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# Sulaimani Seismic Swarm during Spring 1999, NE IRAQ

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## ABSTRACT

*A swarm of earthquakes struck Sulaimani city, for the first time in the known recorded historical seismology of the area, during spring 1999. More than (73) quakes which have magnitudes ranges between (2-4.7) degree were recorded, as well as handreds of tremors. The epicenters were indicated. They are locating NE Sulaimani by distance of about (5-11) km. The approximate depths of the hypocenters show that the swarm had been generated from shallow depths ranging between (2-11) km. The total energy released was calculated to be about (26 X 1017) erg, which is equivalent to an earthquake of magnitude (5.1) degree. The cause of the swarm interpreted to be the continuous movement of sitak– Sulaimani transverse fault during this period.*

## Introduction

A phenomena was recorded in Sulaimani city for the first time, that is a swarm of earthquakes, more than (73) quakes, struck the center of the city which have magnitudes range between (2–4.7) degree according to Richter scale. They were started in 3, Mar., 1999 and ended in 3, Jun., 1999. Sulaimani is an active area from the seismic point of view due to its tectonic and seismic position, which is represented by the thrust zone and Zagrose seismic belt. According to seismic zoning map of Iraq, (1), the city is located in the zone of intensity (5) and the earthquakes that occur in this region are expected to have their magnitude range between (2.5–6) degree. The historical seismic review of the area from (1900-1986) shows the occurrence of about (400) earthquake of different magnitudes most of them generated below (30) km depth, they are denoting to migration of epicenters toward north eastern part of Iraq during the last (25) years,(2).

The studied area comprise Sulaimani city and adjacent area occupying an area of about (2000) $km^2$, that is located between Latitude (35°19` – 35°46`) and longitude (45°13` – 45°37`), Fig (1).

The seismicity of Sulaimani area had not been studied yet, no previous works were documented except that performed by (Ayar, *et.al.,3*) in the area which is locating between latitude (34°30`– 37°00`) and Longitude (44°00` – 46°30`).

So the present study is considered to be a first attempt in this field for enrichment the historical seismicity data of the region as well as clearing the possible causes of the swarm and projecting light on present and future seismicity of the area.

## Field Work

The main aim of the fieldwork is to draw an intensity map of the area and getting an idea about the approximate location of epicenters of the earthquakes. For this purpose the authors depended on personal observations and requesting people in most towns and villages surrounding Sulaimani city. In each station (7 to 10) persons of different ages were requested through previously prepared table forms. About (594) forms were collected and studied statistically. They reveled the following important points: -

1-The intensity seismic map was constructed, Fig (1), Zone of intense affect, (IV), is located NE Sulaimani city and comprise (Sitak, Bnawella, Wallana, Sharsten, Zardabee and Allasiaw ) villages .

2- The people of SW and SE regions of Sulaimani city did not feel the earthquakes or they felt them very slightly.

3- The people of towns and villages that are live in locations on red bed series (such as Qalachwalan, Tagaran, Swra Qalat, Betwat, etc...) had never felt the earthquakes while those located on Tanjero, Shiransh and Kometan Formations did. That may be due to the high ability of thick hard clay bed and cemented layers of conglomerate present in red beds, for absorption of seismic waves (4).

## Data Collection

The data on the swarm were collected from many sources, Fig (5), for the sake of comparison and getting most reliant and precise information. In addition to those, records were obtained from Sulaimani seismic station (SSS), the authors were able to obtained data from:

1-Mousl seismic station, (MSS), Locate (233) km NW of Sulaimani seismic station.

2-Baghdad seismic station, (BSS), Locate (270) km SW of Sulaimani seismic station.

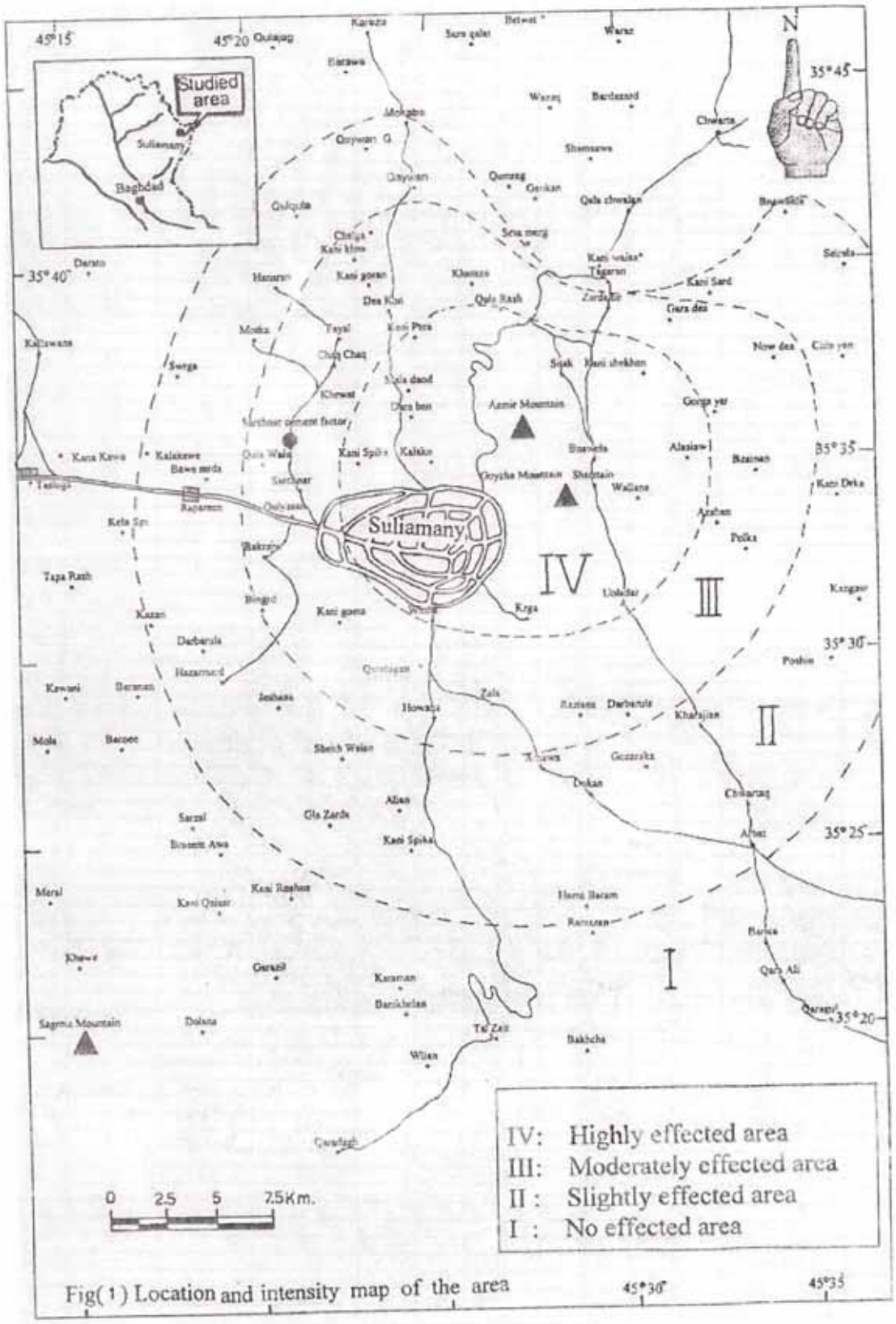
3-Kermanshah seismic station (KSS), Iran, locate (215) km SW of (SSS).

