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# Obtaining an Empirical Earthquakes Duration Magnitude Formula from the Data of the Iraqi Meteorological Organization and seismology (IMOS)

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**Abstract**

This paper calculated the Duration Magnitude (MD) equation using data from the Iraqi Meteorological Organization and seismology (IMOS). It is an empirically determined equation and expressed as:

$$M_D = 0.8582 \times log(\tau_{coda}) - 0.0000262 \times R + 2.1203 \pm S_c$$

The epicentral distance and local geological conditions affect the duration of the coda. The data is obtained from 7 seismic stations in the network. The new proposed duration magnitude equation results from applying linear regression analysis to the data of a seismic signal duration with correlation coefficient $R^2$=0.76; and a standard deviation value of 0.049. Station corrections indicated by Sc are also specified for the seismic stations that range from -0.024 to + 0.02.

**Keywords:** Duration Magnitude, linear regression analysis, IMOS, Station correction, Coda-duration.

# الحصول على صيغة تجريبية لمقدار مدة الزلازل من بيانات منظمة الأرصاد الجوية العراقية وعلم الزلازل (*IMOS*)

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**الخلاصة**

في هذا البحث تم حساب معادلة Duration Magnitude (MD) من بيانات منظمة الأرصاد الجوية العراقية وعلم الزلازل (IMOS) هذه معادلة محددة تجريبياً ويتم التعبير عنها على النحو التالي:

$$M_D = 0.8582 \times log(\tau_{coda}) - 0.0000262 \times R + 2.1203 \pm S_c$$

تؤثر مسافة المصدر والمستقبل والظروف الجيولوجية المحلية على مدة الكودا. يتم الحصول على البيانات من 7 محطات في الشبكة. معادلة حجم المدة المقترحة الجديدة هي نتيجة تطبيق تحليل الانحدار الخطي على البيانات التي لها مدة إشارة زلزالية مع معامل الارتباط $R^2$ = 0.76 ؛ وقيمة الانحراف المعياري 0.049. تم تحديد تصحيحات المحطة المشار إليها بواسطة Sc أيضًا للمحطات الزلزالية التي تتراوح من −0.024 إلى + 0.02.

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## 1. Introduction

In all seismological observatories, estimating the magnitude of an earthquake is a routine procedure. Several magnitude scales depend on the amplitude measurement of distinct seismic phases and the overall signal duration. Many regional networks employ the duration magnitude ($M_D$) because it gives a quick and reliable assessment of the earthquake size using a relatively simple process based on the measurement of the time of recorded seismograms.

The interval of a seismic wave on the time axis of the earthquake record - from the first seismic wave until the amplitude of the wave decreases to at least 10% of its maximum recorded value - is measured as the 'earthquake duration'. It is the concept that [1]first used to develop an earthquake duration magnitude scale using surface wave periods. Numerous authors have examined the use of recorded seismogram duration as a measure of event magnitude. (e.g., [2]; [3]; [4]; [5] and [6]). Furthermore, [7] presented a duration magnitude approach based on P-wave recordings at teleseismic distances for the quick calculation of the moment magnitude, which may be used for tsunami early warning.

The duration magnitude is determined by defining the ground-shaking time, the epicentral distance, and a station correction coefficient in a more generic formulation.

The duration magnitude, according to [8] and [9], is defined as:

$$M_D = a \times \log(\tau_{coda}) + b \times R + c \pm S_c \quad (1)$$

Where $M_D$ is duration magnitude; $\tau_{coda}$ is the signal duration, ; R is the epicentral distance, $Km$; Sc is the station correction, and a, b and c are coefficients to be determined through linear regression analysis.

The aim of the present work can be summarized as follows: First, present a manual procedure worked out specifically for measuring earthquake duration based on the calculation of noise amplitudes along seismic records. Second, calibrated the duration magnitude scale for the region monitored by the Iraqi Meteorological Organization and seismology (IMOS). Third, derive the duration magnitude relationship in the form of Eq. (1). Fourth, analyze a set of (IMOS) data and calculate the regression coefficients and station corrections for Eq. (1) concerning the local magnitude (ML) values provided by the network itself.
Figure 1 represents a seismic map of the studied region. The map shows the distribution of the seismic events and the seismic monitoring network stations used in the study.

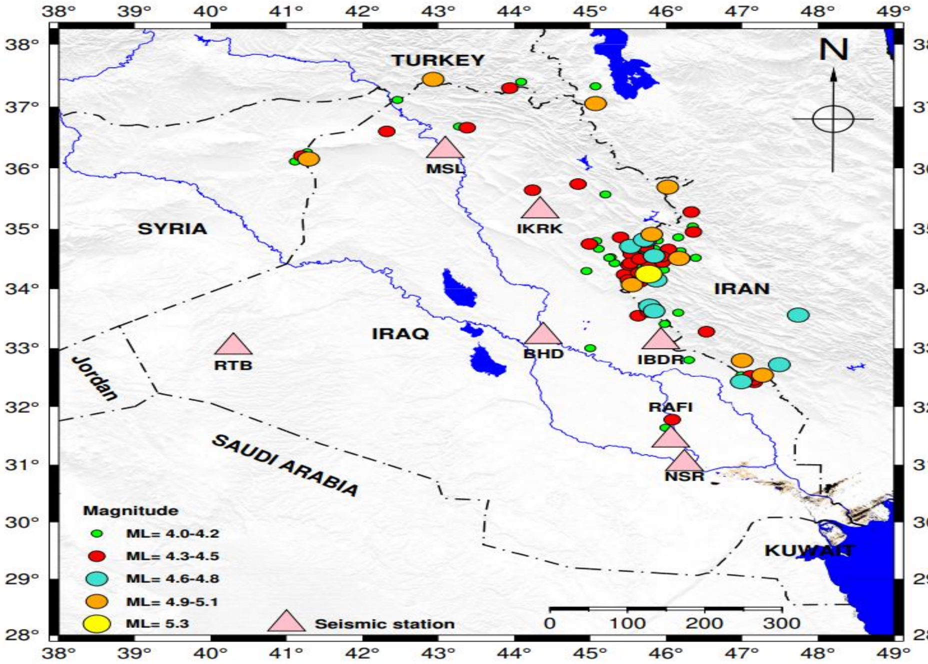



**Figure 1:** Seismic occurrences recorded in the Iraqi Meteorological Organization and seismology (IMOS) between November 2011 and September 2021, as well as the recording stations used in this study. The epicenters of the earthquakes are shown in circles with a color that corresponds to the event magnitude. IMOS stations are depicted as triangles on the map in the legend.

