Science in Context **25**(1), 127–154 (2012).
doi:10.1017/S0269889711000329

"Collective Monitoring, Collective Defense": Science, Earthquakes, and Politics in Communist China

Fa-ti Fan

State University of New York at Binghamton
E-mail: ffan@binghamton.edu

Argument

This paper examines the earthquake monitoring and prediction program, called "collective monitoring, collective defense," in communist China during the Cultural Revolution, a period of political upheavals and natural disasters. Guided by their scientific and political ideas, the Chinese developed approaches to earthquake monitoring and prediction that emphasized mass participation, everyday knowledge, and observations of macro-seismic phenomena. The paper explains the ideas, practices, and epistemology of the program within the political context of the Cultural Revolution. It also suggests possibilities for comparative analysis of science, state, and natural disasters. The paper redefines the concept of "citizen science" and argues that the concept provides a useful comparative perspective on the intimate relationship between science and the macropolitics of modern state and society.

On 27 July 1976 at 6 o'clock in the afternoon, in a food factory in Laoting County, three mules refused to enter the stable. Only after some pulling and beating, the beasts finally went in. Once inside the stable, the mules turned their heads inward and their rumps outward, their ears standing straight up. They refused to eat and kept puffing. This continued until after 9 o'clock in the evening. Their behavior was very unusual. A comrade who was collecting wheat straw on the roof muttered, "Could it be that an earthquake is going to strike?" On the second day around 6 o'clock in the evening, the comrade who was in charge of the livestock saw the three mules raising their heads and pricking up their ears, just as the day before. He yelled, "An earthquake is coming!" Before long, an M7.1 earthquake occurred (Tangshan dizhen qianzhao bianxie xiaozu 1977, 15).

On the morning of 25 July 1976 (three days before the Tangshan earthquake), more than one hundred weasels showed up in the Wentuo Commune of Wuning County. The bigger ones carried the smaller ones, moving into the village through a hole in an old wall. In the evening, around 8 o'clock, there were another dozen or so weasels running around a walnut tree. People killed five of them right there. During the next two days, the weasels kept moving in droves and were not afraid of people at all. They also kept squeaking at night. This was very different from how they usually behaved.

Members of the commune reported that a few days before the M6.5 Ruan County earthquake struck in 1945, there had been a similar situation of weasels moving around during the day (Tangshan dizhen qianzhao bianxie xiaozu 1977).

How do we make sense of these episodes? They are taken from a Chinese science book on earthquake prediction from the 1970s. Numerous books, pamphlets, and periodicals published in China from the 1960s to the 1980s contained anecdotes or "true stories" of a similar nature. Some of the publications were compilations of such anecdotes, and they were widely available as scientific, educational, and propaganda materials. In order to understand these anecdotes, we first have to understand science in communist China during the Cultural Revolution (1966–1976). Only by placing earthquake prediction in the political and cultural context of Mao's China can we comprehend the particular approach and program of earthquake monitoring and defense in China at the time.

China's program of earthquake monitoring was inseparable from the notion of "mass science" (*qunzhong kexue*) or what was sometimes called "the people's science" (*renmin kexue*).[1] There wasn't an official distinction between the two terms, though depending on the context, they could have distinct connotations. *Qunzhong* was, first of all, a political category, as in the *qunzhong luxian* or the "mass line," whereas *renmin* had more of a sense of "the common people" or even the *Volk*. We shall see that the Chinese approach to earthquake prediction drew on the connotations of both terms, namely both "mass" and "folk," and that this combination was not only political, but also epistemological. In the two episodes cited above, the people who made the observations were lay people, not trained scientists. They made the observations in everyday life when they went about doing their daily routines. They did not use any particular instruments in making the observation, or it may be argued that they used animals – mules and weasels – as seismological instruments. What was observed were not microscopic phenomena invisible to the naked eye, nor were they phenomena that could only be described in technical scientific terms. Yet, nevertheless, these anecdotes were often collected and analyzed by trained scientists on official missions for formal scientific institutions.

Earthquake prediction has generated heated debates among scientists, lay people, business establishments, and government agencies in many countries. It reemerged as an emotional and politically sensitive topic in China after the tragic event of the 2008 Sichuan earthquake, which claimed about 70,000 lives. In the Chinese seismological community, advocates of earthquake prediction, many of whom had participated in the scientific enterprise described in this essay and had been sidelined for more than

[1] The basic ideas were already sketched out in Mao Zedong's speech on the occasion of the founding of the Society for Research on Natural Science of the Shan-Gan-Ning Border Region in 1940. The Chinese Communist Party also paid much attention to the popularization of science. An important movement of mass science was the "Mass Scientific Research in Agricultural Villages" (*Nongcun qunzhong kexue shiyan*) movement during the Great Leap Forward, which encourages farmers to do scientific experiments (Quanguo kexie 1964).

two decades, appealed for renewed attention and support. Anger, sadness, passion, and a sense of self-vindication that had roots in conflicts dating back to the 1970s and 80s turned grumbles and suppressed voices into public accusations. In response, the current seismological establishment took steps, issuing official statements and wielding political weight, to quell dissents and criticisms.

The purpose of this essay is not to enter into the debate over the feasibility or otherwise of earthquake prediction. Rather, it is to examine the ideology, organization, and practice of the program of earthquake monitoring, prediction, and defense during the Cultural Revolution, with emphasis on the political and epistemological underpinnings of mass participation in science. In so doing, it seeks to contribute to discussions on the participation and membership in science, especially issues related to lay expertise in science (Wynne 1966; Epstein 1966); and on science and the macropolitics of state and society, particularly the question of science and citizenship (Andrews 2003; Charvolin, Micoud, and Nyhart 2007; Leach, Scoones, and Wynne 2005).

Science and the Cultural Revolution

In the 1950s, China looked to the Soviet Union for scientific assistance. After the rift between the two communist juggernauts in 1959–60, China went through a period of relative scientific isolation until around the mid-1970s, when China rejoined the international community. One familiar way of studying this phase of science in China is, therefore, to place it within the framework of the Cold War, where the main focus is on the role of science and technology in national defense and state rivalry, such as the development of nuclear weapons. Another way is to examine the tensions between science (usually as embodied in the scientific establishment) and the state (often couched in such terms as totalitarianism and control). This latter approach is concerned primarily with the relationships between the scientific community and state politics. Both approaches have created opportunities for discussion of science in political regimes similar to or different from communist China, and scholars have pondered the implications of democracy, professional autonomy, and ideological control for the development of science. Such directions of research are generally amenable to the dominant narrative of science and the Cultural Revolution, which emphasizes the violent intrusion of the state into the scientific community and the disruption of scientific work during that period. Although this narrative captures much of the tragic truth, it describes some areas of science better than others. The party-state needed the scientific elite for certain political or practical reasons. For example, nuclear research, missile science, and other military-related projects continued to develop. Rice hybridization also made notable progress.[2] In a curious way, seismology, too, flourished during the Cultural Revolution.

[2] The historiography is discussed in the essays by Fa-ti Fan, Danian Hu, Sigrid Schmalzer, and Zuoyue Wang, in Elman et al. 2007.

https://doi.org/10.1017/S0269889711000329 Published online by Cambridge University Press

Maoism served as the guiding ideology of the Cultural Revolution. Political propaganda was a fact of life in communist China, but during the Cultural Revolution, the apotheosis of Mao and his thought reached a new, feverish pitch. Under these circumstances, "ideologically correct" science had to be grounded in official Marxism and Mao's thought. Science had to be true to dialectical materialism because this philosophy correctly described the fundamental principles of how Nature works. Friedrich Engels was frequently cited as a philosophical authority on Nature. The goal of science was to conquer Nature, to free oneself from Nature. This notion echoed Engels' theory that labor creates humanity (Schmalzer 2006). Mao declared, "Natural science is one of man's weapons in his fight for freedom. For the purpose of attaining freedom in society, man must use social science to understand and change society and carry out social revolution. For the purpose of attaining freedom in the world of nature, man must use natural science to understand, conquer and change nature and thus attain freedom from nature" (Mao 1940). Indeed, science and technology were the results of and the tools for human struggles against Nature. Ultimately, however, Maoism was less about historical materialism than about moral imperatives and the power of human will. When Mao proclaimed "*ren ding sheng tian*" (humans will triumph over Nature), he was talking about fortitude, perseverance, and a fearless determination to win.

Maoist thought also insisted that science must serve the people. To achieve that, science had to be practical, empirical, and utilitarian. Abstract theoretical science came too close to idealism, which was not only philosophically wrong, but also scientifically unsound. Einstein's theory of relativity ran into trouble during the Cultural Revolution for these reasons (Hu 2005, chap. 4). Sciences that didn't have any obvious utilitarian function were at best intellectual toys of the elite. Maoism had a strong strand of anti-elitism. Mao himself had said that "the lowliest are the smartest; the highest the most stupid" (Mao [1958] 1987). The people learned from their experience and labor, from their long struggle with Nature. Such hard-earned knowledge – concrete, reliable, and often ingenuous despite its humble origins – was truly useful and valuable. Thus, science was inherently political. It was objective, but it was neither neutral nor value-free. It was de facto class-based, and good science required mass participation.[3]

[3] It should be noted that official pronouncements on the nature of science were not consistent. One can find contradicting statements in the documents and publications from different time periods. In an attempt to handle the struggle between genetics and Lysenkoism, for example, Lu Dingyi, a propaganda chief, stated in 1956 that "Every scientist has his own political viewpoint, although natural science itself has no class character." And more emphatically: "As everyone knows, the natural sciences, including medicine, have no class character. They have their own laws of development. . . . It is, therefore, wrong to label a theory in medicine, biology or any other branch of natural science 'feudal,' 'capitalist,' 'socialist,' 'proletarian,' or 'bourgeois.'" This statement, however, has to be understood narrowly in connection with the conflict over Lysenkoism. It was also made before the major Maoist movements, such as the Anti-rightist movement, the Great Leap Forward, and the Cultural Revolution, took place. It did not represent the general tendency of the Maoist view on science.

