TECTONIC MAP OF IRAQ, SCALE 1: 1000 000, 3rd EDITION, 2012

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INTRODUCTION

The first tectonic map of Iraq of the scale 1: 1000 000 was published in 1984 by the Iraq Geological Survey (GEOSURV) with the assistance of some Czech experts (Buday and Jassim, 1984). The map relied basically on the old principles of the geosynclinal theory which was used to visualize the regional tectonics of Iraq. Later on in the year 1997, GEOSURV has updated the map to introduce the second edition of the tectonic map (Al-Kadhimi *et al*., 1997). The general framework of the second edition map is based on that of the first edition, but the details were heavily relied on gravity and magnetic geophysical data. The result was a very complicated map in which the regional tectonic zones were subdivided into smaller and smaller subzones that in sometimes contradict with each other or impossible to justify.

In recent years, however, a new tectonic map that kept pace with the present day tectonic aspects and perspective of the area and the surrounding region was in high demand by many geological institutes, universities and exploration companies. Consequently GEOSURV updated and compiled the available new geological data to introduce the third edition of the tectonic map.

THE THIRD EDITION

Since 1997, when the second edition of the tectonic map was published, several detailed geological survey projects were executed by GEOSURV, and some new information was gained. Such information included new updated geological maps of the scales 1: 25 000, 1: 100 000 and 1: 250 000, reports, researches, analyses of Landsat and Quickbird images, as well as the available exploration wells and seismic survey data. The data was collectively integrated to introduce a new tectonic map based on the modern concepts of plate tectonics. The tectonic perspective of the map was first introduced in 2008 in a special conference held by GEOSURV in Erbil – Kurdistan Region (Fouad, 2008). Extended discussion and consultations continued through the period 2008 – 2012 in Sulaimaniyah, Baghdad, Prague/ Czech Republic, Freiberg/ Germany and Barcelona/ Spain (Fouad, 2012a). Eventually the map which is significantly different from the former one, took it's final form and was published in 2012 (Fouad, 2012b). The following, however, is a short brief to the tectonic zonation adopted in the 3rd edition map and the principles behind it.

THE TECTONIC MAP: PRINCIPLES AND TECTONIC DIVISIONS

Most of the Iraqi territory (~ 95%) occur within the northern part of the Arabian platform of the Arabian plate, whereas only a very limited portion extends within the Eurasian (Iranian) plate. This plate tectonic setting eventually was used to divide the Iraqi territory into two first order segments; the Arabian plate platformal part and the Shalair terrane of the Sanandaj – Serjan Zone of the Eurasian plate, separated by the Zagros Main Thrust (Fig.1a).

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a. The main segments of the Iraqi territory

b. The main tectonic divisions of the Platformal part of Iraq

c. The tectonic division of the Outer Platform

d. The tectonic divisions of the Western Zagros Fold-Thrust Belt

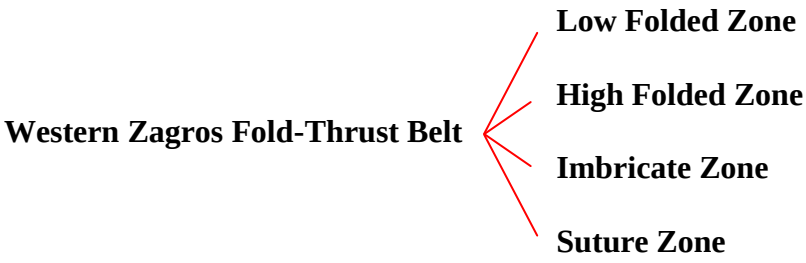

Fig.1: The Tectonic Divisions of Iraq

▪ **Shalair Terrane**

The Shalair Terrane is the northwestern extension of the Sanadaj – Serjan Zone of present Iranian (Eurassian) plate. It consists of meta – sediments and volcanics. The terrane is separated from the Arabian plate by the Zagros Main Thrust, and contains many East – West trending structures.

▪ **The Arabian Platform**

It is the sediment – covered part of the Arabian shield. The thickness of the sedimentary cover progressively increases north and northeast towards the former Arabian plate passive margin.