4-Mhabat seismic station, (MhSS), Iran, locate (135) km NE of (SSS).

5-Geophysics Establishment, Iran, Tahran university.

6-Monthly report of USGS, No 3,4,5,6, (USGS,5).

Table (1) Data collected by the authors from different sources.




Fig(1) Location and intensity map of the area

**Table (1): Shows collected data on the swarm from five seismic stations.**

| No. | Date | Time | | | Magnitude | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | H | M | S | SSS | MSS | BSS | KSS | MbSS |
| 1. | 03 / 03 / 1999 | 22 | 32 | 35 | 4.7 | 4.1 | 4.1 | 3.9 | 4.1 |
| 2. | | 22 | 41 | 21 | 3.3 | 3.1 | - | 3.0 | 3.2 |
| 3. | | 22 | 52 | 17 | 2.5 | - | - | - | - |
| 4. | | 22 | 58 | 43 | 3 | - | - | - | 3.1 |
| 5. | 04 / 03 / 1999 | 00 | 19 | 52 | 3.3 | 3.1 | - | 3.2 | 3.1 |
| 6. | | 00 | 27 | 15 | 2.5 | - | - | - | - |
| 7. | | 00 | 30 | 10 | 2.9 | - | - | - | 2.9 |
| 8. | | 00 | 38 | 23 | 3 | - | - | - | 2.9 |
| 9. | | 00 | 38 | 40 | 2.8 | - | - | - | - |
| 10. | | 01 | 02 | 50 | 2.5 | - | - | - | - |
| 11. | | 01 | 40 | 49 | 2.7 | 3.1 | - | - | 2.5 |
| 12. | | 04 | 58 | 10 | 2.9 | - | - | - | 2.9 |
| 13. | | 06 | 55 | 11 | 2.6 | - | - | - | - |
| 14. | | 16 | 10 | 31 | 4 | 3.6 | 3.5 | 3.8 | 3.8 |
| 15. | | 16 | 08 | 40 | 3.6 | - | - | 3.6 | 3.5 |
| 16. | | 17 | 25 | 27 | 2.8 | - | - | - | 2.7 |
| 17. | | 18 | 30 | 18 | 2.9 | - | - | - | - |
| 18. | | 23 | 11 | 15 | 3 | - | - | 2.8 | 2.7 |
| 19. | 05 / 03 /1999 | 01 | 03 | 19 | 2.8 | - | - | - | - |
| 20. | | 09 | 32 | 21 | 3 | - | - | - | 2.9 |
| 21. | | 18 | 10 | 15 | 3.4 | 3.1 | 3.2 | 3.0 | 2.9 |
| 22. | | 22 | 26 | 40 | 3.3 | 3 | - | 3.1 | - |
| 23. | | 23 | 11 | 23 | 3.2 | - | 3.1 | 3.0 | - |
| 24. | 06 / 03 / 1999 | 03 | 13 | 15 | 3.2 | 3.1 | - | 3.2 | 3.2 |
| 25. | | 04 | 55 | 09 | 3.5 | 3.4 | - | 3.2 | 3.3 |
| 26. | | 04 | 59 | 17 | 3 | - | - | - | - |
| 27. | | 05 | 04 | 22 | 3.1 | - | - | - | - |
| 28. | | 05 | 10 | 15 | 2.9 | - | - | - | - |
| 29. | | 07 | 10 | 41 | 3.3 | - | - | 3.1 | 3.2 |
| 30. | | 11 | 05 | 50 | 4.1 | 3.6 | 3.9 | 3.3 | 3.7 |
| 31. | | 23 | 07 | 41 | 2.5 | - | - | - | - |
| 32. | | 23 | 37 | 33 | 2.5 | 2.7 | - | - | - |
| 33. | | 23 | 57 | 32 | 3 | - | - | 2.9 | - |
| 34. | | 23 | 59 | 15 | 2.5 | - | - | - | - |
| 35. | 07 / 03 / 1999 | 00 | 39 | 05 | 2.5 | 2.6 | - | - | - |
| 36. | | 13 | 49 | 16 | 4.3 | 3.9 | - | 3.6 | 3.7 |
| 37. | | 18 | 15 | 45 | 3.2 | - | - | 3.7 | - |
| 38. | 08 / 03 / 1999 | 06 | 10 | 17 | 2.5 | - | - | - | - |
| 39. | | 06 | 32 | 25 | 3 | - | - | - | 2.9 |
| 40. | | 07 | 45 | 29 | 3.4 | 3.3 | 3.3 | 3.2 | 3.3 |
| 41. | | 13 | 57 | 13 | 2.9 | - | - | - | 2.9 |
| 42. | 08 / 03 / 1999 | 14 | 10 | 21 | 3.1 | - | - | 2.9 | 3.1 |
| 43. | | 19 | 53 | 15 | 3 | - | - | - | - |
| 44. | 09 / 03 / 1999 | 20 | 45 | 29 | 2 | - | - | - | - |
| 45. | 10 / 03 / 1999 | 07 | 50 | 31 | 2.5 | - | - | - | - |
