Research on Prediction of Three Great Earthquakes During the Beginning of the 21st Century in the Northern Xizang Plateau

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The northern Xizang Plateau is a main seismic zone in West China. Since 1700, $M \geq 7$ earthquakes have had an obvious commensurability and orderliness in this region. The main ordered values are 106 ∼ 107a, 77 ∼ 78a, 53 ∼ 54a, 26 ∼ 27a, 11 ∼ 12a, and 3 ∼ 4a. According to the information forecasting theory of Wen-Bo Weng (W. B. Weng, Fundamentals of Forecasting Theory. Petroleum Industry Press, Beijing 1984 (in Chinese)), combining ordered analysis with complex network technology, we try to explore the practical method for $M \geq 7$ earthquake prediction with Chinese characteristics, and build a informational ordered network structure of $M \geq 7$ earthquakes in the northern Xizang Plateau. In this paper, we study the prediction of three great earthquakes (the 2001 Kunlunshan *M8.1*, the 2008 Wenchuan *M8.0*, and the 2010 *M7.1* Yushu earthquake) during the beginning of the 21st century based on the method of ordered network structure, and give many famous earthquake examples in China and abroad. Meanwhile, the cause of formation about the Wenchuan and Yushu earthquake has been discussed primarily. At last, we present some new prediction opinions: the future $M \geq 7$ earthquakes will happen in 2014 – 2015, 2026 – 2027, and 2030 pre and post in this region. The results show that this method has a unique effect on moderate term and long term prediction for great earthquakes.

Key words: Northern Xizang Plateau; Informational Ordered Network Structure; Kunlunshan *M8.1* Earthquake; Wenchuan *M8.0* Earthquake; Yushu *M7.1* Earthquake; Prediction of Great Earthquakes.

1. Introduction

Measured by the China Seismic Network Center, a severe *M8.0* earthquake hit Wenchuan County of Sichuan Province, which is in the eastern Xizang Plateau, on May 12, 2008. Its epicenter was at 31.0° N, 103.4° E, and the focal depth was 14 km. The disaster area was about 500 000 km^2, including a 130 000 km^2 extremely serious area. What's more, 46.25 million people were affected, in which 69 227 people were killed, 17 923 people were missing, and 374 643 people were injured. The direct economic loss was estimated to be 845.1 billion Renminbi (RMB). It was the first event with magnitude $M \geq 7$ in Mainland China since the *M8.1* earthquake of West of Kunlunshan Pass in Qinghai Province occurred on November 14, 2001. And another severe *M7.1* earthquake struck Yushu in Qinghai Province on April 14, 2010, less than two years after the Wenchuan earthquake. The Kunlunshan *M8.1* earthquake, Wenchuan *M8.0* earthquake, and Yushu *M7.1* earthquake are the three major earthquakes occurred in the northern Xizang Plateau at the beginning of the 21st century. So, the occurrence of the three large earthquakes has great significance in the study on earthquake tendency not only in West China, but also in all over Mainland China and even Southeast Asia.

As Guo et al. [1] mentioned, 'geophysical disaster chain' is a new innovative and cross-disciplinary subject, which study the relationship between the different hazards within the broad field of geophysics while the so-called 'strong earthquake disaster chain' is a natural phenomenon in a certain period that earthquake disaster occurs in the same district or occurs orderly in the joint region. In 1997, Xu firstly put forward the concept of information ordered series, and then in 2001 and 2007 he proposed the network hypothesis and the concept of self-organized network, respectively [2 – 5]. In 2010, Xu et al. studied the network structure of $M \geq 8$ great earthquakes [6]. Since the 1990s, we have been devoted to studying strong earthquake activity and its network structure in the region of Xinjiang, Jiangsu-South Yellow Sea, and the northern part of the Xizang Plateau and have achieved a number of important results [7 – 15]. As we think, the active characteristic of $M \geq 7$ earthquakes and its network structure in the Northern Xizang Plateau area are different from that in the region of Xinjiang [16]. Before the Wenchuan *M8.0* earthquake, we found its information according to the ordered network structure in April, 2002 and made the prediction that a $M \geq 7$ earthquake would take place in 2006 – 2007 near the junction of the eastern Kuma fault zone and the North-South seismic belt [9]. Earthquake prediction should be a gradual process. Since then, we followed up of this earthquake, and submitted an internal report to the summary conference of nature disaster prediction in October, 2006. Meanwhile, we proposed our new opinion to the Committee of Nature Disaster Prediction, Chinese Geophysical Society in February, 2007 and January, 2008, respectively, which asserted that a $M \geq 7$ earthquake would strike this district in 2007 – 2008 (see the nature disaster prediction statement of 2007 and 2008). Unfortunately, our research work was stopped because of shortage of running funds. In the guidance of informative prediction theory of Wen-Bo Weng, with previous research results, combining order analysis with complex network technology, this paper will make a summary and supplement based on the previous study of the ordered network structure of $M \geq 7$ earthquake chains to contribute to improve the level of earthquake prediction.

