



Seismicity Study of Khanaqin Area

Nawal Abd Alridha ^{1*}, Hassanain Jasim Mohammed ²

¹ Department of Geology, College of Science, University of Baghdad, Baghdad, Iraq.

² Department of Seismology, Iraqi Meteorological Organization and Seismology, Baghdad, Iraq.

Abstract

A seismicity study of khanaqin city and surrounding area is carried out. More than 270 quakes between 22 Nov. to 30 Dec. 2013 are recorded by Iraqi Seismic Network (ISN). Analyses of these events show earthquakes magnitude range between (1.2 – 5.6) degree, focal depth between (4 – 27) km. Seismotectonic map for studied area is drawn . Isointensity maps for the felt earthquakes are drawn and show the intensity range between (I-VII) according to the modified Mercalli scale. Fault plane solutions for four events in the study area indicate a reverse strike slip solution along planes with NW –SE direction .

Keywords: Seismic, activity, Seismic Swarm.

دراسة زلزالية قضاء خانقين

نوال عبد الرضا^{1*} ، حسنين جاسم محمد^{2*}

¹ قسم علوم الأرض ، كلية العلوم ، جامعة بغداد ، بغداد ، العراق .

² قسم الرصد الزلزالي ، الهيئة العامة للأشياء الجوية والرصد الزلزالي ، بغداد ، العراق .

الخلاصة :

ضرب سرب من الهزات الارضية مناطق شرق قضاء خانقين والشريط الحدودي العراقي – الإيراني في 22 نوفمبر - 30 ديسمبر 2013 . سجلت محطات شبكة الرصد الزلزالي العراقي أكثر من 270 هزة وتم تحليل هذه الهزات فكانت ذوات مقادير تراوحت بين (1.2- 5.6) درجة وأعماق تراوحت بين (5- 27) كم . رسمت خارطة زلزالية تكتونية للهزات في منطقة الدراسة . رسمت أربع خرائط تساوي الشدة الزلزالية في منطقة الدراسة وتراوحت ما بين (I-VII) حسب مقياس ميركالي المعدل . وتم تحليل ميكانيكية أربع هزات ارضية في منطقة الدراسة وتبين بان الحلول اعطت ميكانيكية صدوع مضربية معكوسة بامتداد مستويات ذات اتجاه شمال غرب – جنوب شرق وهذا ما يوافق الوضع التكتوني والزلزالي في المنطقة .

Introduction

Earthquakes of Iraq are better known after 1900 for magnitudes range 2.7 – 7.2 within geographical boundary of the seismicity map of Iraq with a majority of crustal depth shocks [1]. There is general and distinguishable increase in the seismicity of Iraq from south to north and from west to east.

*Email: naalridha55@yaoo.com

The eastern side of the study area is a relatively wide zone of compressional deformation along the Zagros – Taurus active mountain belt, which is entrapped between two plates, the Arabian in the southwest and the Iranian plate in the northeast [2].

Earthquake swarms are events where a local area experiences sequences of many earthquakes striking in a relatively short period of time. The length of time used to define the swarm itself varies, but the United States Geological Survey points out that an event may be on the order of days, weeks, or months. They are differentiated from earthquakes succeeded by a series of aftershocks by the observation that no single earthquake in the sequence is obviously the main shock [3].

Tectonic history

Seismicity and seismotectonic studies of Iraq indicate that seismic activity is moderate to high at northern and northeastern boundaries, and decrease in the south and southeastern direction, [4]. Tectonics and geology of Iraq have been influenced by the collision of Arabia with southern Eurasia [5], [6]. Khanaqin province forms a part of the Zagros Folded Zone which is a part of the northern Arabian passive margin. This passive margin was formed at least during the Triassic and lasted to the Pliocene [7]. It was formed as a result of the opening of the Neotethys ocean as NW trending normal faults together with few NE trending transverse faults controlling the deposition and facies distribution during the Mesozoic – Tertiary time. Towards the northeast, the active margin began to form during the late Cretaceous – Early Tertiary time due to the collision of the Arabian and Iranian plates [8]. With time progression, the active margin migrated towards the southwest and resulted in the folding and uplift of the Zagros Low Folded Zone (including the study area) during the Pliocene [9].

This tectonic inversion was coeval with the previous rifting resulting in formation of SW direction thrust displaced on the previous NW trending normal faults. Khanaqin District is an active area due to its location, which belongs to the unstable shelf in the southwestern margin of the low folded zone that includes Hemrin –Makhul subzone that is structurally the deepest part of the low folded zone. It was the depocentre of the Neogene molass, but has been a subsiding unit during the Mesozoic and Tertiary [7]. figure.1.