The present day surface structural architecture of the Arabian plate margin is the result of deformation of the Late Cretaceous – present Alpine orogeny. The deformation, however, did not involve the entire platform. Therefore, the platformal part of the Iraqi territory has been tectonically divided into an "Inner Platform" to the southwest, which is not involved by significant Alpine deformation and remained relatively stable, and an "Outer Platform" to the

northeast which is involved by the deformation (Fig.1b). The boundary between the two major tectonic parts is considered to be Anah – Abu Jir – Euphrates fault system which marks the last deformational effect of the orogeny.

- **The Inner Platform**

Within this part of the platform, no Alpine compressional deformation can be recognized and the effects of Permo – Triassic rifting are not significant. The Inner Platform is subdivided into the Western Desert Subzone at the northwest and the Southern Desert Subzone at the southeast, based mainly on the morphology and physiography of the area.

- **The Outer Platform**

It is the main part of the Mesozoic Arabian plate passive margin and the Late Cretaceous foreland basin. It is significantly involved by the Alpine orogenic deformation.

Following the modern concepts and the anatomy of the orogenic belts and the associated foreland basins, it is apparent that the geodynamic processes vary considerably across the Outer Platform. Consequently the Outer Platform has been divided into the Mesopotamia Foredeep and Western Zagros Fold – Thrust Belt (Fig.1c).

- **The Mesopotamia Foredeep**

It is the terrestrial remnant of the Zagros foreland basin, that extends southeast to it's marine counterpart "The Arabian Gulf". It is located between the stable continental part (i.e. the Inner Platform) and the Zagros mountain front to the northeast. It is basically flat terrane, covered by Miocene to Holocene restricted marin and continental (molasse) deposits. The foredeep contains many buried structures including neotectonically active ones. Based on it's different mobility and activity, the Mesopotamia foredeep is subdivided into Al-Jazira and Basra subzone in the north and south respectively.

- **Western Zagros Fold – Thrust belt**

It is the main deformed part of the Outer Platform which formed the former Arabian plate passive margin.

The Western Zagros Fold – Thrust Belt (WZFTB) is the deformational product of the Arabian – Eurasian (Iranian) plate convergence since the Late Cretaceous. The belt consists of thick folded and faulted sequence of Paleozoic to Cenozoic sediments.

The nature and magnitude of deformation vary considerably across the belt, and consequently the belt is subdivided into different tectonic zones with different structural characteristics by using the following tectonic and structural principles:

- The intensity of deformation and structural style.
- Age of deformation.
- Tectonostratigraphy and mechanical – structural properties of the deformed multilayer sequence.
- Surface physiography and morphology.

Therefore (WZFTB) has been subdivided into four zones striking subparallel to the Arabian plate margin. The Zones, from southwest to northeast are: the Low Folded Zone, the High Folded Zone, the Imbricate Zone and the Suture Zone (Fig.1d). The following is a brief definition to the zones.

– The Low Folded Zone: It forms the first topographic and morphological front of the (WZFTB). The boundary between the Mesopotamia Foredeep and the zone is taken along the slopes of Hamrin – Makhul mountain range and its continuation northwestwards. The zone consists of a series of widely spaced, low amplitude gentle folds. The folds trend NW – SE but change gradually to E – W as they extend northwestwards. Middle Miocene to Pleistocene sediments dominate the topography. The Low Folded Zone is further subdivided into two subzones, Kirkuk at the southeast and Mosul to the northwest. The former is characterized by the presence of regional detachment consists of Middle Miocene salt layers of Fatha Formation, that have caused decoupling of the surface structures from their subsurface counterparts. The later, however, is strongly affected by the inversion of inherited subsurface Late Cretaceous troughs and the absence of regional detachment.

– The High Folded Zone: The zone contains a number of high amplitude, narrowly spaced tight and overturned folds of different geometries and sizes. The landforms which is dominated by erosion – resistant Cretaceous rock units, are highly structural and reflected on the topography as high rugged anticlinal mountains separated by narrow deep synclinal valleys. The zone is characterized by it's high topographic and structural relief, and attributed to the involvement of the basement in the deformation by thrust faulting beneath the sedimentary cover and that the deformation is a "thick skin" type.

