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The Relation Between Karst Terrains and Rising of Groundwater Level in the Vicinity of Hadith Dam Area-Iraq

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ABSTRACT

This work aims to study the karst terrains in Hadith area. According to geological studies in the area, the carbonate rocks related to the Miocene age and characterized by enrichment with evaporates which more easily dissolved by groundwater. The features of karst topography are including many types such as sinkholes, cavities, and karst springs. After 1986 the construction of Hadith Dam on Euphrates River, the groundwater level in the surrounding area rose gradually and caused increasing in dissolving of the carbonate rocks, which lead to form karst features in the area. In addition to the change of groundwater level, the flow direction also changed in both sides of the Euphrates River which lead to enlarged the collapse of rock and caves and forming karst valley from coalescing sinkholes.

Keywords: Karst terrain; groundwater level; Haditha Dam

1. INTRODUCTION

Karst topography is a geomorphic feature occur in carbonate rocks and it may form in evaporates such as gypsum and halite, by dissolution of rocks under the rising of groundwater level or by the humidity conditions such as continuous of heavy rain-fall for long period, these conditions are more effective when the carbonate rocks characterized by the pressures which forming weak zones in the rocks dissolved easily by water and causing formation of pores spaces and cavities around the masses of the rocks in different shapes which called Karst. There are many examples of these features in different places around the world (Huggett, 2007). Karst topography is a common features in some area in Iraq, which causes severe damages to infrastructures.

The main Karstified rocks are found in limestone rocks of Euphrates Formation, which covers considerable parts of western part of Iraq.

Karst voids are often a major engineering risk associated with construction in areas underlain by carbonate rocks. Several problems are associated with subsurface karstic voids, such as road and highway subsidence, building foundation collapse and dam leakage. Large void formation in a karst environment may lead to sudden and catastrophic failure (Farooq, 2012). The karst occurs in carbonate sedimentary rocks (limestone or Dolomite), which form about 20% of the rocks, outcropped on the earth surface. These rocks

characterized by two main properties; the dissolution by water and permeability. The karst features form as digenetic features in carbonate rocks which consist of high percentage of fracture , joints and thin stratification of the rocks, (Huggett, 2007). The last phase of karstification in Iraq was during Pleistocene (Tyracek and Youbert, 1975 and Sissakian *et al*., 1986 a), when a wet climate was prevailing. Although the climate nowadays is dry to semi-dry, in majority parts of Iraq that are involved in karstification. However,(Sissakian and Al-Mousawi,2007) believe that the last phase of karstification is still continuing as it is evidenced from the development of new karst forms and the rejuvenation of others, especially in Haditha and the Southern Desert vicinities, Fig.1.

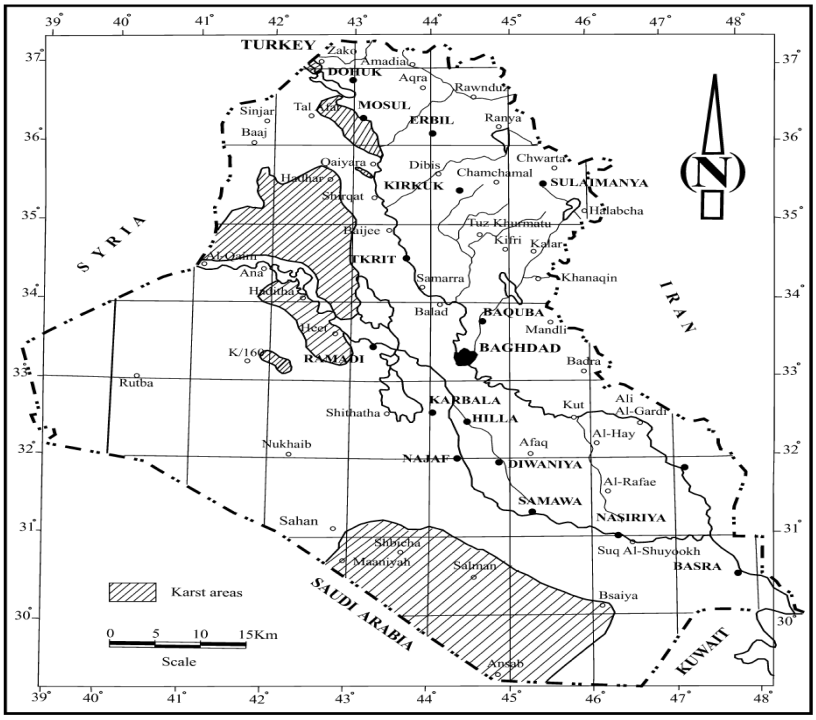

Figure 1: Karst areas in Iraq (Sissakian and Ibrahim, 2005).

