Influence of Structural Factors on Groundwater System - West of Iraq

Hussein Ilaibi Zamil Al-Sudani *

University of Technology. Petroleum Technology Department

dr.hussein_alsudani@yahoo.com

DOI 10.29072/basjs.2018102

Abstract

Water is a vital component to the development of any area. It is easy for the importance of groundwater in water supplies to be underestimated. This study focus on determining the structural effects on geological formations resulted by vertical, oblique and transverse faults and folds and their influence on groundwater occurrences in their formations, flow and hydrogeological parameters in Khan Al- Baghdadi area which located in Anbar governorate in the west of Iraq. Determination of geological formations and water-bearing layers in the area depends on preparation of longitudinal and lateral geological cross sections. These cross sections prepared depending on exposures and extensions of geological formations in the area and 14 wells. The influences of plunging anticline fold affect on groundwater flow. In the western plunging anticline, the groundwater flow path divided into northeast, south and southeast. Abu-Jeer sub surface fault significantly changing groundwater level especially in Kubaisa area. Water levels varied within Euphrates aquifer between northeast and southwest of the area.

Keywords: Groundwater System, Structural Geology, West of Iraq.

Introduction

The use of water is increased due to human population increasing recently [1]. Essentially, the human being settlement depends on water resources availability. Groundwater is one of the important components in development of any area when the surface water is absence. It is also the source of a large percentage of surface water [2]. Geological structures play multi roles on quantity and quality of groundwater including occurrences of aquifers in various types of rocks. Any geological study should include a lithological phase covering stratigraphic phase describing the age, unconformities, and geometrical relationships between different lithologies; as well as a study of structural features [3]. The major structural features impacting on groundwater are fractures and folds. These structures play as hydrodynamic contacts impacting on the groundwater flow pattern. Fractures are subdivided into joints, fissures and faults, which are formed by brittle fracturing of rocks [4].

Structures of folds are an important factor on flow control in a large scale, it might restrict flow. The boundary of folds becomes impermeable of all asymmetrical including anticline or syncline pairs, except the weathered folds. Faults act either as conduit or as drains, properly it makes rocks good aquifers, by lowering water table and thus affecting the distribution of groundwater [5].

In general, several previous studies have been done within western desert area as mentioned below:

1- Transboundary aquifers between Iraq and neighboring countries [6].

1- Hydrogeology of groundwater aquifers in the Western Desert - west and southwest of the Euphrates River [7].

2 - Assessment of groundwater resources in Iraq and management of their use [8].

4- Hydrogeological study of Khan Al-Baghdadi area in Anbar governorate - West of Iraq [9].

This study will focus on identification, description and evaluation of geological structures in Khan Al- Baghdadi area where better understanding of the complexities of the geology and its effects on hydrogeological conditions will achieve by integrating all the data available into useful concepts of groundwater occurrence and flow

Khan Al-Baghdadi area locates in northwest of Anbar governorate in the west of Iraq. The area covers (6290) km^2 within (41º 50'- 42 º 45') E and (33 º 30 ' - 34 º 15') N. The area is relatively flat, rises gradually and gently westwards, except the northwestern part of the area,

where slopes have gentle gradient towards north. The attitude, of the area, varies from 347m, above mean sea level in the western part and less than 100 m near Hit city to the east, (Fig.1) [9].

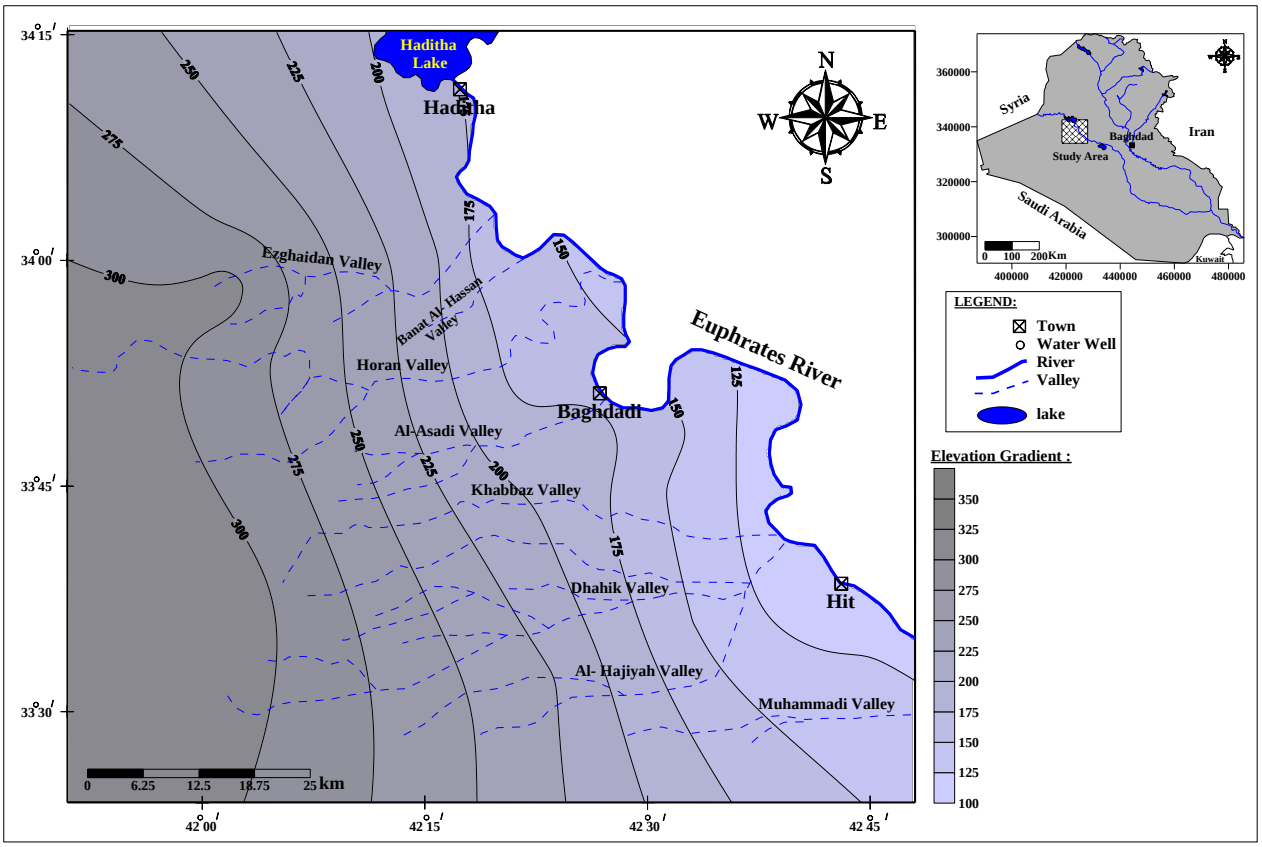

Figure (1) Topographic Map of Khan Al-Baghdadi Area [9].