Maoist thought insisted that science "walks on two legs."[4] One leg was the masses and the other, the experts or specialists. Experts and the people ought to work together. Elite scientists must learn from the people. During the Cultural Revolution, many intellectuals and scientists were sent down to the countryside to "learn from the people." In the meantime, farmers and factory workers were called on to participate in scientific work at research institutes.

Furthermore, Maoist science also emphasized the need to combine both indigenous and Western science. Mao himself believed that there was a lot of unique knowledge in the Chinese lore on medicine. This idea was reflected clearly in the barefoot doctors program (Shanghai zhongyi xueyuan, et al. 1969; Fang 2008). The doctors – often villagers or sent-down youths who had received brief training – used traditional medicine and healing practices together with Western-style drugs. The program provided health care for rural areas, where medical resources were limited. To some extent, the program aimed to serve practical needs. Nevertheless, it was also emphatically ideological and embodied such political ideas as communist society, national traditions, and mass science. Along a similar line, in earthquake studies in the 1960s–70s, the state championed the integration of folk knowledge and more technical seismology.

Earthquakes in 1960s–1970s

There were more than ten major earthquakes (roughly M7 or above) that took place during the 10 years from 1966 to 1976, starting with the Xingtai earthquake in March 1966 and culminating with the Tangshan earthquake in July 1976, which killed a quarter of a million people (Ma Zongjin, et al. 1982).[5] Because much of China is located between two major earthquake zones – one running roughly along the Pacific Rim and the other stretching from the Himalayas to Southeast Asia – earthquakes are not uncommon in many parts of China. Nevertheless, it is unusual that a series of major earthquakes hit China proper with such frequency and intensity as in the 1960s–70s. This period of natural disasters coincided with the Cultural Revolution; fear and anxiety of earthquakes fermented in the environment of social and political upheavals. On the one hand, the Chinese experienced violent social and political storms; on the other, they worried that earthquakes might strike at any time.

Traditionally, earthquakes and other natural calamities had political and cultural significance. A big natural disaster, especially something like a major earthquake, was

[4] Originally, Mao Zedong raised the banner of "walking on two legs" for economic development in the Great Leap Forward, but the slogan was widely adopted later for any kind of policy that emphasized a two-pronged or a balanced or combined approach.

[5] There was another major earthquake that occurred one month after the Tangshan earthquake, but it caused much less damage.

considered an ominous sign of major political changes, such as the end of a reign. This anxiety could easily be amplified by the social and political commotion during the Cultural Revolution. Campaigns against "superstitions" had been a long-time policy of the Chinese Communist Party, yet certain traditional beliefs associated with earthquakes and other natural disasters posed more serious threats to the party-state than others (Smith 2006a; Smith 2006b; Hung 2010). Not surprisingly, the party-state was eager to educate the masses that earthquakes were natural phenomena, that they could be predicted, and that people shouldn't have superstitious thoughts about them. The party-state didn't want its political legitimacy to be questioned or challenged. It might also be true that after the catastrophe of the Great Leap Forward in the late 1950s and early 60s, the political leaders became more cautious and responsive to natural calamities. They were probably very concerned about the political ramifications of a major natural disaster. The fact that the nation's capital, Beijing, was located in an area that seemed to be seriously threatened by earthquakes only heightened the anxiety. If a powerful earthquake struck Beijing, the nation might be thrown into chaos and could become extremely vulnerable to external aggression. Because at the time China considered itself under immediate military threat from the Soviet Union, this worry could not have been far from the minds of its leaders. At any rate, the Chinese programs of earthquake monitoring and defense have to be understood within this social, cultural, and political context.[6]

On more practical matters, most houses in China were not earthquake resistant. Major cities were so densely populated that it would be impractical to tear down and rebuild the houses according to the principles of seismological engineering. It would take too long and cost too much. In comparison, it seemed to make more sense to invest in prevention and defense: developing methods to predict earthquakes, educating people about earthquake prediction and defense, organizing the people for mass emergencies, and so on. This policy of course depended heavily on an assumption, namely, the feasibility of earthquake prediction.[7]

The Xingtai earthquake in 1966, which caused more than 8,000 deaths and more than 50,000 injuries, was the catalyst for a nation-wide campaign to wage war against earthquakes. Zhou Enlai, the premiere, visited the disaster site and summoned a group of scientists to discuss ways of fighting earthquakes. Until then, Chinese scientists hadn't

[6] These comments are based on my interviews and assessments. A word on sources might be called for here. I have relied mainly on printed sources as well as formal or informal interviews with about two dozen participants (including scientists, officials, and lay persons) in the projects of earthquake prediction and defense. I have not obtained access to the official archives. I would not be surprised, however, if many of the relevant documents were not preserved (as this is often the case with the records of scientific institutes from the Cultural Revolution era).

[7] This paragraph is based on my interviews and assessments. This is not to say that the Chinese did not care about seismological engineering. They did. However, in this area, their main focus was on large industrial or civil engineering structures. Any at rate, compared to earthquake prediction, their effort in seismological engineering was very minor.

done much in seismology, and most of them, like most seismologists in the West, considered earthquake prediction beyond the current state of science and technology. At the meetings, however, two eminent figures in Chinese science – the geologist Li Siguang (1889–1971) and the geophysicist Weng Wenbo (1912–1994) – strongly advocated earthquake prediction. Their voice proved decisive. Later, both (especially Li) would play a crucial role in establishing institutions and research in seismology.[8]

During the ten years of the Cultural Revolution, many areas of scientific activity ran into difficulties. Yet, seismology expanded rapidly. The State Seismological Bureau was founded in 1971. The number of seismological stations increased from a handful in the early 1960s to about 250 by the mid-1970s, not including a variety of observatories associated with mass science projects (Raleigh et al. 1977, 237). Most of the seismologists had a background in geology or geophysics. The top ones often had received their education abroad, in Europe before the communist era or in the Soviet Union during the 1950s. Under them were younger scientists who had recently graduated from universities or institutes of science and technology or who had been called from the mines, oil fields, and other places where geologists or geophysicists were found. Not surprisingly, there were scientific differences and political factions within the community: geologists and geophysicists did not see eye to eye on scientific or institutional matters; the dominance of Li Siguang created tensions between his disciples and those of his rivals; and so on. All of these were further compounded with political in-fighting so pervasive during the Cultural Revolution. Overall, however, the seismological community in China functioned relatively well. It was largely shielded from outside political struggles because its mission was considered an effort of national defense. For this reason, the seismological community, despite its internal differences, operated under a shared goal – earthquake prediction.

Earthquake Prediction in China

Due to the frequency of large earthquakes at the time, the Chinese regarded earthquake prediction as an important scientific project. Seismological research in the United States and the Soviet Union cannot be separated from the context of the Cold War (Barth 2003). These nations established networks of seismological observatories across the world in part for the purpose of monitoring underground nuclear tests. Did China harbor a desire to follow their Cold War rivals in developing this application of

[8] My description of the meetings is based on my interviews (see also Fang 1995). Li Siguang's opinions on earthquake prediction in the aftermath of the Xingtai earthquake can be found in his posthumous collection, Li 1977, 15–43, and 94–167. Weng had made contributions to petroleum exploration in China and devoted much of his time to developing theories for forecasting natural disasters. Intellectually impressive and politically powerful, Li (MSc 1918; DSc 1931, University of Birmingham) dominated Chinese geology in the 1950s-70s. Weng (PhD 1936, Imperial College of London) wrote his master's thesis on earthquake prediction and never lost interest in the topic.

seismology at some point, since it had recently joined the nuclear club (in 1964)? It is possible, yet, even if this was true, it could not have been more than a distant wish. Their primary goal was certainly earthquake prediction.[9]

China was not alone in trying to develop methods of earthquake prediction. At the time, Japan, the Soviet Union, and the United States all pursued earthquake prediction or related seismological research (Ohtake 2004; Rikitake 1976; Guowai dizhen bianjibu 1979). Much of the direction of their research, if not the particular techniques, were also quite similar, such as seismic mapping, geodetic measurements, foreshock sequences, electromagnetic fields, and so on. But there were certain features that distinguished China's approaches to earthquake prediction from those of the other nations. For instance, the Chinese researched the historical records heavily and systematically. Although other seismologists also used historical records, the Chinese were fortunate to have inherited a uniquely rich body of historical documents and they combed through them in order to put together a spatio-temporal map of earthquakes in China. By means of historical research, Chinese scientists hoped to find the distribution and recurring patterns of earthquakes over thousands of years (Dizhen wenda bianxiezu 1977, 122; Li 1981, 167–244). Presumably, the knowledge would be helpful to long-term earthquake prediction. In this area of research, other nations could only look at China with envy. Although, as expected, most of the historical records dated back only to the more recent time periods and concentrated on the more populated parts of China, they still constituted an unrivaled body of textual documentation. The Chinese also mined the historical records for accounts of precursory signs to earthquakes, the significance of which will become clear below.

