GEOLOGICAL MAP OF IRAQ, SCALE 1: 1000 000, 4th EDITION, 2012

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INTRODUCTION

Iraq Geological Survey is committed to update the published geological maps, almost periodically and as data are available for updating. Among the updated maps is the Geological Map of Iraq, at scale of 1: 1000 000. It is the 4th edition. The 3rd edition was made in 2000 (Sissakian, 2000), whereas the 1st and 2nd editions were made in 1986 and 1990, respectively (Jassim *et al*., 1986 and 1990). The new map is attached to this article in A3 size.

METHODS AND MATERIALS

▪ Materials Used

In order to update the geological map, the following materials were used:

- Results of the detailed geological mapping executed between 2001 – 2012, covering an area of 15180 Km^2 in the Southern Desert (Najaf – Samawa – Nasiriyah area); covered by 92 topographic sheets at scale of 1: 25 000 and an area of 1000 Km^2 in Sulaimaniyah vicinity, covered by 10 topographic sheets at scale of 1: 20 000. Moreover, about 2000 Km^2 in the area between Al-Fatha and west of Mosul city was mapped with a scale of 1: 25 000. However, almost no difference was found between the regional and detailed geological mapping.
- Updating of 17 geological maps at scale of 1: 100 000
- Updating of 3 geological maps at scale of 1: 250 000
- Using 19 images of Quickbird and Landsat, at different scales with different coverage areas.
- Using 93 images of Google Earth (A4 size), at different scales with different coverage areas.
- Executing 37 field checking visits, since 2006 – 2012, in the northern, northeastern, eastern and southern parts of Iraq.

▪ Information Acquisition

– Results of the Recent Geological Mapping at Scale of 1: 25 000: In areas covered by detailed geological mapping, at scale of 1: 25 000, made by Al-Safi *et al*., 2012, Al-Shwaily *et al*., 2011 and 2012, Ajar *et al*., 2011 and 2012 and Zaini *et al*., 2012 were transferred to the geological map of Sissakian (2000). The recently carried out geological mapping referred to above acquired quite different results as compared to those acquired during the older regional geological mapping (Al-Sharbati and Ma'ala, 1981 Al-Ani and Ma'ala, 1981 and Al-Mubarak and Amin, 1983) both stratigraphically and structurally. Most of the mapped faults (Al-Mubarak and Amin, 1983) were found nonexistent.

– Results of the Field Checking of the Previous Geological Maps: 37 field trips were made to check the geological maps compiled from the interpretation of the aerial photographs. In the field, topographic and geological maps were used, beside high resolution Landsat Quickbird and Google Earth images. The corrected geological data were immediately transferred into geological maps at scale 1: 250 000, in the field. Consequently, the corrected data were transferred to the geological map of Sissakian (2000).

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THE 4th EDITION OF THE GEOLOGICAL MAP

The updated geological map of Iraq, at scale of 1: 1000 000, 4th edition (Sissakian and Fouad, 2012) has significant differences from that of the 3rd edition (Sissakian, 2000). The main differences are:

- **Stratigraphy**

The areas with main differences in the stratigraphy are shown in Fig. (1).

– The Southern Desert: The geology of the area extending from Najaf to Nasiriyah passing through Samawa cities, along the Euphrates River with a width of about (100 – 150) Km has been significantly changed. The mapped Upper Member of the Dammam Formation in large areas was found to be covered by the basal conglomerate of the Euphrates Formation; therefore, it is changed to the Euphrates Formation on the map. The mapped Upper Member of the Euphrates Formation was found to be the Nfayil Formation, especially the Lower Member. The Upper Member of the Nfayil Formation, however, is mapped and presented on the new geological map, in the aforementioned area; for the first time. The Ghar and Zahra formations were more precisely mapped and presented on the new map.

– Al-Teeb – Badra – Khanaqeen – Darbandi Khan Area: Along the Iraqi – Iranian international borders, considerable changes were performed concerning the exposed geological formations. In Al-Teeb – Badra vicinity, the Bai Hassan and Mukdadiya formations were more precisely mapped and presented. In Khanaqeen – Darbandi Khan vicinity, the Bammu Conglomerate was omitted, because it was found to be talus sediments. In Kalar vicinity, between Khanaqeen and Darbandi Khan, the Bammu conglomerate was found to be conglomerates of Bai Hassan Formation, in the form of thrusted beds of a syncline over an adjacent anticline.

