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PROCEEDINGS OF THE LECTURES BY THE SEISMOLOGICAL DELEGATION OF THE PEOPLE'S REPUBLIC OF CHINA

Jet Propulsion Laboratory
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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

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PREFACE

This edited translation was performed by the Mission Analysis Division of the Jet Propulsion Laboratory and was sponsored by the Office of Applications of the National Aeronautics and Space Administration under Contract No. NAS 7-100. The work reported here was performed by citizens of the People's Republic of China, as reported by the Seismological Society of Japan and originally published in the *Journal of the Seismological Society of Japan* in 1976.

CONTENTS

PAPERS

ABSTRACT

This is an English translation of the Japanese text published in the *Journal of the Seismological Society of Japan*, 1976, pages 7-41. The four papers and additional tables and photographs were provided by the delegation from the People's Republic of China which visited Japan between 25 November and 16 December 1975 to report the successful prediction and evacuation, and the studies and actions pursuant to the 4 February 1975 magnitude 7.3 Haicheng earthquake. The paper titles are: General Conditions of Earthquake Studies and Actions in China; An Outline of Prediction and Forecast of the Haicheng Earthquake; Characteristics of the Haicheng Earthquake of 1975; Studies Concerning Earthquake Resistivity of Factory Structures. In addition, the delegation chairman's comments, the Japanese and American editor's and translator's notes, a collection of earthquake photographs from the Haicheng area, and a simplified list of great earthquakes in China (780BC - 1973AD) are included.

It is clear from this material that this is the very first successful, large scale earthquake prediction and evacuation in history. The Chinese scientists are quite candid about noting that the Haicheng situation was particularly favorable, and that certainty in earthquake prediction and evacuation is not yet guaranteed in China or anywhere else. Nevertheless, there is obviously great value in understanding the Chinese approach. They rely on many factors in making first a long-range (several years in advance) forecast of areas at risk, moving on to other indicators in the medium and short range (down to a month or two), finally relying on the imminent precursory phenomena (1-4 days in advance) which make evacuation of buildings a practical undertaking even in the harsh Chinese winter. The unique and detailed Chinese historical records of earthquakes were scientifically very valuable and set the stage for the program. The government established a major program for expanding the professional seismological observatories, established and encouraged thousands of semi-professional and amateur earthquake teams, and educated the public at large in earthquakes and the Chinese earthquake prediction and actions program. The papers provide detailed description of the geological structures, precursory earthquakes, local level changes, well water levels and conditions, telluric earth current measurements and unusual animal behavior patterns, among other observables employed in the Chinese technique. The nature of the earthquake itself is quantitatively presented and compared with other recent seismic events in China. Difficulties in separating precursory earthquakes from ordinary swarm earthquakes are illustrated, and schematics of the conditions under which earthquake prediction is likely to work (or not work) are provided. The last paper discusses the structural strength and the integrity of buildings in China. The Chinese rely on several observables in a process of continually tightening the time and space bounds on the impending earthquake, until a prediction suitable for evacuation can be made (about six hours in advance for the Haicheng earthquake). It appears that it is essential to augment the widely-spaced professional observatories with thousands of semi-professional and amateur stations if one wishes to *catch* the true and imminent precursory phenomena, since they tend to be very strongly localized in the immediate area of the epicenter. This factor has immense implications in the design and implementation of earthquake prediction programs in the west (which have tended to be oriented towards professional high-technology techniques alone).

AMERICAN EDITOR'S NOTE:

The source of these important Chinese papers on the Haicheng earthquake of 1975 is detailed in the Japanese Editor's Note below. This material is available (in Japanese) in: *Journal of the Seismological Society of Japan* (ZISIN), 51st year, 3rd month, 1976. Many of us who are working in the area of Earthquake Hazards Estimation (and possible eventual reliable prediction) feel that the successful Chinese prediction and evacuation in the Haicheng earthquake of 4 February 1975 is the most significant breakthrough in this field in modern times. I first learned of this Chinese program during meetings between JPL and USGS, including F. Jordan and P. Escobal of JPL, and J. Savage of USGS in the early spring. The United States had been invited by the People's Republic of China to send a delegation of scientists on June 1976 to exchange views and data. Discussion with the U.S. delegation chairman, B. Raleigh of USGS, revealed the existence of these papers in the Japanese journal. Not only were we at JPL vitally interested in this material, but it was apparent that the U.S. delegation and others should have access as soon as possible. Unfortunately, Japanese and Chinese (which in their written form are very similar) are not languages commonly studied by western scientists, and this extremely important material could only be skimmed for content by way of the figures in the journal. It was obvious that a translation of this material should be undertaken at once, and to be of the most use, it should be completed in time for use by the delegation to China. This imposed the serious time-constraint of only one month to translate, edit, type, proof, and publish (in preprint form at least).

It was fortunate that a particularly able and experienced Japanese translator with recent experience in translating Geophysics textual material was free to work on this task. An original copy of the Japanese journal text and figures was supplied by M. Ando of USGS, and the following team was hastily assembled to undertake the work: Mrs. M. Ohnuki (Japanese translation); Kwok M. Ong and Chia-Chun Chao of JPL (technical Chinese translation); Paul M. Muller of JPL (editor - and typist! in the interest of time). We agreed to adopt guidelines similar to those stated by the Japanese editor (see below). The translation is complete, and an effort was made to preserve the feeling of the original. Because of this, and the time pressure, the English rendering may at times be rougher than might have been possible under more relaxed and secure conditions. Rapid turnaround took priority, and I take full responsibility for the condition of the text and for errors of any kind. Comments and suggestions from colleagues will be appreciated. There may be sufficient demand for this material to warrant future updates and the opportunity to include errata.

In rendering the intent and flavor of the original, I decided that it would be unfair and inappropriate to arbitrarily delete the occasional references to the teachings of Chairman Mao, and other notations of a kind which some westerners might label as *propagandistic*. The word "propaganda" unfortunately has very negative connotations to many in the west. I think that many colleagues will agree that, as employed in the text by the Chinese scientists, this material is not intended to be negative or derogatory, and we should reserve any moralistic or political judgements. It is arguable that the inclusion of references to the "wisdom of the government and the revolution" in the Chinese cultural and political context is not unlike our inclusion above: "This research supported under NASA contract NAS7-100."

On a more personal level, I must express my deep respect for the immense depth of Chinese history and culture. My view was intensified by recent experience with the ancient Chinese records in my thesis: "*An Analysis of the Ancient Astronomical Observations with the Implications for Geophysics and Cosmology*." The Chinese observations were found to be far more precise and reliable than comparable ancient western data. It was also concluded, among many other remarkable things, that the Chinese calendar (cycle of 60 days) has remained correct without loss or error since at least 1330BC, "a remarkable consistency in human affairs." The present papers on earthquake studies in China note the important role *today* of ancient Chinese earthquake records in defining the areas where earthquakes can be expected within a few years, thereby concentrating detailed local observation programs in the optimum regions. The precursory phenomena and their correlation with long, medium, and short term prediction are also revealed in these ancient data. I was also extremely impressed by the apparently critical role played by amateur observers, who may have numbered more than 100,000 individuals! If the U.S. delegation to China verifies this, we have a precedent in the west for such participation of amateurs in science (note the amateur astronomers observing variable stars, occultations and other phenomena). There were at least a dozen major precursory observables considered in the Chinese decision to predict and evacuate, many of which are readily accessible to local residents. In the west we tend to rely 100% on High Technology but we may be wise to follow the Chinese lead here, and involve thousands of our local citizens in the earthquake program. Despite the different organization of our American Society, it may be that *only* in this way can we expect to gain acceptance of the exigencies of evacuations, and the likely possibility of sometimes erroneous predictions. As a closing comment, need I do more than mention that I am studying Chinese with the intent of fully mastering the language?

Editor's comments in text are shown: { } or †.

FOREWORD BY THE JAPANESE CHAIRMAN:

Michio Otsuka
Chairman of the Seismological Academy

The reason we considered inviting the Chinese seismologists to Japan was the news that they knew {of it} six months prior to the actual large earthquake of magnitude 7.3 on 4 February 1975 in the district Haicheng, province Liaoning, China. Our interest turned into great anticipation when we heard that evacuation orders were given before the actual earthquake, and despite the 90% destruction of houses in the district, the number of dead and injured were few. As far as I know, this is the first instance of such a fantastic prediction (used for evacuation) of an earthquake in the whole world including Japan.

As is always said, earthquake prediction should include when, where, and how big. The difficulty in earthquake prediction is to narrow down the bounds so that it can be practically utilized. The seismological community is still groping for these three uncertain elements. As this was my understanding, I was dubious at first when I heard the news of this successful earthquake prediction in China. However, when I heard about the successful prediction and the fact that the lives and property were saved, I could no longer remain uninterested as a seismologist in a country plagued by the same problem.

It would be much faster to hear directly from the Chinese seismologists, than for us to be guessing. This was the reasoning behind our invitation to the Chinese Academy of Science. Later I found that Dr. Seiji Kaya, chairman of the Japanese Academy for the Advancement of Science had already sent the same kind of invitation. The formal invitation was finally sent under the names of the Japan Academy for the Advancement of Science and the Seismological Society of Japan.

On 25 November 1975, six members of the Chinese Seismological Survey Group arrived. It was Indian Summer, and the members who visit us are as follows: {Table of names is given with photo.}

From the left: Liu Sho-Chang, Cha Chi-Yuan, Yuen Tze-Chien, Ku Kung-Hsu, Hsu Shao-Hsueh, Chu Fung-Ming.

We expressed our strong desire to hear about the earthquake prediction in Liaoning province, and we are very fortunate to receive such experts in the field. The chairman of the {Chinese} delegation greeted us with very impressive words, "As soon as we left Shanghai, the meal was served, but before we finished eating, we could already see the soil of Japan. How close Japan and China are!" The chairman of the delegation, who has the title of Chairman of the Chinese Geophysical Society, could not have overlooked the distance between Shanghai and Tokyo! So I replied that I myself lived in Kyushu, and felt the earthquake of Liaoning myself, and an earthquake affecting both countries should not be studied separately.

It was thus our good fortune that communications began warmly, in a congenial atmosphere, and after three weeks we have completed this friendly coinvestigation without any difficulty. The itinerary of the three weeks cooperative program was as follows:

Itinerary of the Chinese Seismological Team (1975):

Nov 25 Tue Arrive at Tokyo International Airport on Chinese Airliner.
Nov 26 Wed Visit Seismological Society; Earthquake Research Institute of University of Tokyo; Geographic Research Institute; Earthquake Prediction Group; Japan Academy for the Advancement of Science.
Nov 27 Thu Visit Meteorological Bureau.
Nov 28 Fri Visit Skyscrapers and Kajima Construction Research Institute.
Nov 29 Sat Discussions on earthquake-resistant structures at Japan Society of Architecture
Nov 30 Sun Sightseeing in Tokyo
Dec 1 Mon Visit Earthquake Research Institute, University of Tokyo.
Dec 2 Tue Visit National Disaster Prevention Research Center.
Dec 3 Wed Lecture on Earthquake Detection and Prevention in China.
Dec 4 Thu Same with discussions.
Dec 5 Fri Visited factories.
Dec 6 Sat Geographic Survey Council, Faculty of Science University of Tokyo.
Dec 7 Sun Visit Asama Volcanic Observatory
Dec 8 Mon Visit the Earthquake Observatory of the Meteorological Bureau; Nagano District Meteorological Station; Hokushin Small Crustal Motions Station University of Tokyo.
Dec 9 Tue Faculty of Science Nagoya University
Dec 10 Wed School of Architecture, Faculty of Engineering, Kyoto University; Mount Abu Earthquake Observatory, Faculty of Science.
Dec 11 Thu Disaster Prevention Institute, Kyoto University.
Dec 12 Fri Same, with lectures.
Dec 13 Sat Yamasaki Faults.
Dec 14 Sun Sightseeing Kyoto.
Dec 15 Mon Discussion of Cooperative Program.
Dec 16 Tue Leaving Tokyo International Airport.

Throughout the tour, Japanese and Chinese scientists exchanged views. It was a tough schedule, and we are grateful for their untiring efforts in the exchange of knowledge.

The lectures and discussion of the Liaoning Province Earthquake were held at the Auditorium of the Earthquake Research Institute in the University of Tokyo on 3 and 4 December, 1975. This report includes the complete translation of the proceedings of the meetings, from the speaker's manuscripts, prepared by Ms. Noriko Fukutomi, Society for the Advancement of International Trade. Although this report does not require any comment by me, I would like to add a few more words, since I was fortunate enough to have direct contact with the visitors, formally and informally, throughout the tour. As I mentioned in the beginning, the main purpose of our invitation was our interest in the technology of the successful earthquake prediction. We have learned a great deal, and there is a great deal of study left for us to do, based on this report. As the tour went on, I came to realize that our first motive was too simple. That is, earthquake prediction is indeed the cornerstone of effective action, but it is not the whole story. Even if prediction is completely successful, there remains the disaster itself which cannot be physically prevented. Can a place be found for the evacuated residents? Even if there is a place, how can they be evacuated without confusion? What kinds of aid and reconstruction programs can be established? When these questions are answered, then earthquake prediction will become truly practical. I am sorry to say that there is no overall program of this kind in Japan. Whatever the reasons, this is an extremely unfortunate situation for an earthquake prone country like Japan. Behind the news of successful earthquake prediction, we should not overlook the fact that the national organization called "National Earthquake Bureau of China," could gather the complete seismological data, and also control the use of the data.

Although we were mainly interested in the technological aspects of Earthquake Prediction, what the group taught us was not limited to that. I cannot forget the words of the member Hsu: "Now that we have been absent from China for 20 days, we must get right back to work."

I would like you to read this report as the noble record left by people who are dedicated to the prevention of disaster.

I am deeply grateful to the Japanese Society for the Advancement of International Trade which has given us warm support from the beginning to the end, and for providing the interpreter Noriko Fukutomi during the entire program. Ms. Fukutomi has worked very hard as interpreter during the whole tour, and the translation of the lecture manuscripts. It would have been quite impossible for us to publish this report without her help.

For the publication of this report, we used a bequest from the family of the late Professor Hiroshi Kawasumi, given to the Seismological Society for the purpose of the advancement of seismology. We have been concerned with finding a proper use of this bequest, and since the late professor had a strong interest in disaster prevention and was very knowledgeable about Chinese earthquakes, we considered this to be particularly appropriate. I would like to report this to the family of the late professor, and at the same time dedicate this article to the late Professor Kawasumi.

(31 January 1976)

JAPANESE EDITOR'S NOTE:

This collection of papers is based on the lectures, slides, photographs and data that were provided by the good will of the Chinese delegation and the lectures of the group given on 4 and 5 December 1975 in Tokyo. The translation of Chinese into Japanese is provided by Ms. Hiroshi Kawasumi of the Kansai branch of the Japanese Society for the Advancement of International Trade.

Concerning the translation, we made a point to be faithful to the original, rather than readable Japanese. We would ask your indulgence if there are some awkward passages. The characters which have specific connotations in Chinese society for instance, have been marked with footnotes, and been collected together at the end. Following is a brief explanatory note for each paper.

1. The greeting of the chairman, Ku Kung-Hsu. This was recorded on 3 December 1975 at the beginning of the lectures.
2. The paper written by vice chairman Cha Chi-Yuan originally titled "Chinese earthquake, outline of effective action," published in November 1975. In order to help the understanding of the paper, we added some photographs from the magazine *People's China*, March 1974, and photographs belonging to the editor.
3. Paper by Chu Fung-Ming originally titled "Prediction of the Haicheng 7.3 magnitude earthquake; general circumstances of earthquake precursory and premonitory preventive actions," published November 1975.
4. Paper by Hsu Shao-Hsueh originally titled "Report on characteristic seismological activity during the Haicheng earthquake" a memorandum prepared for this lecture, as an explanation for the data charts and figures. Some additional comments have been added with the agreement of the author during the visit.
5. Paper by Yuen Tze-Chien, a lecture manuscript titled "Research on resistance of industrial buildings to earthquakes." There are sections which were translated by general context due to the fact that there were no specific technical terms.

6. The collection of photographs from the Haicheng earthquake epicenter area was taken from the album given to several organizations by the Chinese delegation. The original prints were medium size, and very clear as to detail.
7. The abbreviated list of Great Earthquakes in China was also taken from the materials which were given to organizations and individuals by the Chinese delegation: "List of Earthquakes in China" (Vol. I, II edited by Academy of Science, Geophysics Research Institute of China, 1970). The list is taken from these volumes, which were given to the Seismological Society Library. The detailed data for each earthquake are listed in the books, length 361 pages.

Kazuo Oike (Disaster Prevention Research Institute, Kyoto University)

(1 March 1976)

GREETINGS BY THE CHINESE CHAIRMAN:

Ku Kung-Hsu

Board Chairman of the Chinese Geophysical Society
Vice chairman, Revolutionary Committee of the Geophysical Institute, Chinese Academy of Science

Gentlemen: I am very sorry that I cannot speak Japanese and must work through the interpreter. It is my great pleasure for us, the Chinese Earthquake Delegation, to have received the invitation from the Seismological Society of Japan and the Japanese Society for the Advancement of Science, to visit your country and to undertake academic work with you. I am very pleased to have this opportunity today to report the seismological studies done in China.

Last year we could exchange information about the status of earthquake studies in China and Japan through three Japanese seismologists, Professors Asada, Oike, and Shiji, who have visited our country. We can strengthen and deepen our cooperation concerning earthquake studies of our countries through such exchanges. Based on such exchanges, we would like to promote more vigorous academic cooperation and friendship in the future.

Both our countries have many earthquakes. Our ancestors have left excellent seismological historical records in our written histories. During the past several years, China has experienced a series of several strong earthquakes, and among them were earthquakes which caused damage to property and loss of human life. Therefore, our party and the government are showing a great concern about earthquake studies, with particular interest in earthquake prediction and earthquake resistant buildings. Japan has made great progress in research during the last several years, and has had a great deal of experience in this kind of research. We would like to learn from your experience.

The original basis for the earthquake studies in our country was very inadequate. But after our country was liberated, earthquake studies of the whole country made greater progress. Our academic level is, therefore, not yet as high as we might like. Our techniques are not yet as advanced {as yours}.

Today I would like to report the conditions of our general seismological and earthquake studies and actions, and also would like to present some problems concerning the magnitude 7.3 strong earthquake which occurred on 4 February 1975 in the province of Liaoning. Each of the four members of our delegation has prepared a report for this meeting, and I would like to proceed now with these reports.

Thank you.

Translated by Liu Sho - Chang. (3 December 1975)

GENERAL CONDITIONS OF EARTHQUAKE STUDIES AND ACTIONS IN CHINA

By Vice Chairman Cha Chi-Yuan

Division Head of the National Earthquake Bureau

Today I would like to give an outline of earthquake studies and actions in China, and would like you to get the general impression. China has many earthquakes. We have had 400-some earthquakes of magnitude 6 or greater since 1900, an average of at least 5 per year. During our entire recorded history, great earthquakes with magnitudes of 8 or more have occurred several times. A comparatively famous one is the great earthquake of Central Shensi Province in 1556, which affected ten provinces, and the area destroyed reached 1,100,000 km^2. The locations of great earthquakes are spread across the whole of China, and with the exception of a few provinces (Chekiang, Kweichow etc), many of our great earthquakes are shallow (20-30km), and have caused great devastation for many people.

Our working people have been battling earthquake devastation for a long time, and have a great deal of experience. Seismology has a long history in our country, and various historical writings are rich with valuable records. Comparatively trustworthy records of the oldest earthquake was recorded in 1189BC, in the eighth year of the Chou dynasty, emperor Wen Wang. As early as 132AD, Chang Heng of the Former Han Dynasty, had invented the first seismograph in the world and had recorded a Lungsi earthquake, which occurred in Kansu province in 138AD.

In our country, the recording of pre-earthquake phenomena and experiences with earthquake resistant buildings had begun in the 16th century. However, China was in a feudalistic state, and in recent times it was forced into semi-colonial, semi-feudalistic system, and thus the seismology as well as other fields of science was under oppression by the old system for a long time. Confucianism had substantially prevented the quick advancement of seismology. The Nationalist, anti-revolutionary government was not at all concerned about the life and death of the working

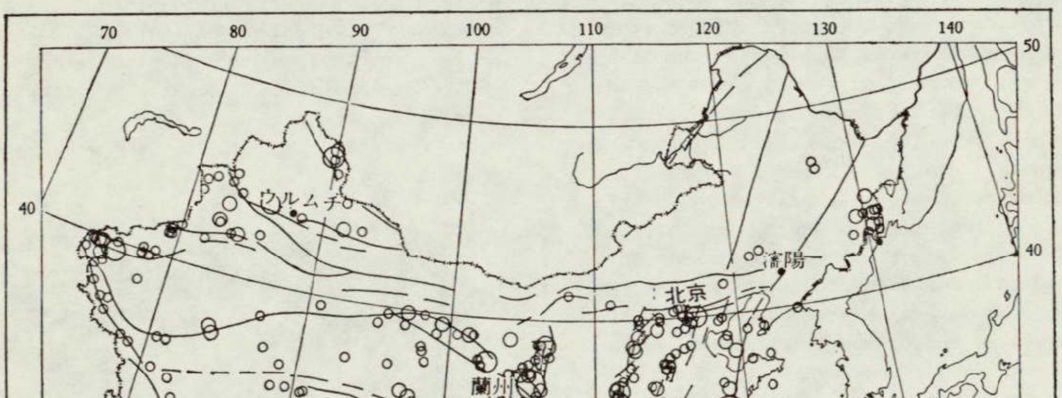
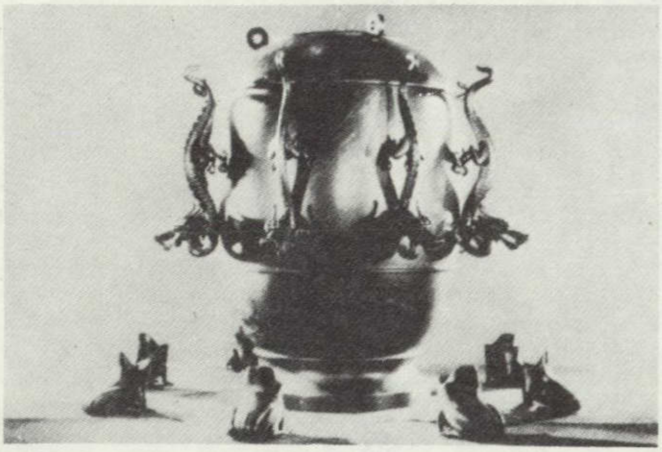


Figure 1: Epicentral locations of large earthquakes in China between 780BC and May 1973AD

Plate 1: Replica of the first seismometer in the world, and Chang Heng, 78-139AD, the man who invented it.



people. What they did was to sell the country for prosperity, and had become the slave of imperialism. Within the country they exploited the oppressed and trampled upon the people and toward the time of the people's revolution, they suppressed them with bloodshed. When an earthquake occurred, they used the opportunity to gain more money, loan money with usurious interest to the hard pressed people, threatened and deceived them, and hounded the working people of the devastated areas to death, while nobody cared about earthquake matters. Therefore, before the establishment of the People's Republic of China, there had been only one earthquake observatory in the whole of China, and only three people working in connection with earthquakes. In 1949, after the establishment of the New China, under the excellent leadership and warm compassion of the Great Leader Chairman Mao, and the Communist Party and Government of China, the Geophysics Research Institute was established, and several earthquake observatories and stations were built, and scientific study of earthquakes commenced, and began contributing actively to the socialistic revolution and development. The seismologists of our country, with the cooperation of historians, systematically consolidated and studied the large bulk of historical seismological records. After several years of work they had investigated 2600 historical writings and 5600 local journals and 15,000 records concerning earthquakes, and provided us with an important set of data for the historical understanding of seismological activities in our country.

In 1966, Hopeh province, Yingtai district, experienced a strong earthquake. Premier Chou En-Lai himself surveyed the disaster area, representing Chairman Mao, and the Central Party, and comforted the people of the disaster area. We have established the goal of earthquake resistance and disaster aid: "Let us all rise for the wealth and strength, and attempt reconstruction with our own hands, to increase production and rebuild our country." Chairman Mao's great call to the people: "Prepare for war, prepare for disaster - for the people." This appeal was delivered to the people, the solemn call, that the people should achieve successful earthquake prediction. Since 1966, Premier Chou has made a series of important statements regarding the successful earthquake prediction and development of earthquake studies and actions. Having established the clear goal of earthquake prediction, earthquake studies and actions in our country have opened a new chapter in earthquake science. Under the proletarian cultural revolution, and anti Lin Piao - Confucius movement, the earthquake studies and actions have made great progress.

Plate 2: The computer room of the Geophysics Research Institute of the Chinese Academy of Science

In order to strengthen the consolidation of leadership, and to overcome the difficult hurdle of earthquake prediction, our government decided to establish a National Earthquake Bureau in 1971, to consolidate and manage a nationwide earthquake study and action program, to consolidate the efforts scattered throughout many government departments into one earthquake bureau, and put the unified program into practical operation. A management organization was established for earthquake studies and actions in each province, city and self-governing district, and in specific earthquake prone areas. At the same time, the earthquake study and action efforts were continuously strengthened, and at present we have 17 major stations throughout our country (except Taiwan province). There are 250 ordinary observatories. Within each province, city and self-governing district there is an earthquake specialty team of corresponding size. The total manpower making up these teams throughout the country (including government officials) is about ten thousand people. Thus the groundwork has been laid for further development in our earthquake studies and action program.

As a result of the victory of our great proletarian cultural revolution, we have achieved rapid progress with the earthquake studies and actions. Within the proletarian cultural revolution and anti Lin Piao - Confucius movement, a great many scientists have criticized the anti revolutionary reformist line of Liu Shao-Chi and Lin Piao, and have urged us to discard the mistaken notions; "earthquake predictions cannot be made," "it is foolish uproar to make earthquake predictions," and have correctly directed the earthquake studies and actions program, and a great change took place in our understanding of earthquake prediction. Those who undertook the extensive earthquake studies and actions have discarded these prejudices and have liberated their thoughts and philosophies and completely renewed their spirit. With courageous thoughts, revolutionary spirit, and daring actions, they went deeply into the relevant practical areas of study, acted boldly, and moved courageously down the road of earthquake studies and actions. This was in accord with the guidelines of Premier Chou En-Lai which have been gradually developed, namely: "Under the consolidated leadership of the party, make prediction and prevention a central goal, and combine experts and the general public as well as simple machines and techniques created by the general public with advanced machines and techniques, and to direct the extensive public involvement in order to achieve successful earthquake prediction and prevention." The great proletarian cultural revolution has caused a radical change in the earthquake studies and actions of our country, and opened a new phase. Furthermore, even the limited number of earthquake observatories and stations which are in the epicenter areas cannot determine the overall picture of spatial distribution of the precursory phenomena in and around the epicenter areas. It is impossible to view the overall picture of the precursory phenomena if we depend only on the earthquake

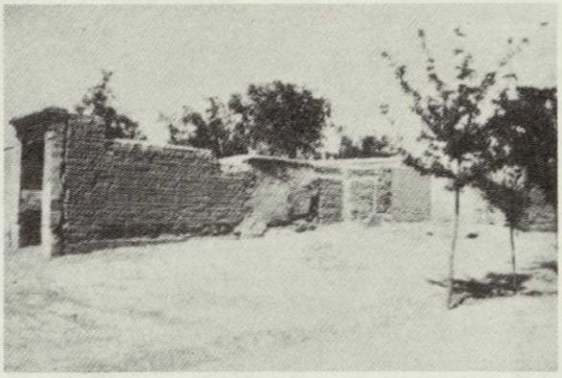


Plate 3: Damaged areas in Yingtai earthquake of 1966 (above)

The newly rebuilt village (below)

Plate 4: People examining the variation of well water level

observatories and stations. It has been our actual experience during these several years that the nature of the precursory phenomena of shallow earthquakes, 20-30km in depth, were varied and complex, and there was no clear way to handle the several precursory phenomena with the limited methods of the specialized earthquake observatories and stations. Yet it has been shown that the general public could grasp an extensive readily observable phenomenon such as abnormal animal behavior, the action of subterranean water, earthquake related lights, with the use of simple observation instruments which they made, or with their eyes. In the area of limitations and difficulties with expert observations, the public can make an important contribution.

Because a large part of the public actually lives in earthquake areas, it is undertaking massive observations and is able to directly experience many earthquake premonitory phenomena. They can see clearly the phenomena that a great many expert teams still could not adequately observe. Therefore, only when experts and the general public work together, and only when simple machines and methods are combined with advanced instruments and methods, can we obtain comparatively complete data on the precursory phenomena. The entire earthquake development process cannot be understood without the participation of the public. Moreover, since the greater part of the public lives in the affected areas, they will be the first to observe the abnormal phenomena, and can pin them down, themselves constituting the required observational network. Once they have the information, they can act immediately to substantially minimize the damage and loss of life.

The earthquake studies and actions of our country are no longer simply an exercise in science and research, but have become a component of the nationwide people's actions under the positive direction and support of each party committee and the government in order to accomplish the great policy of Chairman Mao: "Prepare for war, prepare for disaster - for the people." Those who are undertaking the earthquake science activities are attempting to overcome the difficulties of earthquake prediction, not only to resolve the formidable scientific questions, but to climb the highest peaks of science and to contribute to the advancement of science generally. They also feel they have this responsibility to get over the hurdle of earthquake prediction in order to contribute to the proletarian government as well as workers, farmers, and soldiers, and protect the establishment of socialism, and to minimize the loss of life and property, and ultimately serve the people. The earthquake studies and actions of our country mean not only the active participation of scientific and technical specialists, but also urging the people to rise to the challenge of making their own observations and preventions and to spread the movement. On the other hand, it is to propagate the knowledge of earthquakes in various ways (film, exhibits, posters, pamphlets, public notices and broadcasting), and encourage the public to have an accurate understanding of earthquakes so they may utilize this knowledge as an actual weapon for counter-earthquake actions. At the same time, public observations and predictions are organized and undertaken in earthquake prone and endangered areas. Those who participate in earthquake observations and prediction include workers, farmers, school teachers, students, broadcasters, and meteorologists. Earthquake prediction has already become a public movement of science experiments, and a part of the people's own undertaking.