2. Ordered Network Structure of $M \geq 7$ Earthquakes in the Northern Xizang Plateau

The northern Xizang plateau is a main seismic zone in West China. This paper studies the area of 30 – 40° N, 85 – 105° E, which is the so-called second and the third arc seismic belt. Its northern border is the Altyn–Tagh–Qilianshan–Haiyuan active fault zone and its eastern border the famous North-South seismic belt, which is going from Haiyuan–Wudu across Tsinling Mountains along the Minjiang fault zone and the Longmenshan fault zone to Sichuan–Yunan–Guizhou province. Its southern border is the East Kunlun latitudinal tectonic system. The Qinghai Province is located in the main area, including Gansu, Ningxia, Sichuan, and part of Xizang. There we find a vast complex geological structure, extremely developed fault fold, and very frequent seismic activity [17, 18]. Since 1709, 34 $M \geq 7$ earthquakes have occurred in this region including five $M \geq 8$ earthquakes (Table 1). The three greatest earthquakes occurred in Mainland China during the fifth active period – the Mani *M7.9* earthquake in 1997 and the Kunlunshan *M8.1* earthquake in 2001 – all occurred in the area of the eastern Kunlun fault zone, while the Wenchuan *M8.0* earthquake in 2008 occurred in the Longmenshan fault zone where we find the junction of the southeast part of the northern Xizang Plateau and the North-South seismic belt. The seismic fault length is over 300 km, more than three times that of the Tangshan earthquake, which means that the energy released by the Wenchuan earthquake was about three times higher than that released by the Tangshan earthquake. The rupture lasts 90 seconds, and Wenchuan and Beichuan slipped the most [19]. Thus, this district becomes the main active area in China during the fifth seismic active period.

In the 1980s, the information forecasting theory created by Weng [20], which combines the advantages of Chinese and Western cultures, is a major theoretical innovation in contemporary natural disaster prediction. Forecasting methods can be divided into statistical forecasting and informative forecasting. Statistical forecasting is based on common parts of elements while informative forecasting bases on special parts. Based on hypothesis as few as possible, informative forecasting finds and solves problems in view of practice, and focuses on finding information orderliness from disorder phenomena. A serious natural disaster belongs to an abnormal event, the spatial and temporal distribution of which is different from normal events. Therefore, statistical forecasting methods and fitting models based on continuous functions that are usually used to deal with common elements are often difficult to work. The successful prediction for earthquakes with the information forecasting theory by Weng created a new way for the prediction of major natural disaster [20 – 22]. A network is a set of nodes and edges. A network hypothesis, which regards the earthquake as a multi-level, multi-factor, multi-dimensional network node, is helpful in the research of the complexity of a major earthquake and the information orderliness of the strong earthquake from total and dynamic perspective. A self-organized theory focuses on studying dynamic and orderliness of dissipative structures and finding the basic evolution and unified law of nature. As Xu thinks, a network is the further extension of the system concept. It is open, and it is

Table 1. Catalogue of $M \geq 7$ earthquakes in the northern Xizang Plateau (1700 – 2010).