Ground Penetrating Radar (GPR) is one of the most effective and rapid types of geophysical surveys methods. GPR is a fast geophysical method that allows precise and effective recognition of geological formations below the surface. The application of GPR ranges from engineering applications and geological investigations. Geological surveys were carried out and GPR surveys were suggested in the vicinity of Al-Haditha.The GPR method is a good geophysical tool for detecting karst phenomena and caves. (Lyskowski et al, 2014)

1.1 Study area:

Haditha is in central Iraq, about 200 kilometers west of Baghdad and the city extends along the Euphrates River. Hadith is bounded in the north, by the Al-Rayhana valley, in the east by the Euphrates basement, in the south by the Al-Hurran Valley and to the west by the ends of water Channels. Haditha coordinates (241447-249051)E and (3780139-3804798)N. The area is increasing in elevation from east to the west, see Fig. 2.

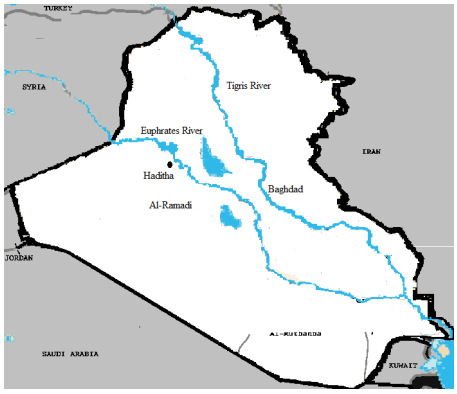

Figure 2: Location of the study area

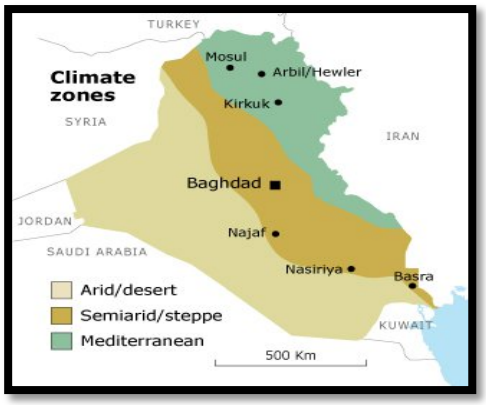

Figure 3: Climate of Iraq

1.2 Climate

Iraqi is located in the arid –semiarid region with long dry summer season and short humid winter The recorded elements of climate according to Hadith meteorological station are: 1. Temperature: is with average 44° C during June, July, and August, and above 0 ° C in January and February. 2. Evaporation: The maximum amount of annual evaporation is about (3000) mm in summer and minimum amount of evaporation is recorded in January when the maximum humidity and lowest temperature .

3. Humidity: annual humidity at January ranges between (35-40) % where the highest humidity and the lowest is at July. 4. Wind: For the years (1988-1992) the Northwesterly wind is 75% in the study area (Al-Hadithy, 1994), see Fig. 3.

1.3 Geology

The area of study located in the unfolded zone western Iraq which characterized by horizontal layers of rocks mostly of carbonate nature extend from Oligocene to Quaternary age. (Jassim and Goff, 2006; Buday,1980). The following formations exposes in the west of Iraq. See Fig. 4.

1. Anah Limestone Formation (Up. Oligocene) this formation composed of reefal limestone mostly subsurface in the area with thickness (40-60)m. outcropped in some valleys in the area mostly massive with thin layers of marl or clay. (Buday, 1980). 2. Euphrates Limestone Formation (L. Miocene) the most wide extends outcropped formation in the area of study. Lithological; composed of massive reefal limestone carbonate, conglomeritic basal carbonate with thickness (2.5-9) m. followed by (18)m. of shally limestone with chalky and white massive limestone with unconformable contact with Anah formation. The formation divided in three parts from the bottom to the top, the upper part formed from highly fractured limestone with dense joints, the karst topography developed mostly in this part. 3. Jerebi Formation (M. Miocene) the formation outcropped west of Euphrates river and composed of limestone. 4. Fatha Formation (M. Miocene) lithologicaly, formed of many cycles of evaporates interbeded with limestone and red mud layers outcropped in limited separated areas in west Iraq. 5. Quaternary deposits mostly clastic deposits of gravel, sand and fine sediments with different thicknesses highly effect by erosion and post digenetic processes consists many geomorphic features such as Hamada, valleys deposits and cavities.