Geological Setting

The area is built up of sedimentary rocks ranging in age from lower Oligocene to Pliocene, with different types of Quaternary deposits (Pleistocene-Holocene), (Fig. 2) [10]. The area lies within different structural zones from east to west, The Tigris subzone up the Mesopotamian zone of the Unstable Shelf and the Salman and Rutba-Jazira zones of the Stable Shelf. The area lies partly within the Stable Shelf represented by two zones (Al-Rutbah and Al-Jazira-Salman zones), and partly within the Unstable Shelf, represented by Mesopotamian zone (Tigris Subzone), (Fig. 3) [11]. There are two transversal deep seated faults, within the area, these are Anah - Fatha Qalat Dizah Fault and Amij - Samarra - Halabcha Fault, both of them have NE-SW. Another important structural feature, is Abu-Jeer fault zone which is also sub surface fault, running N-S. The indications of this fault on the surface are well expressed by numerous springs

(in Hit, Kubaisa and Abu-Jeer vicinities) which yield mineralized water and bitumen seepages [11].

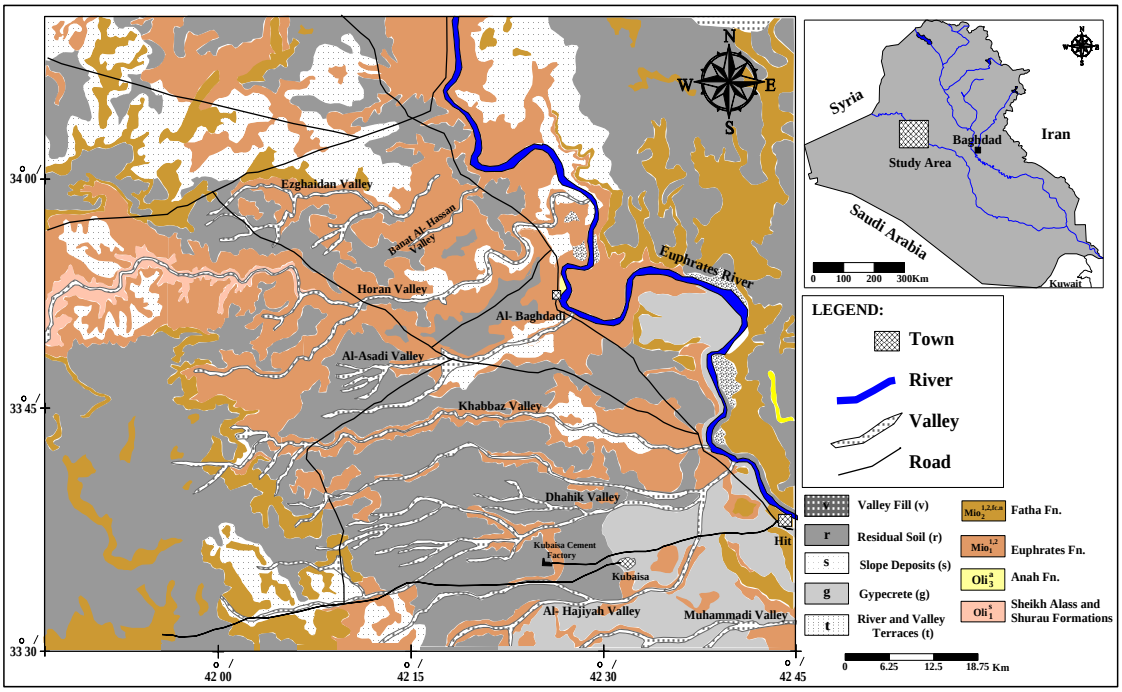

Figure (2) Geological map of Khan Al-Baghdadi Area [10].