Concerning the question of whether the public can participate in earthquake prediction, we have been experiencing a conflict of two thoughts. Some people maintained that since the expert team has not resolved the problem completely, the public could not work on the prediction of earthquakes. But it proved otherwise in actual fact. The key point in overcoming the hurdle of prediction and actually undertaking earthquake prevention, is to assess the precursory phenomena close to and immediately before the actual occurrence of the earthquake. If that is the case, the earthquake observatories and stations should be established in the expected future epicenters, which in itself is a difficult problem for us seismologists. Science and culture are the fruits of the vast working public. The earthquake prediction activities began in earnest following the Yingtai earthquake of 1966. At that time, the expert team could only succeed in making a record of the earthquake, but could not predict it. Nevertheless, the public had informed us of the various abnormal animal behaviors, color and taste changes in subterranean water, the rise and fall of well water, and made up sayings about these things. (Similar phenomena had been reported in previous disastrous earthquakes of our country.) These were also the prediction methods that our expert team had begun to notice. The simple instruments that the public had already invented and constructed, were gradually improved and standardized by the expert teams, and have become an important tool in the public's efforts in prediction. Some examples of such instruments include galvanometers, magnetometers, tilt meters, simple seismographs and so on. At the same time, the public observers and predictors had created a great many methods of analysis and prediction based on their own individual experience. Their experience and a great many discoveries form a rich source of information for the expert's scientific research. For example, the general public discovered before the great Yingtai earthquake and others that there were a great many small earthquakes which could be physically felt, and this was followed by an absence of these for a certain period of time, followed by the major earthquake itself. People had made up a simple saying about this experience:

"Close together - silence - great earthquake." This important discovery has given rise to a significant new project for earthquake experts to study, namely precursory small seismic activities. Furthermore, a great many amateur public observers and predictors studied the scientific techniques, and a substantial number of practical earthquake science experiments were undertaken, and the study of characteristic seismic activities in the stricken areas provided many unique and creative views. Within the public there is a great reservoir of creativity, and an inexhaustible supply of wisdom and talent. I am sure that their scientific activities will become a great and deeply influential force in the development of earthquake science. In actuality, the public observation and prediction members can operate with little or no expense, with simple and direct methods of observation, and can make relatively accurate predictions from their own observations.

For instance, two hours before the Buo Hai earthquake of magnitude 7.4 in July 1969, an animal attendant at Tien Tsin Zoo had predicted the possibility of a great earthquake based on the abnormal reactions of tigers and other animals, and submitted this prediction to the Tien Tsin City earthquake headquarters. The public prediction team in a remote mountainous area of Szechuan province, Hang Ting county, Tse To Tang Production Company (Tibetans), reported that their simple galvanometer had decreased 20 milliamperes suddenly, and they predicted a magnitude 5.5 or greater earthquake would occur not far from the company premises in the afternoon of September 26, 1972; and also based on public observations of abnormal animal behaviors such as chickens flying around and pigs refusing to enter their shelters, horses and sheep running around and so on. An earthquake of magnitude 5.8 actually occurred some 40km distant on the morning of 27 September at 8:08AM. After this earthquake, the simple galvanometer and various animals still exhibited abnormalities. The public made precise observations and predicted that more earthquakes would occur. Two further earthquakes of magnitude 5.8 and 5.5 followed, at a distance of some 30km. Thus they accomplished a victorious prediction. Also, at Szechuan, Maer Hang district, there was an earthquake of magnitude 5.5 on 8 November 1970. The leaders of the Mu Lang Company, near the epicenter, had evacuated the public outside their houses and directed their animals to safer areas, based upon their past experiences with abnormal animal behaviors and the conditions of the small earthquakes which were physically felt. The majority of houses were destroyed in the earthquake but there were no casualties because of the evacuations. In the process of prediction and prevention of the magnitude 7.3 earthquake in Liaoning-Haicheng, the results from public observations made with the simple galvanometer, and a great many observations made of animals and subterranean water, played a central role in the earthquake prediction made by the expert team. As a result, the prediction was welcomed by the public, and caught their spirit, and the level of interest was heightened, and the company of those interested in prediction continued to grow. The collection of data using the various simple instruments was made, and collection points were established for analysis and prediction. The number of groups for public observation and prediction reached 100,000. {!!} The public observation and prediction movement is a new product of socialism, which was created by the general public in the process of fighting earthquake disaster, and is playing a crucial role and is showing a strong life-force. The public prediction movement has already formed a firm basis in our earthquake studies and actions program. The public prediction movement is a basis for our earthquake studies and actions, while the expert team is also an important pillar in this.

The experts feel that it is their responsibility to pursue the policy of earthquake studies and actions of our country, and to strengthen the tie between the experts and the public, and to extend the public observation and prediction activities. They are actively cooperating with the government departments concerned, and are propagating the knowledge of earthquakes among the general public. The experts are working with those who are in the earthquake-prone and endangered areas and had already made successful predictions, in establishing public observation and prediction networks and training and directing the amateur public observers and predictors, helping them to synthesize their experiences and to raise their standard, establishing close communication between public observation points, exchanging data, and holding discussions concerning the circumstances of earthquakes. The experts also provide assistance and coordination in helping the party committees and government agencies to accurately grasp the implications of earthquake study and actions, and are making positive suggestions for earthquake disaster prevention and counter earthquake activities in the various areas of the country.

The seismologists of our country bear an honorable duty to serve the progress of earthquake prediction, and extensively promote scientific research. In other words, they have raised the level of seismological research to a height, rooted deeply in practical application. The main duty of the expert team is twofold: counter-earthquake, and disaster prevention. Roughly speaking, the counter earthquake action undertakes mainly observation and research on strong seismic activities and aftershocks, studies of earthquake resistant structures and effects of various magnitude earthquakes on them, the soil structure, and to consider how the existing buildings can be strengthened and remodeled in the earthquake-prone and endangered areas. As for the prediction work, we emphasize the practical application. We do not hold back our prediction until the theoretical problems are solved.

Plate 5: Seismograph factory in Peking City

We simultaneously conduct the observation, prediction and research activities. Therefore, based on an extensive and emphatic policy, we set up an observation network connecting both the experts and the public (meaning the professional earthquake stations are tied in with public observation and prediction points), and we use this network as the vanguard in collection of the early precursor information. We also established analysis and prediction organizations in each province, city, and self governing district. The National Earthquake Bureau operates an earthquake analysis and prediction facility where the experts synthesize data at appropriate times, analyze them, and periodically hold discussion meetings regarding the general earthquake conditions. (Under critical conditions they hold emergency discussions.) Additionally, they make predictions for the areas in which disastrous earthquakes may be expected, while also establishing research teams. Under the National Earthquake Bureau, there are the following departments: Geophysics, Seismology and Geology, Engineering and Dynamics, Earthquake Measurements, and so on. Various fields of study and science investigate the principles of the growth of earthquakes, the cause and theory of earthquakes, providing a trustworthy theoretical basis for earthquake prediction. In addition, it has a factory for the manufacture of instruments related to seismographs, and provides the necessary equipment for the scientific research activities of earthquake observatories and stations. Concerning the state of science and technology, we have discarded the method whereby we relied mainly on one method of academic or scientific inquiry, and use instead an integration of many disciplines. Experience has shown that one occurrence of a great earthquake is not just a dynamic process, but rather is a complex process including geophysical, geochemical, seismological, and geological implications. Therefore, we are conducting a synthetic study combining geophysics, geology, geodesy, geochemistry, astronomy, mathematics, and so on. As the prediction tool, we emphasize the synthesis of research and observation using the various professional instruments of earthquake conditions, geomagnetism, electrical conductivity, crustal changes, and hydro-chemistry, attempting to discover the precursory elements that possibly accompany earthquakes.

We can see at present that the various scientific and academic methods we are using are definitely effective in earthquake studies and prevention. Concerning the prediction, we are emphasizing a method in which the long range prediction, medium and very short term are combined, namely, taking gradual actions based on a comparatively long range prediction, increasing the density of observations and gradually restricting the range, pinpointing the endangered areas, finally determining the time of the actual earthquake. The occurence of an earthquake is a process of quantitative to qualitative† change, the same as everything else, and will eventually reveal to us a definitive step by step process. As we see from various precursory phenomena, generally speaking, before a great earthquake, a slow and mild long-range change takes place for about a year before. Shortly before the earthquake, comparatively rapid and violent and abrupt changes take place. As these various precursory phenomena take place in approximately the same time, they appear in a related way. In other words, earthquakes exhibit step by step stages in the process of development.

I imagine that the audience will understand the above points very clearly, given the following detailed experience with the Haicheng earthquake.

For several years we had made relatively successful prediction of earthquakes with potentially destructive force of magnitude 5.0 and above. The prediction and disaster prevention of Liaoning-Haicheng earthquake of magnitude 7.3 was relatively successful. This is a clear sign that the socialistic system is superior, as well as the victory of the proletarian cultural revolution. It is a great victory of Chairman Mao's revolutionary line. The experience of the past nine years makes us believe that earthquakes are accompanied by precursory phenomena and can be predicted; and if the disaster prevention work is done well, it can greatly reduce the loss of life and damage. In the near future, we are certain that we can understand the principles of the origin and development of earthquakes, and are confident that we can obtain the leadership in earthquake prediction based on Practice, Recognition, Application.

Friends! Our country is a growing socialistic country. The foundation of our past scientific techniques is weak, and the length of time we have been concerned with earthquake work is short. The earthquake prediction has just started, and we do not yet have much experience. We must wait for the future solution of the scientific and technical problems, of understanding the principles of origin and development of earthquakes, and to make accurate predictions. There will be mistakes and failures in the future, as well as unavoidable errors in reports or through failure of the predictions.

† This is the text's word-order (ed).

We know very well that the earthquake prediction an important and complex problem of science, and there are many elements and subjects to be studied which cannot be clarified within a short period of time since the wealth of precursory phenomena crosses a great many fields of science. At the same time, the frequency of occurrence of great earthquakes is low, and opportunities for observation are relatively few. It is difficult to pinpoint the time and place of an earthquake and to undertake complete and detailed scientific experiments. Also, in order to undertake model experiments in the laboratory, the conditions are restricted. The real precursory phenomena of earthquakes cannot be easily isolated because they involve complex related elements, as well as the uniqueness of the given area's characteristics. The writing of equations and quantities will not necessarily apply uniformly. Furthermore, the observational instruments can only be placed on the earth or near the surface of the crust, and we can only guess the conditions of activities in the depths of the earth, and are unable to obtain directly measured values. Our present knowledge of earthquakes is still immature, and the road ahead of us is not smooth. It will be a long journey and hard work, but those who undertake earthquake study and action are determined to make the effort for many years, cautiously and firmly, and not give up even in the face of failures, and to endeavor and proceed in order to solve the problem of earthquake prediction.

Japan is also an earthquake prone country. Seismology in Japan has a long history, rich historical records, and the Japanese people have a long period of experience fighting earthquake disaster. A great many Japanese scientists are making efforts in earthquake prediction. We are very happy that the Japanese seismological technology is advancing. Through our visit, the Chinese earthquake study delegation will learn from the Japanese people and from those who are related to the earthquake studies and actions in Japan. Let us exchange our experiences, encourage each other, and make efforts to break through the formidable problem of earthquake prediction as soon as possible. I believe I will visit many old friends and will find many new friends, and trust that this will increase the friendship between Chinese and Japanese seismologists. I trust that certainly the exchange of seismological technology and science will be advanced and open up a wide vista.

Friends! Japan and China are right next to each other, and we both are great people. We have a long history of friendship and exchange, and by the establishment of Chinese and Japanese diplomatic relations, we opened a new chapter of our friendship. The Chinese earthquake study delegation is determined to contribute to the increase of our friendship in future generations according to the great leader Chairman Mao's teaching: "Japanese people and Chinese people are good friends."

(3 December 1975 lecture)

OUTLINE OF PREDICTION AND FORECAST OF HAICHENG EARTHQUAKE OF M=7.3

By Chu Fung-Ming

Engineer, Earthquake Bureau Liaoning Province

On 4 February 1975 at 19:36 Peking time, a strong earthquake of M=7.3 shook our nation's Liaoning province, Haicheng-Yingkao district. Given the forecast of this violent earthquake, however, the Party, the government, the armed forces and the people of the affected province immediately took effective prevention measures under the consolidated leadership of Liaoning Province Committee of the Chinese Communist Party, thus greatly minimizing the damage of this densely populated area. This was the very fruit of our great Proletarian Cultural Revolution and Anti - Lin Piao Confucius movement, as well as the vivid and successful demonstration of the superiority of the socialistic system. It was indeed a great victory of Chairman Mao's revolutionary line. The earthquake prediction and forecast have attracted world-wide attention, including our seismologist friends in Japan. I would like to briefly explain the key factors to today's audience so as to give you some knowledge of our earthquake prediction and forecast concerning this particular earthquake.

After the Buohai earthquake of M=7.4, as early as in 1969, the seismic condition of the Liaoning province drew the attention of people participating in earthquake affairs; and as a result, they reinforced their efforts in the area. In 1970, our country held the first National Earthquake Studies and Actions Conference under the encouragement of Chairman Mao and the central officials of the Party and under the direct leadership of Premier Chou himself. Based on our country's policy on earthquake studies and actions, discussions and study sessions were held on the natural trends of seismic activities in each earthquake prone area in our nation, as well as on methods for a further expansion of earthquake studies and actions. Based on the tendency of seismic activities in Huapeh and Buohai districts, and taking the dense population and industry of Liaoning province into consideration, the conference designated Liaoning province as one of the nation's specially watched earthquake areas. After the conference, an earthquake special task force was quickly formed and actively began various works in the province, under the leadership of the National Earthquake Bureau and Liaoning province Committee of the Chinese Communist Party. As earthquake studies and actions went under way, the knowledge concerning the identity of the earthquake prone and endangered areas within Liaoning province continued to grow. Through the four stages of long-term, medium-term, short-term, and immediately prior to the actual earthquake, the knowledge of the boundaries of the earthquake prone areas as well as the probable time of the earthquake were gradually restricted, culminating in the relatively successful forecast at the time of this particular earthquake. The following is an explanation of the four stages of action and their successful results.

The first stage action was undertaken during the period of 1970 through 1973. Its main purpose was to commence works concerning the regionality of earthquakes, to analyze the possibility of earthquake in Liaoning province, and at the same time to pinpoint the earthquake prone areas using the previous studies as a basis.

A collective research project on geological structure of all the areas was commenced in 1970. Incorporating the historical earthquake data, the study investigated the conditions under which earthquakes could occur in Liaoning province. Field observations and studies were conducted in the areas of major faults in Liaoning province, for instance, Yingkao - Kaiyuan - Chinchow - Yaloo River faults, as well as the activity of major faults in Liaopeh and Liaosi districts. At the same time, repeated measurements were taken on long level lines in Liaonan, Liaotung peninsula, Liaopeh districts, in order to gain further knowledge of the crustal movements of the Liaoning province, especially the movements of several major faults in the surrounding areas. In order to discover the conditions in the deep structures, measurement of the magnetic fields were made, as well as observations and research in explosion seismology. Historical earthquake data was collected and arranged, and the characteristics of these earthquakes were studied. Earthquake observatories and stations were set up to watch for minor seismic activity, and observations of topographic changes and their precursory phenomena were made in several fixed locations.

From the analysis of nearly four years of this data, we came to the following conclusions:

(1) Since the Yingtai earthquake of 1966, six strong earthquakes of magnitude 6.0 or more occurred in northern Huapeh and Buohai districts. Since 231BC, these areas have experienced an average of one earthquake of magnitude 6.0 and over every 30 years. This indicates that this area is in a period of increasing seismic activity. This forms the background for a possible earthquake.

(2) Historically, strong earthquake activity in Huapeh and the north-east districts is related to the (Liaoning) structure. A series of new structures in the new Cathysia system, particularly those running N to NE, appear to be dominant: (*i.e.* gravity and artificial earthquake data revealed only the N to NE structures). Also along a series of major faults in the eastern part of our country, such as Cheng - Luhchiang faults, there were several magnitude 7 or greater earthquakes throughout history (the greatest of which was the magnitude 8.5 earthquake of 1668 in Linchi). The north end of this fault reaches Liaoning province. The fact that the epicenters of strong earthquakes since the Yingtai earthquake of 1966 have tended to move N and E, was also taken into consideration. Liaoning province, especially Liaonan and Liaotung peninsula, were considered to be areas requiring close attention (see Figure 1).

(3) Based on field observations of seismic and geological aspects, the following factors were considered crucial: Several major faults in south Liaoning and Liaotung peninsula districts, faults in Chinchow - Tsangho - Yaloo River areas, for instance, are all active faults, and in particular the activity along Chinchow faults has been remarkable. Historically, strong earthquakes had previously occurred in all of Hinghao - Hsungyuh - Chinchou - Yaloo River areas. The seacoast of Liaoning and Liaotung districts was considered a relatively likely earthquake area, since it had recently experienced several magnitude 3 to 4 earthquakes.

(4) Repeated measurement of level lines indicated a relative rise in the SE part of Liaotung peninsula during the past ten years, while NW sections showed relative depressions. On the continent, the center of the depression was located near Yingkao, *i.e.* Yingkao showed a depression of 3-5cm relative to Tsangho and Lutai. Also the line connecting Kaiyuan and Haicheng seemed to form a region suceptible to an abrupt change in vertical movement of the crust. This indicated that the area was due for a violent relative movement in the near future. Our view that this area was in danger of an immediate earthquake was strengthened (see Figure 2).

Synthesizing the data mentioned above, we concluded that Liaoning province would be struck by a relatively strong earthquake. Liaoning and Liaotung peninsula especially, compared to the other districts, had a greater probability of an imminent earthquake, thus establishing a priority for various earthquake related works.

Now we could roughly bound the earthquake endangered area, but would an earthquake actually occur in this area within a few years? This

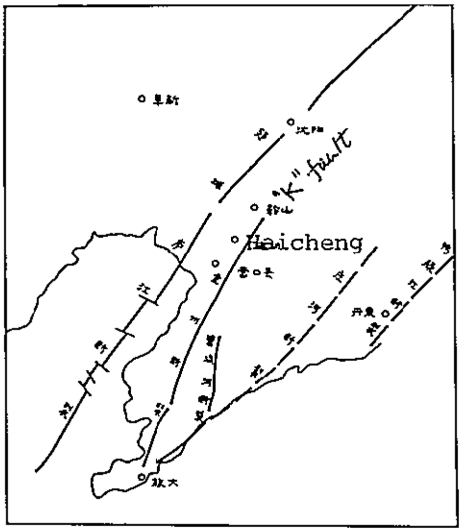


Figure 1a: Distribution of active faults in Liaonan province†

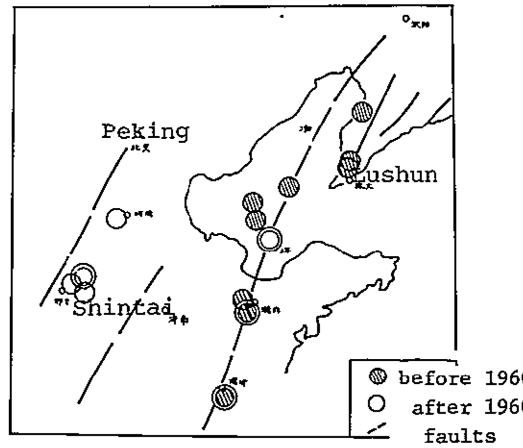


Figure 1b: Epicentral locations in Liaoning province

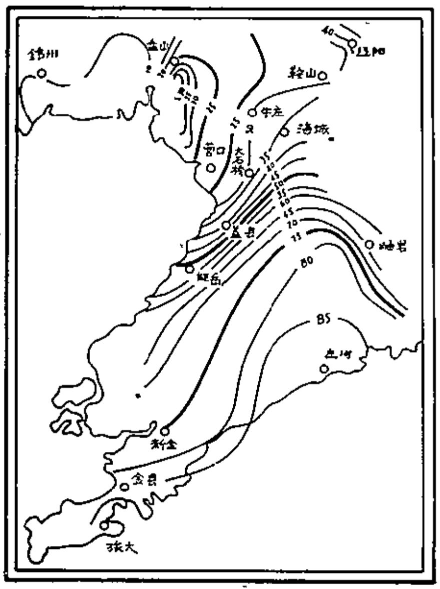


Figure 2a: Results of the precise leveling surveys 5mm contour lines

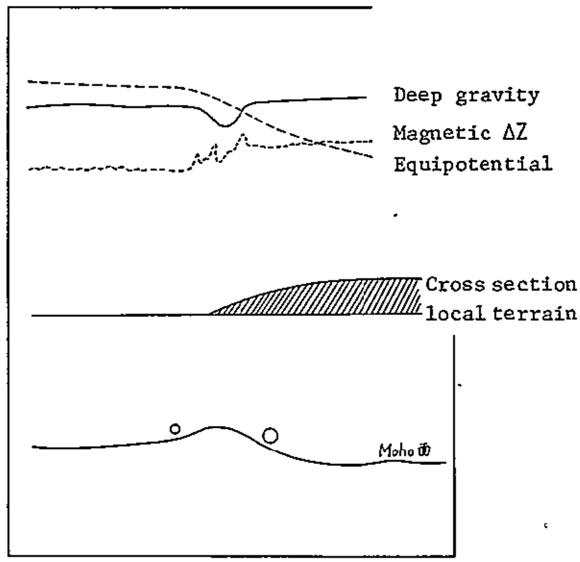


Figure 2b: A schematic view of the tectonics

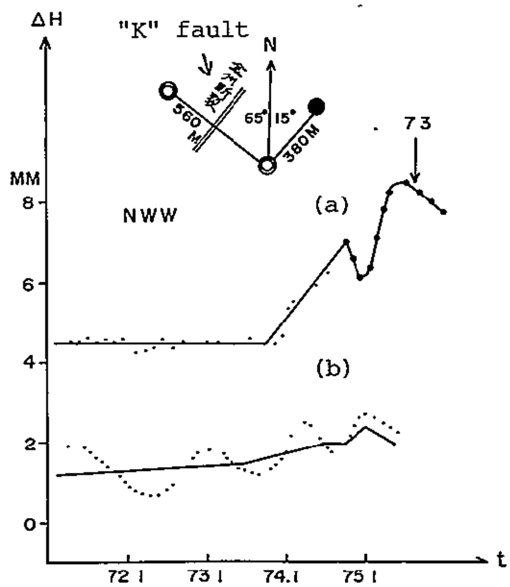


Figure 3: Vertical deformation transverse (a) and parallel (b) on the "K" fault from short level lines

† As far as can be determined, Liaonan province is the southern part of Liaoning province, and refers to the peninsular areas shown in the maps. These two names are distinct in the text, but little confusion should arise if they are used interchangeably by the reader. It would be necessary to do far more research on the Chinese place names and geography than time and resources permit if we wished to establish every place name and region mentioned in the text (ed).

bounded area was very large, and it remained for us to determine in which part the earthquake would actually occur. We therefore began the second phase of the actions based on a policy of prevention first, taking the possibility of earthquake occurrence seriously.

The second phase of our program ran from the latter half of 1973 through October 1974. In this phase we tried to reinforce our observations of various precursory phenomena in the primary earthquake prone areas bounded during the first phase. The following areas were emphasized: Portable means were used to monitor crustal changes and earth's magnetic field, as well as fixed observatory and station observations, encouraging the public to make observations, and detecting medium and short term precursory phenomena in these areas. These activities were undertaken immediately under the leadership and support of each party committee, and with the support of related government departments. As a result of taking these observations we recognized several abnormal phenomena by the first half of 1974. For example:

(1) From September 1973 to June 1974, short level line and crustal change monitoring stations set up in Chinyuan on the south of Chinchow fault detected a cumulative movement of 2.5mm during 9 months on the level contour line across the fault. This was 20 times the normal annual value (0.11mm per year) of the previous two years, indicating a substantial incline of the ground in this region, in the direction of Liaotung bay. Such a large and rapid increase in the slope could possibly be indicating pre-earthquake crustal movements, as had been experienced in other areas (see Figure 3).

(2) As for the measurements of the absolute value of the magnetic field conducted in Lutai district, the values on 22 May 1974 showed an increase of 21.5γ compared with the vertical magnetic intensity at the same position measured on 27 October 1973. This dramatic change could be indicating some substantial crustal movement, and an increase in stress field in the crust (see Figure 4).

(3) The tide observations in Liaotung bay revealed a remarkable rise in sea-level since 1973, the largest being some 10mm.

(4) Each earthquake observatory and station noticed a remarkable increase in the frequency of minor seismic activity in Liaoning province after 1973. For example, in Shenyang area, Kaiyuan area, Erhanchi - Lintung area, in Liaosi, Hsungyuh in Liaoning and the coast of Liaotung peninsula, minor seismic events were occurring at five times the normal annual rate (see Figure 5).

The conditions listed above indicated that the crustal movement of Liaoning and Liaotung peninsula was intensifying. The background of active and intense seismic activities in Huapeh and Buohai districts, and the recently observed anomalous phenomena, implied that a relatively strong earthquake potential was growing within Liaoning and Liaotung peninsula districts.

In June 1974, the National Earthquake Bureau called a conference to discuss the seismic trends of Huapeh and Buohai districts. The anomalies and data noted above were carefully studied, and synthetic analysis of various anomalous phenomena in and around Buohai was undertaken. The conference concluded that a magnitude 5-6 earthquake would occur within 1-2 years in the northern district of Buohai and recommended actions based on the policy of "precaution prevents misery."

The government departments transmitted and distributed the conference recommendations, with their instructions to set up earthquake management sections, asking the expert and public to grasp forecast-prevention movements correctly and firmly, so as to strengthen the earthquake disaster prevention and counter-earthquake action. The Chinese Communist Party, Liaoning committee, and the Provincial Revolutionary Committee further reinforced their guidance of earthquake studies and actions in the entire province, and called conferences of those responsible in cities and districts. The locations for earthquake detection, forecast, and disaster prevention were designated specifically for Liaonan and Liaotung peninsula. The policy was established to undertake earthquake studies and actions, to reinforce the prediction-forecast activities of experts, and to publicize the value of the public's participation in these activities. It was requested that earthquake prediction, forecast and prevention be undertaken with a close tie between the experts and public, as well as between the instruments and methods employed by the public and the more sophisticated professional instruments. Based on the request of the Provincial Revolutionary Committee, the earthquake office of Liaoning province made efforts to strengthen the observation programs of earthquake observatories and stations, as well as the portable observation systems of level-lines and geomagnetism, organizing expert teams to go into the people's companies and production companies in farming villages, city and village factories, and mines, and to the public in general, under the leadership of each party committee, in order to encourage the people to rise up and communicate knowledge about earthquakes and to cooperate in the program. Based on the previously established prediction forecast network, and using every possible means within the local communities, as well as the methods created by the public, the monitoring network was effectively spread across the community. By November 1974, the prediction forecast points in Liaoning and Liaotung peninsula districts constituted the network. There were as many as 232 observation points for such phenomena as underground electric currents, inclinations, ground water and animals, within Yingkao city alone. These points and networks surrounded the professional earthquake observatories and stations. Under professional guidance, the standard of observations and analysis

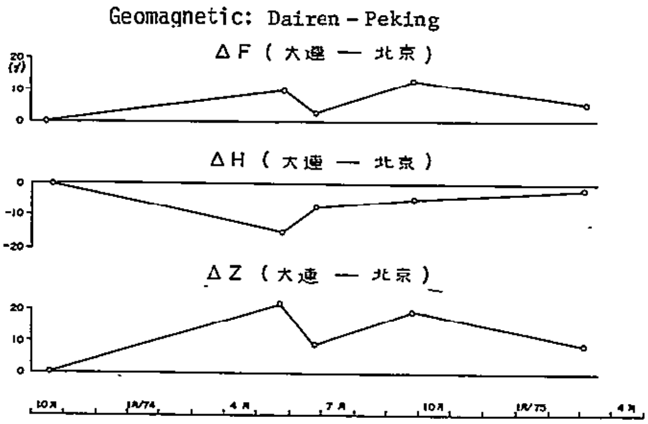


Figure 4: Geomagnetic variations recorded at Dairen

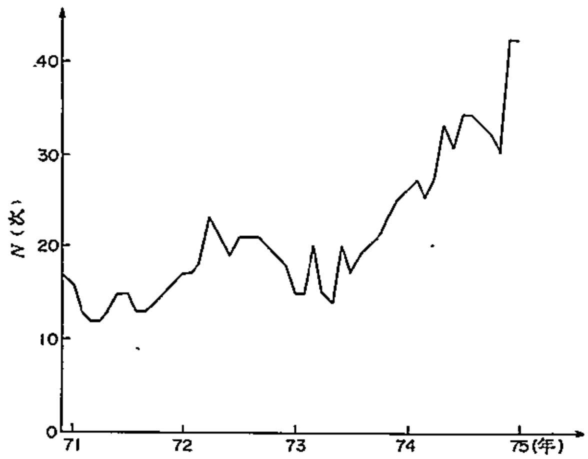


Figure 5: Frequency of earthquakes in Liaonan province

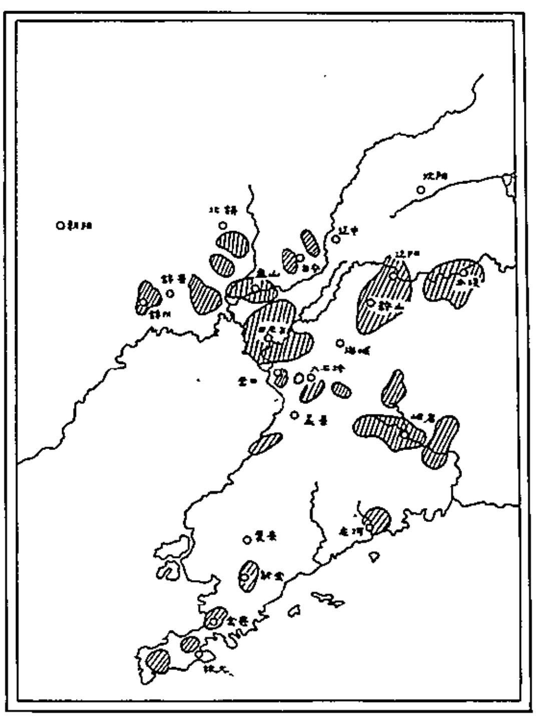


Figure 6: Distribution of unusual animal behaviors

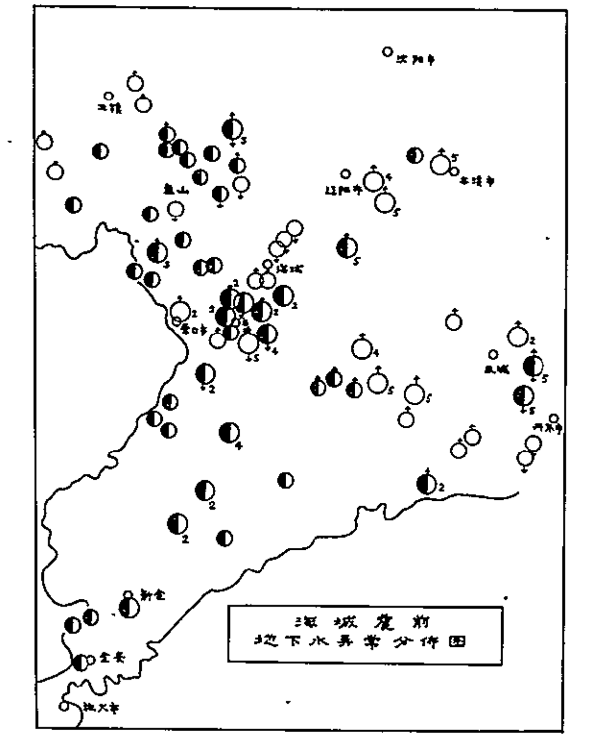


Figure 7: Distribution of wells displaying unusual ground water levels and turbidity immediately before the Haicheng earthquake. The numerals give the number of wells with level changes; the arrows indicate the direction of level change; the half-filled circles indicate turbidity in wells.

