made to find common characteristics, and to relate these with physical conditions of rock properties and stress. The conclusion is reached that the artificial lakes must change the mechanical properties of the rock, to allow a large magnitude shock to occur. Details of how this can happen follow in the next two chapters. The methods of stress calculation devised by Gough and Gough for the study of the Kariba Reservoir are given in detail, and the conclusion reiterated that in general incremental stress due to water loading is not a prime factor in generating reservoir-associated earthquakes.

The discussion of the role of pore pressure follows that given by Snow, and vindicates the theory of Hubbert and Rubey. The discussion on the effect of increased pore pressure in areas of differing tectonic regime is particularly useful, indicating that areas of normal or strike-slip faulting should be more prone to induced seismicity than those of reverse faulting.

In a book such as this some mistakes and defects will occur. Figs. 79 and 80 are interchanged, for example, confusing maps of pre- and post-impounding earthquakes near Lake Benmore. It is also hard to believe, as reported on p. 73, that an 87,000 km^2 area of Greece experienced 28 earthquakes of magnitude 7.1 or more from 1953 to 1965. Such errors, although regrettable, will be noticed only by the most careful reader, to whom they will be immediately obvious.

This book is timely as its topic is well related to current interest in earthquake prediction and control. It is the first book to have been devoted exclusively to the subject, and doubtless will be followed by others as the subject develops. Although it suffers from some deficiencies, it will remain a very useful summary of both case histories and theory, and will give practical leads in helping to decide which factors determine whether or not a given reservoir is likely to be associated with an increase in seismicity.

R. D. ADAMS

This review was originally published in "Physics of the Earth and Planeting Interiors", 13(1), Oct. 1976 and is reproduced with the permission of the author and the publisher.

EARTHQUAKE NOTES

GAZLI, MAY 1976 EARTHQUAKE

The last issue of the Bulletin contained a brief note on the strong-motion record obtained during the 17 May, 1976 earthquake at Gazli, U.S.S.R. Additional information on the earthquake appeared in a recent U.S. Geological Survey Circular and is reproduced here in a somewhat abbreviated form.

"Two days after the April 8, 1976 earthquake (M_S = 7.0) in the western Kysulkum Desert (40.5°N., 63.8°E.), the Institute of the Physics of the Earth (U.S.S.R. Academy of Sciences, Moscow) began operating portable seismic stations in the epicentral area. Initially, a station was established at Gazli, a small town 30 km south of the epicenter, and later at Karakyr Point, located very close to the epicenter of the April 8 event.

The subsurface geology at Karakyr Point consists of clay and sandstone, 1420 m thick, underlain by highly resistant metamorphic schist. During the weeks after the April 8 earthquake, other portable stations were installed in the epicentral area by the Seismological Institute of the Uzbek Academy of Sciences (Tashkent) and other institutions.

From April 10 to May 16 more than 100 aftershocks of the strong April 8 foreshock were recorded, some of them with felt intensities up to VI (M.M. Intensity Scale). The main shock of the sequence occurred on May 17 at 0258:32 GMT with co-ordinates 40.26°N., 63.30°E.; focal depth about 25-30 km; and magnitude M_S = 7.2. The preliminary fault plane solution for the main shock gives a dip-slip mechanism. More than 100 aftershocks were recorded during the next few months; the strongest had a felt intensity of about M.M. VII at the epicenter.

The main shock of May 17 was felt in Gazli with an intensity of about IX. All brick buildings were substantially destroyed, all panel buildings were seriously damaged and cracks appeared in asphalt roads and concrete pavements. Fortunately, the entire population of Gazli had been evacuated after the first shock of April 8 and was living in nearby temporary wooden buildings and tents. Consequently, casualties related to the main shock were held to a minimum. At Karakyr Point the only adobe building collapsed, and cracks up to 10 m long and approximately 1 cm wide were observed in the ground.

The strong-motion record from the main shock of May 17 has some defects: the film supply was depleted while the earthquake was in progress (record is therefore limited to the first 15 sec of strong motion); some parts of the film were slightly spoiled (the record was restored by copying the record using a more suitable exposure time); and irregular film movement took place during a short interval of about one sec^2 (it is probable that the acceleration related to the film transport system was constant during this time interval and thus corresponding corrections were introduced in the record).

The May 17 accelerogram shows the unusual nature of the strong motion, particularly the gradual increase of trace amplitude (the maximum amplitude for each component is indicated approximately 8 sec after the instrument triggered). The maximum recorded acceleration is 1.3 g (one-half of peak-to-peak acceleration) at a period of 0.063 sec. The duration of strong-motion acceleration $\geq$0.5 g is about 6 sec, and the amplitudes of horizontal motion are approximately one-half those of the vertical motion. The aftershock accelerograms are typical of strong-motion records from nearby earthquakes."