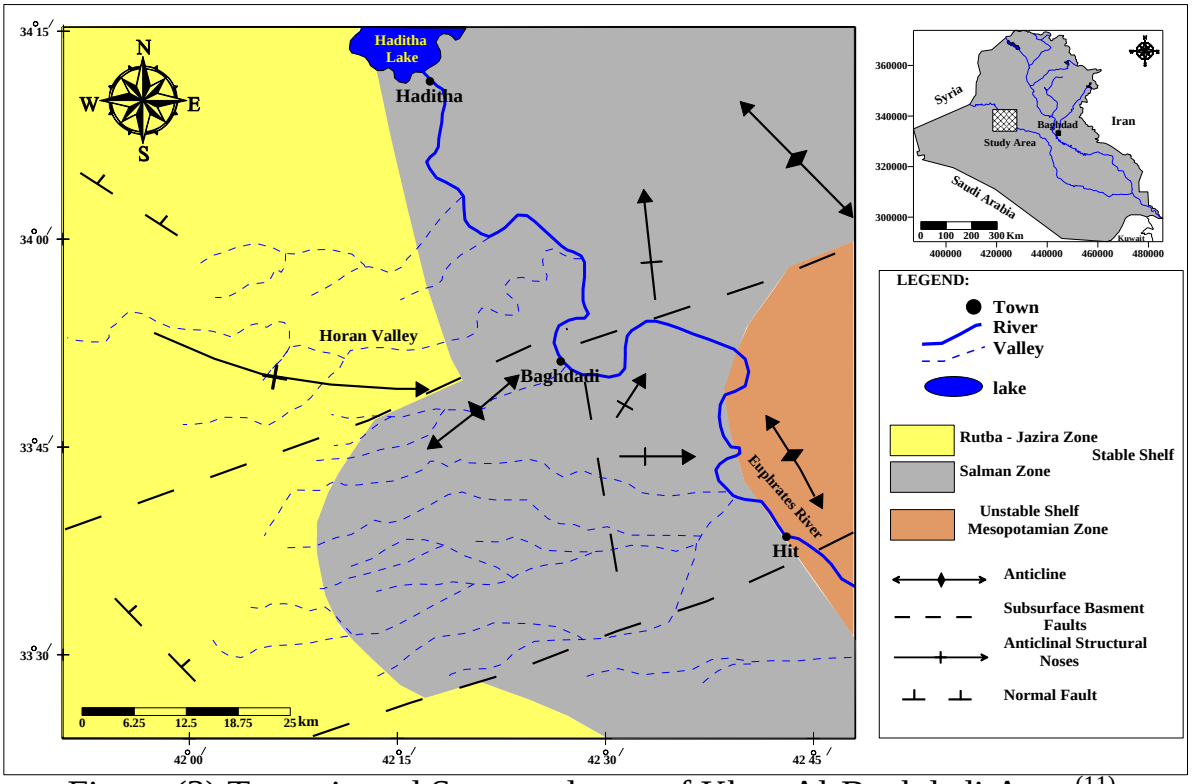

Figure (3) Tectonic and Structural map of Khan Al-Baghdadi Area [11].

Materials and Methodology

The materials used in this study were:

1- Topographic, geological and tectonic maps of area with different map scale.

2- GPS device to determine wells locations, elevations.

3- Preparations of several geological cross section depending on original fieldwork, geological maps and deep wells data.

4- Stratigraphic sheets and hydrogeological data bank [12].

5- Grapher and Surfer software for demonstrating graphs and contour maps.

The work plan in the studied area included the following:

1- Office work including preparing data and preliminary information of the area.

2- Field work including:

- Inventory of water wells and measuring water levels as well as determine geographical positions and other hydrogeological properties of (29) wells using (GPS) device during (2010-2011).

Determination of geological formations and water-bearing layers as aquifer extended in Khan Al-Baghdadi area depends on preparation of longitudinal and lateral geological cross sections to evaluate thicknesses, depths and possible extensions of these formations and their aquifers. These cross sections were prepared depending on exposures and extensions of geological formations in the area as well as (14) deep wells. The next step was comparing the stratigraphic sheets of (47) wells with (Fig. 4), taking into consideration the water levels measured in these wells as well as types of water bearing layers in order to estimate aquifer hydrogeological properties. Mathematical software (Grapher and Surfer) were used to demonstrate the obtained results and drawing geological cross sections as well as contouring maps demonstrating hydrogeological properties of groundwater aquifers.

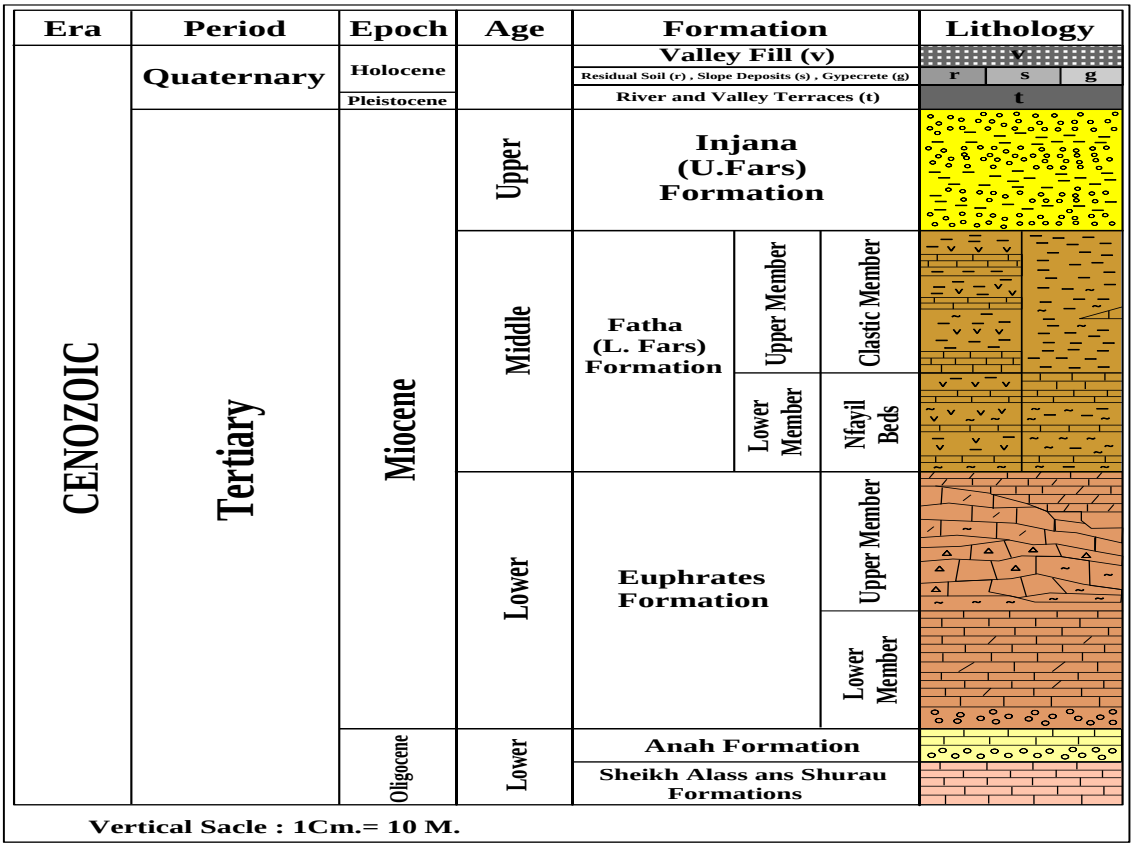

Figure (4) Geological formations sequence in the studied area [10].