– The Imbricate Zone: The zone consists of intensely folded and faulted Paleozoic to Tertiary autochthonous sedimentary sequence with the development of a series of imbricate thrust fan systems. The zone which contain the oldest exposed rocks in Iraq, is best developed in the northern part but becomes less well identified as it extends eastwards towards the Iranian borders.

– The Suture Zone: Intensely deformed rock units of different lithologies and ages forming allochthonous sheets thrusted over the sedimentary sequence of the former Arabian plate passive margin. This zone is the least studied part of Iraq, and a systematic study is needed to a better understanding of it's tectonic history. The Suture Zone terminate sharply by the Zagros Main Thrust fault against the Shalair terrane of the Eurasian (Iranian) Plate.

Figure (2), shows a generalized form of the 3rd edition tectonic map with a simplified tectonic zonation whereas the enclosed map is the final published form of the map.

THE LEGEND

The segments that consist of the main tectonic framework of Iraq as well as the structural zones and subzones were plotted and displayed on the legend.

The legend contains the classical symbols of surface tectonic and structural elements as well as subsurface structures inferred from seismic surveys, gravity and magnetic data.

The generalized stratigraphic column of each tectonic zone is shown too following the updated Geological Map of Iraq (Sissakian and Fouad, 2012) and the available exploration well data. Moreover, the sedimentary sequences were tied and correlated with the main tectonic events of the Arabian plate and the corresponding plate tectonic setting.