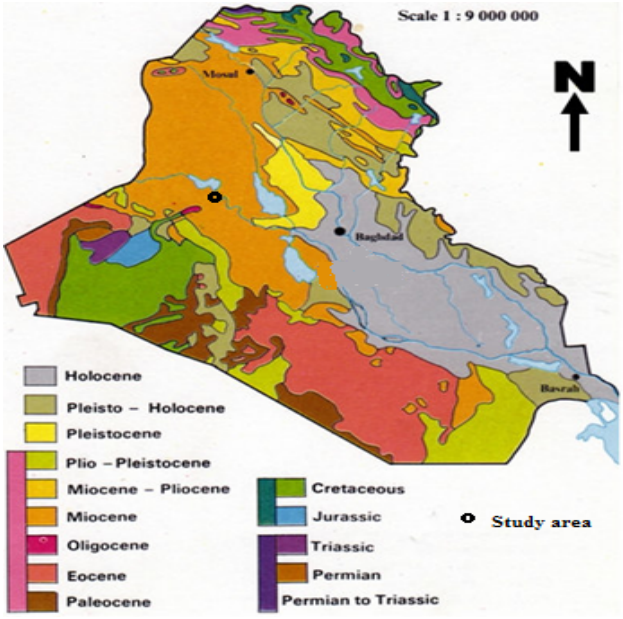

Figure 4: Geology of the study area

2. HYDROGEOLOGY

The ground water characters have been changed as a result of the construction of Haditha dam and the formation of the water reservoir by means of ground water level and flow direction of the ground water (sidqi, 1983). The most important changes are:

1. The flow direction of the groundwater before the construction of the dam was from west to east in the area west of Euphrates river, while in the east side direction, the flow from east and northeast to west. These flow directions were changed after the rising of the water in the reservoir in the front of the dam.
2. The water level in the reservoir rose from 111 to 147 m above sea level and that changed the hydrolic balance because the reservoir water became recharge source to the ground water and reverse flow occurred.
3. Rising the level of the ground water around the reservoir caused to dissolution of the host rocks of Euphrates and Fatha formations especially at the area in contact with the reservoir and that increased to developing the different types of karst features (Al-Hadithy,1994).

3. TYPES OF KARST TOPOGRAPHY

Geomorphology of the study area is characterize by landforms including plateaus, hills, low slope sand plains which formed by wind erosion and karst landforms developed by fluvial and groundwater effects. The karst landforms are obvious in the study area in all formations rock especially in Furat. and in Gypsum layer in Fatha. There are many types of karst topography terrains in the study area such as: **a. Sinkholes:** Sinkholes are features that primarily develop in the subsurface of karst environments. Closed, circular depressions are characteristic features of karst terrains and form due to subsidence of near surface sediments into cavities in the subsurface formed by dissolution. Often, sinkholes form rapidly due to active subsidence processes and have catastrophic results. Sinkholes constitute a significant geologic hazard in karst because of their inherent suddenness. Sinkholes are commonly funnel-shaped, measure a few meters to tens of meters and their general drainage is subterranean (Bates and Jackson, 1984; Montane,2001). These

features are the basic or index landforms of karst terrains (Ford and Williams, 1989; Montane,2001), a sinkhole results from either the transport of superficial material downwards along enlarged channels or collapse of the rock roof over a large bedrock –cavity .(Huggett,2007; Montane, 2001), see Fig. 4.