No.	Dates	Epicentral location		Magnitude	Locality
	Year-month-day	Latitude (°N)	Longitude (°E)	(M)	
1	1709-10-14	37.4	105.3	7.5	Zhongwei, Ningxia
2	1713-09-04	32.0	103.7	7.0	Diexi, Sichuan
3	1718-06-19	35.0	105.2	7.5	Tongwei, Gansu
4	1725-08-01	30.0	101.9	7.0	Kangding, Sichuan
5	1786-06-01	29.9	102.0	7.7	Kangding, Sichuan
6	1816-12-08	31.4	100.7	7.5	Luhuo, Sichuan
7	1866-04-	31.6	100.0	7.0	Ganzi, Sichuan
8	1870-04-11	30.0	99.1	7.2	Batang, Sichuan
9	1879-07-01	33.2	104.7	8.0	South Wudu, Gansu
10	1883-10-	30.2	81.2	7.0	Pulan, Xizang
11	1893-08-29	30.6	101.5	7.0	Daofu-Qianning, Sichuan
12	1896-03-	32.5	98.0	7.0	Shiqu, Sichuan
13	1902-11-04	36.0	96.0	7.0	West Dulan, Qinghai
14	1904-08-30	31.0	101.1	7.0	Daofu, Sichuan
15	1908-08-20	32.0	89.0	7.0	Qilin Lake, Xizang
16	1920-12-16	36.7	104.9	8.5	Haiyuan, Ningxia
17	1923-03-24	31.5	101.0	7.3	Luhuo-Daofu, Sichun
18	1927-05-23	37.7	102.2	8.0	Gulang, Gansu
19	1932-12-25	39.7	96.7	7.6	Changma, Gansu
20	1933-08-25	31.9	103.4	7.5	Diexi, Sichuan
21	1937-01-07	35.5	97.6	7.5	East Alan Lake, Qinghai
22	1947-03-17	33.3	99.5	7.7	South Dari, Qinghai
23	1954-02-11	39.0	101.3	7.2	Northeast of Shandan, Gansu
24	1963-04-19	35.7	97.0	7.0	Alan Lake, Qinghai
25	1973-02-06	31.3	100.7	7.6	Luhuo, Sichuan
26	1973-07-14	35.1	86.5	7.3	Yijitaicuo, Xizang
27	1976-08-16	32.6	104.1	7.2	Songpan, Sichuan
28	1976-08-23	32.5	104.3	7.2	Songpan, Sichuan
29	1981-01-24	31.01	101.11	6.9	Daofu, Sichuan
30	1990-04-26	36.06	100.33	7.0	Southwest of Gonghe, Qinghai
31	1997-11-08	35.2	87.3	7.9	Mani, Xizang
32	2001-11-14	36.2	90.9	8.1	West of Kunlunshan Pass, Qinghai
33	2008-05-12	31.0	103.4	8.0	Wenchuan, Sichuan
34	2010-04-14	33.2	96.6	7.1	Yushu, Qinghai

more suitable for describing some complicated things which exist objectively. So-called 'self-organized' is not the regularity imposed by human's innate recognition but from the nature. The basic characteristic of a self-organized network lies in the lower structural similarity and the large opening degree. In other words, the self-organized network does not have fixed boundaries, structures, and initial conditions. Many researches on earth science can be improved using ideas of self-organized network. According to the informative forecasting theory, we made a deep research on the information orderliness of $M \geq 7$ earthquakes in this region, analyzing the relationship between each interval value of the strong earthquake chain in detail [7 – 10], particular process will not be repeated.

In this paper, we use the number of years to express the strong or great earthquake. There are a total number of 34 $M \geq 7$ earthquakes in Table 1. Among them, the $M \geq 7$ earthquakes occurred twice in 1973 and 1976, and we only use one number for several samples of strong or great earthquakes in the same year. Thus, we get 32 year numbers and $C_{32}^2 = 496$ values of time interval by subtraction in pairs, naming it τ. Statistical analysis shows that earthquakes of $M \geq 7$ in the northern Xizang Plateau have a characteristic of orderliness. The main values of time intervals are as follows: 106 ∼ 107a, 53 ∼ 54a, 26 ∼ 27a, 10 ∼ 11a, 3 ∼ 4a; furthermore, there are 34a, 43a, 67a, 77a, and 80a. Among them, 27a and 53a have the highest frequency, which is remarkable. The ordered values derived from them forms a long chain: 27a – 53a – 80a – 107a – 214a. Based on above research results, by readjusting, detailing, and improving the network structure, this paper tries to construct a figure

