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Predicting the 1975 Haicheng Earthquake

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Abstract The publicized four-stage (long-term, middle-term, short-term, and imminent) prediction of the *M* 7.3 1975 Haicheng, China, earthquake once generated worldwide fascination. Yet the prediction process has remained mysterious because of lack of reports on real-time documentation and details of how warnings were issued. In the present work, study of declassified Chinese documents and interviews of key witnesses have allowed us to reconstruct this important history. Our findings indicate that there were two official middle-term predictions but no official short-term prediction. On the day of the earthquake, a county government issued a specific evacuation order, and actual actions taken by provincial scientists and government officials also effectively constituted an imminent prediction. These efforts saved thousands of lives, but the local construction style and time of the earthquake also contributed to minimizing fatalities. Evacuation was extremely uneven across the disaster region, and critical decisions were often made at very local levels. The most important precursor was a foreshock sequence, but other anomalies such as geodetic deformation, changes in groundwater level, color, and chemistry, and peculiar animal behavior also played a role.

Introduction

The magnitude (M_S) 7.3 1975 Haicheng, China, earthquake is considered the only major earthquake ever to have been predicted. The earthquake occurred at 19:36 local time on 4 February 1975, with the epicenter located near the boundary between the counties of Yingkou and Haicheng, southern Liaoning Province (Figs. 1, 2). The earthquake was caused by the left-lateral slip of a northwest-trending blind fault, unknown prior to the event (Gu *et al.*, 1976), and the seismic moment was reported to be 3×10^{19} N m (Cipar, 1979). The earthquake caused extensive ground failure and liquefaction (e.g., Adams, 1976).

The most comprehensive description in English of the prediction of this earthquake was provided in a report by the Haicheng Earthquake Study Delegation sent to China from the United States a year after the earthquake (Raleigh *et al.*, 1977). Earlier foreign visitors to China provided simpler descriptions (Adams, 1976; Whitham *et al.*, 1976). There are also many accounts published in Chinese (e.g., Zhu and Wu, 1982; Quan, 1988). Despite decades of disappointment in the pursuit of earthquake prediction, Haicheng continues to provide hope.

All publicized stories about the Haicheng earthquake have the following elements. The prediction consisted of four stages: long-term (a few years), middle-term (one to two years), short-term (a few months), and imminent (hours to a couple of days). Professional and massive amateur precursor monitoring helped refine the spatial and temporal predictions gradually. A foreshock sequence triggered the final imminent prediction. Some evacuation orders were given just before the earthquake occurred.

To commemorate the thirtieth anniversary of the Haicheng earthquake, Liaoning Province Earthquake Administration (2005) published a photo collection and showed pictures of some historical documents. Until then, no reports had ever provided documents published prior to the earthquake that predicted that it would happen. Until now, few details of pre-earthquake evacuation have been given. This lack of written records and details has led to suspicion about the reported success (Geller, 1997; Jackson, 2004). Suspicion is deepened by the fact that the earthquake occurred during the political turmoil of the Cultural Revolution (1966–1976), when obtaining accurate information from China was particularly difficult.

Based on what is presently known, it is justifiable to relate the lack of written records and details to the political situation in China for two reasons. First, under pressure to project the notion of success and to emphasize the leadership of the then provincial committee of the Chinese Communist Party, the prediction process as it was described to foreign visitors shortly after the earthquake was dramatized. Stories told to later visitors, such as the U.S. delegation in 1976 (Raleigh *et al.*, 1977), were less dramatized than those told to earlier visitors such as R. D. Adams from New Zealand (Adams, 1976) and the Canadian Seismology Delegation (Whitham *et al.*, 1976) in 1975. This may have been brought about as a result of questioning by visitors. These foreign

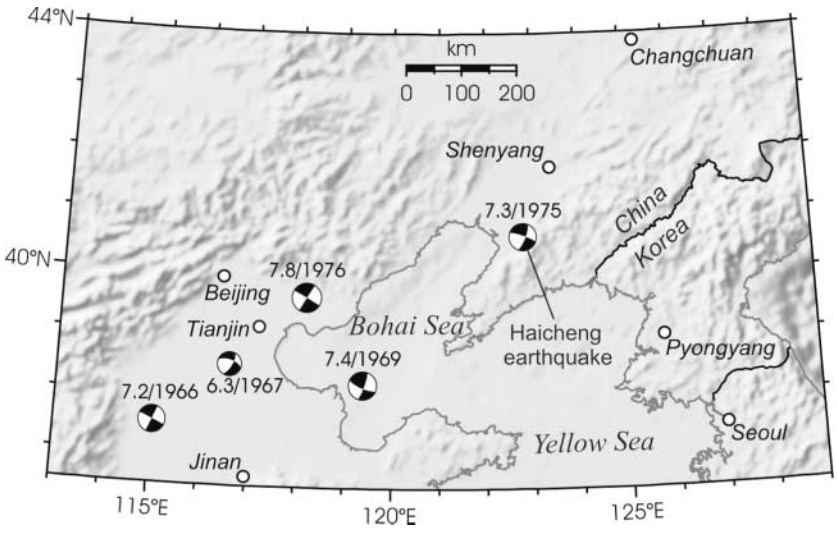

Figure 1. Map of northeast China showing the location and focal mechanisms of large earthquakes in the period 1966–1976. The focal mechanisms are shown as lower hemisphere projections and are labeled with magnitude and year. The names of the earthquakes are Xingtai (1966), Hejian (1967), Bohai (1969), Haicheng (1975), and Tangshan (1976). Over the past 300 years, $M > 7$ earthquakes occurred in the land area within this map only during this 10-year period.

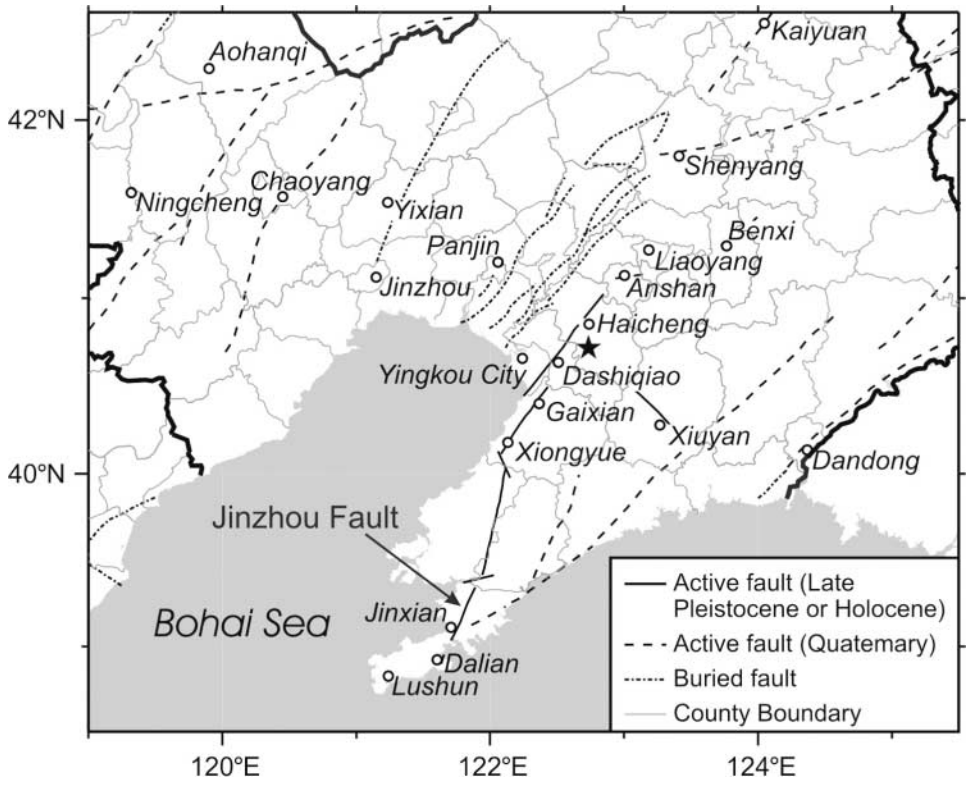

Figure 2. Map of Liaoning Province in 1975 and active faults according to Deng *et al.* (2003). Thick lines show boundaries of the province. A northwestern part of the province shown in this map, including the town of Aohanqi, now belongs to the Inner Mongolia Autonomous Region. Open circles are locations of cities or towns. The government of Haicheng County was located in the town of Haicheng, and the government of Yingkou County was in the town of Dashiqiao. The epicenter of the 1975 Haicheng earthquake is shown with a star.

visitors found it difficult to get their hosts to talk about any lack of success (F. Wu and R. D. Adams, personal communication, 2004, 2005). Second, to demonstrate the correctness of Chairman Mao's ideology, the role of amateurs in monitoring precursory anomalies was exaggerated. At the time, the amateur contribution as described in various reports impressed many people, but the exaggeration has also prompted doubts on the truthfulness and seriousness of these reports.

One practical reason for the former unavailability of real-time documentation is that all critical information was

in restricted or classified documents, including meeting minutes and telephone notes, and so forth. Timely scientific publication was discouraged during the Cultural Revolution, and release of prediction information to foreigners was a criminal offense ("leaking secrets"). However, in accordance with China's secrecy laws and regulations, all these documents have now been declassified. The current political environment is also quite different from that of the time of the Cultural Revolution and its aftermath. Therefore, it is time to take a fresh look into the prediction of the Haicheng earthquake.

To determine what can be learned from the prediction process, the history must be properly documented. In order to do this, we have conducted a document search and interviewed many witnesses including those who created many of the key documents in 1974–1975. Some of the more relevant documents are listed in Appendix A and will be explained in the next section. Most of the documents are stored in the Archives of Liaoning Province Earthquake Administration in Shenyang, but some are in the Archives of China Earthquake Administration (CEA) or its Institute of Earthquake Sciences in Beijing. The official English translation for CEA in 1975 was the State Seismological Bureau (SSB) and during 1998–2003 was China Seismological Bureau.

We focus on documenting the sequence of significant events, and we are particularly interested in how scientists and government officials made critical decisions and recommendations without understanding much about earthquake processes. Important events of the prediction process are summarized in chronological order in Appendix B. We pay attention to what influenced people's thinking in the specific scientific, political, and cultural environments of the time, as well as whether what they thought was correct. Monitoring work and precursory anomalies have been described in great detail in Zhu and Wu (1982). Some details about the techniques used for the monitoring were given in Raleigh *et al.* (1977).

Like most others dealing with earthquake "prediction," we find a need to discuss the meaning of the word first. Chinese use the same word *yubao* for both "forecast" and "prediction," while in English the latter, when used for earthquakes, is meant to be a more precise account of a future event. How to translate the two words into Chinese without losing the distinction is still unresolved. Weather forecast and earthquake prediction are both referred to as *yubao*. In Chinese documents, there is sometimes a distinction between *yubao* (predictive statement) and *yuce* (predictive analysis), but this distinction relates more to government functionality than with preciseness. Indiscriminately translating *yubao* as "prediction" has caused misunderstanding in the past. In this article, we follow this unfortunate tradition and continue to translate *yubao* as "prediction," but we emphasize that on most occasions the word is better understood to be forecast.

We provide three tables for the convenience of the readers. Table 1 lists English transliterations of place names used in Raleigh *et al.* (1977) (and in most other English publications shortly after the Haicheng earthquake) and the official transliterations used in this article. Table 2 lists government levels in China in 1975. Table 3 lists acronyms and names of people used in this article. To help readers understand the peculiar political environment and government structure in China at the time of the Haicheng earthquake, we give a bare-minimum introduction to the Cultural Revolution of 1966–1976 in Appendix C.

Documents

We group the documents listed in Appendix A into seven categories: (1) summary materials of national or interprovincial conferences and related government documents that authorized their restricted circulation, (2) various reports from earthquake workers to the Liaoning provincial government, (3) announcements from the provincial government, (4) local government documents, (5) speeches or oral directives given by upper echelon government officials,

Table 1
Official (Pin-yin) and Previous (Wade-Giles, Used in Raleigh *et al.*, 1977) Transliteration of Place Names

Official*	Previous
Beijing	Peking
Bohai Sea	Pohai Sea
Dalian	Dairen
Dandong	Tantung
Hebei Province	Hopeh Province
Hejian	Hochien
Jilin Province	Kirin Province
Liaodong Bay	Liaotung Bay
Liaodong Peninsula	Liaotung Peninsula
Shandong Province	Shantung Province
Shipengyu Observatory	Shihpengyu Observatory
Tianjin	Tientsin
Xingtai	Hsingtai
Yingkou	Yingkow

*Transliterations that have not changed since 1977 (such as Haicheng and Tangshan) are not listed.

Table 2
Government Levels in China in 1975

Government Level	Notes
State council	Also supervises various ministries
Province or autonomous region	There are a few province-level cities (e.g., Beijing)
City or prefecture*	Directly administers municipalities, enterprises, etc.
County	Directly administers small urban centers
People's commune	From this level down: rural areas only
Production brigade	Usually all families of a village
Production team	

*City as an administrative unit includes an urban district and several surrounding counties. City as a geographic unit usually concerns the urban district only.

Table 3
Acronyms and Names of People (Family Name Is First)

Acronym or Name	Explanation	Page Number of First Appearance
CAS	Chinese Academy of Sciences	p. 762
Cao Xianqing	Head of Yingkou County's Earthquake Office	p. 772
Cha Zhiyuan	Leader of the Earthquake Leadership Group of CAS	p. 762
CEA	China Earthquake Administration (the name was SSB until 1998 and China Seismological Bureau 1998–2003)	p. 757
Gang of Four	Chairman Mao's wife and three allies; a powerful political faction during the Cultural Revolution	p. 780
Gu Haoding	Seismologist of Liaoning provincial Earthquake Office	p. 768
Hua Guofeng	Vice Premier of China; successor of Chairman Mao	p. 774
Hua Wen	High-rank official of RCL; PLA officer	p. 762
Li Boqiu	High-rank official of RCL; one of the Secretaries of the Liaoning provincial Party Committee; PLA General	p. 762
Li Fuxiang	Clerical officer of Liaoning provincial Earthquake Office	p. 769
Li Zhiyong	SSB Scientist	p. 770
Liu Yimin	Junior RCL official directly responsible for Earth Office; civilian "revolutionary cadre" (Appendix C)	p. 766
Ma Binggui	Survey engineer; leader of Jianxian leveling group	p. 764
Mao Yuanxin	High-rank RCL official; one of the Secretaries of the Liaoning provincial Party Committee; PLA officer; Chairman Mao's nephew	p. 766
PLA	People's Liberation Army	p. 762
Qiao Changman	Worker at amateur Haicheng Earthquake Observatory	p. 774
RCL	Revolutionary Committee of Liaoning Province	p. 760
SSB	State Seismological Bureau (Name of CEA until 1998)	p. 757
Wu Ge	Scientist of Liaoning provincial Earthquake Office	p. 778
Yin Canzhen	High-rank official of RCL; PLA officer	p. 762
Zhou Rongxin	Leading cadre of CAS	p. 780
Zhu Fengming	Scientific leader of Liaoning provincial Earthquake Office	p. 760

(6) log books or notebooks of earthquake offices or observatories, and (7) miscellaneous documents. Documents from bodies of the central government such as the State Council and SSB were properly printed in publication quality. Documents at the provincial level were typically mimeographed, but occasionally handwritten, presumably when a typist was unavailable. Most of the documents that we saw from lower-level governments were handwritten. In Appendix A (first column), the documents are indexed with two numbers, the category number followed by a sequence number. For example, "3 – 2" means the second document in the third category. In subsequent reference to these documents, we will only quote these index numbers.

Documents of National or Interprovincial Conferences

National and interprovincial earthquake-prediction conferences were organized by the SSB, typically once or twice a year, to provide forecasts for earthquake potential within the following one to two years for the whole or a large part of China. At these conferences, participants would present their scientific arguments for earthquake potential in various regions and debate them. By contrast with academic gatherings, these conferences are required to form consensus and produce specific opinions as to the likelihood of earthquakes occurring. The acclaimed "middle-term" prediction for the Haicheng earthquake was made at such a conference (1 – 1, 1 – 2).

Reports from Liaoning Earthquake Workers

Earthquake research was one of the few fields in which some scientists could work in a more or less orderly fashion during the Cultural Revolution. Prediction of the Haicheng earthquake was coordinated mainly by a team of scientists in Liaoning Province. From 1971 until the establishment of the Liaoning Seismological Bureau in May 1975, this team functioned under two names: the SSB Shenyang Brigade and the Earthquake Office of the Revolutionary Committee of Liaoning (RCL) (see Appendix C about "revolutionary committees"). In practice, the team reported mostly to the RCL but kept the SSB headquarters informed.

The scientific leader of this team was Mr. Zhu Fengming (Zhu, but Chu in some translations, is the family name; the family name goes first for all Chinese names in this article except for the authors' list and reference list). Zhu graduated from the Department of Geophysical Exploration, Northeast College of Geology, in 1955. He was an expert in petroleum exploration until he began working on earthquake prediction in 1968. His official title in the Earthquake Office was "Technically Responsible Person." During the Cultural Revolution, it was important to distinguish technically responsible persons from the higher-ranking politically responsible persons.

The provincial Earthquake Office had frequent "group discussion" sessions to synthesize information collected by themselves or reported to them by earthquake observatories

and city- or county-level earthquake offices. Piles of notes from these discussions remain on file (e.g., 6 – 2). For matters deemed important, they presented written reports with opinions or discussion conclusions to the RCL officials who were directly responsible for earthquake work. We are told by several regular participants of these discussions that these reports were usually a compromise of different opinions. Only occasionally did the same report contain conflicting opinions. Liaoning's provincial Earthquake Office also had a more formal reporting series of documents called Earthquake Information, to be circulated in a wider government circle, usually the SSB, RCL, and the Standing Committee of the provincial Party Committee. The proclaimed "imminent prediction" was given in the fourteenth issue of this series (2 – 15), composed by Zhu Fengming.

Provincial Government Documents

After receiving information from the provincial Earthquake Office, the RCL might disseminate the earthquake information and give related directives to cities, prefectures, and a few important industrial and military units in the province. The RCL usually paraphrased Earthquake Office reports but sometimes made critical wording changes that reflected its own political judgment. The RCL had two ways of doing the formal dissemination: sending a mimeographed circular and, in exceptionally urgent cases, organizing a "telephone distribution."

Intercity telephone calls in China in the 1970s were made via switchboards. The "telephone distribution" made a clever use of the switchboard. The RCL caller in Shenyang would speak to a number of phone lines simultaneously connected to receivers in different cities. The receivers were able to listen and talk (mostly listen) to the caller but not to one another. There were usually two people on each receiving end, a listener and a recorder. The listener would verbally repeat the caller's sentences to allow the recorder to write them down by hand. The general warning from the RCL on 4 February that an earthquake was about to happen was issued via such a telephone distribution (3 – 14).

The city and prefecture revolutionary committees would then relay the message down to the next government level—counties (Table 2)—and to various city organizations such as industrial and street units. The county committees relayed the message down to communes in the rural area and to various urban organizations within their administration. The communes further relayed the message to production brigades (during 1958–1978, Chinese peasants were organized into the People's Communes, each having a number of production brigades; see Table 2). These communications were made via telephone calls or meetings and therefore took time. Party branches of production brigades or various city units would finally convey the message to individuals, either directly using loud speakers or through junior cadres. In the 1970s, except for an elite class, no individuals in the Chinese mainland had home telephones.

Each level of government might add its own additional, more specific directives when relaying the message to lower levels. From the county level down, the original message from the province would be increasingly simplified and might be distorted. Depending on their own sense of urgency, some local committees might delay relaying the message or even never pass it on. It appeared that organizations in larger cities could be much less zealous in relaying these messages than those in rural areas. For example, during our 2004 interview of a former junior government worker in the city of Dalian (see Fig. 2 for location), he did not recall hearing much about earthquakes during the months before the Haicheng earthquake, despite the fact that Dalian is the nearest large city to the center of attention in the so-called middle-term and short-term predictions.

Some of the restricted documents prepared by various branches of the Liaoning provincial government after the earthquake contain statistics of casualties, house and infrastructure damage, and other economic losses, which were regarded as national secrets at the time.

Local Government Documents

We have included only a small number of documents from city and county governments. These documents reflected how local governments responded to directives from the province and made their own, in some cases extraordinary, decisions (e.g., 4 – 9). Most of these documents are from what were then Yingkou City and Yingkou County, and we have selected a few from a volume of restricted documents concerning the 1975 Haicheng earthquake that was complied in 1986 by the Earthquake Office of Yingkou County (Cao *et al.*, 1986). Only a very small number of copies of this valuable collection were printed and circulated. Among many other documents, it includes records of several provincial "telephone distributions" that were telephone-relayed to the county by the Yingkou City committee, an illustration of the top-down flow of information described in the previous section.