– Sulaimaniyah Vicinity: This area, represented by the Sulaimaniyah Quadrangle at scale of 1: 250 000, witnessed the most significant changes in the geological map. This is attributed to the fact that the existing geological map was originally compiled from the interpretation of aerial photographs. Moreover, the involved area has witnessed the majority of the field checking, because it is easily accessible. Besides, the detailed geological mapping in Sulaimaniyah – Surdash area (Al-Shwaily *et al*., 2011), has revealed the details of the stratigraphy of the area. The Jurassic rocks were discovered in Pera Magroon area and presented on the new geological map; for the first time.

– Dokan Area: In the eastern and southern edges of the Dokan Lake and part of the top of Khalikan anticline, west of Dokan, a new Quaternary unit was mapped; called Dokan Conglomerate (Karim and Taha, 2012). In the southern and eastern edges of the lake, previously Tertiary formations were presented on the map (Sissakian, 2000), it was found that the Dokan Conglomerate, with thickness of about 500 m, is exposed there, locally exhibits tilted beds.

– Darbandi Khan Area: The surroundings of the Darbandi Khan Lake were mapped more correctly, as compared with the previous map (Ma'ala, 2007). Tanjero, Kolosh, Khurmala, Gercus, Pila Spi, Fatha, Injana, Mukdadiya and Bai Hassan formations were mapped and presented on the geological maps of scale 1: 100 000, 1: 250 000 and 1: 1000 000.

