Basin analysis of Cretaceous to Tertiary selected wells in Kirkuk and Bai Hassan Oil Fields, Kirkuk, Northern Iraq

Saad S.Al-Sheikhly[1], Mazin Y.Tamar-Agha[1] , and Maher M. Mahdi [2*]
1Department of Geology, College of Science, University of Baghdad, Baghdad, Iraq.
2 Department of Geology, College of Science, University of Basrah, Basrah, Iraq

Abstract:
Basin analysis (geohistory) is carried out on the Cretaceous to Tertiary succession in five wells at Kirkuk and Bai Hassan Oil Fields during the Aptian to the Recent. The Foothill Zone exhibited a complex subsidence and uplift history over a period of about 132 Ma. The results from studied wells backstripping provide a record of the subsidence and uplift history in a number of important Meso-Cenozoic depositional successions. They show that there are three distinct episodes separated by unconformity surfaces. The value of compaction varies from large during the Cretaceous period to less clearly during the Paleogene and then almost non-existent during the Neogene. Generally, the subsidence is continuous and gradual during Mesozoic and suddenly increases in Cenozoic with obvious effect to the tectonic movements.

Keywords: basin analysis, backstripping, Kirkuk and Bai Hassn Oil Fields, Cretaceous to Tertiary

دراسة تحليل الاحواض من العصر الطباشيري الى الثلاثي من ابار مختارة لحقلي كركوك وباي حسن النفطية ، كركوك ، شمال العراق

سعد سامي الشيخلي[1] مازن يوسف تمراغا[1] ماهر منديل مهدي[2*]
1 قسم علوم الارض، كلية العلوم ، جامعة بغداد ، بغداد ، العراق
2 قسم علم الارض، كلية العلوم ، جامعة البصرة ،البصرة ، العراق

الخلاصة:
لقد تم تحليل الحوض الجيولوجي لحقلي كركوك وباي حسن اذ اجريت الدراسة على خمسة ابار مختارة من العمر الابتين حتى العصر الحديث ضمن نطاق الاقدام المنخفضة وقد تبين وجود انخسافات ومرتفعات في ذلك التاريخ على امتداد 132 مليون سنة وكانت هناك تتابعات رسوبية مميزة لكل عمر، وبينت نتائج ازالة الحمل لكل تكوين بان هنالك ثلاثة اعمار مميزة عادة ماتفصل بسطح عدم توافق يكون لكل عمر قيمة احكام مؤثرة عن الاخرى ويكون اعلى احكام خلال العصر الكريتاسي بينما يقل بصورة واضحة في عصر الباليوجين ويكاد يختفي في عصر

*Email: maher_mandeel@yahoo.com.

النيوجين ، بشكل عام التجلس يكون مستمر وتدريجي في العصر المتوسط بينما يكون ارتفاع التجلس مفاجئ وسريع في نهاية عصر الباليوجين متأثر بالحركات التكتونية الاخيرة التي مرت بها المنطقة.

الكلمات المفتاحية: تحليل الاحواض ، ازالة الحمل ، حقلي كركوك وباي حسن ، شمال العراق.

Introduction

This article summarizes the geohistory of Bai Hassan and Kirkuk Oil Fields at five oil wells (figure -1) located within the Kirkuk Embayment , Periods of changes in the plate tectonic set up in Iraq lead to changes in the tectonic framework of sedimentation in the Foreland Basin [1]. Therefore, the backstripping method is very important in estimating tectonic subsidence and relationship with sedimentation rate. Therefore, the stratigraphic architecture is dependent on rate of change in accommodation and sedimentary supply.

The basin analysis studies for Kirkuk embayment are rare, just [2] study, he analysis the Qamchuqa basin in 13 Oil Fields and reveal six stages of developing in the paleogeography and tectonism.

The aim of this work is to determine the thickness of every stratigraphic formation in Kirkuk and Bai Hassan Oil Field, as an indicator of subsidence and uplift history of the Foreland Basin through the Cretaceous and Tertiary. In addition, to determine the true thicknesses of each Formation at the time of it is deposited.

