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Earthquake Distributions of the Mesopotamia Plain, Iraq

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Abstract: *In this paper, the statistical distributions of earthquake epicenters, hypocenters, and magnitudes were analyzed for the Mesopotamia Plain, which is located at central and southeastern part of Iraq between longitudes 36-48°E and latitudes 26-36°N, for the period of 1900 to 2018 in order to have better understanding of the seismic activities in the study area. For this purpose, the bulletin of the International Seismological Center was used to draw three contour maps depict the earthquake distributions of the study area. The earthquake distributions show that the number, depth, and magnitude of earthquakes decrease from the Iraq-Iran border toward the Mesopotamia Plain.That means the seismic activity of the Mesopotamia Plain is less than the seismic activity of the Zagros Fold-Thrust belt. However, earthquakes at the edges and within the Mesopotamia Plain occur frequently each year.*

Keywords: *Earthquakes distribution, Mesopotamia Plain, Seismicity of Iraq.*

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I. Introduction

The geological setting of Iraq represents the results of the tectonic events during the geological time and mostly the collision between the Arabian and Eurasian plates. The Arabian plate is divided into the Shield, Inner Platform, and Outer Platform. Iraq is occupied by the Inner and Outer Platforms (Fouad, 2010). The Outer Platform is unstable and consists of the Zagros Fold-Thrust Belt and the Mesopotamia Foredeep. The Inner-Platform is stable and includes the western desert of Iraq (Figure 1).

The Mesopotamia Foredeep, which represents intern the terrestrial remnant of the Zagros Foreland Basin, consists of the Al-Jazira Plain and the Mesopotamia Plain. The Mesopotamia Plain is located at the central and southeastern part of Iraq between longitudes 43-48.5°E and latitudes 29-35.5°N, which represents the study area (Figure 2).

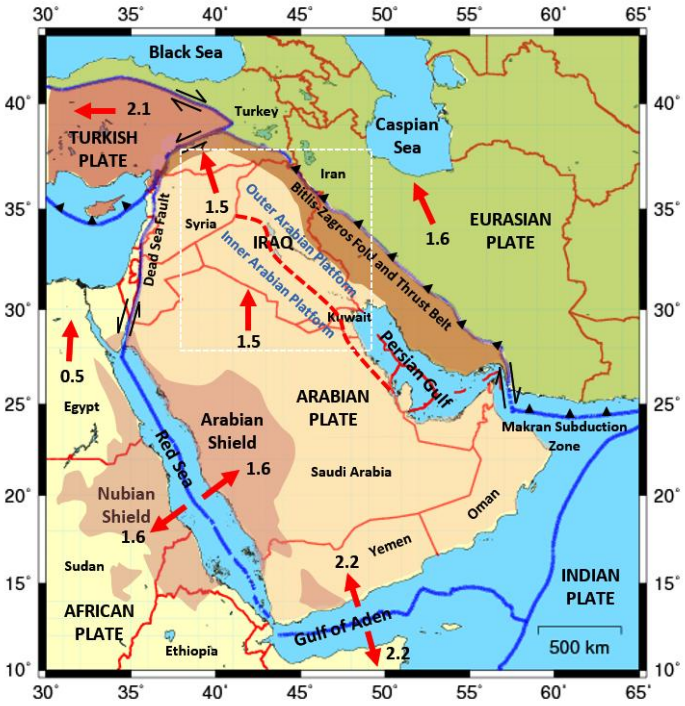


Figure 1: Tectonic setting of the Arabian plate. Red arrows indicate plate motions in cm/year.