Another distinctive feature of Chinese seismology was its emphasis on short-term and imminent prediction (prediction that was within a time frame of weeks or days), whereas most seismologists in other nations were less bold, or more realistic, in assessing the feasibility of short-term earthquake prediction. They settled for research on long-term forecasts or hazard assessment based on geological and seismological models. The distinction between prediction and hazard assessment is crucial. Prediction in the Chinese approach meant pinpointing the precise place, time, and magnitude of an earthquake. If the margin of error was too great to allow appropriate decisions, the prediction was useless. A statement such as this – there is a 50 percent chance of this province experiencing an earthquake of magnitude 7 or larger within the next 30 years – would not have done much good. One could hardly take any action, other than pushing for better urban planning and stricter building codes, based on that kind of information. A prediction should also come early enough for effective action. A warning that would leave no time for people to do anything would be as good as no warning at all. Ideally, there had to be enough time for preventive evacuation of an entire city. Therefore, a prediction is also different from a pre-detection of a coming

[9] The Chinese were certainly aware of this application, as they translated Davies 1969 into Zhongguo kexue jishu qingbao yanjiusuo 1972. But I haven't found much evidence that they actively pursued this line of research in the 1960s and early 70s.

earthquake. A method or instrument that may detect seismic waves that are already approaching would be of little help, for the difference of a second or two would not have saved many lives.[10]

In the mid-1960s, a major American plan to develop earthquake prediction failed to garner enough funding and was aborted (Geschwind 2001, chap. 6; Wyss 1999). Sensible or not, the Chinese did not hesitate to plunge right in. The Chinese attitude owed much to a set of factors: pressure from the political leadership, the relative isolation of Chinese scientists from the international scientific community, the confidence and influence of certain scientific leaders (e.g. Li Siguang), a sense of urgency among the scientists to combat earthquakes, and a can-do spirit fueled by patriotic zeal. In the process, the Chinese developed certain areas of research that were very much their own, notably that of macroscopic phenomena.

With ever more sophisticated technology, modern seismology depended principally on microscopic measurements, using highly sensitive instruments to monitor seismic activities. Although Chinese seismologists did not have the most advanced equipment, they similarly pursued this area of research. However, they also devoted much attention to research on macroscopic phenomena (viz. pre-monitory phenomena that could be observed without using instruments) as well as other phenomena that could be observed with very simple tools. Their approach had sprung from three sources. First, China did not have a lot of advanced equipment, nor did it, at first, have many seismological stations. Since it was impossible to cover a large country like China with so few observatories, Chinese scientists welcomed research direction that would make up for the shortage of advanced observatories. Second, they believed that macroscopic phenomena could lead to pretty accurate predictions of earthquakes, whereas in technologically more developed countries such as the United States, the scientific establishment tended to presuppose that advanced technology rendered observations of macroscopic phenomena superfluous. Third, there was the political content: mass participation, mass mobilization. Since the Chinese believed that certain macroscopic phenomena could be symptomatic of earthquakes, they naturally wanted to have many observers out there looking for them. And, politically, if science was indeed of the masses and for the masses, then people should learn about science and do science. Earthquake prediction, therefore, provided a perfect opportunity for mass science.

Collective Monitoring, Collective Defense

The party-state mobilized the masses in the national enterprise of earthquake monitoring and defense (Jia 1968; Ningjin xian geming weiyuanhui 1968; Anon.

[10] Earthquake prediction has few supporters among seismologists today, but it remains a controversial issue. See the debate organized by the journal, *Nature*, 25 February - 8 April 1999, <http://www.nature.com/nature/debates/earthquake/equake_frameset.html>, and the debate in Science, Geller et al. 1997; Wyss et al. 1997; Wyss 1999; see also Hough 2009.

https://doi.org/10.1017/S0269889711000329 Published online by Cambridge University Press

1970; Beijing shi fangzhen bangongshi 1970). The shortage of seismological stations and a belief in the possibility of short-term earthquake prediction explained only part of the ambition. The enterprise was at the same time scientific research, disaster control, national defense, political campaign, and nation building. Maoist programs of mass science, such as earthquake prediction, barefoot doctors, and various attacks on "elite science," were based on the tenets of integrating experts and the masses and combining indigenous and Western science. The underlying political doctrine asserted the class character of science, exalted everyday knowledge, and projected a utopian vision of scientific and political modernity.

China devised an earthquake monitoring system that aimed to integrate both the experts, who staffed the seismological bureaus and stations, and the masses, who also played a role in earthquake monitoring. According to one estimate, there were also "several tens of thousands" of lay participants in the program (Raleigh et al. 1977, 237).[11] The observation activities of the masses were supervised by the local party committees, schools, communes, etc, rather than the seismological bureaus. Since there were hundreds of these observation units in the "collective monitoring, collective defense" program, it is not surprising that their scientific and technological sophistication varied. The most advanced among them were well-equipped and didn't look too different from regular seismological observatories. But far more common were simple observation units attached to middle schools, factories, communes, government offices, etc. One unit or team usually consisted of several individuals (Oike Kazuo 1978, 163–217).

I have interviewed about ten people who, as school students, had been involved in the earthquake prediction program. In most cases, they recalled the excitement in participating in the activities. They learned about geology, seismology, emergency techniques, etc. Teachers took them to selected places where they set up observation points. They felt that they were doing something valuable, important, exciting. One of them said that as a ninth grader, "I was excited to be on night duty (rare opportunities to sleep overnight outside of my home, despite the suffering from mosquito bites)." These non-expert groups not only conducted observations, but also often made their own instruments. They were encouraged to be inventive (fig. 1). One imagines that it was a little like going to a science summer camp or participating in high school science contests (if one must look for an American analogy). The difference is that the Chinese students were not doing kid's science or learning to do science simply as part of science education. They actually took part in an official national science project. In other words, they were already doing science and contributing to the national effort against natural disasters.

[11] An interviewee told me that there must have been 100,000 people involved. It is impossible to give an exact number as the number varied from time to time, and it also depended on who should be counted or not. The exact number is less important than the fact that the program was very large and extensive and involved many people from all regions and levels.

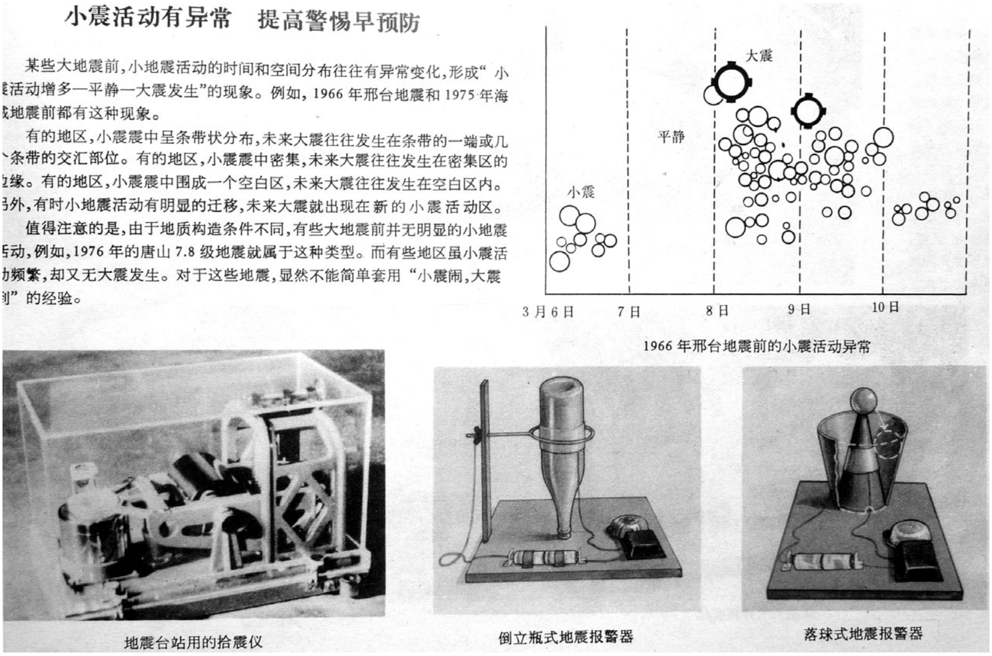

Fig. 1. The two pictures on the lower right show two "home-made" earthquake warning devices. Such instruments could be made by school children or anyone with some basic knowledge of science. The more sophisticated equipment on the left is a seismograph used by Chinese seismological observatories.

Some of the more common objects for observation were ground tilt, geostress, telluric currents, geomagnetism, and well-water variations. In the late 1960s and early 70s, many indigenous instruments were invented for making these observations. A young farmer invented the method of measuring telluric currents by using a simple device that consisted of an ampere meter and two electrodes planted underground at a distance apart. The intensity and variation of underground electric currents were thought to indicate earthquake activities. Through channels, the inventor requested advice from the Seismological Bureau, which then sent a scientist to evaluate the instrument. After some examination, the scientist confirmed the effectiveness of the device. The method was reported in the *Dizhen zhanxian*, an influential journal on earthquake studies at the time, and very soon it became very popular across the nation (Beijing shi yanqing xian gewei hui, Yanqing xian Zhangshan ying diqu dizhen lianhe diaocha zu 1969).[12] When, in 2007, I interviewed the scientist who was assigned

[12] Further discussions of the method can be found in, e.g., Hebei sheng Leting xian huiwei zhongxue keyan xiaozu 1970; and Ningxia huizu zizhiqu Longde xian geming weiyuanhui fangzhen lingdao xiaozu bangongshi 1972.

https://doi.org/10.1017/S0269889711000329 Published online by Cambridge University Press

to examine the instrument and who wrote the report, he still took much pride in introducing the instrument to the broader audience. In the mid-1970s, a young technician invented a simple apparatus to measure geomagnetism that consisted mainly of a magnetic needle, a mirror, and a plastic bucket.[13] The device was widely copied. Ground tilt could be measured with a plump bob hanging from the ceiling and a piece of chalk (Anon. 1975; Liang 1970).