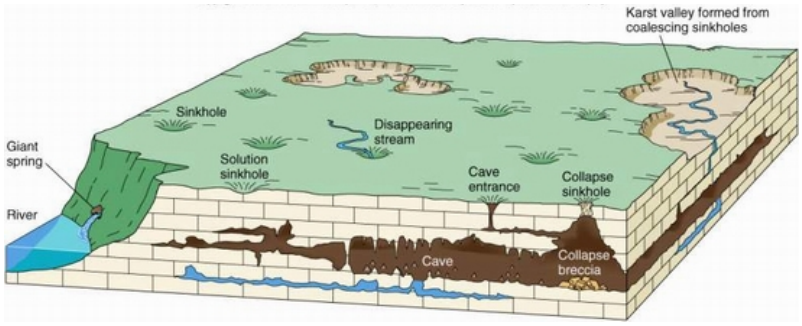

Figure 5: Schematic diagrams of some karst features

The geological survey revealed that the area characterized by numerous sinkholes such as Fhaimi collapse sinkhole, Salman rosa sinkhole collapse and Ana sinkhole collapse which the last one was not allowed to survey . The Fhaimi collapse sinkhole is (27)m. depth and (25)m. diameter and the fig and dates trees have been seen growing in the sinkhole that indicates the shallow groundwater Level (Figure 6) also the limestone rocks are characterized by vertical Joint networks greatly facilitate the circulation of water in karst. Large joints begin as angular, irregular cavities that become rounded by solution (Huggett, 2007), see Fig.7.

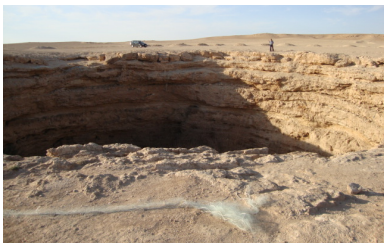

Figure 6: Al-Fhaimi sinkhole

Figure 7: Al-Fhaimi sinkhole

Figure 8: Salman sinkhole

The Salman rosa sinkhole collapse is in limestone rocks overburden by clayey or muddy soil with (18)m. depth and (22)m. diameter and vegetation was seen in the collapse area, see Fig. 8.

b. Caves: Limestone rocks with joints, rapid rising of ground water flow and drainage systems in the area lead to stream flows from caves and appears in Haditha karst area because Haditha has both fluvial and groundwater drainage which leads to dissolution of underlying rocks and reacts chemically with carbon dioxide. The water becomes weakly acidic because it reacts chemically with carbon dioxide that occurs naturally in the atmosphere and the soil. This acid is named carbonic acid and is the same compound that makes carbonated beverages taste tangy. Rainwater seeps downward through the soil and through fractures in the rock responding to the force of gravity. The carbonic acid in the moving ground water dissolves the bedrock along the surfaces of joints, fractures and bedding planes, eventually forming cave passages and caverns. Caves and holes are spread in the study area especially near the pumping station (K3), also field study revealed occurrence of caves in the right side of Haqlan valley which is 3 km. distance from Euphrates valley and also on the main road Haqlania-Haditha.

c. Karst springs: A karst spring is a spring that is part of a karst system. That includes the underground drainage Karst springs are usually the end of a cave system at the place where a river cave reaches the Earth's surface. Thus, it is often possible to enter the caves at a karst spring and explore them(*Elmer*,2001) karst spring. A spring emerging from karstified limestone (Watson, 1972). The amount of water that flows from springs depends on many factors, including the size of the caverns within the rocks, the water pressure in the aquifer, the size of the spring basin, and the amount of rainfall. Ground penetrating radar GPR is one of best methods to locate paleo-collapses and cavities and to detect and characterize karst features (Anchuela, 2009). GPR systems have become the geophysical tools that provide the subsurface window for a variety of geological, engineering, environmental and archaeological applications: determining the thicknesses of soil horizons and depth to water table; detecting air-filled subsurface cavities, buried channels and tunnels (Collins, 1994). Due to the special circumstances that happened within the past two years in the area it was not possible to use the GPR device as it was planned. In future studies and with the availability of the GPR it is recommended to carry on the second planned part of this study.

4. CONCLUSION

The study is concluded that all the outcropped formations are consists of rocks which are dissolvable by water existence as limestone and gypsum rocks which led to forming the Karst topography features that are common in the vicinity of Haditha area. The water level in the reservoir rose from 111m to 147m above sea level and that changed the hydraulic balance because the reservoir water became a recharge source to the groundwater and reverse flow occurred. Also rising the level of the groundwater around the reservoir caused to dissolution of the host rocks of Euphrates and Fatha formations especially at the area in contact with the reservoir and that increased to developing the different types of karst features and rejuvenation the existence sink holes and caves. The karst topography features in the study area are three types of sinkholes, caves, and spring.

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