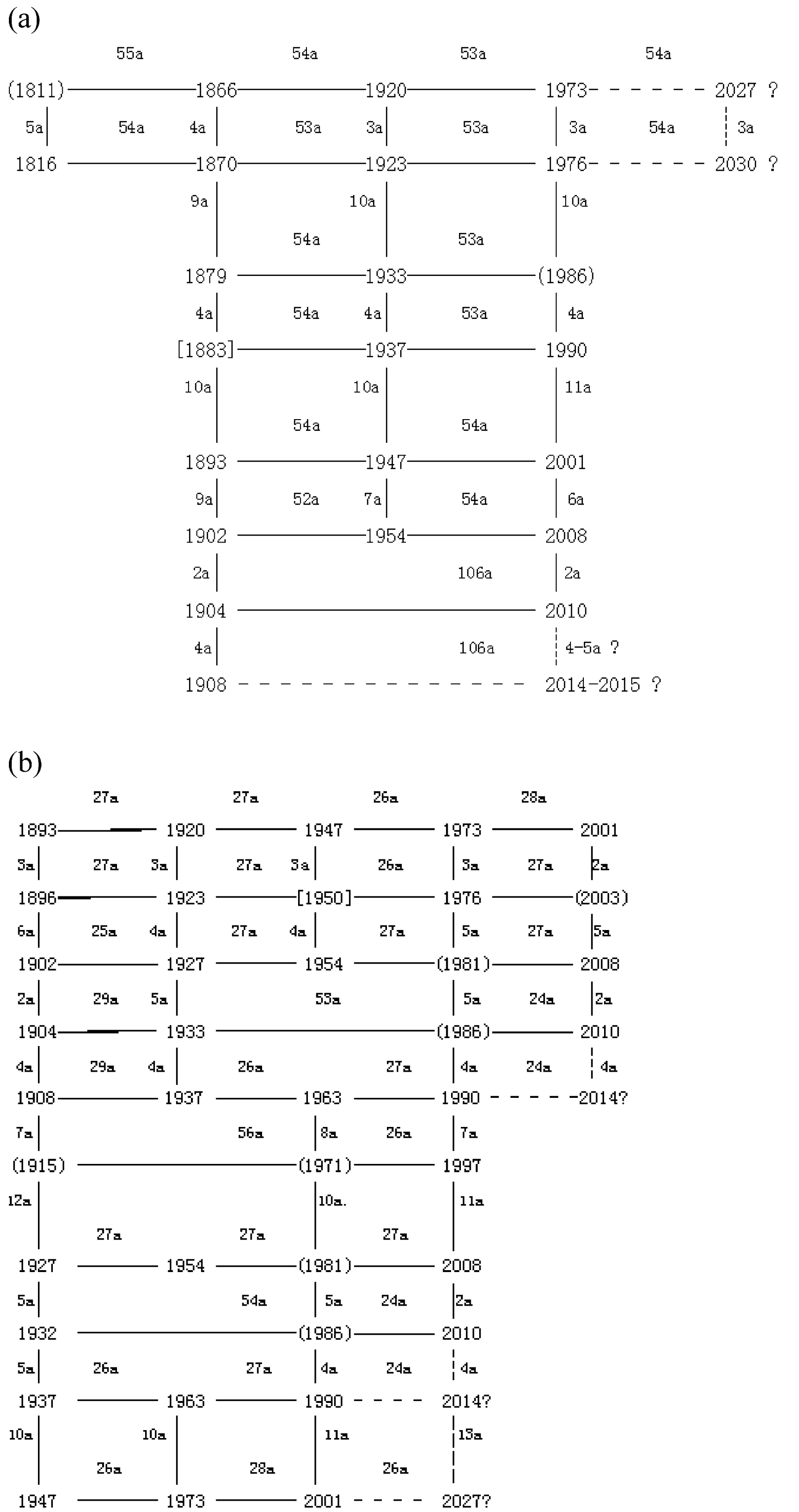

Fig. 1. Ordered network structure of $M \geq 7$ earthquakes in the northern Xizang Plateau. (Note: Dotted line for prediction; some earthquakes of magnitude less than 7 are expressed by parentheses; earthquake occurred in the southern Xizang Plateau is expressed by square bracket, followings are the same.)

of the ordered network structure of $M \geq 7$ earthquakes in the northern Xizang Plateau (Fig. 1).