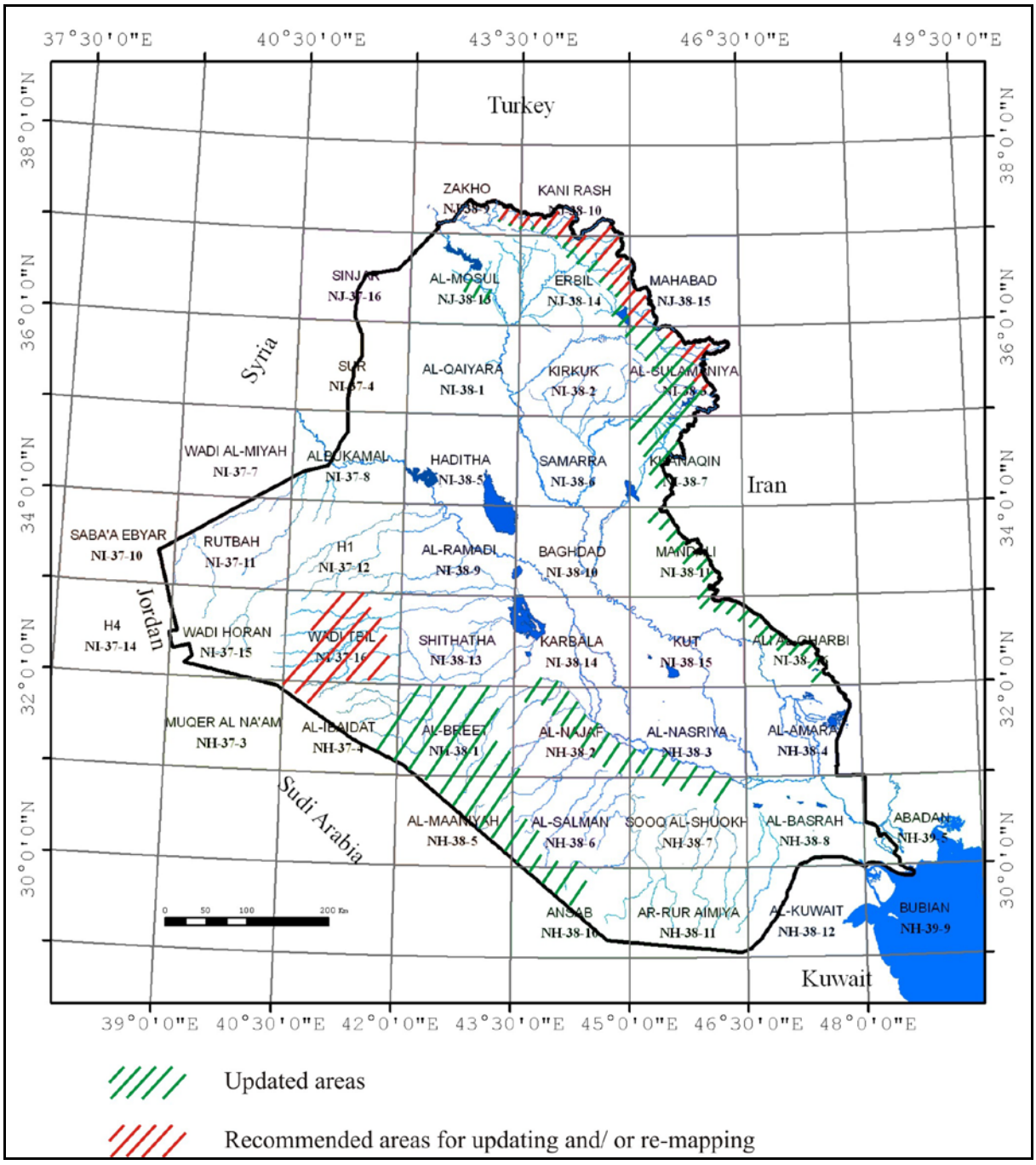

Fig.1: Location map of the updated areas

– Qara Dagh Mountain: This is a long anticline extending NW – SE, located south of Sulaimaniyah city. The exposed geological formations were presented on the geological maps at scale of 1: 100 000, 1: 250 000 and 1: 1000 000 more precisely, as compared with the previous maps. Towards south of Qara Dagh, in Aj Dagh, besides the Pila Spi Formation, Oligocene rocks were mapped. Moreover, southwards of Aj Dagh, the Fatha, Injana, Mukdadiya, and Bai Hassan formations were mapped more precisely, as compared to the previous maps (Ibrahim, 1984 and Ma'ala, 2007).

– Miscellaneous Areas: In different parts of the Iraqi territory (Fig.1), locally slight changes were performed in the stratigraphy, usually correcting the geological contacts and/ or adding some formations, which were not presented on the previous geological map.

- **Structure and Tectonics**

The most significant changes, concerning structural elements and tectonics, which are presented in the updated geological map of Iraq are briefed hereinafter.

– The Southern Desert: All the previously mapped faults in the southern desert (Al-Mubarak and Amin, 1983) were not found during the recent detailed geological mapping (Al-Safi *et al*., 2012, Al-Shuwaily *et al*., 2012, Ajar *et al*., 2011 and 2012 and Zaini *et al*., 2012) and/ or through the field checking trips to the areas involved. The faults were mapped, mainly due to misleading identification of the stratigraphic units, especially between Dammam and Euphrates formations. This is attributed to: **1)** Intense diagenetic processes, which have hindered the true rock lithology, **2)** Widely spread basal conglomerate between Dammam and Euphrates formations, which was considered as Dammam Formation; due to presence of large blocks and boulders of nummulitic limestone, consequently faults were mapped to explain the abnormal contacts, and **3)** The desert varnish that hindered recognition of the true lithology and all those rocks with desert varnish were considered to belong to Dammam Formation; therefore, faults were mapped to differentiate them from other rocks of other formations.

– The Zagros Thrust Fault: This fault has large extension in the northeastern and northern parts of Iraq. Locally, the location was corrected and in other cases the symbol was corrected to indicate the thrusted and overthrusted stratigraphic units.

– Miscellaneous Structural Elements: In different areas, some anticlinal and synclinal axes and/ or fault lines were corrected and/ or added on the basis of field work, especially in the eastern and northeastern parts.

– Tectonics: The tectonic zones of the Iraqi territory were corrected to coincide with those updated by Fouad (2012). These can be obviously seen in the legend of the new geological map and the new Tectonic Map of Iraq, which is added as auxiliary map in the "Explanatory Text" and within the sheet of the updated geological map of Iraq.