Geologic setting

Thickness of the sedimentary succession in studied part of Kirkuk embayment ranges between 2119 and 1600 m to the surface. It comprises the succession from the Aptian on ward (tables-1 and 2) within Foreland Basin. This embayment is a portion of the subzone contains the long anticlines of Hemrin, that form the SW border of the subzone, and the Bai Hassan anticline that form the NE border. These anticlines are 130-200 km long, with several doubly-plunging domes [3].The Kirkuk Oil Field is a sinuous anticline, some 100 Km long and 4-5 Km width towards SE-NW, divided by two prominent saddles (Amsha and debaka) forming three major structural culminations (Baba, Avanh and Khormala). The Bai Hassan Oil Field lies parallel to the Kirkuk structure, it is far 35 Km to the Kirkuk city [4]. The long axis is 32Km and width axis is 4Km, it consists of two domes: S- E called Kithka dome and N-W called Dawood dome, which separate between domes by Shahel saddle [5]. These structures lie in the Foothill Zone within the Unstable Shelf [6], or suspended basin, Foothill Zone of the quasiplatform foreland [7].

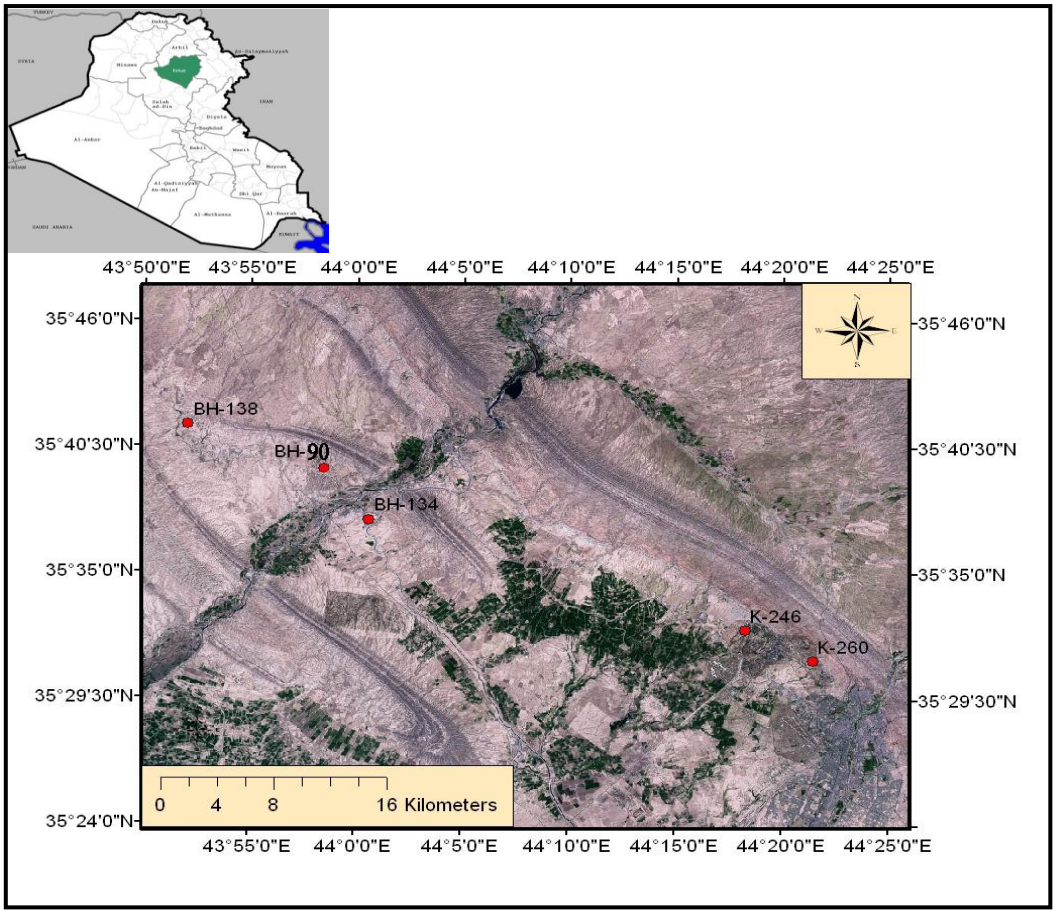


Figure 1- Locations of the studied wells in Kirkuk area (Google Earth with GIS processing)

Subduction of the Neo-Tethys oceanic crust beneath the Iranian continental margin started in the Late Jurassic. This subduction of the Neo-Tethys marks the Suture Zone between the Arabia and Iranian plates then in Late Cretaceous, the obduction of oceanic crust started which is accompanied by the emplacement of ophiolites on to the southern Tethyan passive margin [8].