Some geographical clarification is needed. In China, a county is at a lower administrative level than a city (see Table 2). Haicheng, although called a "county-level city" today, was in 1975 a county under the administration of Anshan City (Fig. 2). Most of the population was in the rural area, and only a small fraction was in the town of Haicheng. Before 1992 when Yingkou County was renamed Dashiqiao City (a "county-level city"), Yingkou County was one of the several counties under the administration of Yingkou City, with its county government located in the town of Dashiqiao (Fig. 2). It was common practice that one of the counties administered by a city had the same name as the city. Even in China, people tended to confuse Yingkou County with Yingkou City; for eample, some relief materials for Yingkou County were shipped to Yingkou City by mistake after the earthquake. When Yingkou is mentioned in official documents and research articles, it is seldom specified whether it

is the city or the county. As a rule of thumb, when Yingkou is mentioned independently of Haicheng, such as in many documents prior to February 1975, it usually means Yingkou City, but when Yingkou and Haicheng are both mentioned, such as in many documents and articles since February 1975, it usually means Yingkou County.

Speeches and Oral Directives of Upper-Echelon Government Officials

During the Cultural Revolution, as throughout most of the Chinese history, words of important individuals were better respected than laws. Notes of speeches and oral directives by provincial and state officials were carefully taken and mimeographed and regarded as official documents. These restricted documents often became study materials for Party members and the masses. They now have become an important source of historical information.

For example, although we are not able to verify the presence of a summary report for the national conference of 13–21 January 1975, which was said to contain a "short-term prediction," the concluding speech by the then leader of the Earthquake Leadership Group of the Chinese Academy of Sciences (CAS) (5 – 5) had the same authority as a summary report. Some of these documents also exemplify the attitude of the ruling group in Liaoning. Some important officials in the provincial government, such as Li Boqiu, Hua Wen, and Yin Canzhen, were high-rank officers of the People's Liberation Army (PLA) concurrently holding RCL civil positions, typical arrangement during the Cultural Revolution (Appendix C).

Log Books or Notebooks of Earthquake Offices or Observatories

An earthquake office was the predecessor of a "seismological bureau" (the translation became "earthquake administration" in 2003). It was a government office dealing with all matters of earthquakes such as monitoring, research, education, and emergency response. An earthquake observatory was a center making specific geophysical and geochemical observations pertaining to earthquakes. The RCL earthquake office was in charge of a number of professional earthquake observatories in the province, but county-level earthquake offices only administered amateur observatories within their own counties. The log books or notebooks of various earthquake offices and observatories are valuable documents. In them, the former earthquake workers scribbled down many worthwhile events, such as earthquakes, anomaly reports from the public, and telephone communications with other Earthquake Offices and various government officials. The log books and notebooks recorded what the front-line earthquake workers saw and knew at a specific time.

The completeness of these records depends on the conscientiousness of the people on duty and how busy they were. In the log book of the Shipengyu Earthquake Observatory (to be discussed in detail in the Role of the Shipengyu Earthquake Observatory section), located near the area shaken by numerous foreshocks, there is relatively little information on 4 February 1975, other than the foreshocks. Obviously, workers were overwhelmed with recording and reporting foreshocks and dealing with enquiries and had little time to take notes of other events. In contrast, the log book of the Earthquake Office of Anshan City, farther away from the foreshocks, contains more information for this day.

Miscellaneous Documents

Some documents serve to provide miscellaneous background information. An example is the SSB report presented at the National Science and Technology Conference in 1972 (7 – 2). Strangely, this slogan-rich newspaper-ready report, with no secrets even by Cultural Revolution standards, was classified at the highest level (top secret). The scanty depiction of some popular beliefs in this report provides clues for understanding people's reactions before the 1975 Haicheng earthquake.

For example, the report quoted a popular saying "small quakes booming, big quake looming." The belief that foreshocks would precede a large earthquake was widespread among the Chinese populace, which may explain why various communes and brigades of the Haicheng earthquake region made their own evacuation decisions before the main shock. The report also said: "Precursors began to appear one or two years before some of the earthquakes greater than magnitude 6; various precursory phenomena ensued and developed, up to the time of the earthquake. . . . For an event larger than magnitude 5 (which may be damaging), obvious anomalies often might occur within a range of 200 km." Empirical rules like these, some of which may have been imported from foreign research (see The 13–21 January National Conference section), would explain how Chinese scientists came to make, rightly or wrongly, some of their time, place, and magnitude predictions for the Haicheng earthquake.

A few post-Haicheng SSB Headquarters documents are also included because they recorded how the prediction efforts were recognized and publicized at the state level. Information in these documents may not be accurate. They oversimplify and prettify prediction efforts. There is no evidence for fabrication of events, but some critical details may have been altered.

Outlook in June 1974

Background

After three centuries of relative quiescence, north China was struck by several large earthquakes over a period of three years: the three earthquakes of M 6.8, 6.7, and 7.2 in the Xingtai area in March 1966, the M 6.7 Hejian earthquake of 1967, and the M 7.4 Bohai Sea earthquake of 1969

(Fig. 1). They all indicated right-lateral motion of north-northeast-trending strike-slip faults, and they appeared to have migrated from southwest to northeast.

The interpretation of these earthquakes was strongly influenced by the then most popular tectonic theory in China, the "geomechanics theory" of Li Siguang (Zhu and Le Grand, 1999). The theory maintains that north-northeast China is part of an integral geological system characterized by neotectonic right-lateral motion along north-northeast-trending structures. In modern plate tectonics terms, this corresponds to internal deformation of the Eurasia plate in a nearly east–west compressive stress regime caused by continental collision at the Himalaya and plate subduction along the Japan–Kuril trenches. Chinese scientists believed that the recent earthquakes in north China represented activation of this large system, which would eventually lead to more earthquakes. In 1970, the RCL Leadership Group for Earthquake Work, the predecessor of the Liaoning provincial Earthquake Office, said in a secret document (2 – 1): "Epicenters of recent strong earthquakes in the Bohai Bay area show a tendency of northward migration. Jinxian and Yingkou that are located on the Bohai Bay may fall into in this area of strong earthquakes and suffer destruction."

Given this background, it is by no means a surprise that in the 1970s the Chinese government greatly strengthened earthquake and anomaly monitoring. The champion of China's earthquake prediction program was the then Premier Zhou Enlai. In 1970, China held its first national meeting on earthquake prediction. In 1971, the SSB was created within the CAS (Allen *et al.*, 1975). In 1972, the SSB began to organize the regular national earthquake-prediction conferences described in the Documents of National or Interprovincial Conferences section. In the meantime, public education to spread knowledge of earthquake processes, preparedness, and prediction was enhanced. For example, a pictorial brochure published by Tainjin City Earthquake Office Editorial Group (1973) not only explained in plain language concepts such as magnitude, intensity, foreshocks, and crustal deformation, but also provided recipes for making amateur observations of telluric currents, well water, animal behavior, and so forth for the purpose of earthquake prediction.

June Conference and State Council Document 69, 1974

The Conference on Earthquake Situation in North China and Bohai Sea Regions was held by the SSB 7–9 June 1974 in Beijing, with 53 participants from 20 organizations. Three attendees including Zhu Fengming were from the SSB Shenyang Brigade (i.e., Liaoning provincial Earthquake Office). The conference was charged with determining earthquake potential in north-northeast China for the next one to two years. The participants suggested a few areas that deserved attention. As mentioned in the Documents of National or Interprovincial Conferences section, conferences of this type not only were required to form consensus but also were required to make statements of likely sites of future earthquakes. The CAS received the conference summary containing such statements (1 – 1) from the SSB and, feeling that the information was critical, modified the summary into a report to the State Council on 15 June. On 29 June, the State Council issued State Council Document 69, 1974, to authorize the distribution of the CAS report to the Revolution Committees of affected provinces (1 – 2).

The key paragraphs of the CAS report are as follows. (Words in square brackets are added by us for clarification.) "Most people [at the conference] think that earthquakes of magnitude 5–6 may occur in this or next year in Beijing-Tianjin area, northern Bohai Sea [area], Handan-Anyang area where Shanxi, Hebei, and Henan Provinces meet, Linfen basin of Shanxi Province, and Linyi area of Shandong Province and central Yellow Sea, and that a magnitude 5 earthquake may occur in Baotou-Wuyuan area of Inner Mongolia."

Six places in north-northeast China were identified as at risk from possibly significant earthquakes within one and a half years. The mention of "northern Bohai Sea" constitutes what was later referred to as the "middle-term prediction" of the 1975 Haicheng earthquake. Out of the six places, the northern Bohai Sea area was the only one struck by a damaging earthquake in the following two years. The original June conference summary had been circulated within the SSB system before the CAS report was created. In the original summary, the above paragraph was followed by another sentence: "Among these places, the Baodi to Hejian area between Beijing and Tianjin and the Jinxian-Dalian area of northern Bohai Sea are exhibiting the most conspicuous precursory anomalies." The Jinxian-Dalian area (Fig. 2) is about 200 km south of the epicenter of the Haicheng earthquake.

The following paragraph illustrates the diversity of opinions at the conference:

> Besides, there are two other opinions. One opinion is based on the characteristics of historical strong earthquakes and a synthesis of broad regional earthquake activity that takes into consideration the influence on north China by the western Pacific seismicity band [i.e., earthquakes along subduction zones such as Japan Trench] and its 400- to 500-km-depth deep-source earthquakes. It suggests that energy for magnitude 7–8 earthquakes has been stored in north China. In addition, northern north China has endured prolonged droughts in recent years and seen meteorological anomalies that have rarely occurred since the founding of the country [i.e., 1949], such as warm winter, cold spring, and humidity imbalance. Many large earthquakes in history were preceded by a similar situation. Therefore, it is proposed that the danger of having earthquakes about magnitude 7 is present in north China. The other opinion is based primarily on the fact that Earth's rotation accelerated since last year and that there were very few strong earthquakes in north China under similar conditions in the past. In addition, strong earthquakes in north China usually have large time separations. Given that the 1969 Bohai Sea earthquake was only four years

> ago, it is proposed that no earthquakes greater than magnitude 5.5 will occur in the next few years.

Here the reference to Earth rotation is reminiscent of another aspect of Li Siguang's "geomechanics theory." According to this theory, the acceleration of Earth's rotation would decrease east–west compressive stress at midlatitude and hence stabilize those north-northeast-trending dextral strike-slip faults. Later research has not shown this effect to be significant as compared to other tectonic forces.

The tone of State Council Document 69 was very cautious:

> Because the present level of science and technology of earthquake *yuce* and *yubao* is not high, the report's suggestion that earthquakes may occur in some places in this or next year is merely an estimate. The earthquakes may or may not occur. However, we should base our work on the assumption that they will occur and be fully prepared. In the meantime, we should also prevent such assumption from causing panic and disturbance to the masses, interrupting production and people's living. More importantly, we should be on guard against class enemies seizing this opportunity to spread rumors to confuse the public and carry out destructive activity.

It is clear from this document that the Chinese government had a genuine concern with both the potential earthquakes and the disorder that a false alarm could create.

As the first central-government document endorsing an earthquake prediction in China, albeit cautiously, State Council Document 69 sent out an extremely strong message. All authors of this article spent their childhood or early youth in the Cultural Revolution (Appendix C). On the basis of our own experience, and after talking with numerous people in China over the past 30 years and especially in 2004, we believe that the psychological significance of Document 69 is immeasurable. The ultimate principle taught to people during the Cultural Revolution was to obey Chairman Mao and the Party, and in the minds of the majority of Chinese people at that time, the State Council represented both. Most of them did not know exactly what was said in the document and depended only on local cadres' interpretations, but the very existence of such a document was symbolically important. The logic was very simple: if the State Council takes the prediction seriously, it must be a really serious matter! Hence this document enhanced earthquake awareness among the general public in a very special way.

Basis for the Middle-Term Prediction

The paragraph in the CAS report that summarizes what were considered precursory anomalies in northern Bohai Sea area is as follows:

> There are four relatively significant anomalies in the northern Bohai Sea area: Leveling measurements at Jinxian [Observatory] had shown very slow changes over the past few years, with an [average] annual rate of 0.11 mm [over a short distance of a few hundred meters], but the cumulative change since September 1973 is as high as 2.5 mm; a 22-gamma [vertical component] geomagnetic anomaly has occurred [over the past 10 months] in Dalian [relative to Beijing]; six tide gauge stations in northern Bohai Sea detected a [relative] sea-level rise of over 10 cm in 1973, a phenomenon that has not been seen for more than a dozen of years; small-earthquake activity also obviously increased.

The four anomalies are listed in decreasing order of importance. We discuss them in the reverse order.

The increase in earthquake activity was only casually mentioned as supporting evidence. According to Zhu and Wu (1982), Liaoning Province and its immediate neighboring areas had very low seismicity in 1972 and 1973, averaging 70 detected earthquakes each year. In 1974 before the June conference, the only "obvious" increase was an earthquake swarm in March at Aohanqi, western Liaoning (Fig. 2), quite far from the future epicenter of the Haicheng earthquake. This part of Liaoning Province now belongs to Inner Mogolia Autonomous Region.

The greater than 10-cm sea-level rise since September 1973 is actually absent in the tide gauge records, as Zhu and Wu (1982) later showed. There must have been an error in the tide gauge results that was soon recognized. This anomaly was seldom mentioned again after the conference.

In the referenced geomagnetic record (Fig. 9 of Raleigh *et al.*, 1977), a ~20-gamma increase from October 1973 to May 1974 is obvious, but the trend stopped around the time of the June conference and does not appear to have had much association with the 1975 earthquake. The use of this transient anomaly for earthquake prediction seems to be fortuitous. Geomagnetic data from other, later-established monitoring sites in northern Bohai Sea area (Zhu and Wu, 1982) did not show any appreciable correlation with the Haicheng earthquake either.

Jianxian leveling played a vital role in both the middle-term prediction (Raleigh *et al.*, 1977) and the proclaimed short-term prediction (The 13–21 January National Conference section). Two short leveling lines were established in Jinxian in 1970 to monitor the active Jinzhou fault (Fig. 2). The nearly east–west line across the fault was 580 m long with eight benchmarks, and the nearly north–south fault-parallel line was 360 m long with six benchmarks. From 1970 until today, both lines have been surveyed twice a day (forward and reverse) without break for 36 years. The Jinxian (now Jinzhou) Earthquake Observatory that surveys these lines has won numerous national awards for its hard work. Since 1973, the observatory has also been monitoring a water well for radon.

The surveys reported at the June 1974 conference were carried out by a four-person team led by Mr. Ma Binggui, a survey engineer graduated from a military college of survey engineering in 1954. Ma was one of the three participants of the June conference representing the SSB Shenyang Bri-

gade. The Jinxian team had another engineer trained in cartography and two trained-on-the-job full-time junior workers. Measurements were made with an Ni004 spirit level meter, and data were neatly hand-plotted on graph paper. The hand-plotting tradition is still being carried on today at this observatory, although computer records are also maintained.

SSB specified quality-control standards for its observatories. Error estimate σ for repeat measurements of height difference between end points of a fault-crossing short leveling line was based on the following formula (e.g., 1978 "Earthquake Observatory Standards").

$$\sigma^2 = \frac{\sum \Delta_k^2}{4Nn},$$

where Δ_k is the difference (mis-closure) between a forward and a reverse survey, N is the number of round-trips, and n is the number of benchmarks on the line. It was reported in post-Haicheng publications (e.g., SSB Geodetic Survey Brigade for Earthquake Research, 1977), and further emphasized by Ma when we interviewed him in 2004, that the monthly σ (i.e., for $N = 28$ to 31 round trips) of the Jinxian surveys was consistently less than 0.1 mm. Acceptable monthly error defined by SSB standards was 0.11 mm. This standard requires an average mis-closure of 0.6 mm for individual round-trip surveys along the east–west line at Jianxian ($n = 8$). This seems to be a very large mis-closure for a line of this length (Bomford, 1971), but monthly averages of daily measurements should cancel out much of the random errors. The accuracy of the monthly averages probably greatly exceeds standards designed for single round-trip measurements.

Elevation changes of the east end of the east–west line relative to the west end during 1972–1984 as reported by Lu *et al.* (1985) are shown in Figure 3. The 1972–1975 part of the same data was reproduced and discussed by Deng *et al.*, (1977), Raleigh *et al.* (1977), Zhu and Wu (1982), Cao and Aki (1983), and Jackson (2004). Prior to 1980, benchmarks at both ends of the line were 2-m-long concrete posts buried in a sediment overburden of 30–40 m in thickness. Since 1980, new benchmarks have been used that consist of nearly 40-m-long steel pipes drilled through the overburden and several meters into the bedrock. During 1980–1984, both old overburden and new bedrock benchmarks were occupied for calibration purposes. The overburden benchmarks showed a gradual westward tilt of the line, but the bedrock benchmarks showed little tilt (Fig. 3).

This comparison and a study of groundwater level changes during the same period led Lu *et al.* (1985) to conclude that pumping of groundwater by a textile mill immediately west of the survey line caused a gradual subsidence of the west-end overburden benchmark. However, Lu *et al.* (1985) argued that, if the groundwater effect were assumed to be linear with time, the elevation changes before and after the 1975 Haicheng earthquake still looked rather anomalous and were probably caused by fault motion. The groundwater effect prior to 1980 is difficult to assess, but it is a potential source of uncertainties to be kept in mind.

Predictions in December 1974 and Early January 1975

Kaiyuan Meeting of 25–27 November 1974

In response to State Council Document 69, the RCL organized its first meeting devoted to earthquake problems on 23 July 1974 to initiate a massive program of earthquake education and to implement amateur training for anomaly observation (3 – 1). Measures taken were described in various provincial and local documents (2 – 4, 2 – 5, 2 – 6, 3 – 3, 4 – 1).

During 25–27 November, the SSB organized a meeting in Kaiyuan County of Liaoning Province, to provide a more detailed outlook for earthquake potential in northeast China. A terse concluding statement (1 – 3) listed six places that had potential to have damaging earthquakes "in the near future." Two of them, Dalian and Yingkou Cities, are in Liaoning Province. Out of the six, the Yingkou area is the only one that has experienced significant earthquakes since this meeting. Representatives from the SSB Shenyang Brigade (i.e., Liaoning provincial Earthquake Office) wrote a more technical report (2 – 7) detailing the Liaoning cases mentioned in the meeting conclusion. This report listed seven areas within Liaoning that had "relatively large earthquake danger," of which the Jinxian and Yingkou-Xiongyue areas and the offshore area within 200 km southwest of Dalian were said to have "greater possibility of having damaging earthquakes in the near future." Thus the emphasis of the report was on the north-northeast-trending active fault system shown in Figure 4 and its southern, offshore extension.

The main difference from the CAS report on the June

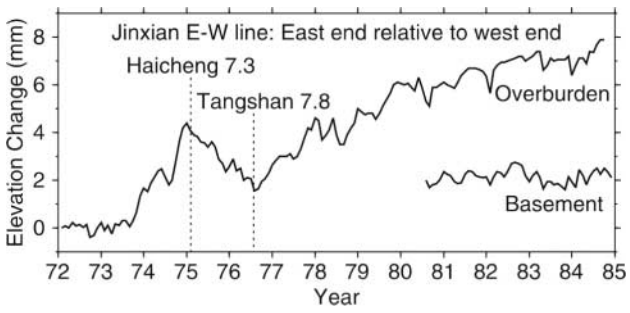

Figure 3. Monthly-average elevation changes of the eastern end of the east–west short leveling line at the Jinxian Observatory relative to its western end. The line is 580 m long across the Jinzhou fault (Fig. 2) with eight benchmarks. Basement end-point benchmarks began to be used from 1980. Old overburden benchmarks continued to be occupied until 1985 for calibration purpose. Times of the Haicheng and Tangshan earthquakes are also shown in the figure.

conference is an increased focus on the Yingkou area. In addition to arguments based on the distribution of active faults, historical earthquakes, recent small-earthquake activity, and Jinxian leveling, the report referred to various other leveling observations. Regarding Yingkou City, it said: "Surrounded by uplift to the east, west and north, Yingkou is the lowest point of [relative] subsidence and may constitute an area of stress concentration. There is also a recent trend of increase in small earthquakes. This is a danger zone deserving attention." The uplift pattern mentioned in this paragraph is roughly consistent with the 1970–1973 geodetic vertical deformation of this area shown by Quan (1988), but it is quite different from changes during 1958–1970, shown in Raleigh *et al.* (1977). The temporal pattern of change may be related to the incubation of the Haicheng earthquake.