## 2. Seismicity of Iraq and Data Source

Iraq is located between latitudes 29.6°–37.27°N and longitudes 38.39°–48.36°E in a very active seismic zone on its northern, northeastern, and eastern boundaries. Most of Iraq have been subjected to seismic activity in the past and may be subjected to seismic activity in the future. The overall seismicity of Iraq is influenced mainly by the Zagros and Taurus systems, with a partial effect of the neotectonic activation of the upper crust [10].

Annual earthquake activity of various strengths is seen in seismic history. The north and northeastern zones have the most seismic activity, whereas the south and southwest significantly decrease. [11] and [10] both documented Iraq's seismicity and seismotectonics.

The forces caused by the Arabian plate movement to the north and northeast, its collision with the Iranian-Turkish plates, as well as the influence of neotectonic activities of the top crust's neotectonic activities are most likely the causes of most earthquakes occurrences in the region [12].

Iraq established a seismic network (IMOS) in 1976 consisting of five short-period stations located in Baghdad, Sulaimaniya, Mosul, Basra, and Rutba [13]. Currently, six new broadband three-component stations are composing the (IMOS) namely Baghdad (BHD), Mosul (MSL), Kirkuk (IKRK), Rutba (RTB), Badra (IBDR), and Nasiriyah (NSR). Data from these stations are used in this study.

After 2014, Nasiriyah station (NSR) was replaced by Al-Rifai station (RAFI), and her place was in Al-Rifai District and is still present at present

## 3. Methodology

The empirical duration magnitude formula relies more heavily on regional and local statistics that depict the region's geometric spreading and elastic absorption characteristics and locality [14]. As a result, an attempt is being made to develop a preliminary magnitude formula using data from Iraqi Meteorological Organization and seismology (IMOS) stations to determine the strength of recorded local and regional seismic events.

In a more general formula, the amount of duration is determined by the time of ground shaking, the epicentral distance, and the station correction factor by Eq. (1). The structure of the crust, as well as the scattering and attenuation conditions, differ from one place to the next. As a result, no generic formulas can be offered. They must be determined locally for each station or network and scaled to the best amplitude-based ML scale available. Furthermore, the specific equation that results is dependent on the $\tau$ definition used, the local noise circumstances, and the sensor sensitivity at the network's examined seismic stations [15].
For determining signal or coda length, the following approaches have been proposed:

- Determine the beginning time from the P-wave arrival to the end of the coda, where the signal vanishes in the seismic noise of equal frequency;
- Duration from the P-wave onset to that time when the coda amplitudes have decayed to a certain threshold level, given in terms of average signal-to-noise ratio or of absolute signal amplitudes or signal level;
- Total elapsed time is coda threshold time minus event origin time [16].

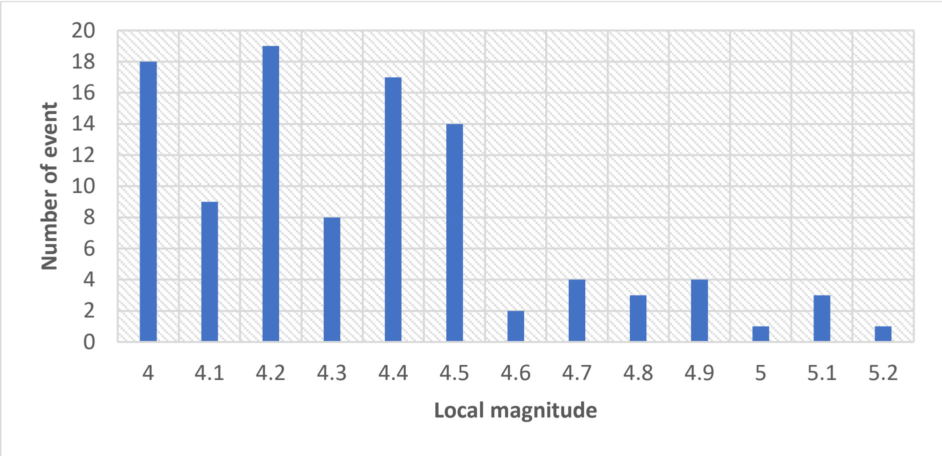
### 3.1 Data Set Preparation and Regression Analysis

The network covers a wide area and is aimed at monitoring the active fault system and is interested in continuous background seismic activity, essentially including micro and moderate earthquakes.