[3] believe that the Late Toarcian-Early Tithonian is differential subsidence and rifting period, while is followed by opening stage of the Southern Neo-Tethys during late Tithonian-Cenomanian. However, this period remains the longest stage (Turonian-Eocene Foreland basin formation). It represents closure of the Neo-Tethys. [1,7] emphasizes that a major geodynamic inversion took place in the Cretaceous in Iraq and changed from extensional tectonism of the Triassic to compressional tectonism throughout the Cretaceous and Tertiary.

Material and methods

In our analysis, we employed the computer Excel sheet having all principal equations to build a model for process all the operation and correction. Five oil wells are selected from the Kirkuk embayment namely

K-260, K-246, BH-90, BH-134 and BH-138. (figure -1)The final well reports, sonic logs are used during this study in order to extract porosity, present thickness and sedimentary environment for each formation (Tables-1 and 2). The ages with corrections for changes in paleowater depth and sea level changes presented by [9-12].

Table 1- Input data for all formations

Formation Name	Enviro.	Lithology	Age	Paleowater depth (m)[10]
Injana	Fluvial	Clastic ,sandstone	7.25-11.6	0-1
Fat'ha	Lagoon	Lime+ evaporite	11.6-13.82	3-6
Jeribe	Shoal	Lime+ dolomite	13.82-15.97	6
Kirkuk group	Reef	Reef limestone	23.03-33.9	20
Jaddala	Outer Shelf	Chalk lime	33.9-47.8	150
Aaliji	Outer Shelf	Argil. + shale	47.8-59.2	180
Shiranish	Outer Shelf	Marly limestone	66-83	200
Hartha	Inn.shelf	Lime+ dolomite	80-83	50
Mushorah	Outer Shelf	Limestone	83-83.3	80
Kometan	Outer Shelf	Limestone	83.3-89.8	180
Gulneri	Outer Shelf	Shale+M. lime	89.8-93.9	200
Dokan	Outer Shelf	Limestone	93.9-100.5	200
Muddud	Inner Shelf	Limestone	100.5-113	50
Jawan	Inner Shelf	Recryst. limestone	110-113	50
Up.Qumchuqa	Inner Shelf	Recryst. limestone	100.5-110	50
Up.Sarmord	Deep Inner Sh.	Limestone	110-113	100
L.Qumchuqa	Inner Shelf	limestone	113-132.9	50

Table 2- Top of formations depth to studied oil wells

Formation Name	Depth (top) BH-134	Depth (top) BH-138	Depth (top) BH-90	Formation Name	Depth (top) K-246	Depth (top) K-260
Injana	0	0	0	**Injana**	0	0
Fat'ha	380	784	238	**Fat'ha**	23	23
Jeribe	875	1202	884	**Kirkuk group**	324.5	327
Kirkuk gr.	1078	1221	1090.5	**Jaddala**	553	559
Jaddala	1150	1471	1133	**Aaliji**	670	684
Aaliji	1246	1602	1247	**Shiranish**	841	888
Shiranish	1304	1646	1284.5	**Kometan**	1024.5	1083
Hartha	-	-	1380	**Gulneri**	1143	1188
Mushorah	1425	1731	1402	**Dokan**	1156	1194
Kometan	1481	1794	1579.5	**Up.Qumchuqa**	1166.5	1206
Gulneri	1665.5	1977	1607	**Up.Sarmord**	1404	1446
Dokan	1676	1988	1618	**L.Qumchuqa**	1455	1511
Muddud	1711-1868	2011	1651		1710	1600
Jawan	-	2056	1678			
		2119	1841			

The geohistory is establishment by backstripping calculation using the conventional methods presented by [13-17].

Results and discussion

The results of the geohistory reveal that subsidence history of the foreland basins of Kirkuk embayment are likely to be rather complicated. There is a closer resemblance in the results of adjacent wells. The compaction of the Cretaceous deposits are about 67-55% , the compaction in Paleogene ranged 23-27% and two Formations was deposited in Neogene, Jeribe and Fatha with percent 21, 9% in well BH-134,183. The Tectonic subsidence during Cretaceous is more effective than thickness of the over lying sedimentary column as shown in table -4 and 6. The compaction of the Cretaceous deposits in BH-90 is ranged between 67 to 55%. As usual more decreasing of compaction in Paleogene and Neogene ranged between 27-9 %, tectonic subsidence close to the total subsidence, making it the most effective in Cretaceous then decreasing during Paleogene but with end of Paleogene there is a speed subsidence as shown in table 3.