M_L 5.2 Liaoyang-Benxi Earthquake, 22 December 1974

From September to late December, a number of small earthquakes, including several felt events, occurred in the northern Bohai Sea region, but clustered activities occurred only offshore. Well radon anomalies were reported from several earthquake observatories (2 – 8). On 22 December, a swarm of earthquakes occurred around the Shenwo reservoir near the cities of Liaoyang and Benxi (Fig. 4), culminating with a M_L 5.2 (M_S 4.8) event. This event attracted great attention because it was the first significant earthquake around the northern Bohai Sea area since State Council Document 69. Earthquakes of this size are relatively infrequent in Liaoning Province; up to 1974, there had been only 8 events greater than M_L 4.9 (M_S 4.5) since 1904 when the first seismic station in China was established in Dalian (Liaoning Province Local History Compilation Committee, 1996). The SSB headquarters sent some people to Liaoning to study the earthquake swarm (7 – 3, 7 – 4). They eventually concluded that the earthquakes were associated with the filling of the Shenwo reservoir that had started in November 1972. However, their conclusions were not presented to RCL until early January. Until then, the widely felt M_L 5.2 earthquake caused great concern to RCL officials. They began to request daily reports from the provincial Earthquake Office and ordered a range of emergency response measures concerning reservoirs, railways, the mining industry, and so on (5 – 1). Under pressure to provide more specific prediction information, the Earthquake Office staff accelerated their work.

False Alarms

The day after the M_L 5.2 Liaoyang-Benxi earthquake, the RCL distributed a circular (3 – 4), apparently drafted by the Earthquake Office. In addition to asking the Liaoyang-Benxi area to maintain a state of high alert, this circular made the following three short-term predictions: (1) An earthquake of around M 5 might occur in the Dandong area, although "its time of occurrence is difficult to predict." The basis for this tentative prediction was that beginning in mid-December, water in some two dozens wells in that area had changed color and taste and had become enriched in Ca^{2+} and Mg^{2+}, and water levels had began to fluctuate. (2) An M 4–5 earthquake might occur 25 December to 10 January in the Panjin-Yingkou-Xiongyue area. Evidence included sighting of snakes coming out of hibernation dens, a radon anomaly at the Panjin Earthquake Observatory, and increased earthquake activity around Yingkou City. (3) An $M > 5$ earthquake might occur in the Dalian area, but "its time of occurrence is difficult to predict." The evidence included the Jinxian leveling anomaly and increased earthquake activity. Approximate locations of these predicted earthquakes are shown in Figure 4. The city of Dandong is about 180 km

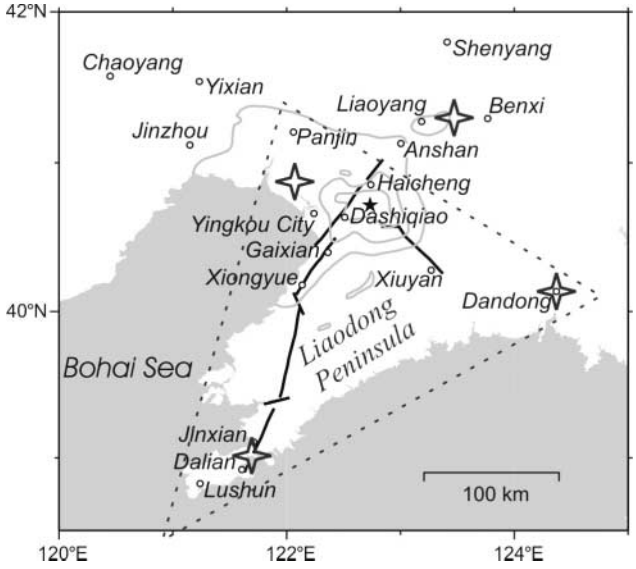

Figure 4. Map of southern Liaoning to show the locations of the Liaoyang-Benxi earthquake swarm of 22 December 1974, discussed in the M_L 5.2 Liaoyang-Benxi Earthquake, 22 December 1974 section (northernmost four-pointed star), four anticipated earthquakes (false alarms) predicted in late December discussed in the False Alarms section (four-pointed stars), the approximate triangular area in Gu's short-term prediction for the Haicheng earthquake, discussed in The 13–21 January National Conference section (dashed lines). Solid lines indicate Late Pleistocene or Holocene active faults, as shown in Figure 2. Spatial distribution of the intensity of the 1975 M_s 7.3 Haicheng earthquake as reported in Zhu and Wu (1982) is indicated using gray curves. The Chinese seismic intensity scale is similar to the modified Mercalli scale and also has 12 levels ranging from nearly unfelt to total destruction (Table 1 of Raleigh *et al.*, 1977; Chen *et al.*, 1988, p. 4). The innermost line around the epicenter (solid star) indicates the area of intensity ≥IX, and the outermost line encompasses the areas of intensity ≥VII. Zhu and Wu (1982) did not give the exact perimeters of intensity ≥VI, but according to their text description, it should extend roughly about 200 km from the epicenter in all directions.

southeast of, and the city of Dalian is about 200 km southwest of, Haicheng. These three predictions later proved to be false alarms.

The evening of 28 December, the provincial Earthquake Office held an overnight emergency meeting of all earthquake observatories of the province to evaluate the current earthquake risk (2 – 9). The meeting continued to recommend high alert in the Liaoyang-Benxi and Yingkou areas and continuation of anomaly monitoring in anticipation of large earthquakes in the Dalian area. The Dandong area (the first prediction just described) was no longer considered a danger zone because well water anomalies had disappeared.

On 29 December, the RCL made an announcement (3 – 6) that paraphrased the conclusions of the overnight meeting and made more specific predictions. It said that the Liaoyang-Benxi area (Fig. 4) might still expect an earthquake around M 5, based on radon anomalies in the Panjin Observatory, tilt anomalies in the Fushun and Shenyang Observatories, and continuing earthquake activity. The announcement also reiterated the predictions for the Panjin-Yingkou and Dalian-Jinxian areas made on 23 December (the second and third predictions). However, it did not mention the 25 December to 10 January time window for Panjin-Yingkou.

On 31 December, the Earthquake Office presented a group-discussion conclusion to the RCL (2 – 11) that predicted a possible earthquake of about M 5 in the Liaoyang-Benxi area (Fig. 4) by 5 January 1975, based on continuing earthquake activity in that area, radon and tilt anomalies in the Panjin Observatory, and telluric current observations at the amateur Haicheng Earthquake Observatory. The RCL immediately announced the prediction (3 – 8). This prediction, a more specific version of the first prediction announced on 29 December, also turned out to be a false alarm. Among all official documents of the provincial Earthquake Office listed in Appendix A, this is the only one that made a formal reference to amateur telluric observations.

Probably because the predicted epicenter was in the area of the 22 December earthquake swarm and therefore the prediction appeared more credible, the provincial government took this prediction much more seriously than other predictions made in the previous week. Mao Yuanxin (one of the Secretaries of the provincial Party Committee; Chairman Mao's nephew) showed a strong interest by ordering an earthquake drill to be organized in preparation for this event (5 – 2). Mao Yuanxin's relation with Chairman Mao reinforced the weight of his words. Other RCL officials quickly followed suit and gave other specific instructions to the Earthquake Office, such as drafting an emergency response plan assuming an $M > 6$ earthquake (2 – 12).

On 4 and 5 January 1975, the provincial Party Committee organized a two-day earthquake preparation meeting involving relevant people from cities, prefectures, industry, and so on. The meeting focused on the M_L 5.2 Liaoyang-Benxi earthquake of 22 December. Apparently, at least at the beginning of the meeting, the RCL officials did not know about the presumed association of that earthquake with filling of the Shenwo reservoir, and they continued to accept the 31 December prediction and made arrangements for response and relief work. General Li Boqui stated in the opening speech (5–3): "It is now clear that the epicenter will be in this area [i.e., Liaoyang-Benxi]."

Speeches made by RCL officials vividly reflected the mentality of the governing group and portrayed the political environment that the provincial Earthquake Office was working in. General Li Boqiu said (5 – 3): "This time, we will demonstrate 'preparedness averts peril.' It's like fighting a war. Be prepared for a big war, early war, nuclear war, and sudden attack. . . . Defeating natural hazards and defeating class enemies are both struggles. They require making the best use of the situation to achieve victory." Yin Canzhen put it more bluntly (5 – 4): "In my view [of earthquake prediction], a false alarm is better than a miss." All former workers of the Liaoning provincial Earthquake Office whom we interviewed in 2004 were more than impressed with the "courage and resoluteness of those military guys."

Several days later, on 10 January, based on the winding down of earthquake activity and other anomalies, the provincial Earthquake Office's group discussion (2 – 13) drew the following conclusion about the Liaoyang-Benxi area: "Although swarms of small earthquakes may still occur in that area in the near future, the possibility of having $M > 4$ events is small." The chaos generated by the 22 December earthquake swarm thus came to an end. Attention then returned to the Liaodong Peninsula and the Jinxian leveling anomaly. The Earthquake Office's report went on to predict that an $M > 5$ earthquake might occur in Liaodong Peninsula, but "the specific time is difficult to predict." It also noted that some members of the Earthquake Office "think that the $M > 5$ damaging earthquake will occur very soon." The RCL circular on 12 January sent a similar message but withheld the statement that "the possibility of having $M > 4$ events is small" for the Liaoyang-Benxi area and did not mention the minority view of the $M > 5$ earthquake being "very soon."

Time predictions for the false alarms issued in late December appear to have been made up rather randomly. Our only explanation is that they were the result of the pressure from the RCL to provide specific time predictions. We have heard about several accounts of senior RCL officials scolding Liu Yimin, an RCL official directly responsible for the Earthquake Office.

These false alarms were not without scientific merit. Their spatial pattern (Fig. 4) is a representation of the distribution of various anomalies known to the earthquake workers. The pattern was not affected by the locations of earthquake offices and observatories, which were rather uniformly distributed across the province. All counties had earthquake offices, and there were professional observatories in other parts of the province such as Kaiyuan, Shenyang, and Chaoyang (see Fig. 2 for locations). There is an obvious

spatial correlation of the anomalies with the epicenter, and to some degree even with the intensity distribution pattern, of the future Haicheng earthquake (Fig. 4). Earthquake workers in Liaoning did not, and we still do not, know how to interpret these anomalies more quantitatively, but their occurrence in such a broad region distributed asymmetrically around the future epicenter may contain information about the active fault system and earthquake processes in that region that requires study.

Some false alarms did have negative consequences. On one occasion, Yin Canzhen mentioned that 600 people left a petroleum production field in Panjin for fear of earthquakes (and went home for an extended New Year vacation); he blamed the Earthquake Office for not timely reporting the incident to RCL (5 – 2).

The 13–21 January National Conference

Mr. Gu Haoding, a seismologist of Liaoning's provincial Earthquake Office, did not attend the group discussion of 10 January, because he had been asked by Zhu Fengming to prepare a presentation on behalf of the SSB Shenyang Brigade for the upcoming National Conference on Whole-China Earthquake Outlook scheduled to be held in Beijing on 13–21 January. Gu graduated from the Department of Geophysics at Peking (Beijing) University in 1966. As a student, he had participated in a field investigation following the *M* 7.2 1966 Xingtai earthquake (Fig. 1). Gu had already presented the "middle-term" prediction on behalf of SSB Shenyang Brigade at the June 1974 conference. The following is a translation of the essential part of what Gu wrote and presented at the January 1975 conference (2 – 14).

1. Based on Jinxian short-line leveling, at least at the Jinzhou fault, the [rock] material is presently at the post-strain-hardening unstable stage of plastic deformation, on the verge of rupture. Increase in precursory anomalies also points to this situation. Therefore, a relatively large earthquake will not be very far and should be in the first half of this year or even January and February.
2. Based on Jinxian's leveling and radon anomalies, Dalian's magnetic anomaly, and the pattern of earthquake activity, there is a greater possibility that the [large] earthquake will occur at the southern tip of Liaodong Peninsula. However, considering current radon anomaly in Panjin and other anomalies in Dandong and Gaixian, the earthquake may occur within a larger region that includes entire Liaodong Peninsula and its offshore areas.
3. Based on the duration of the Jinxian leveling anomaly, the magnitude of the anticipated earthquake is around 6.

These statements are the later proclaimed "short-term" prediction for the Haicheng earthquake, which covered the triangular region shown in Figure 4. It became part of the four-stage prediction in all official stories of the Haicheng prediction.

However, the national conference did not fully endorse this prediction. In his concluding speech at the conference, Cha Zhiyuan, who headed the Earthquake Leadership Group of the CAS, summarized the conference conclusions as follows (5 – 5). "An earthquake of about *M* 7 may occur in Jianchuan, Xiaguan, Lijiang, and Yongsheng of the North-South Seismic Zone in this or next year; for North China, *M* 5–6 earthquakes may occur in the area between Beijing-Tianjian and Tangshan, and in Jinxian-Yingkou area and Dandong in this year; an *M* 6.0–6.5 earthquake may occur in Songpan of Sichuan Province to Wudu of Gansu Province."

This conclusion changed Gu's estimate of *M* 6 within six or even two months to *M* 5–6 within one year. According to Chinese definitions, this is just another middle-term prediction, similar to that made in June 1974 (see the June Conference and State Council Document 69, 1974 section). The conference-accepted term is not as short as Gu's, perhaps because the conference was charged to provide one- to two-year predictions only. However, it is remarkable that, within 20 months after the conference, an $M > 7$ earthquake occurred in every one of the four regions mentioned in this conference conclusion, including the 1975 Haicheng earthquake. The other three all occurred in 1976: the *M* 7.4 Longling earthquake (200 km southwest of Xiaguan) on 29 May, the *M* 7.8 Tangshan earthquake on 28 July, and the *M* 7.2 Songpan earthquake on 16 August.

The basis for Gu's "short-term" prediction is similar to that for the June 1974 middle-term prediction, but his description of the anomalies is more detailed. Other parts of Gu's opinions (1 – 4) that are not translated here summarized leveling surveys after the June meeting, groundwater radon anomalies in several observatories, and a tilt anomaly in the Shenyang Observatory. All these observations were later discussed in some detail by Raleigh *et al.* (1977). There is also brief mentioning of groundwater fluctuations and sighting of snakes and frogs coming out of hibernation dens. As in the June prediction, the focus of attention was the Jinzhou fault (Fig. 2; see the June Conference and State Council Document 69, 1974 section), although a larger region including Haicheng-Yingkou was also identified because of the spatial distribution of various reported anomalies.

In his summary of leveling results, Gu mentioned "two interesting incidents." On one occasion, results of repeat leveling of a 10-km line crossing the Jinzhou fault showed an elevation change of 2.7 mm within 10 days. On the other occasion, the surveyors of the Jinxian short-leveling lines had difficulty leveling their spirit level because the air bubble kept drifting in one direction, suggesting rapid ground tilt over minutes to hours. These signals were much too large to be counted as noise, but the surveyors had no means to further explore them. Similar aseismic deformation transients are presently under intense scientific investigation using modern techniques such as GPS (e.g., Dragert *et al.*, 2001).

Gu's time estimate for his impending earthquake is a slightly more specific, and hence more in line with the con-

ference, expression of "anytime soon." He applied the laboratory-observed rock failure process, which is highly nonlinear and cannot be used to predict the exact time of failure. When he was challenged for his seemingly very short time estimate during the conference, he emphasized the urgency of the situation by replying that the earthquake could occur "even before the end of this conference."

When we asked him about his magnitude estimate during an interview in 2004, he said that it had been based on an empirical relation between the duration of preseismic deformation anomaly and earthquake magnitude reported by Japanese scientists. According to Ishibashi (1982), two formulae of this type were proposed by Japanese scientists prior to 1975. Gu probably used the formula by Tsubokawa (1969): $\log_{10} T = 0.79M - 1.88$, where T is the duration of the deformation anomaly in days, and M is the magnitude. Given that the Jinxian leveling anomaly had lasted for about 500 days by January 1975, this formula would predict a magnitude 5.8. The other Japanese formula, $\log_{10} T = 0.52M - 0.24$, by Fujii (1974), would predict a magnitude 5.7. Given a few more months, both formulae would predict a magnitude approaching 6.

Just before the Earthquake

Provincial Prediction and Warning

After the December earthquake swarm in the Liaoyang-Benxi area, earthquake activity in and around Liaoning Province nearly came to a hiatus (Zhu and Wu, 1982). In January, the RCL officials' sense of urgency subsided, as reflected by the paucity of official earthquake documents in that period. This might have to do with the recognition that the December Liaoyang-Benxi earthquakes had been triggered by reservoir filling. However, in interesting contrast, reports of groundwater and animal behavior anomalies increased after the end of December. Daily numbers of the reported "macroscopic anomalies" stayed high throughout January and peaked around 23 January, 1975, as shown in Figure 5. These anomalies will be further discussed in the Relation of the Anomalies with the Earthquake section.

The best illustration of what provincial government officials and earthquake workers in Shenyang knew in the last few days before the Haicheng earthquake is in the log book of the provincial Earthquake Office (6 – 4). We have translated the notes in this book from 31 January through 3 February, the day before the earthquake (Appendix D).

A report on 31 January by Zhu Fengming gave a three-point summary, upon request from a junior RCL officer (Appendix D). The first point reiterates the Earthquake Office's conclusion of January 10 that no significant earthquakes were expected in the area of the 22 December 22 earthquake swarm (the False Alarms section). The second point mentions reoccurrence of anomalies in the Dandong area without claiming them to be earthquake precursors. The third point shows that the Earthquake Office (1) fully accepted the conclusion of the January national conference and did not insist on Gu's short-term prediction (see the 13–21 January National Conference section) and (2) took the conference prediction very seriously. At the end, Zhu requested that a time be scheduled for him to report to RCL about the recent national conference (the 13–21 January National Conference section). Zhu explained to us in 2005 that he had verbally informed some of the RCL officials about the national conference upon his return from Beijing, but the RCL officials never found the time to listen to a systematic report before the 4 February Haicheng earthquake. This probably also reflects RCL's decreased sense of urgency with regard to earthquakes.

Several very small earthquakes in the normally quiet Yingkou-Haicheng area were detected on 1 and 2 February by the Shipengyu Earthquake Observatory, located about 20 km southwest of the future epicenter (Fig. 6). As shown in the provincial Earthquake Office's log book (Appendix D), these events did not cause any concern. Beginning from the evening of 3 February, there was a surge of earthquake activity in the same area. This burst of seismicity truly alarmed the provincial Earthquake Office. They correctly predicted (Appendix D): "If a large earthquake is to occur, the magnitude of these small events may increase and their occurrence may become more frequent." By midnight, the

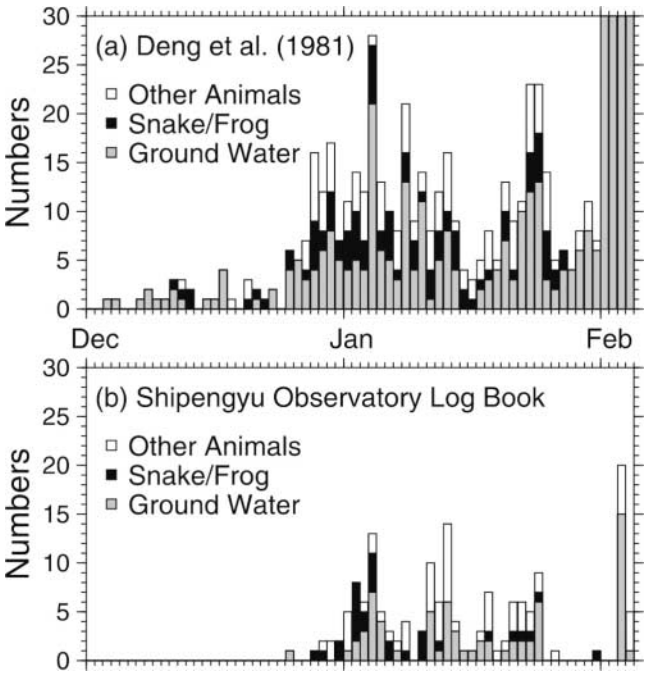

Figure 5. (a) Daily numbers of macroscopic anomaly reports from 1 December 1974 through 4 February 1975, reported in Deng *et al.* (1981) based on interviews of eyewitnesses right after the Haicheng earthquake. Numbers for the last four days of the plotted period are in the hundreds and greatly off the scale. (b) Macroscopic anomaly reports recorded in Shipengyu Earthquake Observatory's log book (not used in Deng *et al.* 1981).

Shipengyu observatory had recorded 33 small earthquakes in its log book (6 – 1). All events were estimated to be 20 to 21 km southeast of the observatory (based on V_s–V_p arrival-time difference and the direction of first motion recorded on their short-period three-component seismograph). The magnitude (M_L)–time sequence of the more than 500 events, which are now confidently recognized as foreshocks, is shown in Figure 7. There are about 20 more events in Figure 7 than are actually recorded in Shipengyu Observatory's log book, because later analyses helped identify some additional small events. A similar data set was shown in M_S by Wu *et al.* (1978). Some of these events were later used by Jones *et al.* (1982) in a relocation study.

At 0:30, 4 February, after group discussions, Zhu composed the fourteenth issue of *Earthquake Information* (2 – 15; Appendix E) to explain the situation to the provincial government. Two more issues of Earthquake Information were written and mimeographed at 5:00 and 8:00 a.m., reporting the continuing upward trend of earthquake magnitude. By 8:00 a.m., over 200 events had been recorded, culminating in the largest foreshock of M_L 5.1 (M_S 4.7) at 7:51 a.m.