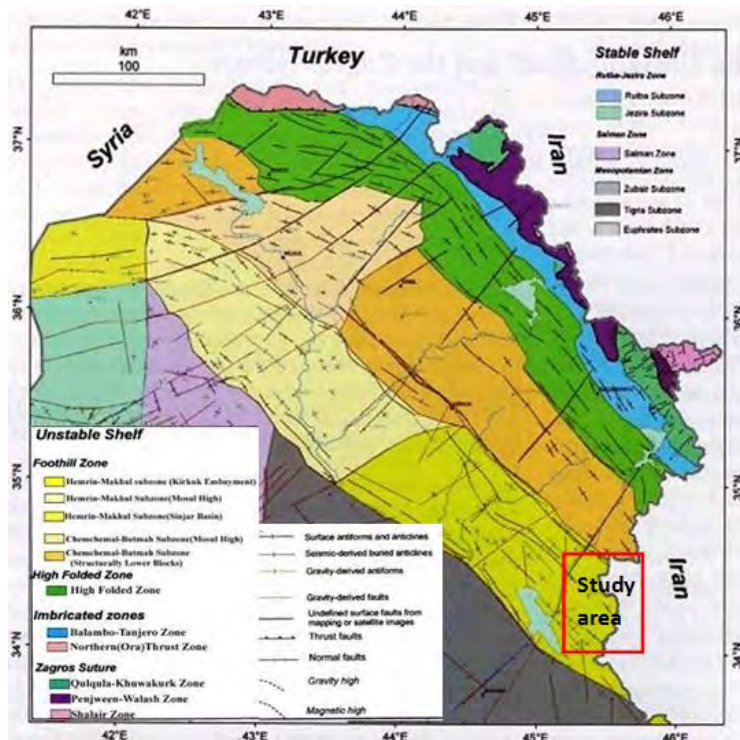


Figure 1- Tectonic zones and structural elements and the location of the study area [7].

This compressional movement resulted in NW trending folds and formation of lateral and oblique ramps along the transverse faults figure 2.

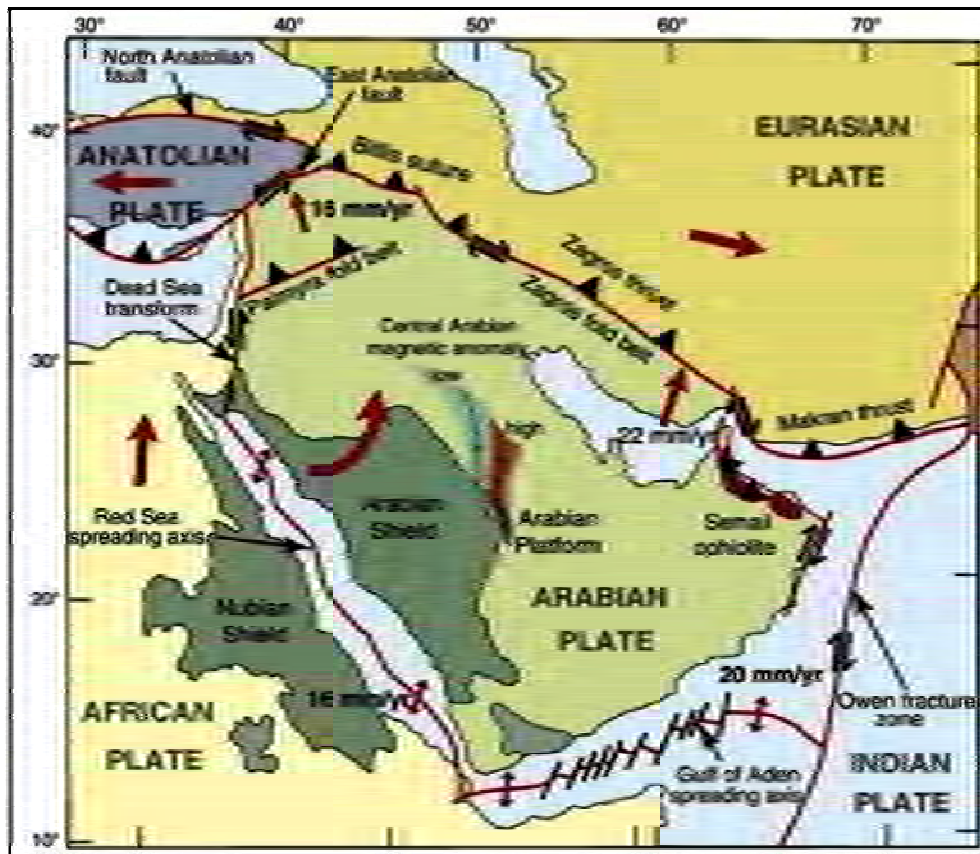


Figure 2 - Map of Arabian Plate motion relative to Africa [10]

Faults system at Khanaqin area

The Tectonic map of Iraq of Buday and Jassim [11] considered a NE trending subsurface fault runs between the northern part of Razaza Lake and Khanaqin area. It is identified as a basement fault in the Mesopotamian area and as unknown fault in Khanaqin area. Jassim and Goff [7] slightly changed the location of this fault and made it coincides with Diyala River and extended between Halabjah and the Iraqi- Saudi Arabia borders figure 3-A. It has been named Sirwan Fault and assumed as a transversal fault system separating the Mesopotamian block from the Central Iraqi block figure 3-B. They also assumed that Sirwan Fault define the southern limit of the so-called Kirkuk Embayment and it displaces the depoaxis of the Cretaceous- Paleocene sequence right laterally across it [12].

