
Introduction

1. Generalities

For the Maghreb region, earthquake hazard constitutes a constant threat to human life and property, sometimes causing major economic losses and disruption. The rapid urbanization, development of critical engineering works, industrialization of cities with modern types of buildings and the concentration of populations living or settling in hazardous areas are matters of growing concern, as they contribute to heavier loss of life and increase considerably the costs of disaster damage. In recognition of the threat to the major investment at risk in this part of the World from strong earthquakes, governments of the respective countries should multiply and join their efforts to continue the study and analysis of the seismicity of the region with a view to reducing the earthquake risk; this is a field of research where interaction and cooperation of teams in the different concerned countries may give the best results in the short term. The first step in mitigating the risk of the community from earthquake hazard is an assessment of the hazard itself. The environmental concerns and an increased official and public awareness of earthquake hazards has, in the last decade, led to a rapid rise of interest in seismicity and seismic hazard and risk evaluations in the Maghreb region. For this purpose, this project is intended to investigate the seismicity of the region, *i.e.* to derive laws governing the space and time distribution of earthquake occurrence in different seismic zones using both macroseismic and instrumental observations.

2. Statement of problem

The increasing interest in the evaluation of seismic hazard in the Maghreb region as a result of the construction of large engineering structures, such as dams and nuclear power plants, and the siting of new complex industrial and residential zones require earthquake data which are as accurate, complete and homogeneous as possible. For this purpose, and from the point of view of long term prediction and seismic hazard assessment, it is imperative that input data in the Algerian and neighbouring region catalogues be revised and homogenized. Although catalogues or listings of the Maghreb region are available, they cover different time periods, use different types of magnitudes, are incomplete at a given region and are grossly deficient in several respects, particularly in magnitude, depth and location. For some events, especially those prior to 1960, epicentral locations, magnitudes and other pertinent earthquake characteristics are inaccurate or simply not available. Some of these catalogues of Hée (1925,1950), Rothé (1950), Roussel (1973) and other more recent works are derivative of earlier compilations, containing no new information, and occasionally having errors and duplications in entries. Due to these deficiencies, the first task was to establish an inventory of all existing catalogues covering the region for this period and to compare and combine their entries. This procedure allows one to check the accuracy of the catalogues and, in particular, the naming of original sources used in their compilation. New macroseis-

mic data retrieved from primary sources, such as published technical papers, newspaper reports, special studies, historical records and also unpublished material, are used to solve ambiguities among catalogues and to improve the regional coverage. The macroseismic information and the re-examination of instrumental observations are utilized to relocate the position and recalculate the size of major earthquakes during the twentieth century.

From this improved earthquake data, purged of spurious and erroneous events, the analysis of the seismicity in the region has been realized and the laws controlling the space and time distribution of earthquake occurrences in the Maghreb region have been derived. A small number of most important events, which represents the seismicity in the region, is selected, and each of them is then studied in detail; macroseismic data were completely revised, surface-wave magnitude computed, macroseismic and instrumental epicentres relocated, intensities re-evaluated and an isoseismal map was constructed. From this data sample, magnitude-intensity and intensity-attenuation laws have been derived.

3. Specific problem and research aims

The main purpose of this work is to establish a uniform catalogue of all earthquakes reported in the Maghreb region, which satisfies the conditions of homogeneity, and to derive from this basic data set the general laws inherent in the seismic activity of this region.

The area under consideration, which is defined as the Maghreb, includes Algeria, Morocco, Tunisia and the South Iberian Peninsula, is limited by the 20°N and 38°N and 10°W and 12°E, and shown in map 1. The term «Maghreb» is used to illustrate the extent of the interest of this project, although Algeria constitutes our main concern. In fact, there are numerous reasons

for investigating beyond the boundaries of each country and looking rather into the North African-South Iberian Peninsula region, designated as the Maghreb, as a unit and for evaluating the final seismic hazard of the entire zone under similar criteria:

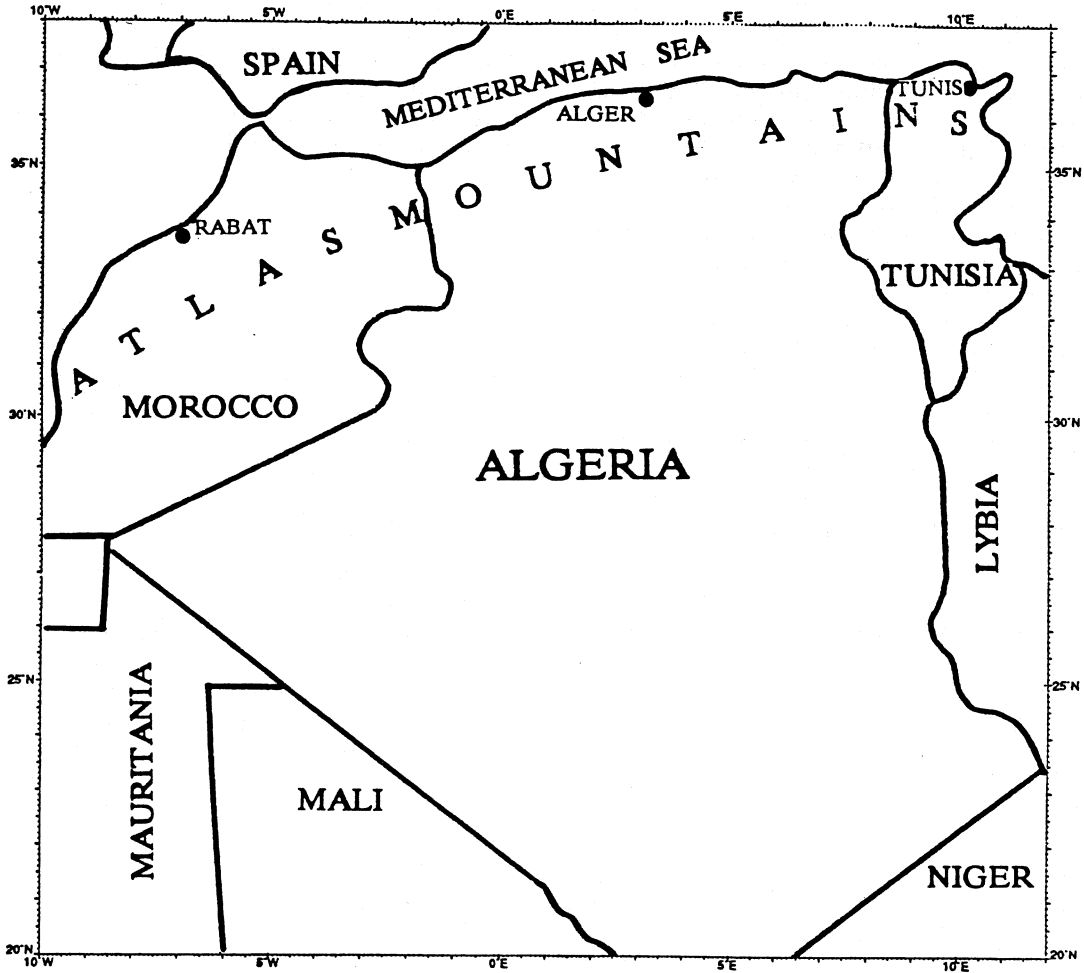
1) similar geological process: the countries limiting the western part of the Mediterranean Sea and its adjacent continuation in the Atlantic Ocean have had, since hundred million years ago, the same tectonic process marked by a relative motion alternating between left and right lateral along the border of the African and Eurasian plates;

