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Disaster Prevention and Mitigation

A Compendium of Current Knowledge

Volume 3

SEISMOLOGICAL ASPECTS

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FOREWORD

The Office of the United Nations Disaster Relief Co-ordinator (UNDRO) presents the third volume in the series entitled "Disaster Prevention and Mitigation". The purpose of these publications is to provide the international community with a comprehensive review of existing knowledge of the causes and characteristics of natural phenomena and the preventive measures which may be taken to reduce or eliminate their impact on disaster-prone developing countries.

These volumes are being prepared in accordance with General Assembly resolution 2816 (XXVI), which calls upon the Office of the United Nations Disaster Relief Co-ordinator to promote the study, prevention, control and prediction of natural disasters, including the collection and dissemination of information on technological developments.

The aims of these studies are, first, to identify the existing knowledge and expertise which may be applied directly toward the prevention of natural disasters, particularly in developing countries and, secondly, to identify the gaps in current knowledge which require concerted action by the international community.

During the last two decades the international community has become increasingly alarmed by disasters, which have tended to be more destructive as they affect ever larger concentrations of population.

While the response of the international community has been focussed primarily on relief action, it is now realized that the actual and potential consequences of disasters are becoming so serious and increasingly global in scale that much greater emphasis will henceforth have to be given to planning and prevention. The effects of natural phenomena must be viewed not only in humanitarian and broad social terms, but also - and primarily - in economic terms. Natural disasters are a formidable obstacle to economic and social development. In terms of percentage of gross national product, the losses caused by disasters in some disaster-prone developing countries more than cancel out any real economic growth. There has thus been a growing awareness by Governments of the need to focus more attention on disaster preparedness and prevention, and a recognition of the fact that disaster prevention and pre-disaster planning should be an integral part of national development policy.

The "International Strategy for Disaster Prevention", proposed by UNDRO and approved by the General Assembly at its twenty-ninth and thirtieth sessions, will provide the conceptual framework for all national and international action in the prevention and mitigation of natural disasters. This strategy will harness the collective human and material resources of the world towards removing the scourge which natural disasters represent for many disaster-prone developing countries. The present series on "Disaster Prevention and Mitigation" provides one of the inputs for the formulation of the strategy.

The present volume, Seismological Aspects, deals mainly with ways of studying earthquakes and the measures which can be taken to mitigate or prevent their disastrous effects. It also discusses the different

methods devised for this purpose and identifies subject areas in which research is still necessary.

All the publications in the series "Disaster Prevention and Mitigation" are addressed to a broad range of users, including high-level government officials, administrators, technical experts in the field and specialists in the various areas of disaster prevention. They are also designed to guide officials at the national and regional level in the formulation of policies for preventive measures against the types of natural phenomena affecting their region.

The Office of the United Nations Disaster Relief Co-ordinator invites the readers of this volume, Seismological Aspects, to provide the United Nations with their comments and suggestions.

This publication was prepared by the Office of the United Nations Disaster Relief Co-ordinator with the collaboration of Mr. Alberto Castellani and Mr. Jean Rothé. The production of this volume, as well as the other studies in this series, was made possible by the active co-operation of the United Nations Environment Programme (UNEP).

CONTENTS

I. INTRODUCTION

The earthquake record

Since ancient times earthquakes have always been regarded as one of the most formidable natural threats to human life and property. The suddenness of their occurrence without any warning, the noise which often accompanies them, the violence of movements which in a few seconds turn a prosperous town into a pile of rubble, their effects on the terrain - cave-ins, faults, mountain landslides, clouds of dust - all contribute to man's fear and helplessness.

It is estimated that since the year 1000 A.D. more than five million people have perished in earthquakes. In fact, the numerical estimates that can be attempted vary widely according to the period considered. For the quarter-century 1926-1950, Montandon (1959) give a total of slightly more than 350,000 victims, or about 15,200 a year. For the recent period, 1949-1968, the figures are lower: 75,000, or less than 4,000 a year. One can recall the toll of the earthquake in Peru (31 May 1970): 54,000 dead, 150,000 injured and 1,700,000 homeless. The Tokyo earthquake (1 September 1923) caused 140,000 deaths, destroyed or set fire to 575,000 houses and damaged 126,000 others. The Tashkent earthquake (25 April 1966), although it caused the deaths of only 10 people, nevertheless injured 1,000 and destroyed 28,000 houses, leaving 250,000 people homeless. Many more examples could be given.

The average annual number of victims since the beginning of the twentieth century may be about 24,000. Since 1975, however, the record has been particularly serious: destructive earthquakes have struck densely populated areas in Guatemala, Indonesia, Italy, Turkey, Romania and especially China (over 650,000 dead).