| 46. | | 14 | 35 | 12 | 2.5 | - | - | - | - |
| 47. | | 18 | 40 | 10 | 2.5 | - | - | - | 2.9 |
| 48. | 11 / 03 / 1999 | 06 | 40 | 42 | 2.9 | 2.8 | - | - | 2.9 |
| 49. | | 10 | 30 | 50 | 2.5 | - | - | - | - |
| 50. | 12 / 03 / 1999 | 08 | 13 | 43 | 2.4 | - | - | - | - |
| 51. | 13 / 03 / 1999 | 13 | 10 | 10 | 2.3 | - | - | - | - |
| 52. | 14 / 03 / 1999 | 14 | 45 | 21 | 3.3 | 3.2 | 3.1 | 3.1 | 3 |
| 53. | | 15 | 10 | 19 | 2.4 | - | - | - | - |
| 54. | 15 / 03 / 1999 | 23 | 32 | 29 | 2.6 | - | - | - | - |
| 55. | 16 / 03 / 1999 | 01 | 52 | 11 | 2.3 | - | - | - | - |
| 56. | | 10 | 57 | 25 | 2.7 | - | - | 2.7 | 2.8 |
| 57. | 17 / 03 / 1999 | 09 | 17 | 38 | 2.6 | - | - | - | - |
| 58. | 18 / 03 / 1999 | 16 | 23 | 23 | 2.7 | - | - | - | 2.6 |
| 59. | 31 / 03 / 1999 | 12 | 18 | 56 | 2.6 | - | - | - | - |
| 60. | 22 / 03 / 1999 | 15 | 54 | 55 | 3.0 | - | - | 3.0 | - |
| 61. | 24 / 03 / 1999 | 14 | 03 | 24 | 3.4 | - | - | 3.3 | 3.2 |
| 62. | 04 / 04 /1999 | 17 | 23 | 24 | 3 | 3.1 | 3 | 3.1 | 2.9 |
| 63. | | 22 | 51 | 40 | 2.8 | - | - | 2.7 | 2.8 |
| 64. | 05 / 04 / 1999 | 23 | 46 | 45 | 2.4 | - | - | - | - |
| 65. | 24 / 04 / 1999 | 11 | 39 | 07 | 3.9 | 3.6 | 3.8 | 3.8 | 3.6 |
| 66. | 04 / 05 / 1999 | 01 | 53 | 10 | 2.5 | - | - | - | 2.4 |
| 67. | | 05 | 05 | 42 | 3.3 | - | - | 3.2 | 3.1 |
| 68. | 14 / 05 / 1999 | 07 | 25 | 26 | 2.7 | - | - | 2.7 | 2.9 |
| 69. | 15 / 05 / 1999 | 11 | 43 | 31 | 2.6 | - | - | - | - |
| 70. | 26 / 05 / 1999 | 21 | 14 | 11 | 2.6 | - | - | - | 2.5 |
| 71. | 27 / 05 / 1999 | 05 | 50 | 00 | 2.3 | - | - | - | - |
| 72. | 02 / 06 / 1999 | 00 | 54 | 34 | 3.1 | 3.1 | - | 3.2 | 3.1 |
| 73. | 03 / 06 / 1999 | 11 | 12 | 41 | 2.1 | - | - | - | - |

## Tectonic, structure and stratigraphy

Tectonically Sulaimani city is located within balambo-Tanjero miogoeosyncline zone, representing the northern extremities of the high folded zone. Their seismicity is due to force resulting from movements of the Arabian plate to the north and northeast causing reactivation of the basement faults as high angle reverse faults (6). Global plate tectonics modeling permits identification of northern drift of the Arabian plate at a rate of (3) cm/year as the motor of the tectonics (7), (Fig 2), (8).

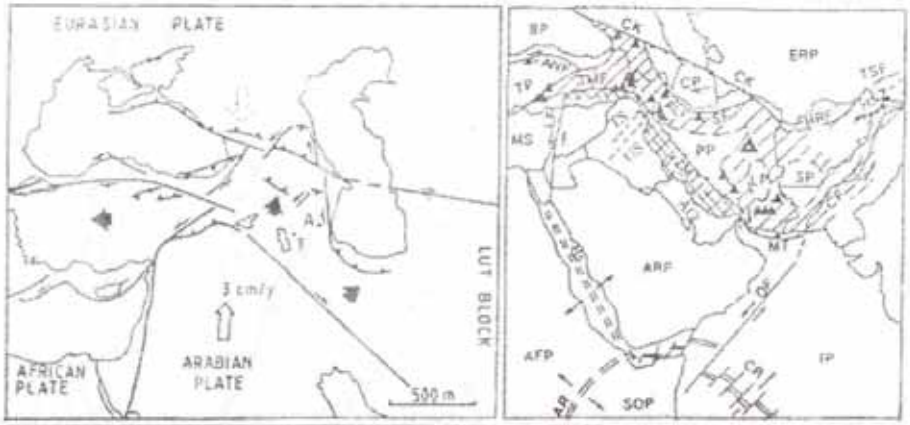



**Fig (2) The mechaanim of nthe main plates movement. (Nawroozi, 1971)**

On the other hand Masin (9) mentioned that Arabian plate moves anti clockwise by a mean velocity ranges between (4.3-4.8) cm/year. Hassani (10) also denoted to the quakes in Iraq, as a neighbor of alpine belt, are mainly due to tectonic activities of Arabian, Anatolian and Iranian plates, (Fig 2). The Iranian and Anatolian plates laterally ejected, and the lesser Caucasus is pushed against the Mesozoic bac-arc basin to the north (11).