Ibrahim [13] suggested a N-S trending dextral strike slip fault running between the Iraqi- Iranian borders northeast of Mawat to the Iraqi- Iranian borders east of Khanaqin and he called this fault as Khanaqin Fault figure 4. He assumed that this fault is defining and separating Kirkuk embayment to the west from the Lurestan zone of the Zagros to the east [12].

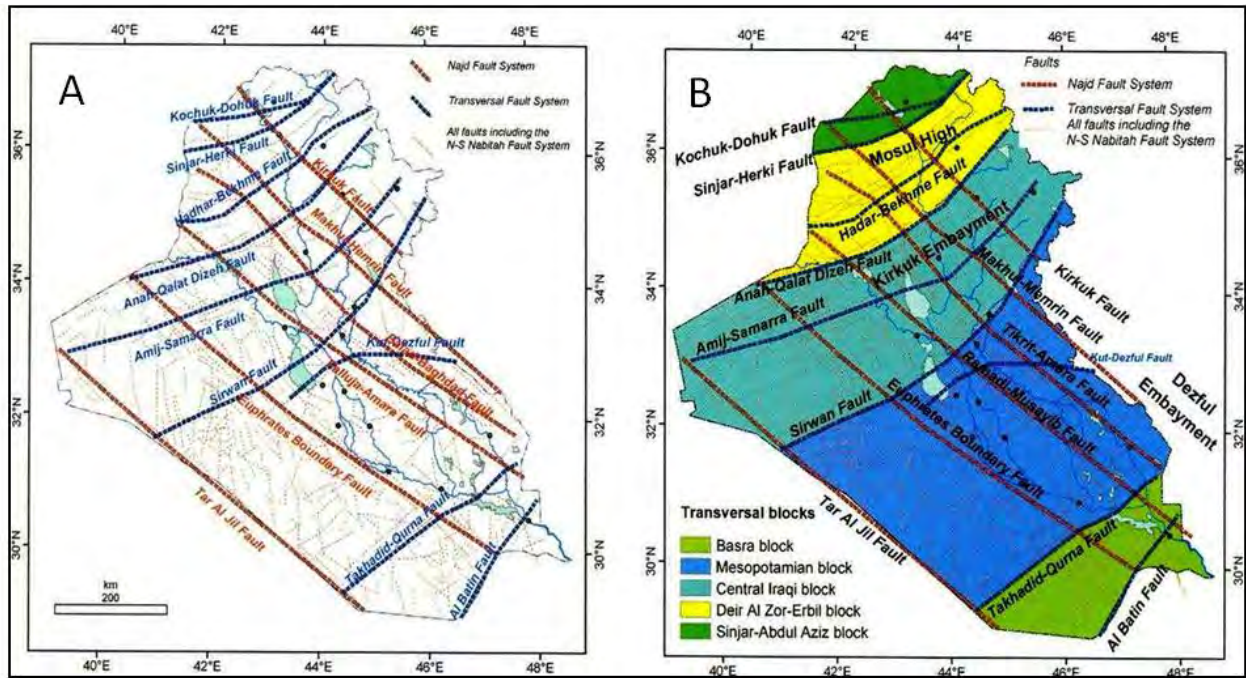


Figure 3 – A - Distribution of faults and fault zones. B- Transversal faults [7].

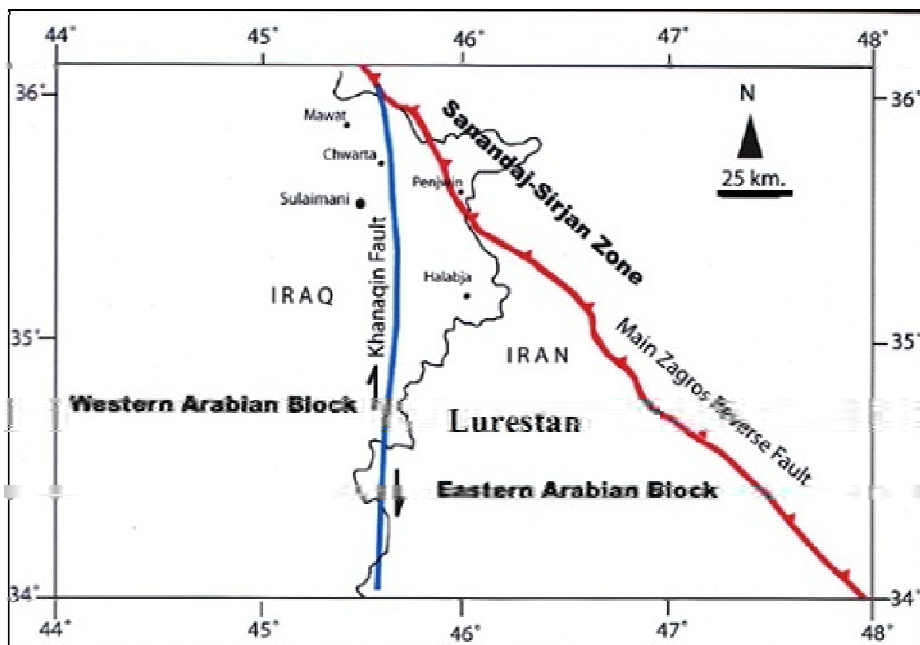


Figure 4-Map showing Khanqaqin Fault divides the Arabian block into Eastern and Western Arabian blocks [14] in [13].