We may use a textbook for middle-school students as an example of these observation activities. The "Activities in Earthquake Monitoring and Prediction for Youngsters" (*Shaonian dizhen cebao huodong*) was issued by the Shanghai Seismological Office and several middle schools in 1978. The book consists of eight chapters, starting with an introductory chapter, "What Is an Earthquake," and moving on to discuss, chapter by chapter, "The Macroscopic Phenomena of Earthquakes," "Underground Electric Currents," "The Electricity of Plants," "Geomagnetism," "Ground Deformation and Ground Tilt," "Geostress," and "Other" (which includes chemicals in water, radon levels, and ground temperature). The chapter on macroscopic phenomena covers these topics: animal behavior, plant behavior, underground water variations, ground deformation, sea level and tides, climate and weather changes, earthquake sounds, and earthquake light. In many of the chapters, Do It Yourself (DIY) instruments and sample charts are introduced. Measuring the ground tilt with a bob pendulum, for example, requires the observer to measure and record the data three times a day (8am, 13pm, and 18pm). The data to be recorded include the tilt, room temperature, humidity, and weather. The observer should also sign his or her name (Shaonian dizhen cebao huodong bianxie zu 1978).

This mass participation in scientific activity was not unique to earthquake studies, nor to the Cultural Revolution era. During the Great Leap Forward, the people were also encouraged to invent new tools, machines, fertilizers, and methods for increasing agricultural and industrial production (Nongyebu nongju gaige bangongshi 1959). In fact, in some important ways, the "investigation in agricultural meteorology" campaign in the late 1950s foreshadowed what would happen in earthquake monitoring a decade later.[14] With the Great Leap Forward, which ended in misery, the frenzy of invention

[13] For an illustration of the instrument, see Shaanxi sheng geweihui dizhenju bian 1977, 50–51. There were exhibitions of new inventions for earthquake prediction (see, e.g., the report on such an event in Beijing). The inventions include devices to measure ground tilt, ground sound waves, and well-water level (Beijing shi zhaokai jiangxue huoyong Mao Zedong sixiang chuangzhi cebao dizhen tu yiqi jiangyong hui 1970).

[14] During the Great Leap Forward, the drive to increase agricultural production took the nation by storm. Because of the obvious impact of weather on agriculture, agricultural meteorology became an urgent and important problem. The national and local authorities launched the "Integrated Investigation in Agricultural Meteorology" movement (*nongye qixiang zonghe diaocha*). The purpose was to investigate and solve the problem of the relationship between local weather and agricultural production. Due to space constraints, I can only mention a few charactertistics most relevant to the earthquake monitoring program. The activities included setting up basic meteorological stations in communes, gathering the local weather lore, collecting the experiences of old farmers and fishermen, and compiling and distributing the results to the masses. To collect the wisdom and experiences of the old farmers, for example, the commune leaders were supposed to call for meetings

died down. Now, the new political and practical conditions revived the activity, this time with a concentration on earthquake prediction.

Most of the masses were not organized into active groups or teams manning observation points. But they were still participants in the earthquake prediction program. They received information about earthquakes through political and educational channels – party offices, neighborhood organizations, production brigades, commune units, etc. – and through propaganda venues – pocket-size pamphlets, mimeographed handouts, colorful posters, exhibitions, film screenings, school competitions, and propaganda tours to the countryside. They learned about the basic science of earthquakes, methods of earthquake prediction, emergency defense, and so on. Although most people usually didn't use instruments or keep a routine record of what they observed, they were urged to pay attention to any macroscopic seismic phenomena. When they noticed any unusual phenomenon that might indicate the coming of an earthquake, they had to immediately report it to the local offices. It was their duty to do so. Together the various levels of mass science would form a blanket warning system of earthquakes.

Arguably, the warning system was an extension of the surveillance society under the communist rule. People had been constantly admonished to be vigilant, to keep an eye out for enemies of the party-state, and to report any suspicious activities, only this time, the enemy was a natural force. Of course, one should not assume that this system worked seamlessly. Political instabilities during the Cultural Revolution could be disruptive. Besides, people always had their own ideas, desires, aims, and lapses. Boredom, negligence, and indifference seeped in after the initial excitement. How many people could keep on checking the same unchanging meter and recording the readings day after day, thrice a day without occasionally slacking off? Symbolic incentives – stationery or a little money – were provided. At the year's end, a celebratory meeting gathered people together; prizes, certificates, and the like were handed out. Even so, the outcome might be uncertain. Nevertheless, we should not underestimate

of old farmers as well as interview them individually. The communist regime had both practical as well as political purposes in pushing for this kind of agricultural meteorology. The politics and ideology of Maoism, similar to what would later influence earthquake prediction, carried the day. On the more practical aspect, local meteorological stations filled gaps in the coverage of weather forecasts. Meteorological observatories staffed by trained meteorologists existed mainly at the provincial level. There were serious limitations as to what they could do to predict weather changes of an area as large as a province, especially where the topography and weather conditions varied drastically and rapidly. Weather could be exceedingly complex and localized. Therefore, much had to be done at the commune level. The main responsibilities of the commune meteorological station were (1) listening to the broadcast, combining it with one's own observation of the sky, and making the forecast thereby; (2) planning agricultural production and preventing damage caused by bad weather according to the forecast; (3) working with the masses to carry out simple agricultural meteorological observation, forecasts, and research; and (4) propagating meteorological knowledge to the masses. In every issue of the major journal on agricultural meteorology, the *Nongye qixiang*, many pages were devoted to weather lore, inventions of simple meteorological instruments, and innovative agricultural techniques for different weather conditions that creatively combined indigenous and foreign methods (see, e.g., the editorial, Nongye qixiang shao, zu de gongzuo changsuo shi zai tianjian han qunzhong zhong 1959, 2–3; Jian Bing 1959, 4–6; Shangxisheng qixiang ju 1959, 5–7).

the seriousness and dedication many people felt about earthquake monitoring. What they were expected to do was after all what they would want to do for themselves – that is, protect themselves and their families. In an area of potential major earthquakes, this was a matter of life and death.

The Semiotics and Phenomenology of Earthquakes

The main function of the warning systems was to keep an eye out for precursory signs of earthquakes. The Chinese believed that some of these precursory signs were macroscopic phenomena that could be observed by common people. Therefore, the program of earthquake prediction incorporated folk wisdom and everyday observations that described "anomalous" natural phenomena that might indicate the coming of an earthquake – animal behavior, unseasonable weather, well-water variations, underground temperature, and so on.[15] These anomalous signs indicated a forthcoming earthquake just as symptoms suggest a hidden but menacing disease. Some of the anomalies were obvious, such as foreshocks; others were obscure, such as cloud formation. Seen in this way, the Chinese way of earthquake prediction may be likened to a science of reading anomalous signs or symptoms of earthquakes; that is, a semiotics of earthquakes. However, observing and reading signs is often difficult. What an experienced or perceptive doctor can find out about the bodily disorder of a patient by checking the pulse or looking into the ears may escape another doctor completely. Similarly, the precursory signs of earthquakes could be obscure or elusive. The next section will discuss what it took to observe the precursory signs of earthquakes and how it worked in the Chinese project of mass participation in earthquake prediction. Here I would like to comment on another methodological tendency of the Chinese approach to seismology, what might be characterized as phenomenological.

Although Chinese scientists also attempted to explain the causal relationships between these macroscopic phenomena and earthquakes, their approach relied mainly on correlating possible precursory phenomena and earthquakes rather than building geophysical models of seismicity. In this regard, their approach was primarily phenomenological. They were willing to cast their net wide, collecting and considering a broad range of possible symptoms without first systematically constructing a theoretical causal model. For example, there was a belief among the Chinese that droughts often preceded earthquakes, and a seismologist developed a method to correlate the relationship between droughts and earthquakes.[16] His interest was in

[15] Examples can be found in Guangdon Sheng Geming Weiyuanhui Dizhen Bangong Shi and Guojia Dizhenju Guangzhou Dizhen Dadui 1973, 33–72; Guangdon Sheng Geming Weiyuanhui Dizhen Bangong Shi and Guojia Dizhenju Guangzhou Dizhen Dadui 1977; Tangshan dizhen qianzhao bianxie xiaozu, ed., 1977; Zhu and Jiang 1980.