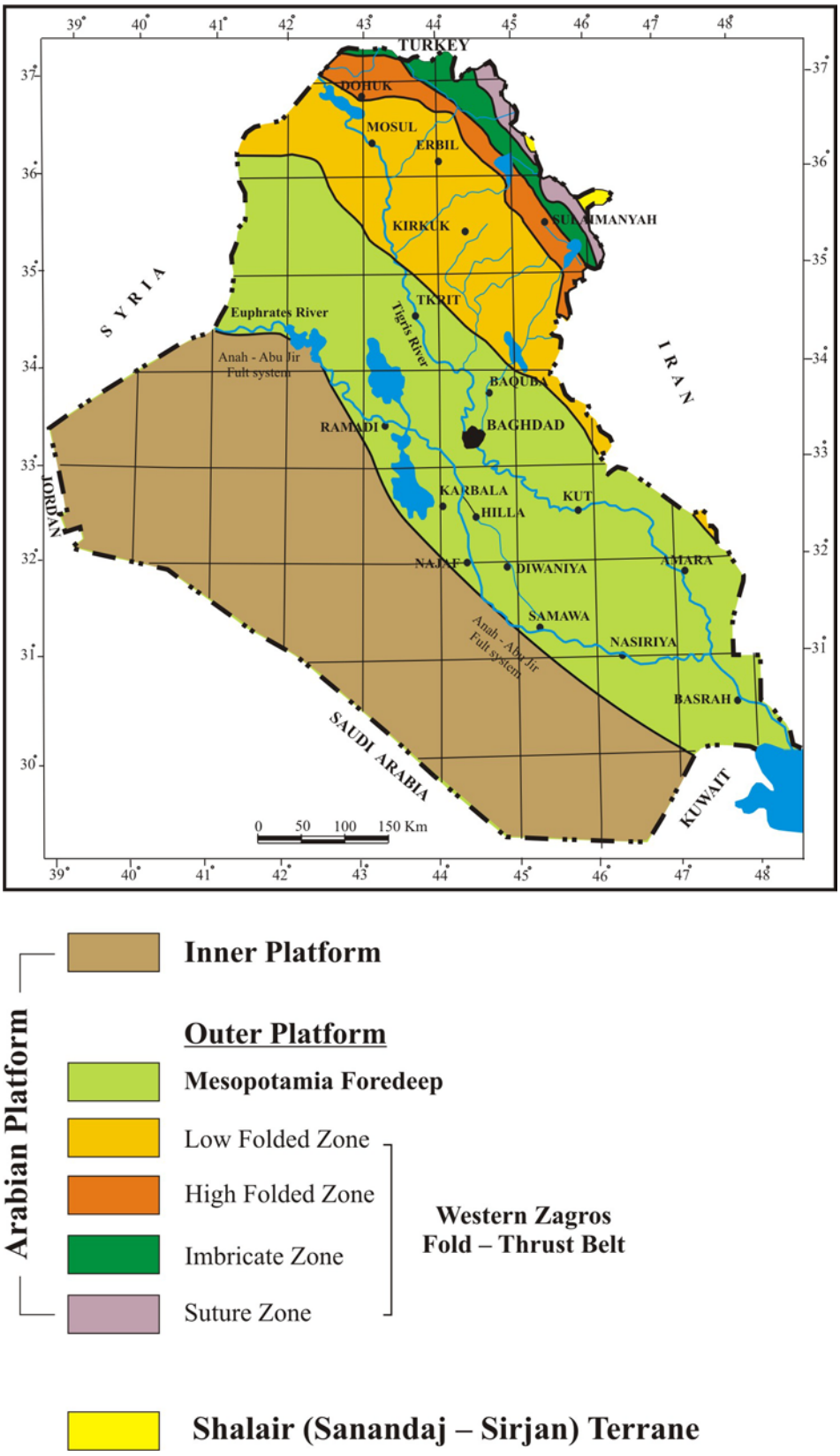

Fig.2: Tectonic divisions of Iraq (after Fouad, 2008 and 2012a and b)

AUXILIARY MAPS AND ILLUSTRATION FIGURES

Four auxiliary maps and two illustration figures were added to the tectonic map for clarification, comparison and illustration. These are:

- **Map of the Present Tectonic Setting of the Arabian Plate**

The map shows the plate boundaries and their nature, and the relative motion of the Arabian Plate with respect to the adjacent plates (based on Johnson, 1998).

- **Generalized Tectonic Map of Iraq**

It is a simplified representation of the updated 3rd edition version of the Tectonic map at the scale of about 1: 9000 000. The map illustrates the general tectonic divisions of Iraq in a simple form and legend.

- **The Tectonic Map, the second edition**

It represents a simplified version of the former tectonic map (2nd edition), published by GEOSURV (Al-Kadhimi *et al*., 1997) at the scale of 1: 9000 000. The map is added to show the significant variation in the tectonic divisions between the second and the third editions of the tectonic maps.

- **Earthquake Epicenters Map**

The map marks the position of all recorded earthquake epicenters in Iraq and the surrounding vicinity. The magnitude of seismic events, in Richter scale, are plotted with different colors. The data are taken from US Geological Survey archives.

- **Plate Tectonic Reconstruction**

The figure illustrates the history of the Arabian plate and it's position and relative motion during the Paleozoic Mesozoic and Cenozoic era. The reconstruction is based mainly on Brew (2001).

- **Arabian Plate Tectonic Evolution**

The figure shows the tectonic evolution of the Arabian plate passive margin since the Late Permian – Early Triassic until it's deformation and the formation of the Zagros Fold – Thrust Belt and the Mesopotamia Foredeep.

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Dr. Saffa F.A. Fouad, graduated from University of Baghdad in 1979, with B.Sc. degree in geology, he got his M.Sc. and Ph.D. degrees from the same University in 1983 and 1997, respectively, in Tectonics and Structural Geology. He joined GEOSURV in 1984, and nominated as Expert in 2006. Currently, he is working as the Acting Director General. His main field of interest is tectonics and structure of the Zagros Mountain Rang of the Iraqi territory. He has about 71 documented reports and published papers.
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REPUBLIC OF IRAQ
MINISTRY OF INDUSTRY AND MINERALS
IRAQ GEOLOGICAL SURVEY