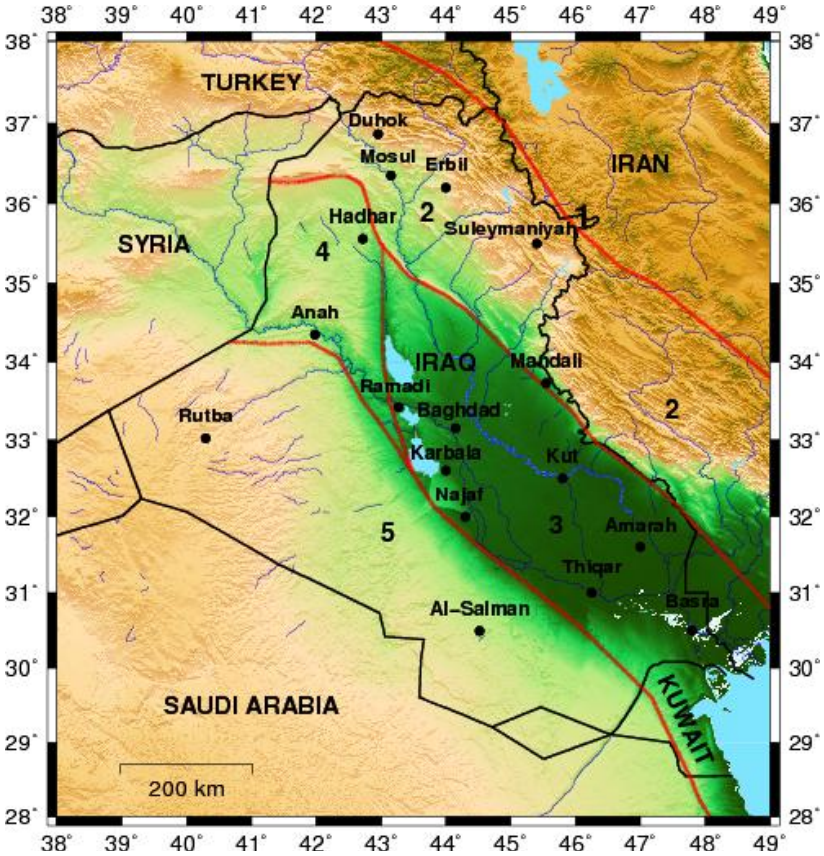


Figure 2: The tectonic divisions of Iraq after Fouad (2010). 1Sanandaj-Sirjan Zone. 2 Zagros Fold-Thrust Belt. 3 Mesopotamia Plain. 4 Al-Jazira Plain. 3 and 4 Mesopotamia Foredeep. 2, 3, and 4 Outer Platform. 5 Inner Platform.

The Mesopotamia Plain is flat terrain, slopping very gently toward the Persian Gulf. It has subsurface complex structures like folds, faults, and salt structures. These subsurface structures are entirely concealed beneath the Quaternary cover and represent important oil fields in the middle and southern Iraq. Besides these structures, there are high and complex stratigraphic columns containing the deferent types of sedimentary rocks. The area characterized by the existence of many gently plunging subsurface structures of different sizes that usually have a very poor reflection of the surface relief (Karim, 1993; Aqrawi *et al*., 2010).

Earthquake distribution is one of the important subjects in seismology that was studied by many seismologists (e.g. Kagan, 2007, 2010 and Kagan and Jackson, 2016). In this study, the distributionof earthquake number, depth, and magnitudewithin the Mesopotamia Plain are studied and mapped. The study attends to analyze the earthquake catalogue of Iraq in order to provide information on the spatial distributions of earthquakes in the Mesopotamia Plain.

II. Earthquake Catalog

The International Seismological Centre (ISC) was established in 1964 in order to collect, archive and processing seismic station and network bulletins, and preparing and distributing the definitive summary of world seismicity. One of the current mission of the ISC is to maintain the ISC Bulletin, which is the longest continuous definitive summary of world seismicity (jointly with ~130 seismic networks and data centres around the world). List of earthquakes from the ISC Bulletin was collected to study the earthquake activity in the Mesopotamia Plain for the period from 1900 to 2018.

The bulletin of the International Seismological Center (ISC) was used for many reasons. First,the accuracy of the hypocenter location is very high comparing with other catalogues. The ISC bulletin includes earthquakes were reported by local catalogues such as Iranian Seismological Center (IRSC), Kuwait Institute for Science Research (KISR), and Kandilli Observatory and Earthquake Research Institute (KOERI).

III. Seismic Activity

Almost ninety per cent of earthquake occurrences in the world is associated with two distinct seismic belts, namely the Alpine belt and the Circum-Pacific belt. The Alpine belt (Mediterranean belt)extends from Cape Verde Islands and Portugal in the west to the Himalayas and East Indies in the east. This belt passes

through southern Europe and extends eastward into Turkey, bearing southward along the Iraqi-Iranian boundary. Earthquakes in Iraq and the neighbouring countries are therefore associated with the Alpine belt (Al-Tamimi, 1969).

A number of destructive earthquakes have taken place in Iraq, and the seismic bulletin of the International Seismological Center (ISC) has reported thousands of earthquakes in Iraq and neighbouring countries for the period from 1900 to 2018. Figure 3 shows the geographical distributionof earthquakes and their magnitudes. In addition, the figuredepicts that the Mesopotamia Plain is active seismologically andearthquakes with magnitudes reach 5.9 Mw have occurred during the last hundred years.