[16] Details of the method and calculations can be found in Geng 1985. My account is also based on my interviews with Geng in September 2007. Geng developed his theory in the early 1970s.

finding out how to use droughts or meteorological data to calculate the occurrences of earthquakes. He labored through large quantities of data and derived certain formulae for predicting earthquakes based on the historical records of droughts. But what were the geological and physical models that might explain the relationship? The question seemed to him a little beside the point, and he didn't have a lot to say about it. He simply responded that the heat inside the earth has effects on the atmosphere. (In a nutshell, the flow of heat from inside the earth caused by seismic movements will have effects on the atmosphere. Severe droughts thus indicate major seismic movements.) There were many other prediction theories in a similar vein. The "doubling of geomagnetic variation" method, developed in the late 1960s, determined the corresponding relationship between geomagnetic variations related to the orbiting of the earth and the occurrences of earthquakes. According to the inventor of the theory, he first noticed a particular correspondence between the readings of geomagnetic meters in various locations and the occurrences of earthquakes. He surmised that the geomagnetic variations were also related to the revolution of the earth around the sun, especially the resulting solid-earth tides. (Since the variation seemed to be seasonal, he attributed it to the influence of the sun rather than the moon.) Before long, he also noticed a correspondence between the occurrences of earthquakes and of magnetic storms (caused by solar activity). Based on these discoveries and some calculation, he developed a formula for prediction of earthquakes. In explaining the theory to me, he admitted that the causes of earthquakes are obscure, yet he also maintained that one of the factors resides in the relationship between the sun and the earth.[17]

To mainstream Western scientists, these approaches must seem rather naïve and superficial. Yet, to the Chinese seismologists at the time, the principal issue was whether a method worked or not: if a method actually predicts earthquakes, it is good, regardless of how much or little it might reveal deeper geophysical properties. This is not to say that Western geology and seismology had no use for the phenomenological approach. On the contrary, phenomenology remained a fundamental component of the established methodology in geology. For instance, certain critical contributions to the theories of continental drift and later plate tectonics benefited from phenomenological reasoning (Oreskes 1999, 63–64, 81, 84, 95, chap. 9). I recently asked a seismologist based in the United States for his general opinion about the Chinese theories of earthquake prediction. The seismologist had extensive contact with his Chinese colleagues in the late 1970s and early 80s, and he once took some of the Chinese research seriously enough to look into it. His reply was that many of the Chinese theories based on phenomenological reasoning were not testable. We don't necessarily have to accept the underlying implication of his comment – that is, there is a fundamental epistemic

[17] Based on my interview with Zhang Tiezheng on October 10, 2007. Zhang said that later, in the mid-1970s, he began to think that magnetic storms might actually be caused by seismic activity. In any case, the way he developed his theory was to try to find regularity in series of empirical numbers based on simple and intuitive understanding of astronomy, geology, and seismicity.

https://doi.org/10.1017/S0269889711000329 Published online by Cambridge University Press

divide between what he considered as testable or untestable theories – to see that there was indeed a notable difference in interest, degree, emphasis, and style in seismological approaches between the Chinese scientists and their American counterparts. Compared to American seismology, the Chinese research focused much more closely on the predictive, rather than the explanatory, power of a theory.

Everyday Knowledge and Macroscopic Phenomena

Overall, the phenomenological and semiotic approaches fit in well with Maoist mass science and the "collective monitoring, collective defense" program. Most of the lay participants had only the most basic knowledge of geology and seismology or, in remote areas, hardly any at all; their main responsibility was to observe any macroscopic phenomena that might indicate the possible occurence of an earthquake. To illustrate how this mass participation in scientific observation worked, I shall look at two particular areas of observations – underground water and animal behavior. In earthquake prediction, the Chinese paid much attention to undergroundwater variations, such as unusual changes of well water level, taste, appearance, and temperature (fig. 2). The underlying rationale was that seismic activities would likely affect things underground; they might alter the chemistry and physical position of underground water. There were numerous anecdotes about how well-water looked and tasted different before an earthquake. One such "true story" related that on the eve of an earthquake, a tofu factory couldn't make tofu by using the water from their well (presumably because the chemical content of the water had changed) (Guo 1982, 53–54). A rhyme frequently included in the material for science dissemination about earthquake prediction says:

> Wells play a vital role,
> Earthquake signs they may tell;
> Their levels may strangely change,
> Their waters may bubble or turbid be
> With taste becoming bitter or sweet;
> On finding such strange events,
> Report them quickly as you can. (Adapted from Tang 1988, 154)[18]

Some wells were believed to be particularly sensitive and accurate in predicting earthquakes, and they acquired a reputation among the local population. These "treasure wells" were treated like windows into the deep bowels of the earth. Certain other symptoms received similar consideration. People were instructed to pay attention to ground temperature, unseasonable weather, and most significantly, animal behavior.

[18] During the Mao era, it was a common practice to use rhymes to disseminate information among the rural population and the less educated.

https://doi.org/10.1017/S0269889711000329 Published online by Cambridge University Press

Fig. 2. A seismological team inspecting the well-water. The picture emphasizes the collaboration between an expert, in a lab coat, and the people. Because Maoist ideology included the principle of gender equality, many of such propaganda posters featured women scientists.

Chinese seismologists accepted that aberrant animal behavior could exhibit premonitory phenomena of an earthquake. Again, there was a rationale behind this belief: animals are often more sensitive than humans to changes in natural environments. The Chinese found in historical records and folk wisdom much evidence to support this notion, although they didn't do controlled research into the connections between earthquakes and animal behavior/physiology until the 1970s (Zhonguo kexueyuan shengwu wuli yanjiusuo dizhen zu 1977; Jiang 1980; Jiang and Chen 1993). Animals thought to be useful for earthquake prediction included a wide range of pets, live stock, domestic pests, and wild animals; dogs, cats, cows, horses, pigs, chickens, pigeons,

Fig. 3. The pictures show how animals might exhibit precursory warnings of an earthquake. Horses might become difficult to control; ducks refuse to go in the water, and chickens fly up to the trees; dogs bark wildly; and snakes wake up from hibernation and crawl out of their hiding places.

parrots, ducks, mice, rabbits, fish, and snakes seemed all able to detect and respond to minute changes before an earthquake (fig. 3). One frequently cited example was the bizarre behavior of snakes in the weeks before the Haicheng earthquake in 1975. There were witness accounts of snakes crawling out of their hibernation holes in the February cold of North China and freezing to death (Zhongguo kexueyuan shengqu wulisuo dizhenzu 1977, 66–67). Some described vivid images of snakes struggling to come out despite the fact that their front halves were already numb in the cold. Burrowing animals were believed to be particularly sensitive to changes underground. However, live stock and other animals that most people came in contact with every day could also serve as convenient instruments. A widely circulated rhyme on animal behavior and earthquake prediction says:

> Before quakes abnormal animal behaviors may appear,
> The people should be prepared to fight the war [against earthquakes];
> Cattle, sheep, horses or mules may strangely refuse to enter their sheds;
> Mice may start moving about during the day, appearing to be in great fear;

https://doi.org/10.1017/S0269889711000329 Published online by Cambridge University Press

> Chickens may fly up to the trees, and pigs may run around restlessly, even breaking their sties;
> Ducks may refuse to go in the water, and dogs may bark madly. (Adapted from Tang 1988, 152)

The animals mentioned in the ballad are all pets, livestock, or home pests. The content had been gathered from folk knowledge, and the rhyme was intended mainly for people in the countryside; that is, people who worked in the field and who were close to the natural environment. These people usually lived in areas without the best coverage of seismological networks, and they had to help themselves predicting earthquakes, including, in this instance, using animals as seismic detectors. In fact, they could contribute to the "collective monitoring, collective defense" program by utilizing their lay expertise. More than most people, farmers were able to notice aberrant behavior of animals when they saw it. They were good observers because they were familiar with the routine or normal behavior of these animals. (In urban areas, zoo keepers took on the role of good observers of anomalous animal behavior.) People who handled livestock every day were particularly well equipped, as suggested in the episode about three mules cited at the beginning of this paper. This kind of expertise came from people's daily labor, from their daily struggle with nature. It was based on an epistemology that derived from practice and work and tradition.

Thus, monitoring macroscopic phenomena relied very much on everyday experience. Everyday experience was crucial, because it provided the background of normality against which the aberrant and the anomalous emerged. Here, everyday experience was no less a social than an individual acquirement. Most people didn't experience significant earthquakes so many times as to be able to compile premonitory symptoms; they had to start with the existing lore. Folk knowledge – traditional knowledge that had been passed onto and circulated among a local population – was often community-based knowledge and skill. Together with other social and individual knowledge, folk knowledge, experience, and skill constituted some kind of "lay expertise" (Wynne 1996; Epstein 1996). Although it didn't come from formal, institutionalized education and training, it could be just as specialized as any other expertise. Being able to make a good observation required one to have accumulated sufficient experience, knowledge, and practice. Only when one was familiar with the routine and the normal – either a particular weather pattern or the typical behavior of particular animals at a certain time and place and in a certain situation – could he or she immediately notice the more subtle kind of anomalies. From the standpoint of Maoism, this expertise was not only social, but also thoroughly political – because it was embedded in class and derived from labor. The expertise, however, was also often tied to a particular place, and everyday knowledge was intensely local. The value of knowledge owed much to its localness. This reminds us of the "Investigation in Agricultural Meteorology" movement in the late 1950s mentioned above. Similarly, the movement also tried to draw on the local experience and knowledge about natural forces. Since the aim of the Chinese approach to earthquake prediction was to pinpoint an earthquake rather to provide long-term forecast or hazard assessment, precision was key. Knowledge that corresponded precisely to a place would be useful for accurately predicting an earthquake.

Therefore, the use of folk knowledge in earthquake prediction involved two levels. At one level, the knowledge was thought to be portable and applicable from place to place. Why else would the Chinese authorities want to collect and disseminate it? At another, this knowledge necessarily required modification from place to place and from condition to condition. It had to be adapted to a particular place and, say, a particular group of animals. In collecting, organizing, and disseminating folk knowledge, the state attempted to appropriate the knowledge for practical as well as political purposes and to transform the "traditional" folk practice into something radically "modern" in its political meaning and scientific application. In other words, it sought to claim the ownership and meaning of the body of knowledge. Yet, in actuality, the process often ran into difficulties.