The Anatolian block is moving westward, Iranian block eastward while Arabian block is moving northward (12), so the convergence of Arabian-Eurasian plates is obvious.

From structural point of view, two major Pira-Magrun and Azmer anticlinoriums, lithological properties, as well as the rate of erosions, are main factor controlling topography; drainage pattern; mass wasting and polygenetic valley filling sediment. The southeastern plung of Pira-Magrun anticlinorium (trends NW-SE) sinks beneath the city from the western parts (Fig-3), while the south-western limbs of Azmer anticlinoroium is bounding the city from the north and north eastern parts.

Generally, both above-mentioned anticlinoriums are subjected to Surdash-Tikrite (from NW) and Halabja- Sammara (from SE) transversal deep-seated faults, trending almost (NE-SW), which are expressed topographically and geomorphologically, Fig (3).

Furthermore, imbricate mesoscopic structures (e.g. Chevron box anticlines; narrow synclines: normal and reverse faults) also characterize the cretaceous rocks exposed within certain sectors of the city and its surroundings.

Stratigraphically, the oldest exposed strata are carbonates and green marls of Balambo Formation (Hautruvian – Turonian; (Fig.4), (13), while the youngest rocks are Olive green clastics of Tanjero Formation (Maastrichtian), which underlies the city from the north, whilst the western parts are underlain by well-bedded, highly jointed Oligosteginal limestone of Kometan Formation.

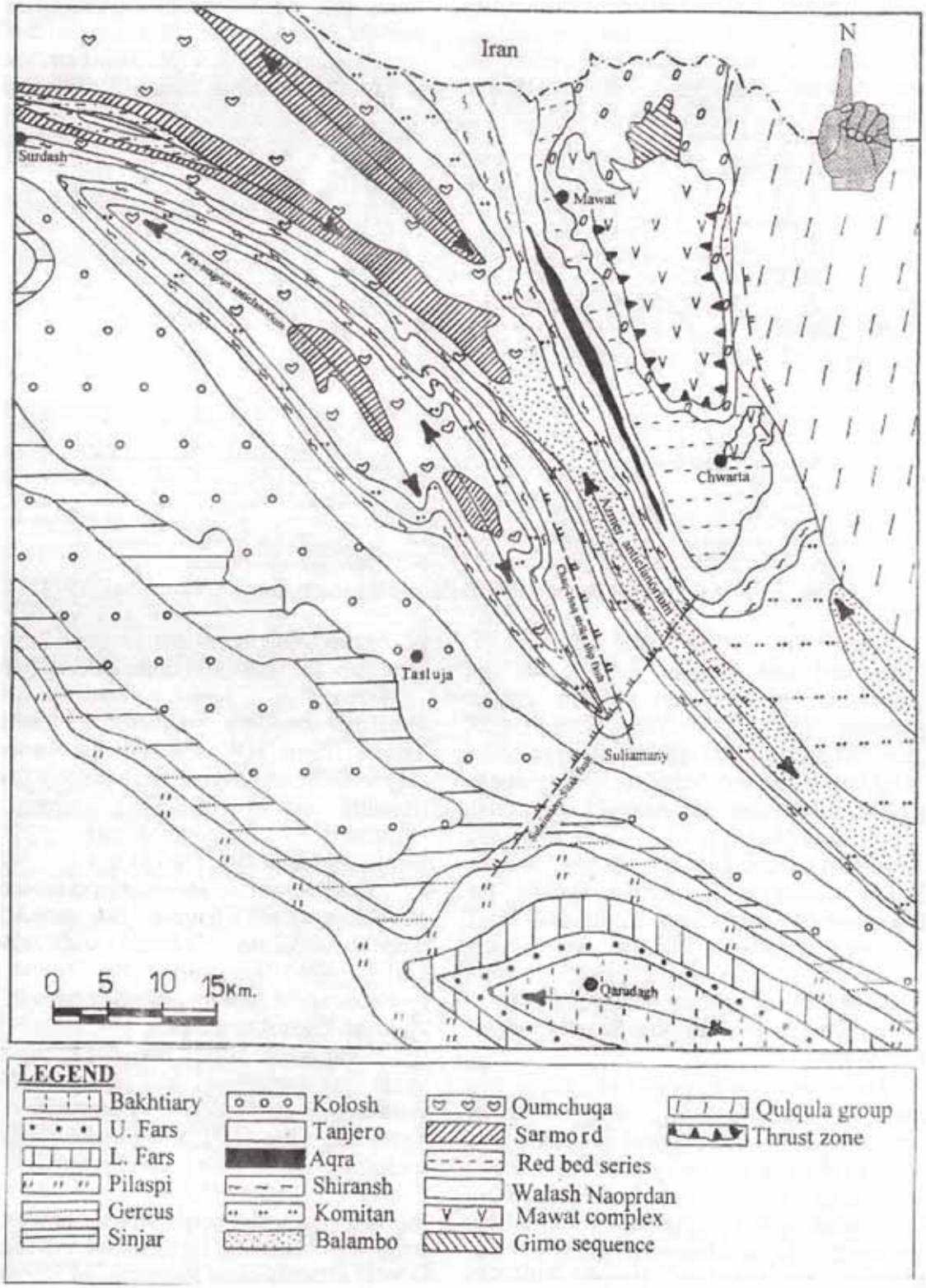
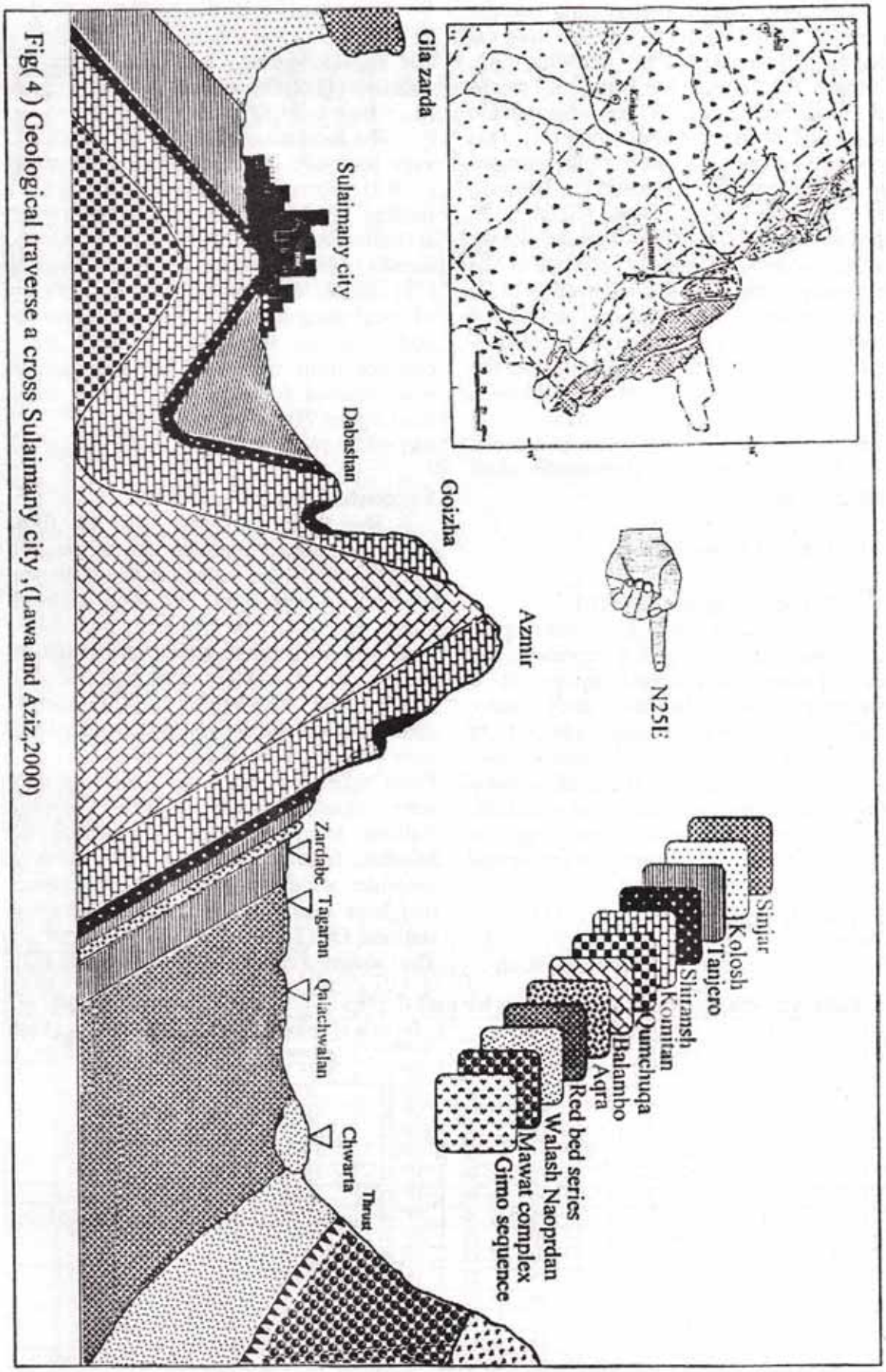