The brief fourteenth issue of *Earthquake Information* was later officially proclaimed as the imminent prediction of the Haicheng earthquake. Although it was not written in a definitive style, by stating that "the magnitudes are still increasing" and "a relatively large earthquake is very likely to follow," it sent a warning of unprecedented urgency. Similar wording had never been used in previous reports from the provincial Earthquake Office. Zhu brought the brief report to Liu Yimin, the junior RCL official directly responsible for the Earthquake Office. Liu then took Zhu to see Mr. Hua Wen, a Vice Chairman of RCL, at 8:00 a.m.

The former workers of the Liaoning provincial Earthquake Office whom we interviewed in 2004 are unanimous on one point: none of them ever attempted to, or felt they were able to, predict an earthquake to a day. Mr. Zhu Fengming told us that when he wrote "a relatively large earthquake is very likely to follow," he was "thinking of a time frame of one to two weeks." However, when they reported the earthquake situation to Mr. Hua Wen in the early morning of 4 February 1974, Hua Wen felt a much heightened sense of urgency. To our surprise, it was Hua's 8:00 a.m. administrative decision that effectively helped to bring about the provincial prediction of the Haicheng earthquake.

According to an account from the Lianing provincial Earthquake Office (2 – 21) written after the earthquake, when the office staff proposed to dispatch earthquake workers to examine the Yingkou-Haicheng area before arranging emergency response, Hua Wen said: "There may not be enough time for that. You'd better fix a meeting place, and we [RCL] will notify relevant cities and counties to muster there to discuss response measures immediately."

Following this order, Liu drove to the town of Haicheng with Gu Haoding and a clerical officer of the Earthquake Office Li Fuxiang. They organized an emergency meeting in the Haicheng guesthouse during 14:00–15:30. The meeting was attended by a total of 12 people, including government officials of Haicheng and Yingkou Counties and an officer of a PLA troop that was staying in that area. At the meeting, Li Fuxiang from the provincial Earthquake Office estimated a magnitude of greater than 6 and said "the large earthquake may occur within the next few days" (2 – 21).

At 10:30 a.m., while Liu's trio was driving from Shenyang toward Haicheng, the RCL organized a telephone distribution (see the Provincial Government Documents section for how a telephone distribution worked). The formal RCL announcement (3 – 14) broadcasted in this distribution was brief. It reported the large number of earthquakes, with "the largest being M 4.7," and slight damage in what was to become the epicentral area. Apparently, by this time, reports of damage caused by the foreshocks had begun to trickle in. The RCL announcement said that "the magnitude is continuing to climb, and the earthquakes are abnormally frequent" and asked all relevant regions to be on high alert. The formal announcement was accompanied by characteristically military-style personal directives from General Li Boqiu. The Yingkou City committee relayed the provincial distribution to the Yingkou County at 11:30 a.m. According to Yingkou County's telephone records (4 – 10), General Li's directives contained four points:

1. Determine the scope of the [impending] earthquake. How large will the epicentral area be?
2. Define an alert zone and take emergency measures. Maintain duty and patrol day and night. Those who have unsafe houses should sleep elsewhere.
3. [Committees of] cities, counties, and communes should be on duty. Stand fast at your posts. Report and take actions quickly if there is urgent situation.
4. Strengthen guarding of factories, mining structures, reservoirs, bridges, mining tunnel entrances, and high-voltage power lines. Stand fast at your posts. Designate persons for individual posts. Report urgent situation.

It is apparent that in General Li's mind that (1) the large earthquake would surely occur ("How large will the epicentral area be?"), and (2) it could occur as soon as in the same day ("Those who have unsafe houses should sleep elsewhere.").

By the afternoon, it became very clear that the foreshocks had caused substantial damage. The provincial Earthquake Office submitted the 17th issue of Earthquake Information to the provincial government at 2:00 p.m. (2 – 18, Appendix E). This is an important document, because the serious damages reported in it, such as collapse of gables and chimneys, may in part explain why some communes, brigades, and individuals in the epicentral area made their own evacuation decisions without explicit instructions from higher levels. However, from 1:00 p.m. onward, the foreshock activity dramatically decreased (Fig. 7). This decrease and the cold weather complicated evacuation work.

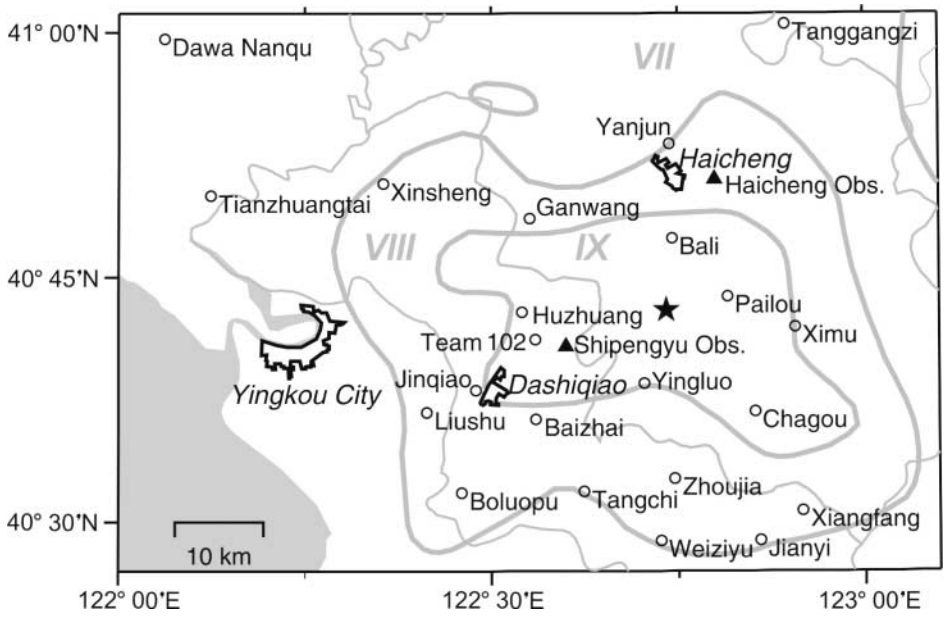

Figure 6. Map of the epicentral area of the 1975 Haicheng earthquake (epicenter shown as a star) showing locations of some of the towns, communes, and other types of population centers mentioned in the text. Thick gray curves show spatial distribution of the intensity of the earthquake (same as in Fig. 4). Thin gray curves indicate county boundaries. Urban areas of Yingkou City and towns of Dashiqiao (in Yingkou County) and Haicheng (in Haicheng County) are outlined with thick solid lines.

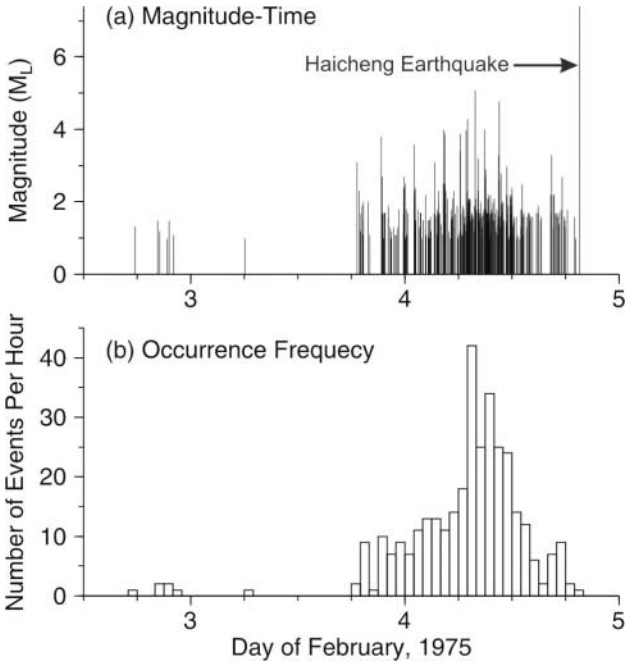

Figure 7. Foreshock sequence of the Haicheng earthquake. Data are from SSB Analysis and Prediction Center (1980).

Role of the Shipengyu Earthquake Observatory

The Shipengyu Earthquake Observatory was established in 1970 near the village of Shipengyu in Yingkou County. It was one of the observatories of the SSB Shenyang Brigade (i.e., Liaoning provincial Earthquake Office) but was administered by the Yingkou City government. In 1975, it had 13 workers, operating a short-period, three-component, smoke-recorder type 64 seismograph made in China. They also had a tilt meter, although their tilt data (shown by Raleigh *et al.* 1977) were never mentioned in any precursor discussions prior to the Haicheng earthquake. It is said that, in the few years before the Haicheng earthquake, the observatory made and distributed over 100,000 copies of brochures and organized over 100 film or slide shows to spread earthquake knowledge (7 – 10). After the earthquake, the observatory was the first one of the six organizations to be mentioned by the SSB for rendering "meritorious services in the analysis-prediction of southern Liaoning earthquake" (7 – 10).

In early February 1975, because the future epicenter was only 20 km away (Fig. 6), the observatory became the most important source of foreshock information not only for the provincial Earthquake Office but also for all other local governments and other earthquake offices of southern Liaoning. The foreshocks were hand recorded in the observatory's log book (6 – 1), which also contains accounts of various anomalies and felt and damage reports for the foreshocks that were

reported to them by amateur observers and by other earthquake offices.

The Shipenyu Observatory had many communications directly with local communities and various organizations, and apparently these had a strong influence on their decisions regarding evacuation. Note that the word "evacuation" in this article and all previous stories about Haicheng means moving people out of their houses and does not mean transporting them to a different area. To illustrate the wide range of communication, we list here some of the 28 telephone records in the log book the day before the Haicheng earthquake, mostly in the evening. Population centers mentioned in this list can be found in Figure 6.

1. Zhu Fengming of the provincial Earthquake Office called and inquired about earthquake situation . . .
2. Since the beginning of the earthquakes [i.e., foreshocks], phoned city's Party Committee three times . . .
3. Told Yingkou and Gaixian Counties to inform relevant communes to enhance preparation [for a large earthquake] . . .
4. Xinsheng Farm Earthquake Office: felt [an earthquake] at 4:30; a table moved before the earthquake occurred.
9. Mr. Ma of Tangchi Commune: felt three times at 18:30, 18:40, and near 21:25 . . .
11. Mr. Cao of Yingkou County: His county's Party's Standing Committee asks if the city's Party Committee has any opinions; all communes in the county felt; . . . at 22:45; shaking broke glass . . .
12. Anshan City Earthquake Office: felt at 21:23 . . .
13. The PLA Subarea Headquaters . . . phoned . . .
17. Mr. Cao of Yingkou County: (1) Water in twelve wells in Zhangguan Brigade of Baizhai Commune dropped 30–50 cm tonight; (2) several wells had water during the day but are dry now (11 p.m.?); (3) horses are neighing; (4) In Qiaozhen [i.e., Jinqiao in Fig. 6], there are chickens making large noise and trying to escape.
20. Police at the East Train Station enquired about earthquakes.
25. Liushu Commune in the city suburb reports: many cows in city's milk farm moo.
26. Comrade Fan from the suburb phoned: Already told comrade Xu to carry out preparation and relief work.

If many of these communications seem outside the responsibilities of an earthquake observatory, the following log book entry on the day of the earthquake is even more astonishing: "Informed Tianzhuangtai and Dawa Nanqu by telephone, be prepared for a possible large earthquake tonight." Here the observatory, over the phone, issued an unofficial imminent earthquake prediction directly to a local community. This entry is between two notes on the same page of the log book about foreshocks. The earlier note says: "Total of 315 [foreshocks] from 16:00, 3 February, to 10:00, 4 February, 16 were felt and with $M > 3$." The later one says: "501 from 12:38, 3 February, to 18:30, 4 February." Hence the time of the prediction phone call is probably between 10:00 and 18:30 on 4 February.

Tianzhuangtai and Dawa Nanqu (northwest corner of Fig. 6) are relatively far from the area of intense foreshocks. It is logical to infer that the observatory must have issued similar messages also to communities in and near the foreshock area but had no time to record them in the log book. These messages must have spread quickly and convinced some communities to evacuate.

Our interviews of witnesses have verified the following widely publicized story: The movie operator of the Shipengyu Production Brigade was convinced by workers of the Shipengyu Observatory of an impending earthquake that night and decided to show movies outdoors overnight to attract people away from their houses. The earthquake occurred during the movie show. Another person (Mr. Jia) involved in this story also became well known. He disbelieved the prediction, refused to see the movies, and kept his 4- or 5-year-old child in the house with him. The child was killed by house collapse when the earthquake came, although Mr. Jia himself survived.

We do not understand why observatory workers believed a large earthquake was very possible for that night. Perhaps they were alarmed by the increasing trend of foreshock magnitudes and intuitively anticipated an even larger event to follow. Anticipation for a large earthquake had been re-enforced repeatedly since the distribution of State Council Document 69 (see the June Conference and State Council Document 69, 1974 section). It is also possible that they followed an empirical three-stage formula of "many foreshocks, short hiatus, large earthquake" and based their prediction on a temporary quiescence of foreshock activity in the afternoon (Fig. 7). This formula was created in China on the basis of a foreshock sequence of the 1966 Xingtai earthquake and widely quoted in earthquake education materials (e.g., Tianjin City Earthquake Office Editorial Group, 1973).

Another possibility is that they were influenced by other people. Li Zhiyong, one of the scientists sent to Liaoning from Beijing by the SSB Headquarters to investigate the 22 December 1974 earthquake (see the M_L 5.2 Liaoyang-Benxi Earthquake, 22 December 1974 section), wrote in a recent article (Li, 2005) that he happened to be in the City of Yingkou on 4 February and told the city government that an $M > 6.8$ earthquake might occur "before midnight, probably around dinner time." He said he based his reasoning on the above three-stage formula and a comparison with the foreshock sequences of the 1966 Xingtai earthquake and the recent 22 December Liaoyang-Benxi earthquake. Since the Shipengyu Observatory was administered by the City of Yingkou, someone in the city government might have consulted with the observatory about Li's prediction. Li was reportedly awarded by various organizations afterward for his prediction efforts. We have not searched for documents that would corroborate Li's story.

Evacuation in Yingkou County

What happened in Yingkou County on 4 February 1975 must be the most remarkable story ever involving the "strug-

gle" with earthquakes. The Head of the Earthquake Office of Yingkou County, located in the town of Dashiqiao with the county government (Fig. 6), was Mr. Cao Xianqing (known as Cao Diban, i.e., Mr. Earthquake office), a legendary name known to everyone involved in Haicheng earthquake prediction but never mentioned in state- and provincial-level official documents. Cao, born in Yingkou, was a young carpenter when he joined the PLA in 1947. He learned to read and write in the army. Mr. Cao told us during an interview in 2004 that he had "fought with the Fourth Army of the PLA from northeast China to Guangdong Province" during the civil war in late 1940s and that he had done "supply work" during the Korea war. He said that, after retiring from the army in 1954, he had been doing "party work" before being instructed to establish Yingkou County's Earthquake Office in September 1974, just a few months before the Haichang earthquake.

Cao joined a delegation, organized by the Yingkou City government, to Sichuan and Yunnan Provinces to learn about earthquakes and amateur earthquake prediction. There had been reports of successful earthquake prediction in those areas. The trip started on 15 November 1974 and lasted for "more than forty days" (Cao *et al.*, 1986). He was passionate about his Earthquake Office duties and enthusiastically supervised a network of amateur observatories in the county. His efforts apparently gained him the trust of the county's Party Committee. However, at least on one occasion in early December, his work was criticized for inflaming earthquake education and panicking the public (4 – 2).

From 27 December 1974 (just after his trip) until 3 February 1975, he presented 16 issues of "Briefing Notes" (all included in Cao *et al.*, 1986) to the county government. A few issues were simple copies of provincial circulars. Some issues contained earthquake activity information that he obtained directly from seismologists of the nearby Shipengyu Observatory. In several issues, there were numerous accounts of peculiar groundwater/surface water fluctuation and animal behavior and amateur telluric current observations.

For example, in the third issue of 31 December, he wrote the following about amateur telluric current observations at Huzhuang Commune's (Fig. 6) post office: The reading was "normally 60 μA, but dropped by 17 μA on 30 December, by 26 μA at 6:26 a.m. and 58 μA at 9:00 on 31 December." Mr. Cao also regularly reported readings from Huzhuang and four other amateur groups under his supervision to the Shipengyu Observatory, sometime a few times a day. The Huzhuang amateur group that collected these data was later recognized by the SSB for having "rendered meritorious services in the analysis-prediction of southern Liaoning earthquake" (7 – 10), not only for making these observations but also for their performance when the earthquake occurred. Their data, reproduced in Figure 21 of Raleigh *et al.* (1977), were never formally used by professionals of the Liaoning provincial Earthquake Office before the Haicheng earthquake.

The fifth issue of Cao's Briefing Notes, dated 4 January, reported the following: "According to reports on 4 January from a number of units of our county, water level of wells in Jianyi Commune generally dropped (one well that originally had a water level of 1 m below ground is now dry), water level of the Xiangfang reservoir dropped by 0.5 m, one well in Sanjiazi Brigade of Weiziyu Commune dropped by 70 cm (today) and its water has turned muddy and bitter, and two snakes were found (still kept) in Laodong Brigade of Boluopu Commune during 28 December to 3 January." These were valuable observations. The communes and the reservoir mentioned here are all in the southernmost part of the map area of Figure 6.

Cao believed that the above phenomena were precursors of earthquakes. In January, while the earthquake activity in the province had become relatively quiet, he was so sure about the imminence of a large earthquake that he made some precautionary arrangements. In a notebook from his Earthquake Office (6 – 3), a record entered on January 28 indicates that by this time the county already organized a 7-person communication group, a 21-person rescue team, and a 16-person transportation team, and prepared 25,000 kg of baked foods, 1000 winter jackets, 10,000 pairs of winter shoes, 1000 winter hats, 1000 cotton quilts, and so forth in preparation for a large wintertime earthquake. An entry made on 22 January in the log book of Shipengyu Observatory recorded that "all communes in Yingkou County have formed Earthquake Offices," apparently to Cao's credit.

Cao maintained frequent telephone communication with the Shipengyu Observatory and was fully aware of the development of foreshock activity. On 3 February, Cao presented the last issue of his Briefing Notes to the county government to report the few small earthquakes recorded at the observatory since 1 February, warning that "the situation is still developing." During the same day, most likely in the evening, he received telephone notification from the Shipengyu Observatory to prepare for a possible large earthquake (see item 3 of telephone records of the Shipengyu Observatory on 3 February shown in the Role of the Shipengyu Earthquake Observatory section). On 4 February at 7:51 a.m., the largest foreshock (M_L 5.1) occurred, and his Earthquake Office's notebook recorded collapse of chimneys and gables.

At 8:15 a.m., 4 February, the Standing Committee of the Party Committee of Yingkou County held an extended emergency meeting upon Cao's recommendation. The meeting was attended by eight people including Cao, plus a minute-taker. In his oral report at the meeting, Cao said: "A large earthquake may occur today during the day or in the evening. County Party Committee please take measures." The meeting concluded with the following sternly worded moratorium (4 – 9).

1. From this moment, all meetings in all urban and rural areas are cancelled.
2. From this moment, all public entertainment and sport activities in all urban and rural areas are suspended.

3. From this moment, all business activities are suspended.
4. From this moment, all production work is suspended.

The minutes of the meeting also recorded the following specific directives. "Immediately inform all communes. Each party member is responsible for a specific set of families [to make sure they leave their houses], and each militiaman is responsible for a specific set of individuals. Militiamen must be on duty for all urban and rural areas and persuade the masses to move to safe areas. Party's leadership must be strengthened. If the earthquake comes too quickly to allow warning, each commune or brigade should take its own actions. Ensure that people are out of their houses and cattle are out of their sheds." By designating specific families and individuals to be the responsibility of a specific party member or militiaman, the county government wanted to make sure that not a single person in the county was left unattended. In 1975, especially in rural areas, many party members and militiamen had unquestionable loyalty to the party and would carry out these orders to the letter.

The meeting adjourned at 9:00 a.m. When the 10:30 provincial warning was relayed to the county at 11:30 and when Cao represented his county at the provincial emergency meeting in Haicheng guesthouse in the afternoon, evacuation in Yingkou County was already well underway. Undoubtedly, the provincial warning served to re-enforce the sense of urgency and further helped evacuation work in the county.

Throughout 4 February, Cao continued to announce that a large earthquake would occur on that day, urging immediate evacuation across the county. Several professional seismologists we interviewed in 2004 have various humorous but friendly recounts of what Cao said on that day. He intuitively interpreted the afternoon decrease in earthquake activity (Fig. 7) as the final energy buildup before rupture. He reportedly said that the later the earthquake struck, the larger would it be, and the magnitude would be "7 at seven o'clock (p.m.), and 8 at eight o'clock, . . ." (Qian, 1986). Some think that he extrapolated the increasing trend of the foreshocks (Fig. 7) to come up with this magnitude-time estimate. During our interview with him in 2004, he confirmed that he did say that the earthquake would occur before 8 p.m. When asked why this time was so important, he offered the following explanation.