The "collective monitoring, collective defense" program belonged to the "offices of earthquakes" (*dizhen bangongshi*, which was part of the political branch), but the offices worked with the scientific branch; that is, the "seismological brigades" (*dizhen dadui*). The two branches regularly held joint-meetings, in which the seismic situation was analyzed and discussed. Usually, anomalies were first reported to the offices of earthquakes, which made an initial evaluation. If need be, the offices would contact the seismological brigades, invite them to examine the situation, and ask for their advice. The channels of responsibility and collaboration were designed in part to filter reports. In some areas at least, seismological offices were swamped with such reports. It was simply beyond their capacity to send scientists to the field to examine all or most of reported anomalies. Quantity was one problem. Quality was another. Not surprising, it was extremely difficult to control the quality of these observations. Measurements of the level of underground water might seem exact, but the interfering factors were innumerable. Reports on animal behavior were qualitative. Everybody had different thresholds for "strange behaviors." Everybody drew the line between the normal and the anomalous somewhat differently. Moreover, there was the individual and social psychology. If you urge people to look for anomalous phenomena, they are bound to find them. If the pressure or the excitement is high, people will see anomalies everywhere. The Chinese program of earthquake prediction was confronted with all these challenges.[19]

Political Earthquakes

Earthquakes were not simply natural events that had to be dealt with. They were also full of political meaning, at least as told in the "true stories" circulated in various forms

[19] It must have been common that many instances of abnormal macroscopic phenomena were mistakenly reported as precursory signs of earthquakes (see Ren 1992 and Shaonian dizhen cebao huodong biaxie zu 1978, 21–24).

of publications and propaganda. We can analyze these "true stories" as narratives. These narratives functioned as morality tales. Take for example the first episode cited at the beginning of this article. The protagonists were doing their routine work when they noticed something unusual. Rather than purposefully looking for anomalies, they were simply being very alert and vigilant. To be a good comrade is to be a vigilant soldier in the people's war against earthquakes. Such language and morals were familiar to people in communist China. For years they had been constantly admonished to spot and report on rightists, counter-revolutionaries, class enemies, and anyone who allegedly posed a threat to communist society and the party-state. Just as in political campaigns, ignoring the directions of the party-state was not only foolish, but also politically damnable. The Haicheng earthquake of 1975 supplied the best lesson of all. The day before the powerful earthquake occurred, the local officials already mobilized to evacuate people from their homes. Yet, despite the order, there were those who didn't obey or, after staying in the cold for a while, returned to the houses. Consequently, they were killed in the earthquake (Jiang 1978, 89). Thus, the lesson of the incident was clear: the ones who died in the earthquake were the ones who did not believe that the party-state could predict earthquakes. They got themselves killed or injured because they failed to put full faith in the communist government and because they did not absolutely follow the leadership of the party-state. The story was not simply about predicting and escaping a natural disaster; it was also about political loyalty and the authority of the party-state.

On the other hand, there were of course false alarms, although they were rarely mentioned in the propaganda materials. The official principle was that one should rather err on the side of false warnings than missed warnings. ("Ning yuan cuo bao, bu neng lou bao.") But there was a limit to tolerance of false alarms. Earthquake warnings would mean interruptions of work and everyday routine for a whole city. There could be considerable economic and political consequences. If this happened in California, one can imagine the impact on commerce, industry, the stock market, and real estate as well as the anger, protests, and complaints that would ensue (Geschwind 2001; Turner, Nigg, and Paz 1986). An earthquake warning would also mean an increase of public anxiety and fear. In a major city, the margin of error would be narrow because the consequences could be enormous. Therefore, those who found themselves in a position to issue earthquake warnings probably felt that they were caught between Scylla and Charybdis (Mei Shirong et al. 1993, 16; Guo 1987, 16–17).[20]

The "successful" prediction of the M7.3 Haicheng earthquake caught the attention of the international seismological community. The delegations from Japan, New Zealand, and the United States, among others visited China and investigated what the Chinese had done (Adams 1976; Raleigh 1977; Turner 1978; Gimenez 1976).[21]

[20] China passed laws to regulate earthquake forecast in 1998 (see Dizhen yubao guanli tiaoli shiyi biaxiazu 1999).

[21] A few years ago, a Chinese-Canadian seismologist reviewed the original Chinese documents from the time and reassessed the prediction of the Haichen earthquake (Wang et al. 2006). He concluded that luck had been the primary reason of the "successful" prediction.

Some of them were impressed with what they saw, and they thought that the Chinese might be on to something in certain areas of their research.[22] Both sides of this scientific contact were concerned with more than seismology, however. The Chinese used it to raise the international status and visibility of Chinese science just at a time when China was breaking through its international isolation; they were eager to gain recognition and membership in the international scientific community (Behrman 1976; Fan 2007; Schmalzer 2009).[23] Obviously, the foreign visitors were shown only what China wanted them to see. It is also true that scientific visitors to China at the time often brought with them their political views and their imagination about the country. Still some of them used the opportunity to advance arguments for lessons to be learned. In any case, the Chinese approach to earthquake prediction and defense gained international notice. However, the Tangshan earthquake in 1976 reminded many of how difficult it was to predict an earthquake. The M7.8 earthquake struck without any significant warning.[24] It demolished a whole city and killed a quarter of a million people. The year was a memorable one in modern Chinese history. It also witnessed the deaths of Zhou Enlai and Mao himself; the Gang of Four fell from power; the Cultural Revolution ended. To many, the earthquake seemed to mean something more than just a natural disaster. It marked the end of an era.

Conclusion

If we accept that science, as cultural production and social practice, is not free of politics, then, in this respect, science in communist China was hardly unique. We cannot treat science in any country as though it is devoid of politics: science is neither devoid of the micropolitics of the scientific community, nor is it immune from the macropolitics of society and polity. Maoist mass politics and mass science challenged the Weberian idea of technocracy and modernity, which the scientific establishment in Western societies holds up as the true characterization of itself – detached, objective,

[22] For example, China's attention to animal behavior spurred interest among Western scientists, e.g., Simon 1976; Evernden 1976; Wallace and Teng 1980; Evernden 1982; Tributsch 1982 (see also Ikeya 2004 for a Japanese perspective).

[23] Communist China (the People's Republic of China), which had replaced Taiwan (Republic of China) for a seat in the United Nations only a few years before, quickly became an active member in international seismological research, especially earthquake prediction (see, e.g. UNESCO 1984). Space limitations do not permit further discussion of the international ramifications of Chinese seismology here. It is the topic of a paper I am currently working on.

[24] This is the dominant and official view of Chinese seismology, but a number of seismologists who considered themselves marginalized by the scientific establishment have argued that many precursory signs had actually been detected and that it was a mistake on the part of those who were then in charge not to issue a warning or evacuation order before the earthquake struck (see, e.g, Qian 2005). This contention made it into the public realm on the thirtieth anniversary of the Tangshan earthquake in 2006 and in the wake of the 2008 Sichuan earthquake.

rational, impersonal, apolitical, governed by rules, and run by experts. Maoist thought and science attacked this notion of technocracy and insisted on the primacy of politics – that is, constant class struggle and revolutionary creativity from the masses (Whyte 1973). Thus, Maoism erected a different vision of political and scientific modernity. Yet, Maoist mass science was also fiercely dogmatic. It was mostly top-down despite its claim of the mass line. The party-state said that earthquakes could be predicted. Nobody, then, could be skeptical. Whoever doubted openly that earthquakes could be predicted would run the risk of being labeled as a counter-revolutionary, an enemy of the party-state. Ultimately, the "collective monitoring, collective defense" program depended, in principle, on a highly regimented society. It was a program of collective defense, not entirely different from that of the commune militia.

With its close ties to the state and its didactic political function, Maoist mass science cannot be readily compared to "popular science" in democratic societies. It was also different from "public science," as it is commonly understood, for the latter assumes the separation between the public (say, the public sphere) and the private realm. Maoist ideology left little room for such a separation. Nor could Maoist science be reduced to "amateur science," "lay science," "vernacular science," or "science dissemination and popularization," although it contained elements of all of them.[25] One could perhaps simply leave it as it was, calling it "mass science" or "people's science," and not try to make comparisons to other historical cases. Yet, I think that would be unfortunate. Not only would it simply relegate science in communist China to a corner in the historiography of modern science, turning it into a mere oddity, an object of curiosity, but it would also miss an excellent opportunity to ask important questions about science and modernity.

Fundamentally, Mao's mass science was concerned with the relationship between science and the legitimate membership of a particular political entity. In this sense, it may be fruitfully compared to what might be called "citizen science" (Charvolin, Micoud, and Nyhart 2007). I suggest that the term has two different, but related, meanings. "Citizen science" has usually been used in a positive sense. It refers to a voluntary, collaborative, complementary, and broad-based participation in scientific activities, and it has often been used to suggest a sense of democratic participation. Familiar examples of this include the Citizen Science project initiated by the Cornell Lab of Ornithology, the Common Birds Census project launched by the British Trust of Ornithology, the Skywarn program of the National Weather Service for tornado spotters starting from the 1970s, and perhaps the collaboration between NASA's

[25] For a recent discussion on "popular science" and related concepts, see the Focus section, "Historicizing Popular Science," in *Isis* 2009, 100:310–368. Andrews's *Science for the Masses* (Andrews 2003) relies on the notions of "public science" and "the popularization of science." It focuses on the role of print culture and public discourse in science popularization. This has to do with his approach and perspective, but it also has to do with the historical fact that even the Soviet Union did not go as far as Mao's China in pursuing the kind of mass science discussed in this essay.

Chandra Observatory and backyard astronomers (Doswell, Moller, and Brooks 1999; Charvolin 2007).[26] (This is not to say that there aren't tensions between the scientists and the amateurs in such joint endeavors, but that is a different matter.)