Rustles and Discussion

(Table. 1) showed the statistical data of aquifers properties, while (Fig. 5) showed the map of water wells investigated as well as longitudinal and lateral geological cross sections. The fifth lateral geological cross sections were prepared from southwest to northeast direction, (Table. 2). The first longitudinal cross section was prepared lateral to Euphrates River from northwest to southeast direction. The second longitudinal cross section was extended in the western part of the area from north part to south and southeast. (Fig. 6, 7, 8) shows the five laterals and two longitudinal geological cross section prepared in studied area.

Table (1) Statistical data shows aquifer properties in Khan Al- Baghdadi area.

Statistic	Number of values	Minimum	Maximum	Mean	Standard deviation
Elevation (m)	32	100	316.9	217.72	67.781
Static water level (m.)	43	0	154.7	61.67	42.654
Dynamic water level (m)	42	1.5	155.9	73.324	39.011
Piezomteric level (m.a.s.l.)	31	69	219	161.97	36.264
Total depth (m)	47	45.5	902.6	152.03	122.07
Aquifer depth (m)	34	31	154.7	79.288	30.944
Thickness (m.)	42	15	110	62.11	26.61
Maximum yield (m^{*3}/day)	45	76	6480	859	993.73
Transmissibility (m^{*2}/day)	33	19	1700	350.8	366.7

Table (2) Data used to prepare geological cross sections in the area.

Well No.	longitude	latitude	Top (m)	S.W.T (m)	Bottom (m)	W. Bearing (m)	Geological Formations
1	421500	340000	210	31	110	179	Euphrates
3	422300	333200	230	61	147	169	Fatha, Euphrates and Anah
9	423300	333600	150	4.5	117	145.5	Euphrates
10	422210	335215	165	3	80	162	Euphrates and Anah
12	422030	340030	150	54	100	96	Euphrates
15	420042	340008	276.4	99	902.6	177.4	Euphrates , Anah , Dammam , Umm-ErRadhuma and Tayarat
18	420245	335430	280	66	172	214	Euphrates , Anah , Dammam , Umm-ErRadhuma and Tayarat
22	422600	335500	155	41.1	85	113.9	Euphrates
25	421400	341100	190	50	142	140	Fatha and Euphrates
28	424500	333600	120	3	100	117	Euphrates
29	420118	333701	316.9	154.7	225	162.2	Fatha, Euphrates, Anah , Dammam and Umm-ErRadhuma
32	420500	340400	257	103	192	170	Euphrates , Anah and Dammam
39	424000	333500	125	0	200	125	Euphrates
B (Biader)	424050	334843	110	41	100	69	Euphrates

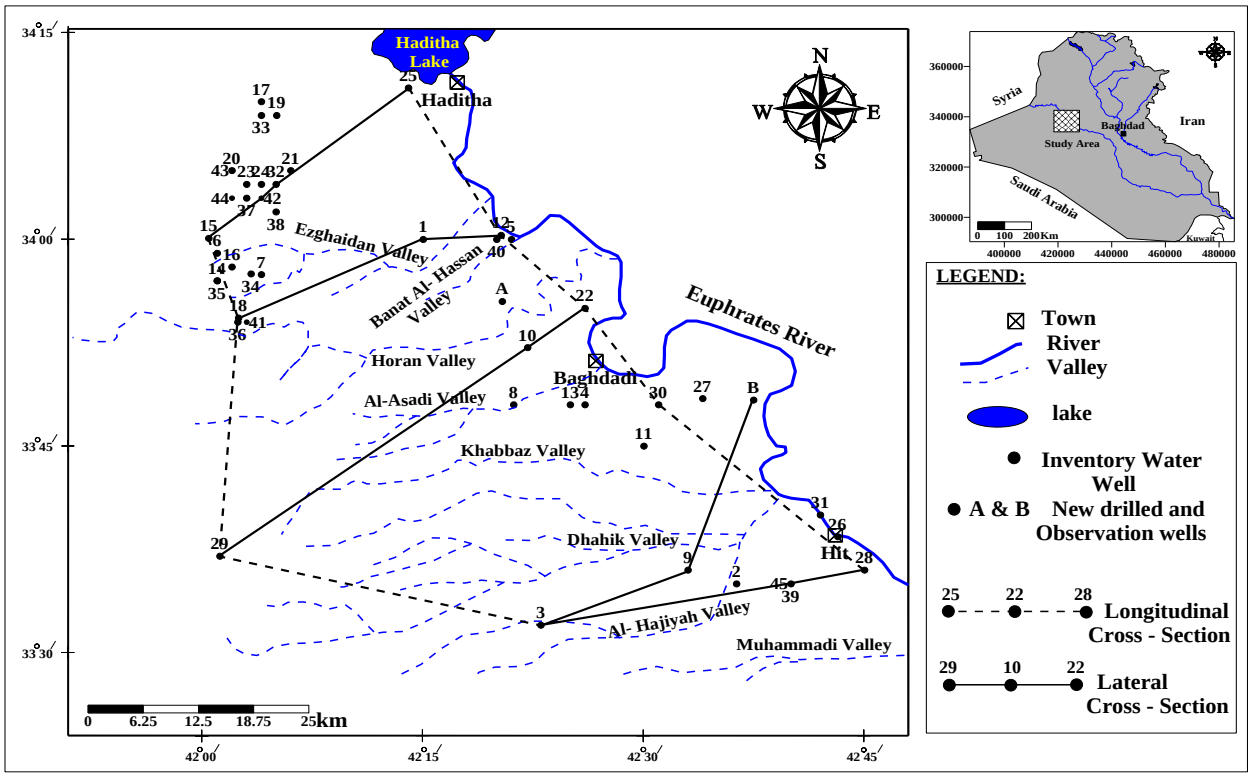

Figure (5) Geological cross sections and wells location map in the studied area.