He knew of a statement in a book called *Yinchuan Xiaozhi* (Serendipitous Historical Records of Yinchuan) that "excessive autumn rain will surely be followed by a winter earthquake." He said that it had rained excessively in the autumn of 1974, and the winter would have ended at 8 p.m. on 4 February, 1975, and therefore the earthquake had to happen before 8 p.m. on that day.

We later located the book he referred to. It is a compilation of notes made between 1754 and 1755 by a private teacher named Wang Yichen, shortly after a large earthquake had occurred on 3 January 1739 in what is today's Ningxia Autonomous Region (Wang, 1755). In this book, Wang wrote the following passage: "Ningxia is prone to earthquakes. People are used to tremors every year. Earthquakes occur mostly in winter or spring. If well water suddenly turns muddy, there is lasting cannon-like sound from the ground, gangs of dogs bark furiously, one should be mindful of earthquakes. Excessive autumn rain will surely be followed by a winter earthquake." The passage was widely quoted in public earthquake education materials in Liaoning Province in the forms of wall posters or brochures. Mr. Cao probably read some of those posters or brochures.

In China, a year is divided into 24 solar terms. In 1975, 4 February was indeed the last day of the last solar term, that is, the end of winter in this system. However, the precise winter–spring transition was at 6:59 p.m., an hour earlier then Cao thought. The Haicheng earthquake did not occur in the winter after all. It occurred at 7:36 p.m., 37 minutes into the spring.

The spectacular evacuation work in Yingkou County attracted the immediate attention of political leaders (5 – 7; 5 – 8). But it would later become a matter of disappointment that Mr. Cao could not satisfactorily explain his predictions in the final weeks and especially the final day. More importantly, in post-Haicheng propaganda campaigns, the central government of China would like to see the prediction as a success achieved by the masses over a much larger region under the leadership of the provincial Party Committee. The issue of the provincial Party Committee's leadership will be revisited in the Recognition of the Prediction Efforts section. The efforts of Yingkou County, in many ways ahead of the provincial efforts, were not publicized or told to foreign visitors. In the first foreign scientific report of the prediction of the Haicheng earthquake (Adams, 1976), Yingkou County was not even shown on the map.

Zhu and Wu (1982) described the evacuation of the town of Dashiqiao as follows. "The town of Dashiqiao, in the region of intensity IX, took measures such as stopping shopping and public entertaining activities, relocating guesthouse guests and hospital patients, and dispersing the masses before the earthquake. Although 66% of the buildings in the town collapsed, only 21 people died, out of a population of 72,000." What they neglected to mention is that the town of Dashiqiao was the location of the Yingkou County government and its Earthquake Office.

The Yingkou County government and Mr. Cao never won national and provincial awards for rendering "meritorious services in the analysis-prediction of the southern Liaoning earthquake." The explanation was that the awards were given only to professional and amateur earthquake workers, not to government officials. Those who worked in the Liaoning provincial Earthquake Office and various observatories were considered professional and amateur workers. Those who worked in county-level earthquake offices, like Mr. Cao, were somehow regarded as government officials.

Action and Inaction in Haicheng County

Contrary to the popular belief in the west that the "Chinese government announced in 1975 that the city of Haicheng had been evacuated in advance" (Scholz, 1997), Haicheng County was scolded after the earthquake for not having done as a good job as Yingkou County. When visiting the disaster relief command post in Haicheng a week after the earthquake, Mao Yuanxin (Chairman Mao's nephew) remarked: "Yingkou did a better job than Haicheng" (5 – 7). On 9 May 1975, Vice Premier Hua Guofeng intimated the following comments to delegates of the Third National Earthquake Work Conference (5 – 8).

> Among the areas that we have had some direct contact, it was in the countryside of Yingkou County that the education [about the impending earthquake] was relatively in-depth and popular. [People in] some of these places slept outside on both the 3rd and 4th [of February]. Yingkou [county government] issued warning beforehand and announced it with loudspeakers. [People in] some communes of Haicheng overheard the announcement from Yingkou, but Haicheng's own warning was issued late and did not reach all the people. Therefore, Haicheng's life losses were heavier in comparison. . . . The greatest casualty was in the Haicheng guesthouse. The guesthouse attendants knew there would be an earthquake, so they only arranged guests to stay on the first and second floors, not the third floor. They did some propaganda . . . and asked the guests to sleep with their winter clothes on. That evening [of the earthquake] they only gave this kind of general notice, unlike Yingkou's specific imminent warning. . . . Anshan's masses and cadres have complaints, because the leading cadres did not disseminate any imminent earthquake warning.

Here Hua Guofeng mildly criticized the government of Anshan City because the City was administratively responsible for Haicheng County. Haicheng's Earthquake Office was not directly supervised by the County's Revolutionary Committee, an arrangement commonly viewed as an indication that earthquake work was not given a high priority. The county government did hold a meeting on 4 February to prepare for a large earthquake, but it was not until 6 p.m., rather late in the day. The earthquake occurred right after the meeting was adjourned.

According to witnesses we interviewed in 2004, people in the town of Haicheng were aware of the possibility of a large earthquake, but they chose to stay inside their rooms in the evening of 4 February. Most of them survived the earthquake, but casualties were indeed greater than in the town of Dashiqiao, with 153 deaths (based on 4 – 11), despite the fact that the town of Haicheng suffered less building damage (intensity XIII) than Dashiqiao (intensity IX) (Fig. 6). Forty-four people died due to the collapse of parts of the three-storey guesthouse (Fig. 8) (based on 4 – 11), where the provincial Earthquake Office had organized its emergency meeting in the afternoon. Most of the victims had just checked in for an agriculture conference.

However, although not across the whole county, evacuation indeed took place sporadically in parts of Haicheng. We were told the following story by Mr. Qiao Changman, a former worker of the amateur Haicheng Earthquake Observatory. Workers of the observatory had been making amateur telluric current observations. Their readings showed a large jump a couple of hours before the M_S 4.7 event (largest foreshock) in the morning. Just before 2 p.m. the readings showed a similar but larger jump. They then predicted that an earthquake "greater than M 4–5" might occur "within three hours." Mr. Qiao produced a written version (as evidence) of the prediction and asked a fellow worker to hand-deliver it to Haicheng County's Earthquake Office. During his bicycle trip to the Earthquake Office, the messenger told some friends about this prediction. The news then quickly spread and triggered evacuation in that neighborhood, in the northeastern suburb of the Haicheng County.

Mr. Qiao and coworkers must have also immediately reported their prediction by telephone to the Earthquake Office of Anshan City, 40 km away, because we later found a record of their prediction at 2 p.m., 4 February, in the log book of Anshan's Earthquake Office (6 – 5). We did not check whether the Haicheng Observatory had made other (false) predictions previously.

Publicized and Unpublicized Evacuation Examples

A few glorious evacuation examples were publicized in Chinese soon after the earthquake. We quote some of these examples in this section. The examples have been used for propaganda purposes, and some of the details may not be accurate. We have not scrutinized the details but believe the reported deaths (or lack of) in them are not grossly wrong. These examples either do not mention how the decision for evacuation was made or indicate that the decision was made at a very local level. The fact that only selected examples were publicized indicates that the warning and evacuation process was very uneven throughout the disaster region. Locations of communes mentioned in these examples can be found in Figure 6.

The Liaoning provincial Earthquake Office wrote a report in March 1975 (7 – 11). It is obvious from its style and wording that the report was written for the masses, not for government officials. As suggested by the title of the report, credits were given to the leadership of Chairman Mao. The success was said to be the "fruit of the Great Proletarian Cultural Revolution and of the Campaign of Criticizing Lin Biao and Confucius" (Appendix C). During the Cultural Revolution, failing to use lavishly these standard expressions would bring trouble to the writer/speaker. The report contains a few evacuation cases.

"The [amateur] analysis-prediction center at Huzhaung Commune post office, Yingkou County, consists of three female switchboard/telegraph operators." After describing how the amateur group made their telluric current and other anomaly observations (also see the Evacuation in Yingkou County section), the report went on to say: "On 4 February

Figure 8. Damaged building of the Haicheng guesthouse (built with bricks and concrete). The building had an E shape in plan view, with the three back wings oriented perpendicular to the front wing. Left: Front view. Right: Back view, two side wings at the back collapsed. The center back wing did not collapse (shown in the background on the left-hand side).

at 6 p.m., they obtained information that a large earthquake might occur that evening and reported it to the commune. The commune's Party Committee immediately decided to disseminate the information. Within half an hour, the girls made over 70 switchboard connections and made 78 phone calls to notify all production brigades rapidly. As a result, more than 30,000 people of the whole commune left their houses in time, and casualty was minimized." The time (6 p.m.) when they obtained the information is obviously incorrect. Yingkou County's moratorium was issued in the morning, and this Huzhuang Commune group, one of Mr. Cao's favorite amateur monitoring teams, would have been among the first to receive a notice from Mr. Cao. The time appears to have been altered to be only 1.5 hours before the earthquake to dramatize the girls' heroic deeds to save lives.

The report praised Team 102 of the Metallurgical and Geological Exploration Company (Fig. 6) for their precursory anomaly monitoring. The self-potential data from this amateur group was later reproduced in Figure 13 of Raleigh *et al.* (1977). After describing how the group made their observations and reported their findings to the Yingkou County's Earthquake Office and Shipengyu Observatory, the report said: "According to information provided by them, the Party Committee of the Team and some neighboring units timely directed employees and their families to safe areas. Although the earthquake caused extensive house collapse, none of the more than 1200 people of these units was killed." Here the Party Committee of Team 102 and "some neighboring units" are said to have made their own evacuation decisions. Warnings from Mr. Cao, the Shipengyu Observatory, and the province might also have contributed to some degree.

The report also cited an urban and a rural example not from Yingkou County:

> Three thousand four hundred seventy-one people of 801 families live on Yangguang Street, Xishi District of Yingkou City. . . . When the earthquake was coming, the [street] Party Branch followed the predesigned response plan to organize masses to move to safe places. One hundred twenty-two rooms collapsed on this street, but not a single person was killed or severely injured. Party Branch of Qianjiao Brigade of Yanjun Commune, Haicheng County, held an emergency branch meeting before the earthquake and took effective response measures. They gave notices personally or through loudspeakers, requiring 'human leave houses and cattle leave sheds,' and organized militiamen to conduct inspection and persuasion [to leave houses] family by family. The earthquake caused severe collapse of houses, but there was not a single casualty among the 780 people and 18 cattle.

Zhu and Wu (1982, p. 184) gave two examples from Haicheng County:

> In Yingluo Commune, Haicheng County, located in the most severely damaged region, the masses were evacuated outdoor before the earthquake. Although 95% of the 28,027 rooms in the commune collapsed, only 44 people out of a population of 35,786 died. . . . In Dingjiagou Production Brigade of Pailou Commune, Haicheng County, also located in the most severely damaged region, the masses were mobilized to stay in earthquake-resistant shelters 10 m away from houses since Feb. 3. Although 550 out of 700 rooms collapsed, there was not a single casualty among the 878 people of the brigade.

Vice Premier Hua Guofeng told the following story in his May 9, 1975, confidential speech to delegates of the Third National Earthquake Work Conference (5 – 8):

> February 11 would be the Chinese New Year. Anshan City sent a leading cadre and a greeting delegation to [the town of] Dashiqiao on February 4, to express good wishes and give a stage

> performance [to entertain the Headquarters of the 39th Army]. Dashiqiao is the location of Yingkou County [government]. . . . Because of an earthquake prediction for that day, the Army Headquarters had to decide whether to have the greeting ceremony and watch the performance. Since Anshan's leading cadre was already there, the ceremony had to take place [to show respect for the leading cadre], but the performance was canceled. . . . So they held the ceremony with all the seven doors of the assembly hall kept open [for easy escape]. The Anshan's leading cadre gave a greeting speech, and the army hosts expressed their gratitude. The ceremony was adjourned right after the speeches, without having the performance. When people had just walked out of the assembly hall, the earthquake occurred, and the hall collapsed. An officer who was directing people to exit was injured, but the rest of the one thousand people were all safe.

We learned from several independent sources that the short ceremony began at 7:00 p.m. and ended around 7:20. Following standard ritual, high-rank officers and leading cadres who sat on the stage left the hall first, and others followed in an orderly fashion, just in time for the 7:36 p.m. earthquake. It is said that the Army Commander was initially furious over the idea of letting an earthquake prediction interrupt the greeting ceremony, but he became so grateful after the earthquake that he personally told the story to the Vice Premier. This close call is well known among earthquake workers who themselves experienced the Haicheng earthquake, but there is some controversy regarding who provided the earthquake prediction for the army. Hua Guofeng and some others said it was the Shipengyu Observatory, but Mr. Cao insists that it was his Earthquake Office. We think the army might have obtained information from a number of sources, but Mr. Cao's prediction might have been the most specific.

Basis for Evacuation Decisions

The Canadian Seismology Delegation to China after the Haicheng earthquake wrote in their report (Witham *et al.*, 1976): "Final responsibility for the prediction of a hazardous situation appears to rest with the provincial seismological brigade or bureau, or its sub-units closer to the predicted epicentral region, but the evaluation of this prediction and a decision to evacuate an area is a political one that appears to be made at the commune, county or city level not necessarily in a uniform way." Ralph Turner wrote in the "Mobilizing the Masses" section of the U.S. delegation report (Raleigh *et al.*, 1977): "In early February it appears that rural communes, factory committees, and urban street committees received information and advice from higher levels (county and city) but made their own decisions. It is even possible that the decisions were made at the brigade level."

These two astute early observations were somehow unnoticed or forgotten by western media and science community. The story has typically been simplified as "in 1975 Chinese officials ordered the evacuation of Haicheng, a city with one million people, just days before a 7.3-magnitude earthquake" (National Geographic News, 11 November 2003). As shown above, a characteristic of the evacuation before the Haicheng earthquake is its nonuniformness. Consequently, it is both interesting and important to ask on what basis some of the local committees decided to evacuate.

On 4 February 1975, the commune or brigade leading cadres would have obtained information directly or indirectly from six different sources: (1) the general provincial warning relayed to them through city and county committees, (2) in the case of Yingkou County, an evacuation order from the county committee, (3) nearby earthquake observatories, particularly the Shipengyu Observatory, (4) local amateur precursory monitoring groups such as the team of the Haicheng Observatory, (5) neighboring villages and industrial units, and (6) the foreshocks and the damage they were already causing.

In Yingkou County and some neighboring Haicheng villages that overheard Yingkou's loudspeaker broadcast, the decision was easier to make. In the neighborhood of the Shipengyu Observatory, the villagers relied on their trust in the observatory workers. Those who heard about the amateur prediction by the Haicheng Observatory also had a good reason to evacuate.

It was a difficult problem in most other areas, because there was no warning evidence to indicate that the earthquake would occur as soon as the same evening. Li Fuxiang of the provincial Earthquake Office merely said "within the next few days" at the emergency meeting held in Haicheng guesthouse in the afternoon of 4 February (Provincial Prediction and Warning section). Local committees and individuals had to weigh the uncertain risks of an earthquake for that night against the certain risks in staying outdoors in the Liaoning winter for an unspecified number of nights. The cold weather was not a trivial factor, as reflected in the number of deaths due to hypothermia after the earthquake, which will be discussed in the Deaths and Injuries section.

The situation in the two days before the earthquake must have been very confusing. A rather peculiar example is recorded in the notebook of Yingkou County's Earthquake Office (in the town of Dashiqiao) on 3 February 1975 (6 – 3). One director asked the office to tell two local committees to pay close attention to a reservoir near them but not to inform the masses about the worsening earthquake situation. Because the Shipengyu Observatory could detect numerous unfelt small earthquakes, government officials and earthquake workers knew the real situation better than did the public. Concealing earthquake information from the public, perhaps to prevent panic or just out of bureaucratic habit, seems to be completely contrary to what the earthquake workers were trying to do. To this director, the situation was certainly not serious.

Undoubtedly, the foreshocks were powerful messages from nature, making it easier to persuade people to leave

their houses. Because of the frequent foreshocks, warnings from the province, local governments, and nearby observatories were taken much more seriously than earlier false alarms. Some individuals, especially those who had their houses damaged, may have voluntarily decided to stay outdoors until receiving clear assurance that it was safe to return inside. In Hua Guofeng's 9 May 1975 speech (5 – 8), he mentioned that some peasants in the Yingkou County told him that they had stayed outdoors during the night before the main shock. An evacuation example from Haicheng County (Dingjiagou Brigade) cited in the preceding section also mentioned that people had stayed in shelters during that night. There was no official provincial or county warning on 3 February. It cannot be ruled out that these peasants may have had some unofficial warning from the county's Earthquake Office, but their direct apprehension of foreshocks was probably the primary reason.

How the afternoon decrease of foreshock activity was interpreted seems to have made a vital difference. By the evening when the outdoor temperature was becoming less and less comfortable, it must have been quite a temptation to assume that the earthquake risk had diminished. People killed in the Haicheng guesthouse may have made this assumption. Most workers of the provincial Earthquake Office, however, believed that the worst was yet to come. In the 2004 interviews, several of them said that they had this "gut feeling" because of the overwhelming precursory anomalies they had seen over the past month. There is a record in the log book of Anshan City's Earthquake Office (6 – 5): at 2:40 p.m. on 4 February 1975 (during the relative foreshock quiescence), Zhu [Fengming] of the provincial Earthquake Office in Shenyang, when answering the phone and listening to reports, "estimated that a large earthquake might occur." Workers of the provincial Earthquake Office and other offices and observatories deserve thanks for their intuitive judgment that afternoon.

The readiness of the local committees to respond to imminent warnings or equivalent messages from higher government levels or other sources, and the readiness of the masses to comply can be explained by the education efforts prior to the earthquake, since June 1974. The psychological effect of State Council Document 69 and the educational effect of the massive precursory monitoring campaign were both important factors. Ralph Turner made the following observations in the "Mobilizing the Masses" section of the U.S. delegation report (Raleigh *et al.*, 1977).

> In this process, at least two things of importance had happened. Scientifically based medium- and short-term predictions from the national and regional arenas had been discussed by many county and local leadership groups, so that they were prepared to respond to the local signs of earthquake imminence. And many of the leadership groups had become responsibly involved in the impending decision process when they joined in establishing amateur observation groups within their own units and began to receive reports from them. Presumably, both of these developments would have contributed toward the readiness of civil unit leaders to make the difficult decision of February 3 and 4.

Damage and Effects of Prediction Efforts

Damage

The damage caused by the Haicheng earthquake is summarized by Quan (1988): "The earthquake damaged 5,080,000 m^2 of urban housing, 867,000 rural house rooms, 1,670,000 m of various transport pipelines and lines, over 2000 bridges of different types, and over 700 hydraulic facilities. Sand fountaining buried more than 180 km^2 of farmland. The total economic loss was about 0.8 billion yuan, with 61% in cities and 39% in the countryside." Note that it was customary to measure living space (including schools, offices, and factories) by area in urban areas but by the number of rooms in rural areas. The "urban housing area" includes the construction area of individual floors of multistorey buildings.

Damage estimates made by the Liaoning Seismological Bureau (successor of the provincial Earthquake Office) in a secret document a year after the earthquake were generally greater (2 – 22). For example, it said 14,630,000 m^2 of urban housing and 1,840,000 rural rooms were damaged, and the total economic loss was estimated to be 1 billion yuan. Later estimates reported by Quan (1988) are probably more accurate. Early estimates may have been inflated in order to seek more financial aid from the central government. Because these damage estimates did not affect the propaganda value of the prediction, we do not think any conscious effort was made to alter the facts for political purposes.

Deaths and Injuries

The issue of death toll, like many other issues, became confusing because it was kept secret during and shortly after the end of the Cultural Revolution. Geller (1997) contrasted phrases like "few fatalities" in four references, all published by foreign writers during 1975–1978, with the death toll of 1328 reported by Quan (1988) and said: "The large disparity between the reports of 1975 and 1988 casts doubt on claims for the Haicheng prediction." There is actually no real disparity, because death toll information was simply not available to foreign writers in the 1970s.

Discreetly, earthquake workers in Liaoning worked very hard to obtain accurate casualty estimates, because the State Council wanted the numbers badly. Survey sheets were distributed to all communes and city units to obtain casualty statistics. In our document search, we have seen a number of versions of those sheets (2 – 20), demonstrating how the numbers were collected, checked, and refined. In the archives of the now Haicheng City, we found a list of names of all people who died in the county of Haicheng due to the 1975 earthquake, with their age, gender, and cause of death clearly indicated (4 – 11). The list was completed in March 1975.

We found the following numbers from telephone records of the Liaoning provincial Earthquake Office in Shenyang (2 – 20). On 13 February 1975 the numbers reported to the central government delegation (led by Vice Premier Hua Guofeng) to the disaster region were 1475 dead (excluding deaths caused by fire and hypothermia) and 16,618 injured. At 17:15 on 15 February the numbers reported to the State Council by telephone were 1395 dead and 17,875 injured. At 19:00, 19 February, civilian casualties reported to the State Council, again by telephone, were 1380 dead and 17,875 injured, with a breakdown for individual cities, towns, and communes. The next day, 21 dead and 401 injured in the army were added to the numbers. These numbers are meant to represent casualties caused by collapsing buildings only. It is unclear why the State Council did not require statistics of casualties due to related causes such as fire. Perhaps it was a preemptive effort to prevent local governments from inflating numbers in order to get more aid.