Historical and Recent Seismicity

Historical earthquakes mean all earthquakes that happened before 1900 A.M. and Iraq has a rather long-well documented seismic history [15]. Table 1 shows the historical earthquakes for the study area, As we note four earthquakes their intensities range from (VI - VIII) and their magnitudes range from (3.5 -7), while their depths were between 5 to 30 Km, [16].

Table 1- Shows the historical seismicity of the study area [16].

No	Date		Locality	Coordinates		Mag	Depth (Km)	Approx Intensity
	A.H	A.D		N	E			
1	Rajeb 289	-	Baghdad	33.9	45	3.5	5	VI
2	347	-	Baghdad- Hulwan	34	45	5	8	VII
3	11 Shawwal 529	-	Zagros – Mosul – Baghdad	34	45.5	5.3	5	VII
4	-	12 Apr 1867	Mendili – Jalawla – Baghdad	34	45.2	7	30	VIII

By recent seismicity, we refer to all earthquakes, which were occurred after 1900 A.D [15]. Regarding the studied area, (128) earthquakes within a circular area of radius 50 km with magnitudes range (1.4 – 5.2) degree were collected.

Seismic Swarm

Seismic swarm was started at khanaqin and surrounding areas during the period of 22/11/2013 until 30/12/2013. More than 270 earthquakes were detected and recorded by ISN. Some of these earthquakes had been felt by people at khanaqin and some major cities in Iraq. Figures 5 and 6 show the number of earthquakes during Nov. and Dec – 2013. The range of magnitude is (1.2 – 5.6) degree as shown in figure 11, while the depths (4 – 27) km, most of the events range between (2.0 – 2.9) degree as shown in figure 7.

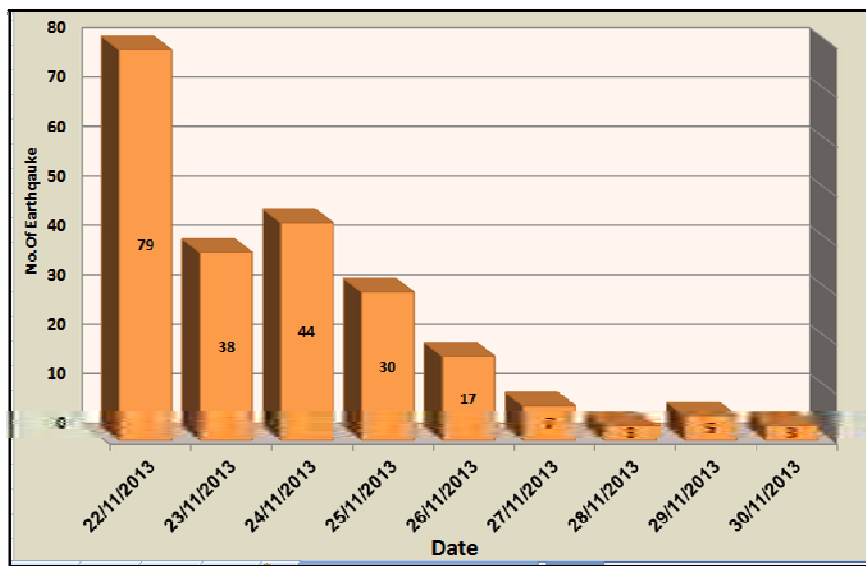


Figure -5 Shows the number of earthquakes during (22 November 2013) in the study area .

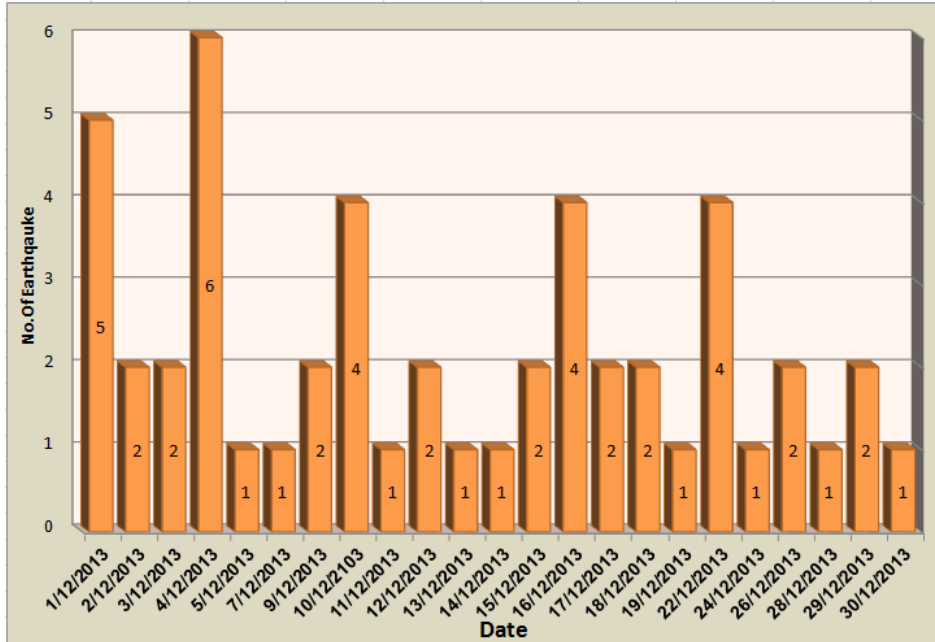


Figure 6 - Shows the number of earthquakes during December 2013 in the study area.

