A MICROSEISMIC STUDY IN THE DERBENDIKHAN DAM AREA NORTH EASTERN IRAQ

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SUMMARY

The investigation of Derbendikhan dam site represents the first step in a program to monitor important dams and reservoirs in Iraq. A three component short period seismic system was operated for a total of 1900 hours.

Seventy eight events were identified from different epicentral distances, from which 34 with S-P $\leq$ 2 sec identified as induced events.

The recorded data was subjected to statistical analysis to determine rate of occurrence, variation with time and other parameters relating epicentral intensity, magnitude and energy release. Ten selected events, five of them induced were fourier analysed and differences between natural and induced events were noticed in consistency with previous events recorded elswhere in Iraq.

Geology and Seismotectonics

The Derbendikhan Dam area is located in the NE part of Iraq between longitudes 45° 22' 30" - 46° 7' 30" East, and latitudes 35° 30' - 34° 52' 30" North. The dam is constructed on Diyala river, about 60 km southeast of Sulyaimaniya city, Figure (1).

The area is situated in a belt of northeast-southwest trending anticlines and synclines between the Mesopotamian plane and high Zagros mountain along the Iraq-Iran frontier.

The exposed rocks range in age from Paleocene to Miocene. Miocene rocks are the oldest rocks (Kolosh Formation), and the Paleocene rocks are the youngest rocks (Lower Fars Formation). The main geological structures are folds, faults, fissures, cracks, joints and many solution channals (1).

Iraq is located at the northeastern boundary of the Arabian Plate which is marked by a nearly continuous line of epicenters along the Zagros-Tauros mountain ranges (2).

Derbendikhan area is located in folded foreland zone of Zagros-Tauros mountain range. In this case, the seismicity is completely associated with the seismicity of this zone.

Five events having epicenter within the area under investigation, are reported, two of them before filling of the Derbendikhan lake, the other three after the filling (2). Good correlation between macro and micro seismicity of the area was observed.

The height of Derbendikhan dam is about 128 meters, and the overall reservoir volume is 3 milyar cubic meters.

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The reservoir triggers seismic activity either by increasing the pressure in the ground water, or by adding to the existing solid stress (3).

The hight of the water seems to be more important than the total volume of the reservoir, and some particular geological conditions are necessary for the release of the shocks, such as old faults, fissures, cracks and joints (4).

Previous Work

The first microearthquake survey of Iraq was carried during 1975 (5). This was of recconniassance type, which was followed in 1976 by a detailed study of a certain area (6). As for studying induced events, a detailed study was carried in Mishrag Sulphur mine during 1977 (7).

Data Collection

Seismic activity in Derbendikhan area, was monitored during the period from January 1978 up to March 1978, using the portable three component, high gain, short period seismic system of the Department of Geology, University of Baghdad.

The total recording time obtained was 1900 hours of continuous recording, of which only 1550 hours were used for statistical analysis, and for fourier analysis, (1).

78 events were identified from different epicentral distances, out of these events 34 were found to have $S-P \leqslant 2$ sec. (Plate 1). These were considered to be related to the hight of water in Derbendikhan lake. The remaining events which have $S-P > 2$ second were considered as background natural events, Plate (2).

STATISTICAL ANALYSIS

a: The rate of microearthquake occurrence, was equal to 1.46 event per day for the total number of events, and 0.518 event per day for the induced events.

b: The daily variation indicates that there are peaks of high activity in the hours from 02-04 GST and from 14-20. for the total number of events. As induced seismic events the hours from 16-20 GST are active.

c: The spatial distribution is unimodel and have its peak between 0-1 second corresponding to epicentral distance from 0-10 km.

d: The duration of oscillation, which is a measure of the energy radiated during earthquakes varies inversly with the number of events. The predominant duration of oscillation is 50 second for total number of events, and ranges from 0-25 seconds for the induced events.

e: There is poor correlation between observed data and the Poisson's distribution.

f: The value of constant (m) in Ishimoto-Iida relation (8) was computed to be 1.14, 1.10, 1.24, for Z, E-W, and N-S components respectively, for the total number of events, while for induced events it was found to be 1.11, 1.39, 1.31 for the three components respectively.

g: The relation between magnitude and epicentral intensity is linear and is represented by equation 1. The relation between magnitude and energy release is also linear, and is represented by equation (2), (9)(10).

$$M = 2.177 + 1.670\ Io \quad \ldots\ldots\ (1)$$
$$\log E = 11.784 + 1.522\ M \quad \ldots\ldots\ (2)$$

h: There exists positive relation between water level in Derbendikhan Lake and number of events having S-P$\leqslant$2 sec., is observed, Fig. (2).