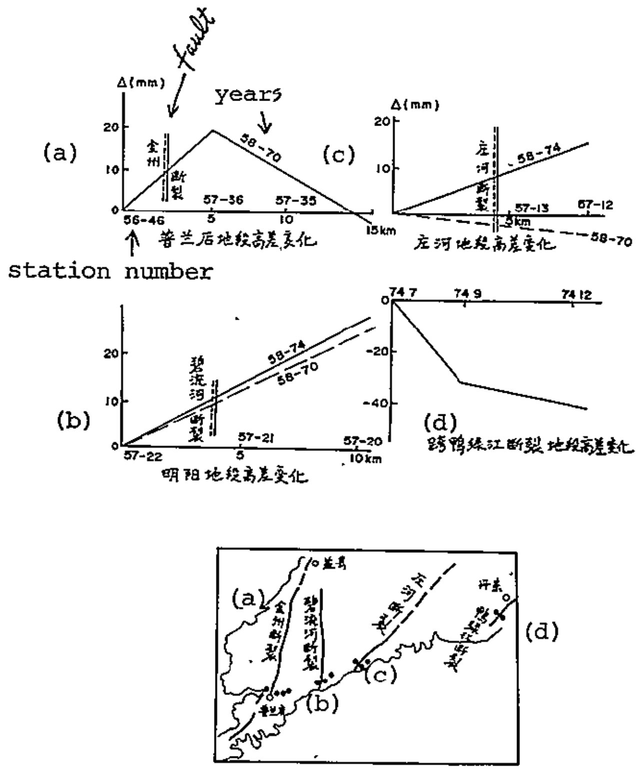


Figure 8: Precise leveling routes across faults (lower); and vertical changes for individual lines (upper).

was improved. Thus, the observation forecast network in Liaoning and Liaotung peninsula was established, with joint cooperation of public and professional, and an intensive observation forecast-actions program was underway.

In order to analyze the overall development and changes in the earthquake conditions, and to improve forecast systems, earthquake groups in each province and city, in Buohai seacoast and other related government departments, developed close cooperation with one another, exchanging data in real time and holding periodic discussions of earthquake conditions, throughout the organization of the national earthquake bureau. The conference held in November 1974 covering seismic trends in three NE provinces conducted studies based on the previously accumulated data as well as new data from Liaonang. For example: (1) all four short level lines sections (one being 10km) located in Liaotung peninsula, found inclines in the NW direction. The fact that the above observation station showed an increase in rate of crustal movement indicated not only violent activity in Chinyuan fault, but also an accelerated movement of the depression in the NW sections of the peninsula, while the SE sections showed a rise. (2) The short level line at Chinyuan showed a dramatic rise since September. (3) The geomagnetic field in Lutai district showed a positive anomaly of 13γ even on 25 September 1974. (4) Minor seismic activity in Hsungyuh and Liaotung bay south continued to increase. The conference declared "such districts as Yingkao-Darien are prone to relatively large and destructive earthquakes in the near future, and future work should be concentrated in these areas." Thus the bounds of the forecast in the northern district of Buohai were further restricted.

We entered the third phase (November 1974) following the above noted assignment of duties and preparations, concentrating efforts on observing short term precursory phenomena. According to the data on several pre-earthquake phenomena from several great earthquakes in our country, all of them had relatively remarkable short term precursory phenomena, especially easily observed anomalous phenomena. Because the forecast prediction network had been basically established on a cooperative basis of experts and public in Liaoning district, we were confident that we could catch and discover the pre-earthquake short-term precursory phenomena in this district.

In the middle of December 1974, many anomalous phenomena in various wells and animal behavior were noticed by the public prediction forecast network in Tantung district. The following phenomena were noticed in many areas: (1) Snakes hibernating came out of their burrows and were frozen stiff on the snow; rats appeared in groups and were so agitated that they did not fear human beings (a member of Tanchengtung People's Commune of Tantung, Sun Tao-yi discovered over 20 rats and could catch them with his bare hands), and other anomalous behavior was observed in domestic birds and animals. (2) In four people's communes wells, in areas such as Chulienchang in Tantung district, the water suddenly became turbid and foamed, and the level changed. (3) The vector diagram of inclinations in Shenyang district showed a break and knots {?}. The Radon content in Panchin, Tangkangtze, Tantung districts showed a positive anomaly of 20 to 40%.

An emergency discussion was held and concluded that there was the possibility of a magnitude 4-5 earthquake in the Liaonang district in the near future. On 22 December, 70km north of Haicheng, on the border of Liaoyang and Panchi, an earthquake of magnitude 4.8 occurred. Although this earthquake was close to the forecast area, we still held to our conclusion that a greater earthquake would occur in the region to the south.

The occurrence of this earthquake drew special attention from the National Earthquake Bureau and the Provincial Committee, and the Provincial Revolutionary Committee communicated through emergency phone calls requesting each area to strengthen the earthquake prediction forecast activities, and to take emergency prevention measures. The Provincial Committee instructed that "based on the fact that there is a possibility of earthquake, everyone needs to prepare always for great morning and evening earthquakes." They immediately called an emergency earthquake disaster prevention meeting, and established duty assignments concerning earthquake disaster prevention and first-aid measures. After the meeting, the information concerning earthquakes, particularly counter-earthquake disaster steps, was publicized in each area, attempting to reach every family. Within cities, farming villages, factories and mines, people established the procedures for earthquake disaster prevention according to the conditions appropriate to the locality. Based on the instructions of the Provincial Committee, earthquake prevention and disaster drills were undertaken, so that such action can be practically implemented in mine shafts, smelters, and densely populated residential areas. Also tests and reinforcements of dams, mine shafts, factory facilities and dangerous residences were undertaken.

Since the earthquake of Liaoyang, the observations from various measuring instruments and from the public prediction forecast network continued to record the above easily observed anomalous phenomena.

(1) The easily observed anomalous phenomena seemed to spread throughout the areas: Liaoyang, Panchi, Anshan, Yingkao, Chinchow & Lutai. The anomalous animal phenomena were observed in snakes, rats, hens, pigs, geese, ducks, birds, fish, horses, cows, sheep, dogs, rabbits, cats, tigers, deer, and including more than 20 species. Examples include: stunned animals, running away, madly barking, and refusing food. Anomalous levels in well water were really remarkable. Most wells showed a rise. According to the overall calculation from 81

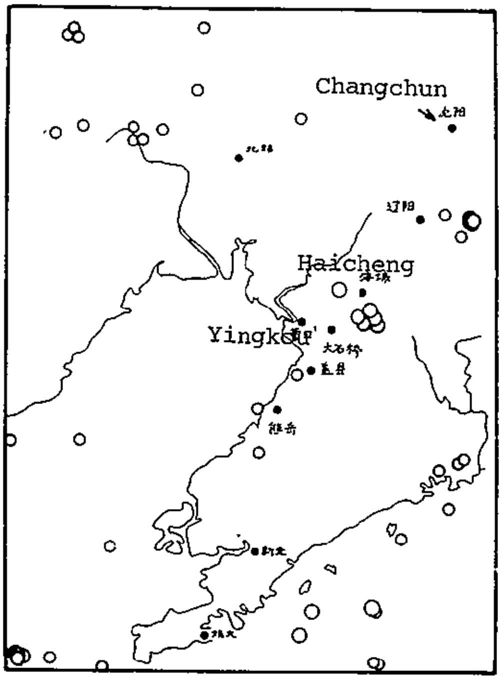


Figure 9: Distribution of epicenters in Liaoning district (o) Jan 1972 - Feb 1973

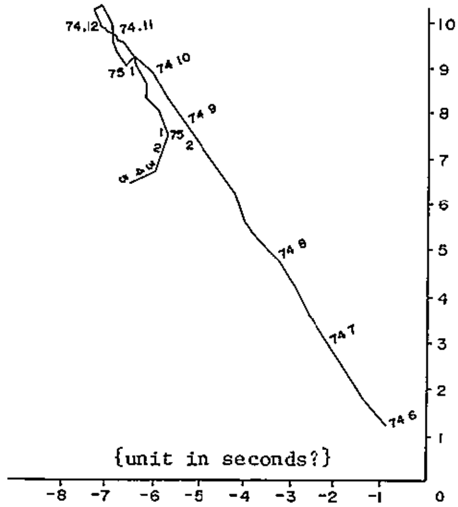


Figure 11: Variation of ground inclination vector at Shenyang observation point

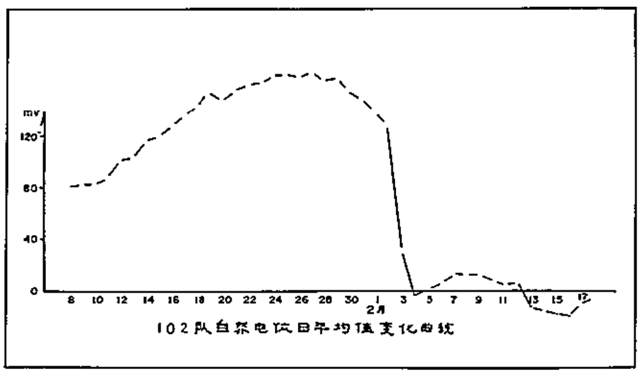


Figure 10: Daily average of natural earth current observed by Troop 102 with a sensor spacing of 60 meters

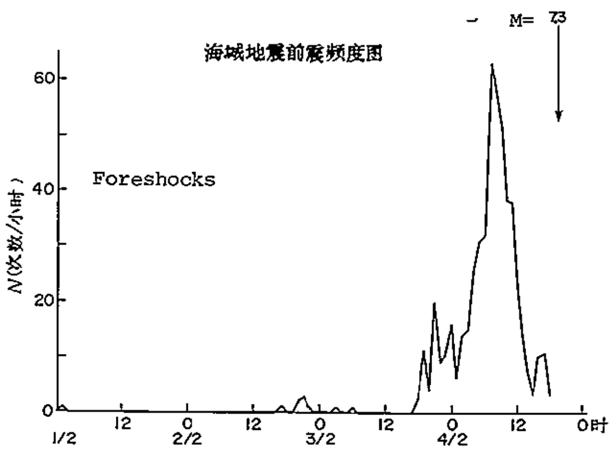


Figure 12: Hourly number of premonitory earthquakes before the Haicheng earthquake

observation points at the time, 55% indicated rises while 15% indicated falls; 30% showed change of color or foaming. The anomalous wells were distributed along the line of structure, and in several places underground water was observed to boil up (Figures 6 and 7).

(2) The observed curve of short level line data in Dhinyuan after the dramatic accelerated change since September, entered a level and constant unstable condition {that is what the text says, but what it means technically is unclear}. It resembled the standard curve applying to rock stress and crushing experiments performed in laboratories, and therefore indicated that we had entered the period immediately before an earthquake (see Figures 3 and 8).

(3) The distribution of magnitude 3 and 4 earthquakes during 1974 in Liaoning and its seacoast clearly indicated that the Chinyuan - Yingkao area was empty, and therefore anomalous (Figure 9).

Such conditions demonstrated the possibility of progressing seismic conditions in Liaoning, in addition to further narrowing the time limit for a relatively strong earthquake. In mid January 1975, the National Earthquake Bureau again called a conference on nationwide seismic trends. Based on the theoretical analysis of anomalous phenomena, and taking into consideration the background of seismic activity in Huapeh and Buohai north, they clearly recommended that Yingkao, Chinyuan and Tantung districts be designated the earthquake prone districts for magnitude 5.5 to 6.0 in the first half of 1975, and should be watched more carefully. Thus the time of forecast and possible areas were further restricted.

The fourth phase reinforced the various observations, and watched precursory phenomena to catch the big earthquake. Based on the above conference recommendations, and under the instructions of the Provincial Committee, the earthquake office of the province called an emergency meeting of those who were responsible in earthquake offices and earthquake observatories and stations of such areas as Yingkao, Panchin, Lutai and Tantung on 28 January, and transmitted the spirit of the conference of the National Earthquake Bureau studying the possibility of strengthening the observations and grasping the precursory phenomena. In addition, the conference requested that such people go out to the public at large and let them rise up and make a thorough publicizing of precise knowledge of earthquake and earthquake disaster prevention. They also requested that the observation activities by the public, as well as the earthquake observatories and stations, be strengthened, and the earthquake disaster prevention measures be undertaken within each organization, factory, mine, in cities and towns, people's productions companies, and in farming villages.

After the assignment of duties and dissemination of information, the local leaders and the public improved their knowledge of earthquake studies and actions, and safety measures, and were mentally prepared for the possibility of earthquake. They have become active in prediction forecast and earthquake disaster prevention, observing seriously the various anomalous phenomena, and immediately reporting when such phenomena are discovered.

In the beginning of February 1975, various easily detected anomalous phenomena had become increasingly remarkable:

(1) Anomalous phenomena of animals increased, especially among large animals such as cows, horses, dogs and pigs. The deer ranch in Anshan observed the deer to be startled, jumping in their stalls, running around aimlessly and bumping into each other. Among them, a three year old plum flower deer (brown deer with white spots) broke his leg trying to jump over the fence.

(2) Anomalous phenomena in well water gradually advanced from SE and NW directions toward Yingkao-Haicheng. According to the data on well water already collected at that time, the well water of Panchin still showed a rise, and in two wells in Yingkao, Yuyen & Panchin, the water blew out. In a hot spring in Tangkangtze, on the contrary, the hot water stopped spouting three times (it was observed also in Liaoyang that the hot water stopped spouting twice before the earthquake, but the time was relatively short). The most remarkable was the people's commune of Shiaotze River, Yuyen prefecture, where the pond water had air bubbling in it, broke the ice and shot up like a water fountain.

(3) The electric current in the ground measured by a simple instrument made by the public near Yingkao Earthquake Station showed an abrupt change starting on 2 February. The electric current underground measured by this simple instrument created by the public at amateur prediction point of Geology 102 Troop showed (on a 60m distance between electric probes) a slow rise after early January, and then dipped dramatically on 2 February, recording more than 100mv drop at 0 Hours, 4 February (see Figure 10). At the same time, a wide range anomaly appeared at Haicheng Observatory Station, Kuchuang Mail and Telegraph Office.

(4) The level meter which Shenyang Earthquake Station had placed within a cave in a mountain, showed an accelerated break in the SW direction, away from the normal motion, on 30 January.

(5) Most remarkable was the minor seismic activity occurring 20km away from the Yingkao Earthquake Station on 1 February (see Figure 12).

There were four characteristics of these minor earthquakes: First, the districts which experienced these minor earthquakes were districts in which earthquakes seldom had occurred in the past. Second, the frequency and intensity continually increased, *i.e.* one on 1 Feburary, seven on 2 February, and many more on 3 February - all of the kind which can be felt. On the morning of 4 February, earthquakes of magnitude 4.7 and 4.2 occurred. Third, the primary direction of the P wave was constant, and most of the primary movement was down-thrust. Fourth, the positions were concentrated in one small area.

Yingkao Earthquake Observatory made an analysis of such minor seismic activities and of data collected by simple instruments created by the public, and gave out a forecast of a relatively strong earthquake in the area within several days.

Liaoning Province earthquake office analyzed data gathered from various areas, and concluded that the above phenomena could indicate a possible pre-earthquake anomaly. They also feared that a relatively strong earthquake could occur after the minor seismic activities in Haicheng and Yingkao districts, and forwarded their opinion concerning the earthquake conditions and forecast to the Provincial Committee at 0:30 on 4 February. On that same morning, the Provincial Committee sent out instructions on earthquake disaster prevention measures, and transmitted this to the related city committees. At 10:00 AM, the Provincial Revolutionary Committee notified all the provinces through emergency telephone calls that there was a possibility of strong earthquake in Haicheng Yingkao districts. At 14:00, the provincial earthquake office called a conference for earthquake disaster prevention in Haicheng prefecture, transmitted the instructions of the Provincial Revolutionary Committee to the responsible personnel of each prefecture and studied actual duty assignments for earthquake disaster prevention.

Yingkao, Anshan city committee called many emergency meetings in accordance with the instruction of the Provincial Committee. They assigned emergency duties, organized the public and made simple structures for disaster prevention. In Yingkao prefecture, hospital patients were evacuated while the aged and weak were organized and evacuated into the disaster prevention structures. Vehicles and items for first aid purposes were prepared while first aid and medical troops were organized. In certain people's communes and production forces, the public was evacuated from housing structures onto an open area where they were shown films. Guards and watches were placed in important working areas.

Thus when the actual strong earthquake occurred at 19:36 (Peking time) on 4 February, the majority of the people and large domestic animals were well away from structures, while automobiles were left apart from garages†. Many important materials were moved from storehouses. Although damage to the structures was severe, loss and injuries to human beings and animals were greatly minimized. As each party committee had acted accurately and carefully on earthquake disaster measures, and organized the public for such actions, no loss of human life was reported in several people's communes and production forces, despite the fact that the earthquake damage was disastrous in the most violently shaken areas, as high as 90% of the structures being destroyed in certain locations. Over 3,000 people of the Chakao production force, Haicheng Pailo people's commune, were organized and evacuated by the leaders who acted in accordance with the instructions of the above, and there were no injuries except for one injured child. On the other hand, there were some injuries and casualties in some people's communes and production forces. For instance, Shihpangku production force in Yingkao, the public was instructed and organized for evacuation. And yet two members of the company who were relatively influenced by old thoughts did not trust the forecast. They brought their child home during the night and went to bed. Among all of 3400 some people of this production force, these three were the only casualties. Such examples show the overall effect of the earthquake disaster prevention.

After the earthquake, Chairman Mao, the Central Party and the government departments were deeply concerned. The central party sent out a group of members to comfort the stricken. Under the guidance of each committee and the encouragement of the central party, and with the great support of the Chinese People's Liberation Army and people all across the nation, the people of the affected areas followed the motto: "Rise up and build strength and wealth, develop production with your own hands, and rebuild the homeland." Counter-earthquake and aid activities began at once, seeking quick recovery of production, rearrangement of their lives, and the bringing forth of new development in industry and production, as well as rich harvest in the fields. The destroyed structures are now mostly rebuilt, while new villages and housing developments have been created. The public is in high spirit, and are striving forward under the banner: "The agriculture of the nation learns from hard winters, while industry learns from catastrophe."

(Lecture on 3 December 1975)

† This is no minor matter. Emergency and other vehicles trapped in their garages were a major problem in the San Fernando, Calif. earthquake.

CHARACTERISTICS OF THE HAICHENG EARTHQUAKE OF 1975

By Hsu Shao-Hsueh

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I would like to explain the characteristics of the seismic activities at the time of the Haicheng earthquake. I can divide this into two sections: First, an explanation of the basic conditions of the seismic activities in the Haicheng earthquake; Second, an explanation of the basic conditions of the seismic activities relating to the forecast.

(Figure 1) A strong earthquake shook the areas near the Punkao People's Commune, in Haicheng Prefecture, Liaoning Province, on 4 February 1975. The intensity in the epicentral areas was magnitude 9 {Chinese scale used here is believed to be similar to modified Mercalli}. The long axis of the affected area at magnitude 9 was 50km, short axis 37km, and the entire area was 760km^2. The affected areas at magnitude 7 was 9,200km^2, and the maximum area over which the earthquake could be felt stretched to Kiangsu province on the south, and Weiyin on the north, Mongolia and the region of Wuhan on the west, the radial distance reaching generally 1000km.

The basic parameters of the main shock: the time of the earthquake was 19h 36m 06s (Peking time), epicenter was located in east longitude 122° 48', and north latitude 40° 39', and the epicentral depth was 12km, and magnitude 7.3 (Richter).

(Figure 2) After the main shock of magnitude 7.3, nearly 100,000 aftershocks were recorded. Figure 2 gives the distribution chart of observed earthquakes of magnitude 2 or over between 1 February and 31 March 1975. Aftershocks were concentrated in the area 70km long, and 30km wide, and the epicentral depth distribution was between 1 and 17km, and 90% of them were less than 12km.

This earthquake was accompanied by numerous foreshocks. Shihpangku earthquake station, 20km away from the main shock, recorded over 500 foreshocks. The foreshocks which could determine the epicenter were all concentrated around the main shock. Small foreshocks which could not determine the epicenter also were concentrated around the main shock based on the estimate of S minus P wave times. In the figure (2), the solid circles represent foreshocks. The direction taken by the aftershocks was 69° from N to W. As for the vertical cross-section of this direction, see the next figure.

(Figure 3) This is a cross-section of 69° NW. The following three figures are the cross-section of the directions at right angles. As can be seen in these figures, the distribution of inclination angles of foreshocks is relatively steep, and the epicentral orientations were in agreement with this.

(Figure 4) This figure demonstrates the epicentral orientations obtained from the first motions of P waves from the main shock. Please see the attached chart below the figure. Viewing the distribution of aftershocks, we can choose nodal-plane "A" as the fault plane. Therefore, the structure of the epicentral zone was a horizontal, left displacement fault. This view was proven by measurements of crustal movement after the earthquake and surface surveys of the fault.

(Figure 5) This figure shows the epicentral orientation obtained by superimposing ten first motion distributions from foreshocks. Viewing this figure {shows}: (1) the epicentral mechanisms of the foreshocks are stable; (2) the epicentral orientation of the foreshocks, and the main shock, showed excellent agreement.

(Figure 6) The area of local crust depression closely matched the region of large aftershock activity. The broken lines in the figure show the aftershock areas. The arrow pointing down shows the depression, and the length represents the magnitude. The strike direction of maximum depression is NW and is in agreement with the foreshock areas. According to the triangulation, the hori-

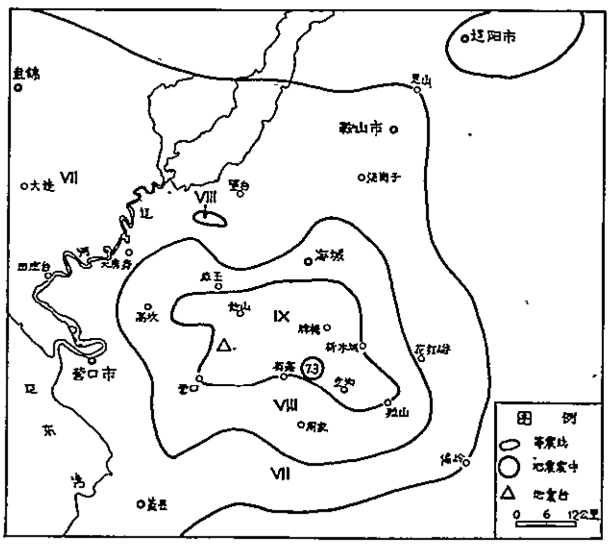
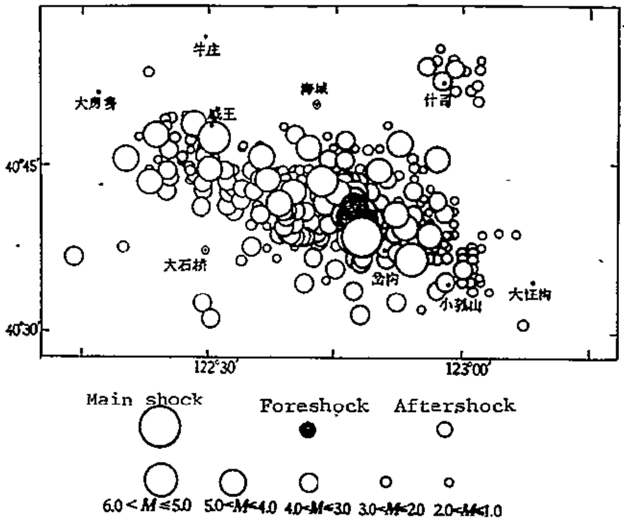


Figure 1: Intensity distribution in the Haicheng Earthquake (modified Mercalli scale)
o epicenters Δ seismograph stations



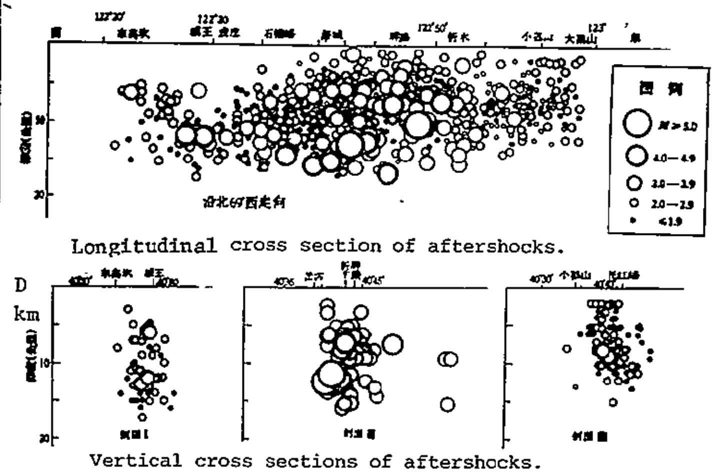
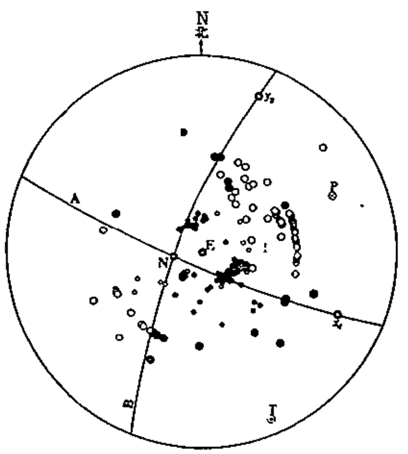


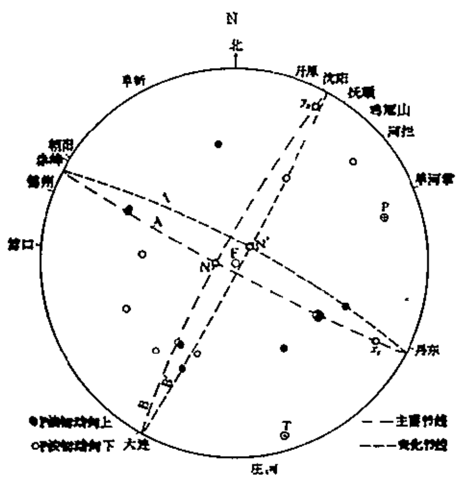
Figure 2: Distribution of epicentral locations in Haicheng earthquake 1 Feb. - 31 Mar. 1975

Figure 3: Distribution of epicentral depth in Haicheng earthquake 1 Feb. - 31 Mar. 1975



P-wave first motions (main shock)
● compression o dilation

	节面A	节面B	X轴	Y轴	P轴	T轴	N轴
走向	292°	202°	115°	20°	67°	154°	261°
倾向	22°	112°					
倾角	81°	75°	15°	9°	17°	4°	73°



	节面A	节面B	X轴	Y轴	P轴	T轴	N轴
走向	298°	209°	118°	28°	72°	154°	269°
倾向	NE	ES					
倾角	85°	80°	10°	4°	11°	4°	79°

← Direction of angle of inclination ↑

Figure 4: Distribution of P-wave first motions in main shock of Haicheng earthquake

Figure 5: Comparison of the stress axes of the main shock A-B with foreshocks A′-B′

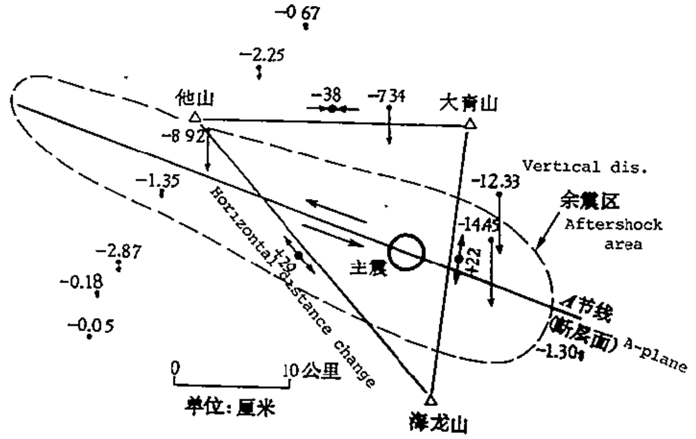


Figure 6: Horizontal and vertical displacements resulting from the Haicheng earthquake (cm)

zontal movement of the two sides across the fault is a dilation. The side which connects the two points which do not cut across the fault (having different epicentral distances) experienced a compression. This indicates that there was the horizontal movement of a left displacement fault. Incorporating all of the above phenomena, we can conclude that nodal plane *A* was left displacement. This was in accordance with the epicentral orientation mentioned above.

(Figure 7) The crack structure in the Shiaokushan District also clearly shows that the fault was left displacement. The strike direction of these cracks is close to the East-West direction. The length over which the crack can be detected is 5.5km, and 10 to 60 meters wide: over 300 cracks in parallel forming the detectable area {along the fault}. The direction was relatively constant, and unaffected by topography in the area. In many places, we could observe the phenomena such as severed tree roots. The maximum amount of left displacement reached 55cm.

(Figure 8) We analyzed the fault plane from the distribution of first motions of foreshocks, main shock, and aftershocks. The foreshock orientation and main shock orientation were in agreement. Roughly estimated, the stress drop in the main shock was 4.8bar (length of fault estimated at 70km, maximum horizontal displacement 55cm). Compared to previous M=7.3† earthquakes, the stress drops of which were 30-40 bars, the scale of this particular earthquake was one order of magnitude smaller. The horizontal strain measured by triangulation was 2×10^{-5}, which is also an order of magnitude below that of the Yingtai earthquake. The Haicheng earthquake of 1975 is therefore considered to have had a small stress drop.