**Fig (3) Geological and structural map of the area. Mod. (Lawa and Aziz2000)**




Fig(4) Geological traverse a cross Sulaimany city ,(Lawa and Aziz,2000)

The generalized stratigraphic column could be stated briefly as follow (from the oldest): Balambo Fn; Kometan Fn; Shiransh Fn; Tangero Fn; Aqra Fn; Tanjero Fn; Red bed series; Walash- Naopurdan series and Mawat igneous complex. This sequence shows variations into Sarmord Fn; Qamchuqa Fn; Kometan Fn; Shiransh Fn; Kolosh Fn; and Sinjar Fn (the youngest). The facial change during the cretaceous is mainly related to the paleogeographic situation as well as basin configuration, which is controlled essentially by deep seated faults (Chaq-Chaq strike slip fault; Fig.3) between the two mentioned anticlinoriums. Moreover, the red molasse of the miogeosynclinal basin is altered into penecontem-poraneous Kolosh clastic facies in the unstable shelf during the paleocene.

## Calculation Of Seismic Coefficient

### Local Richter Magnitude (ML)

Seismic magnitude is a measure of earthquake intensity, and it represents the total amount of released energy in a generation point. In the study under consideration the local magnitude (ML) is the most reliable amount for representing magnitudes because all the quakes were very close to the Sulaimani seismic station. So the local magnitude depending on duration period and distance of epicenters were found as follow (14):

$M_D = bo + b_1 \log D + b_2 \nabla$ .....(1)

Where:

$M_D$:Local magnitude, depend on duration

$\nabla$ : Distance of epicenter by Km.

$bo , b_1 , b_2$ : Are constants .