The original article in the U.S. Geological Survey Circular describes the recording instruments in detail, and also contains two photographs of damaged buildings at Gazli. The report was compiled by C. Rojahn of the U.S. Geological Survey (who visited the region late in 1976), using material received from N. V. Shebalin.

A copy of the digitized strong-motion record has been obtained from the U.S. Geological Survey, and corrected by PEL. Preliminary processing indicates that the corrected peak ground motion parameters are about 2 to 3 times that recorded in El Centro, although there is considerable doubt as to the validity of the vertical component.

THE MAGNITUDE OF EARTHQUAKES

The use of various types of earthquake magnitude may confuse some engineers. Publication of Warwick Smith's paper in this Bulletin provides an opportunity to clarify the concept.

The concept of earthquake magnitude was introduced to represent in a simple way the size of an earthquake, and is an attempt to relate this to the radiated energy.

Magnitudes are of three main types. Local magnitudes make use of observations at seismographs within about 2000 km, while for earthquakes at greater distances, magnitudes may be found from either surface waves or body waves. Magnitudes are derived from the common logarithm of the maximum amplitude of the particular phase recorded on the seismogram, and in some instances the corresponding period of the phase must also be used.

The first definition of magnitude, by Richter in 1935, was intended only for local Californian earthquakes. It was determined from the record of standard Wood-Anderson torsion seismographs of period 0.8 s, within 600 km of the earthquake. This local magnitude, M_L, was defined as log A - log A_o, where A was the maximum trace displacement in millimetres, and A_o a term varying with distance. A_o was chosen so that the logarithm of the trace amplitude in micrometres gave the magnitude directly when the earthquake was 100 km away.

In 1945 Gutenberg extended the magnitude scale to be applicable to distant earthquakes by measuring the amplitude of surface waves of period about 20 s. Surface-wave magnitudes, M_s, may be found from long-period recordings of shallow earthquakes, but it is often desirable to be able to determine magnitudes from body waves (P and S waves) recorded on short-period seismographs. For deep earthquakes, that produce no surface waves, magnitudes from body waves are the only ones available. In 1956, therefore, Gutenberg and Richter defined "body-wave magnitude", denoted by m_b. This is derived from the logarithm of the maximum value of the ratio of the amplitude to the corresponding period of the wave considered, and may be determined from the phases P, PP or S.

In recent years, the concept of seismic moment, M_o, has also become useful as a supplement to magnitude. This has the physical representation of the product of the fault area, the displacement, and the rigidity modulus of the rock, with dimensions of newton-metres. It cannot be derived simply from seismograms, except in some cases by integration, and is usually determined from the zero-frequency level of the spectrum of radiated energy. The magnitudes M_s, m_b and M_L are derived from waves of different period, and with moment, M_o, are distinct spectral parameters of an earthquake. Their relative values in any particular earthquake will thus depend on the spectral characteristics of that earthquake. One must not therefore expect to find simple relations that are universally applicable among the various types of magnitude. In early studies, however, efforts were made to relate all magnitudes to the radiated energy of earthquakes. This led to the development of formulae such as

$$m_b = 1.7 + 0.8\ M_L - 0.01\ M_L^2$$

$$m_b = 0.63\ M_s + 2.5$$

Such formulae may be used as a rough guide to average relationships between the different magnitude scales, but it is wiser to consider each scale as representing the energy content at a different period and to realise that the same earthquake will in general be expected to have significantly different readings on the three scales.

Typical relations might be:-

M_s	m_b	M_L
5.0	5.6	5.4
5.5	6.0	5.8
6.0	6.3	6.2
6.5	6.6	6.6
7.0	6.9	7.0
7.5	7.2	7.4
8.0	7.5	7.8

UNIVERSITY PUBLICATIONS

In an effort to keep readers abreast of research activities in New Zealand Universities, we list below recent thesis, reports and publications of the Civil Engineering Departments of Canterbury and Auckland Universities. The list is restricted to thesis on structural and earthquake engineering and publications on earthquake engineering since 1976, excluding articles in N.Z. Engineering or in the Bulletin.

Canterbury University

Theses and Project Reports:

Moore, T. A., "Finite Element Analysis of Box-Girder Bridges". Ph.D. Thesis, 1976.

Thompson, K. J., "Ductility of Concrete Frames under Seismic Loading". Ph.D. Thesis, 1976.

Wilby, G. K., "Response of Concrete Structures to Seismic Motions". Ph.D. Thesis, 1976.

Travers, J. H., "A Study in Earthquake Engineering - In Particular: Considerations of the Seismic Response of Layered Ground". M.E. Thesis, 1976.

Munro, I. R. M., "Seismic Behaviour of Reinforced Concrete Bridge Piers". M.E. Project Report, 1976.

Paul, R. J., "Dynamic Behaviour of Storage Tanks". M.E. Project Report, 1976.