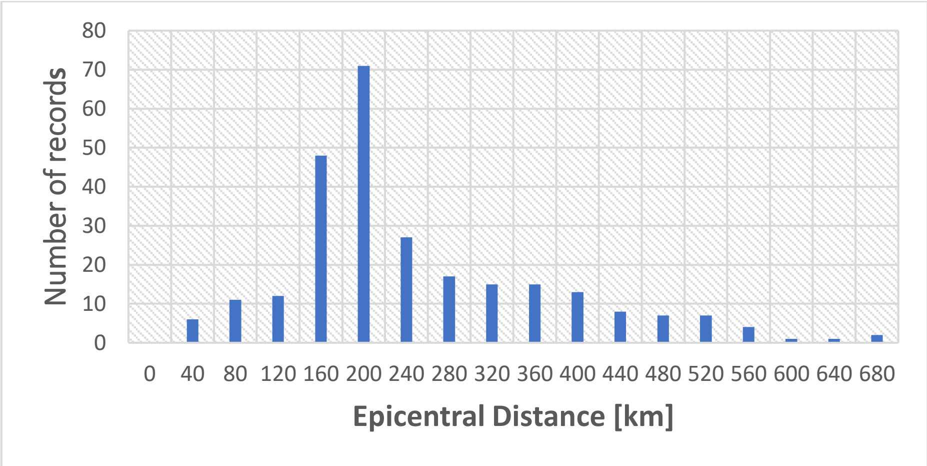
For the present work, a set of 108 earthquakes, recorded at 7 stations of the (IMOS) from November 2011 to September 2021, with magnitudes ranging from 4 to 5.2, are analyzed using SEISAN computer software. MiniSEED or SEISAN format is the original seismic data format. The procedure for assigning $M_D$ follows the approach given by [15]. The measured amplitudes from the vertical components of high-gain broadband channels (BH and HH) have been filtered in the 0.1 – 1 Hz band. The estimated noise amplitude for each seismogram that was accessible in order to filter out recordings with considerable noise contamination.

The estimated noise amplitude for each available seismogram was calculated to eliminate recordings with significant noise contamination. The method described by [15] involved measuring the noise amplitudes before and after an event. We use the events captured by one or more stations, which enables us to exclude too noisy data.

This restriction resulted in a reduction of the original data set to 266 waveforms, or 108 events. A few earthquakes with magnitudes between 4 and 5.2 and epicentral distances between 7.25 and 694.17 km, respectively.
Figure 2 shows the distribution of occurrences as a function of magnitude Figure 2a and the distribution of recordings as a function of epicentral distance Figure 2b, respectively.




**(a)**




**(b)**

**Figure 2**: Seismic events recorded in the Iraqi Meteorological Organization and seismology (IMOS) from November 2011 to September 2021 and the recording stations used in this study. (a) Distribution of earthquakes selected as a function of local magnitude. (b) The number of records as a function of the epicentral distance.

After that, in a series of seismograms, the $M_D$ equation by linear regression analysis using Eq. (1), coda length ($\tau_{coda}$) and epicentral distance (R) was calculated.
The time gap between the onset of the $T_P$ wave and the signal's finish $T_C$ is known as the coda length where :

$$\tau_{coda} = T_C - T_P \quad (2)$$

The selection of the P-wave arrival time, $T_P$, is easy and was done as part of the earthquake determination process. However, deciding where to place the $T_C$ after the coda is difficult since various stations have varied ambient noise levels influencing where the $T_C$ is placed. The Seisan Software uses the steps below to read maximum amplitude in order to overcome this challenge:

1. Raw data are reviewed by Seisan
2. Filter (0.1 - 1 HZ) is used.
3. select the P-wave arrival time Figure 3a.
4. The amplitude is calculated by placing the cursor at the top of the cycle of the maximum amplitude and pressing (A), then placing it at the bottom of the same cycle and pressing (A). Amplitude (zero to peak) and period are now stored (Figure 3b).

This manual procedure is repeated to determine the maximum noise amplitude before the seismic event. Similarly, following the seismic event, the amplitudes are calculated until amplitudes identical to those before the event are achieved, at which point the termination of the seismic signal (coda) is determined[16] Figure 4.

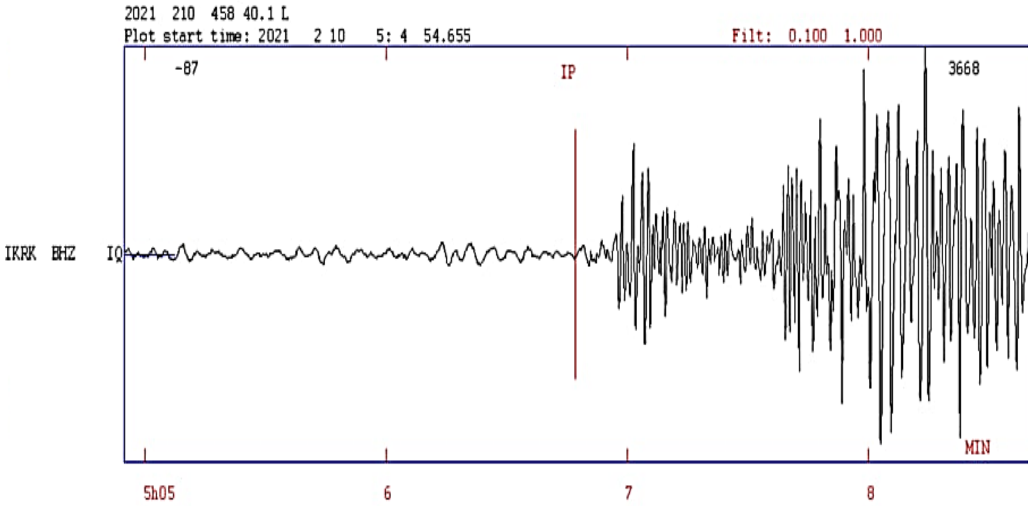



**Figure 3: a** Z-component for a seismic event recorded by IKRK station and reviewed by Seisan software in raw data form. The date of the seismic event is 2/10/2021; the origin time is 04:58:40; the coordinates are 36.388 as latitude and 41.286 as longitude, and the depth is 10 km. This event is one of the 108 events of the dataset of the present study. The trace belongs to Kirkuk station (IKRK), and the component is Z of 10 samples per second (BHZ). The plot start time is 05:04:54.655. X-axis is the time. The whole time window is about 3.5 minute.