With some samples of strong or great earthquakes in this region, by double timing shaft, the ordered network structure of the $M \geq 7$ earthquake chains during 1811 – 2010 are given in Figure 1, which was adapted from the original figure suggested in 2003 [10]. Figure 1b is the detailed structure of Figure 1a. Each earthquake is named by its occurred year number in Figure 1, extending by time sequence from left to right and from up to down. To ensure the relationship between samples, a few samples are repeated. Some nodes in the network are earthquake samples with magnitude less than 7, which are expressed by parentheses, such as 1811 (Luhuo 6.7), 1881 (Wudu 6.5), 1915 (Qumalai 6.5), 1971 (Zado 6.5), 1981 (Daofu 6.9), and 1986 (Menyuan 6.5). In Figure 1b, a great earthquake of *M8.6* struck Chayu of Xizang in 1950, and it is expressed by square brackets, which belongs to the southern Xizang Plateau, for considering a great earthquake of $M \geq 8$ may be controlled by motivate factors of a large scale of deep earth. In Figure 1a, the Pulan *M7.0* earthquake in 1883 is also expressed by square brackets for the same reason (followings are the same). Both 54a (or 53a) in Figure 1a and 27a (or 26a) in Figure 1b are the main chains of horizontal lines, which play a major role in prediction and constitute the main frame of earthquake activities, transferring from left to right. Though the vertical line is not as regular as the horizontal line, it is basically equal to its opposite line in each rectangular, as an assistant of main chains in prediction. In a word, though not perfect, Figure 1 shows typical and steady characteristics of ordered network structure, and it reveals that the interval values of 106 ∼ 107a, 53 ∼ 54a, 26 ∼ 27a, 10 ∼ 11a, and 3 ∼ 4a have a special predicting significance.

The network structure given in Figure 1 has fully shown the information of the Kunlunshan *M8.1* earthquake, the Wenchuan *M8.0* earthquake, and the Yushu *M7.1* earthquake. If the research was continued with enough fund, the Wenchuan earthquake and the Yushu earthquake might be captured so that the losses could be reduced. The Wenchuan and the Yushu earthquake make a supplement and improvement on the network structure, which has a higher credibility. Therefore, we can presume that the next $M \geq 7$ earthquake may occur in 2014, 2027, and 2030 pre and post (Error is ± 1 a).

3. Examples for Prediction

3.1. Prediction of the Luhuo Earthquake in 1973 and the Songpan Earthquake in 1976

According to the information orderliness of $M \geq 7$ earthquakes, we can get prediction expressions of the Luhuo *M7.6* and the Songpan *M7.2* earthquake according to the first and the second horizontal lines given in Figure 1a, as can be seen in Figure 2.

3.2. Prediction of the 1990 Gonghe M7.0 Earthquake and the 1997 Mani M7.9 Earthquake

We can get prediction expressions of the 1990 Gonghe *M7.0* earthquake and the 1997 Mani *M7.9* earthquake as can be seen in Figure 3.

3.3. Prediction of the 2001 Kunlunshan M8.1 Earthquake and the 2010 Yushu M7.1 Earthquake

Prediction charts of the Kunlunshan *M8.1* earthquake in 2001 and the Yushu *M7.1* earthquake in 2010 are as follows (Figs. 4 – 6).

During 1997 – 2000, the author had made an accurate prediction of the Kunlunshan earthquake based on Figure 4 and proposed that the next earthquake of $M \geq 7$ may occur around 2000 [23 – 25]. Now, we can still make a prediction of the 2010 Yushu earthquake based on Figure 4. The structure of 77 ∼ 78a in the figure is so orderly, steady, and clear that the prediction has a quite higher credibility.

3.4. Prediction of the Wenchuan M8.0 Great Earthquake in 2008

Figures 5 and 6, which are details of Figure 1, show that interval values of 53 ∼ 54a and 26 ∼ 27a have great significance in the prediction of the 2001 Kunlunshan *M8.1* and the 2008 Wenchuan *M8.0* earthquake. Figure 5 is made up of three horizontal lines in the upside of Figure 1a. The interval between the first line

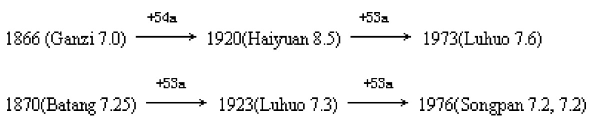

Fig. 2. Prediction of the Luhuo earthquake in 1973 and the Songpan earthquake in 1976.