On March 19, 1975, a secret document by the Medical Group of Liaoning Provincial Earthquake Relief Command Post (3 – 17) reported that the earthquake (ground shaking) killed 1475 and injured 16,618, fires after the earthquake killed 187 and injured 1302, and the freezing temperature caused "a number of" casualties.

The number 1328, later reported by Zhu and Wu (1982), is the widely quoted official death toll of the Haicheng earthquake. They refer to the number as deaths caused "directly" by the earthquake (i.e., ground shaking only). In a 2004 interview, one of the authors, Mr. Wu Ge, explained that earlier statistics of direct deaths were higher because some local committees inflated the numbers in order to obtain more government financial aid.

More complete statistics were given in an article by Li (1986) a few years later. In addition to the 1328 deaths, he reported that there were 4292 with severe injuries and 12,688 with minor injuries in the "direct" category. For the first time, he also clearly explained the meaning of "indirect" casualties by reporting that 372 people died from freezing, suffocation, or CO poisoning, 6578 people suffered frostbite, 341 died in fires, and 980 suffered burning injuries. Many of the temporary shelters were unable to resist the freezing weather, and some of them caught fire. The same numbers were later reported in Liaoning Province Local History Compilation Committee (1996), with breakdowns for each affected county. According to the March 1975 victim list from Haicheng (4 – 11), 808 people in this county were killed due to building collapse, accounting for 61% of the total number of direct deaths. Also in this county, 109 people died of hypothermia, including 64 children aged 2 and younger, 58 people died in fires, and 43 people including 38 children aged 2 and younger died of suffocation because too much material was used to cover them to keep them warm in shelters. Combining "direct" and "indirect" causes, the total death toll of the Haicheng earthquake is 2041, and the total number of people injured is 24,538.

Reasons for the Low "Direct" Fatality

Zhu and Wu (1982) indicated that the total population of the disaster region was 8.3 million. The number depends on how the disaster region is defined. But even if the population is assumed to be only 1 million, the number of deaths is still exceedingly small, given the extensive collapse of houses. The number of severe injuries is also very small. After visiting the disaster region, Raleigh *et al.* (1977) estimated that "casualties in excess of 100,000 would have ordinarily been anticipated."

Organized evacuation, for whatever reason, certainly saved many lives. For example, had the Headquarters of the 39th Army proceeded with the stage performance, the consequence would have been disastrous (Publicized and Unpublicized Evacuation Examples section). A reasonably fair comparison between Haicheng and Yingkou counties can be made using the number of "direct" casualties (dead and injured) normalized by the number of collapsed rooms within each county. According to Liaoning Province Local History Compilation Committee (1996), total direct casualties in Haicheng and Yingkou Counties were 13,150 and 1567, respectively. Based on a table of statistics (2 – 20) prepared by the RCL Earthquake Office on 16 February 1974, the numbers of collapsed rooms in Haicheng and Yingkou including both rural and urban areas were 436,703 and 144,844, respectively. We referred only to this table because in later reports urban house damage was measured in area instead of number of rooms. The numbers indicate that for every 1000 collapsed rooms, there were 30 casualties in Haicheng but only 11 in Yingkou. Uncertainties in counting collapsed rooms cannot explain the significant difference between the two counties. What made the difference is probably the much better evacuation work in Yingkou County (see the Evacuation in Yingkou County and Action and Inaction in Haicheng County sections).

It is intriguing that fatalities were relatively low even for areas with no organized evacuation. Based on discussions with a number of witnesses and our own observations, we think the traditional wood-frame houses of southern Liaoning and the time of the earthquake played important roles.

Traditionally, houses in that area are built with a mixture of wood and bricks. A wooden frame is first constructed and firmly attached to the ground. The frame consists of several pillars and beams, usually each made out of a single tree, and a wooden roof truss. Brick walls fill the space between the pillars, and there are no bearing walls. The first layer of the roof, directly nailed to the truss, is usually wooden boards. A very thick layer of thatch straw or brick tiles is then used to cover the wooden boards to make a complete roof. The wooden frame was very resistant to ground shaking. When a house is said to have collapsed during the Haicheng earthquake, it is usually the brick walls that collapsed. For those with brick tiles on the roof, the tiles typically slid down the roof slope onto the ground outside.

Stripped of their walls and roof but still standing, these wooden house frames became a common sight of the post-earthquake epicentral area (Fig. 9).

A small number of those who stayed inside were killed by inwardly collapsing walls. Some were severely injured, but most were unharmed or suffered only minor injuries. The majority of the families in both rural and urban areas around the epicenter lived in similar houses, and most of them survived house collapse even if they did not stay outdoors. Some people were killed or injured by brick tiles falling off the roof when trying to escape, and casualties due to this cause must be significant. In 2004, when we interviewed a resident of the town of Haicheng who experienced this earthquake, he really wondered whether it would have been safer to stay calmly inside or to run out.

The most dangerous buildings were the more modern ones built only with bricks and concrete (not re-enforced), especially the relatively few two- or three-storey buildings. These were office buildings, department stores, movie theatres, assembly halls, guesthouses, factories, schools, and so forth. It was very fortunate that the earthquake occurred after work, while many of these buildings were vacant. The civilian Yingkou County moratorium did not prevent the 39th Army from using the assembly hall in the town of Dashiqiao, but as we have seen, the hall was fortuitously evacuated just in time.

The time of the earthquake might be responsible for the low casualty for another reason. During the Tangshan earthquake in 1976, on the top of the list of causes of death was choking by dust (Chen *et al.*, 1988). The Tangshan earthquake occurred at 3:43 a.m., when people were fast asleep. Suddenly woken up in a terrible scene and unaware of what was happening, people screamed and inhaled the dust generated by house collapse. Had the Haicheng earthquake occurred during sleep hours, many people might have died for this reason.

Although the "indirect" casualties due to fire and hypothermia are unproportionally high by modern standards, the situation might have been even worse had not been for the education campaign before the earthquake and various official and unofficial warnings. In 2004, we interviewed a survivor in the town of Haicheng who lost his sister in the earthquake. His story is probably very representative.

On 4 February 1975, the man heard rumors of an earthquake for that night from various unofficial sources. By 7:30 p.m., it was bedtime for his two young children. Not knowing exactly what to do, he decided to put the children to bed with their winter clothes on so that they could readily escape and remain warm in case of an earthquake. When the earthquake occurred at 7:36 p.m., he snatched the children from bed, holding one under each arm, but he did not have time to run out. Luckily, the collapsing walls did not harm them. The decision to let the children sleep with their winter clothes on proved to be a wise one. The children survived the cold night after the earthquake had destroyed their house. Several others we interviewed also mentioned that they were wearing winter clothes in preparation for an escape.

Recognition of the Prediction Efforts

The earliest accounts of pre-earthquake warning and evacuation were given the day after the earthquake in the third special issue of the SSB (restricted) series "Earthquake Situation" (7 – 7). After reporting the severe damage, it went on to say:

> Small earthquakes increased in the morning of the 4th, and the provincial Earthquake Office [in Shenyang] reported the situation to the provincial Party Committee. Following the Committee's directives, Earthquake Office workers went to Haicheng and Yingkou to arrange preparation work. Most of the 80 plus families in the Zhuanwanzi Brigade of Bali Commune, Haicheng County, moved to the outdoor before the earthquake.

Figure 9. Examples of damaged or collapsed houses in Haicheng County to show the shake-resistant nature of their wooden frames. Left: Chagou Commune. Right: Ganwang Commune. See Figure 6 for locations of the communes.

> Ninety percent of the houses collapsed, but only two people were injured. There are more than 110 families in the Laoda Brigade of Ximu Commune. Seventy percent of their houses collapsed, but only three people were injured.

See Figure 6 for the locations of the two communes mentioned here. Two days later, Zhou Rongxin, leading cadre of the CAS mentioned at a meeting that he had read about the prediction work from Confidential Reference Materials of People's Daily (an internal publication to be read by very high-rank Party officials only) (5 – 6).

The process of publicizing the Haicheng prediction appears to have been influenced by the political situation in China. With Chairman Mao's health deteriorating, friction between the Gang of Four (Appendix C) and other Party leaders, including Mao's would-be successor Hua Guofeng, intensified. Mao Yuanxin and the Liaoning provincial Party Committee were keen followers of the Gang of Four. On 10 February the eighth special issue of SSB (restricted) series "Earthquake Situation" reported comments made on 8 February by then Vice Premier Hua Guofeng who was visiting the disaster region (7 – 8). He praised Shipengyu Observatory's prediction work and the evacuation work in various places, without mentioning the Liaoning provincial Party Committee. Two hours later, the SSB issued the ninth special issue and provided an outline of the prediction story (7 – 9). The outline praised the leadership of the Party Committee of Liaoning Province, without mentioning the Shipengyu Observatory and the Yingkou County government, and cast the prediction work into a four-stage procedure (long-term, middle-term, short-term, and imminent). All subsequent descriptions of the prediction of the Haicheng earthquake (e.g., Yingkou City Editorial Group, 1975; Jiang, 1978), including stories told to foreign visitors, built upon this official outline. At this time, the Gang of Four was in complete control of the country's propaganda machines.

In the months to follow, Hua Guofeng continued to praise the Shipengyu Observatory and Yingkou County, while other official reports continued to emphasize the leadership of the provincial Party Committee. In these official reports, details that did not help accentuate the central theme of the provincial Party Committee's leadership, such as Yingkou County's emergency meeting and evacuation order being earlier than the general provincial warning, were ignored or kept vague. This momentum was continued after the Cultural Revolution and on until today. After Chairman Mao's death and the end of the Cultural Revolution, most senior officials in the Party Committee and Revolutionary Committee of Liaoning Province were ousted because of their connection with the Gang of Four. Hua Guofeng personally ordered the arrest of Mao Yuanxin in October 1976.

An official propaganda campaign began on 13 March 1975, when all major Chinese newspapers published a press release by Xinhua News Agency from the day before. The opening paragraph of the press release is as follows:

> The State Council issued a general notice today, complimenting units that rendered meritorious services in the analysis-prediction of the southern Liaoning earthquake. The notice said: At 19:36, 4 February 1975, the Haicheng-Yingkou area of southern Liaoning Province was struck by a magnitude 7.3 strong earthquake. The earthquake-work team of our country predicted this earthquake; under the unified leadership of the Liaoning Provincial Committee of the Chinese Communist Party, the Party [members], government, army, and masses in the epicentral area took timely and effective preventative measures, so that losses caused by the earthquake in this densely populated area were greatly reduced. This is a vivid demonstration of the superiority of our country's socialist system. This is a great victory of Chairman Mao's proletarian revolutionary line!

Here the key phrase is "under the unified leadership of the Liaoning Provincial Committee of the Chinese Communist Party." After the Cultural Revolution, this paragraph was still quoted in publications about the Haicheng earthquake, but politically astute authors replaced the key phrase with "under the unified leadership of the Central Party Committee and Party Committees of all levels" (e.g., Jiang, 1978).

Discussions on Precursory Anomalies

Chinese earthquake workers separate precursory anomalies into microscopic and macroscopic (e.g., Zhu and Wu, 1982). The former are those that are detected with modern instruments, either professionally or by amateur groups, such as changes in seismicity, geodetic deformation, water chemistry, geomagnetic field, telluric current, crustal stress, and so forth. Macroscopic anomalies are those reported by observers with or without primitive measuring tools, such as changes in animal behavior, groundwater (level, flow, color, smell, etc.), unusual light or sound, and so forth. Microscopic anomalies monitored by amateur groups prior to the Haicheng earthquake were mainly changes in telluric current. There were more than 70 such monitoring groups within 100 km of the future epicenter (Zhu and Wu, 1982).

Truthfulness of Reported Anomalies

Although it is impossible to verify each anomaly report, there is no evidence that there was systematic fabrication of anomaly reports after the earthquake. The log books of the Shipengyu Observatory and the Earthquake Office of Anshan City and the notebook of Yingkou County's Earthquake Office contain many, albeit incomplete, reports of macroscopic and microscopic anomalies.

Many of the microscopic anomalies have been scrutinized by the U.S. delegation (Raleigh *et al.*, 1977). One exception is the telluric current readings responsible for the prediction by the Haicheng amateur observatory (see Action and Inaction in Haicheng County section). We found that in the SSB document to promote the observatory as one of the six units that rendered "meritorious services in the analysis-prediction of southern Liaoning earthquake" (7 – 10), the

time of their reading jump was altered from before 2 p.m. to 3:50 p.m., so that the 7:36 p.m. earthquake was nearly within the observatory's predicted 3-hour time window. This explains why such a celebrated data set was not shown to the U.S. delegation. However, incidents like this seem to be rare.

Usefulness of the Anomalies in Predicting the Haicheng Earthquake

As others have concluded, the foreshock sequence (Fig. 7) was the most important evidence used in the imminent prediction of the Haicheng earthquake. Routine description of the foreshocks has the sequence beginning with an M_L 1.4 event recorded by the Shipengyu Earthquake Observatory on 1 February at 1:35 a.m., followed by seven similarly small events on 2 February (Wu *et al.*, 1978). In the log book of the observatory, only four events were recorded for 2 February. The additional three events must have been identified through reanalysis of seismograms after the earthquake. The five small earthquakes known seismically on 1 and 2 February were not accompanied by any felt reports and did not attract much attention (Appendix D). Useful information at the time from the entire foreshock sequence included the large number of events, their increasing magnitudes, their consistent direction and distance from the Shipengyu Observatory, and most directly, the damage they caused. More quantitative aspects of the foreshocks, such as the *b*-value and source location, were not studied until after the Haicheng earthquake.

To the workers of the Liaoning provincial Earthquake Office, the Jinxian leveling data and other professionally made observations, such as the radon and tilt anomalies discussed by Raleigh *et al.* (1977), were useful in sending alerting signals months and weeks before the earthquake, although there is no evidence that these data played any role in the provincial imminent prediction.

The workers did not have time to analyze anomalous telluric current changes reported by amateur workers, nor did they seem to be very interested because of observational noise and artifacts. Some of the amateur telluric observations shown by Raleigh *et al.* (1977), such as those obtained by middle school students, were regularly mentioned during group discussions of the provincial Earthquake Office (6 – 2) but never quoted in its official reports. These observations became prominent in propaganda campaigns after the earthquake. The merit of the massive amateur involvement in microscopic precursory monitoring before the Haicheng earthquake is in its educational effects, as discussed in the Basis for Evacuation Decisions section, not in its scientific contribution.

The macroscopic anomalies, on the other hand, were more useful to the professional workers. For one thing, the reports were easier to deal with than the amateur microscopic observations. The workers did not have to worry too much about observational noise but only needed to assume that most of the observers were honest and had used their common sense.

About the macroscopic anomalies and professionally observed microscopic anomalies, we learned the following two points from our discussions with former earthquake workers in Liaoning. First, the workers would not attach much significance to an isolated report, such as on radon fluctuation and aberrant animal behavior, but they would pay some attention to many reports that showed an unusual temporal and spatial pattern. Second, the role of these reports was to alarm earthquake workers. The workers did not know how to use these reports directly for prediction, but they found the pattern of their appearance alarming on the basis of past experience, such as what was recorded in ancient Chinese documents, for example "Yinchuan Xiaozhi" (Wang, 1755) (see the Evacuation in Yingkou County section), and occurrence of similar patterns accompanying other recent earthquakes in China.

Relation of the Anomalies with the Earthquake

For some of the anomalies, their theoretical relation with earthquakes may require decades or centuries of research. An empirical answer can be based on anything between the lack of other obvious causes and a significant correlation established with many earthquakes. For the Haicheng earthquake, the relationship of most of the reported anomalies to the earthquake is uncertain but cannot be ruled out.

In addition to the undisputable foreshocks, we find it difficult to ignore reports of changes in groundwater level and animal behavior. This is not to say that the other anomalies can be easily ignored. The difference is in the spatial coverage. Tens of reports from different places in the area are more difficult to ignore than, say, a fluctuation of water radon in one well.

Reports of such macroscopic anomalies for three months before the earthquake and for a region extending over 150 km from the epicenter in all directions were synthesized by Deng *et al.* (1981). The daily numbers of reports of groundwater change, snake or frog sighting, and aberrant behavior of other animals from 1 December 1974 through 4 February 1975, the day of the Haicheng earthquake, shown in their article are reproduced in Figure 5a. Because their data were based mainly on interviews of witnesses after the Haicheng earthquake, we were concerned about psychological effects of the earthquake, that is, witnesses might begin to remember phenomena that they would not have had paid attention to had there not been the earthquake.

For this reason, we searched for reports that were recorded prior to the earthquake. The best collection of such reports is those recorded in the log book of the Shipenyu Observatory, shown in Figure 5b. Deng *et al.* (1981) neither used nor saw this log book (Deng, personal communication, 2005). Yingkou County's Earthquake Office's notebook and Cao's Briefing Notes (Evacuation in Yingkou County sec-

tion) also contain many anomaly reports, but not in a systematic way. Two pages of the Shipengyu Observatory's log book are shown in Figure 10 as an example. What was recorded in the log book must be from a much smaller area than covered by Deng *et al.* (1981) and must be a small fraction of the anomaly observations, because not everyone regularly communicated with this observatory, but we think it is a representative and objective data set. In both data sets in Figure 5, there were few or no records of macroscopic anomalies until late December 1974. The increase in anomaly reports was not related to the timing of earthquake education campaigns, which took place a few months earlier (3 – 1, 2 – 4, 2 – 5, 2 – 6).

The 22 December 1974 Liaoyang-Benxi earthquake swarm (M_L 5.2 Liaoyang-Benxi Earthquake, 22 December 1974 section) did not immediately trigger a rise in the number of anomaly reports either around the Shipengyu Observatory or in the larger area. Nor did the three false alarms issued by the RCL on 23 December (False Alarms section). An increase in anomaly reports in late December preceded the major false alarm issued on 31 December. This pattern does not suggest a strong influence of the earthquakes and predictions on people's attention on anomalous phenomena. The major increase of anomaly reports in early January, particularly on 4 January, may be attributed to the influence of the 31 December false alarm. The log book recorded a small

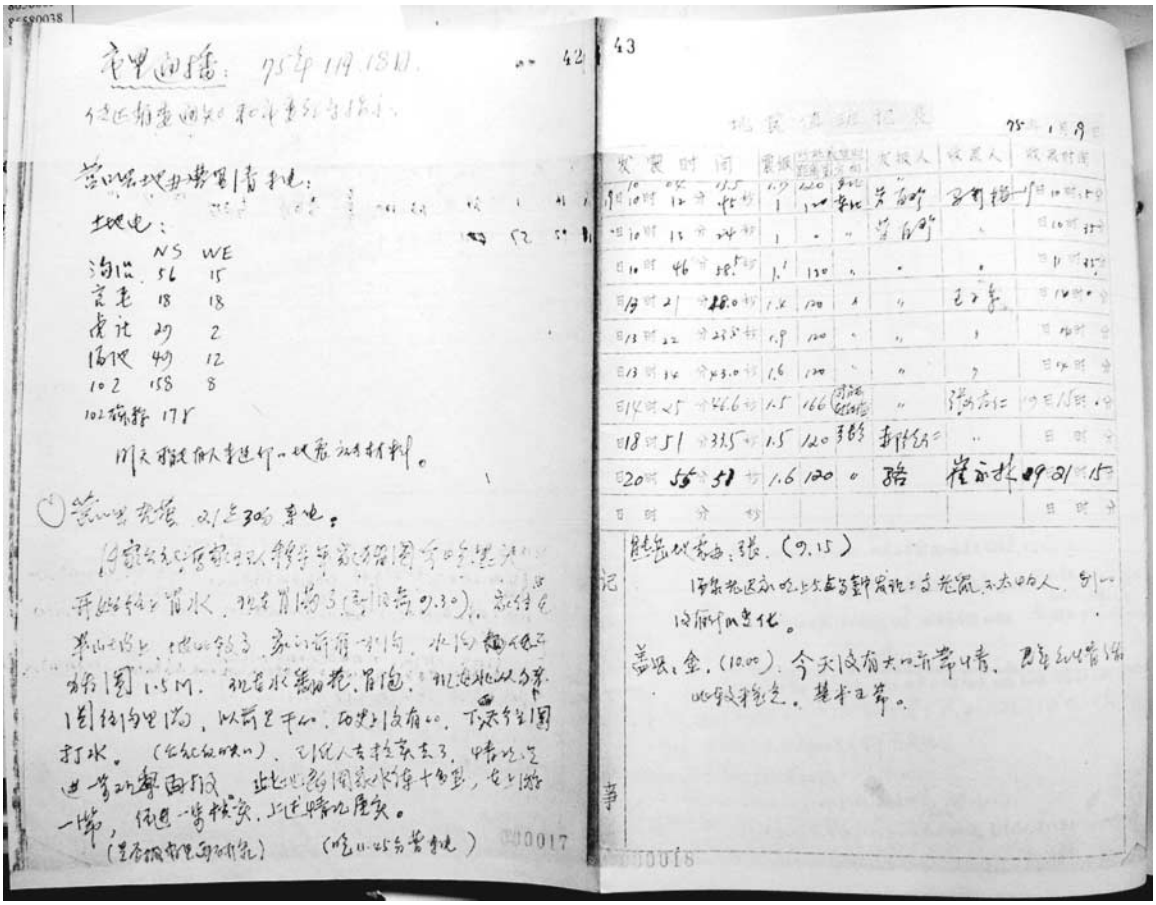

Figure 10. Two pages of the 1975 log book of the Shipengyu Observatory that contain anomaly reports. Upper half of left page (18 January): "Cao Xiangqing of Yingkou County Earthquake Office phoned; amateur telluric current readings: . . . [list of readings from five amateur groups]." Lower half of the same page: "Mr. Cao phoned from Yingkou County at 21:30; water suddenly began to ooze from the ground in Mou Guangjun's pigpen in Fengjiafu Brigade of Zhoujia Commune. Now (9:30 p.m.) [the pen is] full of water. His yard is on the slope of a relatively high hill. There is a ditch in front of his yard lower than the pigpen by 1.5 m. Now water is turning and bubbling. Now water is flowing to the ditch from the pigpen. [The pigpen] was dry before. It's never happened in history." The sentences in the two pairs of parentheses are: "Whether to report this to the province needs further discussion" and "Cao called [again] at 11:45 pm". Lower half of right page (19 January): "Zhang of Xiongyue [County] Earthquake Office (9:15): three mice were seen unafraid of people in Mr. Chi's residence in Wenquan past 6 p.m. No other changes."

earthquake in the Xiongyue area with a number of felt reports on 13 January and a felt report on 19 January, but these events did not prompt an increase in anomaly reports. What seems to be the most interesting is that the number of reports sustained through January and sharply rose around 23 January, opposite of the decreasing trend in both seismicity and attention paid to earthquake prediction during this time (Provincial Prediction and Warning section).