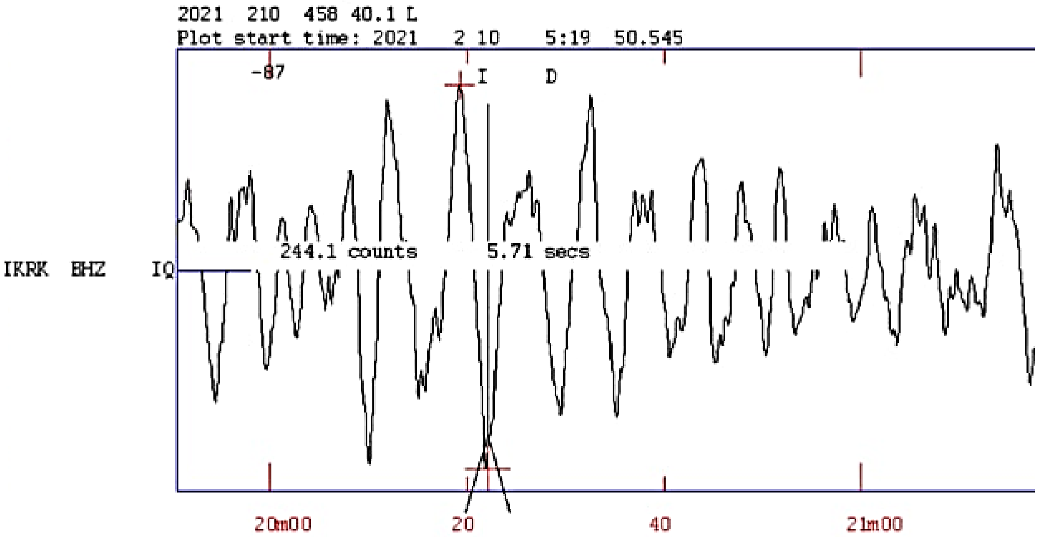



**Figure 3: b** Reading amplitude on seismogram record of the event that was recorded by Kirkuk station (IKRK). Zero to peak amplitude is 244.1counts and the period of the cycle of the maximum amplitude is 5.71 seconds.

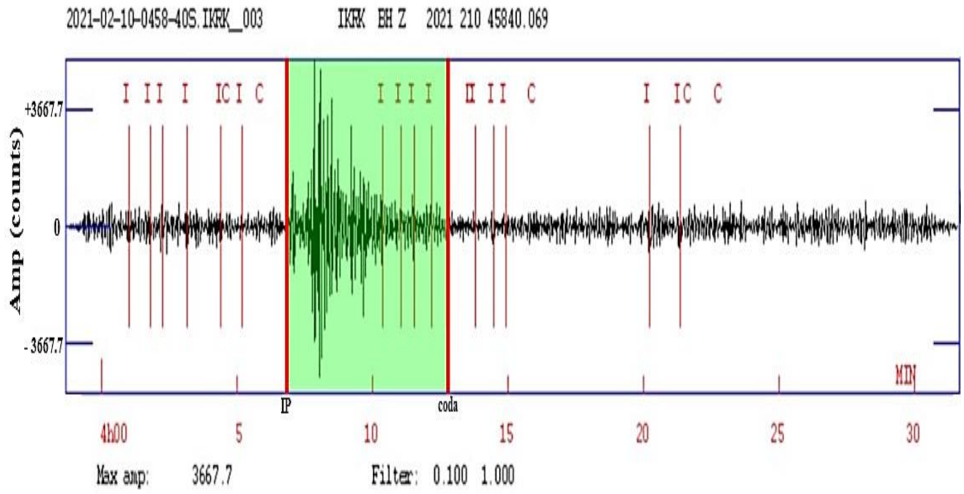



**Figure 4:** Seismogram records of the event that was recorded by Kirkuk station (IKRK) and reviewed by Seisan software in raw data form. Filter (0.1 - 1 HZ) was used. The green area represents the duration from the beginning of the P wave until the amplitudes become equal to the amplitudes of the noise before the event.

By linear regression analysis and by using the relevant ML data for the studied data events, the $M_D$ equation is found to be:

$$M_D = 0.8582 \times \log(\tau_{coda}) - 0.0000262 \times R + 2.1203 \pm Sc \qquad (3)$$

where a, b, and c are coefficients to be determined by linear regression analysis; $log(\tau_{coda})$ is the coda length in seconds; R is the epicentral distance in Km and Sc is the station correction.

ML values are used to construct Eq. (3), which range from 4 to 5.2. The result is a sufficient range with this region's reliably determined MD. The Eq. (3) correlation coefficient is $R^2$=0.76, and the standard deviation (SD) is 0.046 Figure 5.

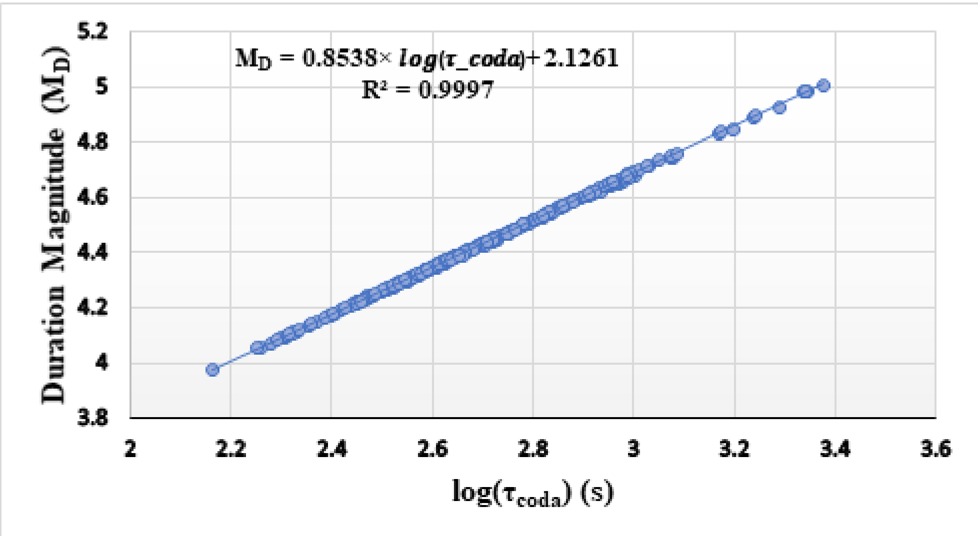



**Figure 5:** Duration magnitudes obtained from Eq. (3) plotted against the logarithm of duration for the studied earthquakes. The continuous line represents the best fit for the data.