For small distances, less than 200 km, the equation (1) can be written as follow:

$M_D = bo + b_1 \log D$ .....(2)

The local magnitude rely on duration is very accurate, its resolution reaches about (± 0.3) degree, depending on the precise reading of duration period and also on an accurate indication of the end of seismic signals. Table (1) shows local magnitude of (73) quakes determined from the equation of local magnitude for Sulaimani area for body waves and also for very small distance from epicenter. The equation (3) was derived from equation (2) by using least square fitting method:

$M_D = 1.53 \log D + 1.1$ .....(3)

## Epicentral Determination

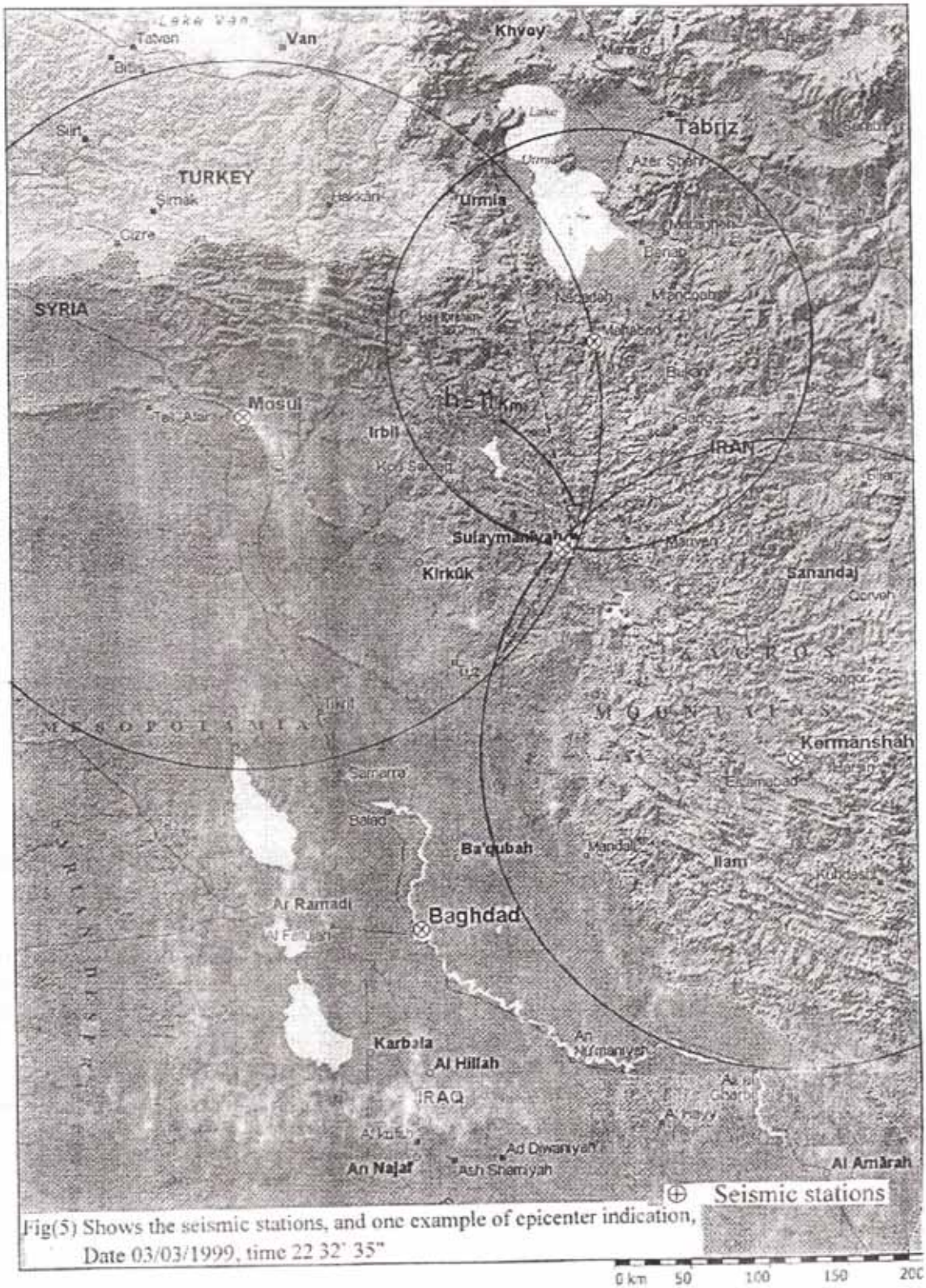
The lack of data on the three components of Sulaimani seismic station did not permit the authors to determine the position of epicenter by using azimuth angle method. Therefore the method of intersection circles is used for this purpose, center of the circles represent seismic station and the radius is distance of epicenters obtained by the product of S-P with velocity of the seismic waves.

From table (1) we observe that the data were obtained from different seismic stations, Mosul, Baghdad, Krmanshah and Mhabat, fortunately about (15) locations of epicenter were indicated for those quakes that have been recorded in more than two stations, Fig (5).

The obtained results are given in table (2)::

**Table (2): Shows locations of epicenter and depths of focus of the some quakes.**

| S | Date | | | Time | | | Location of Epicenter | | Magnitude | Depth ( km ) of focus |
|---|---|---|---|---|---|---|---|---|---|---|
| | Day | Month | Year | Hour | Minute | Sec | Latitude | Longitude | | |
| 1. | 3 | 3 | 1999 | 22 | 32 | 35 | 35° 36` | 45° 29` | 4.7 | 11 |
| 2. | 3 | 3 | 1999 | 22 | 41 | 21 | 35° 34` | 45° 26` | 3.3 | 7.5 |
| 3. | 4 | 3 | 1999 | 00 | 19 | 52 | 35° 36` | 45° 28` | 3.3 | 2 |
| 4. | 4 | 3 | 1999 | 16 | 10 | 31 | 35° 34` | 45° 27` | 4.0 | 3.2 |
| 5. | 4 | 3 | 1999 | 23 | 11 | 15 | 35° 37` | 45° 30` | 3.0 | 5.1 |
| 6. | 5 | 3 | 1999 | 22 | 26 | 40 | 35° 34` | 45° 30` | 3.3 | 6.7 |
| 7. | 6 | 3 | 1999 | 04 | 55 | 09 | 35° 33` | 45° 26` | 3.5 | 5.9 |
| 8. | 6 | 3 | 1999 | 11 | 05 | 50 | 35° 36` | 45° 26` | 4.1 | 10.1 |
| 9. | 8 | 3 | 1999 | 14 | 10 | 21 | 35° 36` | 45° 28` | 3.1 | 9.3 |
| 10. | 11 | 3 | 1999 | 06 | 40 | 42 | 35° 35` | 45° 27` | 2.9 | 6.7 |
| 11. | 14 | 4 | 1999 | 17 | 23 | 24 | 35° 35` | 45° 25` | 3.0 | 2.9 |
| 12. | 24 | 4 | 1999 | 11 | 39 | 07 | 35° 34` | 45° 31` | 3.9 | 8.1 |
| 13. | 4 | 5 | 1999 | 15 | 5 | 42 | 35° 35` | 45° 32` | 3.3 | 3.6 |
| 14. | 14 | 5 | 1999 | 7 | 25 | 26 | 35° 31` | 45° 27` | 2.7 | 2.1 |
| 15. | 2 | 6 | 1999 | 0 | 54 | 34 | 35° 37` | 45° 27` | 3.1 | 4.4 |