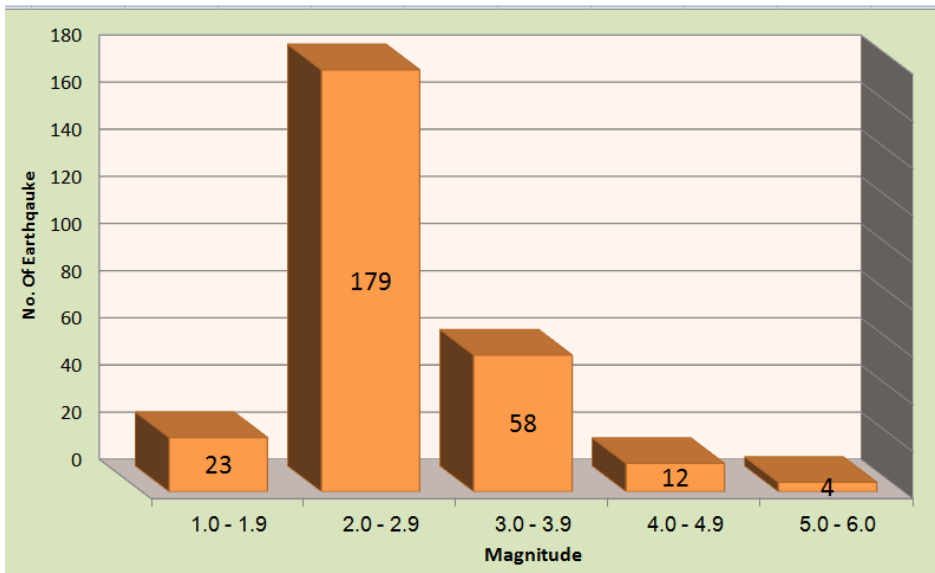


Figure 7 - Shows the number of earthquakes with a magnitude through the duration from 22 November to 30 December 2013 in the study area.

Earthquake intensity

The intensity of an earthquake is based on the damage to structures, damage to the ground surface, and observed effects on people and other features [17]. The Modified Mercalli Intensity Scale is a measure of the amount of shaking (and damage) at a particular site. The intensity of an earthquake will vary depending on where the site is relative to the epicenter [18].

Eleven events were felt by the people who lived in the provinces of Diyala, Kirkuk ,Sulaimaniya , Baghdad, Kut, Babylon and Diwaniyah . According to modified Mercalli Intensity scale , isointensity maps were drawn as shown in figure 8 , more detail is shown in table 2 .

Table 2- show events that have been drawn in figure 8 of the study area

No. Event	Date	Time	Location	Magnitude	Io
1	22-11-2013	06:51:25	34.54 N – 45.42 E	5.6	VI
2	22-11-2013	18:30:55	34.56 N – 45.73 E	5.6	VI
3	23-11-2013	23:26:23	34.23 N – 45.40 E	5.1	VI
4	24-11-2013	18:05:42	34.30 N – 45.66 E	5.6	VII