To examine the influence of the recording distance on the signal duration, we prepared a plot to show this relation. Figure 6 reveals that the plotted duration values suggest a slight increase in duration with distance.
For other seismic regions and local earthquakes recorded at distances shorter than 100 km, [17] established that "the total duration of the seismogram is nearly independent of the epicentral distance or azimuth and can be used effectively as a measure of earthquake magnitude". In our situation, the assertion made by [17] appears true for earthquakes up to 400 km away.

On the other hand, the long durations of the earthquakes in this study were probably the result of propagation in a more complex medium despite the data's huge overall scatter. These equations must consider how the source-to-station path affects the duration of seismic signals.

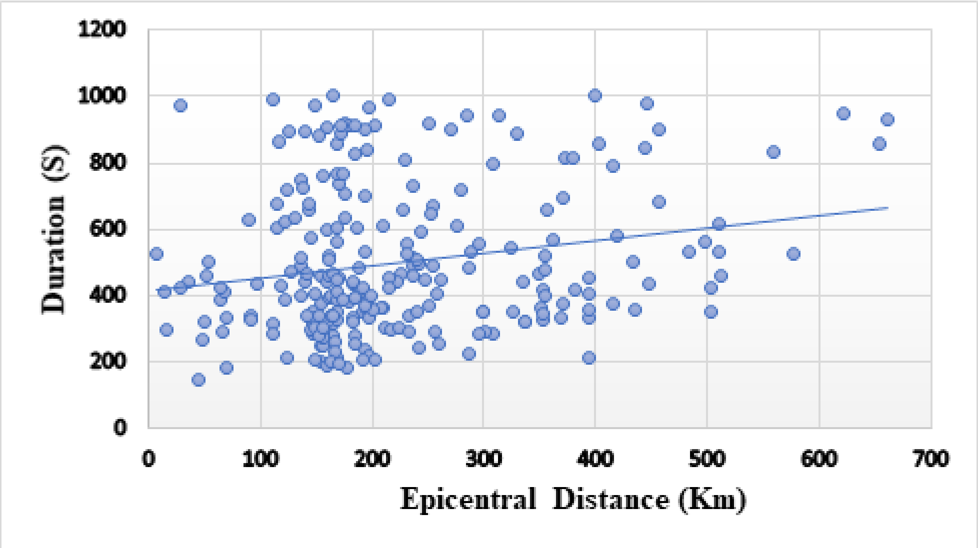



**Figure 6:** The linear relationship between the epicentral distances and the duration values for all the studied seismic recordings.

Coda magnitude formulas are unique to each region and stations were selected accordingly. Some studies do not calculate the distance term due to the small size of the earthquakes and the network [18]; [19] and [20]. The structure of the crust and its properties dominate the values of the magnitude scales so that no single formula can be applied everywhere, just like ML [21].

### 3.2 Station Corrections (Sc)

Station correction coefficients (Sc) are used to reduce the systematic over- and/or underestimation of magnitude values recorded at each station. A station correction coefficient (Sc) is established to be connected with each recording station in order to enhance magnitude estimation accuracy. Station corrections are evaluated from the average difference values between the magnitude values for each station to the average recorded seismic event magnitude obtained from each seismic station [22].

Table 1 displays the values of the Sc for the stations that have been used. The correction values of the stations are very low and do not affect the accuracy of the magnitude estimates.
A very detailed analysis (which is beyond the scope of this paper) is required to understand whether there is a correlation between the station correction coefficient and local geology.

**Table 1:** Station corrections (Sc)

| No. | Station code | Station correction (Sc) |
|---|---|---|
| 1 | IBDR | -0.02412 |
| 2 | NSR | -0.01076 |
| 3 | IKRK | 0.001258 |
| 4 | MSL | 0.00514 |
| 5 | RAFI | 0.007246 |
| 6 | RTB | 0.01997 |
| 7 | BHD | 0.02077 |

## 4. Results

In the present work, one type of magnitude equation was calculated by using data from the Iraqi Meteorological Organization and seismology (IMOS), which can be used by the network in its seismic monitoring activities. This measure of duration magnitude has been experimentally determined and expressed according to Eq. (3).
Source and receiver distance and local geological conditions affect the duration of the coda.

The duration magnitude equation is the result of applying linear regression analysis to data with a seismic signal duration obtained from 7 stations of the network, with correlation coefficient $R^2$ = 0.76. The standard deviation (SD) rate to the magnitudes was also calculated, which is 0.049 (Tables 2 and 3).

The linear relationship was drawn between the values of the duration magnitude, and the logarithm of the duration for all the studied seismic events and this relationship indicates a reasonably good fit as ($R^2$=0.9997) (Figure 5).
Also, a linear relationship was drawn between the epicentral distances and the duration values for all the studied seismic recordings, and this relationship indicates a slight increase in duration with distance, and the scatter of the data is significant at all distances due to the influence of geological conditions and the physical properties of the Earth crust (Figure 6).

The station corrections indicated by Sc were defined for each station to ensure that the calculated duration magnitude equation could be applied to the network. Station corrections range from -0.024 to +0.02.