Fig(5) Shows the seismic stations, and one example of epicenter indication, Date 03/03/1999, time 22 32' 35"

All the founded epicenters are located NE Sulaimani city by distances range between (5–11) km from the center of the city Fig (6), comprising sitak, Bnaweela, sharsten and kalakin villages which are considered as week zones because they are located, or adjacent, on/to Sitak-Sulaimani transverse fault. So the authors can surely mentain that the cause of the swarm is most probably coming from rejuvenation of this fault. The occurrence of two springs at that area during this period is quite evidence especially during the last dry year.

## Depth estimation of hypocenter

Hypocenter or focus is a place where potential elastic energy is released, in the form of seismic waves due to additional accumulation of strength on the rocks. Determination of the focal depths are not an easy task. There are different methods for calculations depending on qualitative and quantitative interpretation of the available data. In the present study several trials were made for the determination of approximate depths as follow:

1- Using Shipallin graphical chart that makes a relation between seismic intensity, magnitude and focal depth.

2- Circle method, by using a available data recorded in each of the three stations and drawing circles of radius equal to a distance of epicenter, as shown in Fig (5) we observed that in all cases the three circles does not intersects in one point that is an obvious evidence denoting to that the focus is not at the surface, (15).

The depths calculated by the two above methods are approximately the same except in some cases when a small difference of about (± 500) m was appeared. The focal depths were ranging between (2-11) km below the ground surface, table (2).

## Energy release from the swarm

The general seismicity of any area could be evaluated not only from the number of earthquakes recorded within a definite interval but also by the total energy released from these quakes (5). A simple equation that was suggested by Abe and Quaah (16), (17), was used for measuring energy released by an earthquake as follow:

$$\text{Log } E = A + B\,m$$

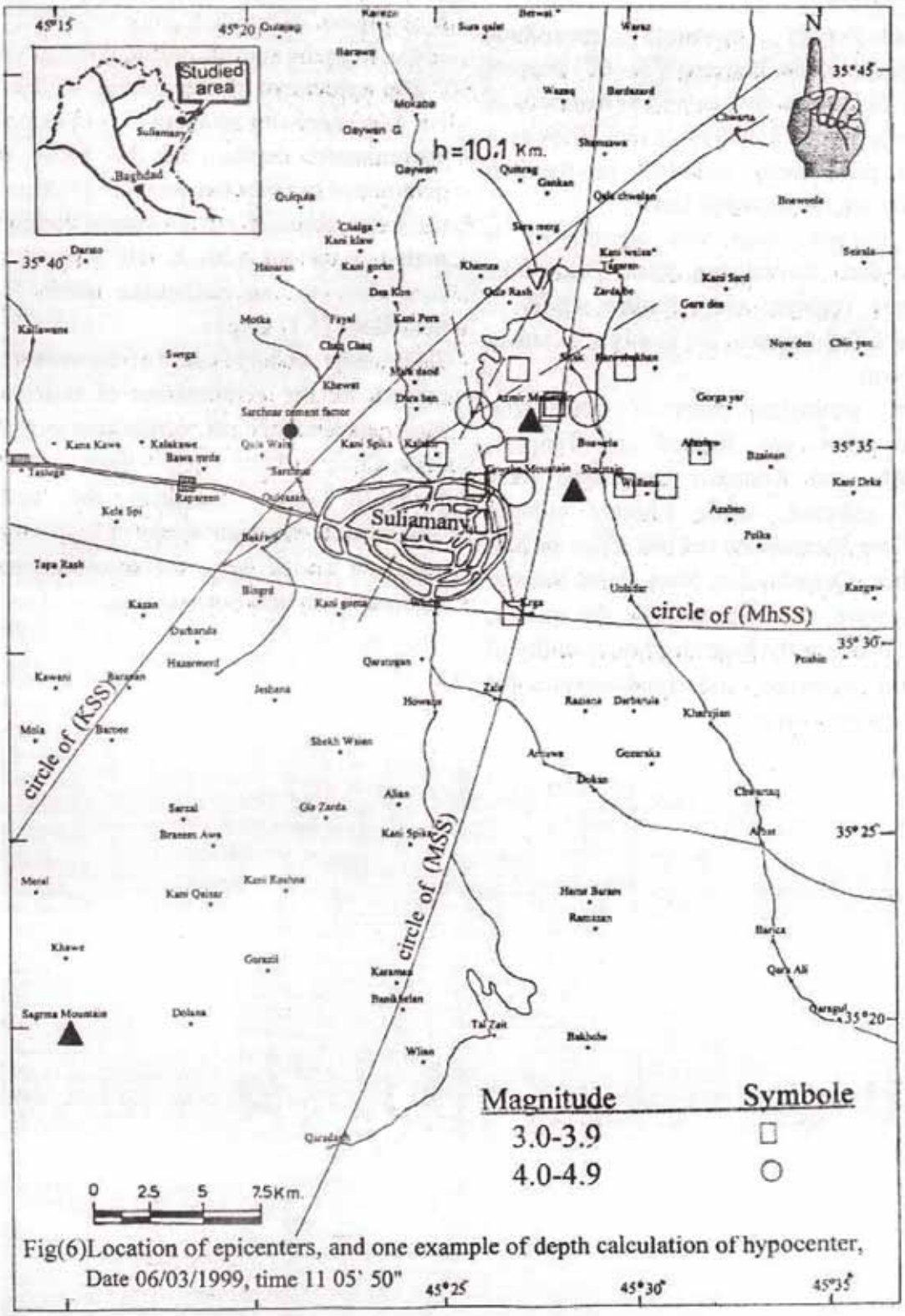
Measuring of the two constant (A, B) is, sometimes, very difficult due to the lack of information, therefor, the equation suggested by Riznichenko (18), could be used: -