There is slightly matching of K-260 and K-246 wells (table -5 and 7), the compaction in Cretaceous about 60- 40 %. Moreover, the compaction during Palegene and Neogene wells about 13-9 %. The tectonic subsidence is gradually with total subsidence except the unconformity surfaces, the tectonic subsidence still effective but less than Bai Hassan wells.

The results from studied well backstripping provide a record of the subsidence and uplift history in a number of important Meso-Cenozoic depositional successions. you can note high range of tectonic subsidence continuous in Mesozoic, while the uplift obvious during Eocene because of the closing phase for Arabian plate with Turkish and Iranian plates that lead to deposit high thicknesses of clastics with huge subsidence. Alternatively, might be the result of the main features of paleogeography, which do not a coherent description of the geological development.

The Bai Hassan Oil Fields are affected by tectonism more than Kirkuk Oil Fields during Cretaceous and continuous to the Recent, but in Kirkuk Oil Field, the tectonism is decreasing effect especially in Cenozoic. Emphasizing [11] that, during specific periods and in specific areas, for example the Late Cretaceous (at the southern end of the plate), subsidence played the dominant role, while there is sparsity of Cenozoic MFS on the Arabian Plate result of postdepositional erosion due to regional uplift.

Table 3- The decompacted, restored and compacted thickness with total and tectonic subsidence for BH- 90 well.

FM.	7.25	11.60	13.82	15.97	23.03	33.90	47.80	59.20	66.00	80.00	83.00	83.30	89.80	93.90	100.5	110.0
	Thick	Thick	Thick	Thick	Thick	Thick	Thick	Thick	Thick	Thick	Thick	Thick	Thick	Thick	Thick	Thick
Injana	**238.00**															
Fat'ha	646.00	**682.69**														
Jeribe	206.00	214.37	**250.19**													
Unconf.	0.00	0.00	0.00	**0.00**												
Kirkuk gr.	43.00	44.60	51.26	54.63	**54.63**											
Jaddala	114.00	118.02	134.51	142.69	142.69	**144.69**										
Aaliji	37.00	38.10	42.22	44.04	44.04	44.47	**45.68**									
Unconf.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**								
Shiranish	96.00	100.46	121.51	133.42	133.42	136.47	145.79	149.28	**149.28**							
Hartha	22.00	22.97	27.48	29.99	29.99	30.63	32.57	33.29	33.29	**35.42**						
Mushora	45.00	46.92	55.82	60.72	60.72	61.96	65.72	67.11	67.11	67.91	**72.27**					
Kometan	160.00	166.25	194.55	209.77	209.77	213.58	225.01	229.21	229.21	231.59	244.57	**251.37**				
Gulneri	11.00	11.41	13.09	13.89	13.89	14.09	14.64	14.84	14.84	14.95	15.54	15.83	**17.03**			
Dokan	33.00	34.17	39.39	42.14	42.14	42.81	44.84	45.57	45.57	45.99	48.24	49.41	54.41	**54.86**		
Muddud	27.00	27.94	32.08	34.24	34.24	34.78	36.36	36.94	36.94	37.27	39.03	39.94	43.82	44.16	**45.15**	
Jawan	163.00	168.21	190.94	202.62	202.62	205.48	213.94	217.00	217.00	218.72	227.96	232.71	252.69	254.44	259.46	**263.81**

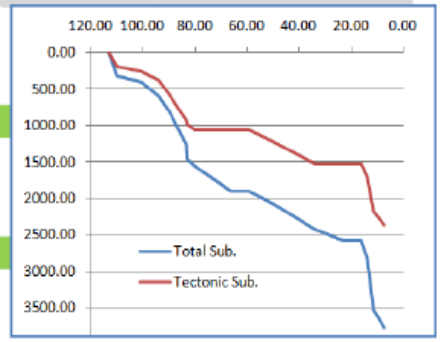


Table 4- The decompacted, restored and compacted thickness with total and tectonic subsidence for BH- 134 well.