**Table 2:** Presents the seismic events recorded by the Iraqi Meteorological Organization and seismology (IMOS) between November 2011 and September 2021.

| No. | *Event Date* | *Origin Time (UTC)* | *Lat . E* | *Long. N* | *ML* | *Duration Magnitude* |
|---|---|---|---|---|---|---|
| 1 | 2011-11-29 | 07:54:18 | 34.707 | 45.104 | 4.0 | 4.189 |
| 2 | 2011-12-06 | 14:55:30 | 37.354 | 43.806 | 4.5 | 4.530 |
| 3 | 2012-02-28 | 22:57:42 | 32.503 | 46.913 | 4.5 | 4.622 |
| 4 | 2012-02-29 | 04:59:39 | 32.457 | 46.930 | 4.7 | 4.538 |
| 5 | 2012-10-03 | 21:32:27 | 32.589 | 46.932 | 4.0 | 4.284 |
| 6 | 2012-04-18 | 19:59:47 | 32.422 | 46.832 | 4.4 | 4.628 |
| 7 | 2012-04-19 | 07:29:40 | 32.460 | 46.972 | 4.4 | 4.588 |
| 8 | 2012-04-20 | 01:39:34 | 32.481 | 46.995 | 5.1 | 4.946 |
| 9 | 2012-04-21 | 06:05:40 | 32.432 | 47.101 | 4.5 | 4.647 |

| | | | | | | |
|---|---|---|---|---|---|---|
| **10** | 2012-04-22 | 07:59:45 | 32.411 | 47.039 | 4.2 | 4.596 |
| **11** | 2012-04-24 | 18:30:51 | 32.420 | 46.958 | 4.3 | 4.241 |
| **12** | 2012-05-08 | 20:24:03 | 37.373 | 42.977 | 4.9 | 4.733 |
| **13** | 2013-01-19 | 16:44:42 | 31.780 | 46.080 | 4.4 | 4.498 |
| **14** | 2013-01-20 | 17:04:46 | 31.640 | 45.990 | 4.0 | 4.135 |
| **15** | 2013-01-24 | 16:24:45 | 31.630 | 45.986 | 4.2 | 4.293 |
| **16** | 2013-03-13 | 06:14:40 | 36.610 | 43.290 | 4.2 | 4.673 |
| **17** | 2013-07-13 | 17:25:59 | 37.195 | 42.438 | 4.5 | 4.222 |
| **18** | 2013-02-08 | 01:04:41 | 36.689 | 43.276 | 4.0 | 4.391 |
| **19** | 2013-10-14 | 20:24:43 | 34.923 | 45.935 | 4.0 | 4.418 |
| **20** | 2013-05-11 | 03:59:51 | 34.851 | 45.055 | 4.0 | 4.169 |
| **21** | 2013-11-22 | 10:07:48 | 34.446 | 45.458 | 4.5 | 4.233 |
| **22** | 2013-11-22 | 15:19:47 | 34.385 | 45.499 | 4.0 | 4.326 |
| **23** | 2013-11-22 | 19:19:20 | 34.304 | 45.612 | 4.2 | 4.276 |
| **24** | 2013-11-22 | 20:59:43 | 34.262 | 45.613 | 4.2 | 4.480 |
| **25** | 2014-02-02 | 15:57:44 | 33.508 | 46.012 | 4.7 | 4.594 |
| **26** | 2014-04-16 | 01:11:16 | 35.631 | 45.301 | 4.9 | 4.725 |
| **27** | 2014-07-28 | 05:11:51 | 33.619 | 45.587 | 4.4 | 4.316 |
| **28** | 2014-08-31 | 14:42:45 | 33.719 | 45.736 | 4.0 | 4.223 |
| **29** | 2015-02-15 | 08:01:34 | 32.785 | 46.840 | 4.4 | 4.578 |
| **30** | 2015-11-07 | 18:24:48 | 35.753 | 44.754 | 4.2 | 4.434 |
| **31** | 2015-06-10 | 06:23:52 | 34.877 | 45.111 | 4.2 | 4.294 |
| **32** | 2016-10-08 | 04:53:57 | 35.345 | 46.249 | 4.4 | 4.356 |
| **33** | 2016-11-15 | 01:18:34 | 33.550 | 46.101 | 4.1 | 4.398 |
| **34** | 2017-07-28 | 23:49:58 | 37.330 | 45.070 | 4.5 | 4.244 |
| **35** | 2017-12-11 | 17:33:58 | 34.857 | 45.844 | 4.0 | 4.346 |
| **36** | 2017-12-11 | 21:13:58 | 34.621 | 45.770 | 4.6 | 4.426 |
| **37** | 2017-12-11 | 21:30:44 | 34.588 | 45.782 | 4.0 | 4.281 |
| **38** | 2017-12-11 | 22:09:51 | 35.072 | 45.858 | 4.8 | 4.725 |
| **39** | 2017-11-13 | 00:19:52 | 34.613 | 45.765 | 4.3 | 4.267 |
| **40** | 2017-11-13 | 03:13:59 | 34.972 | 45.863 | 4.2 | 4.279 |
| **41** | 2017-11-13 | 04:25:56 | 34.454 | 45.851 | 4.4 | 4.263 |
| **42** | 2017-11-13 | 04:33:59 | 34.435 | 45.795 | 4.7 | 4.598 |
| **43** | 2017-11-13 | 04:59:59 | 34.528 | 45.753 | 4.4 | 4.341 |
| **44** | 2017-11-13 | 08:27:58 | 34.547 | 45.576 | 4.0 | 4.332 |
| **45** | 2017-11-13 | 09:17:56 | 34.438 | 45.770 | 4.2 | 4.383 |
| **46** | 2017-11-13 | 14:59:55 | 34.378 | 45.576 | 4.0 | 4.240 |
| **47** | 2017-11-14 | 07:33:59 | 34.597 | 45.789 | 4.2 | 4.319 |
| **48** | 2017-11-14 | 15:14:48 | 34.570 | 45.688 | 4.2 | 4.352 |
| **49** | 2017-11-15 | 06:56:54 | 34.539 | 45.845 | 4.5 | 4.416 |
| **50** | 2017-11-15 | 14:56:43 | 34.597 | 45.578 | 4.1 | 4.410 |
| **51** | 2017-11-17 | 13:57:31 | 34.590 | 45.601 | 4.2 | 4.240 |
| **52** | 2017-11-18 | 03:56:32 | 34.524 | 45.627 | 4.5 | 4.676 |
| **53** | 2017-11-19 | 00:56:18 | 34.444 | 45.922 | 4.0 | 4.368 |