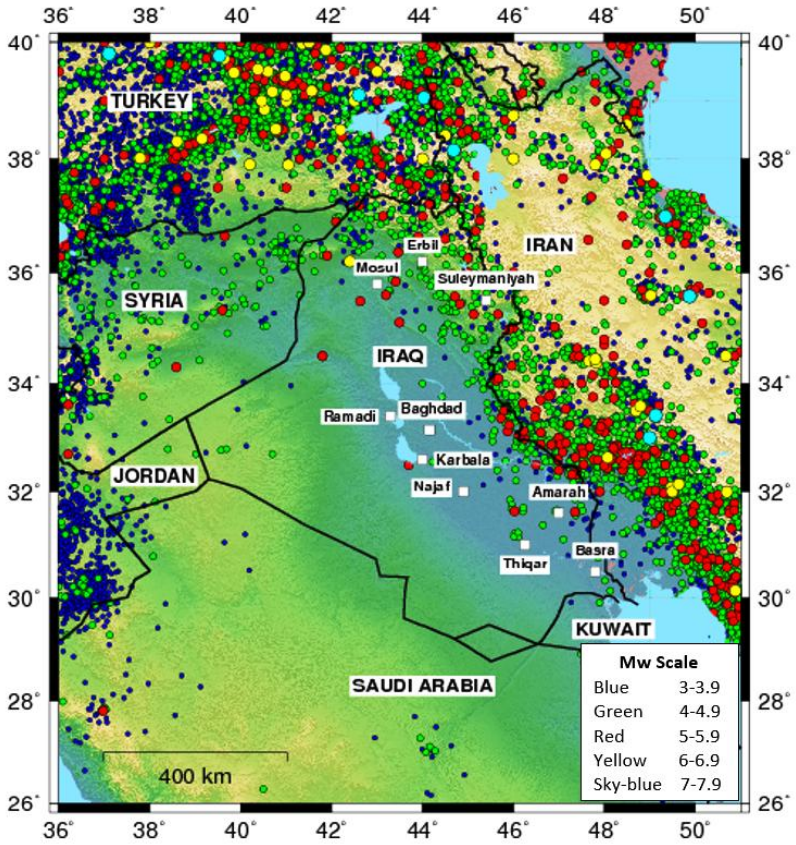


Figure 4: Earthquakes map of Iraq and adjacent countries based on the ISC Bulletin for the period from 1900 to 2018.

IV. Earthquake Distribution

Contour maps of earthquake number, depth, and magnitude distributions were plotted based on the ISC bulletin for 118 years from 1900-2018. In order to plot these maps, circles with 0.5-degree diameter were selected and each one of these circles has a centre located at the intersection between a selected longitude and latitude. Therefore, a set of longitudes and latitude with 0.5 degrees squires was drawn. At each intersection point, a number of earthquakes, the maximum depth, or the maximum magnitude that located within the circle was written (Figure 5).The line on a map joining points of equal values is the contour line. In this way, three contour maps of number, depth, and magnitude of earthquake distributions were plotted (Figure 6).

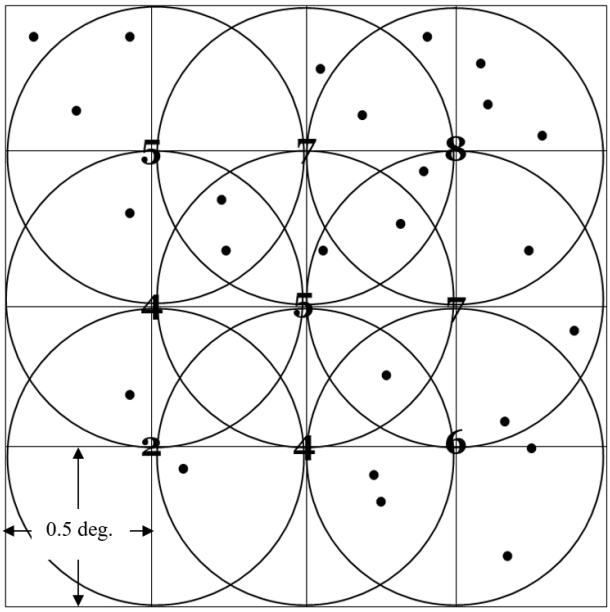
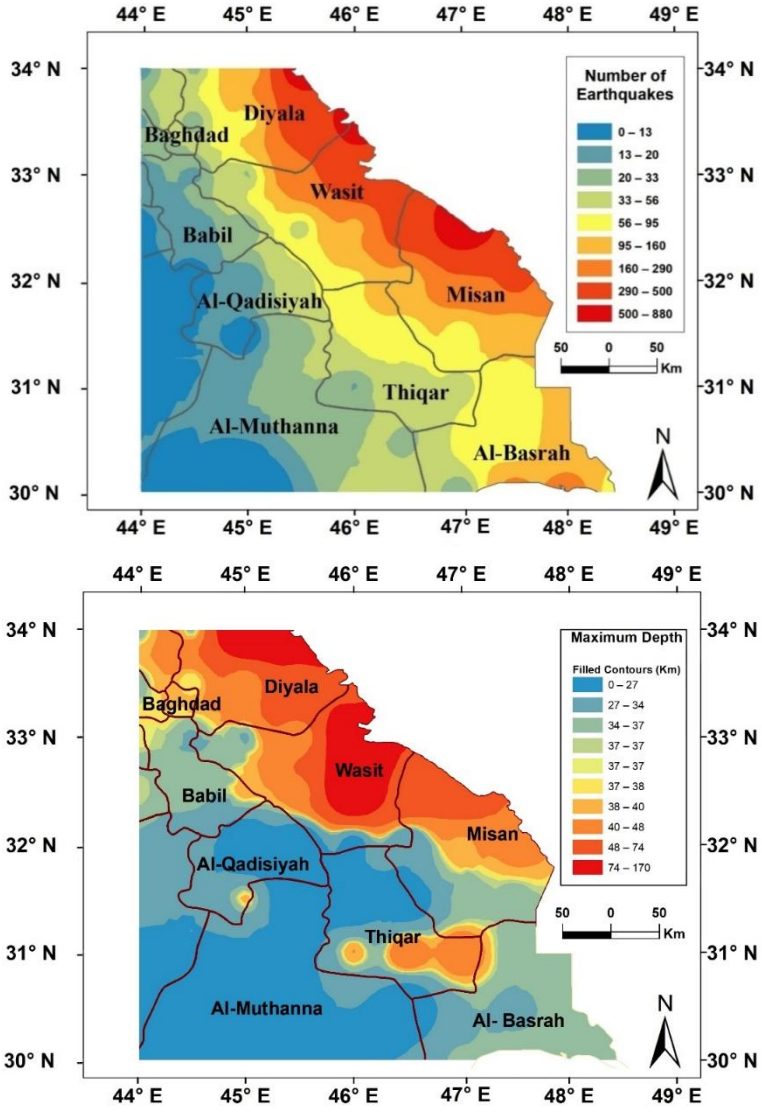