Very high figures have been given for various earthquake disasters in history :

1556	Shan-tse	(China)	830,000 dead
1693	Sicily	(Italy)	60,000 dead
1730	Hokkaido	(Japan)	137,000 dead
1737	Calcutta	(India)	300,000 dead
1755	Lisbon	(Portugal)	60,000 dead
1783	Calabria	(Italy)	50,000 dead
1797	Peru and Equador		40,000 dead
1868	Peru and Equador		40,000 dead
1908	Messina	(Italy)	83,000 dead
1920	Kansu	(China)	100,000 dead
1923	Tokyo	(Japan)	140,000 dead
1970	Chimbote	(Peru)	54,000 dead
1976	Tangshan	(China) more than	650,000 dead
1976	Guatemala		22,778 dead
1977	Bucharest	(Romania)	1,570 dead

For a single country, the time interval between disasters is often very irregular. The example of Italy is particularly characteristic: four disasters occurred in 25 years between 1905 and 1930, with a total of 120,000 victims; after 1930, there was no big earthquake until the Friuli disaster in 1976. In several countries subject to earthquakes (Yugoslavia, Morocco, etc.) however, there has so far been only one serious disaster during the twentieth century, and in Romania only two.

This irregularity underscores the need to study earthquake risk over periods which are as long as possible, covering several hundred years. Some writers consider that a period of 1,000 years is necessary (see: International Atomic Energy Agency, Earthquake Guidelines for Reactor Siting, Vienna, 1973). Such a study would entail long and difficult historical research.

The material losses due to earthquakes are difficult to express in accurate figures, owing to the lack of precise statistics. Moreover, variations in exchange rates, inflation and living standards make it difficult to compare the estimates made for different disasters. The following are some of the figures published for recent disasters:

26 July 1963	Skopje (Yugoslavia)	500 million dollars
28 March 1964	Alaska (USA)	538 " " " "
29 July 1967	Caracas (Venezuela)	50 " " " "
13 August 1967	Arette (France)	4 " " " "
15 January 1968	Sicily (Italy)	320 " " " "
29 September 1969	South Africa	24 " " " "
31 March 1970	Peru	507 " " " "
9 February 1971	California (USA)	553 " " " "
23 December 1972	Managua (Nicaragua)	800 " " " "

These figures are not easily comparable; a more accurate way of assessing damage would be to evaluate the amount of damage, for example, as a percentage of the gross national product. Such evaluations are still very rare. It can only be pointed out that from this point of view, the earthquake of May 1960 in Chile, of 1963 at Skopje in Yugoslavia, of 31 May 1970 in Peru and, especially, that of February 1976 in Guatemala were genuine national calamities which had a heavy impact on the economy of the stricken country. The repeated effect of relatively slight but numerous shocks can also be important : the damage caused by the 2500 shocks felt between January and June 1972 in the region of Ancona(Italy) was estimated at 300 million dollars.

To the purely material damage must be added the direct and indirect economic consequences: abandonment of towns and villages, forced unemployment, production losses and additional cost of health and other social services. These economic losses are much more difficult to evaluate, but they are often greater than the material damage when expressed as a percentage of the national product.

The human and economic losses are today particularly serious in the developing countries. The increase in population and the tendency towards urban concentration may increase the toll of future earthquakes when the focus is near large cities,as occurred in China, Guatemala, Turkey and recently in Romania. A map showing epicentres is very different from one showing the effects of earthquakes on humanity. The distribution of population tends to concentrate human losses in the Mediterranean basin, Western Asia and along the Pacific coast (fig. 1-1).

The seismicity of the earth remains approximately constant, but during the last few years two phenomena have converged. First, it happens that certain seismic foci have been near densely populated areas; secondly, population growth in the developing countries has caused a very rapid expansion of towns and a considerable proliferation of large urban or semi-urban areas, the growth of which is, for the most part, neither planned nor controlled. The juncture of these two phenomena is causing, and will continue to cause, increasingly severe human and economic losses. It is therefore necessary that not only should urban growth be planned, but also that the process of control should systematically take into account not only earthquake risks, but all natural risks. Taking earthquake risks into consideration in national development and town planning involves not only building standards and methods, but also problems relating to the location of human settlements and the use of land. As to planning and establishment of entirely new human