Most of the aftershock orientations were close to those of the foreshocks and main shock. Within the earthquake orientations listed in the upper section of the figure, four were different from the others. The algebraic signs of the first motions of these four quakes, recorded by the earthquake observatories, were mostly reversed. Interpretation of this observation awaits further study. Some view this as a readjustment from excessive offset, while others view it as caused by a kind of block motion.

The epicentral dimension, seismic moment, stress drop and the amount of offset for 80 foreshocks and aftershocks were measured, using the amplitude data of the half period of the first motion of P waves. The results were as follows: (1) Stress drops were within the range 0.1-1.0 bar, which is relatively low. (2) There were two places in which stress drop was relatively high. These correspond to the orientations with reverse signs.

This constitutes the basic conditions of the earthquake, following is item two, characteristics of the seismological activity.

† M = Richter Magnitude, and "magnitude" will refer to the modified Mercalli scale in the text.

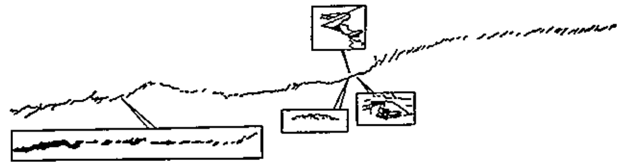


Figure 7: A sketch of crack distribution and orientation

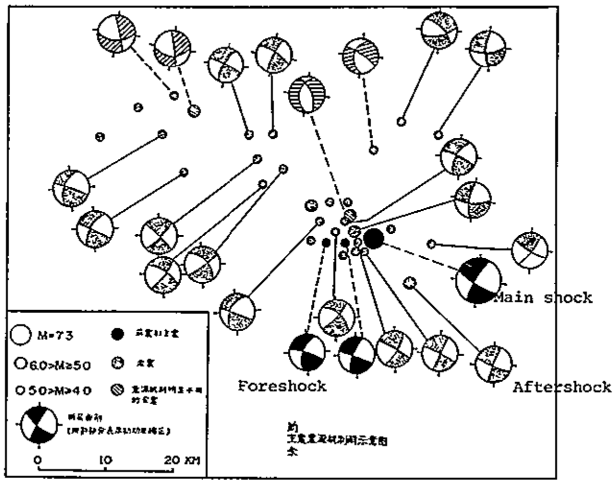


Figure 8: Earthquake orientation: shaded areas represent compression of first motion

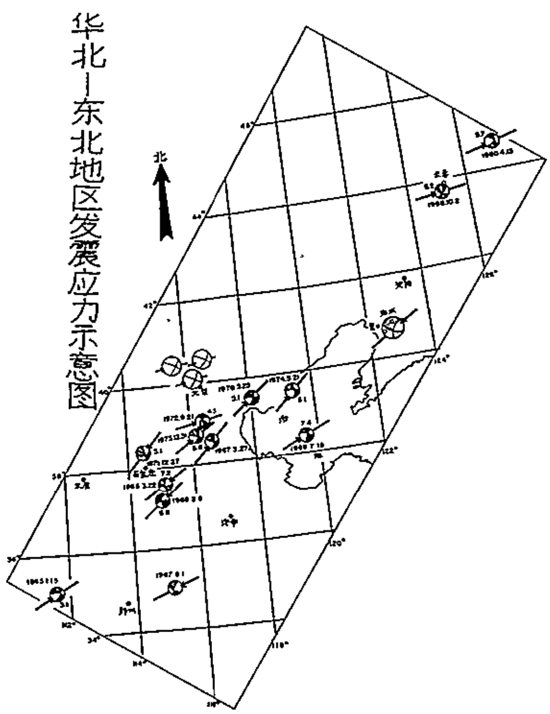


Figure 9: Maximum compressional axes in Huapeh and Tungpeh districts

Figure 9 demonstrates several earthquake orientations in Huapeh district. The two nodal lines of orientation in Huapeh run, for the most part, in the north - northeast and west - northwest directions. Hence the stress field is considered to be comparatively uniform. The main compressional axis runs in the northeast - southwest direction. The Liaonan - Haicheng districts are located within this uniform stress field.

(Figure 10) In view of its topography and structure, Liaonan and Huapeh districts are identical. All of the topographical aspects from Mt. Taisungon to Mt. Taiseng and from Chungliao plains to Huapeh plains are similar.

The great fault of Cheng-Luhchiang cuts across Buohai and extends as far as Liaonan. This and the uniform stress field of this area correspond to one another.

(Figure 11) With the Yingtai earthquake of 1966, seismic condition of Huapeh district entered an active period. Earthquakes occurring since the Yingtai earthquake are as follows: 8 March 1966, M 6.8 in Lungyao; 22 March 1966, M 7.2 in Ningtsun; 27 March 1967, M 6.3 in Hochien; 28 July 1969, M 7.4 in Buohai. The direction of these earthquakes has tended to shift from southwest to northeast. This fact had been repeatedly discussed since the Yingtai earthquake of 1966.

Following the Yingtai earthquake of 1966, earthquakes of M 6.3 and 4.5 occurred in Pehpiao. On 2 October 1966, an earthquake of M 5.2 occurred in Chianchung. (From the figure, the audience will be able to appreciate that there were very few earthquakes in Tungpeh district since 1944.) These earthquakes left a strong impression on the people. Professor Lee Sze-Kwang pointed out at that time that, "from the structural point of view, we must take these earthquakes seriously."

Taking into consideration such facts as the uniformity of the stress field and the direction of the fault, anyone would naturally ask the question: "aren't earthquakes going to develop toward the northeast in the future?"

(Figure 12) We could observe the velocity variation of seismic waves in this particular area. I would like to stress a point here, and that is that we did not have a clear knowledge concerning the velocity variation of seismic waves in this area until after the main shock of M 7.3 in Haicheng. Today we are still in the process of analyzing and studying the data, and the following results are only tentative.

First of all, we noticed that the wave velocity varied significantly over a large land area. First it showed a slight variation (figure 12a: Prior to 1974), and later it recovered (b). Another condition we noticed was that the epicentral region of the main shock did not show any variation until the time of foreshocks. There were three other points outside of the area shown in the figure, *i.e.* 1.67, 1.64, and 1.56.

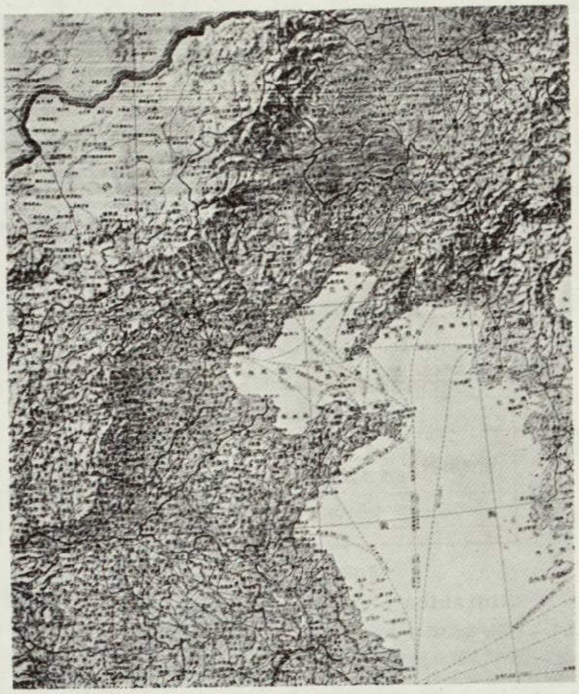


Figure 10: Topographic map of the Liaonan and Huapeh districts

Figure 11: Migration of major earthquakes since 1966

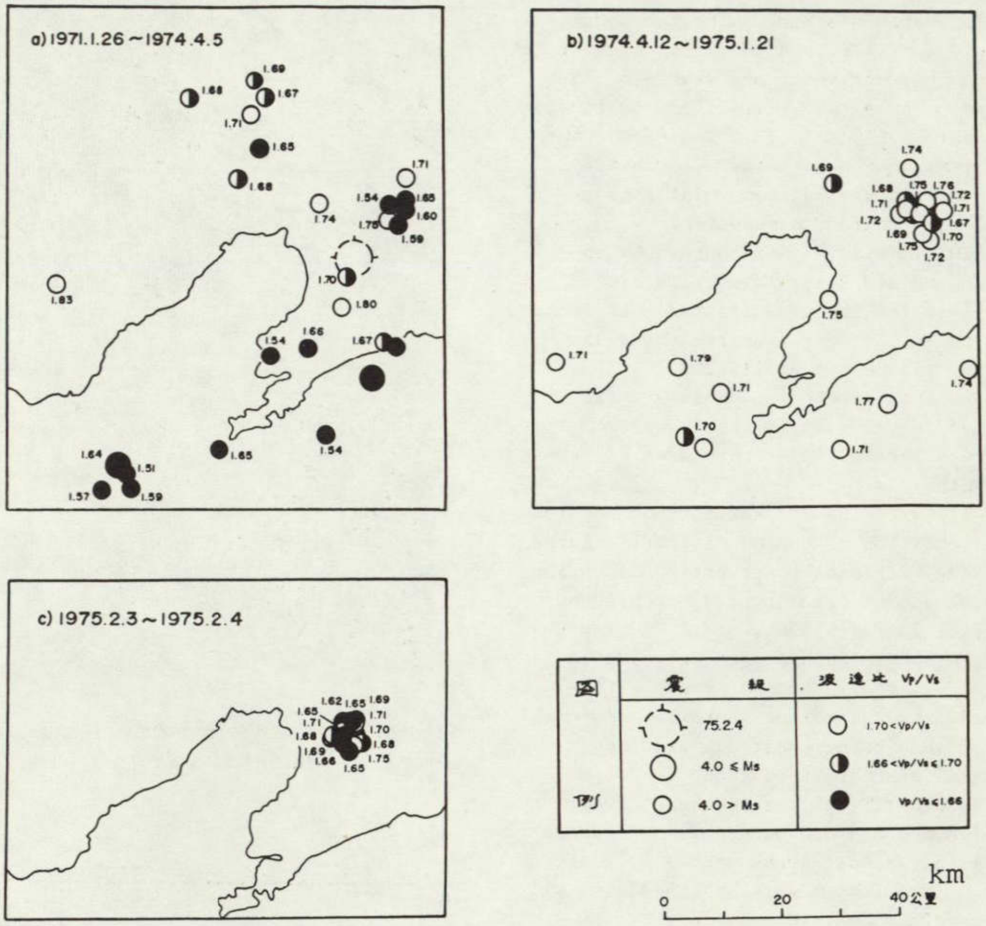


Figure 12: Distribution of anomalies in seismic wave velocity

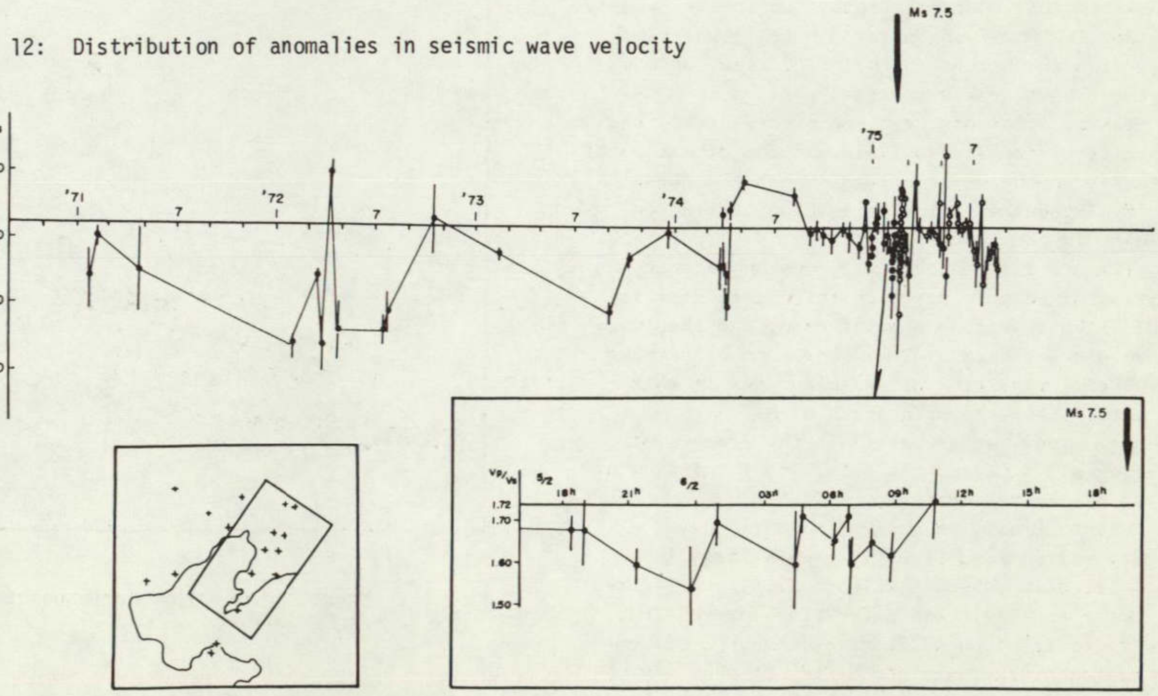


Figure 13: Plot of V_p/V_s

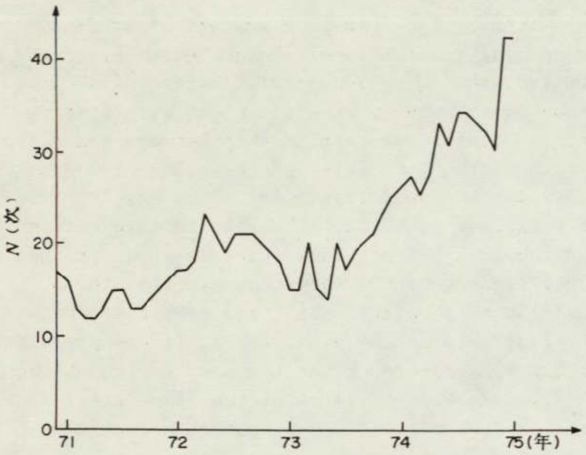


Figure 14: Variation in frequency of earthquakes in Liaonan district

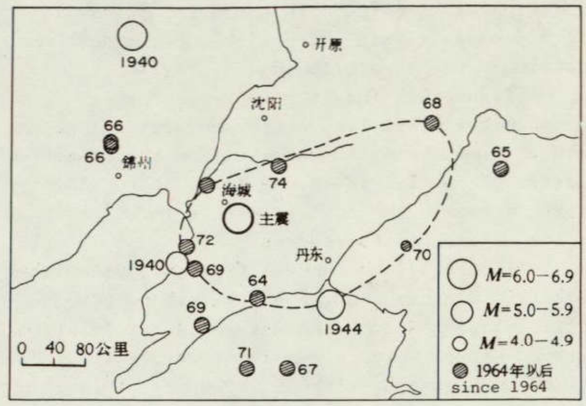
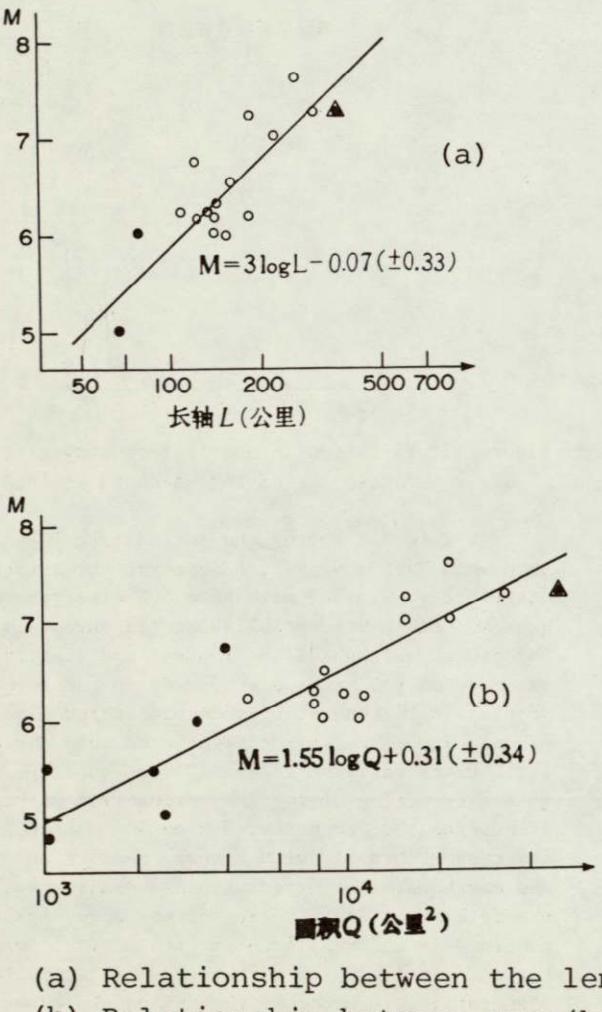


Figure 15: Epicentral distribution of earthquakes in district M ≥ 5 1940-1957; M ≥ 4 1958-1974



(a) Relationship between the length(km) and M,
(b) Relationship between area(km^2) and M.

时间 (yr)	地点 (place)	M (M)	空区长轴 h(公里) (h km)	空区面积 Q(公里²) (area km²)	选用震级
1944.9	乌恰	7.0	210	16000	≥4.0
1949.2	轮台	7.2	300	34200	≥4.0
1955.4	乌恰	7.0	250	22600	
1966.9	中甸	6.4	160	8800	≥3.0
1968.2	台湾	7.0	100	4000	≥4.0
1970.1	通海	7.7	105	5400	≥5.0
1970.2	普洱	6.2	140	8000	≥3.0
1970.2	大邑	6.2	115	5000	≥3.0
1971.8	马边	≈6.0	140	8600	≥4.0
1972.1	柯坪	6.2	180	12000	≥3.0
1970—1973	普洱	≈7.2	184	16000	≥4.0
1973.6	精河	6.0	150	11000	
1973.8	南坪	6.2	134	10000	≥3.0
1973.8	普洱	6.3	148	8000	≥3.0

Figure 16: Relationship between the length (of the blank area) L in km and M; and between the area Q in km^2 and M.

The curve representing the chronological variation provides us with a crucial observation which demands careful attention and further research. See the following figures:

(Figure 13) This figure represents the chronological variation of the velocity of seismic waves, using the earthquakes within the framed portion of the figure in the lower left. The figure shown in the lower right is an enlargement of the portion of foreshocks.

(Figure 14) The annual frequency of earthquakes in Liaonan showed a remarkable increase after 1974. Based on the data of about 20 strong earthquakes in China since 1944, we observed that all of them passed, without exception, through stages in which the seismic activity became vigorous. At the peak of activity, the frequency was 2 to 10 times as much as that during inactivity. (See Table 1 for instance.)

Table 1

Year	Month	Epicenter	Magnitude	N (active) / N (quiescent)
年	月	震　　央	M	N（活動期）/ N（平静時）
1944	9	新彊喀什西南	7.0	4.8
1949	2	新彊库车东北	7.2	10
1961	4	新彊巴楚西	6.8	3.3
1966	9	云南中甸东南	6.4	2.2
1968	2	台湾玉山东北	7.0	3.7
1973	8	四川南坪西南	6.2	2.6
1973	8	云南普洱	6.3	2.6

Viewing the various conditions mentioned above, the anomalous condition of seismic activity in Liaonan district could no longer be ignored.

(Figure 15) This figure shows the distribution of earthquakes of M=5 and over during the period 1940-1974, and those of M=4 and over during the period 1958-1974, in Liaonan district.

Among earthquakes with M=5 and over occurring in Liaonan district since 1940, we know of only three that occurred between 1940 and 1944. No earthquake with M=5 or over occurred in the 30 years from 1944 through 1974. After the nationwide standard earthquake observatory network was set up in 1958, any earthquake with M=4 or more that hit this district should have been observable. And yet, as is shown in the figure, no earthquake of M=4 occurred in Liaonan district, not even after 1964. The spatial distribution of seismic activity of M=4 or more was a blank area. The meaning of the blank area as a *precursory* {*ital* ed} phenomenon was actively discussed in our country as well as in other countries. Our country has a great wealth of earthquake examples {from the historical records}. There was no doubt that such examples had significant meaning in earthquake forecasting. Based on the size of such a blank area, we can predict the size of future earthquakes.

(Figure 16) This is a summary of studies concerning remarkable earthquake examples of our country, that were accompanied by the blank area. These earthquakes were all violent, registering M=6 and over. The relationship between M and the length of the long axis {of the blank area} is shown in the upper figure (a). The margin of error in this case is ±0.03. The relationship between M and the area of the blank space is shown in the lower figure, with a margin of error of ±0.34. Based on this relationship, and from the length of the long axis of the blank space, it was predicted that the magnitude of the Liaonan earthquake would be 7.5, and from the area of the blank area, it was predicted that the Liaonan earthquake would be M 7.6.

The above factors were significant seismic characteristics in the medium term forecast of the Haicheng earthquake. Let us turn to a study of the characteristics immediately before the earthquake.

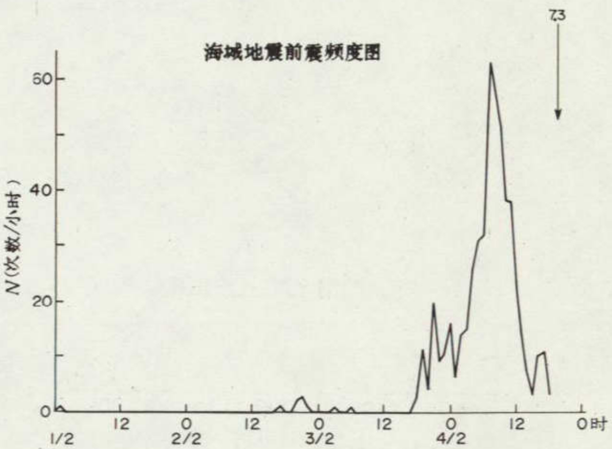


Figure 17: Variation in hourly frequency of the foreshocks of the Haicheng earthquake

(Figure 17) During the period from 1 February through 4 February 1975, Shihpangku earthquake observatory recorded more than 500 minor earthquakes. Since its establishment in August 1970, Shihpangku earthquake observatory and stations recorded only 9 minor earthquakes in the five years. The strongest of them registered a magnitude of only 1.3. The characteristic of this series of earthquakes was: the frequency rose quickly, earthquakes occurring during the period from 01 hour to 11 hour of the 4th numbered some 400 - then activity ceased abruptly with a very small value of B. The earthquakes occurred within a small area, and the epicentral distribution of the foreshocks was confined in an area 14 x 8 km with a stable orientation. Among 79 foreshocks whose first motion was discernible, recorded by the Shihpangku observatory, the first motion of 78 was all extension and the wave pattern was similar. Whether these were true foreshocks or swarm type earthquakes became an intriguing question.

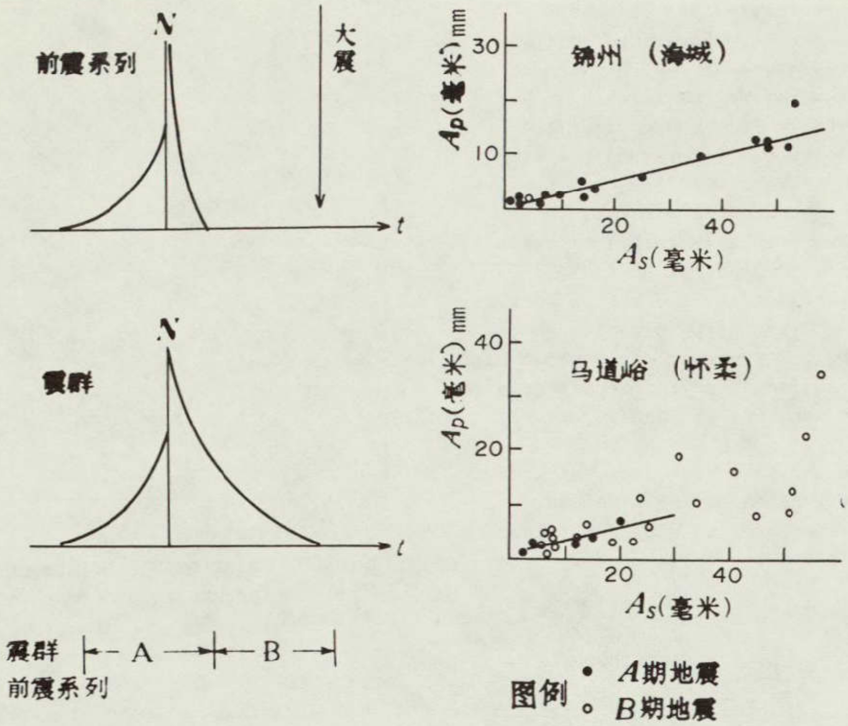


Figure 18: Comparison between frequency and P/S maximum amplitudes, for foreshock type earthquakes (upper) and swarm type earthquakes (lower). • A period earthquakes: o B period earthquakes.

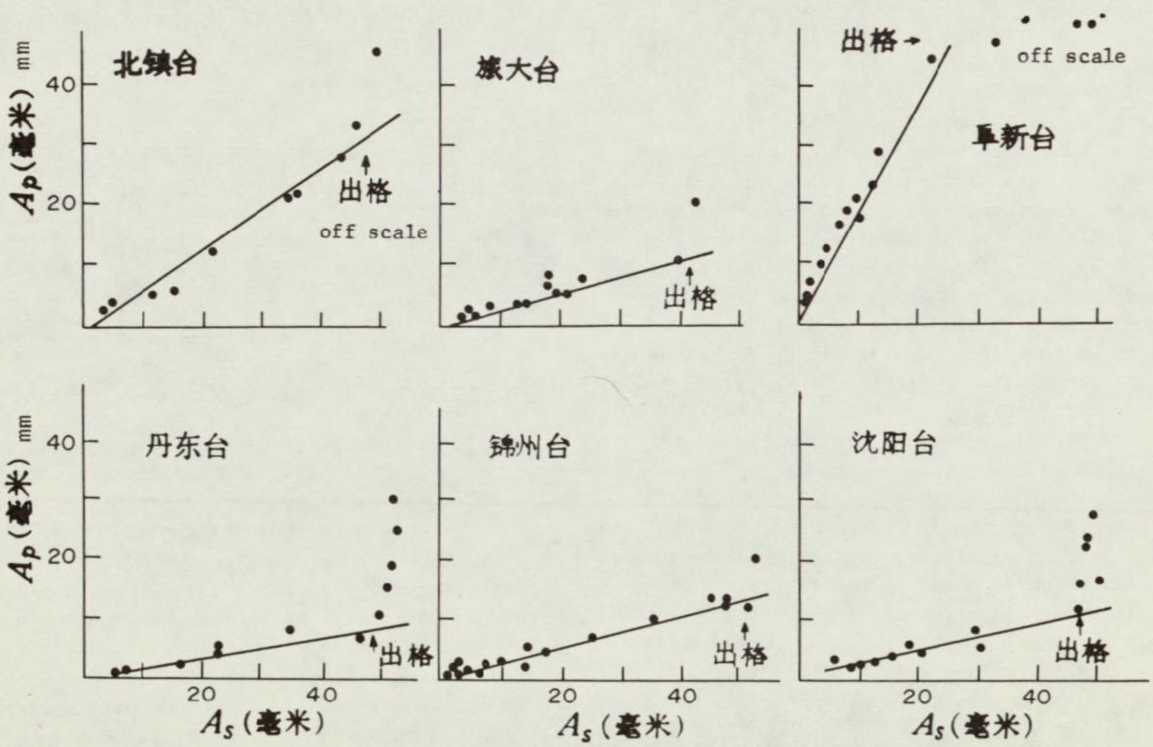


Figure 19: Ratios of maximum P and S wave amplitudes of the Haicheng earthquake foreshocks at six observation stations

(Figure 18) This figure is a schematic drawing of the swarm and foreshock type earthquakes. The characteristics of the activity of swarm type earthquakes before the release of major energy (A period) differs from those after the release (B period). The two figures on the right demonstrate those that are viewed from the A_s/A_p relationship. Please notice the right of these figures. The amplitude ratio is relatively stable in the A period, while in B, it is unstable.

The characteristic of foreshock type activity is similar to those of swarm type earthquakes during A period, but is not very clearly shown or demonstrated. Those during B period represented in the A_s/A_p chart, tend to line up in a relatively straight line.

The swarm type and foreshock type earthquakes are difficult to distinguish during A period. During B period, however, we can always distinguish swarm type earthquakes.

Table 2

Characteristics of swarm-type earthquakes

	A period	B period
Amplitude, Frequency	Rise	Fall
M	Rise	Fall
Value of B	Small	Large
Spatial distribution	Concentrated	Diffuse
Orientation	Stable	Change

Please see the following figures concerning conditions prior to the Haicheng main shock of M 7.3.

(Figure 19) The amplitude ratio of A_s/A_p recorded at earthquake observatories and stations located around this earthquake system was stable up to the time immediately before the great earthquake, as is demonstrated in the figure. Incorporating with the characteristics mentioned above, the rise (increase) is rapid, and the spatial distribution is concentrated with the value of B being minimal. Therefore, we could not identify these quakes as swarm-type earthquakes. It was necessary, in other words, to define these as foreshock type earthquakes. If these shocks were, indeed foreshocks, how strong would the future earthquake be?

(Figure 20) Based on the statistics of earthquakes in our country accompanied by foreshocks, the relationship between the main shock and foreshock was as shown in the figure. Taking this relationship into consideration, it was predicted that the foreshock of M 4.7 would correspond to the strong shocks of M 6.7 (the actual condition of the Haicheng earthquake is shown Δ).

Viewed from the characteristics of the medium to long term seismic activity mentioned above, this district was ready for a strong earthquake. Then a series of earthquakes occurred on one side of the blank space. These earthquakes exhibited

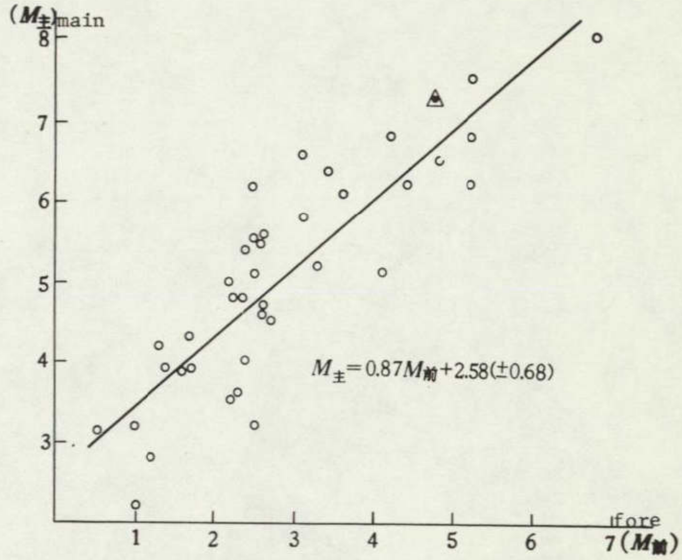


Figure 20: Relationship between magnitudes of foreshocks and main shocks in China

the characteristics of swarm type earthquakes. Their scale appeared to indicate the possibility of a strong earthquake in the future. These conditions all supplemented and supported one another. We therefore decided that the seismic activities which we were observing indeed were valid precursory phenomena. The specific kinds of precursory phenomena noted above are naturally limited in their capacity to forecast earthquakes under other conditions. The following schematic drawing illustrates our views.