Most of wells penetrate the Quaternary deposits with different deposits types and thickness as well as geological formations described earlier. As Quaternary deposits have limited thickness within their extension, these deposits weren't drawing within cross sections. It can be seen that geological water bearing layers in the western part of Khan Al-Baghdadi area consist of Tayarat, Umm Er-Radhuma and Dammam (subsurface) formations especially in the northwestern part of the area, (Fig. 6) sections A,B,C. The groundwater is confined in Umm Er-Radhuma and Dammam formations in the central part of the western side, (Fig. 6) sections B and C. Anah and Euphrates formations becomes the essential geological water bearing layers in the northeast part of the area, (Fig. 6) section C. The most important characteristic of the geological formations and its aquifers in the eastern area of Western desert and in the north region of Anbar governorate is hydraulic connections among sequenced geological formations where groundwater moves from deeper water-bearing layers into lesser depth through groundwater flow to eastern direction, [7,9]. This characteristic allows recharging aquifers with huge quantities of groundwater as well as turns these aquifers into confined condition under higher pressure of overlain geological

formation [13]. According to this, Fatha, Euphrates and Anah formations are non water bearing layers or dry in the western area of the region, while gradation of groundwater aquifers from eastern side of the basin to the western side presented as Fatha, Euphrates, Anah, Dammam, Umm Er-Radhuma and Tayarat formations according to the vertical sequence of geological formations. The influences of extension of plunging anticline fold especially in the western part of the basin, as well as the effects of Abu-Jeer sub surface fault which running N-S in the southeast, significantly changing groundwater level in aquifers especially in Kubaisa area where many water springs indicated this influence, (Fig. 6) sections B and C and (Fig. 7) sections D and E. The groundwater levels in wells (1,10,9 and 39) increased significantly while these levels return to normal status as indicated in wells (12,22, B and 28). The longitudinal cross sections as shown in the (Fig. 8), the aquifer in the eastern side of the area were formed only by Euphrates formation. In the western side, the longitudinal cross section, as mentioned before, indicated that Fatha, Euphrates, Anah and Dammam formations, are non water bearing layers. Some of these formations (especially Anah and Dammam) turns into aquifers as groundwater moves east and northeast, and finally, completely these formations turns into aquifers in the eastern side near Euphrates River left bank.

The effect of the structural factor is also observed on Euphrates aquifers, as seen in (Fig. 8) section F, where water levels significantly varied between northwest and southeast of the basin. These variations can be seen more effectively as shown in (Fig. 9) which indicates groundwater flow direction. Plunging anticline, transverse fault and vertical fault affect on groundwater flow, as the western plunging anticline divided groundwater flow path into northeast, south and southeast. The groundwater which moves from right limb of plunging anticline merge with water moving from left side of transverse fault and Abu-Jeer sub surface fault indicated in south part of the basin producing several springs as shown in figure (7) sections E and D. Groundwater flow direction map prepared depending on (31) wells [9] and (Table. 1). Groundwater flow map shows increasing depth of water levels in the western side of the area and decreased gradually towards eastern side of the basin in a confined aquifer.