These anomalies could be interpreted as precursors of the Haicheng earthquake. The sharp rise in the number of reports on 1 and 2 February 1975, shown by Deng *et al.* (1981), may reflect some psychological effects, since no such reports were recorded in Shipengyu Observatory's log book for these two days. From the evening of 3 February, when the foreshock activity escalated, the anomaly reports became even more difficult to evaluate. However, some anomalies are too large to ignore. For example, the log book of Anshan City's Earthquake Office recorded a telephone message from a hospital at Tanggangzi hot spring (northeast corner of Fig. 6) on 4 February 1974 at 4:45 a.m., which reported that the flow rate from the hot spring had suddenly increased by about one-third.

Among the animals, the most difficult to ignore are the snakes coming out hibernation dens when the average temperature was much below freezing. There were nearly 100 snake sightings within one month prior to the earthquake (Zhu and Wu, 1982). Although they must represent a tiny fraction of the total snake population in southern Liaoning, such suicidal behavior is extremely difficult to explain. What the snakes and other animals sensed is not known. It could be as simple as vibrations caused by earthquake tremors that were not detected by the then very sparse seismic network.

Although Jinxian leveling data did indeed contribute to the predictions made in June 1974 and January 1975, their actual relationship to the Haicheng earthquake is not understood. On the east–west line (Fig. 3), elevation of the eastern end with respect to the western end continued to increase after the June 1974 conference until shortly before the Haicheng earthquake, then decreased rapidly until the 1976 Tangshan earthquake (Fig. 3). The Haicheng earthquake was not the immediate cause for this abrupt change, because it occurred later. A few much less frequently surveyed longer leveling lines closer to the epicenter did not show the same temporal behavior, although they were consistent with a general tilt of the Liaodong Peninsual down to the northwest (Raleigh, *et al.* 1977). The 1975 Haicheng earthquake eventually occurred some 200 km northeast of the Jinxian leveling site, not on the Jinzhou fault (Fig. 2). The 1976 Tangshan earthquake was to the west of the leveling site, also about 200 km away. However, not being able to model the relation between the leveling anomaly and these earthquakes does not rule out the existence of a relationship. While the physical model is unknown, the temporal pattern of the Jinxian leveling changes shown in Figure 3 suggests a relationship between these changes and the Haicheng and Tangshan earthquakes. The real challenge is whether the relationship can be used for prediction purpose.

Jackson (2004) questioned the relevance of the Jinxian anomaly because it did not climax with the Haicheng earthquake and "measurements much closer to Haicheng did not show similar tilts." The expectation that an anomaly should be strongest at the time of the earthquake and nearer to the site of the future earthquake is based on a temporally and spatially smooth mechanical model and is probably too simplistic. Depending on the mechanism (e.g., if viscous deformation in the lower crust or upper mantle is involved), an anomalous phenomenon can be of a low-frequency nature and may not show rupturelike coseismic changes, even though it may be part of the same process that leads to the earthquake. If the governing process has a large spatial scale, seismic rupture in one place with slow deformation in another place 200 km away before and/or after the earthquake is not an unreasonable scenario.

Applicability of the Precursory Anomalies to Other Earthquakes

Can similar anomalies be used as precursors to other earthquakes? This question is the most fascinating but is inducive to misleadingly superficial answers. For any one type of anomaly, the answer to the question may be "no." For example, use of significant foreshocks, the most important precursor for Haicheng, was not applicable to the disastrous 1976 M 7.8 Tangshan earthquake (Fig. 1). Within two months prior to the Tangshan earthquake, not a single foreshock was detected by the regional seismic network that could detect events of $M_L \geq 1.7$ (Chen *et al.*, 1988) or $M_S \geq 1$ (SSB Editorial Group, 1982), although some other types of anomaly that had preceded the Haicheng earthquake also to some degree preceded the Tangshan earthquake (SSB Editorial Group, 1982). What geological structures could account for the difference in the foreshock patterns between the two large earthquakes? This is an important question yet to be addressed. No obvious anomalies were observed prior to the M 6.0 Parkfield, California, earthquake of 2004, despite the massive instrumentation on site in anticipation for this event (Bakun *et al.*, 2005). Reports of precursory anomalies are also absent for many other earthquakes on Earth. What is responsible for the presence or absence of precursory signals is also an important question to be addressed.

The use of one type of "diagnostic" precursory anomaly for earthquake prediction is likely unrealistic. Earthquakes are sufficiently different from one another to cause different anomalies. Earthquakes also modify geological structure and affect certain rock properties (such as permeability and porosity), such that the same anomaly may not occur, or occur differently, for two consecutive earthquakes in the same region. Besides, there are numerous anomalous phenomena that are not followed by earthquakes.

However, since earthquake is a failure process that involves rupture initiation, some combination of different

anomalies may precede some large earthquakes. Before proceeding with experiments and statistical analysis, some careful studies of the anomalies' local environments are needed. It is simplistic to expect, for example, that earthquakes in all geological conditions should be preceded by similar diagnostic electrical signals and that animals in southern California and most of Japan, which regard earthquakes as a fact of life, should panic in the same way as animals in the Haicheng-Yingkou area, where seismicity is normally lower.

Here is one example to show the need for site-specific studies. Before the Haicheng earthquake, there were a few sightings of groups of disoriented mice unresponsive to people and cats around them. They represent a tiny fraction of the total mouse population in that area, and their behavior must have some site-specific reason. One possibility is that their dens were invaded by some toxic gas emitted from the ground, perhaps due to fracturing before the large earthquake. Without knowing what happened to these mice, why most other mice were not bothered in this way, it will be unfruitful to try to use mouse behavior as an earthquake precursor.

Conclusions

Our findings have largely confirmed the sequence of events before the Haicheng earthquake that the U.S. delegation was told during their visit to China in 1976 (Raleigh *et al.*, 1977), with the following four significance disparities. (1) The events do not fit the ideal model of four-stage (long-term, middle-term, short-term, and imminent) prediction. In particular, there was no official short-term prediction, although such a prediction was made by individual scientists. (2) We have noticed some major factual inaccuracies in the story they learned. For example, the claim that on 4 February 1975 the provincial government was "given a prediction of a strong earthquake near Haicheng for that day" is untrue. (3) The story publicized and told to foreigners in the 1970s was biased by a desire to emphasize the leadership of the Party Committee of Liaoning Province. Details were either neglected or exaggerated to help emphasize this point. (4) The importance of amateur microscopic-anomaly, such as telluric currents, monitoring was exaggerated in the story told to foreigners and the public.

Our findings show that, within months prior to the event, there was indeed a general middle-term prediction for magnitude 5–6 earthquakes to occur within one or two years in the north Bohai Sea area and five other places in north China. The focus of attention in Liaoning was around Jinxian, an area some 200 km southwest of the actual epicenter. There were a number of false alarms within one and half months prior to the earthquake, in the aftermath of an earthquake swarm some 60 km northeast of the future epicenter, which was later considered to have been caused primarily by the filling of a reservoir. Less than a month before the earthquake, there was another official middle-term prediction for a magnitude 5–6 earthquake to occur within a year in the region of Liaodong Peninsula including Yingkou-Haicheng, together with similar predictions for three other places in China.

On the day of the earthquake, Yingkou County was the first to issue an imminent prediction, and there were unofficial imminent predictions by professional or amateur earthquake workers in other places later during the day. None of these predictions can be scientifically explained. There was no explicit provincial imminent prediction, but a report from earthquake workers to the Liaoning provincial government in the morning of 4 February 1975, and the ensuing government announcements effectively constitute an imminent prediction.

Warning issuance and evacuation were very uneven across the disaster region. In Yingkou County, an explicit and firm evacuation order was issued before any provincial warning. In other places, evacuation decisions were made by local committees or individuals that were influenced by the general warning from the provincial government. Many places, such as the town of Haicheng, were not evacuated.

The location of the impending earthquake became apparent because of foreshocks that intensified 24 hours before the main shock. However, except in some exceptional instances such as in Yingkou County (see the Evacuation in Yingkou County section), the time of the impending earthquake was never specified, and the magnitude was underestimated. The general lack of specific time prediction, however, was to a large extent compensated by the actual actions taken by earthquake workers and government officials.

Jinxian leveling data were the primary basis for the two middle-term predictions. Changes in groundwater level, color, and chemistry, and animal behavior also played a role in alarming the public. Amateur microscopic-anomaly monitoring served to spread earthquake knowledge and enhance earthquake awareness. Our study has confirmed that it was the foreshocks alone that triggered the final decisions of warning and evacuation, as concluded in the U.S. delegation report and nearly all other studies of this earthquake (Raleigh *et al.*, 1977; Scholz, 1977; Wu *et al.*, 1978; Jones *et al.*, 1982; McNally, 1982; Zhu and Wu, 1982). The Haicheng experience demonstrated that at least some earthquakes do have precursors that may lead to some prediction.

According to published statistics, 2041 people died during the Haicheng earthquake and 24,538 were injured, including 4292 severely injured. Measures taken by various levels of government on 4 February 1975 in the Yingkou-Haicheng area indeed saved thousands of lives. But we think the construction style in that region and the time of the earthquake also saved lives.

Although the prediction of the Haicheng earthquake was a blend of confusion, empirical analysis, intuitive judgment, and good luck, it was an attempt to predict a major earthquake that for the first time did not end up with practical failure. Revisiting this history has raised scientific questions about earthquake processes and precursors. It also has raised questions about the role of the government and public in

earthquake prediction and preparation. May history remember those who died in the Haicheng earthquake and those who helped others survive.

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Appendix A

Table A1 on following pages.

Appendix B

Chronology of Events in the Prediction of the Haicheng Earthquake

The title of the section detailing the event is given in parentheses.

1974

7–9 June National conference and the proclaimed middle-term prediction (June Conference and State Council Document 69, 1974)

15 June CAS report to State Council on the above conference (June Conference and State Council Document 69, 1974)

29 June State Council Document 69, endorsing the above report (June Conference and State Council Document 69, 1974)

23 July First RCL meeting devoted to earthquake problems (Kaiyuan Meeting of 25–27 November 1974)

25–27 Nov. SSB interprovincial meeting in Kaiyuan (Kaiyuan Meeting of 25–27 November 1974)

22 Dec. Earthquake swarm in Liaoyang-Benxi area (M_L 5.2 Liaoyang-Benxi Earthquake, 22 December 1974)

23 Dec. Three false alarms issued by RCL (False Alarms)

31 Dec. RCL false Prediction of M 5 event in Liaoyang-Benxi by 5 Jan. (False Alarms)

1975

4–5 Jan. Provincial meeting reinforcing the 31 Dec. prediction (False Alarms)

10 Jan. End of warning for Liaoyang-Benxi area (False Alarms)

13–21 Jan. National conference and the second middle-term prediction (The 13–21 January National Conference)

Gu Haoding's short-term prediction (The 13–21 January National Conference)

1 Feb. First foreshock at 1:35 (Provincial Prediction and Warning)

3 Feb. Foreshocks intensify in the evening with felt events; provincial Earthquake Office began to pay attention (Provincial Prediction and Warning)

4 Feb.

0:30 Proclaimed imminent prediction (Earthquake Information: Issue 14) written by Zhu Fengming (Provincial Prediction and Warning)

7:51 Largest foreshock (M_L 5.1) (Provincial Prediction and Warning)

8:00 Hua Wen ordered RCL Earthquake Office to call emergency meeting (Provincial Prediction and Warning)

8:15–9:00 Yingkou County's emergency meeting, Cao Xianqing's prediction for a large earthquake "today," and the county's evacuation order (Evacuation in Yingkou County)

10:30 Provincial general warning through telephone distribution (Provincial Prediction and Warning)

11:30 Provincial warning relayed to Yingkou County (Evacuation in Yingkou County)

14:00 Earthquake Information: Issue 17; foreshock-caused damage (Provincial Prediction and Warning)

14:00 Emergency meeting in Haicheng Guesthouse organized by provincial Earthquake Office (Provincial Prediction and Warning)

14:00 Prediction of $M > 4$–5 earthquake within 3 h by amateur Haicheng Observatory that triggered local evacuation (Action and Inaction in Haicheng County)

Before 18:30 Shipengyu Observatory informed people by phone to "be prepared for a possible large earthquake tonight" (Role of the Shipengyu Earthquake Observatory)

18:00–19:00 Haicheng County's emergency meeting (Action and Inaction in Haicheng County)

19:00–19:20 39th Army's greeting ceremony in Dashiqiao's assembly hall (Publicized and Unpublicized Evacuation Examples)

19:36 M 7.3 Haicheng earthquake

Feb. 5 Account of prediction in third special issue of SSB's Earthquake Situation (Recognition of the Prediction Efforts)

Table A1

List of Chinese Documents Relevant to the 1975 Haicheng Earthquake in Chronological Order, All Declassified

Index	Date, Time (dd/mm/yy)	Title and/or Type	Issuing/Publishing Organization/Individual	Notes*
2–1	10/10/70	Synopsis of investigation report on earthquake danger zones in the Kaiyuan-Dalian region of Liaoning Province	Earthquake Work Leadership Group, RCL	Kaiyuan-Shenyang-Yingkou-Dalian corridor singled out for danger of large earthquakes in Liaoning Province
7–1	15/05/72	Summary of precise leveling survey at Jinzhou (i.e., Jinxian) Observatory (experience exchange material)	Luda (i.e., Lushun and Dalian) City Earthquake Observatory	
7–2	09/72	Progresses in earthquake prediction work—report presented at the National Science and Technology Conference	SSB	
2–2	17/01/74	Opinions on earthquake outlook in Liaoning Province	SSB Shenyang Brigade	Ningcheng-Yixian and Yingkou-Dalian-Dandong named as two earthquake-prone areas in Liaoning; magnitude estimate ≤ 3
1–1	22/06/74	SSB Document 084, 1974: Notice to distribute Summary of Conference on Earthquake Situation in North China and Bohai Sea Regions	SSB	The acclaimed "middle-term prediction"; six places identified for M 5–6 earthquake potential within 1–2 yr, north Bohai being 2nd on the list
	(09/06/74)	(Attachment: the Summary named above)		
1–2	29/06/74	State Council Document 69, 1974: Forwarding Report by Chinese Academy of Sciences on Earthquake Situation in North China and Bohai Sea Regions	State Council of the People's Republic of China	State Council's cautious endorsement of SSB's 1–2-yr predictions
	(15/06/74)	(Attachment: the Report named above)	(Chinese Academy of Sciences)	
2–3	29/06/74	Report on earthquake situation in coastal regions of our province and on strengthening prediction and preparation work	RCL Earthquake Office and SSB Shenyang Brigade	Briefing on 7–9 June conference; written before receipt of SSB and State Council documents; suggestions to enhance earthquake work in the province
2–4	10/07/74	Earthquake Notes, Issue 12	RCL Earthquake Office and SSB Shenyang Brigade	Accounts of mass education campaign; effects of showing earthquake knowledge films
3–1	23/07/74	Minutes of a meeting of the RCL to relay State Council Document 69, 1974, and to arrange earthquake work in the province		First provincial government meeting dedicated to earthquake work
2–5	09/08/74	Report on follow-through of State Council Document 69, 1974	RCL Earthquake Office and SSB Shenyang Brigade	Administrative adjustment at various levels of government to enhance earthquake work
4–1	22/11/74	Notice about several attention-deserving issues in present earthquake work	Earthquake Work Leadership Group, Yingkou City	An effort to curtail public panic and overheat in earthquake education
2–6	25/11/74	Report on follow-through of State Council Document 69, 1974	RCL Earthquake Office and SSB Shenyang Brigade	Report of mass education campaign concerning earthquakes
1–3	27/11/74	Opinions on earthquake outlook in Northeast China (Conclusions of Conference on Earthquake Outlook in Northeast China)	Conference on Earthquake Outlook in Northeast China (held in Kaiyuan)	Listed six places in the three northeastern provinces for near-future earthquake potential, including Yingkou and Dalian of Liaoning Province
2–7	27/11/74	Opinions on earthquake outlook in Liaoning Province	SSB Shenyang Brigade	Listed Jinxian, Yingkou for greater earthquake danger in near future; handwritten in Kaiyuan
6–1	01/12/74–07/02/75	Pages of log book of Shipengyu Earthquake Observatory	Shipengyu Earthquake Observatory	Logs of foreshocks and aftershocks; records of anomaly reports (animal, water level, etc.) and notes of telephone communication

(*continued*)

Table A1
Continued

Index	Date, Time (dd/mm/yy)	Title and/or Type	Issuing/Publishing Organization/Individual	Notes*
4–2	02/12/74	Comrade Shen Mu's directives on earthquake education work and Zhao's additional comments	Shen of Yingkou City government, Zhao of Yingkou County government	Criticized overheating in earthquake education; also in Cao p. 93
3–2	03/12/74	Circular on earthquake situation	RCL	Reports of felt earthquakes in Benxi; Cao p. 8
3–3	11/12/74	RCL Planning Committee Document 304, 1974: Notice to forward "Report on Strengthening Earthquake Work in our Province" by RCL Earthquake Office	RCL Planning Committee	Encouragement of amateur networks for anomaly monitoring
	(03/12/74)	(Attachment: the above named report)	(RCL Earthquake Office)	
2–8	17/12/74	Earthquake Information, Issue 10	RCL Earthquake Office and SSB Shenyang Brigade	Provincewide updates on small earthquakes; general alert; accounts of leveling, radon, electric inductance anomalies; also in Cao p. 8
6–2	20/12/74–07/02/75	RCL Earthquake Office group discussion notes	RCL Earthquake Office	Total 12 sessions: 9 during 20/12/74, 31/01/75; 3 during 05/02/75, 07/02/75
5–1	23/12/74	Typed records of oral instructions on Liaoning Province's earthquake preparation upon listening to reports on following through Mao Yuanxin's earlier instructions	Li Boqiu	In response to 22/12/74 M_L 5.2 (M_S 4.8) Benxi earthquake; demands for rapid reports and recommendations from RCL Earthquake Office; arrangements for emergency response
3–4	23/12/74, 19:00	Circular on earthquake situation	RCL	Reports of earthquakes in Liaoyang-Benxi area; prediction of M 4–5 earthquake in Panjin-Yingkou-Xiongyue region 25 Dec.–10 Jan., M 5 in Dandong area, and $M > 5$ near Jinxian in near future (all false alarms); accounts of leveling, water well, radon anomalies and snake sightings; also in Cao p. 6
4–3	24/12/74	Telephone distribution in response to 23 Dec. provincial circular on earthquake situation	Earthquake Office of Yingkou City	Cao p. 7
3–5	28/12/74	Circular on earthquake situation since provincial telephone distribution	RCL	Reports of felt earthquakes; mention of snake sightings and water level changes in wells
2–9	29/12/74	Concluding report of an overnight conference of all earthquake observatories of Liaoning Province (20:00 28/12–6:00 29/12)	RCL Earthquake Office	Continuing attention on Liaoyang-Benxi; continuing attention on Jianxian; Dandong acquitted
3–6	29/12/74	About group-discussion opinions on earthquake outlook in our province	General Office of RCL	Prediction of $M \sim 5$ in "near future" in Liaoyang-Benxi-Anshan and $M > 5$ in Panjin-Yingkou-Dalian
2–10	30/12/74	Earthquake Information, Issue 13	RCL Earthquake Office and SSB Shenyang Brigade	Reports of small earthquakes in Benxi City
3–7	30/12/74	Circular on earthquake situation	RCL	Identical with Earthquake Information Issue 13
4–4	30/12/74	Report on earthquake preparation work	Earthquake Office of Yingkou City	Handwritten; for city leadership only, not to be distributed
2–11	31/12/74	Group discussion conclusions	RCL Earthquake Office	Prediction of M 5 earthquake near Liaoyang-Benxi by 5 Jan. (false alarm)
3–8	31/12/74, 19:00	Circular on earthquake situation	RCL	Official announcement of the above prediction