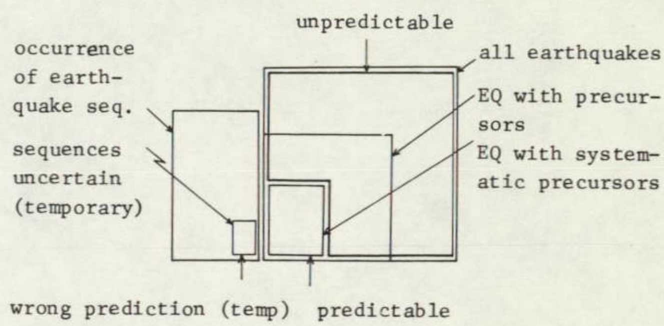


Figure 21: Schematic of earthquake prediction relationships: strong earthquakes with a series of systematic precursors occupy only a part of the whole.

The precursory characteristics immediately before an earthquake mentioned above can be used as a forecast factor only for this part, as is illustrated in the smallest rectangle on the center right of the figure. As for those with swarm-type earthquakes as precursors, we won't be able to define that part for some time to come, and there will be erroneous forecasts. This circumstance is shown by the small rectangle in the center left of the figure. Most of such misforecasts will not stand long, however. When the characteristics of the B period of the swarm type earthquakes gradually become apparent, we can correct such mistakes. As has been explained thus far, we believe that the Haicheng earthquake was subject to reliable forecast, as assessed from the characteristics of seismic activities.

(Lecture 4 December 1975)

STUDIES CONCERNING EARTHQUAKE RESISTIVITY OF FACTORY STRUCTURES

By Yuen Tze-Chien

Research Assistant in the Engineering Mechanics Division
of the Chinese Academy of Science

The purpose of our research on structures is mainly for application to the design of future buildings. The studies we have undertaken thus far can be roughly classified into two categories, namely, the studies on dynamic behavior of factory structures, and the latent resistivity of these structures to earthquakes. The study of dynamic behavior of factory structures attempts to measure the oscillatory behavior of the structure through oscillation experiments on typical structures and structural models. The latent resistivity of structure, on the other hand, is to discover the horizontal resistivity of structures or structural elements through large-scale reduced models. We saw to it that the resistivity of the entire structural elements would be demonstrated as much as possible from the point of view of structural design. Based on this premise, we must make such entire resistive elements resist shocks. This is why we are emphasizing at present, in the areas of the factory structures, the improvement of design methods and exploitation of latent resistivity. I would like to discuss the following three aspects.

(1) Oscillatory quality of factory structure. We base our quake resistance design on elasticity theory. This requires research on the oscillatory behavior of structures.

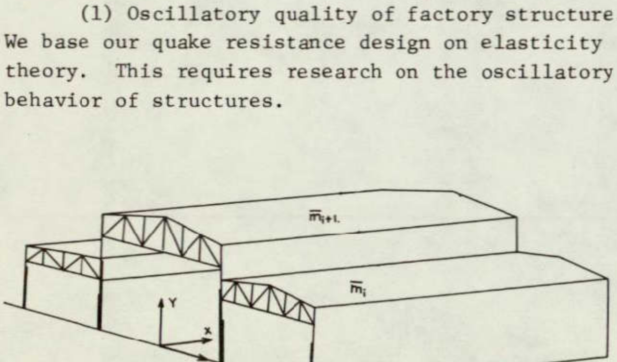


Figure 1: Schematic drawing of typical factory structure (one story)

Most of our one-story factory structures look like Figure 1. Generally speaking, all of them have cone-shaped walls on both ends of the eaves. The results of numerous measurements and experiments on models indicates that when such buildings are shaken, the deformation of the roof system cannot be neglected. The major deformation is shearing, and we view a roof as a beam affected by shearing type deformation when we analyze the oscillatory quality of such factory structures. The equation of motion of the i th roof of a factory structure with n roofs of various heights will be:

$$G_i F_i \frac{\partial^2 Z(i,X,t)}{\partial X^2} = \sum_{k=1}^{n} \frac{K_{ik}}{d} Z(k,X,t) + \overline{m}_i \frac{\partial^2 Z(i,X,t)}{\partial t^2}$$

and if we assume that $\frac{G_i F_i}{m_i}$ = constant, the individual frequency of s degree of the factory structure will be:

$$\omega_{sj} = \sqrt{\omega_s^2 + \beta_j \frac{GF}{\overline{m}}}$$

The oscillation type of the factory structure is:

$$Z(i,X) = Y(i) \cdot X(X)$$

- G_i, F_i Rigidity against and cross section area of the i th roof, respectively.
- K_{ik} Resistivity of the i th roof, in case one of the frames of the k th roof is displaced, and the displacement of other roofs is zero.
- d The length of the frame span
- $\overline{m}_i$ Mass of the i th roof per unit length
- ω_s Angular frequency of the s degree oscillation type of one frame.
- β_j Parameter which defines the boundary condition of the roof.

The results of the analysis above and that of the actual measurements and of tests using models show agreement. In practice, we simplify the above equation.

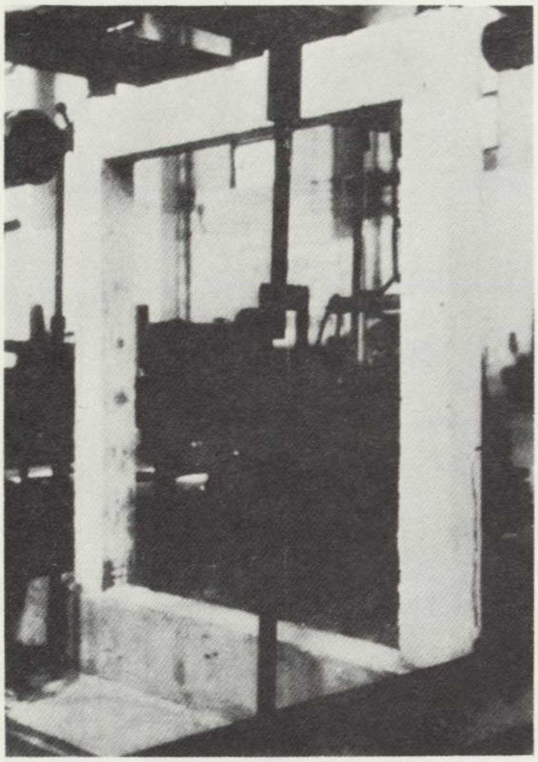


Figure 2: Rahmen structure model (1:3)

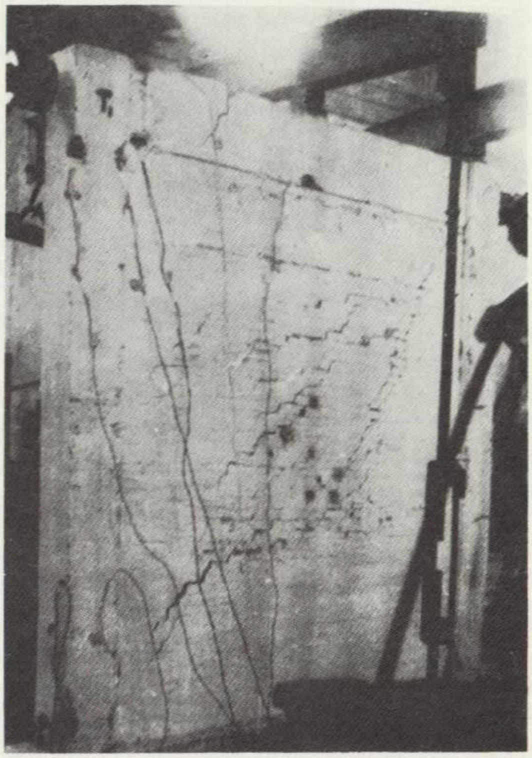


Figure 3: Rahmen structure with brick wall. The load was added until it gave way.

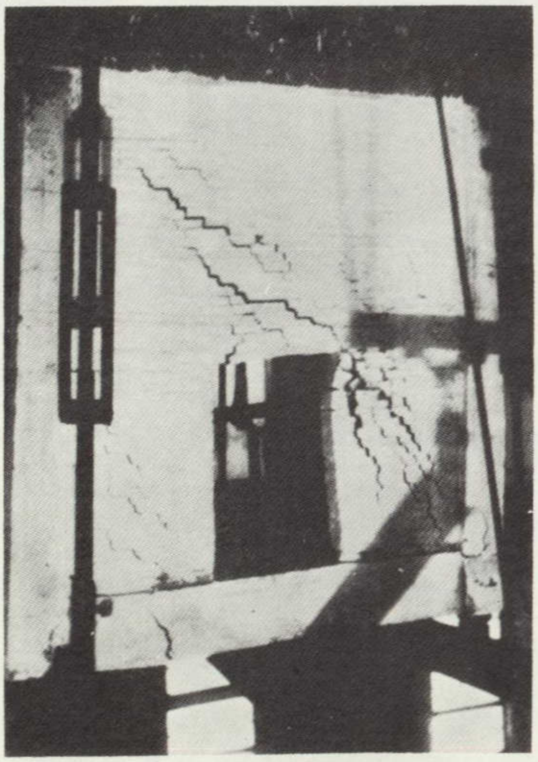


Figure 4: Brick wall without Rahmen structure, load added to the point of breaking.

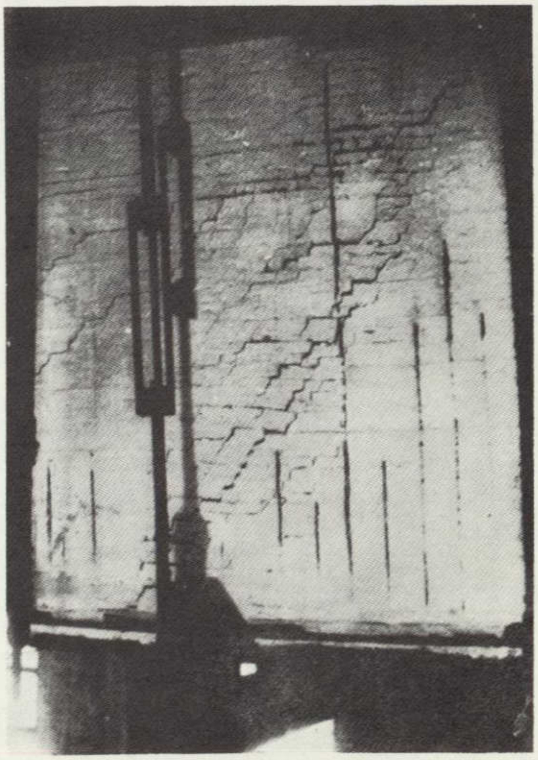


Figure 5: Rahmen structure with brick wall and an opening, load added to the breaking point

(2) Resistivity of brick walls against horizontal forces. A great majority of the multi-layered Rahmen structures frequently used in our multi-storied industrial and housing structures use brick walls. Brick walls in non-earthquake prone areas simply divide and enclose space. In earthquake prone areas, however, brick walls provide a resisting structural element against horizontal forces. They exhibit resistivity against uniform horizontal forces. We performed numerous model experiments in the past in order to understand this resistivity, so as to be able to utilize the maximum quake resistant qualities. The tests on models were performed under the following four conditions: (1) Rahmen structure without brick walls; (2) Rahmen structure with brick walls; (3) Brick walls without Rahmen structure; and (4) Rahmen structure with brick walls having openings. The test load was placed from both the negative and positive directions until the model gave way.

Through these experiments we gained the following insights. The motions of the Rahmen structure with brick wall, under the influence of the horizontal force, can be divided into two phases. The first phase extends to the time when cracks appear. During this first phase, the brick wall and the Rahmen structure constitute a parallel joint structure, the brick wall being the main component. As the horizontal load is increased, cracks begin to appear in the wall, and this is the second phase. The rigidity of the wall at this point rapidly decreases, as the load begins to be distributed to the Rahmen structure. The maximum resistivity of the brick wall together with the Rahmen structure is somewhat greater than the total of durability (the ability to hold up against the load) of each of the components working separately. We discovered that the reason the brick wall could prevent the destruction of Rahmen structure was that the latter did not instantly lose its stability under excessive distortion.

In view of the above results, we could distribute the horizontal load according to the rigidity of brick wall and Rahmen structure, and could take the total of rigidity of both components as the structure's overall maximum rigidity.

(3) Condition of damage on factory structures caused by the Haicheng earthquake. On 4 February 1975 the Liaonan district of our country was hit by an earthquake registering M 7.3, epicentral magnitude was over 9 (on the Chinese scale). The western perimeter of the affected area in this earthquake was the shore of the lower Liao River and the plains on the coast. The level of the ground water in this area was relatively high and the ground surface was covered with 1-5 meters thick clay. Underneath the clay was an approximately 10m thick layer of sand and silt bed. The east perimeter was the Chienshan mountain range where the surface layer is very thin. Severely shaken areas were located mainly on the hills of Haicheng and Taishihchiao areas, where the surface (covering) layer ranges from several to some 40 - 50 meters. The variation of the topograpical and geographical features from east to west is considerable. The characteristics of the quake damage in the western and the eastern areas showed agreement with the topographical differences. The structural destruction in the central hills and that in the eastern mountainous areas was mainly caused by the earthquake motions of the earth; while, in the coastal plains on the west, one of the causes of structural damage was that the subsoil lost its strength, in addition to that caused by movement of the earth.

The following are the styles in which the majority of the factory structures are constructed in Liaonan district:

(1) One-story factory buildings with reinforced concrete pillars.
(2) One-story factory buildings with brick pillars.
(3) Factory buildings with more than 2 stories with Rahmen structure in reinforced concrete.
(4) Brick structured factory buildings of more than two stories.
(5) One story cotton mills.

Our study revealed the following facts. Most of the above buildings could resist this earthquake. Some factory buildings did sustain relatively severe damage, however, and among them the most severely damaged were those in one story with brick pillars and multi-story brick structures. The nature of damage in the brick factory buildings of two or more stories resembled that in brick civil buildings. All of them had X-shaped cracks and diagonal cracks on the walls that supported the weight. This type of building, even though sustaining considerable damage, did not collapse.

This was mainly because all of such damage was caused by shearing. Among those buildings damaged by shearing, comparatively few brick walls sustained

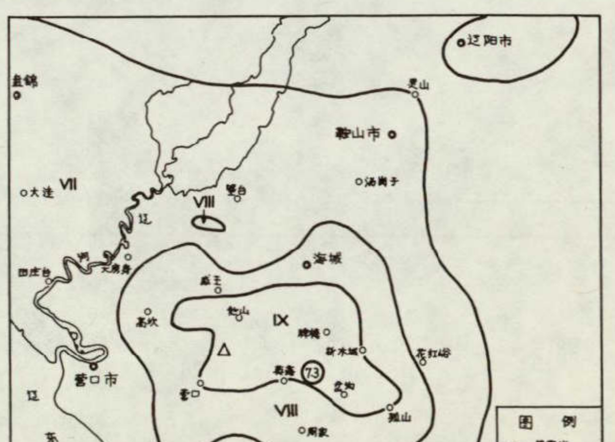


Figure 6: Amplitude distribution in Haicheng earthquake (Chinese Mercalli scale)

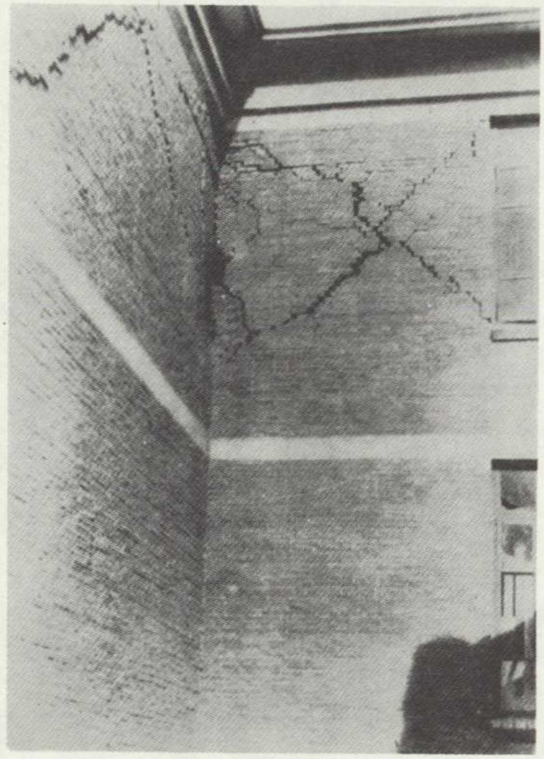


Figure 7: Nature of damage in brick construction of more than two stories

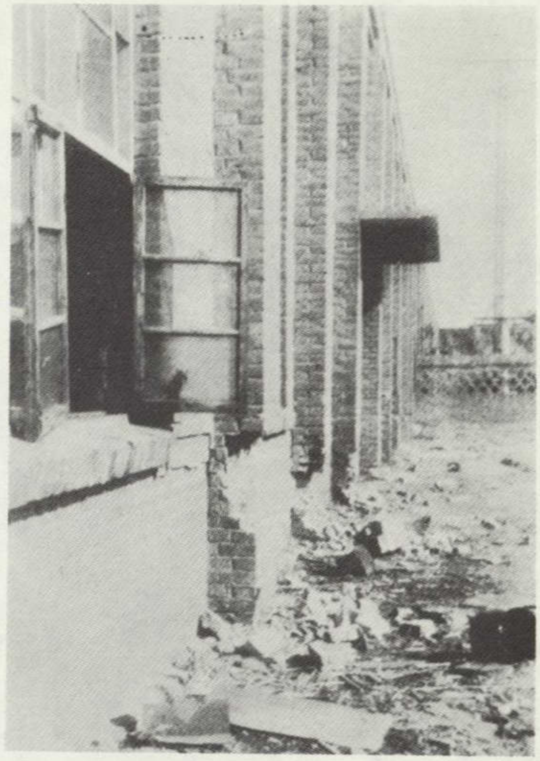


Figure 8: Damage to the base of pillars supporting the wall

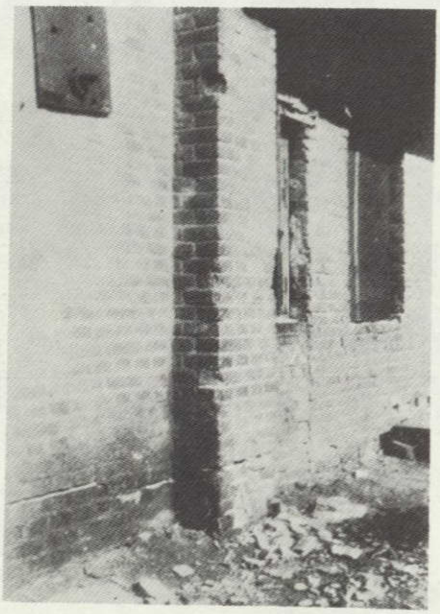


Figure 9: Damage in the lower part of a factory building with brick pillars

damage caused by vertical forces. Furthermore, as this type of structure possesses relatively strong joints which constrain it vertically and horizontally, the walls do not readily lean or collapse. Therefore, they can still support the upper structure.

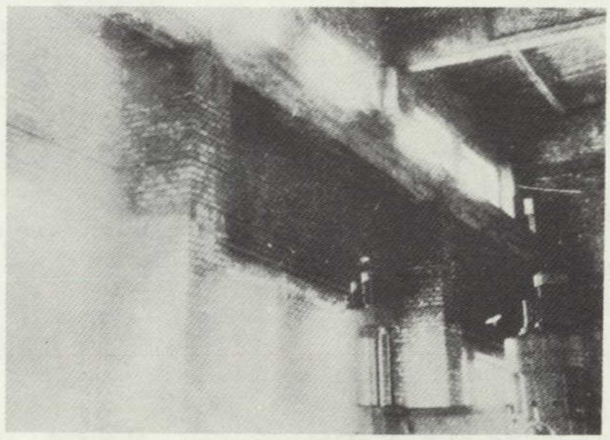


Figure 10: Damage to the upper part of the pillar supporting the walls

The damage sustained in the one-story factory buildings with brick pillars appeared in the lower part of pillars which supported the walls, caused by bending forces (see Figures 8 and 9). In some of the factory buildings, the upper parts of the pillars that supported the walls were damaged as well (Figure 10).

At the same height as the damage to the pillars supporting the walls, horizontal cracks were found on the vertical walls. This damage was all concentrated in the center portion of the factory

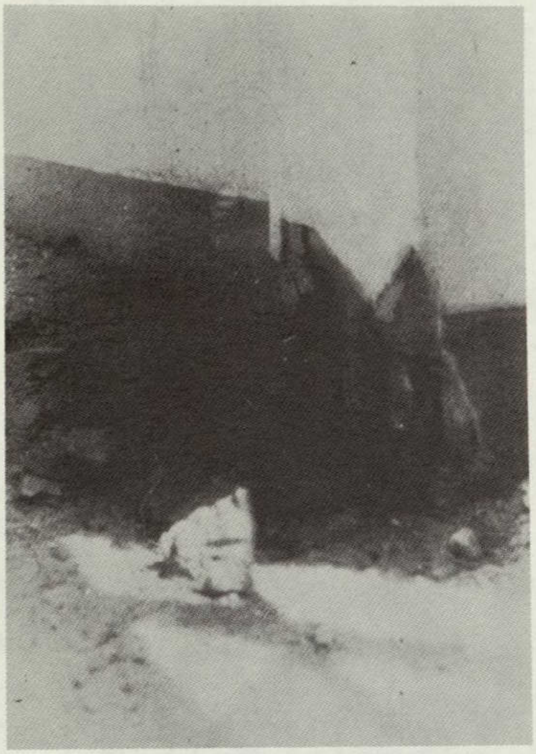


Figure 11: Damage in the lower part of the concrete pillars

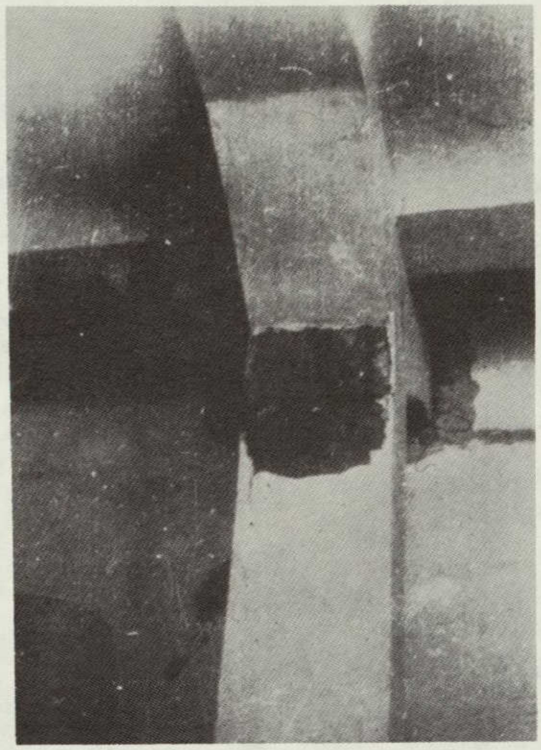


Figure 12: Damage in the top portion of the pillars in Rahmen structure

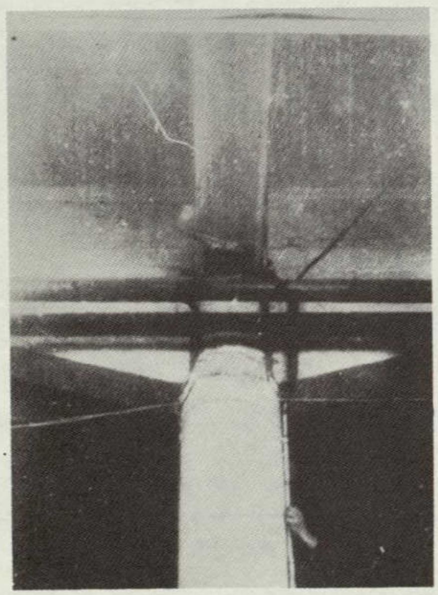


Figure 13: Damage in the cross member support on the concrete pillar

Figure 14: Collapsed walls on the ends of a building

buildings. Damage was limited in the pillars supporting the walls and the horizontal walls close to the ends of the building. This is in agreement with the three dimensional displacement mentioned before in the analysis of the oscillatory behavior of the factory buildings.

As for the damage sustained by one-story factory buildings with reinforced concrete pillars, it resembled the case of such buildings with brick pillars, *i.e.* the damage in the center section of the building was comparatively severe. Concrete pillars had horizontal cracks on the lower parts or above the corbels (brackets), caused by the pulling force. The steel bars within the pillars were not damaged. Among concrete pillars, the damage caused by shearing and bending was minimal (Figure 11).

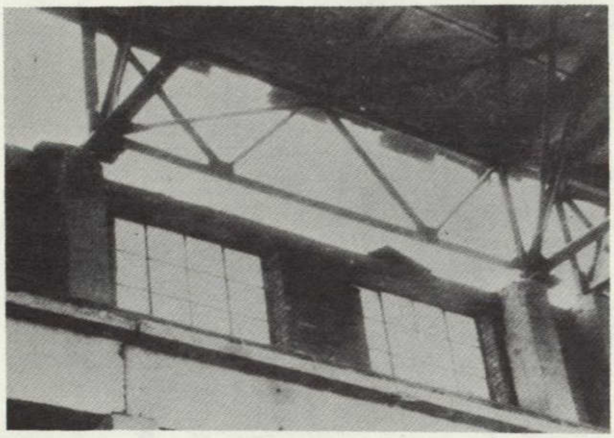


Figure 15: Upper part of this vertical wall collapsed

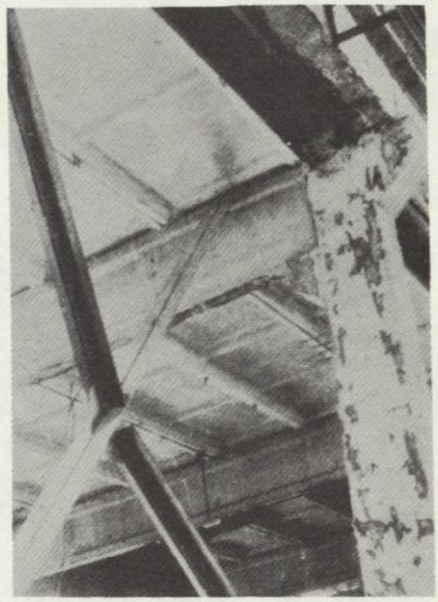


Figure 16: Support between pillars is severed

Figure 17: Damage in horizontal support

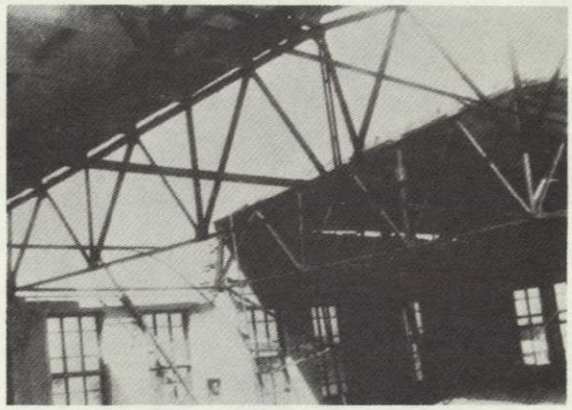


Figure 18: Large roof board fell

The damage illustrated above all occurred in the areas stricken at magnitudes between 8 and 9. In the areas stricken with quakes of magnitude 7, such damage was relatively limited. The damage sustained by factory buildings with brick pillars in areas of magnitude 8-9 was mainly in the structure supporting the weight, whereas that in the buildings with reinforced concrete pillars was mainly in the protecting and encasing structures such as roofs, etc.

Damage was relatively small in cotton mills. This may be due to the lightness of their roofs and to the short span of these buildings.

Multiple-story Rahmen structures of reinforced concrete sustained the least damage in the Haicheng earthquake. Generally speaking, the damage was sustained in walls which functioned as encasing and protection, and in the upper or lower part of the pillars used in Rahmen structures (see Figures 12 and 13).

In the case of factory buildings, the most common damage was leaning or collapsing of the end walls and the upper part of vertical walls (Figures 14 and 15). The traces which supported the roofs were either bent or severed (Figures 16 and 17).

Twisted beams {?} occurred in all the areas stricken at magnitudes between 7 and 9, but there were not many and the degree of the damage was minimal.

In the western part of the stricken area, liquefaction of sand was relatively common. The factory buildings damaged by the liquefaction of sand were not large in number (Figure 19). Due to the motion of the embankment, some bridges were damaged. A 60m tall industrial building stood on a saturated sand base where liquefaction could occur. In the earthquake, sand and water gushed out in many places and cracks appeared on the ground, but the building neither sank nor leaned due to its preventive design.