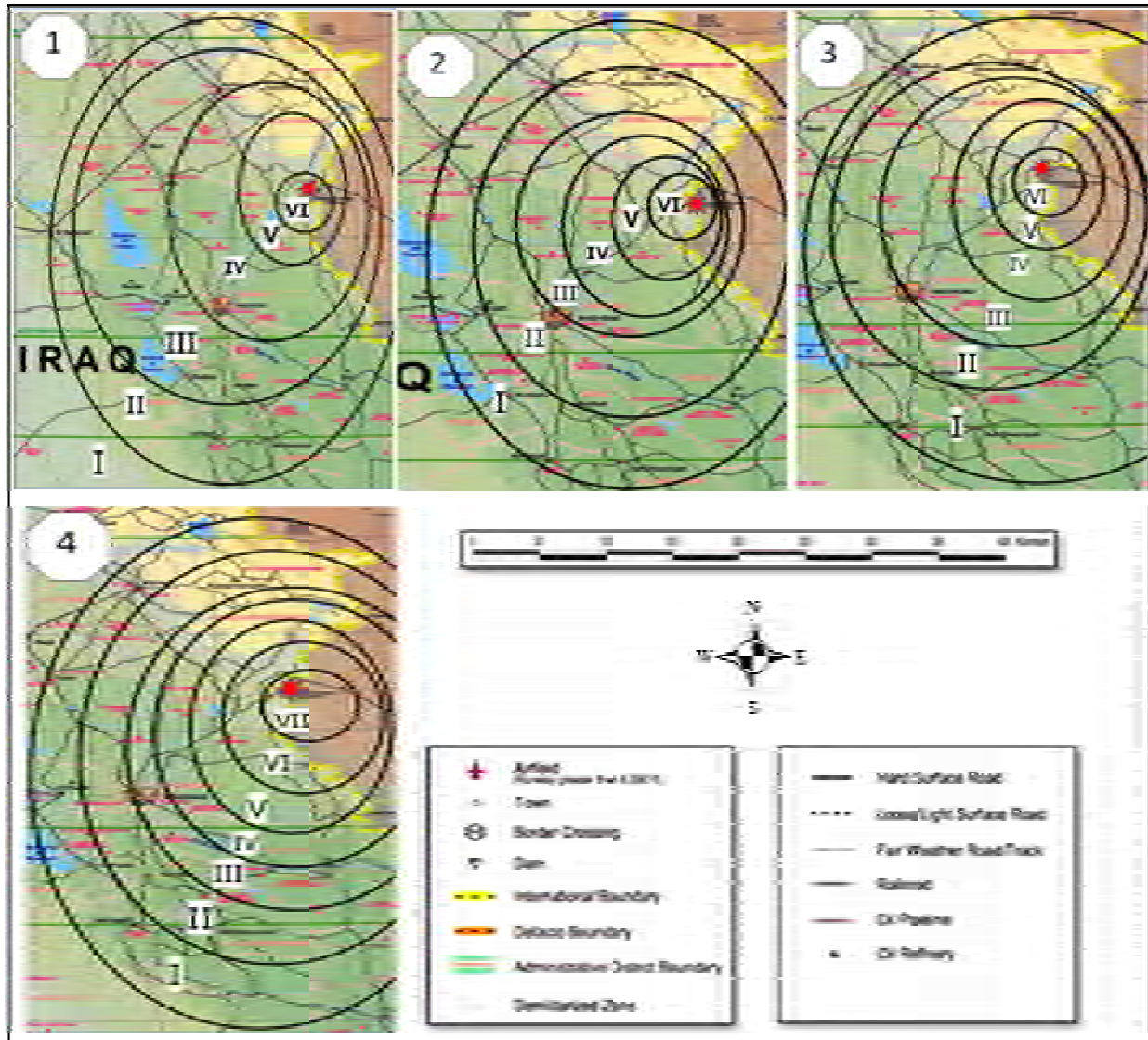


Figure 8 - Shows Isointensity Maps in the study area .

Earthquake focal mechanism

Focal mechanisms can provide useful information about structure and kinematics of faults and can constrain the crustal stress field in which the earthquakes occur. First-motion polarities of P-wave are the most common methods for the fault plane solutions from short-period data. The spatial distribution of P-wave first-arrivals and their polarities (compression or dilatation) are used to determine the two nodal planes [19]. Focal mechanism solution for four events were analyzed using SEISAN computer software

figure 9. The results show thrust with some strike-slip solutions along planes with SE-NW, maps of these results were drawn as seen in figure 10.