Formation	0.00	7.25	11.60	13.82	15.97	23.03	33.90	47.80	59.20	66.00	83.00	83.30	89.80	93.90	100.50
	Thick	Thick	Thick	Thick	Thick	Thick	Thick	Thick	Thick	Thick	Thick	Thick	Thick	Thick	Thick
Injana	**380.00**	**380.00**													
Fat'ha	**495.00**	**495.00**	**541.01**												
Jeribe	**203.00**	**203.00**	**217.19**	**246.26**											
Unconf.	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**										
Kirkuk gr.	**72.00**	**72.00**	**76.55**	**85.59**	**91.06**	**91.06**									
Jaddala	**96.00**	**96.00**	**101.72**	**112.89**	**119.54**	**119.54**	**122.34**								
Aaliji	**58.00**	**58.00**	**60.89**	**66.02**	**68.79**	**68.79**	**69.90**	**71.50**							
Unconf.	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**						
Shiranish	**121.00**	**121.00**	**130.47**	**151.49**	**165.39**	**165.39**	**171.53**	**181.03**	**187.66**	**187.66**					
Mushorah	**56.00**	**56.00**	**60.04**	**68.84**	**74.54**	**74.54**	**77.03**	**80.84**	**83.48**	**83.48**	**90.00**				
Kometan	**184.50**	**184.50**	**196.43**	**221.88**	**237.95**	**237.95**	**244.87**	**255.38**	**262.56**	**262.56**	**280.06**	**289.56**			
Gulneri	**10.50**	**10.50**	**11.15**	**12.38**	**13.09**	**13.09**	**13.38**	**13.80**	**14.09**	**14.09**	**14.74**	**15.08**	**16.40**		
Dokan	35.00	35.00	37.04	41.29	43.93	43.93	45.05	46.74	47.88	47.88	50.63	52.10	58.17	**58.59**	
Muddud	157.00	157.00	165.40	182.74	193.31	193.31	197.77	204.44	208.94	208.94	219.67	225.37	248.48	250.04	**255.48**

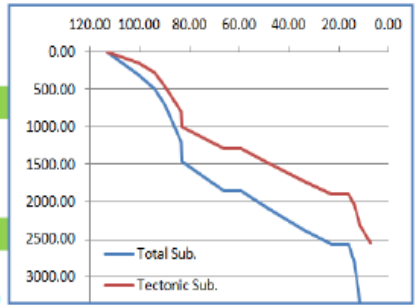


Table 5- The decompacted, restored and compacted thickness with total and tectonic subsidence for K- 246 well.

Formation	0.00	7.25	11.60	13.03	23.03	33.90	47.80	59.20	66.00	83.30	89.80	93.90	100.50	110.00	113.00
	Thick	Thick	Thick	Thick	Thick	Thick	Thick	Thick	Thick	Thick	Thick	Thick	Thick	Thick	Thick
Horizone	**0.00**														
Injana	23.00	**23.02**													
Fatha	304.00	316.93	**319.10**												
Unconf.	0.00	0.00	0.00	**0.00**											
Kirkuk group	232.00	238.01	239.30	259.83	**259.83**										
Jaddala	125.00	126.54	127.13	136.40	136.40	**146.02**									
Aaliji	204.00	207.06	207.78	218.56	218.56	228.77	**235.21**								
Unconf.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**							
Shiranish	195.00	195.00	196.07	213.38	213.38	232.24	245.47	274.10	**274.10**						
Kometan	105.00	105.00	105.50	113.52	113.52	122.05	127.91	140.26	140.26	**156.91**					
Gulneri	6.00	6.00	6.03	6.43	6.43	6.84	7.10	7.62	7.62	8.26	**8.68**				
Dokan	12.00	12.00	12.05	12.91	12.91	13.82	14.44	15.73	15.73	17.45	18.66	**18.74**			
Up.Qumchuqa	240.00	240.00	240.96	256.23	256.23	272.10	282.78	304.68	304.68	333.04	352.66	353.90	**356.42**		
Up.Sarmord	65.00	65.00	65.23	68.82	68.82	72.50	74.94	79.87	79.87	86.09	90.29	90.56	91.09	**104.56**	
L.Qumchuqa	89.00	89.00	89.29	93.89	93.89	98.55	101.63	107.80	107.80	115.51	120.67	120.99	121.64	137.87	**143.64**

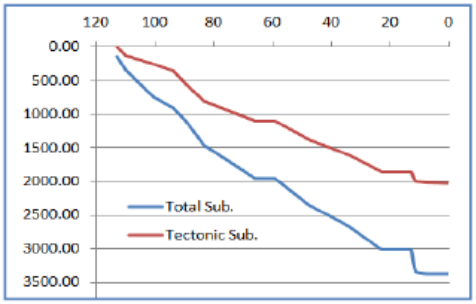


Table 6- The decompacted, restored and compacted thickness with total and tectonic subsidence for BH- 138 well.