| | | | | | | |
|---|---|---|---|---|---|---|
| **54** | 2017-11-19 | 05:58:22 | 35.157 | 46.334 | 4.0 | 4.486 |
| **55** | 2017-11-20 | 15:33:58 | 34.700 | 45.730 | 4.2 | 4.150 |
| **56** | 2017-11-21 | 17:43:56 | 34.536 | 45.676 | 4.2 | 4.163 |
| **57** | 2017-11-22 | 07:44:54 | 32.877 | 46.381 | 4.4 | 4.181 |
| **58** | 2017-11-22 | 16:39:58 | 34.922 | 45.756 | 4.8 | 4.758 |
| **59** | 2017-11-22 | 19:45:59 | 34.730 | 45.655 | 4.2 | 4.291 |
| **60** | 2017-11-26 | 05:45:58 | 34.562 | 45.785 | 4.0 | 4.402 |
| **61** | 2017-06-12 | 05:51:59 | 35.105 | 45.842 | 4.2 | 4.384 |
| **62** | 2017-08-12 | 07:55:57 | 34.396 | 45.725 | 4.4 | 4.523 |
| **63** | 2017-12-18 | 02:45:59 | 34.591 | 46.086 | 4.4 | 4.346 |
| **64** | 2017-12-19 | 09:13:57 | 34.763 | 45.857 | 4.1 | 4.289 |
| **65** | 2017-12-21 | 02:47:58 | 34.563 | 45.777 | 4.6 | 4.345 |
| **66** | 2017-12-26 | 09:00:31 | 34.844 | 46.152 | 4.9 | 4.741 |
| **67** | 2017-12-29 | 16:23:21 | 34.716 | 45.528 | 4.5 | 4.302 |
| **68** | 2018-08-29 | 05:31:27 | 34.613 | 46.291 | 4.3 | 4.364 |
| **69** | 2018-08-31 | 20:59:05 | 34.608 | 46.127 | 4.5 | 4.625 |
| **70** | 2018-01-09 | 05:29:49 | 34.344 | 45.545 | 4.1 | 4.371 |
| **71** | 2018-09-19 | 18:56:44 | 33.693 | 45.673 | 5.3 | 4.948 |
| **72** | 2018-10-17 | 03:09:15 | 34.433 | 45.475 | 4.3 | 4.489 |
| **73** | 2018-11-17 | 19:12:44 | 34.609 | 46.293 | 4.5 | 4.331 |
| **74** | 2018-11-25 | 17:02:44 | 34.348 | 45.665 | 4.5 | 4.590 |
| **75** | 2018-11-27 | 06:27:50 | 34.385 | 45.707 | 4.7 | 4.647 |
| **76** | 2018-09-12 | 03:19:03 | 34.364 | 45.744 | 4.3 | 4.615 |
| **77** | 2019-12-03 | 11:58:23 | 34.243 | 45.580 | 4.5 | 4.555 |
| **78** | 2019-01-04 | 10:13:59 | 33.704 | 45.713 | 5.1 | 4.900 |
| **79** | 2019-01-04 | 10:51:59 | 33.702 | 45.799 | 4.2 | 4.230 |
| **80** | 2019-04-17 | 19:59:57 | 33.188 | 46.445 | 4.4 | 4.201 |
| **81** | 2019-11-05 | 10:17:42 | 34.870 | 45.755 | 4.4 | 4.894 |
| **82** | 2019-07-17 | 15:17:59 | 34.452 | 45.614 | 4.5 | 4.278 |
| **83** | 2019-09-17 | 19:27:59 | 35.313 | 46.282 | 4.1 | 4.403 |
| **84** | 2020-09-01 | 10:49:56 | 34.739 | 45.501 | 4.9 | 4.552 |
| **85** | 2020-01-28 | 20:32:06 | 33.712 | 45.757 | 4.4 | 4.353 |
| **86** | 2020-01-29 | 04:52:58 | 33.682 | 45.783 | 4.1 | 4.449 |
| **87** | 2020-01-29 | 17:58:25 | 37.246 | 45.038 | 4.1 | 4.658 |
| **88** | 2020-03-13 | 06:58:23 | 32.720 | 47.490 | 4.3 | 4.547 |
| **89** | 2020-03-16 | 06:57:12 | 35.640 | 44.240 | 4.0 | 4.418 |
| **90** | 2020-06-04 | 07:44:56 | 34.522 | 45.232 | 4.4 | 4.427 |
| **91** | 2020-10-04 | 13:11:10 | 34.550 | 45.298 | 4.0 | 4.246 |
| **92** | 2020-05-18 | 17:10:13 | 34.175 | 45.597 | 4.2 | 4.338 |
| **93** | 2020-03-07 | 19:29:36 | 35.112 | 45.347 | 5.0 | 4.438 |
| **94** | 2020-07-07 | 08:00:59 | 34.314 | 45.695 | 4.4 | 4.503 |
| **95** | 2020-07-07 | 12:57:58 | 34.326 | 45.596 | 5.1 | 4.487 |
| **96** | 2020-08-07 | 06:57:32 | 34.317 | 45.586 | 4.2 | 4.439 |
| **97** | 2020-09-08 | 08:56:44 | 34.198 | 45.582 | 4.3 | 4.654 |

| | | | | | | |
|---|---|---|---|---|---|---|
| **98** | 2021-01-26 | 09:59:26 | 36.200 | 41.210 | 4.8 | 4.470 |
| **99** | 2021-01-26 | 11:08:50 | 36.214 | 41.229 | 4.1 | 4.860 |
| **100** | 2021-01-02 | 22:08:31 | 36.332 | 41.110 | 5.1 | 4.604 |
| **101** | 2021-10-02 | 04:58:40 | 36.388 | 41.286 | 4.1 | 4.297 |
| **102** | 2021-11-02 | 22:01:57 | 34.629 | 45.290 | 4.4 | 4.701 |
| **103** | 2021-03-14 | 22:41:28 | 34.328 | 45.440 | 4.3 | 4.361 |
| **104** | 2021-06-04 | 14:58:26 | 35.705 | 46.014 | 4.0 | 4.988 |
| **105** | 2021-06-09 | 12:12:44 | 37.553 | 44.213 | 4.0 | 4.298 |
| **106** | 2021-08-09 | 15:36:50 | 34.770 | 45.222 | 5.3 | 4.652 |
| **107** | 2021-09-24 | 23:36:08 | 36.655 | 42.354 | 4.6 | 4.468 |
| **108** | 2021-09-28 | 08:53:25 | 34.572 | 45.433 | 4.3 | 4.417 |