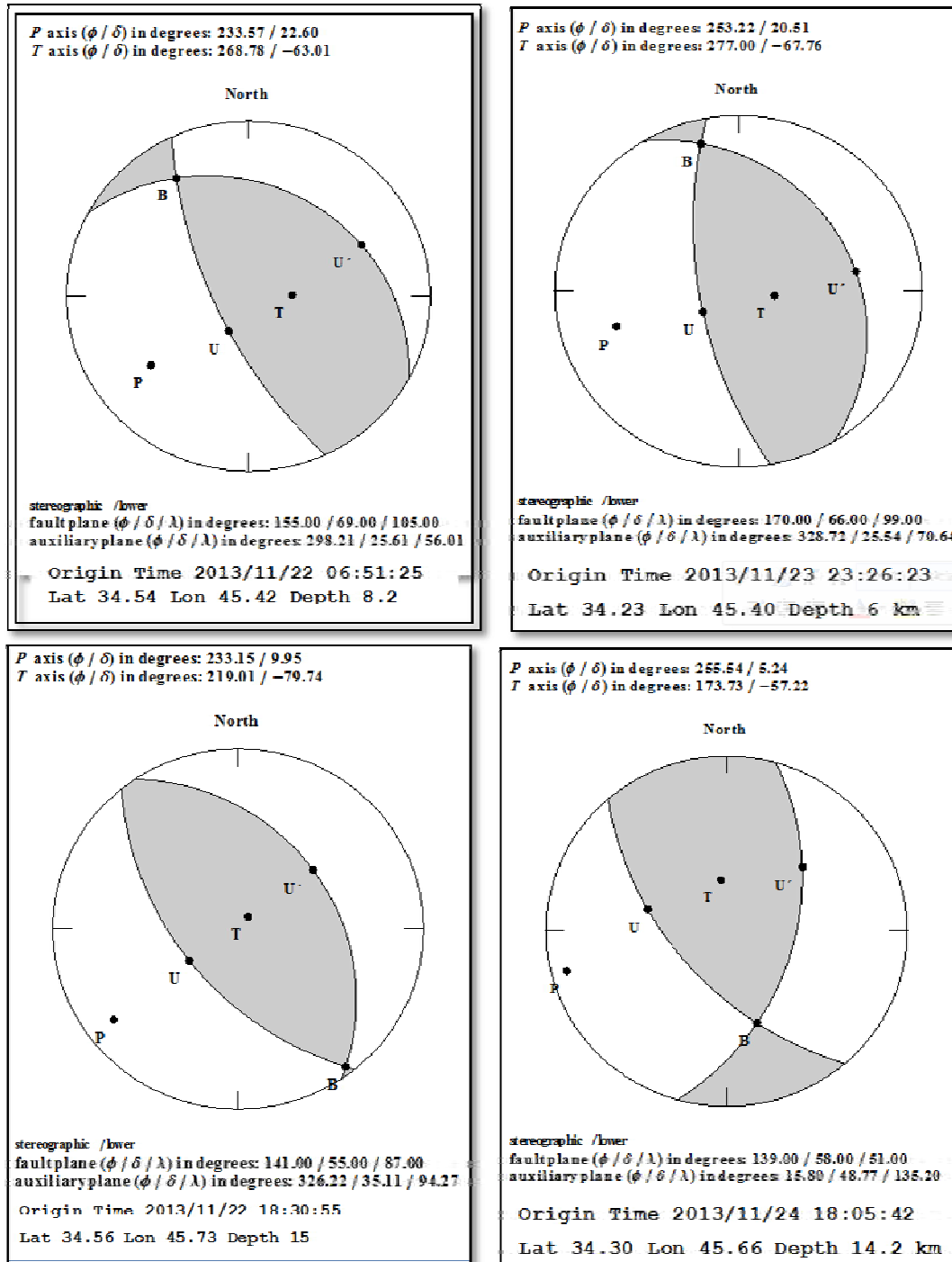


Figure 9 - Shows Fault Plane Solutions for four events of the study area.

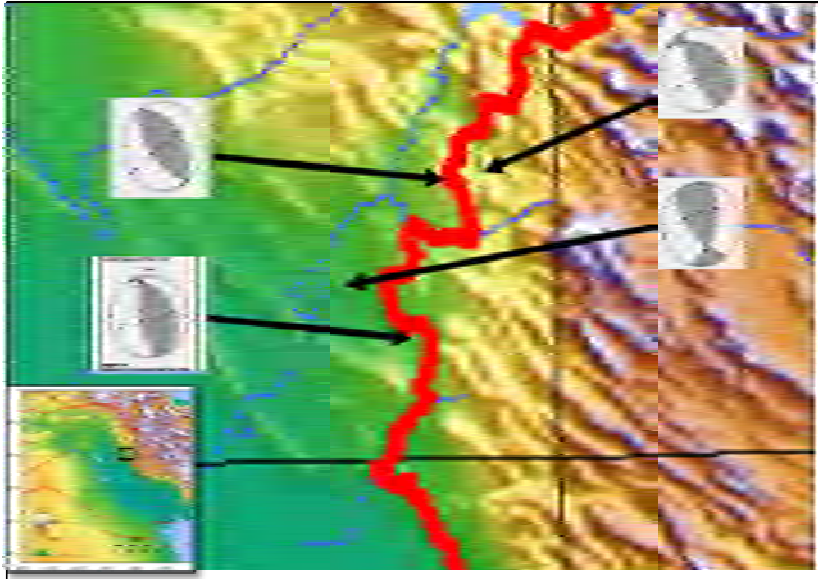


Figure 10 - Shows map of mechanical analysis of four events in the study area.

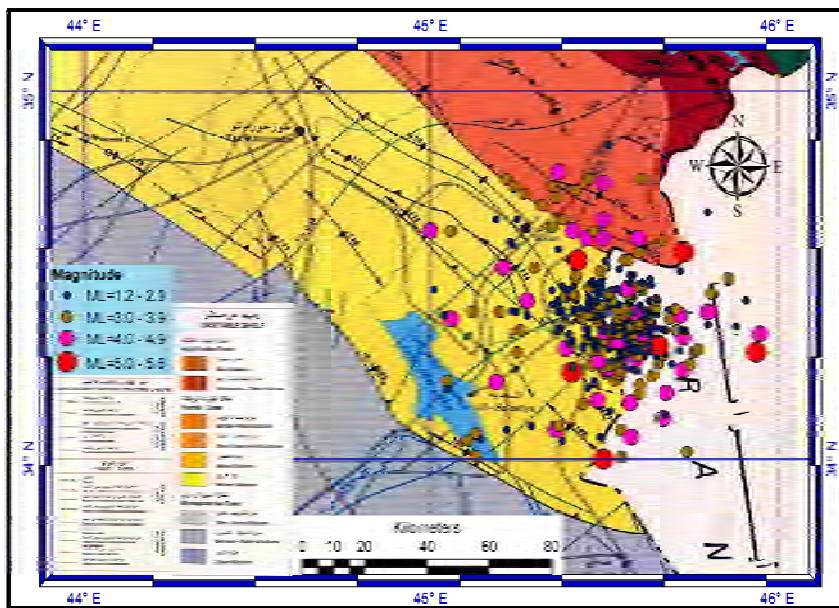


Figure 11- Seismotectonic of study area.