- **The Legend**

The legend of the updated geological map is modified in different aspects: **1)** The time interval of each epoch and era is adjusted according to ICS (2012). **2)** The stratigraphic units in the legend are divided into different parts of Iraq, as they are exposed and according to the updated tectonic zones of Iraq (Fouad, 2012). **3)** Locally, and due to scale limitations, special colors were used to indicate a combination of different formations. **4)** The colors of the presented stratigraphic units are selected to coincide with those suggested by ICS (2012).

5) The legend includes the geological time scale in Ma, depending on ICS (2012). **6)** Each Era, Period and Epoch is given a thickness, which coincides with its time span. This is performed to the lowest divisions, like lower, middle and upper for each unit, in the geological time table. Moreover, the orogenies are added to the legend, depending on their acting duration through geological time.

▪ **Geological Cross Sections**

Three geological cross sections were added to the new geological map: **1)** In the Western Desert, crossing the Ga'ara Depression, extending northeastwards to Khlaisiyah Oil well. **2)** In the central northern part, from east of Mosul to Kani Rash area, and **3)** In the northeastern part, starting from east of Kirkuk extending northeastwards, crossing Qara Dagh and till the Iraqi – Iranian borders, to cover part of the Zagros Suture Zone. The three cross sections were compiled depending mainly on the surface data beside some oil wells and seismic data (in Anah Grabben).

▪ **Auxiliary Maps**

Four auxiliary maps were added to the new geological map, they are all at scale of about 1: 9000 000, and six other maps and illustration figures were added to the Explanatory Text.

– Updated Geological Data Location Map: This map is at scale of about 1: 9000 000 (Fig.1), it represents the locations where the geological map is updated, as compared to the previous edition of the Geological Map of Iraq (Sissakian, 2000). Moreover, it also shows the areas where the authors believe that doubtful data are still present, and need updating in near future.

– Lithological Map of Iraq: It is constructed for clarifying the lithological distribution over the Iraqi Territory, at scale of about 1: 9000 000 (Fig.2). The rock types are grouped in 14 units, depending on the lithology of the rock units.

– Tectonic Map of Iraq: It is a simplified version of the Tectonic Map of Iraq (Fouad, 2012) at scale of about 1: 9000 000. It explains the present tectonic zones.

– Geological Hazards Map of Iraq: It is a generalized map at scale of about 1: 9000 000, which represents the main geological hazard types that are acting within the Iraqi territory, it is compiled by Sissakian *et al*. (2011).

– Chronological Map of Iraq: It is a generalized map at scale of about 1: 9000 000, which represents the distribution of the chronological units presented in 21 chronological units. The map is compiled using GIS technique. However, locally and due to scale limitations, some units are combined together and some others are omitted, because their coverage areas are very small and almost invisible in the compiled map.

– Physiographic Map of Iraq: This map is at scale of about 1: 9000 000, and exhibits the main physiographic provinces in Iraq. It is slightly modified from Barwari *et al*. (2003). The physiographic provinces are: **1)** Western Desert Province, **2)** Southern Desert Province, **3)** Mesopotamian Plain Province, **4)** Al-Jazira Province, **5)** Low Amplitude Mountainous Province, **6)** High Amplitude Mountainous Province, and **7)** Extremely Rugged Mountainous Province.