**Table 3:** Some of the seismic events that have been studied. The table includes the date of the event, the station code, the epicentral distance between the event and the station recorded for it in km, duration in seconds, duration magnitude, and local magnitude.

| *No.* | *Data* | *Station Name Code* | *Distance (Km)* | *Duration (second)* | $M_d$ | $M_L$ |
|---|---|---|---|---|---|---|
| **1** | 2011-11-29 | IBDR | 193.245 | 235 | 4.15 | 4.0 |
| **2** | 2011-06-12 | RTB | 577.607 | 527 | 4.44 | 4.5 |
| **3** | 2012-10-03 | IKRK | 393.409 | 331 | 4.27 | 4.4 |
| **4** | 2012-04-21 | BHD | 270.707 | 897 | 4.64 | 4.9 |
| **5** | 2012-04-24 | BHD | 258.707 | 403 | 4.34 | 4.5 |
| **6** | 2013-05-11 | RTB | 483.54 | 533 | 4.44 | 4.4 |
| **7** | 2013-11-22 | MSL | 307.484 | 285 | 4.21 | 4.1 |
| **8** | 2015-02-15 | NSR | 136.880 | 747 | 4.58 | 4.7 |
| **9** | 2016-10-08 | BHD | 287.571 | 533 | 4.45 | 4.4 |
| **10** | 2016-11-15 | RAFI | 235.775 | 461 | 4.40 | 4.4 |
| **11** | 2017-12-11 | IBDR | 168.664 | 210 | 4.10 | 4.0 |
| **12** | 2017-12-11 | RAFI | 352.124 | 324 | 4.26 | 4.7 |
| **13** | 2017-11-13 | RAFI | 336.833 | 321 | 4.66 | 4.9 |
| **14** | 2017-11-13 | BHD | 182.597 | 433 | 4.38 | 4.8 |
| **15** | 2018-08-29 | IBDR | 170.417 | 455 | 4.39 | 4.8 |
| **16** | 2018-08-31 | IKRK | 185.055 | 825 | 4.61 | 4.9 |
| **17** | 2019-11-05 | IBDR | 196.367 | 1743 | 4.98 | 5.3 |
| **18** | 2019-09-17 | BHD | 286.582 | 483 | 4.41 | 4.6 |
| **19** | 2020-01-29 | RAFI | 653.497 | 859 | 4.62 | 4.9 |
| **20** | 2020-03-16 | RAFI | 497.588 | 564 | 4.46 | 4.4 |
| **21** | 2020-03-16 | MSL | 127.994 | 472 | 4.41 | 4.4 |
| **22** | 2020-03-07 | MSL | 243.282 | 590 | 4.49 | 4.0 |
| **23** | 2021-08-09 | IKRK | 106.526 | 1067 | 4.71 | 4.6 |
| **24** | 2021-09-24 | IBDR | 511.554 | 457 | 4.38 | 4.3 |
| **25** | 2021-09-28 | IKRK | 135.614 | 511 | 4.44 | 4.0 |

## 5. Discussion

In this study, the duration was calculated manually, along with the seismic data taken from the Iraqi Meteorological Organization and seismology. The method used to estimate signal duration depends on the noise level amplitude before and after the event. After data collection and working on Seisan and Excel software, parameters a, b and c, were determined to establish the duration magnitude relationship by linear regression analysis. Then, the station correction factor was calculated for the statistical significance of the recording stations in the used database.

Seismic stations should be placed strategically and in particular low-noise locations. However, some network stations are placed in places that are not ideal for seismic recording, and therefore their recordings are high in noise, which affects the accuracy of determining the duration, in addition to stopping several stations for a while and then returning them to work, which causes difficulty in working.

Thus, each seismic station can respond to seismic waves differently due to the influence of specific physical factors. These characteristics may be related to the geological and environmental conditions at each station, which can influence the response of the seismic sensors.

Only the vertical components of the seismic data were utilized to calculate the duration. The amplitude (and hence the duration) of the different components of the Earth's motion can vary substantially as a function of the source's radiation pattern at a given distance from the source to the receiver and the earthquake magnitude

.

Although such a technique is predicted to produce a reasonable estimate of distance for regional events (that is, distances >100 km), it may provide biased results findings for distances (R > 700 km) that are likely to be connected to amplitude.

## 6. Conclusions

Regarding the practical implementation of the proposed methodology, the duration magnitude calculation routine can easily be incorporated into the procedures currently running on the (IMOS) for magnitude calculation. The extracted duration magnitude equation can also be used to obtain more accurate magnitude values from the local magnitude. Furthermore, several factors can be optimized to obtain larger magnitude estimates for stability and reliability. For example, more restrictive criteria for selecting records can be adopted, and the equipment used in stations can be developed to obtain greater accuracy.

The empirical formula for the duration magnitude scale was developed using primary seismic data from the IMOS seismic stations. As a result, the magnitude equations are influenced by the precision and trustworthiness of the seismic data employed.

There may be some inadvertent mistakes, and errors might occur if the end of the event is not appropriately estimated. The station adjustment has been taken into consideration.

The suggested technique can give a quick, impartial, and data-driven estimate of event magnitude and can be a helpful tool for the comprehensive/statistical study of the (IMOS) recorded earthquakes.

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