Seismotectonics of the study area

The seismotectonic of Iraq cannot be dealt with a more regional consideration of the seismotectonics of the Arabian peninsula according to the location of Iraq in the northeastern part of it . Mapping of earthquakes epicenters to provide a geographical distribution of seismic activity gives the seismotectonic relation between units of different tectonic types . Using ISN Iraqi Seismicity data file, epicentral map is prepared , then a seismotectonic map figure 11 which is constructed as well, using all available seismic , tectonic and geological information. This map may surmise the emerging relation of the distribution pattern of epicenters to the structure and tectonic of Iraq.

Conclusions:

- The study area was subjected to four historical earthquakes.
- (128) events occurred within a circular area of radius 50 km around Khanaqin for period 1900 -2012.

- Iraqi Seismological Network (ISN) recorded about 276 events during 22 Nov – 30 Dec /2013.
- Earthquakes were analyzed to find magnitude, focal depth and intensity. The results show , $M_l=(1.2 - 5.6)$ degree , $h=(4 - 27)$ km , $I_o=(I - VII)$ respectively
- Fault plane solutions for study area indicate thrust with some strike slip solutions along planes with NW- SE direction.
- Seismotectonic map for studied area is drawn, it shows the distribution pattern of epicenters to the structure and tectonic of Iraq.

References:

1. Alsinawi, Sahil A. and Ghalib, H. A. **1974**. On the seismotectonics on the Arabian Peninsula. *Aglobal tectonic approach Bull. Coll. Sci*, 15, P: 151-169.
2. Jasim, N. A. **2013**. Seismicity Evaluation Of Central And Southern Iraq.M.Sc. Thesis. Department of Geology, College of Science, University of Baghdad. Baghdad, Iraq, p140.
3. USGS."Earthquake Swarms at Yellowstone.**2008**. United States Geological Survey. Retrieved 2008-08-27.
4. Alsinawi, S.A. **2002**. Seismicity, Seismotectonics, Crustal Structure and Attenuation Data on Iraq. The Relemer Meeting, Antakya,Turkey, 12-14 December, 2002.
5. Berberian, M. and King, G. **1981**. Towards a paleogeography and tectonic evolution of Iran. *Can. J. Earth Sci*, 18, pp: 210–265.
6. Adams, R.D.andBarazangi, M. **1984**. Seismotectonics and seismology in the Arab region: a brief summary and future plans, *Bull. seism. Soc. Am.* 74, pp: 1011–1030.
7. Jassim, S.Z., Goff, J.C. **2006** . *Geology of Iraq*. 1st ed. Dolin, Prague, p.315.
8. Hijab, B. R. and Al- Dabbas, M. A. **2000**. Tectonic Evolution of Iraq. *Iraqi Geological Journal*,. 32(33) pp: 26- 47.
9. Dewey, J. F., Pitmaa, W. c., Byan. W. B. F and Bonnin, J. **1973**. Plat Tectonic and Evolution of the Alpine system. *Geol. Soc. Am. Bull*, 84. pp: 3137- 3180.
10. Johnson, P. R. **1998** . Tectonic map of Saudi Arabia and adjacent areas, Deputy Ministry for Mineral Resources, Saudi Arabia, USGS -TR-98-3.
11. Buday, T. and Jassim, S.Z. **1987**. *The Regional Geology of Iraq*. Vol.2: Tectonic, Magnetism, and Metamorphism, Publication of GEOSURV, Baghdad, Iraq, 352p.
12. Al-Hachem, A.E.K. **2012**. The fault at Khanaqin area and its effect on Hemrin South Structure. M.Sc. Thesis. Department of Geology , College of Science, University of Baghdad. Baghdad, Iraq. p116.
13. Ibrahim, A. O., **2009** . Tectonic style and evolution of the NW segment of the Zagros Fold- Thrust - Belt , Sulaimaniya Governorate, Kurdistan Region NE Iraq. Un published Ph.D. Thesis. .Department of Geology , College of Science, University of Sulaimaniya. Sulaimaniya, Iraq. 187p.
14. Bahroudi, A. and Talbot, C.J. **2003**. The configuration of the basement beneath the Zagros Basin. *Journal of petrol. Geology*, 26, pp: 257-282.
15. Alridha, Nawal.A and Jasem, Noor.A. **2013**. Seismicity Evaluation of Central and Southern Iraq, *Iraqi Journal of Science*, 2013, Vol 54, No.4, pp:911-918.
16. Al-Dabbagh H. A. **1999**. Review and analyses of some earthquakes events in Iraq. M.Sc. Thesis. Department of Geology , College of Science, University of Baghdad. Baghdad, Iraq, p116.(Arabic reference).
17. Richter, C. F. **1958**. *Elementary Seismology*, W. H. Freeman, San Francisco, 768 pp.
18. Wald DJ, Quitoriano V, Heaton TH, Kanamori H, Scrivner CW, Worden CB. "TriNet "ShakeMaps".**1999**. rapid generation of peak ground motion and intensity maps for earthquakes in Southern California. *Earthquake Spectra*; 15 (3) pp: 537-555.
19. Vamvakaris, D.A., Papazachos, C.B., Karagianni, E.E., Scordilis, E.M. and Chatzidimitriou P.M. **2004** . Determination of fault plane solutions using waveform amplitudes and radiation pattern. *Bulletin of the Geological Society of Greece* vol. 36, Proceedings of the 10th International Congress, Thessaloniki.