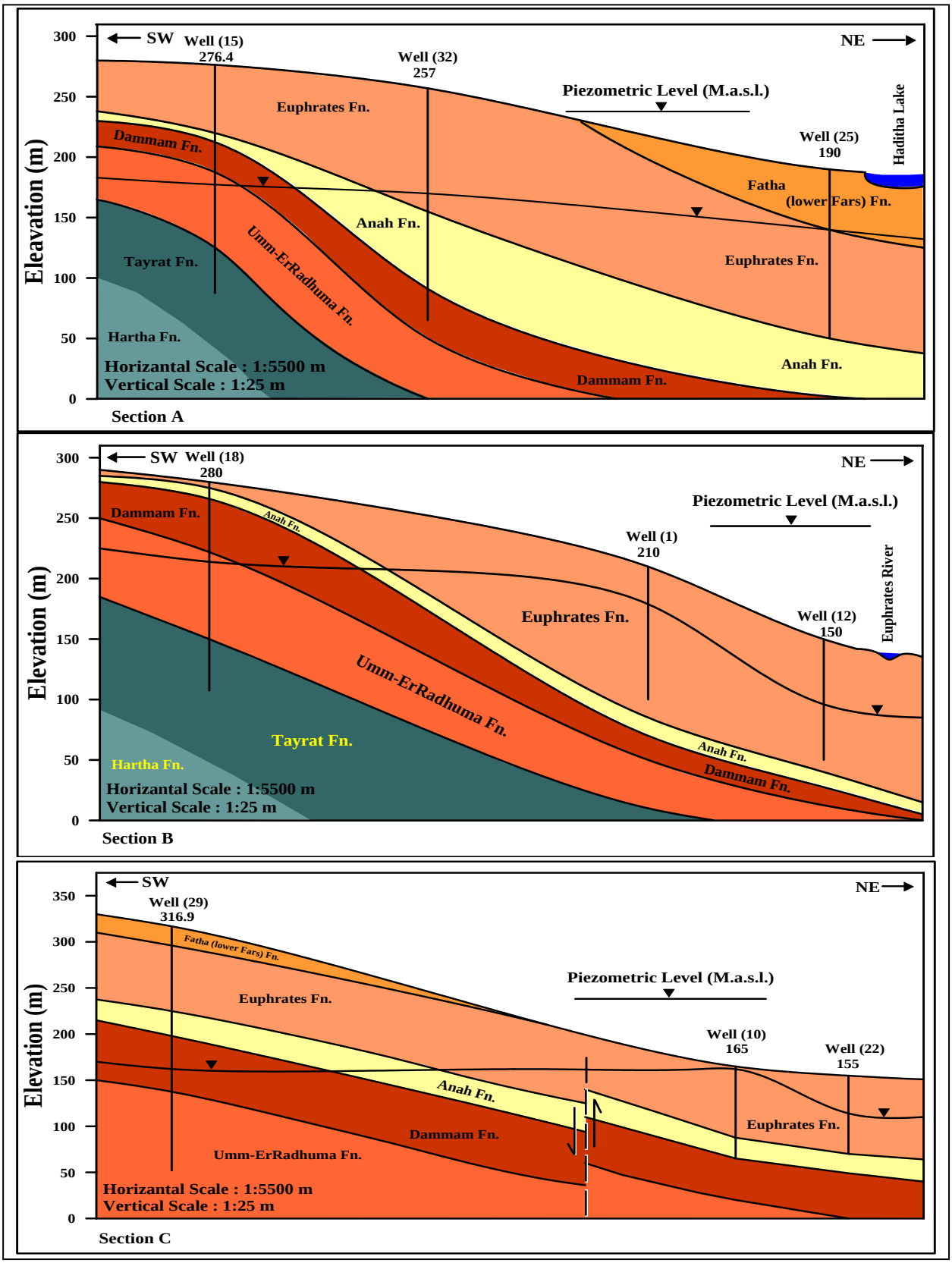

Figure (6) Lateral cross -sections in studied area.

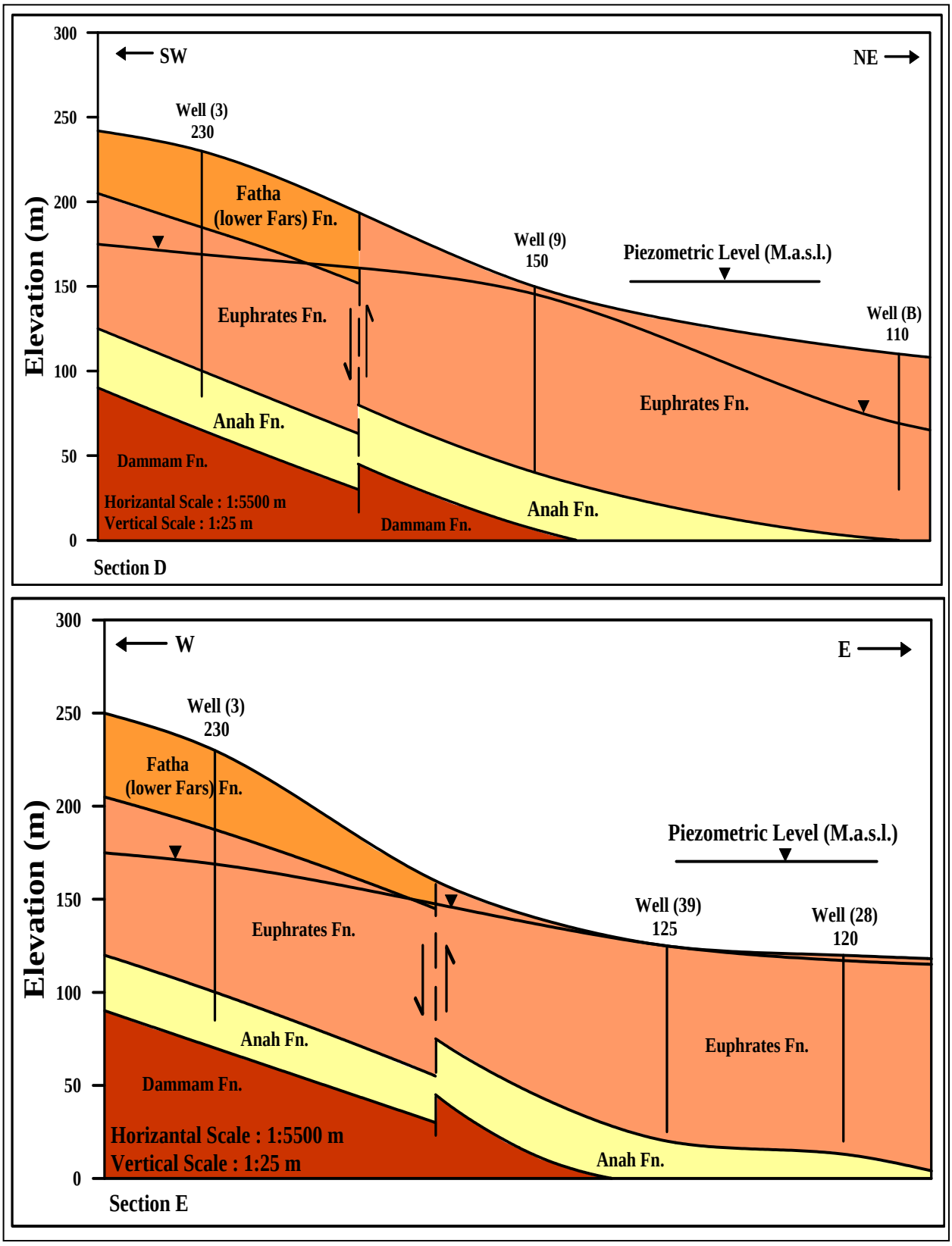

Figure (7) Lateral cross -sections in studied area.