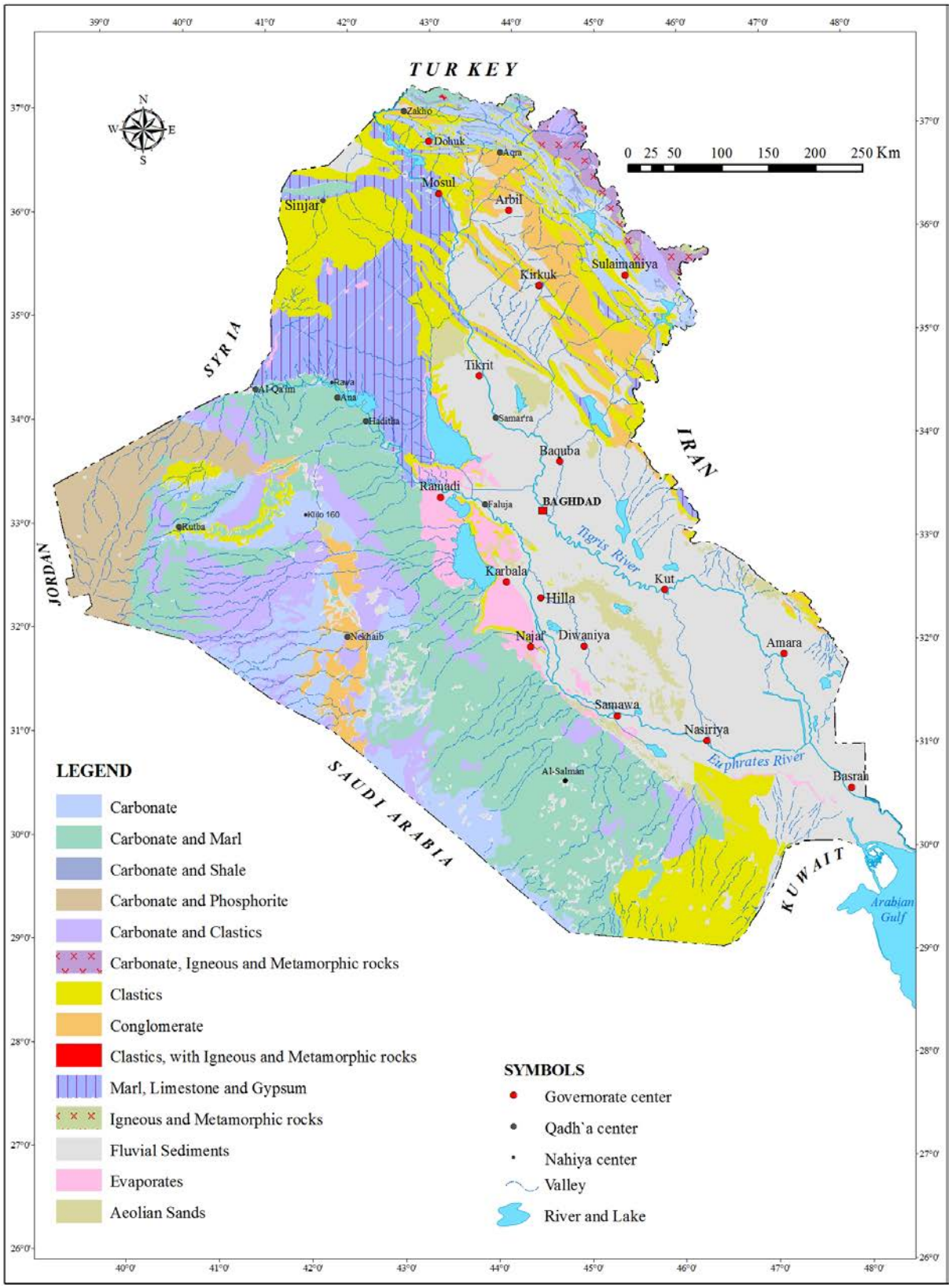

Fig.2: Lithological Map of the exposed formations
(after Sissakian and Al-Khalidi, 2012)

–Lithological Index of the Exposed Geological Formations in Iraq: The exposed geological formations and/ or units presented on the new geological map are tabulated alphabetically in a special chart that shows the main lithological constituents of each formation. The lithologies of the formations are grouped into 11 units.

–Topographic Map with Type localities of the Exposed Formations in Iraq: This map is at scale of about 1: 9000 000, it is enclosed in the text. It clarifies, generally, the topography of the Iraqi Territory, which is expressed by means of different colors given to seven height intervals.

The type localities of the exposed geological formations in Iraq are added to this map too. They are presented by means of four different symbols, indicating four different types of type localities, these are: **1)** In oil well, **2)** In outcrop, **3)** Supplementary, and **4)** Supplementary in oil well.

– Authors Index Map: This map is at scale of 1: 1000 0000, it includes the name of the first author of each compiled geological map at scale of 1: 250 000. Those maps were used in compilation of the Geological Map of Iraq (Sissakian, 2000), which is used as a base map for compilation of the updated Geological Map (Sissakian and Fouad, 2012).

