, with the onset of faulting in the Jurassic. The Sheiba High, to the north of Tiba, shows thinning and possible erosion of the Mesozoic section, as well as minor effects of inversion during the latest Cretaceous. There is a broad section of stable inter-rift platform, of which the Shaltut-Mekdam Horst is a part. This platform exhibits a much thinner Jurassic section than in areas where rifting occurred. Finally, the Al Azayem Basin shows a thick Jurassic section, with minor amounts of inversion features against the rift-bounding fault. Much of this basin is located beneath the Paleo-Nile deposits which has obscured previous attempts of imaging the older syn-rift section. (See map below for seismic line location)

Regional Jurassic Fault Linkage Geometries



Summary

The Jurassic rift architecture of the northeastern Western Desert is complex and characterized by several rift transfer and linkage geometries including: transfer zones, isolation zones, relay ramps, and rift jumps. Several of the large, high intra-rift structures, such as the Shaltut-Mekdam and Sheiba highs formed during the Jurassic rifting event and were relatively unaffected by the Late Cretaceous Syrian Arc transpressional event. In this portion of the Western Desert most of the rifts trend in an east-west direction except along the coastline and along the Alamein-Yidma inversion trend where a northeast-southwesterly trend dominates. The structures that form where the rift segments change orientation, link, transfer and/or jump are extremely important elements in basin and petroleum systems analyses because they can be effective traps and also set-up migration focal points or shadows.

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