Formation	0.00	7.25	11.60	13.82	15.97	23.03	33.90	47.80	59.20	66.00	83.00	83.30	89.80	93.90	100.50
	Thick	Thick	Thick	Thick	Thick	Thick	Thick	Thick	Thick	Thick	Thick	Thick	Thick	Thick	Thick
cover	**0**														
Injana	784.00	**784.00**													
Fat'ha	418.00	418.00	**492.25**												
Jeribe	19.00	19.00	21.82	**24.58**											
Unconf.	0.00	0.00	0.00	0.00	**0.00**										
Kirkuk gru	250.00	250.00	283.47	314.95	316.78	**316.78**									
Jaddala	131.00	131.00	146.31	160.04	160.82	160.82	**172.94**								
Aaliji	44.00	44.00	48.32	51.77	51.95	51.95	54.69	**56.40**							
Unconf.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**195.77**						
Shiranish	85.00	85.00	97.97	111.69	112.53	112.53	126.12	135.94	139.83	**139.83**					
Mushorah	63.00	63.00	71.97	81.28	81.84	81.84	90.88	97.31	99.84	99.84	**105.36**				
Kometan	183.00	183.00	206.25	229.74	231.13	231.13	253.31	268.73	274.71	274.71	287.62	**298.58**			
Gulneri	11.00	11.00	12.35	13.54	13.61	13.61	14.62	15.27	15.52	15.52	16.02	16.44	**17.87**		
Dokan	23.00	23.00	25.64	28.24	28.40	28.40	30.80	32.45	33.08	33.08	34.43	35.56	39.71	**40.01**	
Muddud	45.00	45.00	50.01	54.92	55.21	55.21	59.72	62.79	63.96	63.96	66.47	68.58	76.21	76.75	**77.94**

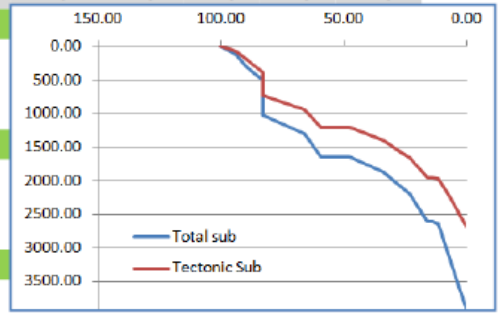
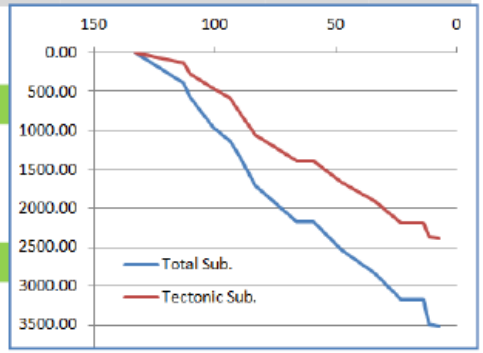


Table 7- The decompacted, restored and compacted thickness with total and tectonic subsidence for BH- 260 well.

Formation	7.25	11.60	13.82	23.03	33.90	47.80	59.20	66.00	83.30	89.80	93.90	100.50	110.00	113.00
	Thick	Thick	Thick	Thick	Thick	Thick	Thick	Thick	Thick	Thick	Thick	Thick	Thick	Thick
Horizone	**23.00**													
Fat'ha	301.0	**303.07**												
Unconf.	0.00	0.00	**0.00**											
Kirkuk g	229.0	230.24	249.84	**249.84**										
Jaddala	117.0	117.55	126.10	126.10	**134.92**									
Aaliji	171.0	171.61	180.58	180.58	189.06	**194.10**								
Unconf.	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**							
Shiranish	183.0	184.05	201.01	201.01	219.52	231.82	254.91	**254.91**						
Kometan	119.0	119.59	129.05	129.05	139.11	145.65	157.65	157.65	**175.12**					
Gulneri	13.00	13.06	13.96	13.96	14.85	15.40	16.35	16.35	17.61	**18.62**				
Dokan	10.00	10.05	10.78	10.78	11.56	12.06	12.96	12.96	14.26	15.37	**15.51**			
Up.Qumch.	238.0	238.99	254.54	254.54	270.67	280.92	299.25	299.25	324.93	346.41	349.05	**351.12**		
Up.Sarmord	51.00	51.19	54.10	54.10	57.08	58.94	62.24	62.24	66.75	70.45	70.90	71.25	**81.80**	
L.Qumchuqa	255.0	255.82	268.52	268.52	281.31	289.24	303.06	303.06	321.68	336.63	338.42	339.83	381.02	**392.28**