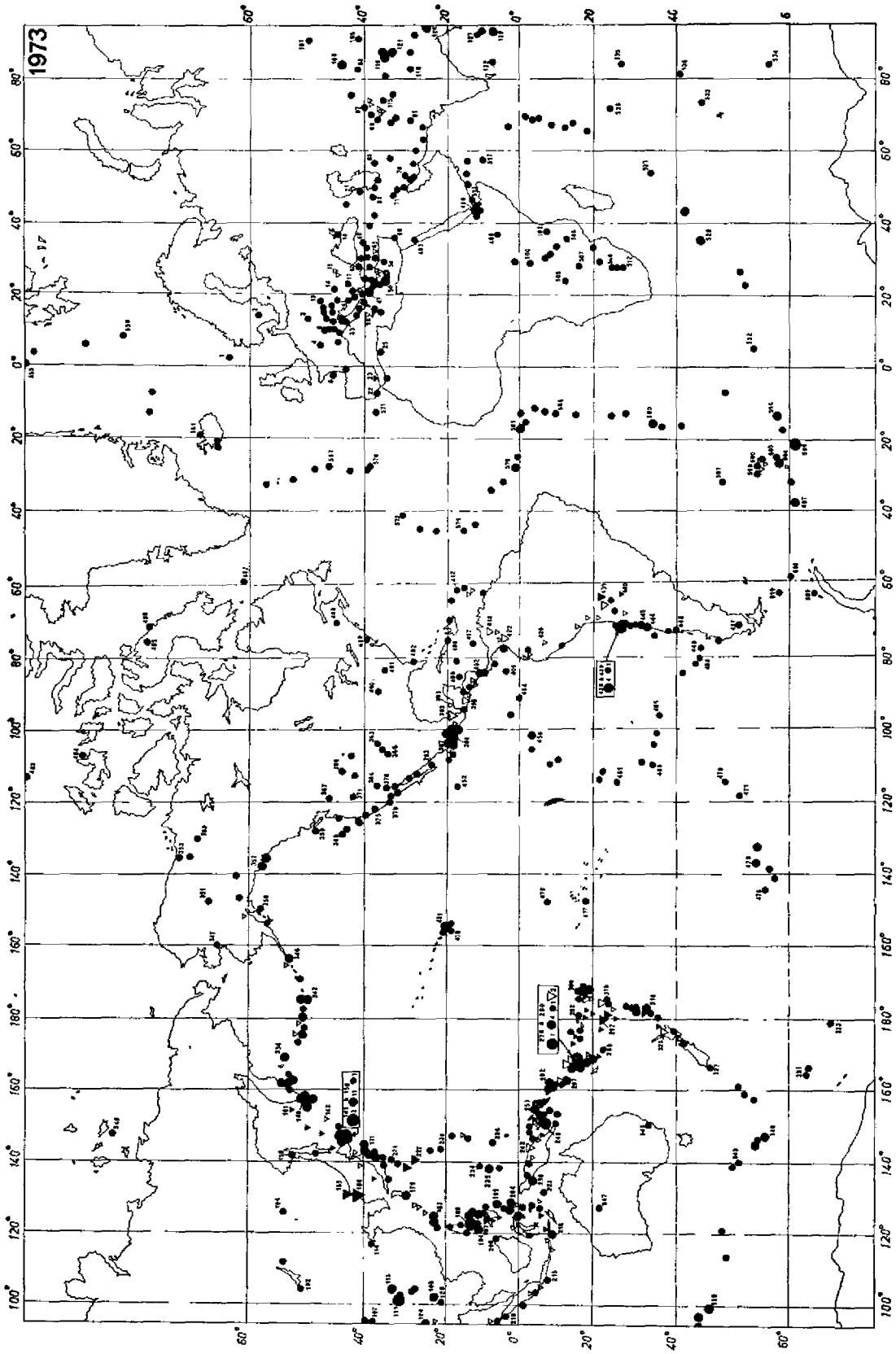

Fig. 1-1 : Map of epicentres (earthquakes in 1973).

settlements, the question of their location - with reference to earthquake risk and other natural dangers - is all the more important because it will affect very long-term disaster risks. In the same vein, the agricultural life of an area affected by earthquakes may also be disrupted both by the abandonment of land and by changes occurring in the countryside, particularly in the case of a violent earthquake, by the disappearance of springs and changes in the level of the water table. The reduction of earthquake risk is indeed closely linked with national development and economic planning.

In considering the reduction of losses due to earthquakes, it is necessary to take account both of our knowledge of the natural phenomenon and the technical means by which man and his works can be protected against the danger. The action to be taken is influenced by local conditions, depending both on the natural risk and on the resources which each community can devote to its own protection. Local problems cannot be considered in isolation, however; earthquake risks must be evaluated according to geological conditions and tectonic activity considered first on a regional scale. It is only at a later stage that the vulnerability of a small area, on the scale of a town or building site, for example, can be defined and used for purposes of prevention.

In the present study, after a few general remarks on earthquakes, the means of investigation used to gain an understanding of the natural phenomenon itself are discussed. The extent to which the possibilities of mitigating and preventing the risks connected with earthquakes can be determined depends on our knowledge of the phenomenon. We are thus led to examine, in particular, the very important - though controversial - question of seismic micro-zoning and its incidence on national development, town planning and building. The Office of the United Nations Disaster Relief Co-ordinator considers that the considerable progress

already made in this field will make it possible to improve substantially the techniques of vulnerability analysis, and to provide those responsible for development with more reliable criteria for the location of various types of activity and man-made installations (infrastructure, habitat, major investments,etc.).