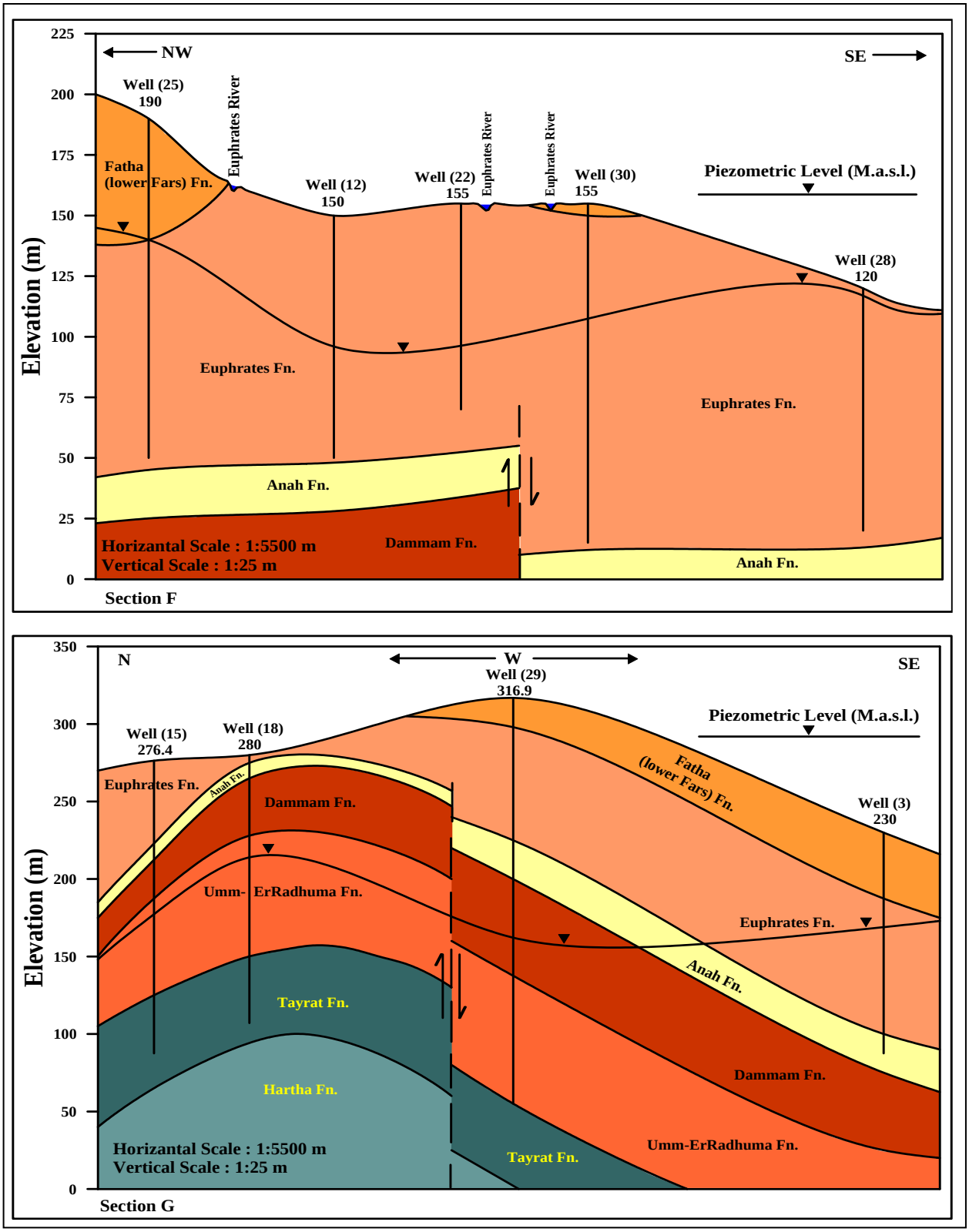

Figure (8) Longitudinal cross -sections in studied area.

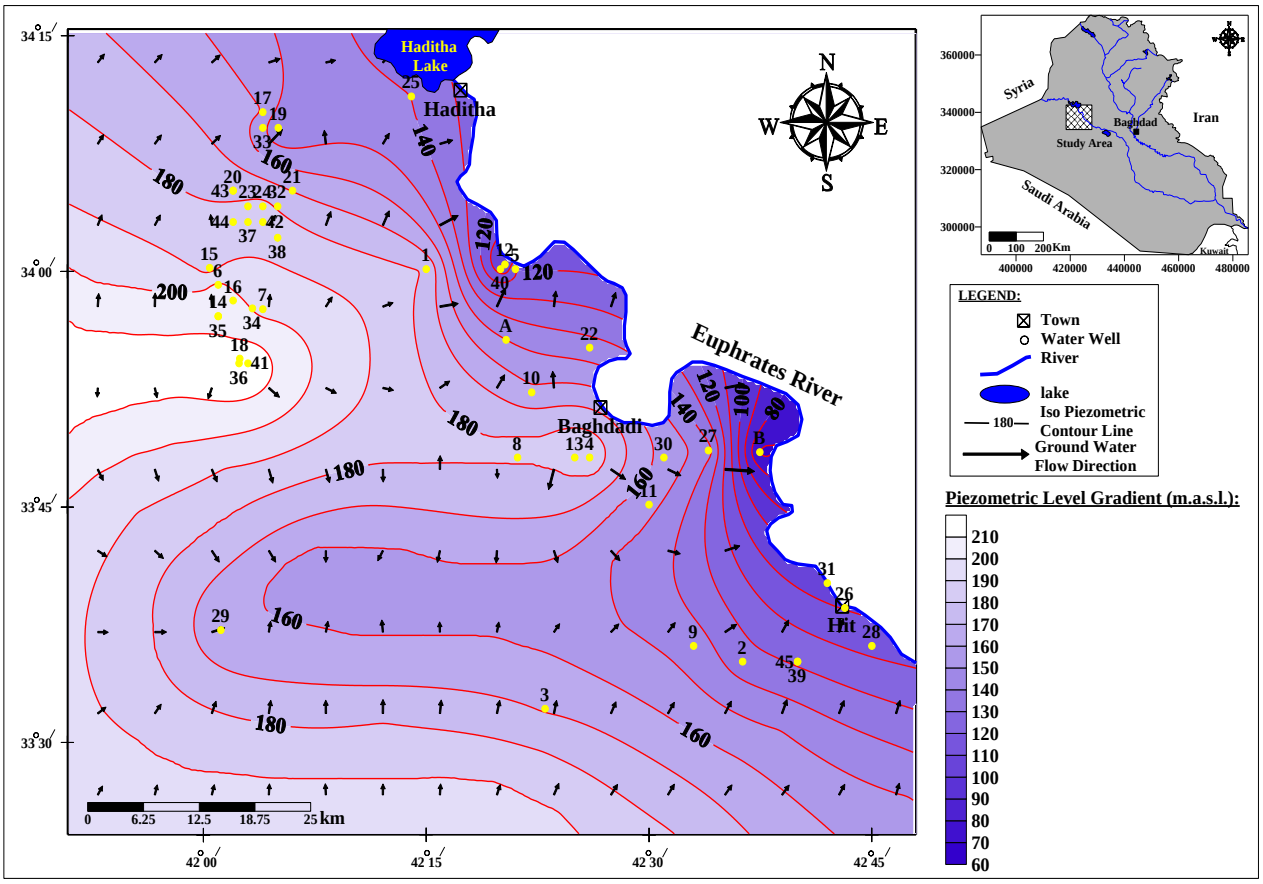

Figure (9) Groundwater flow direction in Khan Al-Baghdadi Area.