References

1. Numan, N.M.S. **2000.** Major Cretaceous Tectonic Events in Iraq, *Raf.Jour.Sci*., 11, (3), pp:32-52.
2. Al-Zaidy, A. A. **2010**. Basin development and reservoir characterization of the Qamchuqa Formation, NE Iraq. Ph.D. Thesis, University of Baghdad.p:171.
3. Jassim, S.Z. and Goff, J.C. **2006**. Geology of Iraq. Dolin, Prague and Moravian Museum, Brno, Czech Republic, p:332.
4. Dunnington, H.V. **2005**. Generation, migration, accumulation, and dissipation of oil in Northern Iraq, *GeoArabia*, , 10(2), Gulf PetroLink, Bahrain, pp:39-84.
5. Al-Shaikh , Z. D. and Ziyaioglu .**1992**. Some Aspects of the Regional Gravity Field Over Northern Iraq and its Geological Interpretation .Dirasat , . 19 B, *Pure and Applied Sciences* 3, pp.34-54.
6. Buday, T. and Jassim, S. Z. **1987.** The Regional Geology of Iraq, Vo.2: Tectonism, Magmatism and Metamorphism, publication of GEOSURV, Baghdad, p:352.
7. Numan, N.M.S. **1997.** A Plate Tectonic Scenario for the Phanerozoic Succession in Iraq, *J.Geol.Soc.Iraq*, 30, (2), pp:.85-110.
8. Allahyari , K., Saccani, E., Pourmoafi ,M., and Beccaluva, L. **2010**. Petrology of mantle peridotites and intrusive mafic rocks from the Kermanshah ophiolitic complex (Zagros belt, Iran): implication for the geodynamic evolution of the Neo-Tethyan oceanic branch between Arabia and Iran. Ofioliti, 35, (2), pp: 71-90.
9. Haq, B.U., Hardenbol, J. and Vail, P.R. **1987**. Chronology of fluctuating sea levels since the Triassic,. *Science jour*, V (235), pp.1156-1167.
10. Micro-strat Inc, **1998**, www.micro-strat.com/micro-strat.htm
11. Sharland, P.R. Archer, P.R, Casey, D.M, Davies, R.B. Hall, S.H, Heward, A.P., Horbury, A.D. and Simmons, M-DS. **2001**. Arabian plate sequence stratigraphy, an intedrated approach, *Geo Arabia* speciel publcaition, :372 .
12. Al-Husseini, M. I. **2008**. Middle East geological Time Scale, GeoArabia, *J. Middle East Petroleum Geosciences*, 13,(4), (chart).
13. Steckler, M.S. and Watts, A.B**. 1978**. Subsidence of the Atlantic- type continental margins off New york: Earth and planetary science letters, 41, pp: 1 - 13.
14. Van Hinte, J.E. **1978.** Geohistory analysis-application of micropaleontology in exploration geology, *AAPG*, V.62, (2), pp:201-222.
15. Magara, K. **1978.** Compaction and Fluid Migration: Practical Petroleum Geology, Elsivier, Amsterdam, p:319.
16. Allen, P. A. and Allen, J.R. **2005**. Basin analysis, Blackwell publishing, second edition, p:549 .
17. Xie Hui A.B., Zhou Di, A., Li Yuanping, C., Pang Xiong ,C., Li Pengchun , A., Chen Guanghao, A, Li Fuchenga, C., Cao, J**. 2014**. Cenozoic tectonic subsidence in deepwater sags in the Pearl River Mouth Basin, northern South China Sea, *Tectonophysics*, pp:615–616, pp.:182–198.