(*continued*)

Table A1
Continued

Index	Date, Time (dd/mm/yy)	Title and/or Type	Issuing/Publishing Organization/Individual	Notes*
5–2	31/12/74–05/01/75	Typed records of oral instructions by provincial leaders	Mao Yuanxin, Yin Canzhen, Hua Wen	In response to the 31 Dec. prediction of *M* 5 event; account of 600 people leaving petroleum production field for fear of impending earthquake
2–12	01/01/75	Emergency response draft plan: Important issues in earthquake preparation in Liaoyang-Benxi-Anshan area	RCL Earthquake Office	As follow-up of the 31 Dec. prediction
5–3	04/01/75, evening	Opening speech at earthquake work meeting organized by Party Committee of Liaoning	Li Boqiu (based on hand-taken notes)	In response to 22/12/74 M_L 5.2 Benxi event; one account of earthquake-shelter fire causing death
5–4	05/01/75, morning	Speech at earthquake work meeting organized by Party Committee of Liaoning	Yin Canzhen (based on hand-taken notes)	Promotion of "a false alarm is better than a miss"
3–9	05/01/75, 20:00	Circular on earthquake situation	RCL	Reports of small earthquakes in Liaoyang-Benxi area and one event near Dandong
3–10	07/01/75, 22:00	Circular on earthquake situation	RCL	Reports of small earthquakes in Liaoyang-Benxi area and other areas, sighting of groups of rats on highway, well water color change
4–5	08/01/75	Earthquake Information, Issue 2	Earthquake Office of Yingkou City	One account of earthquake rumor; handwritten
4–6	08/01/75	Speeches at a city government meeting on earthquake preparation	Party Secretary of Yingkou City (based on hand-taken notes)	Handwritten
4–7	08/01/75	Report on trip to Sichuan and Yunnan Provinces to study earthquake situation and suggestions for next-step earthquake work	Cao Xianqing, Earthquake Office of Yingkou County	Advocacy of massive amateur precursor monitoring; Cao p. 24
4–8	01/75	Earthquake preparation and response plan (draft)	Earthquake Office of Yingkou County	Handwritten; an earlier (25/12/74) version is in Cao p. 22
3–11	08/01/75, 22:00	Circular on earthquake situation	RCL	Reports of small earthquakes near Liaoyang-Benxi
6–3	10/01/75–04/02/75	Pages of notebook of Yingkou County's Earthquake Office		Preparation of relief materials before the earthquake; a 3 Feb. instruction not to reveal earthquake situation to the public; foreshock-caused damage, animal behavior, and water level anomalies
2–13	11/01/75	Conclusions of group discussion of 10/01/75	RCL Earthquake Office	Handwritten; Liaoyang-Benxi acquitted; prediction of M 5 earthquake in Dandong-Yingkou-Dalian-Panjin but "difficult to determine time and location"
3–12	12/01/75	Circular on earthquake situation	RCL	Paraphrase of 10 Jan. group discussion conclusions
7–3	13/01/75	Report on a trip to Liaoning Province to help carry out earthquake work in the Liaoyang-Benxi area	Seven-people SSB team led by Xu Zhonghuai	Handwritten; on 22/12/74 Benxi (Shenwo reservoir) M_L 5.2 (M_S 4.8) earthquake
2–14	13/01/75	Opinions on large-earthquake outlook in 1975 in Liaoning Province (notes prepared for a speech at the National Conference on Whole-China Large-Earthquake Outlook, 13–21 Jan. 1975)	Gu Haoding on behalf of SSB Shenyang Brigade	The proclaimed "short-term prediction"; handwritten by Gu Haoding; prediction of *M* 6 earthquake in Jan.–Feb. or within six months in Jinxian-Dalian area or Liaodong Peninsula and offshore areas
7–4	16/01/75	Synopsis of report presented to Party Committee of Liaoning Province (Attachment: Analysis opinions for this earthquake)	SSB Investigation Team to Liaoning (to determine the nature of the Dec. 22 Liaoyang-Benxi earthquake)	

(*continued*)

Table A1
Continued

Index	Date, Time (dd/mm/yy)	Title and/or Type	Issuing/Publishing Organization/Individual	Notes*
3–13	18/01/75	Circular on earthquake situation	RCL	Report of felt earthquakes in Liaoyang-Benxi area
5–5	21/01/75	Concluding speech at the National Conference on Whole-China Large-Earthquake Outlook	Cha Zhiyuan (based on hand-taken notes)	Changed Gu's short-term prediction to one year; prediction for four regions in the country, including Liaodong Peninsula
6–4	27/01/75–04/02/75	Pages of log book of RCL Earthquake Office (i.e, SSB Shenyang Brigade)	SSB Shenyang Brigade	
6–5	01/02/75–11/02/75	Pages of log book of Anshan City Earthquake Office	Anshan City Earthquake Office	Mostly notes of telephone communication
2–15	04/02/75, 00:30	Earthquake Information, Issue 14	RCL Earthquake Office	Surge of small earthquakes in Yingkou-Haicheng area; the acclaimed "imminent prediction"
2–16	04/02/75, 05:00	Earthquake Information, Issue 15	RCL Earthquake Office and SSB Shenyang Brigade	Reports of small and felt earthquakes; no confirmed damage
2–17	04/02/75, 08:00	Earthquake Information, Issue 16	RCL Earthquake Office and SSB Shenyang Brigade	Report of increasingly larger, felt earthquakes; M_L 5.1 event at 07:51
4–9	04/02/75, 08:15	Minutes of (extended) emergency meeting of Standing Committee of the Party Committee of Yingkou County	(Minutes taken by Yang Ying)	Evacuation order issued by the county government
3–14	04/02/75, 10:30	Telephone distribution from the provincial government	RCL (based on telephone notes)	Provincial warning of "increasing magnitude" and reports of slight damage, with Li Boqiu's oral directives; also in Cao p. 17
4–10	04/02/75, 11:30	Telephone record: Yingkou City Party Committee's relay of provincial instructions and the city's own instructions	(Notes taken by Liu Boyu, Yao Zhenying, Yingkou County)	Provincial warning and Li Boqiu's directives; additional directives from city government; Cao p. 17
2–18	04/02/75, 14:00	Earthquake Information, Issue 17	RCL Earthquake Office and SSB Shenyang Brigade	Accounts of confirmed damage caused by foreshocks in Yingkou-Haicheng area
2–19	04/02/75, 20:00	Earthquake Information, Issue 18	RCL Earthquake Office and SSB Shenyang Brigade	First report of the Haicheng earthquake
7–5	04/02/75	Earthquake Situation, Issue 9: A strong earthquake struck Yingkou—Haicheng area of Liaoning Province	SSB	
7–6	05/02/75	Earthquake Situation, Special Issue 2: Follow-up report on *M* 7.3 earthquake in Yingkou—Haicheng area of Liaoning Province (1)	SSB	
7–7	05/02/75	Earthquake Situation, Special Issue 3: Follow-up report on *M* 7.3 earthquake in Yingkou—Haicheng area of Liaoning Province (2)	SSB	Accounts of warning and evacuation before the earthquake
5–6	07/02/75, morning	Speech at the Emergency Conference on Earthquake Situation	Zhou Rongxin (notes hand-taken by Liu Nanren and Wang Chengmin)	Praise of prediction and preparation work before the earthquake; handwritten
3–15	08/02/75	Investigation Report on House Damage and [Need for] Rebuilding in the Earthquake Disaster Area	Joint Investigation Group of Liaoning Provincial Planning Committee and Construction Committee	
3–16	08/02/75	Recovery of Electricity Network after 4 Feb. Earthquake (Situation of Electric Power in northeast China, Part 5)	Northeast China Electric Power Bureau	Summary of power interruption caused by the earthquake, damage to major facilities, and repair efforts
7–8	10/02/75, 14:00	Earthquake Situation, Special Issue 8: Distribute and follow through Vice Premier Hua Guofeng's instructions on earthquake work	SSB	First official announcement of successful prediction, praising Shipengyu Observatory

(*continued*)

Table A1
Continued

Index	Date, Time (dd/mm/yy)	Title and/or Type	Issuing/Publishing Organization/Individual	Notes*
7–9	10/02/75, 16:00	Earthquake Situation, Special Issue 9: Brief introduction of prediction and prevention work before the large Haicheng earthquake	SSB	First official outline of the prediction process, praising the leadership of Liaoning provincial Party Committee
2–20	10/02/75–20/02/75	Various statistics forms and telephone records regarding casualties and damage	RCL Earthquake Office	
5–7	11/02/75	Oral instructions on earthquake work when visiting Haicheng	Mao Yuanxin (telephone-relayed by Ding Guoyu, notes taken by Cui Dehai and Liu Puxiong)	Stating "Yingkou [County] did a better job than Haicheng [County]" (in terms of pre-earthquake warning)
2–21	18/02/75	Recounts of emergency meeting on earthquake preparation held on 4 Feb. 1975, 2:00–3:30 pm, in the town of Haicheng	RCL Earthquake Office	Hua Wen's oral instructions to Liu Yimin et al. at 8:00, 4 Feb. and details of the Haicheng meeting in the afternoon
7–10	13/03/75	SSB Document 033, 1975: Notice about learning from organizations that rendered meritorious services in the analysis-prediction of southern Liaoning earthquake (Attachment: Deeds materials of six units)	SSB	The six units were: Shipengyu Observatory, Jinxian Observatory, Panjin Observatory, Haicheng County Amateur Observatory, Huzhuang Commune Post Office amateur group, and Team 102's amateur group
4–11	15/03/75	List of victims in Haicheng County killed in the earthquake	Revolutionary Committee of Haicheng County	With name, gender, age, and cause of death (building collapse, hypothermia, fire, and suffocation)
3–17	19/03/75	Summary of Medical Work in Earthquake Relief Effort	Medical Group of Liaoning Provincial Earthquake Relief Command Post	Casualty statistics
5–8	09/05/75, 16:18–17:50	Speech when meeting delegates of the Third National Earthquake Work Conference	Hua Guofeng (based on hand-taken notes)	Accounts of uneven pre-earthquake warning work in disaster region; story of 39th Army greeting ceremony
7–11	—/03/75	Chairman Mao's revolutionary line guides us to march on to victories: Report on the prediction and preparation work for the Haicheng-Yingkou magnitude 7.3 earthquake	RCL Earthquake Office	Accounts of evacuation orders issued by local leadership of commune, brigade, etc.
2–22	16/03/76	Brief Report on Haicheng Earthquake Damage and Relief Materials	Business Department of Liaoning Seismological Bureau	Statistics of casualty and damage; higher numbers than in Quan (1988); total loss estimated to be 1 billion yuan

*References to "Cao" are to *Collection of Documents Regarding the M 7.3 Earthquake (Restricted Documents)*, a 99-page informal volume compiled by Cao Xianqing *et al.* in 1986 on behalf of the Yingkou County Earthquake Office. Only a very small number of copies were printed.

Feb. 10 Hua Guofeng's version of the prediction story in eighth special issue of SSB's Earthquake Situation (Recognition of the Prediction Efforts)
Official version of the prediction story in ninth issue of same series (Recognition of the Prediction Efforts)
March 13 Prediction success announced in all major Chinese newspapers (Recognition of the Prediction Efforts)

Appendix C

The Cultural Revolution, 1966–1976

The People's Republic of China was founded in 1949 after Chairman Mao Zedong led the Chinese Communist Party and its army (PLA) to win the civil war of 1946–1949. In order to establish rapidly a Soviet-style economy and social order, Mao launched a series of political and economic campaigns over the ensuing decade, including organizing

peasants into People's Communes in 1958. The campaigns brought disastrous consequences to the economy. By 1959 and 1960, Chinese agriculture was ruined, resulting in one of the worst famines in history.

Stunned by his own inability to run the economy, Mao allowed other Party leaders to fix the situation in early 1960s. But a few years later he decided that those other leaders were guiding China to a capitalist direction, which was against Marxist principles. He warned people that the 1949 victory was by no means the end of the "class struggle" and asked them to "continue the revolution under the proletarian dictatorship." In 1966, he launched the Cultural Revolution and mobilized hundreds of millions of masses to fight "class enemies," especially those "within the Party."

Most veteran Party cadres were purged in 1966–1967. Many people who had assumed some supervisory roles before 1966 (ranging from the President of China to school teachers) were publicly denounced and humiliated by "revolutionary mass organizations" (e.g., the "Red Guards"). But the PLA was little affected except at the very top level. In 1967–1968, provincial and lower-level governments were dismantled and replaced with "revolutionary committees." However, various mass organizations, who all claimed to be true followers of Mao, had been denouncing one another and become increasingly violent. In order to control the situation, numerous PLA officers were given positions in civilian revolutionary committees.

Revolutionary committees were based on a "three-way combination" of leaders of revolutionary mass organizations, PLA officers, and civilian revolutionary cadres. "Revolutionary cadres" were Party veterans considered well behaved in the Cultural Revolution. All civilian units (factories, schools, stores, communes, brigades, etc.) formed their own revolutionary committees to run day-to-day business. Small or rural revolutionary committees might or might not have PLA representatives. With rare exceptions, leaders of mass organizations gradually became unimportant at the provincial level. Members of the Party committee or branch usually formed the core of a revolutionary committee and assumed true leadership.

The enormous Cultural Revolution campaign had a number of subcampaigns. The Haicheng earthquake occurred at the end of the Campaign of Criticizing Lin Biao and Confucius. Lin Biao, Chairman Mao's once "handpicked" successor, betrayed Mao and died during an attempt to flee in 1971. It is still not clear why Confucianism was blamed.

Mao's wife and her three allies became very powerful during the Cultural Revolution. But Chairman Mao later was disgusted by their power-seeking activities and called them the "Gang of Four." Mao eventually "handpicked" Hua Guofeng as his successor. In October 1976, less than a month after Mao's death, Hua Guofeng arrested the Gang of Four and ended the Cultural Revolution. A few years later, Hua stepped down as the Party leader, and Deng Xiaoping started sweeping economic reforms in China.

Appendix D

Notes in the Log Book of RCL Earthquake Office (SSB Shenyang Brigade) in the Last Few Days Prior to the Haicheng Earthquake

31 January 1975

(by Wang Guiying)

When Zhu Fengming etc. came to the [office of] Revolutionary Committee to report work, I asked him about the first item of their group discussion conclusion, i.e., there might be an earthquake. He said that that opinion was later withdrawn.

Director Dong [a military officer of RCL responsible for the Earthquake Office] phoned to enquire about earthquake situation of the past few days. . . . Director Dong's instruction: Tell Zhu . . . write a report for the leading cadres. There has been no report [from the Earthquake Office] for a few days. I promptly phoned Zhu and asked him to write the report immediately. He promised to bring it here.

(19:10) Earthquake Situation Report

(by Zhu Fengming)

1. In the Gujiazi—Gongchangling earthquake area [i.e., the area of the 22 December 1974 earthquake swarm around the Shenwo reservoir], frequency of earthquake occurrence has gradually decreased. . . . Because there are still occasional anomaly reports from that area, and considering our analyses of general behavior of reservoir earthquakes, we estimate that clusters of small earthquakes may still occur in early and mid-February, but their magnitude may not exceed 4.

2. Since January 20, well and animal anomalies appeared in more than 20 places along two bands around Dandong City. . . . This is the third time such anomalies have occurred in that area since [the beginning of] December. It is still difficult to say whether these are precursors for a large earthquake. Assuming worst-case scenario and to be fully prepared, the city of Dandong has strengthened prediction work and is closely watching the development of these anomalies.

3. During the National Conference on Whole-China Large-Earthquake Outlook held in Beijing during 13–21 January, based on analyses, it was decided that the Jinxian-Yingkou and Dandong areas of Liaodong Peninsula might have earthquakes of magnitude 5–6 within this year. Therefore, we paid great attention to anomalies in this region. For emergency response, the provincial Earthquake Office already held a meeting of heads of earthquake offices of Lushun-Dalian, Yingkou, Dandong, and Panjin [Cities] and of observatories on 28 January and made initial arrange-

ments to enhance prediction and preparation. Full arrangements are to be made after reporting to provincial leading cadres.

There is another matter to seek advice from Director Dong. We wish to meet Commander Hua [i.e., Hua Wen] to report on the Beijing Conference and earthquake work. Some arrangements need to be made. Can this be scheduled right away?

1 February 1975

(by Quan Yingdao, Li Guimei)

No issue to record today.

(by Zhong Yizhang)

Nothing.

2 February 1975

(by Meng Huilin, Wang Guiying)

Nothing today.

3 February 1975

(by Gu Haoding, Li Guimei)

Tanggangzi spring resumed outflow on January 31, five o'clock in the evening. No earthquake activity today.

(by Li Xin)

[time and magnitude of nine foreshocks detected at Shipengyu Observatory and some notes]

(by Zhu Fengming, Tian Chuanlu)

Location: about 20 km southeast of Guantun Commune [i.e., location of Team 102 in Fig. 6] of Yingkou County. Time: 3 February, from 18:38 until 20:02, a total of nine small earthquakes occurred, with the largest being magnitude 2.5 and locally felt.

Earthquake activity in the Yingkou area has never been as intense as this.

The [provincial] Earthquake Office cannot yet draw a conclusion on what will follow and is still closely watching the situation. If a large earthquake is to occur, we estimate that the magnitude of these small earthquakes may increase, and their occurrence may become more frequent. Will timely report any new situation to the provincial government.

[records of many small earthquakes, felt reports, unusual light, animal reaction, etc.]

Appendix E

Translation of Two Earthquake Reports Available to the Liaoning Provincial Government on February 4, 1975

Earthquake magnitudes in these documents are M_S, which were converted from M_L using formula $M_S = 1.13 M_L - 1.08$, as required by SSB in 1975. See Figure 6 for locations of communes mentioned in these documents.

Earthquake Information, Issue 14, 4 February 1975, 0:30

Prepared by: RCL Earthquake Office

Submitted to: SSB, RCL, Members of Standing Committee of Provincial Party Committee

According to recordings by the seismic network in our province, from 18:00 to 24:00 on 3 February, 23 earthquakes occurred in Zhoujia, Pailou, and Chagou, and so on Communes, the area where our province's Yingkou and Haicheng Counties meet, of which 15 were greater than magnitude 1, with the largest being an *M* 3.3 event at 21:23. The earthquakes were felt in [the cities of] Yingkou, Anshan, and Liaoyang, and Xiuyan [County] of Dandong [City] but caused no damage.

Judged from the seismicity pattern, the magnitudes are still increasing. Taking into consideration the anomalies in our province and the results of recent National Conference on Whole-China Large-Earthquake Outlook (which confirms that *M* 5–6 earthquakes may occur in the Yingkou-Jinxian and Dandong and so on areas of our province's Liaodong Peninsula), a relatively large earthquake is very likely to follow, and we must be on guard. At present, relevant observatories around the earthquake area are carefully monitoring the development of the earthquake activity. Earthquake Offices of Yingkou and Anshan Cities have notified relevant communes to strengthen office duty and patrol, carry out prediction and preparation, and organize militiamen to inspect reservoirs.

Earthquake Information, Issue 17, 4 February 1975, 14:00

Prepared by: RCL Earthquake Office and SSB Shenyang Brigade

Submitted to: SSB, RCL, Members of Standing Committee of Provincial Party Committee (60 copies printed)

Today, from 07:51 to 14:00, another 212 earthquakes occurred in the earthquake area between Yingkou and Haicheng Counties, including two events greater than magnitude 3, namely,

08:57 3.5

10:35 4.2

Based on reports from Earthquake Offices of Anshan and Yingkou Cities, we are presently aware of the following situation: In Pailou, Chagou, Yingluo, and Zhoujia and so on Communes, 27 houses had gable or chimney collapse due

to shaking, shelves in one store fell due to shaking and damaged goods, and a peasant in Pailou Commune had a head bruise when a chimney fell.

The provincial Earthquake Office has sent eight people one after another to the earthquake area to cooperate with the locals in earthquake preparation and relief.

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