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T U R K E Y

S Y R I A

I R A N

J O R D A N

S A U D I A R A B I A

K U W A I T

Tigris River

Euphrates River

Arabian Gulf

PH

Mic-Pie

REPUBLIC OF IRAQ
MINISTRY OF INDUSTRY AND MINERALS
IRAQ GEOLOGICAL SURVEY

GEOLOGICAL MAP OF IRAQ

35 17.5 0 35 70 105 140 175 Km

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REGIONAL TECTONIC UNITS

ARABIAN PLATE, NORTH ARABIAN PLATFORM

OROGENY	ERA	PERIOD	EPOCH	Geological Time (Million Years)	INNER PLATFORM	Mesopotamia Foredeep and Zagros Fold - Thrust Belt (Low Folded, High Folded and Imbricate Zones)	Zagros Suture Zone	EURASIAN (IRANIAN) PLATE: Shalair Terrane
LATE ALPINE	CENOZOIC	QUATERNARY	HOLOCENE	0.001				
			PLEISTOCENE	2.588				
		NEOGENE	PLIOCENE	5.333	Zahra, Dibdibba	Bai Hassan, Mukdadiya, Injana		
			MIOCENE U	12	Mukdadiya, Injana			
			MIOCENE M	16	Fatha, Nfayil	Fatha (Undifferentiated)		
			MIOCENE L	23.03	Ghar – Euphrates, Ghar, Euphrates	Euphrates, Serikagni, Dhiban, Jeribe		
MIDDLE ALPINE		PALEOGENE	OLIGOCENE U	33	Baba, Azkand, Anah	Azkand, Anah, Tarjil, Baba, Bajwan		
			OLIGOCENE L	33.9	Sheikh Alas, Shiranish	Palani, Sheikh Alas, Shiranish		
			EOCENE U	43	Rutba, Jil, Dammam	Jeddala, Avana, Aljij, Pila Spi, Avana, Gercus, Khurmala, Sinjar, Kolosh		
			EOCENE M	48				
			EOCENE L	56.0				
			PALEOCENE U	58	Akashat, Umm Er Radhuma	Sinjar		
			PALEOCENE L	66.0				
EARLY ALPINE	MESOZOIC	CRETACEOUS	Upper	100.5	Digma, Tayarat, Hartha, Mus'ib, Ruthah, Mauddud, Nahr Umr, Marbat Beds	Shiranish, Aqra – Bekhme, Mergi, Hadina, Qamchuqa, Sarmord, Garagu, Balambo, Tanjero, Shiranish, Kometan, Gulneri, Dokan, Balambo	Intrusive Complexes, Qandil Series	Kata Rash Series, Shalair Series
			Lower	145.0				
		JURASSIC	Upper	163.5	Najmah, Muhaiwir, Amij, Huqaimiyat, Ubaid	Chia Gara, Barsarin, Naokelekan, Sargelu, Sehkaniyan, Sarki	Qulqula Series	
			Middle	174.1				
			Lower	201.3				
		TRIASSIC	Upper	235.0	Zor Horan, Mulussa	Baluti, Kurra Chine, Geli Khana Beds, Bedu, Mersa Mir	Avroman Limestone	
			Middle	247.2				
			Lower	252.0				
HERCYNIAN	PALEOZOIC	PERMIAN	Upper	272.3	Ga'ara	Chia Zairi		
			Lower	298.9				
		CARBONIFEROUS	Upper	323.5	Red Beds	Harur, Ora, Kaista, Chalki, Peripiki Red Beds		
			Lower	358.9				
		DEVONIAN	Upper	382.7				
			Middle	393.3				
			Lower	419.2				
		SILURIAN	Upper	433.4	Silurian			
			Lower	443.4				
		ORDOVICIAN	Upper	458.4		Khabour		
			Middle	470.0				
			Lower	485.4				
CALEDONIAN		CAMBRIAN	Upper	497				
			Middle	521				
			Lower	541.0				

QUATERNARY SEDIMENTS

HOLOCENE
- Aeolian Sand
- Depression Fill
- Flood Plain
- Inland Sabkha
- Estuarine Sabkha
- Tidal Flat
- Active Marsh
- Dry Marsh
- Crevasse Splay

PLEISTOCENE – HOLOCENE
- Sheet Run off
- Gypcrete
- Alluvial Fan
- Polygenetic

PLEISTOCENE
- Habbaniyah Gravels
- Horus Gravels
- Dokan Conglomerate
- River Terraces
- Al-Fatha Fan Conglomerate

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