However, there is another implication of "citizen science" that also deserves attention. A citizen is a member of an organized political entity, most likely that of a state. "Citizen science" is, therefore, not simply any broad participation in science, but one that has to do with the ideology, institutions, and functions of a state. Thus defined, "citizen science" is inextricable from the politics of the state, which can mean measures of state control, nation-state building, surveillance, discipline, and general participation through the operations of state apparatus or through the constitution and practice of citizenship. Consider such examples: the science education involved in the civil defense programs in the 1950s and (if taking into account the tangling of scientific nationalism, scientific internationalism, and Cold War international politics) the Moonwatch program of the Smithsonian Astrophysics Observatory for tracking satellites in the 1950s–70s (McEnaney 2000; McCray 2006).

To be sure, the peculiar political system of Mao's China produced a distinct kind of "citizen science." In most Western examples cited above, the amateurs volunteered or were recruited to help the professional scientists to conduct scientific work. They were expected to follow the guidance of professional science, and the goal was not to challenge or subvert the scientific establishment. In this respect, it was quite different from Maoist mass science, which drew much from unconventional sources of scientific knowledge. As we have seen, the Chinese enterprise of earthquake prediction depended in part on scientific observation informed by everyday experience and folk knowledge. The scientific observation was as political as it was epistemological. The generous inclusion of everyday and folk knowledge in Maoist mass science reminds us not so much of "amateur science" as of "vernacular science" – e.g., the lay science in the Love Canal incident or even the non-elite versions of anti-evolutionary theories.[27] (The crucial difference is that Maoist mass science was officially sanctioned and enforced with the might of the state.) Yet, in other respects, Maoist mass science was perhaps not so unique among other forms of citizen science. It reflected the intimate relationship between science and the macropolitics of modern state and society.

[26] See also the websites of the Citizen Science project, Cornell Laboratory of Ornithology and the Common Birds Census, British Trust for Ornithology.

[27] For Love Canal, see Allan Mazur 1998. Anti-evolutionary theories proposed by non-professional scientists are innumerable and flood the Internet. This analogy is limited, however. Few professional scientists accept anti-evolutionary theories, least of all, the folk versions of them, whereas many, though hardly all, Chinese scientists in the 1960s and 1970s believed in the value of everyday observation and folk knowledge.

References

Adams, Robin D. 1976. "The Haicheng, China, Earthquake of 4 February 1975: The First Successfully Predicted Major Earthquake." *Bulletin of the New Zealand National Society for Earthquake Engineering* 9(1):32–42.

Andrews, James T. 2003. *Science for the Masses: The Bolshevik State, Public Science, and the Popular Imagination in Soviet Russia, 1917–1934*. College Station: Texas A&M University Press.

Anon. 1959. "Nongye qixiang shao, zu de gongzuo changsuo shi zai tianjian han qunzhong zhong" [The worksites for the outposts and groups of agricultural meteorology are among the agricultural fields and the masses]. *Nongye qixiang* [Agricultural meteorology] 8:2–3.

Anon. 1970. "Shixian dizhen yubao bixu dagao qunzhong yundong" [To realize earthquake prediction, we must mobilize the masses]. *Dizhen zhanxian* [Battlefront against earthquakes] 5–6:6–7.

Anon. 1975. *Dizhen changshi* [Common knowledge on earthquakes]. Beijing: Renmin chubanshe.

Barth, Kai-Henrik. 2003. "The Politics of Seismology: Nuclear Testing, Arms Control, and the Transformation of a Discipline." *Social Studies of Science* 33:743–781.

Behrman, Dan. 1976. "China Predicts a Major Earthquake. For the First Time in Human History, an Entire Population Was Saved from Disaster." *The UNESCO Courier: a Window on to the World* (May):11–13.

Beijing shi fangzhen bangongshi. 1970. "Guanyu kaizhan qunzhongxing dizhen gongzuo de yixie tihui" [Some thoughts from experience about the mass work related to earthquakes]. *Dizhen zhanxian* 5–6:8–11.

Beijing shi yanqing xian gewei hui, Yanqing xian Zhangshan ying diqu dizhen lianhe diaocha zu. 1969. "Tu didian fangfa jieshao" [Introducing the telluric-current method]. *Dizhen zhanxian* 4:29–31.

Beijing shi zhaokai jiangxue huoyong Mao Zedong sixiang chuangzhi cebao dizhen tu yiqi jiangyong hui. 1970. "Qunzhong shi zhenzheng yingxiong" [The masses are the real heroes]. *Dizhen zhanxian* 5–6:21–25.

British Trust for Ornithology. *The Common Birds Census*. <http://www.bto.org/survey/complete/cbc.htm>. Last accessed, August 27, 2010.

Charvolin, Florian, André Micoud, and Lynn Nyhart, eds. 2007. *Des sciences citoyennes? La question de l'amateur dans les sciences naturalistes*. La Tour d'Aigues: Editions de l'Aube.

Charvolin, Florian. 2007. "La réussite du programme Feederwatch vue par les profanes: compte-rendu critique." In *Des sciences citoyennes? La question de l'amateur dans les sciences naturalistes*, edited by Florian Charvolin, Micoud, and Lynn Nyhart, 202–218. La Tour d'Aigues: Editions de l'Aube.

Cornell Laboratory of Ornithology. <http://www.birds.cornell.edu/netcommunity/citsci/>. Last accessed, August 27, 2010.

Davies, David, ed. *1969. Seismic Methods for Monitoring Underground Explosions*. Stockholm: SIPRI.

Dizhen wenda bianxiezu. 1977. *Dizhen wenda* [Questions and answers about earthquakes]. Beijing: Dizhi chubanshe.

Dizhen yubao guanli tiaoli shiyi biaxiazu. 1999. *"Dizhen yubao guanli tiaoli" shiyi* [Explanation of 'Regulations on Administration of Earthquake Predictions']. Beijing: Dizhen chubanshe.

Doswell III, Charles A., Alan R. Moller, and Harold E. Brooks. 1999. "Storm Spotting and Public Awareness Since the First Tornado Storm Forecasts of 1948." *Weather and Forecasting* 14:544–557.

Elman, Benjamin, et al. 2007. Focus section on "Science and Modern China." *Isis* 98:524–583.

Epstein, Steven. 1996. *Impure Science: AIDS, Activism, and the Politics of Knowledge*. Berkeley: University of California Press.

Evernden, J. F., ed. 1976. *Abnormal Animal Behavior Prior to Earthquakes.* Conference Proceedings, U.S. Geological Survey. Menlo Park CA.

Evernden, J. F. 1982. "Earthquake Prediction: What We Have Learned and What We Should Do Now." *Bulletin of the Seismological Society of America* 72:343–349.

Fan, Fa-ti. 2007. "Redrawing the Map: Science in Twentieth-Century China." *Isis* 98:524–538.

Fang Xiaoping. 2008. "From Union Clinics to Barefoot Doctors: Village Healers, Medical Pluralism and State Medicine in a Chinese Village." *Journal of Modern Chinese History* 2(2):221–237.

Fang Zhangshun, ed. 1995. *Zhou Enlai yu fangzhen jianzai* [Zhou Enlai and the defense against earthquakes and the reduction of disasters]. Beijing: Zhongyang wenxian chubanshe.

Geller, Robert J., et al. 1997. "Earthquakes Cannot Be Predicted." *Science* 275(5306):1616.

Geng Qingguo. 1985. *Zhongguo hanzhen guanxi yanjiu* [Research on the relationship between droughts and earthquakes in China]. Beijing: Haiyang chubanshe.

Geschwind, Carl-Henry. 2001. *California Earthquakes: Science, Risk and the Politics of Hazard Mitigation*. Baltimore: Johns Hopkins University Press.

Gimenez, Martha. 1976. "A 'People's War' Against Earthquakes." *Mass Emergencies* 1:323–341.

Guangdon Sheng Geming Weiyuanhui Dizhen Bangong Shi and Guojia Dizhenju Guangzhou Dizhen Dadui. 1973. *Dizhen ji qi yufang* [Earthquakes and how to prevent their damage]. Guangzhou: Guangdong renmin chubanshe.

Guangdon Sheng Geming Weiyuanhui Dizhen Bangong Shi and Guojia Dizhenju Guangzhou Dizhen Dadui. 1977. *Dizhen zhishi huace* [Illustrated pamphlet on knowledge about earthquakes]. Beijing: Dizhen chubanshe.

Guo Qinhua. 1982. *Zhenqian qiguan* [Unusual sights of pre-earthquake phenomena]. Beijing: Dizhen chubanshe.

Guo Qinhua. 1987. *Dizhen qianhou sanshiliu ji* [Thirty-six strategems before and after an eathquake]. Beijing: Dizhen chubanshe.

Guowai dizhen bianjibu. 1979. *Dizhen yubao han dizhen xue* [Earthquake prediction and seismology]. Beijing: Kexue jishu wenxian chubanshe.

Hebei sheng letting xian huiwei zhongxue keyan xiaozu. 1970. "Tu didian zidong Jiluyi" [Telluric-current auto-recorder]. *Dizhen Zhanxian* 5–6:46–47.

Hough, Susan. 2009. *Predicting the Unpredictable: The Tumultuous Science of Earthquake Prediction*. Princeton: Princeton University Press.

Hu, Danian. 2005. *China and Albert Einstein*. Cambridge: Harvard University Press.

Hung, Chang-tai. 2010. "The Anti-Unity Sect Campaign and Mass Mobilization in the Early People's Republic of China." *China Quarterly* 202:400–420.

Ikeya, Motoji. 2004. *Earthquakes and Animals: From Folk Legends to Science*. Singapore: World Scientific.

Jia Engao. 1968. "Gongnongbing bixu chengwei dizhen kexue jishu de zhuren" [The workers, peasants, and soldiers must be the master of science and technology about earthquakes]. *Dizhen zhanxian* 8:14–18.