TECTONIC MAP OF IRAQ

Scale 1:1,000,000 3rd edition

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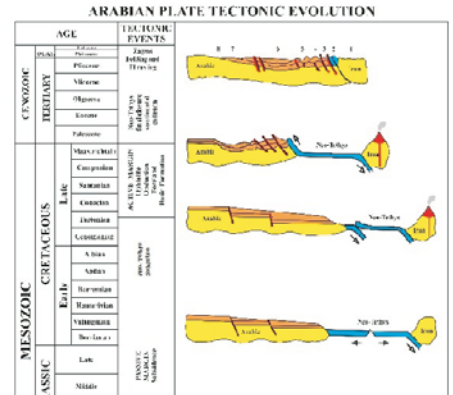
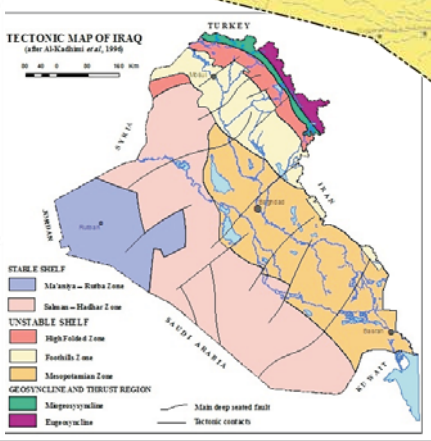
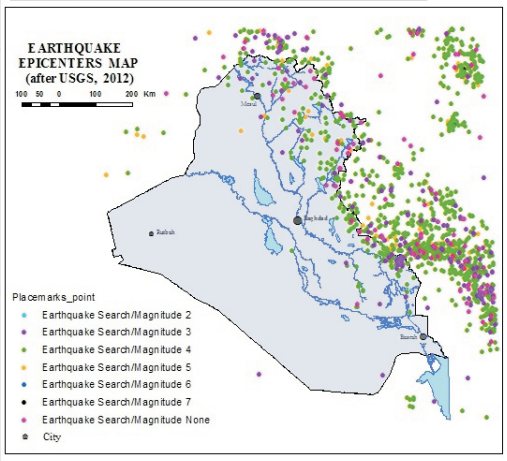
PLATE RECONSTRUTION
(Modified after Brew, 2001)

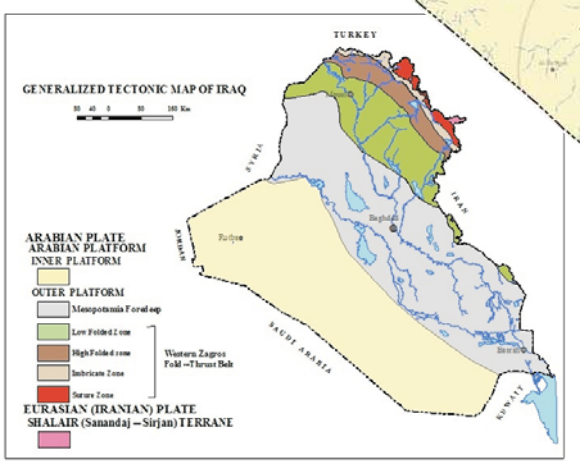
(Modified after Brew, 2001)