$$\text{Log } E = 4 + 1.3m$$

Also there are many other relations between seismic wave energy (E) and seismic magnitude such as those suggested by Richter and Iida (12):

$$\text{Log } E = 11.8 + 1.5\,m$$
$$\text{Log } E = 12.66 + 1.4\,m$$

These relations denote that, an increase of seismic magnitude by one unit lead to increase in energy released by (32) unit. The above mentioned equations are also used for measuring energy release of micro seismic waves .The total energy released from the swarm during 3/3/1999 to 3/6/1999 is calculated and it reaches about ($26 \times 10^{17}$) Erg, that is equivalent to an earthquake which has a magnitude (5.1) degree according to Richter scale.




Fig(6)Location of epicenters, and one example of depth calculation of hypocenter, Date 06/03/1999, time 11 05' 50"

**Conclusions**

1-About (73) moderate magnitude earthquake range between (2 – 4.7) degrees struck Sulaimani city, as well as hundreds of tremors, during 3/3/1999 to 3/6/1999 as a swarm phenomena recorded for the first time, during the recorded history.

2-An intensity map was constructed. It shows that the villages Sitak, Binaweela, Sharsten, Tagaran, and Allasiaw, which are located NE Sulaimani, are highly affected by the swarm.

3-From geological point of view those villages that are located on Tangero, Shiransh, and Kometan formations were highly effected, while adjacent villages which are located on red bed series such as Zardabee, Qalachwalan, Swra Qalat, Betwat, etc..., were not vibrated by the quakes, which is due to the high absorption ability of red bed materials and conglomerates for seismic wave energy.

4-Red bed series is very good site for foundations of building, high way, factories, ...etc, from the seismic hazard point of view.

5-The epicenters of the quakes are located NE Sulaimani city by about (5 – 11) km. The approximate depths of the focus were determined to range between (2- 11) km.

6-Energy released by the swarm during this period is about ($26 \times 10^{17}$) Erg , it is equivalent to an earthquake which has a magnitude (5.1) degree .

7-The most probable cause of the swarm was related to the rejuvenation of Sulaimani-Sitak transversal fault, which intersects with Chaq-Chaq strike slip fault beneath Sulaimani city. Finally the authors recommend the applications of Iraqi seismic code as a vital issue for constructions in Sulaimani city and Surrounding.

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# شەپۆلە بوومەلەرزەکەی بەهاری ۱۹۹۹ ی شاری سلێمانی ، باکووری رۆژهەلاتی عێراق

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## پوختە

شەپۆلێکی بوومەلەرزە شاری سلێمانی گرتەوە بۆ یەکەم جار لە مێژووی ناوچەکەدا لە بەهاری ساڵی ۱۹۹۹ ٠ زیاتر لە (۷۳) لەرینەوە بە توندی (۲–۷ر٤) پلە تۆمار کرا جگە لە سەدەهای تر کە توندیەکانیان کەمتر بوون٠ شوێنی ڕووداندیان لە سەر زەوی دیاری کرا لە باکووری رۆژهەلاتی شاری سلێمانی بە دووری (۵–۱۱) کم٠ قوڵی شوێنی دروست بوونی ئەم شەپۆلە بوومەلەرزەیە دۆزرایەوە دەرکەوت زۆر کەمە و لە نێوان (۲–۱۱) کم دایە٠ توانرا ئەو ووزەیە بدۆزرێتەوە کە لە ئەنجامی ئەم شەپۆلە دەرپەڕیوە دەکاتە نزیکەی (۱۰x۲٦ ۱۷) ئێرگ ، ئەم بڕەش یەکسانە بە ووزەی بوومەلەرزەیەک کە توندیەکەی (۱ر۵)پلە بێت٠ لە کۆتایدا هۆی ڕووداندی شەپۆلەکە پەیوەندی هەبوو بە جوولانی درزی سلێمانی–سیتەک بە بەردەوامی لەو ماوەیەدا٠

# عصفة من الهزات الارضية في ربيع ۱۹۹۹ لمدينة السليمانية، شمال شرق العراق

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## الخلاصة

ضربت عصفة من الهزات الارضية مدينة السليمانية لاول مرة في التاريخ الزلزالي المسجل للمنطقة في ربيع عام ۱۹۹۹ ٠ سجلت اكثر من (۷۳) هزة ذات مقادير زلزالية تتراوح بين (۲–۷ر٤) درجة بالإضافة الى مئات من الرعشات الدقيقة٠ تم تحديد المراكز السطحية لها حيث تقع شمال شرق المدينة بمسافات (۵–۱۱) كم٠ تبين بان الهزات تولدت من الأعماق الضحلة و ذالك من خلال إيجاد أعماقها البؤرية حيث تتراوح بين (۲–۱۱)كم٠ تم حساب الطاقة المتحررة من هذه العصفة بحوالي (۲٦ x ۱۰ ۱۷ ) أرك و هذه تكافئ هزة أرضية ذات مقدار زلزالي يساوي (۱ر۵) درجة٠ اعزي سبب حدوث الموجة الى حركات في فالق سليمانية–سيتك خلال هذه الفترة٠

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