Fourier Analysis

Ten events were Fourier analysised five events were natural, while the other five were induced. The general conclusions from the analysis are:

(a) The predominant frequency for the P-wave of natural events ranges between 0.25-3.8 HZ, for the three components, while for induced event it ranges between 0.5-4.0 HZ for the three components.
(b) The decrease in energy of the P-wave reaches a value of about 35% at a frequency range of 2-4 Hz, while for the induced events it ranges between 3-5 Hz.
(c) The maximum amplitude spectra appear in the range from 0.5-4.8 Hz for natural events, and from 1.5-4 Hz for induced events.
(d) The induced events are characterized by high frequency, short duration of oscillation, and short S-P interval.
(e) The shape of amplitude spectra of induced events is simple, while the shape of natural events is more complicated.
(f) All the results of natural event are consistent with the results obtained by (6) and (7). The results of induced events is also consistent with those obtained at the Mishrag Sulphur Mine (7).

References

(1) Ayar, B.S. (1978) "Seismicity Investigation of Derbendikhan Area" M.Sc. Thesis, University of Baghdad, 140 p. Unpublished.
(2) Alsinawi, S.A. and Ghalib, H.(1975) "Seismicity and Seismotectonics of Iraq" Bull. Coll. Sci. Univ. Baghdad, vol. 16, pp. 369-413.
(3) Gough, D.I. (1976) "Induced Seismicity" Intergovernmental Conference on Eq. Mitigation-SC-76/Seism/6- Unesco, Paris.
(4) Rothe, J.P. (1970) "Seismic Artificials" Tectonophysics vol. 9, p. 215-238.
(5) Alsinawi, S.A. and Banno, I. (1976) "Microearthquake Survey of Iraq" Bull. Coll. Sci. Univ. Baghdad, vol. 17(1), 201-230.
(6) Alsinawi, S.A. and Al-Shukri, H.J. (1979) "Microseismicity of the Badra Area, Iraq" Tectonophysics, 60(pp. 289-292).
(7) Alsinawi, S.A. and Al-Eqabi, G. (1978) "Induced microearthquake activity in the Mishrag Sulphur Mine" Fifth Iraqi Geol. Cong. Proc., Baghdad (in Print).
(8) Ishimoto, M. and Iida, K. (1939) " Observations Sur les Seismes envegistres pare Le microseismographe construit devnierement (1) Bull. Earthq. Res. Inst. v. 17, pp.443-478.

(9) Tsumura, K. (1967) "Determination of earthquake magnitude from total duration of oscillation, Bull. Earthq. Res. Inst. v. 15, pp. 7-18.
(10) Gutenberg, B. and Richter, C.F. (1956) "Earthquake magnitude, Intensity, energy and acceleration" Bull. Seism. Soc. Amer. v. 46, pp. 105-143.

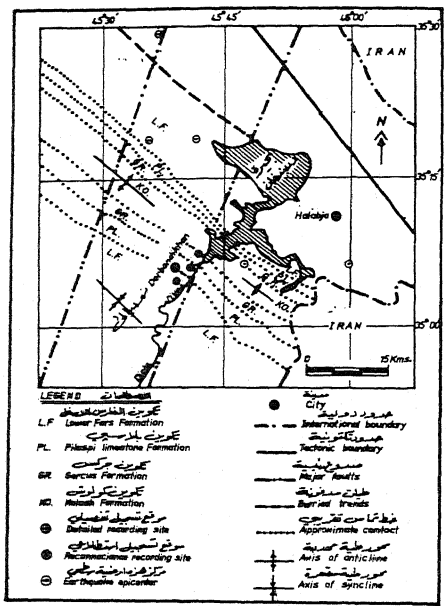

Fig. 1. General geologic and seismotectonic map of Derbendikhan, showing the recording sites.

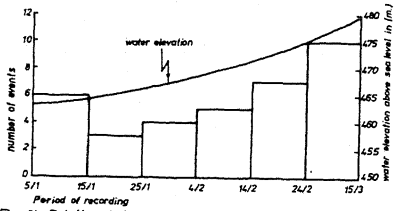

Fig. 2. Relation between the number of induced events and elevation of water in Derbendikhan lake.

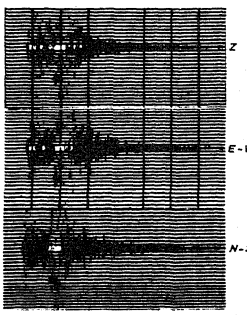

PLATE 1.

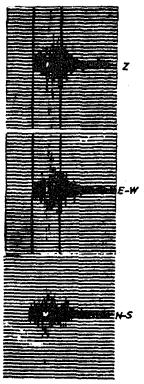

PLATE 2.