In order to analyze the damage inflicted upon the factory structures, we chose the simplest one-story structure with spans of the same height as our model for analysis. Taking the deformation of the roof braces into consideration, and using Figure 20 as the simplified model for calculation,

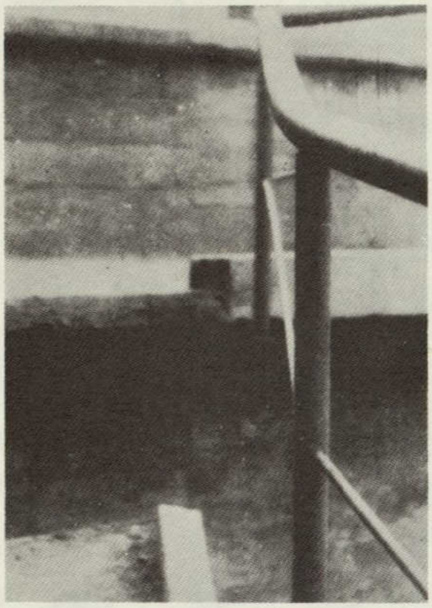
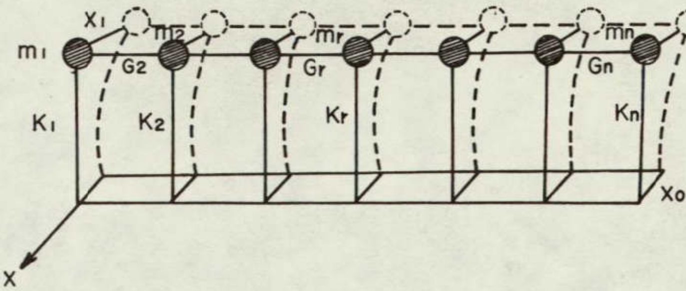


Figure 19: Uneven depression (up to 40cm) due to the liquefaction of sand



K_r: Rigidity of the r th frame
G_r: Rigidity of the roof between the r th and the r-1 st frames
m_r: Mass carried on the top of the r th frame
X_0: Displacement due to earthquake

Figure 20: Model of one story factory structure used in the analysis

we tried to obtain a solution by amplifying the two records of the M=5.3 foreshocks so as to make them correspond to the magnitude 8 and 9 local earthquake amplitude, and using this input for analyzing a certain group of factory structures. The following conclusions were reached in the analysis.

(1) The result obtained from analysis and the nature of observed damage agreed. (2) The earthquake coefficient employed in the equations and the observed magnitude roughly coincided.

Haicheng earthquake experience shows that the number of brick structures damaged severely even within the area afflicted with strong tremors was quite small, while those with minor or superficial damage were many. This appears to indicate that properly designed brick factory structures can resist relatively strong earthquakes.

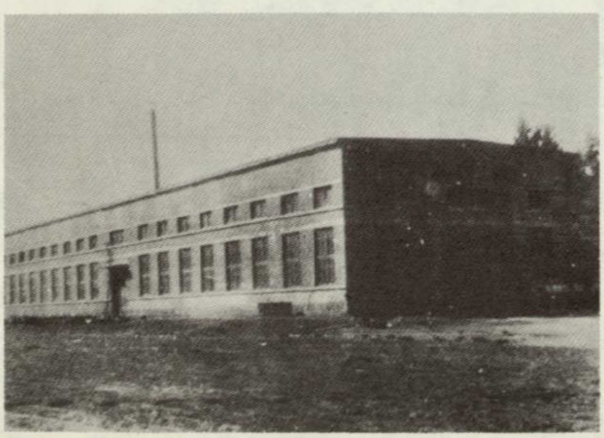


Figure 21: Brick factory building which did not collapse with tremor of magnitude 9

Summarizing the above, we can categorize the damage sustained by industrial factory structures:

(1) This area had never experienced a relatively strong earthquake in {recent} history. The basic magnitude is comparatively small {?}. Most of the buildings were not built with the idea of quake resistance. The roof traces and links of some factory buildings lacked strength and rigidity. There was no provision for linking the encasing structure and the main structure, and those which had some provision were generally inadequate. For example, the cross-section of the traces which supported the roofs and the braces were generally too small, and the number of the welded points linking the roof boards and the frames, and the length of welding, were not sufficient, and there was no provision for firm links between the walls and pillars.

(2) Rigidity was lacking in the major structural elements resisting the horizontal force. For instance, the cross section of pillars supporting the walls of some of the factory structures with brick pillars was relatively small and the rigidity of the mortar was insufficient.

(3) The destruction of upper structure caused by the base that lost its function, namely the cracks in the ground or liquefaction of sand, resulted in partial subsidence of buildings.

(4) Our major experience concerning factory structures under the present earthquake taught us: (a) The strength and support of the linking points of roofs should be reinforced in future designs. (b) Uniformity of factory buildings should be emphasized. Ring beams are effective in strengthening the structural uniformity. (c) Building sites should be selected in favorable locations, considering the quake resistance factors.

(4 December 1975)

TRANSLATION NOTES

	Self Governing State	Administrative Section	District	Union	State & County Incorporated Areas	Prefecture	Self Governing Prefecture	Division	Self Governing Division	Town
Peking C.†						9				
Tientsin C.						5				
Hopeh P.			10		9	137	2			
Shansi P.			7		7	101				
Inner Mongolia S.G.D.				4	6	16		27		
Liaoning P.			4	1	11	44	2	7		
Kirin P.	1		3	1	10	39	2	7		
Heilungkiang P.			8	1	12	63	1	9	3	
Shantung P.			9		9	106				
Shanghai C.						10				
Kiangsu P.			7		11	64				
Anfei P.			9		8	70				
Chekiang P.			8		3	65				
Kiangsi P.			6		8	80				
Fukien P. §			7		6	60				
Taiwan P.	*(Still waiting to be liberated)*									
Honan P.			10		14	110				
Hupeh P.			8		6	73				
Hunan P.	1		9		8	85	4			
Kwangtung P.	1	1	7		10	94	3			
Kwangsi S.G.D.			8		6	72	8			
Shensi P.			7		5	93				
Ningsha S.G.D.			3		2	16		1		
Kansu P.	2		8		4	66	6	2		
Chinhai P.	6				1	32	5			
Sinkiang S.G.D.	5		6		4	74	6			
Szechuan P.	3		12		9	181	3			
Kweichow P.	2		6		4	70	9			
Yunan P.	8		7		4	106	15			1
Tibetan S.G.D.			5		1	71				
TOTALS	29	1	174	7	178	2012	66	53	3	1
	District: 211			*State &† County*		*Prefecture:* 2135				

† P. = Province; C. = City; S.G.D. = Self Governing District.

§ Includes Chinmen Prefecture which still awaits liberation.

Table I: Statistics on administrative sections existing on 31 December 1973

The following administrative sections have been established: 22 Provinces, 3 directly governed cities (Peking, Shanghai, and Tientsin), and 5 self-governing districts. Table I indicates the administrative divisions.

The country of China is divided into several districts, commonly defined as follows:
The vast northern area includes Shingkiang Uigur self-governing district, Tibetan self-governing district, and Chinling mountain ranges north of the Wai River. It is divided into four sections.

(1) Northeast district - Taisungon mountains, Shiaosungon mountains and the Changpei mountain range.
(2) Huapeh district - the basins of the Yellow and Wai River and Wangtu plateau in the west.
(3) Inner Mongolia - Sinkiang district - includes western part of northeast district, Inner Mongolian self-governing district, northern part of Ningsha Islamite self-governing district, northwestern part of Kansu province and Sinkiang Uigur self-governing district.

(4) Chinhai - Tibetan district - area south of Chinling mountains, Wai River, and Hoga section of the Tibetan self-governing district.

(5) Southwest district - western part of Szechuan province, mountains west of Yunan province, and the southern tip of the eastern part of the Tibetan self-governing district.

(6) Huachung district - lower valley and tributary area of the Yangtze River.

(7) Huanan district - southern part of Fukien, Canton, Kansi, and Yunan provinces and self-governing districts, and Taiwan, and some islands in the southern Sea of China.

National Earthquake Bureau

This bureau comes directly under the Department of Interior, and controls all earthquake related studies and actions. The director of the bureau is one of the Vice Premiers, and there are several deputy directors. It was founded in 1971 to consolidate the guidance of hitherto unorganized earthquake studies, prediction, and disaster prevention. Although it is directly under the Dept. of Interior, its management is entrusted to the Chinese Academy of Science (*Academia Sinica*).

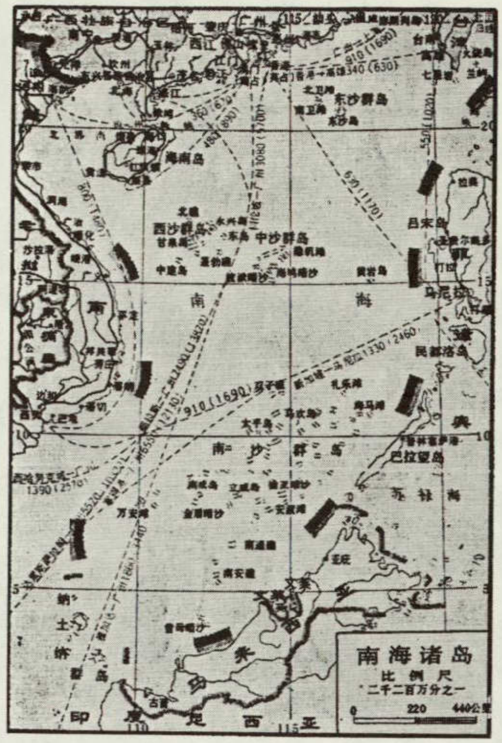
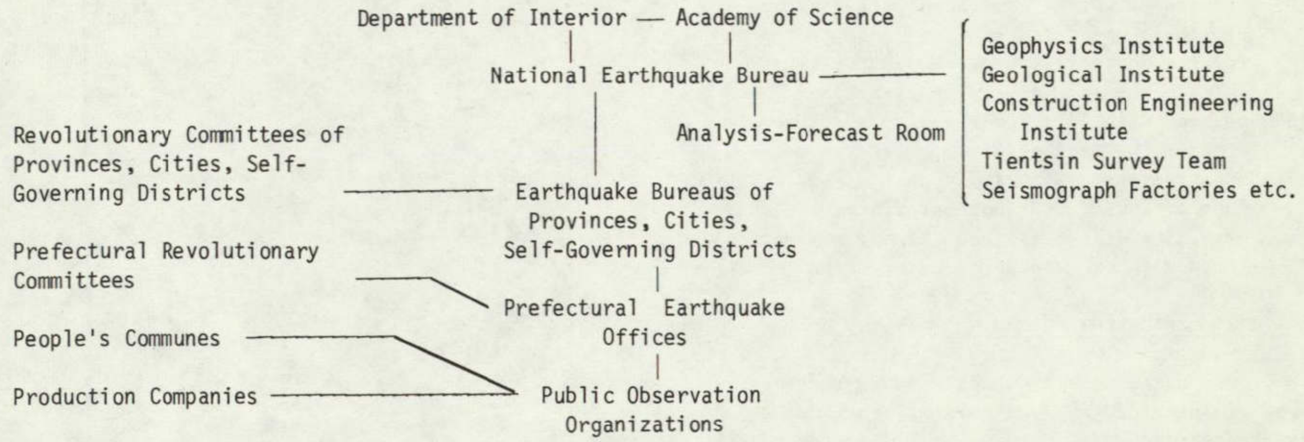


Plate I and II: Maps of the Chinese Administrative Divisions and Sections

Table II: The Relationship Between the Administrative Organization and Earthquake Affairs Organization



Standard Observatory: These observatories are the center of every district. There are approximately 250 such observatories. They perform earthquake survey, analysis of data, earthquake prediction for the public, promotion of preventive knowledge, and education. They are equipped with a comparatively good selection of professional instruments, and are manned by about 10 workers.

Earthquake Stations: These stations work under the direction of Earthquake Observatories, equipped with the minimum instruments necessary for observation. The scale is smaller than that of earthquake observatories, and they are manned by several professional workers.

Movable Stations: So-called portable survey team.

Earthquake Office: These offices are permanently set up under the jurisdiction of the local administrative sections for management of the earthquake related activities. They do not themselves perform surveys or studies. Based on the observations, they make reports to the Revolutionary Committee, transmit opinions, present suggestions to the administration, and handle appointments of people for disaster prevention.

Seismological brigade: In the original Chinese, the word used was *brigade*, meaning a company within the armed forces. In this context, however, it is a group of earthquake experts. It can be read as "forces fighting earthquakes."

Amateur Observers and Forecasters: In the original Chinese, the word "extra-curricular observer-reporter" was used, meaning those who participate in earthquake observation and forecast, in addition to their own line of work. See the article in *People's China* magazine (September 1975), "A spot report of the great earthquake in southern area of Liaoning Province," concerning the way these amateur observer-forecasters are organized, what their thoughts are, and how they work.

Public Participation in Earthquake Studies & Action: In the original, it is "earthquake workers." This word is used all through the text and means professional people in earthquake forecast, disaster prevention, including researchers, technicians, and administrators. Within the Japanese translation, the words such as "earthquake experts" and "people participating in earthquake actions" are used. Also the word, "earthquake actions" is translated as "earthquake studies and actions," or "works related to earthquakes," etc.

Readily Observable Anomalous Phenomena: The original word is "widely observed anomalous phenomena." Within these lectures, the word is used to illustrate, mainly, the *immediate* observations of anomalous phenomena, such as anomalous conditions of well water or animal behavior.

Magnitude: The (local) magnitude scale used in China is (in the units) 1-12. The following is an explanation of this scale, prepared mostly for use in the farming communities (from *Earthquake*, Little Natural Science Series, published by Peking People's Publishing Company).

1 - 2 Tremors which cannot be felt by people, but are recorded by seismographs.

3 Tremors felt by a few people inside structures.

4 - 5 Tremors felt by all the people, although there may be differences in degree depending on individuals. Things inside structures shake, with dust falling.

6 Tremors causing damage in comparatively old structures. Some structures may collapse. In some cases, cracks appear on moist, soft earth Land and rock slides occur in some mountains.

7 - 8 Most of the structures are damaged. Cracks appear in tall factory chimneys. Some casualties among animals and humans.

9-10 Structures are severely damaged. Many cracks appear on the ground. Great waves are observed in lakes and dams. Rails twist in some parts of railways.

11-12 All the structures collapse. Deformation of the ground is severe. A devastating natural disaster.

Peking Time: The time of East Longitude 120° is used as the standard time throughout China. It is, therefore, Greenwich time + 8 hours, or Japanese standard time - 1 hour.

Combination of crude tools created by the public and advanced survey instruments: In China, this is called "union of earth and ocean." "Earth" means the old, traditional method or the method created by the public, while "ocean" means the modern, advanced instruments. Many instruments used in earthquake observatories and research institutes are domestic. Therefore, it is not appropriate to interpret the "ocean" as "western." Incorporation of these two can be quite meaningful, considering the country's present condition, in which the production of such instruments is not fast enough. It is meaningful also, for scientific education of the public, as well as for their active participation in earthquake studies and activities.

Earthquake Resistance: This actually means "counter earthquake," but has a meaning of positive attitude towards disaster. It is translated as "counter earthquake" in this text.

Simplified List of Great Earthquakes in China †

780BC - 1973AD $M \geq 6$

Edited by the Geophysical Institute of the Chinese Academy of Science (June 1974)

This simplified list of great earthquakes, of M greater than 6 which have occurred in China from 780BC through 1973AD, was edited in accordance with the slogan of our great leader, Chairman Mao, "Prepare for war, prepare for disaster; for the people," so as to take decisive actions concerning earthquake studies and actions, under a series of Premier Chou's significant instructions, for the use of those who participate in works relating to earthquakes.

1. Time of the Earthquakes:

Earthquakes prior to 1900 are listed with year, month and date, based on historical records. The earthquakes occurring since 1900 and recorded by seismographs, are listed with hour, minute, and second, using Peking time (east longitude 120°).

2. Epicentral Positions:

Epicentral positions of the earthquakes prior to 1900 are where the severest damage occurred, based on local observations. As for those since 1900, most of them are recorded by instruments. Among them, 95% were corrected and redefined by analysts in the past. The accuracy of the epicentral positions are classified in the following three categories:

(a) There is no uniform accuracy for earthquakes prior to 1900, due to the absence of seismograph records.

(b) The accuracy of those since 1900 is measured by instruments and well defined. Among them, those which were measured by both the instruments and immediate observations (locally recorded) are listed with (*), the epicenter taken to be that determined by local direct observations. Generally speaking, those with comparatively high accuracy correspond to the categories (1)-(2) of epicenters defined by instruments.

(c) The accuracy of epicenters measured by instruments is classified in the following five categories:

Categories: (1) error <10km; (2) error <25km; (3) error <50km; (4) error <100km; (5) error >100km.

3. Intensity of Earthquakes:

The parameter of intensity is represented by magnitudes and epicentral frequency. The epicentral frequency of the earthquakes prior to 1900 was estimated from the local direct observations, and was converted into magnitude with the experimental (empirical) equation: $M = 0.5I_0 + 1.5$ as a basis, and taking into consideration the size of the damaged area and the area in which the earthquake was felt. It is recorded to the nearest ¼M. In cases where the magnitude cannot be determined due to the lack of direct local observations, the magnitude is recorded in less precise terms such as M 6-7, or M 7-8. For the earthquakes since 1900 which were measured by instruments, magnitudes we measured ourselves are used. Those with high accuracy are recorded to 0.1M, and those not so high are recorded to ¼M, with insufficient examples given in parenthesis. Those with direct local observational data are listed with epicentral frequency as often as possible.

In guiding us, Chairman Mao taught that "As we are here to serve the people, we are not afraid to be criticized if indeed we have faults." Although we did correct the proofs of this Simplified List, some errors are still unavoidable. We hope that those who participate in earthquake related work will examine it and criticize it (if necessary).

END OF THE TEXT

† The tables are reprinted following the photos, commencing on page 45.

PHOTOGRAPHS TAKEN DURING SURVEY OF THE EPICENTRAL AREAS OF

HAICHENG EARTHQUAKE, LIAONING PROVINCE, CHINA

4 February 1975

Photo 1: Haicheng District Punkao People's Commune. Most houses in this area collapsed. Most walls fell to the west. The front pillars of this brick house leaned east. Walls separating rooms all collapsed. The machine factory stood to the right of the house, but collapsed after the earthquake. (Mag 9 area)

Photo 2: The front of this Haicheng Guest House partially fell after the quake. Cracks appeared in many places. (Mag 9 area)

Photo 3: The bath house in Taishihchiao, Yingkao Prefecture. Top portion of the end walls fell with the tremor. (Mag 9 area)

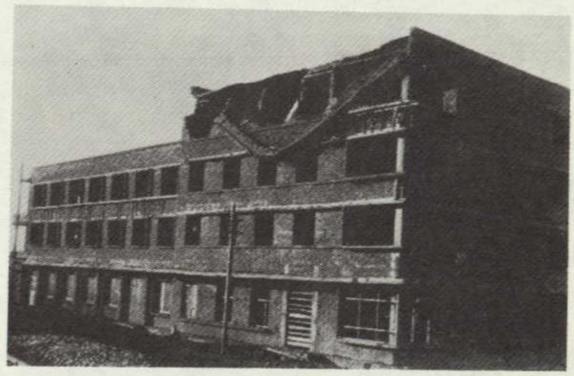


Photo 4: The top portion of a service building east of Panshanching railway, Panchin district, (unfinished) was destroyed by the tremor. Cracks appeared in many places. (Mag 7 area)

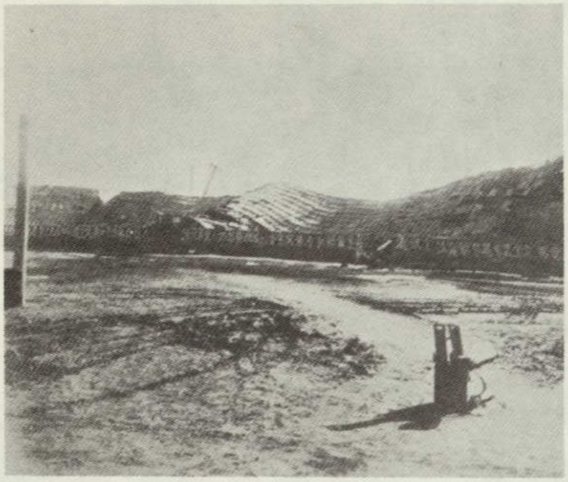


Photo 5: The roof of the Erchehkoh Club, Panchin district, collapsed after the earthquake. (Mag 7 area)

Photo 6: Collapsed parts of walls and roofs of brick and wooden buildings on the corner of 5th street and People's Road, Tiehsi, Anshan City. (Mag 7 area)

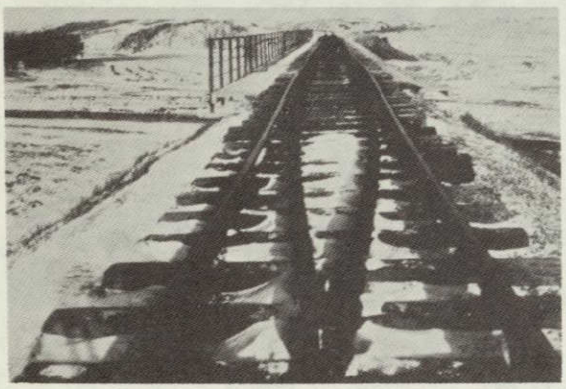


Photo 7: Rails on Chiaochapao Bridge were twisted. (Magnitude unspecified)

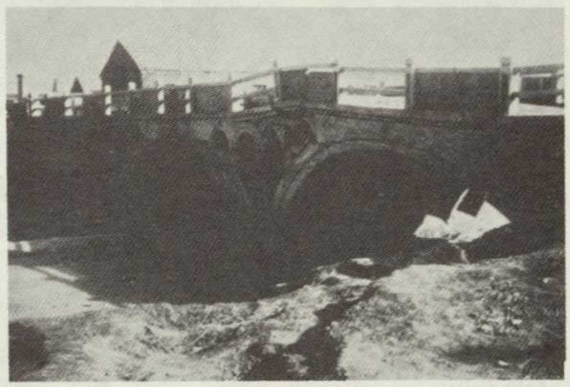


Photo 8: The mid-section of Hungkwang Great Bridge in Kwenchipao of Chikao Commune in Yinkao Prefecture, buckled and the arch was destroyed after the quake. (Mag 8 area)

Photo 9: A cylindrical brick chimney of a paper mill in Yingkao Prefecture, operated by Kaoken People's Commune - 30m high, base diam. 1.7m, top diameter 1m, 70cm thick - fell in many pieces. The top half fell southwest, smashing the boiler room. Base portion fell toward the north. (Mag 8 area)

Photo 10: The top 7-8m of the 27m tall brick chimney of the boiler of Tangkangtze Sanatorium in Anshan City was knocked off, while another iron chimney was bent in the direction of 310° northwest. (Mag 7 area)

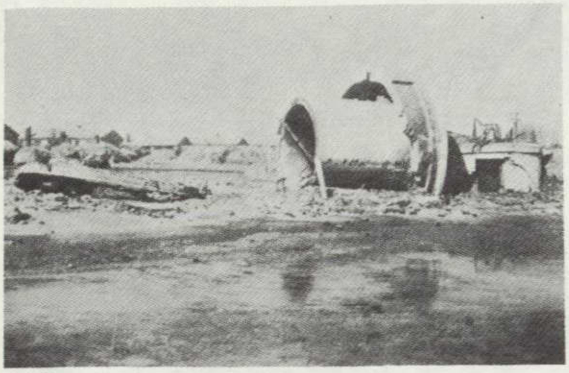


Photo 11: The inverted water tank (29.5m tall) in East Family District of Senseng Farm, Yingkao Prefecture, toppled over. (Mag 8 area)

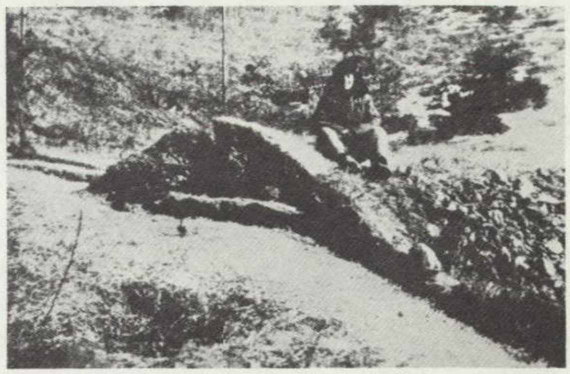


Photo 12: Cracks caused by compressional twist on the base rocks in Liao River area Ertaokoh, Koshan Commune, Haicheng. The cracked portions buckled into a "cabin" shape. (Mag 8 area)

Photo 13: Cracks caused by tensive twisting of the base rocks in Liao River area in Ertaokoh, Koshan Commune, Haicheng. Maximum width was 70cm, left displacement.

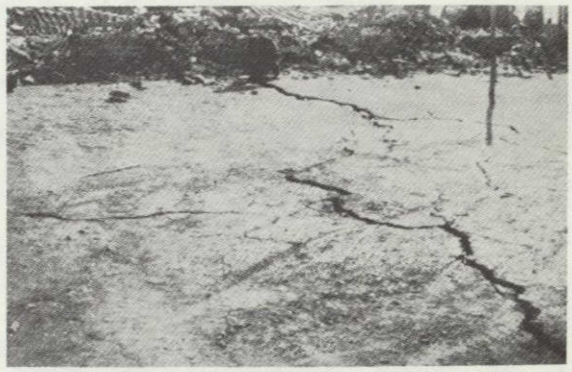


Photo 14: The brick wall of Kuh Fang-sen Hosi Elementary School of Punkao Commune, Haicheng Roof slates collapsed after the quake. There were two sets of cracks in the earth, one set running north-south, the other east-west. Width 5-15cm, visible depth 1.35m. (Mag 9 area)

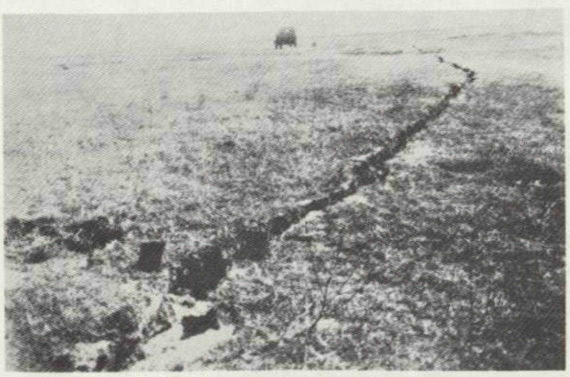


Photo 15: Fissures 110° southeast, near Weichiapao, Kenmuh Commune, Haicheng, had width of 10-40cm and was jagged. Alongside the crack, there was gushing of sand and water. The marker is placed where the left displacement is apparent (degree 36cm). (Mag 8 area)

Photo 16: Cracks appearing in the earth in Tienchiang-Tai paper mill in Panchin district were 3.2m wide according to a report. When the photo was taken on 12 Feb., the width was 2.4m and the crack ran northeast (50°) with a visible depth (to water surface) of 1.5m, left displacement 14.5cm. (Mag 8 area)

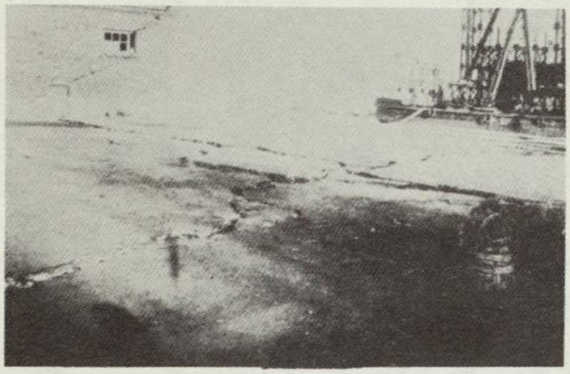


Photo 17: One set of cracks in Tienchuang-Tai paper mill ran 50° northeast, while the other set ran 110° southeast. Width was 5-30cm. The latter crack ran through a warehouse, with the warehouse walls showing jagged cracks. (Mag 7 area)

Photo 18: Approximately 1m thick ice on Yungshung Dam in Panchin district was pushed up onto the embankment. There were cracks in the ice along the edge of the dam caused by pressure. (Mag 7 area)

Photo 19: A roadside ditch near Date Tree Production Company of Kaolifang Commune in Taian Pref. was frozen over with 30cm thick ice and covered with snow. After the quake, the layer of ice buckled out. (Mag 7 area)

Photo 20: A tree in the div. 6, 5th Prod. Company of Senseng Farm, Yingkao pref. was torn by a crack. The widrh was reported to be 20cm. When this photo was taken (23 Feb.) the width was 5cm and the length of the crack was 91cm. The fissure was filled with gushed sand. (Mag 8 area)

Photo 21: In Kaochiatung, Kaochia Farm in Panchin, buildings with roofs of barley stalks, unbaked mud brick walls and flat roof structure, sank. The beams and the roof sank 1m deep into the ground. There was no evidence of gushed sand or water. The walls seen in this photo belong to the sunken building, but the walls did not sink. (Mag 7 area)

Photo 22: Holes made by gushing sand and water on the ground of a granary in Tien Chuang-Tai, Panchin district. The direction of holes was 20° northeast. The thickest sand was about 40cm. (Mag 8 area)

Photo 23: The Tien Chuang-Tai Granary in Panchin has 1m thick base of asphalt and rocks beneath its cement floor. The earthquake caused gushing sand and water, burying sacks of flour and soy beans to a depth of 0.5m. The amount of sand and water was enough to cover two stacks of sacks, and cracks were seen on many parts of the walls.

Photo 24: A hole was formed after the earthquake in a 2.5m wide road running north-south in the 3rd division, 5th company, Senseng Farm, Yingkao. The cave-in occurred when a cow walked on it, PM of 5 Feb. Depth of hole is not known, gushing sand and water was observed nearby. (Mag 8 area)

Photo 25: There was gushing sand and water in a rice paddy of Senseng Farm, Yingkao. It pushed the ridge over 3m out of the field. (Mag 8 area)

Photo 26: Depression in the river bed north of Koshan Commune, Haicheng. The wall of this hole consists of loose gravel. According to a report, the depth of depression was 4m, and the diameter of the crescent shaped depression was 5m. (Mag 8 area)

Photo 27: One of the poplar trees south of Koshan Commune in Haicheng (height of trees 15m) was buried in a depression except for the top 2m. The shorter diameter of the depression was 7m while the longer diameter was 5m. The wall of the depression was loose gravel.