Conclusions

1- According to the vertical geological formations sequence, the geological water bearing formations in Khan Al-Baghdadi area gradually formed by Tayarat, Umm Er-Radhuma and Dammam (subsurface) formations in the western part, Umm Er-Radhuma and Dammam formations in the central part, Euphrates as essential formation and Anah with Fatha as an occasional formations in the east and northeast part of the area.

2- The most important characteristic of the geological formations in the area is hydraulic connections among sequenced geological formations where groundwater moves from deeper water-bearing layers into lesser depth, this characteristic allows recharging aquifers with huge quantities of groundwater as well as turns these aquifers into confined condition under higher pressure of overlain geological formation.

3- The influences of plunging anticline fold extension affect on groundwater flow, as the western plunging anticline divided groundwater flow path into northeast, south and southeast, while Abu-Jeer sub surface fault significantly changing groundwater level especially in Kubaisa area where many water springs indicated this influence as well as water levels varied within Euphrates aquifer between northeast and southwest of the basin.

4- Groundwater flow map shows increasing depth of water levels in the western side of the area and decreased gradually towards eastern side of the basin in confined aquifer.

References

(1) Abdul, R., Shivanna and Musthafa, A. (2015). Geological structure that have control on groundwater occurrence of Chamarajanagar Taluk , Chamarajanagar district , southern Karnataka. International Journal of Geology. 5 (1): 1-9.

(2) Delleur, J.W. (2000). The Handbook of Groundwater Engineering. U.S.A.

(3) Langstaff , C.S and Morril , D. (1981) . Geological Cross-Section . Boston. USA.

(4) Roberts, J.L. (1982). Introduction to Geological Maps and Structures. Better World Books. ISBN 10: 008023982X. U.S.A.

(5) Mulwa J, Gaciri S, Barongo J, Opiyo-Akech N and Kianji K . (2005) . Geological and structural influence on groundwater distribution and flow in Ngong area, Kenya. African Journal of Science and Technology. 6 (1): 105-115.

(6) Jawad, S.B., Abdulrazaq, M.I. and Ahmed, A.M. (2008). Transboundary aquifers between Iraq and neighboring countries. Ministry of Water Resources. Baghdad.Iraq.

(7) Jawad, S.B., Naom, F.H., Zamil, H.I., Mohammad Ali, B. (2001). Hydrogeology of Groundwater aquifers in the Western Desert - West and Southwest of the Euphrates River. Ministry of Irrigation. Baghdad. Iraq.

(8) Jawad, S.B. and Ridha, S.A. (2008). Assessment of groundwater resources in Iraq and management of their use. Ministry of Water Resources. Baghdad.Iraq.

(9) Al-Sudani, H.I. Z. (2017a). Hydrogeological study of Khan Al-Baghdadi area in Anbar Governorate - West of Iraq. Diyala Journal for Pure Sciences. 13 (2): 192-207.

(10) Sissakian, V.K.; and Hafidh, S. Q. (1994). The Geology of the Haditha Quadrangle Sheet NI-38-5 (GM 13) Scale 1:250 000. (GEOSURV). Baghdad. Iraq.

(11) Sissakian, V.K.; and Salih, S.M. (1994). The Geology of the Ramadi Quadrangle Sheet NI-38-9 (GM 13) Scale 1:250000. (GEOSURV). Baghdad. Iraq.

(12) General Commission of Groundwater. (2011). Geological and Hydrogeological information of Groundwater wells in Anbar Governorate. Ministry of Water Resources. Baghdad. Iraq.

(13) Al-Sudani, H.I.Z. (2017b). Groundwater Investigation in Iraqi Marshland Area. Diyala Journal for Pure Sciences. 13 (3): 12-29.

تاثيرات العوامل التركيبية على نظام المياه الجوفية - غرب العراق

حسين العيبي زامل السوداني

قسم تكنولوجيا النفط . الجامعة التكنولوجية

المستخلص

المياه عنصر حيوي في تطوير أي منطقة حيث من السهل أن يتم تقييم اهمية المياه الجوفية كعنصر مهم من عناصر امدادات المياه . تهدف هذه الدراسة الى تحديد التأثيرات التركيبية على التكوينات الجيولوجية الناتجة الصدوع العمودية والمائلة والمستعرضة بالاضافة الى الطيات وتأثيراتها على تواجد وجريان المياه الجوفية ومعاملاتها الهيدروليكية في منطقة خان البغدادي والتي تقع في محافظة الأنبار في غرب العراق . يتوقف تحديد التكوينات الجيولوجية والطبقات الحاملة للمياه في المنطقة على إعداد المقاطع الجيولوجية العرضية والطولية ، حيث اعدت هذه المقاطع اعتماداً على منكشفات وامتداد التكوينات الجيولوجية المنتشرة بالاضافة الى بيانات (14) بئرا محفورة في المنطقة. بينت الدراسة تاثيرات امتدادات الطية المحدبة الغاطسة على اتجاهات جريان المياه الجوفية حيث تقسمت خطوط جريان المياه الجوفية على جانبي الطية المحدبة الغاطسة الواقعة في المنطقة الغربية من المنطقة باتجاه الشمال الشرقي والجنوب والجنوب الشرقي . بينما كان تاثير صدع ابو جير تحت السطحي متمثلاً بتغيير كبير لمناسيب المياه الجوفية وخاصة في منطقة كبيسة ، فضلا عن تغير مناسيب المياه الجوفية في مكمن الفرات الجوفي في الشمال الشرقي والجنوب الغربي من منطقة الدراسة .

الكلمات المفتاحية : نظام المياه الجوفية ، الجيولوجيا التركيبية ، غرب العراق.