2) similar present compressional state of stress: the actual state of stress in the entire region is dominated by a compression with a principal axis along the NNW-SSE direction;

3) similar historical development: the historical development of the countries in the region shows many common factors, such as cultural background, which lasted for several centuries and are still apparent today. Similarities in population settlements, building stock characteristics and socio-economic and demographic conditions, etc., are very important parameters in the whole process of seismic hazard studies in the region.

The selection of this area allows investigation of any earthquake, affecting although not occurring in a specific zone of the Maghreb, which may influence the seismic hazard assessment in any particular zone of the region under survey. The term «Atlas» is used here to define the block containing the Atlas mountains along the whole of North Africa (map 1).

The period between 1900 and 1990 has been chosen for this part of the project. It deals with the twentieth century which is characterized by a rapid development of instrumental seismology and by adequate seismological services operating in and around countries of the Maghreb. It is be-



Map 1. The limits of the region under study defined as the Maghreb.

lieved that during this period of time, homogeneous data for earthquakes above a certain magnitude can be obtained for the entire region. However, the overall detection capability was significantly reduced for long periods of time during the unstable years between 1914 and 1922 and again between 1940 and 1947 as a result of permanent or temporary suspension of some stations and services.

Chapter I examines the various source documentary materials that have been found to include macroseismic data, and correlates the events to the prevailing historical situations throughout the twentieth century. This chapter gives a clear idea of the completeness of data in the region, and acknowledges how different factors have influenced the report of earthquakes recorded during this period.

Chapter II discusses the non-instrumental information; macroseismic data collected directly from field studies and first-hand investigation of regional earthquake effects. This type of information gives a practical framework within which early and recent earthquakes are analyzed by using a uniform methodology. It also deals with the distribution, the evolution and the characteristics of the building stock in the region, which constitute major influencing factors during the re-estimation of intensities, and thus the size of the ground shaking.

Chapter III presents brief descriptions of the largest and most informative earthquakes to have occurred in the Maghreb region during the twentieth century. It also illustrates other specific issues of interest which are directly related to earthquake occurrences.

Chapter IV describes the development of the network of seismographic stations in and around the Maghreb region and the problems caused by the imperfection of the instruments. Determination of instrumental magnitudes and their revision as well as epicentres and focal depths are also discussed.

Chapter V examines the historical development of the catalogues and listings of earthquakes which include events in the Maghreb region. It presents the structure and characteristics of the catalogue of earthquakes in the region established in this study. This chapter also presents the application of techniques of completing the homogenized available data. The completeness of this catalogue is then discussed.

Chapter VI presents the results of an investigation of the magnitude-intensity and intensity-attenuation relationships for Atlas zone and Algeria earthquakes using both macroseismic and instrumental information.

Chapter VII deals with the distribution of earthquakes in the Maghreb region. It

gives the regional setting as well as the interpretation of the seismic map obtained from the new catalogue. Frequency-magnitude relationships in different zones of the Maghreb and seismic strain in the Atlas block are discussed.

Conclusions.

4. Impact of research

This work is addressed to a broad range of users, including high-level government officials, administrators, civil engineers, architects, earth scientists, seismologists, planners, technical experts, researchers in all these disciplines, and the general public.

The findings of this research should be an integral part of the whole process of economic and social development in Algeria and adjacent regions. They constitute a fundamental mean which should guide officials at the national and regional levels in the formulation of development strategies in seismically active zones, land-use planning, enforcement of appropriate building code and decision-making of policies for preventive measures against earthquake risk affecting the considered zone.

5. Conclusions

An earthquake catalogue forms a valuable input for seismic hazard assessment and microzonation studies, and represents a work which can never be definitively closed. However, the type of information assembled, which is characterized by an appreciable degree of reliability, completeness and homogeneity, allows one confidently to use the catalogue obtained towards a study of seismicity in the Maghreb region.

The present work supersedes all the previous catalogues for references to earthquakes in the Maghreb region.