TABLE OF HISTORICALLY RECORDED CHINESE EARTHQUAKES

#	Date	Lunar Cal.	Epicenter Region	Lat	Lon	M	mag.	Comment
编号	地震日期		震中位置			强度		备注
	公历	农历	地区	北纬(度)	东经(度)	震级	烈度	
1	前 780	周幽王二年	陕西岐山	34.5	107.8	6~7		
2	前 231	秦始皇十六年	山西临汾、汾阳间	36 5	111 5	6½	八	
3	前 193 2	汉惠帝二年正月	甘肃临洮	35 4	103 9	6~7		
4	前 186 2.22	汉高后二年正月乙卯	甘肃武都	33 4	104 8	6~7		
5	前 70 6 1	汉本始四年四月廿九日	山东诸城、昌乐一带	36 3	119 0	7	九	
6	前 47.4 17	汉初元二年二月戊午	甘肃陇西东北	35 1	104 6	6¾	九	
7	46.10.23	汉建武廿二年九月戊辰	河南南阳	33 0	112 5	6½	八	
8	128.2.23	东汉永建三年正月丙子	甘肃甘谷	34 7	105.4	6½	八	
9	138.3.1	东汉永和三年二月三日	甘肃临洮兰州一带	35.5	104.0	6¾	九	
10	143.10	东汉汉安二年九月	甘肃甘谷西	34.7	105.3	7	九	震中不确
11	180 秋	东汉光和三年秋	甘肃高台西	39 4	99 5	7½	十	↓
12	512.5.21	后魏延昌元年四月戊辰	山西代县	39 0	113 0	7½	十	epicenter
13	734.3.19	唐开元廿二年二月壬寅	甘肃清水附近	34 7	106 3	7	九	uncertain
14	756.11.27	唐至德元年十一月辛亥	甘肃张掖酒泉	39 0	100 5	6	七	
15	777	唐大历十二年	河北束鹿宁晋	37 8	115 2	6	八	
16	788.3.8	唐贞元四年正月廿六日	陕西安康东南	32 5	109 2	6½	八	
17	793.5 27	唐贞元九年四月十三日	陕西渭南华县一带	34 5	109 7	6	七至八	震中不确
18	814.4.2	唐元和九年三月丙辰	四川西昌一带	27 9	102 2	6~7		
19	839	唐开成四年	甘肃岷县	34 4	104 0	6~7		
20	876.7 14	唐乾符三年六月廿日	宁夏青铜峡南	37 8	105 9	6½	八至九	
21	1022 4	辽太平二年三月	山西大同应县	39 7	113 1	6½	八	
22	1038 1 9	宋景祐四年十二月二日	山西定襄忻县	38 4	112 9	7¼	十	
23	1057	宋嘉祐二年	河北固安	39 5	116 3	6¾	九	震中不确
24	1067.11	宋治平四年九月	广东潮安、潮阳、揭阳一带	23 6	116 5	6¾	九	
25	1068.8 14	宋熙宁元年七月十四日	河北沧县河间一带	38 5	116 1	6	八	
26	1125 8 30	宋宣和七年七月乙亥	甘肃兰州一带	36 0	103 9	7	九	
27	1143 4	南宋绍兴十三年三月	宁夏银川	38 5	106 3	6½	八	
28	1209 12.4	金大安元年十一月丙申	山西浮山	36 0	111 8	6½	八至九	
29	1216 3 17	南宋嘉定九年三月辛亥	四川雷波	28 3	103 6	6~7		
30	1219.5 21	金兴定三年四月十八日	宁夏固原	36 0	106.2	6½	八至九	
31	1290 9 27	元世祖至元廿七年八月癸巳	辽宁宁城	41 5	119 3	6¾	九	
32	1291 8 25	元至元廿八年八月一日	山西临汾一带	36 1	111 5	6½	八	
33	1303 9.17	元大德七年八月六日	山西洪洞赵城一带	36 3	111 7	8	十一	
34	1305.5 3	元大德九年四月乙酉	山西怀仁大同一带	39 8	113 1	6½	八至九	
35	1306 9.12	元大德十年八月壬寅	宁夏固原南	35 9	106 1	6½	八至九	
36	1314.10.5	元延祐元年八月廿六日	河北涉县武安	36 5	113 8	6	八	
37	1337.9 8	元顺帝至元三年八月辛巳	河北怀来一带	40 4	115 7	6½	八	
38	1352 4 18	元至正十二年闰三月丁丑	甘肃会宁东南	35 6	105 3	7	九	震中不确
39	1368 7 8	元至正廿八年六月壬戌	山西徐沟	37 6	112 5	6	七	
40	1440.10 26	明正统五年十月一日	甘肃永登兰州间	36 2	103 4	6¾	八	
41	1445.12.12	明正统十年十一月癸未	福建漳州	24.6	117 6	6	七至八	
42	1467.1.19	明成化二年十二月十四日	四川盐源盐边间	27.1	101.4	6½	九	
43	1477.5.13	明成化十三年四月一日	宁夏银川	38.5	106 3	6½	八	
44	1481.7.15	明成化十七年六月十九日	云南鹤庆剑川一带	26 5	100 0	6	八	
45	1484.1.29	明成化廿年一月庚寅	北京居庸关一带	40.4	116 1	6¾	八至九	
46	1487.8.10	明成化廿三年七月廿二日	陕西临潼	34 3	109 1	6¾	八	
47	1495.4.10	明弘治八年三月十六日	宁夏中卫东	37 6	105 6	6¼	八	
48	1500.1.4	明弘治十二年十二月四日	云南宜良	24 9	103 1	6¾	九	
49	1501.1.19	明弘治十四年正月初一	陕西朝邑	34 8	110 1	7	九	
50	1502.10.17	明弘治十五年九月十七日	河南濮城	35 7	115 3	6½	八	
51	1512.10.8	明正德七年八月庚午	云南腾冲东	25 0	98 7	6½	八	
52	1515 6 17	明正德十年五月初六	云南永胜西南	26 6	100 8	7½	十	
53	1515.10.23	明正德十年九月庚子	云南大理	25 7	100 2	6	八	
54	1536.3.19	明嘉靖十五年二月癸丑	四川西昌冕宁间	28 2	102 2	6¾	九	
55	1536.10 22	明嘉靖十五年十月庚寅	河北通县南	39 8	116 8	6	七至八	
56	1548 9 13	明嘉靖廿七年八月十二日	山东蓬莱附近	37 8	120 7	6	八	
57	1556.1.23	明嘉靖卅四年十二月十二日	陕西华县	34 5	109 7	8	十一	
58	1561.7.25	明嘉靖四十年六月十四日	宁夏中宁	37 4	106 0	7¼	九至十	
59	1568.4.25	明隆庆二年三月廿八日	渤海湾	39 0	119 0	6		
60	1568.5.15	明隆庆二年四月十五日	陕西西安东北	34 4	109 0	6¾	九	
61	1571.9 9	明隆庆五年八月庚戌	云南通海	24 1	102 7	6	八	
62	1573.1 10	明隆庆六年十二月初七	甘肃岷县	34 4	104 0	6¾	八至九	
63	1577.3 13	明万历五年二月廿四日	云南腾冲	25 0	98 6	6½	八	
64	1581.5 18	明万历九年四月十六日	河北蔚县与山西广灵间	39 8	114.5	6	七至八	
65	1585.3.6	明万历十三年二月六日	安徽巢县	31 2	117 7	6	七	
66	1587.4 10	明万历十五年三月三日	河南修武	35 3	113 5	6	七	
67	1588 8 9	明万历十六年闰六月十八日	云南通海曲溪	24 0	102 8	6	八	
68	1600 9 29	明万历廿八年八月廿三日	广东南澳	23 5	117 0	7	九	
69	1604 10 25	明万历卅二年闰九月三日	甘肃礼县	34 2	105 0	6	七至八	
70	1604.12.29	明万历卅二年十一月九日	福建泉州海外	25 0	119 5	8		
71	1605.7.13	明万历卅三年五月廿八日	广东琼山文昌间	19.9	110 5	7½	十	
72	1606.11.30	明万历卅四年十一月一日	云南建水	23 6	102 8	6½	八至九	

编号	地震日期		震中位置			强度		备注
	公历	农历	地区	北纬(度)	东经(度)	震级	烈度	
73	1609.7.11	明万历卅七年六月十一日	甘肃酒泉东南	39.2	99.0	6¾	九	
74	1614.10.23	明万历四十二年九月廿一日	山西平遥榆社	37.2	112.5	6	七至八	
75	1618.5.20	明万历四十六年四月廿六日	山西介休	37.0	111.9	6½	八	
76	1618.11.16	明万历四十六年九月卅日	河北蔚县与山西广灵间	39.8	114.5	6	七至八	
77	1622.3.18	明天启二年二月七日	山东郓城南	35.5	116.0	6	七至八	
78	1622.10.25	明天启二年九月廿一日	宁夏固原北	36.5	106.3	7	九至十	
79	1623.5.4	明天启三年四月六日	云南祥云	25.5	100.5	6	七至八	
80	1624.2.10	明天启三年十二月廿二日	江苏扬州	32.5	119.5	6	七	
81	1624.4.17	明天启四年二月卅日	河北滦县	39.7	118.7	6¼	八	
82	1624.7.4	明天启四年五月十九日	甘肃庄浪	35.4	105.9	6	七至八	
83	1626.6.28	明天启六年六月五日	山西灵丘	39.4	114.2	7	九	
84	1627.2.16	明天启七年正月初一	宁夏中宁附近	37.5	105.5	6	八	
85	1630.1.16	明崇祯二年十二月甲寅	四川平武西	32.6	104.1	6¼	八	
86	1631.8.14	明崇祯四年七月十七日	湖南常德澧县	29.2	111.7	6¾	八	
87	1634.1	明崇祯六年十二月	甘肃西和	34.0	105.2	6	七至八	
88	1642.6.30	明崇祯十五年六月四日	山西平陆安邑间	34.9	111.1	6	八	
89	1652.3.23	清顺治九年二月十四日	安徽霍山东北	31.5	116.5	6	七至八	

编号	地震日期		震中位置			强度		备注
	公历	农历	地区	北纬(度)	东经(度)	震级	烈度	
90	1652.7.13	清顺治九年六月初八	云南弥渡	25.4	100.5	6½	九	
91	1654.7.21	清顺治十一年六月初八	甘肃天水	34.3	105.5	7½	十	
92	1657.4.21	清顺治十四年三月八日	四川汶川	31.5	103.7	6	八	
93	1658.2.3	清顺治十五年正月初二	河北涞水	39.4	115.7	6	七至八	
94	1661.2.15	清顺治十八年正月十七日	台湾台南	23.0	120.2	6	七至八	
95	1665.4.16	清康熙四年三月二日	河北通县	39.9	116.7	6½	八	
96	1668.7.25	清康熙七年六月十七日	山东郯城莒县间	35.3	118.6	8½	十二	
97	1679.9.2	清康熙十八年七月廿八日	河北三河平谷	40.0	117.0	8	十一	
98	1680.9.9	清康熙十九年八月十七日	云南楚雄	25.0	101.5	6¾	八至九	
99	1683.11.22	清康熙廿二年十月五日	山西原平一带	38.7	112.7	7	九	
100	1688.6.14	清康熙廿七年五月十七日	云南剑川	26.5	99.9	6¼	八	
101	1695.5.18	清康熙卅四年四月六日	山西临汾襄陵	36.0	111.5	8	十	
102	1704.9.28	清康熙四十三年八月卅日	陕西陇县	34.9	106.8	6	七至八	
103	1709.10.14	清康熙四十八年九月十二日	宁夏中卫南	37.4	105.3	7½	九至十	
104	1711.10.22	清康熙五十年九月十一日	台湾嘉义、高雄海滨	23.5	120.0	6½	八	
105	1713.2.26	清康熙五十二年二月初二	云南寻甸南	25.4	103.2	6½	九	
106	1713.9.4	清康熙五十二年七月庚申	四川迭溪	32.0	103.7	6½	八	

编号	地震日期		震中位置			强度		备注
	公历	农历	地区	北纬(度)	东经(度)	震级	烈度	
107	1718.6.19	清康熙五十七年五月廿一日	甘肃通渭南	35.0	105.2	7½	十	
108	1720.7.12	清康熙五十九年六月癸卯	河北沙城	40.4	115.5	6¾	九	
109	1721.1.5	清康熙五十九年十二月八日	台湾台南	23.0	120.3	6	八	
110	1725.1.8	清雍正二年十一月廿四日	云南嵩明宜良间	25.1	103.1	6	八	
111	1730.9.30	清雍正八年八月十九日	北京西郊	40.0	116.2	6½	八强	
112	1732.1.29	清雍正十年正月初三	四川西昌西南	27.7	102.2	6	八	
113	1733.8.2	清雍正十一年六月廿三日	云南东川	26.2	103.1	6¾	九	
114	1736.1.30	清雍正十三年十二月十八日	台湾嘉义台南间	23.1	120.3	6	八	
115	1738	清乾隆三年	青海玉树附近	33.0	96.6	6½	八	
116	1739.1.3	清乾隆三年十一月廿四日	宁夏银川平罗	38.9	106.5	8	十强	
117	1751.5.25	清乾隆十六年五月初一	云南剑川	26.5	99.9	6½	九	
118	1755.1.27	清乾隆十九年十二月十六日	云南易门东	24.7	102.2	6½	八	
119	1755.2.8	清乾隆十九年十二月廿八日	云南石屏东	23.8	102.7	6	八	
120	1761.5.23	清乾隆廿六年四月十九日	云南玉溪	24.4	102.5	6	八	
121	1761.11.3	清乾隆廿六年十月初七	云南玉溪	24.4	102.5	6	七	
122	1763.12.30	清乾隆廿八年十一月廿六日	云南通海江川间	24.3	102.8	6½	八	
123	1765.2.9	清乾隆卅年正月廿日	新疆精河	44.7	82.9	6	七至八	

编号	地震日期		震中位置			强度		备注
	公历	农历	地区	北纬(度)	东经(度)	震级	烈度	
124	1765.9.2	清乾隆卅年七月十八日	甘肃武山、甘谷间	34.8	105.0	6½	八至九	
125	1785.4.18	清乾隆五十年三月十日	甘肃玉门东北	39.9	98.0	6	七至八	
126	1786.6.1	清乾隆五十一年五月六日	四川康定、泸定	29.9	102.3	7½	九	
127	1786.6.18	清乾隆五十一年五月廿三日	新疆霍城附近	44.0	80.8	6	七	
128	1789.6.7	清乾隆五十四年五月十四日	云南通海、华宁	24.2	102.8	6½	九	
129	1792.8.7	清乾隆五十七年六月丁亥	台湾嘉义	23.6	120.5	6¾	九	
130	1792.9.7	清乾隆五十七年七月廿一日	四川乾宁附近	30.5	101.5	6	八	
131	1793.5.15	清乾隆五十八年四月六日	四川乾宁	30.5	101.5	6	七至八	
132	1799.8.27	清嘉庆四年七月廿七日	云南石屏	23.8	102.4	6½	八至九	
133	1803.2.1	清嘉庆八年正月初十	云南祥云宾川	25.6	100.6	6	七至八	
134	1806.1.11	清嘉庆十年十一月廿二日	江西会昌南	25.3	115.7	6	七至八	
135	1811.3.18	清嘉庆十六年二月廿四日	台湾淡水西海中	25.2	121.3	6~7		
136	1811.9.27	清嘉庆十六年八月十日	四川甘孜东	31.7	100.3	6	七至八	
137	1812.3.8	清嘉庆十七年一月廿五日	新疆伊宁东	43.7	83.0	7~8		
138	1814.11.24	清嘉庆十九年十月十三日	云南石屏	23.7	102.5	6	七至八	
139	1815.10.13	清嘉庆廿年九月十一日	台湾淡水附近	25.2	121.2	6½	八	
140	1815.10.23	清嘉庆廿年九月廿一日	山西平陆东北	34.8	111.2	6¾	九	

编号	地震日期 公历	农历	震中位置 地区	北纬(度)	东经(度)	强度 震级	烈度	备注
141	1820.8.3	清嘉庆廿五年六月廿五日	河南许昌	34.1	113.9	6	八	
142	1829.11.19	清道光九年十月廿三日	山东临朐益都	36.6	118.5	6	八	
143	1830.6.12	清道光十年闰四月廿二日	河北磁县西	36.4	114.2	7½	十	
144	1831.9.28	清道光十一年八月廿三日	安徽凤台东北	32.8	116.9	6¼	八	
145	1832.8	清道光十二年七月	甘肃玉门昌马	39.9	96.9	6½	八	
146	1833.9.6	清道光十三年七月廿三日	云南嵩明杨林	25.2	103.0	8	十一	
147	1837.9～10	清道光十七年八～九月	甘肃岷县临洮间	34.6	103.7	6	八	
148	1839.2.7	清道光十八年十二月廿四日	云南洱源	26.1	100.0	6	八	
149	1839.2.23	清道光十九年正月初十	云南洱源	26.1	100.0	6	七至八	
150	1839.6.27	清道光十九年五月十七日	台湾嘉义	23.4	120.4	6½	八	
151	1842.6.11	清道光廿二年五月三日	新疆巴里坤	43.6	93.0	6	八	
152	1845.2	清道光廿五年正月	台湾彰化	24.1	120.5	6	八	
153	1848.12.3	清道光廿八年十一月八日	台湾彰化	24.1	120.5	6¾	九	
154	1850.9.12	清道光卅年八月七日	四川西昌	27.8	102.3	7½	十	
155	1852.5.26	清咸丰二年四月初八	宁夏中卫	37.5	105.2	6	八	
156	1861.7.19	清咸丰十一年六月十二日	辽宁金县	39.1	121.7	6	八	
157	1862.6.6	清同治元年五月十一日	台湾嘉义台南间	23.3	120.3	6½	八	

编号	地震日期 公历	农历	震中位置 地区	北纬(度)	东经(度)	强度 震级	烈度	备注
158	1867.12.18	清同治六年十一月廿三日	台湾基隆北海中	25.5	121.7	6		
159	1870.4.11	清同治九年三月十一日	四川巴塘	30.0	99.0	6¾	九	
160	1876.8.5	清光绪二年六月十六日	云南永平	25.4	99.4	6	七至八	
161	1879.7.1	清光绪五年五月十二日	甘肃武都南	33.2	104.7	7½	十	
162	1881.7.20	清光绪七年六月廿五日	甘肃舟曲东	33.6	104.6	6½	八	
163	1882.12.2	清光绪八年十月廿二日	河北深县西北	38.1	115.5	6	八	
164	1882.12.9	清光绪八年十月廿九日	台湾彰化南	23.8	120.5	6¼	七至八	
165	1884.11.14	清光绪十年九月廿七日	云南普洱	23.0	101.1	6½	八	
166	1885.1.14	清光绪十年十一月廿九日	甘肃天水南	34.5	105.7	6	七至八	
167	1887.12.16	清光绪十三年十一月二日	云南石屏	23.7	102.5	6¾	九	
168	1888.6.13	清光绪十四年五月四日	渤海湾	38.5	119.0	7½		
169	1888.11.2	清光绪十四年九月廿九日	甘肃景泰附近	37.1	104.2	6¼	八	
170	1893.8.29	清光绪十九年七月十八日	四川乾宁	30.5	101.5	6	八	
171	1895.7.5	清光绪廿一年闰五月癸丑	新疆塔什库尔干	37.7	75.1	6	八	

Date Time Lat Lon Acc. M Mag Comment & Place

编号	地震日期	发震时刻(北京时间)	震中位置 北纬(度)	东经(度)	精度类别	强度 震级	烈度	参考地名及备注
172	1901. 2 15		26.0	100.0		6	八	云南邓川
173	1902. 8.22	11-00	40.0	76.5*	(4)	8¼	十一	新疆阿图什附近
174	1904 8 30		31.2	100.9		6	八	四川道孚西北
175	11 6	04-25	23.5	120.3	(3)	6¼	八	台湾嘉义
176	1905 8 25	17-46-45	43.0	129.0	(4)	6¾		吉林安图附近 h: 470 公里
177	1906 3 17	06-42	23.5	120.5	(2)	6¾	九	台湾嘉义
178	4.14	03-18	23.4	120.4	(2)	6	八	台湾嘉义
179	12 23	02-21-00	43.9	85.6*		8	十	新疆玛纳斯西南
180	1909. 4 15	03-54	25.0	121.5	(5)	7¼		台湾台北附近
181	5 11		24.4	103.0		6½	八	云南弥勒
182	1910 1 8	22-49-30	35.0	122.0	(5)	6¾		黄海
183	4.12	08-22-13	25.5	122.5	(4)	7¾		台湾基隆东北 h 200 公里
184	7 12	15-36-12	37.0	76.0	(5)	6¾		新疆塔什库尔干、皮札一带 h. 120 公里
185	1911.10.15	07-24-00	31.0	80.5	(5)	6¾		西藏噶尔、普兰一带
186	1913 3.6	10-09	30.0	83.0	(4)	6¼		西藏仲巴附近
187	3 6	19-04	30.0	83.0	(4)	6½		西藏仲巴附近
188	8		28.4	102.3	(2)	6	八	四川冕宁
189	12 21	23-37-35	24.2	102.5	(2)	6½	九	云南峨山
190	1914 7 6	14-37-30	24.0	122.0	(4)	6¾		台湾花莲附近
191	8 5	06-41-36	43.3	93.1	(4)	7½		新疆巴里坤
192	10.9	10-39-10	35.0	78.0	(5)	6½		新疆喀喇昆仑山口南
193	1915. 4.28	11-19-46	34.5	96.0	(5)	6½		青海曲麻莱
194	5 5	23-12-08	34.0	96.0	(5)	6½		青海治多东
195	12 3	10-39-19	29.5	91.5	(4)	7		西藏拉萨东

注：h 表示震源深度

编号	地震日期	发震时刻(北京时间)	震中位置 北纬(度)	东经(度)	精度类别	强度 震级	烈度	参考地名及备注
196	1916 8 28		23.9	120.7		6	八	台湾南投
197	11 15	06-31-33	24.0	121.0	(4)	6		台湾埔里附近
198	1917 1 5	00-50-06	24.0	121.0	(3)	6¼		台湾埔里附近
199	1 24	08-48-12	31.3	116.3		6¼	八	安徽霍山
200	7.31	07-54-05	28.0	104.0		6½	九	云南大关北
201	7 31	11-23-10	42.5	131.0	(4)	7½		吉林珲春东南 h: 460 公里
202	9 5	00-42-16	39.0	95.0	(5)	(6)		青海门达台
203	1918 2 5	01-54-49	29.6	87.8	(5)	6		西藏拉孜、日喀则一带
204	2 10	04-46-26	43.0	130.0	(4)	6½		吉林珲春附近 h: 450 公里
205	2.13	14-07-13	23.5	117.0*		7¼	十	广东南澳
206	4 10	10-03-54	43.5	130.5	(4)	7¼		吉林珲春北 h 570 公里
207	1919. 5 29	18-59-45	31.5	100.5	(5)	6¼		四川炉霍一带
208	7 24	10-03-20	40.0	76.0	(5)	6½		新疆阿图什一带
209	8 26	03-55-15	32.0	100.0	(5)	6¼		四川甘孜一带
210	8.29	03-34-22	24.0	121.0	(4)	6		台湾埔里附近
211	11 1	03-02-(10)	23.5	117.0*		6		广东南澳 编号 205 地震之余震
212	12 21	03-34-00	23.0	121.7	(4)	6¼		台湾台东东北海中
213	12 21	04-37-27	22.0	122.0	(4)	7		台湾兰屿东海中
214	1920 1 23	05-44-30	25.5	122.0	(5)	6¼		台湾基隆东北海中
215	5.2	16-27-50	35.0	90.5	(5)	6¼		青海乌兰乌拉湖一带
216	5.2	22-46-40	35.0	90.5	(5)	6¼		同 上
217	6.5	12-21-28	23.5	122.0	(3)	8		台湾花莲东南海中
218	10 12	14-54-48	36.0	81.0	(4)	6½		新疆于田西南
219	10 20	18-02-16	24.0	120.0	(5)	6½		台湾台中西海中
220	10 21	03-16-00	24.0	120.0	(5)	6¼		台湾台中西海中

编号	地震日期	发震时刻（北京时间）	震中位置			强度		参考地名及备注
			北纬（度）	东经（度）	精度类别	震级	烈度	
221	1920 12 5	07-08-23	25.0	119 5	(4)	6		福建泉州东海中
222	12 16	20-05-53	36 5	105 7*		8½	十二	宁夏海原
223	12 25	19-33-08	35 6	106 3	(3)	7		宁夏泾源附近
224	12.28	11-16-30	35 5	105.5	(3)	6¼		甘肃静宁附近
225	1921. 1.7	17-42-25	38 0	107 0	(4)	6		宁夏吴忠东
226	3 19	16-19(45)	23 5	117 0*		6¼		广东南澳 编号 205 地震之余震
227	4 2	17-36-45	23 3	122 0	(4)	6½		台湾花莲东南海中
228	4.12	17-36-00	35 8	106 2*		6½		宁夏固原
229	7.19	01-03-00	23 0	121.7	(5)	6		台湾台东东北海中
230	10.15	00-43-45	30 5	91.0	(5)	6½		西藏拉萨当雄一带
231	1922 7.19	20-54-50	25 5	120 0	(5)	6		福建平潭东海中
232	9 2	03-16-06	24 5	122 0	(3)	7½		台湾宜兰东南海中
233	9.5	01-53-35	24 0	120 0	(5)	6½		台湾海峡
234	9.15	03-31-39	24 6	122 3	(3)	7¼		台湾宜兰东
235	9 17	06-44-36	25 0	121 5	(3)	6		台湾台北附近
236	9.17	15-22-36	25 0	121 5	(3)	6		同 上
237	9 17	15-53-06	25 0	121 5	(3)	6¼		同 上
238	9 17	17-59-18	25 0	121 5	(3)	6¾		同 上
239	9.18	14-20-00	25 0	121.5	(4)	6		同 上
240	9.29	06-01-05	39 2	120 5	(5)	6½		渤 海
241	10.14	11-56-25	25 0	121 5	(4)	6		台湾台北附近
242	10.15	07-46-45	25 0	121 5	(3)	6¾		台湾台北附近
243	10 17	00-01-32	39 5	91 0	(3)	6½		新疆罗布泊东南
244	10 27	22-22-40	23 3	122.0	(4)	6½		台湾新港东海中
245	12 2	11-46-36	24 0	120 0	(5)	6¼		台湾海峡
246	1923. 3.24	20-40-06	31 3	100 8*		(7¼)	十	四川炉霍、道孚
247	4.23	11-17-00	29 0	124 5	(5)	6¾		东 海
248	7 1	15-54-55	23 0	101 0*		6½	八	云南普洱附近
249	7.2	10-31-55	25 0	121 5	(4)	6½		台湾台北附近
250	8		28 7	102 2*		6	八	四川冕宁大桥
251	8 27	19-15-00	24 8	120 4	(5)	6¼		台湾海峡
252	10 20	11-19-49	30 0	99 0	(4)	6½		四川巴塘
253	1924 7.3	12-40-10	36 8	83 8	(3)	7¼		新疆民丰东
254	7.12	03-44-44	37 1	83 6	(4)	7¼		新疆民丰东
255	7.22	22-23-46	24 0	121 0	(5)	6¼		台湾埔里一带
256	10.9	04-37-57	30 0	90 0	(4)	6½		西藏拉萨西北
257	1925 3 16	22-42-17	25 7	100 3*		7		云南大理洱海
258	3 17	07-50-26	25 0	100 5	(5)	(6¾)		云南弥渡南涧一带
259	4 17	03-52-41	20 4	120 3	(3)	7		台湾恒春南海中
260	12 7	16-34-30	37 0	76 5	(4)	6		新疆叶城西南
261	1926 6 4	14-50-48	35 0	89.5	(4)	6		西藏员特咯穆湖
262	8 3	11-41-30	22 0	121 0	(4)	6½		台湾恒春东
263	8 7	06-45-59	35.4	78 7	(5)	6¼		新疆和田西南
264	9.12	23-43-36	22 0	120 5	(4)	6¾		台湾恒春附近
265	1927 2 3	11-53-10	33 5	121 0	(3)	6½		黄海
266	3.15	01-37-39	25 4	103 1*		6	八	云南寻甸附近
267	3 16	05-48-37	38 2	98 2	(4)	6		青海哈拉湖附近
268	4.30	21-56-47	38 5	78 0	(4)	6		新疆英吉沙东南
269	5.18	05-44-16	44 0	131 0	(4)	6½		黑龙江东宁附近 h: 430 公里
270	5 23	06-32-47	37.6	102 6*		8	十一	甘肃古浪
271	1927. 5 23	21-51-10	37 7	102.2	(2)	6		甘肃古浪附近
272	8 25	02-09-00	23 0	120 5	(4)	6¾		台湾甲仙附近
273	9 23	21-54-13	42 3	85 6	(3)	6¾		新疆和静西
274	1928 3 8	06-43-28	37 6	102 2	(4)	6		甘肃古浪附近
275	6.7	14-24-35	44 0	131 0	(4)	6		黑龙江东宁附近 h: 430 公里
276	8.5	22-41-51	16 0	119.0	(5)	(6¼)		南海中沙群岛东
277	1929. 1.14	02-44-39	40 7	111 3*		6	八	内蒙呼和浩特西毕克齐附近
278	3.22	11-04-04	24 0	103 0	(4)	6¼		云南通海附近
279	8 19	10-43-16	25 1	121.3	(3)	6¾		台湾桃园附近
280	8 20	04-44-32	24 7	121 7	(4)	6¼		台湾宜兰附近
281	8.21	00-38-26	24 7	121.7	(4)	6½		台湾宜兰附近
282	9 12	06-18-42	24 7	121.7	(4)	6		台湾宜兰附近
283	10 17	04-27-37	25 8	98 7	(3)	6½		云南腾冲北
284	10 24	14-34-13	22 0	118 0	(4)	6½		南海东沙群岛东北
285	1930 4.29	02-34-37	25 8	98 6	(3)	6¼		云南腾冲北
286	7 14	03-27-21	38 1	98 2	(2)	6½		青海哈拉湖东
287	8.21	04-54-12	24 5	122 2	(4)	7		台湾宜兰东南海中
288	9.22	07-04-14	25 8	98 4*		6½	八	云南腾冲北
289	9.26	02-33-34	25 3	98 9	(3)	6		云南腾冲东北
290	11.4	23-38-03	25 6	98.3	(4)	(6)		云南腾冲北
291	12 2	15-01-26	25 8	98.3	(4)	6		云南腾冲北
292	12 8	16-01-05	23 2	120 6	(2)	6		台湾台南东
293	1931. 1 2	07-52-22	23 5	122.0	(4)	6¾		台湾花莲东南
294	2 13	08-40-45	25 5	122 0	(4)	6		台湾基隆东北海中
295	7.25	20-40-06	25 5	98 5	(4)	(6)		云南腾冲北
296	1931 8 11	05-18-43	47 1	89 8	(3)	8	十一	新疆富蕴附近
297	8.18	22-21-04	47.4	90 0	(3)	7¼		新疆富蕴附近
298	9.21	18-27-20	19.8	113.1	(3)	6¾		南海西沙群岛北
299	11 5	20-19-33	47 0	90 0	(3)	6¼		新疆富蕴附近
300	1932 3.6		30 1	101 8*		(6)	八	四川康定一带
301	4 6	17-11-18	31 4	115 0	(2)	6	八	湖北麻城北
302	8 21	12-15-35	24 5	121 5	(4)	6½		台湾宜兰西南
303	8 22	19-12-42	36 1	121 6	(2)	6¼		山东青岛东海中
304	9 11	22-13-12	45 1	83 0	(3)	6		新疆精河附近
305	10 9	20-49-49	23 5	122 5	(4)	6		台湾花莲东海中 h: 130 公里
306	10 24	05-27-48	24.5	122 3	(4)	6¼		台湾宜兰东海中
307	12 16	03-33-38	21 0	121 0	(4)	6		台湾恒春南海中
308	12 25	10-04-27	39 7	97 0*		7½	十	甘肃玉门昌马
309	1933. 2.13	10-49-15	46 3	90 5	(2)	6½		新疆富蕴南
310	4.19	14-44-36	24.3	121 5	(3)	6½		台湾花莲西北
311	6 7	19-46-08	27 5	99 9	(2)	6¼		云南中甸附近
312	8 11	16-54-06	25 9	98 4	(2)	6½		云南腾冲北
313	8 25	15-50-30	32 0	103 7*		7½	十	四川茂汶北
314	9 9	13-02-35	44 0	130 0	(4)	6¼		黑龙江牡丹江东南 h 590 公里
315	9.26	02-51-27	38 3	86 9	(2)	6¾		新疆若羌西南
316	1934 1 12	21-31-52	23 7	102 7	(2)	6	八	云南石屏南
317	1 19	20-33-11	25 9	98 3	(3)	6		云南腾冲西北
318	1 21	01-56-16	41.1	108 3*		6¼	八	内蒙五原附近
319	1.21	06-52-23	25 5	122 0	(4)	6		台湾基隆东北海中
320	4 16	21-40-18	21 5	121 5	(4)	6		台湾兰屿南