Figure 5: A set of longitudes and latitude with 0.5 degrees squires that was used to draw the contour lines of the number, maximum depth, and maximum magnitude at each circle centre. Dotes represent earthquake epicentres.



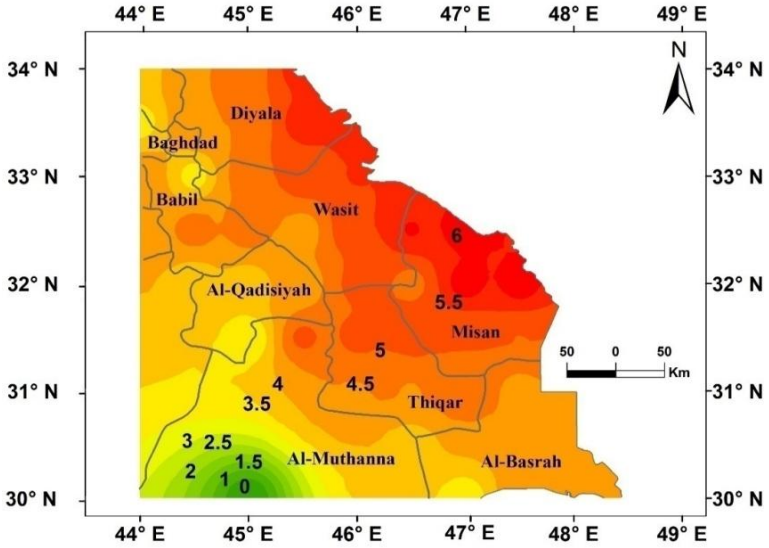


Figure 6: Earthquake number, depth, and magnitude distributions that were plotted based on the ISC bulletin for 118 years from 1900-2018.

V. Discussion and Conclusion

A fault called Mandili-Badra-Amarah is located at the boundary between Iraq and Iran and it represents the mountain front fault of the Zagros Fold-Thrust belt. According to Abdulnaby *et al*. (2016), this fault is the northeastern boundary of the Mesopotamia Plain and it is the most seismically active fault in Iraq. The earthquake distributions show that the number, depth, and magnitude of earthquakes decrease from the Iraq-Iran border toward the Mesopotamia Plain. The maximum magnitudes of earthquakes at Iraq-Iran border exceed 6 Mw and decrease towards the southwest of the Mesopotamia Plain. The maximum value of magnitude within the western desert is 3 Mw.That means the seismic activity of the Mesopotamia Plain is less than the seismic activity of the Zagros Fold-Thrust belt.

The Mesopotamia Plainwas consideredtectonically unstable by Buday and Jassim (1984 and 1987) and stableby Jassim and Göff (2006). In this study, the Mesopotamia Plain was considered as an unstable taken into considerations the seismic activities. Earthquakes at the edges and within the Mesopotamia Plain occur frequently each year.

A homogeneous distribution of earthquakes can be seen within the Mesopotamia Plain. However, Alsinawi (1986) proposed that the distribution of seismic activities in Iraq is inhomogeneous and scattered due to the changes in the geometry of the edge of the Arabian plate along the collision zone with the Iranian and Turkish plates, and due to the rotational movements within the Arabian plate itself.

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