ARABIAN PLATE TECTONIC EVOLUTION









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REGIONAL STRATIGRAPHY OF THE TECTONIC ZONES

ERA	PERIOD	EPOCH	Geological Time (Million Years)	Arabian Plate, Northern Arabian Platform – Inner Platform	Arabian Plate, Northern Arabian Platform – Outer Platform: Mesopotamia Foredeep, Zagros Fold – Thrust Belt (Low Folded, High Folded and Imbricate Zones)	Arabian Plate, Northern Arabian Platform – Outer Platform: Zagros Suture Zone	Eurasian (Iranian) Plate: Shalair (Sanandaj – Sirjan) Terrane	Main Tectonic Events	Plate Margin
CENOZOIC	QUATERNARY	Holocene							
		Pleistocene	1.81						
	NEOGENE	Pliocene	5.33	Zahra/ Dibdibba	Bai Hassan			Zagros Fold – Thrust Belt development	FORELAND BASIN
		Miocene		Injana	Injana				
				Fatha/ Nfayil	Fatha				
				Ghar Euphrates	Jeribe Dhiban Euphrates				
				Euphrates Anah/ Azkand	Akkaz/d Anah Tarjil Baba			Continental final collision The final closure of Neo-Tethys	
				Sheikh Alas/ Shiranish	Shiranish Sheikh Alas Tribes				
	PALEOGENE	Oligocene	23.03	Ratga	Jaddala	Series		Red Sea rifting	
				Dammam	Pila Spi Avana	Red Bed	Naopurdan Group		
		Eocene	33.9	Akashat	Aaliji Gercus Sinjar/ Khurmala		Walash Group		
				Umm E Radhuma	Kolosh				
		Paleocene	55.8	Dibdibba Tayarat Hartha Mu'd Rutba	Tanjero Shiranish Aqra – Bekhma Mergi		Piran Limestone	Ophiolite obduction and foreland basin development. Intracontinental stretching and faulting (Sinjar, Anah troughs)	
			65.5					92 Ma.	
MESOZOIC	CRETACEOUS	Late		Mauddud	Hadina Qamchuqa Sarmord Kometan Balambo		Kata Rash Series	Subduction of Neo-Tethys oceanic crust beneath Central Iran	PASSIVE MARGIN
		Early		Nahr Umr			Shalair Series		
			145.5	Najmah Muhaiwir Amij Huqaimiyat Ubaid	Chia Gara Barsarin Naokelekan Sargelu	Qulqula Series	Qandil Series		
	JURASSIC	Late							
		Middle							
		Early	199.6		Sehkaniya Sarki				
	TRIASSIC	Late		Zor Horan Mulussa	Baluti Kurra Chine Geli Khana Bedu Mirga Mir		Avroman Limestone	Passive margin development and subsidence	
		Middle							
		Early	251.0					Rifting and Neo-Tethys opening	
								255 Ma.	
PALEOZOIC	PERMIAN		299.0	Ga'ara	Chia Zairi				
	CARBONI – FEROUS	Pennsylvanian						(2nd Arabia glaciation)	INTRA – CRATONIC
		Mississippian	359.2	Ora - Kaista	Harur Ora Kaista Chalki Ibrahim			Hercynian Orogeny	
	DEVONIAN	Late							
		Middle						Caledonian Orogeny (Gondwana glaciation)	
		Early	416.0						
	SILURIAN		443.7	Akkas					
	ORDOVICIAN	Late		Khabour	Khabour			Hormuz salt pull-apart basin Najd Fault System	
		Middle						610 Ma.	
		Early	488.3						
	CAMBRIAN		542.0						
PROTER-OZOIC								Amalgamation of island arcs and micro plates and the formation of the Arabian Shield	Basement

ARABIAN PLATE
ARABIAN PLATFORM
ARABIAN INNER PLATFORM
- Western Desert Subzone
- Southren Desert Subzone

ARABIAN OUTER PLATFORM
Mesopotamia Foredeep
- Al – Jazira Subzone
- Mesopotamia Subzone
- Basrah Subzone

WESTERN ZAGROS FOLD – THRUST BELT
Low Folded Zone
- Kirkuk Subzone
- Mosul Subzone

High Folded Zone
Imbricate Zone
Suture Zone
- Qulqula – Khuwakuk Subzone
- Penjween – Walash Subzone

EURASIAN (IRANIAN) PLATE
SHALAIR (SANANDAJ – SIRJAN)TERRANE

SURFACE STRUCTURES
- Axis of anticline
- Thrust or reverse fault (barbs on upthrown block)
- Normal fault (hachures on downthrown block)
- Transverse fault
- Strike – slip fault (arrows indicate relative displacement)
- Fault of unspecified type or with multiple displacements (dashed when uncertain)
- Sanam salt pluge

Geophysically Inferred Subsurface Structures
Structures Inferred from Seismic Surveys
- Axis of anticline
- Normal fault
- Structural high
- Structural trough

Structures inferred from Gravity and/or Magnetic Surveys
- Axis of subsurface anticline and structural high derived from gravity surveys
- Axis of subsurface anticline and structural high derived from magnetic and gravity surveys
- Normal fault derived from gravity and magnetic surveys
- Normal fault derived from gravity surveys

TOPOGRAPHIC SYMBOLS
- International Boundaries
- Express way No.1
- Paved road
- Unpaved road
- Railway
- River
- Valley
- Lake
- Governorate center
- Qad'a center
- Nahiyah center
- Geological interest

Present Tectonic Setting of the Arabian Plate (Johnson, 1998)

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