Jian Bing. 1959. "Zenyang liyong nongmin jingyan ji suan nongye qixiang zhibiao" [How to use the experiences of farmers to calculate the index of agricultural meteorology]. *Nongye qixiang* 9:4–6.

Jiang Fan. 1978. *Haicheng dizhen* [Haichen earthquake]. Beijing: Dizhen chubanshe.

Jiang Jinchang. 1980. *Qiyi de benling: qiantan dongwu yuzhi dizhen* [Strange abilities: introduction to animals and earthquake prediction]. Beijing: Dizhen chubanshe.

Jiang Jinchang and Chen Deyu. 1993. *Dizhen shengwuxue gailun* [General treatise on seismological biology]. Beijing: Dizhen chubanshe.

Leach, Melissa, Ian Scoones, and Brian Wynne, eds. 2005. *Science and Citizens: Globalization and the Challenge of Engagement*. London: Zed Books.

Li Shanbang. 1981. *Zhongugo dizhen* [Earthquakes in China]. Beijing: Dizhen chubanshe.

Li Siguang. 1977. *Lun dizhen* [On earthquakes]. Beijing: Dizhen chubanshe.

Liang Zongdai. 1970. "Jieshao liang zhong tuyiqi" [Introducing two indigenous instruments]. *Dizhen Zhanxian* 5–6:45–46.

Ma Zongjin, et al. 1982. *Zhongguo jiu da dizhen* [Nine major earthquakes in China]. Beijing: Dizhen chubanshe.

Main, Ian, et al. 1999. "Is the reliable prediction of individual earthquakes a realistic scientific goal?" Organized by *Nature*, 25 February - 8 April 1999. <http://www.nature.com/nature/debates/earthquake/>. Last accessed 26 August 2010.

Mao Zedong. 1940. "Speech at the inaugural meeting of the Natural Science Research Society of the Border Region (5 February 1940)." <http://www.marxists.org/reference/archive/mao/works/red-book/ch22.htm>. Last accessed November 7, 2011.

Mao Zedong. [1958] 1987. *Jianguo yilai Mao Zedong wengao* [Nation building must rely on Mao Zedong's writings] 7:236–238. Beijing: Zhongyang wenxian chubanshe.

Mazur, Allan. 1998. *A Hazardous Inquiry: The* Rashomon *Effect at Love Canal*. Cambridge MA: Harvard University Press.

McCray, W. Patrick. 2006. "Amateur Scientists, the International Geophysical Year, and the Ambitions of Fred Whipple." *Isis* 97:634–658.

McEnaney, Laura. 2000. *Civil Defense Begins at Home*. Princeton: Princeton University Press.

Mei Shirong, et al., eds. 1993. *Zhongguo dizhen yubao gailun* [General treatise on earthquake prediction]. Beijing: Dizhen chubanshe.

Ningjin xian geming weiyuanhui. 1968. "Kao Mao Zedong sixiang, kao guanda qunzhong zai dizhen zhanxian shang dada yichang renmin zhanzheng" [Relying on Mao Zedong thought and relying on the masses in fighting a people's war on the battlefront against earthquakes]. *Dizhen zhanxian* 8:26–29.

Ningxia huizu zizhiqu Longde xian geming weiyuanhui fangzhen lingdao xiaozu Bangongshi. 1972. "Tu didian, dixia shui yubao dizhen xiaojie" [Explanation of how to predict earthquakes by using telluric currents and underground water]. *Dizhen zhanxian* 10:35–39.

Nongyebu nongju gaige bangongshi, ed. 1959. *Tuyang jiehe dagao gongju gaige yundong de jingyan* [Experiences of the movement "to improve tools by integrating indigenous and foreign methods"]. Beijing: Nongye chubanshe.

Ohtake, Masakazu. 2004. "The Late Professor Takahiro Hagiwara: His Career with Earthquake Prediction." *Earth Planets Space* 56:ix–xiii.

Oike Kazuo. 1978. *Chūgoku no jishin yochi* [Earthquake prediction in China]. Tokyo: Nihon Hōsō Shuppan Kyōkai.

Oreskes, Naomi. 1999. *The Rejection of Continental Drift: Theory and Method in American Earth Science*. New York: Oxford University Press.

Qian Gang. 2005. *Tangshan da dizhen* [The great Tangshan earthquake]. Beijing: Dandai Zhongguo chubanshe.

Quanguo kexie. 1964. *Nongcun qunzhong kexue shiyan huodong jingyan jiaoliuhui fayan cailiao huibian* [Collections of speeches at the meeting of the "village mass agricultural experimentation" movement]. Beijing: Quanguo kexie.

Raleigh, Barry, et al. (the Haicheng Earthquake Study Delegation). 1977. "Prediction of the Haicheng Earthquake." *EOS, Transactions, American Geophysical Union* 58(5):236–272.

Ren Baode. 1992. *Fei hongguan yichang yibai li* [One hundred examples of non-seismic-related macroscopic anomalies]. Beijing: Dizhen chubanshe.

Rikitake, Tsuneji. 1976. *Earthquake Prediction*. New York: Elsevier Scientific.

Schmalzer, Sigrid. 2006. "Labor Created Humanity: Cultural Revolution Science on Its Own Terms." In *China's Cultural Revolution as History*, edited by Joseph Esherick, Paul Pickowicz, and Andrew Walder, 185–210. Stanford: Stanford University Press.

Schmalzer, Sigrid. 2009. "Speaking about China, Learning from China: Amateur China Experts in 1970s America." *Journal of American-East Asian Relations* 16:313–352.

Shaanxi sheng geweihui dizhenju bian. 1977. *Dizhen yuce yufang zhishi* [Knowledge about earthquake prediction and defense]. Xian: Shaanxi renmin chubanshe.

Shaonian dizhen cebao huodong bianxie zu. 1978. *Shaonian dizhen cebao huodong*. Shanghai: Xinhua shudian.

Shanghai zhongyi xueyuan, et al. 1969. *Chijiao yisheng shouce* [Barefoot Doctor's Handbook]. Shanghai: Shanghai kexue jishu chubanshe.

Shanxi sheng qixiang ju. 1959. "'Tuyang shengzhan' si jiehe, yubao fuwu dayuejin" [Four integrations of indigenous and foreign methods at provincial stations, the great leap forward of forecast services]. Nongye qixiang 1:5–7.

Simon, Ruth B. 1976. "Animal Behavior and Earthquakes." *California Geology* 29(9):210–211.

Smith, Steve A. 2006a. "Local Cadres Confront the Supernatural: The Politics of Holy Water (Shenshui) in the PRC, 1949–1966." *China Quarterly* 188:999–1022.

Smith, Steve A. 2006b. "Talking Toads and Chinless Ghosts: The Politics of 'Superstitious' Rumors in the People's Republic of China, 1961–1965." *American Historical Review* 111:404–427.

Tang Xiren. 1988. *A General History of Earthquake Studies in China*. Beijing: Science Press.

Tangshan dizhen qianzhao bianxie xiaozu, ed. 1977. *Tangshan dizhen qianzhao* [Precursory signs of the Tangshan earthquake]. Beijing: Dizhen chubanshe.

Topham, Jonathan. 2009. "Historicizing "Popular Science." *Isis* 100:310–368.

Tributsch, Helmut. 1982. *When the Snakes Awake: Animals and Earthquake Prediction*. Cambridge MA: MIT Press.

Turner, Ralph. 1978. "Earthquake Prediction Volunteers: What Can the United States Learn from China?" *Mass Emergencies* 3:143–160.

Turner, Ralph H., Joanne M. Nigg, and Denise Heller Paz. 1986. *Waiting for Disaster: Earthquake Watch in California*. Berkeley: University of California Press.

UNESCO. 1984. *Earthquake Prediction: Proceedings of the International Symposium on Earthquake Prediction*. Tokyo: Terra Scientific.

Wallace, Robert E., and Ta-Liang Teng. 1980. "Prediction of the Sungpan-Pingwu earthquakes, August 1976." *Bulletin of the Seismological Society of America* 70:1199–1223.

Wang, Kelin, et al. 2006. "Predicting the 1975 Haicheng Earthquake." *Bulletin of the Seismological Society of America* 96(3):757–795.

Whyte, Martin King. 1973. "Bureaucracy and Modernization in China: The Maoist Critique." *American Sociological Review* 38(2):149–163.

Wynne, Brian. 1996. "May the Sheep Safely Graze? A Reflexive View of the Expert-Lay Knowledge Divide." In *Risk, Environment and Modernity: Towards a New Ecology*, edited by Scott M. Lash, Bronislaw Szerszynski, and Brian Wynne, 44–83. London: Sage.

Wyss, Max, et al. 1997. "Cannot Earthquakes Be Predicted." *Science* 278 (5337):487–490.

Wyss, Max. 1999. "Without Funding. No Progress." 11 March, in the Week 3 section of the *Nature* debate: <http://www.nature.com/nature/debates/earthquake/equake>. Last accessed November 7, 2011.

Zhongguo kexue jishu qingbao yanjiusuo. 1972. *Jianshi dixia baozha de dizhen Fangfa* [Seismic methods for monitoring underground explosions]. Beijing: Zhongguo Kexueyuan Diqiu Wuli Yanjiusuo.

Zhongguo kexueyuan shengwu wuli yanjiusuo dizhen zu. 1977. *Dongwu yu dizhen* [Animals and earthquakes]. Beijing: Dizhen chubanshe.

Zhu Jiezuo and Jiang Zaixiong. 1980. *Yufang dizhen de hongguan zhishi* [Knowledge about macroscopic phenomena for earthquake defense]. Chengdu: Sichuan minzu chubanshe.