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			北纬（度）	东经（度）	精度类别	震级	烈度	
321	1934. 6.23	13-19-55	33.0	92.8	(3)	6		青海吉利布拉克附近
322	8.7	19-50-04	44.6	87.7	(4)	6		新疆乌鲁木齐北
323	8.11	16-18-21	24.7	121.5	(4)	6½		台湾宜兰附近
324	12.15	09-57-40	31.3	89.0	(2)	7		西藏奇林湖附近
325	1935 1.3	09-50-17	30.8	88.2	(2)	6½		西藏申扎附近
326	2.10	03-19-37	24.5	121.7	(3)	6¼		台湾宜兰南
327	2.22	16-55-28	24.2	121.8	(4)	6		台湾花莲东海中
328	3.29	07-47-51	43.0	131.0	(3)	6¼		吉林珲春东 h. 550 公里
329	4.17		24.5	120.8*		(6)	八	台湾苗栗
330	4.21	06-01-54	24.5	120.8	(3)	7	十	台湾台中新竹间
331	4.21	06-26-26	25.0	120.5	(4)	6		台湾海峡
332	4.28		29.4	102.3*		(6)	七至八	四川石棉泸定间
333	5.5	07-02-24	24.3	121.3	(4)	6		台湾花莲西北
334	5.21	12-22-34	28.8	89.5	(3)	6¼		西藏江孜附近 h· 140 公里
335	7.17	00-18-58	24.6	120.8	(2)	6½		台湾新竹附近
336	7.26	18-32-31	33.3	101.1	(3)	6		青海久治附近
337	9.4	09-37-42	22.2	121.3	(2)	7¼		台湾兰屿西北
338	9.4	09-54-30	22.3	121.3	(4)	(6)		台湾兰屿西北
339	9.4	11-28-08	22.3	121.3	(4)	6		台湾兰屿西北
340	12.18	15-10-36	28.6	103.7*		6	八	四川马边附近
341	12.19	00-59-30	29.1	103.3	(3)	6		四川马边附近
342	1936. 1.28	02-30-22	45.0	91.6	(4)	6		新疆北塔山附近
343	2.7	16-56-27	35.4	103.4	(2)	6¾	八	甘肃康乐和政一带
344	4.1		22.5	109.4*		6¾	九	广西灵山东北
345	4.27	07-59-11	28.7	103.7*		6¾	九	四川马边附近
346	1936 4.27	13-42-37	28.7	103.2	(3)	6		四川马边附近
347	5.16	15-05-44	28.5	103.6	(2)	6¾		四川马边附近
348	8.1	14-24-30	34.2	105.7	(2)	6	八	甘肃天水南
349	8.22	14-51-35	22.0	121.2	(3)	7¼		台湾恒春东海中
350	1937. 1.7	21-20-41	35.5	97.6	(2)	7½	十	青海都兰西南
351	8.1	04-35-48	35.2	115.3*		7	九	山东菏泽附近
352	8.1	18-41-05	35.3	115.4*		6¾	八	山东菏泽附近
353	11.16	05-37-34	35.0	78.0	(4)	6½		新疆喀喇昆仑山口南, h 100 公里
354	12.8	16-32-11	23.1	121.4	(2)	7		台湾台东东北
355	12.9	04-38-43	22.9	121.5	(4)	6¼		台湾台东附近
356	12.14	02-53-57	22.7	121.2	(4)	6¾		台湾台东附近
357	12.17	17-32-12	22.7	121.2	(4)	6¾		台湾台东附近
358	1939. 3.14	13-14-21	32.3	103.6	(2)	6		四川松潘南
359	5.14	20-03-03	23.0	99.8	(4)	6		云南澜沧南
360	8.23	05-37-24	37.4	98.5	(3)	6		青海天峻附近
361	9.7	12-03-17	23.9	121.7	(4)	7		台湾花莲附近
362	10.13	23-26-23	23.9	121.7	(4)	6¼		台湾花莲附近
363	10.21	14-46-22	43.5	131.0	(4)	6¾		黑龙江东宁南 h: 550 公里
364	11.21	09-11-31	29.9	95.3	(3)	6		西藏波密西
365	12.3	06-14-20	33.2	90.4	(3)	6		西藏安多西北
366	12.7	07-00-51	22.9	121.5	(4)	7		台湾火烧岛北海中
367	12.7	23-00-56	22.9	121.5	(4)	6		台湾火烧岛北海中
368	1939 2.23	23-40-46	44.0	84.0	(4)	6		新疆乌苏西南
369	5.16	15-20-12	23.9	121.7	(4)	6		台湾花莲附近海中
370	1940. 1.19	13-23-48	42.7	121.3	(4)	6		吉林通辽南
371	1940 4.6	21-43-02	23.8	102.4*		6	八	云南石屏
372	7.10	13-49-52	44.9	130.4	(4)	7¼		黑龙江穆棱附近 h: 560 公里
373	9.3	22-40-37	30.7	91.7	(3)	6¼		西藏拉萨东北
374	10.4	12-35-51	30.5	91.5	(4)	6		西藏拉萨东北
375	1941. 1.21	20-42-01	27.5	91.9	(2)	6¾		西藏错那附近 h. 180 公里
376	4.19	15-53-45	39.1	97.0	(2)	6		青海哈拉湖西北
377	5.5	23-18-27	46.7	127.1*		6	八	黑龙江绥化
378	5.16	15-14-32	23.6	99.4	(3)	7		云南耿马附近
379	6.12	07-13-31	30.1	102.5	(3)	6		四川泸定天全一带
380	10.8	23-24-20	32.1	103.3*		6	八	四川黑水东
381	10.31	14-31-06	25.4	98.4	(4)	6¼		云南腾冲北
382	12.17	03-19-42	23.3	120.3	(2)	7		台湾嘉义南
383	12.26	22-48-09	22.2	100.1*		7		云南澜沧东南
384	1942. 2.1	01-30-47	22.8	101.0*		6¾	八	云南思茅
385	5.25	05-19-32	22.9	121.5	(4)	6¼		台湾火烧岛北
386	7.9	05-22-27	43.0	122.0	(4)	6		吉林通辽南
387	9.2	02-59-34	47.0	127.0	(4)	6		黑龙江绥化北
388	9.24	11-38-58	23.9	121.7	(4)	6½		台湾花莲附近
389	1943 10.23	00-01-15	24.3	122.3	(4)	6¼		台湾花莲东
390	11.7	16-25-45	22.0	119.0	(4)	6		台湾高雄西南
391	11.24	05-51-35	24.6	121.1	(5)	6		台湾新竹苗栗一带
392	11.24	21-17-13	22.6	121.5	(5)	7		台湾火烧岛附近
393	12.2	13-08-57	22.9	121.5	(4)	6½		台湾台东东北
394	1944 3.10	06-03-43	44.0	84.0	(5)	6½		新疆乌苏西南
395	3.10	06-12-57	44.0	84.0	(5)	7¼		新疆乌苏西南
396	1944 9.29	00-25-07	39.1	75.0	(3)	7		新疆喀什西南
397	9.28	00-52-57	38.5	74.8	(5)	6		新疆塔什库尔干北
398	10.18	02-36-56	31.4	83.3	(2)	6¾		西藏昂拉仁错
399	10.29	08-11-30	31.3	83.4	(3)	6¾		西藏昂拉仁错
400	11.6	13-49-05	31.3	83.4	(3)	6		西藏昂拉仁错
401	12.19	22-09-04	39.7	124.3	(3)	6¾		辽宁丹东南海中
402	1945. 4.11	00-15-39	24.3	122.3	(4)	6¼		台湾花莲东北
403	8.2	06-23-28	24.3	121.6	(3)	6½		台湾花莲附近
404	8.3	01-52-07	20.4	120.4	(5)	6		台湾南海中
405	9.23	23-34-23	39.7	115.7*		6¼	八	河北涿县附近
406	10.21	11-21-03	23.7	120.5	(4)	6¼		台湾嘉义附近
407	1946. 1.11	09-33-29	44.0	129.5	(4)	7¼		黑龙江牡丹江南 h· 580 公里
408	2.20	07-55-23	35.0	88.5	(4)	6		西藏曼特克木湖西北
409	3.16	19-31-25	24.6	121.1	(5)	6		台湾新竹苗栗一带
410	6.2	09-08-58	23.8	121.8	(4)	6¼		台湾花莲东南海中
411	9.9	18-36-38	23.2	121.4	(4)	6		台湾新港附近
412	11.7	03-56-23	34.5	80.6	(3)	6¼		西藏日土东北
413	12.5	06-46(39)	23.0	120.3*		6¾	九	台湾台南附近
414	12.19	10-57-19	24.7	122.5	(4)	6½		台湾宜兰东海中 h· 100 公里
415	1947. 2.10	12-02-02	31.8	85.4	(4)	6¼		西藏改则东南
416	3.16	17-32-34	24.3	122.3	(4)	6		台湾花莲东北海中
417	3.17	16-19-41	33.3	99.5	(3)	7¾		青海达日附近
418	4.3	04-45-06	24.3	122.3	(4)	6¼		台湾花莲东北海中
419	7.29	21-43-33	28.6	93.6	(3)	7¾		西藏朗县东南
420	8.17	17-04-40	24.3	122.3	(3)	6		台湾花莲东北海中

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421	1947. 8.24	19-37-04	41.5	81.9	(4)	6¼		新疆拜城南
422	1948 2.13	12-57-11	36.0	80.5	(3)	6¼		新疆和田东南
423	3.3	17-10-02	18.8	119.0	(2)	7¼		南海东沙群岛东南
424	5.23	17-13-18	37.7	121.9*		6		山东威海海中
425	5.25	15-11-34	29.7	100.3*		7¼	十	四川理塘南
426	6.27	08-08-23	26.6	99.6*		6¼	八	云南剑川
427	10.4	13-56-51	23.9	121.7	(4)	6		台湾花莲附近
428	10.23	12-47-00	24.3	122.3	(3)	6¼		台湾花莲东北
429	12.6	22-09-12	22.9	121.5	(4)	6		台湾台东东北
430	12.21	07-07-19	23.4	121.6	(4)	6		台湾大港口附近
431	1949. 1.19	23-00-00	23.8	121.8	(4)	6½		台湾花莲东海中
432	2.24	00-08-11	41.9	83.2*		7¼		新疆库车东北
433	5.25	16-23-49	42.0	83.6	(3)	6¾		新疆库车东北
434	6.15	17-42-42	33.3	100.0	(4)	6		青海达日附近
435	1950 2.3	07-33-39	21.7	100.1	(3)	7		云南勐海西南
436	2.3	10-51-52	22.1	99.9	(3)	6¾		云南勐连东南
437	2.23	19-01-10	29.0	96.5	(4)	6		西藏察隅附近
438	8.15	22-09-34	28.4	96.7	(2)	8½		西藏察隅
439	8.16	00-29-28	28.7	96.6	(4)	(6)		西藏察隅附近
440	8.16	00-49-56	28.7	96.6	(4)	(6)		同上
441	8.16	01-16-51	28.7	96.6	(4)	(6)		同上
442	8.16	02-38-40	28.7	96.6	(4)	6		同上
443	8.16	03-58-45	28.7	96.6	(4)	(6)		同上
444	8.16	14-41-57	28.7	96.6	(4)	6		同上
445	8.18	09-07-47	28.7	96.6	(4)	6¼		同上
446	1950. 9.30	15-28-55	28.7	94.2	(4)	6½		西藏米林南
447	10.5	12-50-12	29.2	95.1	(4)	6¼		西藏墨托附近
448	11.2	15-07-35	24.6	121.1	(4)	6		台湾苗栗东
449	12.3	14-26-52	29.0	96.0	(4)	6		西藏墨托东南
450	1951. 1.28	21-26-28	24.3	122.3	(4)	6		台湾花莲东北海中
451	3.17	12-27-35	30.9	97.4	(2)	6		西藏昌都附近
452	4.15	07-40-59	28.4	93.8	(3)	6½		西藏米林南
453	10.22	05-34-18	23.8	121.7	(2)	7¼		台湾花莲西南
454	10.22	06-55-26	23.9	121.7	(4)	(6)		台湾花莲附近
455	10.22	11-29-27	24.1	121.8	(3)	7		同上
456	10.22	12-28-05	24.0	121.9	(3)	7		同上
457	10.22	13-17-44	23.9	121.7	(4)	6½		同上
458	10.22	13-23-53	23.9	121.7	(4)	(6)		同上
459	10.22	13-43-03	23.8	121.9	(4)	7		同上
460	10.22	19-11-03	23.9	121.7	(4)	6½		同上
461	10.22	20-48-38	23.9	121.7	(4)	6½		同上
462	10.22	21-01-13	23.9	121.7	(3)	6¼		同上
463	10.22	22-46-42	23.9	121.7	(4)	6		同上
464	10.22	23-29-47	23.9	121.7	(4)	6¾		同上
465	10.23	00-06-55	23.9	121.7	(4)	6		同上
466	10.23	02-42-35	23.9	121.7	(4)	6		同上
467	10.23	04-51-39	23.9	121.7	(4)	6		同上
468	10.23	09-19-36	23.9	121.7	(4)	6½		同上
469	10.23	16-55-13	23.9	121.7	(4)	6½		同上
470	10.24	11-39-00	23.9	121.7	(4)	6		同上

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471	1951. 10.24	21-42-14	23.9	121.7	(4)	6		台湾花莲附近
472	10.25	20-19-40	23.9	121.7	(4)	6¾		台湾花莲附近
473	11.17	12-45-58	31.0	91.6	(4)	6¼		西藏当雄附近
474	11.18	17-26-37	30.9	91.5	(2)	6¾		西藏当雄附近
475	11.18	17-35-50	31.1	91.4	(3)	8		西藏当雄附近
476	11.25	02-47-13	22.9	121.5	(4)	7½		台湾台东东北海中
477	11.25	02-50-29	23.4	121.4	(3)	7¼		台湾大港口附近
478	11.26	14-38-29	22.9	121.5	(4)	6¾		台湾台东东北海中
479	12.5	14-58-32	22.9	121.5	(4)	6½		台湾台东东北海中
480	12.21	16-37-29	26.5	99.8*		6¼	九	云南剑川
481	12.26	18-07-04	31.3	90.6	(2)	6¼		西藏当雄北
482	12.27	00-30-52	39.6	95.7	(2)	6		甘肃肃北东
483	1952. 6.19	20-12-59	22.7	99.8	(2)	6½	八	云南澜沧东
484	6.20	13-46-15	23.9	121.7	(3)	6¾		台湾花莲附近
485	6.23	20-03-08	24.3	122.3	(4)	6		台湾花莲东海中
486	8.18	00-02-11	31.0	91.5	(2)	7½		西藏当雄附近
487	9.30	20-52-02	28.5	102.3*		6¾	九	四川冕宁石龙一带
488	10.6	06-04-30	37.1	93.2	(2)	6		青海乌图美仁附近
489	11.1	07-51-40	33.3	101.0	(2)	6		青海久治附近
490	1953. 7.10	03-02-08	39.9	78.3	(3)	6		新疆巴楚附近
491	10.12	01-08-06	32.4	82.9	(2)	6¾		西藏改则西
492	12.3	22-54-08	31.4	85.7	(2)	6¾		西藏特里纳木错附近
493	1954. 2.11	08-30-15	39.0	101.3	(2)	7¼	十	甘肃山丹
494	2.11	12-53-46	39.0	101.5	(3)	(6)		甘肃山丹东北
495	7.31	09-00-00	38.8	104.2	(2)	7		甘肃民勤东腾格里沙漠中
496	1955 1.29	01-02-39	33.2	82.4	(2)	6½		西藏西提附近
497	3.22	14-14-12	25.9	98.4	(2)	6		云南泸水西
498	4.4	19-11-28	21.8	121.1	(2)	6½		台湾恒春东
499	4.14	09-29-02	30.0	101.9	(2)	7½	九	四川康定折多塘一带
500	4.15	11-40-58	39°54'	74°32'*		7	九	新疆乌恰西北
501	4.15	12-13-25	39.9	74.7	(4)	7		新疆乌恰西北
502	4.24	20-59-12	44.2	83.6	(2)	6½		新疆精河东南
503	6.5	14-11-21	24.2	121.4	(4)	6		台湾花莲东北海中
504	6.7	08-48-54	26.5	101.1	(2)	6	八	云南华坪附近
505	9.22	11-25-07	23.9	122.5	(4)	6¾		台湾花莲东海中
506	9.23	23-06-23	26.3	101.9*		6¾	九	云南永仁东北
507	9.24	18-21-28	22.1	121.5	(4)	6¾		台湾兰屿附近
508	1956 2.12	19-49-27	18.9	119.9	(2)	6½		南海东沙群岛东南 h: 40 公里
509	1957. 1.3	20-45-30	43.9	130.6	(2)	7		黑龙江东宁附近 h: 590 公里
510	2.24	04-26-19	23.8	121.9	(2)	7.2		台湾花莲东南海中
511	4.14	15-11-56	30°35'	84°16'	(1)	6½		西藏阿木中附近
512	7.19	21-02-15	24.6	122.7	(2)	6.1		台湾宜兰东南海中 h 100 公里
513	10.20	02-28-57	23.7	121.6	(2)	6.8		台湾花莲海 h 40 公里
514	1958 1.23	02-29-00	23°37'	121°43'	(1)	6.1		台湾花莲东南 h 50 公里
515	2.8	07-23-36	31.5	104.0	(2)	6.2		四川茂汶东南
516	2.19	03-48-44	20.6	120.3	(2)	6		台湾七星岩南海中 h: 10 公里
517	2.28	07-27-54	20.8	120.2	(2)	6.5		台湾七星岩西南海中
518	3.15	08-24-05	22.8	122.0	(2)	6		台湾台东东海中
519	10.28	18-46-32	30°35'	84°29'	(1)	6¼		西藏阿大中附近
520	12.21	13-46-29	44°33'	80°52'	(1)	6½		新疆赛里木湖附近

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521	1959. 4.27	04-40-38	24°47'	122°42'	(1)	7½		台湾宜兰东海中 h. 130 公里
522	4.27	21-09-24	33 2	92 6	(2)	6		青海唐古拉山口东北
523	6.2	10-37-48	21 0	120 9	(2)	6		台湾七星岩南海中
524	6.2	12-57-21	21 0	121 2	(2)	6¾		台湾七星岩东南海中
525	6 2	13-42-37	21 3	121 4	(3)	6		台湾七星岩东南海中
526	6 28	03-11-28	41 9	80 0	(2)	6¾		新疆温宿北 h· 20 公里
527	8.15	16-57-03	22°11'	121°08'	(1)	7		台湾恒春东
528	8 16	09-21-06	22 1	121 4	(2)	6		台湾兰屿附近
529	8.18	08-34-02	22 2	121 8	(3)	6 5		台湾兰屿东北 h. 165 公里
530	9 25	10-36-51	22°06'	121°26'	(1)	6¾		台湾兰屿附近 h: 25 公里
531	10 29	22-30-31	42 5	130 5	(3)	6¾		吉林珲春南 h· 500 公里
532	11.11	04-56-15	36 2	88 7	(2)	6		西藏哈拉木伦山口东
533	11.15	18-25-16	38°45'	75°19'	(1)	6 4		新疆公格尔山附近 h. 40 公里
534	1960. 11. 9	18-43-42	32°47'	103°40'*		6¾	九	四川松潘东北
535	1961. 2 5	03-09-18	24 2	122 8	(2)	6 2		台湾花莲东海中
536	4.1	23-18-26	39°55'	77°48'	(1)	6 5		新疆巴楚西
537	4.4	17-46-40	39 9	77 8	(2)	6 4		新疆巴楚西
538	4.9	23-35-09	24 1	122 2	(2)	6		台湾花莲东海中 h· 30 公里
539	4.14	00-34-39	39°53'	77°45'*		6 8	九	新疆巴楚西 h 20 公里
540	5.14	03-19-39	25 5	122 4	(2)	6 1		台湾基隆东北 h: 250 公里
541	6 4	15-33-03	34°09'	81°54'	(1)	6 5		西藏奈罗尔错
542	6 27	15-03-41	27°46'	99°41'*		6	八	云南中甸 h. 5 公里
543	9.17	16-41-56	24 1	122 2	(2)	6 3		台湾花莲东海中 h: 30 公里
544	12.3	16-40-30	25 0	123 0	(2)	6 3		台湾基隆东南海中 h: 145 公里
545	1962. 3.19	04-18-53	23°43'	114°40'	(1)	6 1	八	广东河源
546	1962. 5 21	20-02-52	37 1	96 0	(2)	6 8		青海北霍布逊湖附近 h 25 公里
547	6 24	09-21-18	25 3	101 1*		6 2	七强	云南南华
548	6 25	19-10-25	24 1	122 7	(3)	6 5		台湾花莲东海中 h: 35 公里
549	8 20	02-26-38	44°41'	81°35'	(1)	6 4		新疆赛里木湖 h: 25 公里
550	10 9	05-56-19	24 4	121 9	(2)	6		台湾花莲东北海中
551	1963 2 13	16-50-07	24 4	122 2	(2)	7		台湾南澳东海中
552	3 4	21-38-43	24 5	121 9	(2)	6		台湾苏澳附近海中
553	3 10	10-53-29	24 7	122 2	(3)	6 1		台湾苏澳东北海中 h· 25 公里
554	4 19	15-35-21	35 7	97 0	(2)	7		青海阿兰湖
555	4 21	12-38-25	24°13'	122°22'	(1)	6		台湾花莲东海中 h· 40 公里
556	4 23	17-55-07	25 8	99 5	(2)	6	六	云南云龙东南 h· 20 公里
557	6 26	22-09-21	36 4	76 7	(2)	6		新疆麻扎 h 100 公里
558	7 24	19-32-21	24 6	122 1	(2)	6 2		台湾苏澳东海中
559	8 29	16-53-50	39°48'	74°12'	(1)	6½		新疆乌恰西
560	1964 1.18	20-04-40	23°12'	120°36'	(1)	7		台湾台南东南 h: 25 公里
561	10 22	07-09-16	28 2	93 8	(2)	6 6		西藏米林南
562	11 26	18-21-10	25 0	122 0	(2)	6 3		台湾基隆东南 h 20 公里
563	1965 4 27	06-15-37	20 7	121 0	(3)	6		台湾恒春南海中
564	5 18	01-19-31	22 5	121 3	(2)	6 6		台湾台东南海中 h· 50 公里
565	6 27	19-36-10	23 7	121 7	(2)	6		台湾花莲南海中
566	7 3	19-26-12	22 4	101 6	(2)	6 1		云南江城西南 h. 15 公里
567	11 13	12-33-55	43 6	88 3*		6 6		新疆乌鲁木齐东
568	1966 2 5	23-12-32	26°12'	103°12'*		6¾	九	云南东川
569	2.13	18-44-41	26°06'	103°06'	(1)	6 2		云南东川
570	3.6	10-15-58	31 4	80 5	(3)	6 6		西藏噶尔附近
571	1966. 3.8	05-29-14	37°21'	114°55'	(1)	6 8	九强	河北隆尧东北 h 10 公里
572	3.22	16-11-36	37°30'	115°05'	(1)	6 7		河北宁晋东南
573	3.22	16-19-46	37°32'	115°03'	(1)	7 2	十	河北宁晋东南
574	3 26	23-19-04	37°36'	115°16'	(1)	6 2	七强	河北束鹿南 h· 15 公里
575	3 29	14-11-59	37°28'	114°53'	(1)	6		河北巨鹿 h· 25 公里
576	7.1	13-50-39	24 8	122 5	(2)	6 1		台湾苏澳东北海中
577	9.16	01-10-49	22 9	121 6	(3)	6		台湾火烧岛北
578	9.28	22-00-23	27°15'	100°25'*		6 4	八至九	云南中甸东南
579	10 14	09-04-47	36 8	87 5	(2)	6		新疆阿其克库勒西
580	1967 3 4	13-09-26	21 4	121 9	(2)	6 1		台湾兰屿东南 h 125 公里
581	3.14	14-58-06	28 4	94 4	(2)	6 2		西藏米林南
582	3 27	16-58-20	38 5	116 5	(2)	6 3	七	河北河间大城一带 h 30 公里
583	5 11	22-50-59	39°18'	73°48'	(1)	6¼		新疆乌鲁克恰提西南
584	8.30	12-22-09	31°37'	100°20'*		6 8	九	四川炉霍西北 h: 8 公里
585	8.30	19-08-51	31°42'	100°20'	(1)	6		四川炉霍西北
586	10.25	08-59-44	25 0	122 7	(2)	6½		台湾基隆东海中
587	1968. 1.13	15-03-45	24 0	122 4	(3)	6 2		台湾花莲东海中
588	2.26	18-50-36	23 6	121 1	(2)	6¼		台湾玉山东北
589	10 20	15-08-39	26 3	122 2	(4)	6 1		台湾基隆东北海中 h 15 公里
590	1969 2 12	06-08-54	41 5	79 3	(2)	6½		新疆乌什附近
591	7 18	13-24-49	38 2	119 4	(2)	7 4		渤海 h 35 公里
592	7.26	06-49-43	21°45'	111°45'*		6 4	八强	广东阳江
593	1970. 1 5	01-00-37 0	24°12'	102°41'	(1)	7 7	十强	云南通海 h 13 公里
594	2 7	06-10-39 7	23°05'	101°02'	(1)	6 2		云南普洱 h 15 公里
595	2 19	15-10-02 8	27°35'	94°08'	(1)	6 1		西藏米林南 h·12 公里
596	2 24	10-07-34 4	30°39'	103°17'	(1)	6 2	七至八	四川大邑西北 h 15 公里
597	11 14	15-58-21 6	22°53	121°14'	(1)	6 5		台湾台东北 h 38 公里
598	1971 3 23	17-52-11	41 5	79 3	(2)	6 0		新疆乌什 h 20 公里
599	3.24	04-47-16 1	41 6	79 5	(2)	6 1		新疆乌什 h-20 公里
600	3.24	21-54-16 4	35 5	98 1	(2)	6 3		青海玛多北 h 13 公里
601	4 3	12-49-00 5	32 2	95 1	(3)	6 3		西藏色扎西北 h 20 公里
602	4 3	12-50-42 3	31 9	95 4	(3)	6 5		西藏色扎 h 20 公里
603	4 28	23-32-00 5	23 0	101 2	(1)	6 7	八	云南普洱 h-15 公里
604	5 23	04-03-30 6	32 5	92 3	(2)	6 5		西藏安多东北 h 20 公里
605	9 14	11-11-04 5	23 0	100 9	(1)	6 2		云南普洱 h 33 公里
606	10 31	04-48-47 8	22 9	121 4	(2)	6 0		台湾新港南 h·35 公里
607	1972. 1 4	11-16-54 9	22 5	122 0	(2)	7 2		台湾火烧岛东海中
608	1 8	13-27-53 3	21 1	120 2	(2)	6 7		台湾恒春西南海中
609	1 16	04-21-49 5	40 1	78 9	(2)	6 2		新疆柯平巴楚间
610	1 25	10-06-25-6	23 0	122 3	(2)	8 0		台湾新港东海中
611	1 25	11-41-23 1	23 2	121 9	(2)	7 6		台湾新港东海中
612	4 17	18-49-42 2	24 2	122 5	(3)	6 1		台湾花莲东 h 35 公里
613	4 24	17-57-21 8	23 5	121 3	(2)	7 3		台湾凤林西南
614	7 23	00-41-01 5	31 4	91 5	(3)	6 0		西藏那曲西 h:15 公里
615	9 23	03-57-29 3	22 6	120 8	(2)	6 6		台湾台东西南
616	9 23	10-14-27 2	22 4	121 1	(3)	6 4		台湾台东南
617	11 10	02-41-15 2	23 7	121 4	(3)	6 3		台湾凤林
618	11 21	10-47-14 2	23 9	121 7	(3)	6 2		台湾省花莲附近 h:14 公里
619	1973 2 6	18-37-08 3	31 3	100 9	(1)	7 9	十	四川炉霍 h 17 公里
620	2.8	00-06-27	31 5	100 3	(1)	6 0		四川炉霍 h 8 公里
621	1973 6 3	07-57-04 6	44 3	83 7	(2)	6 0	十	新疆精河东南 h:32 公里
622	7.14	12-51-21	35 3	86 5	(3)	7.3		西藏亦基台错 h:33 公里
623	7 14	21-39-30	35 4	86 6	(3)	6 0		西藏亦基台错 h·30 公里
624	8 11	15-15-34 6	32°53'	104°00'	(1)	6 5		四川南坪西南 h·8 公里
625	8 16	11-58-07 1	22 9	101 1	(1)	6 3	八	云南普洱 h 10 公里
626	9 8	15-25-45 4	33 3	86 9	(3)	6 0		西藏沙里西
627	9 10	15-43-28 7	42 6	131 8	(2)	6 4		吉林珲春东南 h:575 公里
628	9.12	07-18-50 8	25 6	124 5	(3)	6 7		东海赤尾屿附近 h 140 公里
629	9 29	08-44-01 9	41 8	130 9	(2)	7 7		吉林珲春东南 h 590 公里

END OF THE DOCUMENT