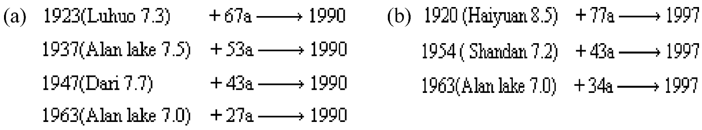

Fig. 3. Prediction of the 1990 Gonghe *M7.0* earthquake (a) and the 1997 Mani *M7.9* earthquake (b).

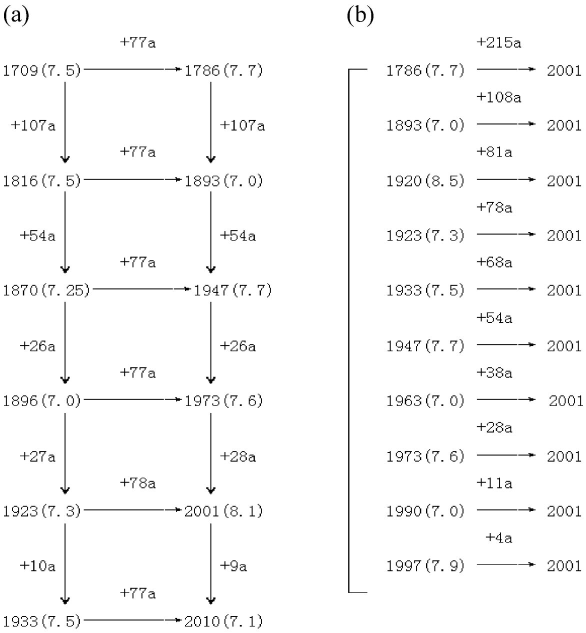

Fig. 4. Ordered network structure of $M \geq 7$ earthquakes in the northern Xizang Plateau and sketch of prediction for the 2001 Kunlunshan *M8.1* earthquake and the 2010 Yushu *M7.1* earthquake.

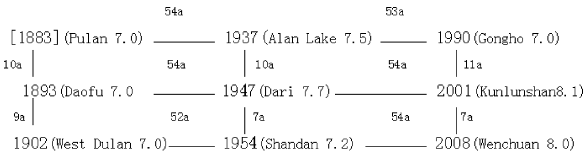

Fig. 5. Ordered network structure of the Kunlunshan *M8.1* and the Wenchuan *M8.0* earthquake's prediction.

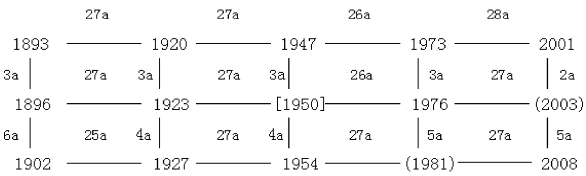

Fig. 6. Ordered network detail structure of Figure 5.

and the second line is 10 ∼ 11a, while 7 ∼ 9a between the second and the third line, which shows a quite obvious regularity. The four earthquakes occurred in 1947, 1954, 2001, and 2008 constitute a rectangle, which shows that it is not accidental for the Wenchuan *M8.0* earthquake. Figure 6 is a detailed graph of Figure 5, in which the earthquake chains transfer very regularly. Consequently, it reveals that 26 ∼ 27a is the main rhythm of $M \geq 7$ earthquakes in the Xizang Plateau.

3.5. Prediction of $M \geq 7$ Earthquakes in the Future

In summary, Figure 7 is given as brief introduction of the 2001 Kunlunshan *M8.1* earthquake, the 2008 Wenchuan *M8.0* earthquake, the 2010 Yushu *M7.1* earthquake, and prediction for future $M \geq 7$ earthquakes in the 21st century. This figure is the bottom part of Figure 1a, and it looks like a rectangular, including six horizontal lines. The same as in above figures, in Figure 7, horizontal lines play an important role in the prediction with vertical lines as assistant. In Figure 7, the first horizontal line transfers from the Pulan *M7.0* earthquake in 1883 to the Gonghe *M7.0* earthquake in 1990 with the interval of 107a, the second one transfers from the Daofu *M7.0* earthquake in 1893 to the Kunlunshan *M8.1* earthquake in 2001 with the interval of 108a, the third one transfers from the west of Dulan *M7.0* earth-

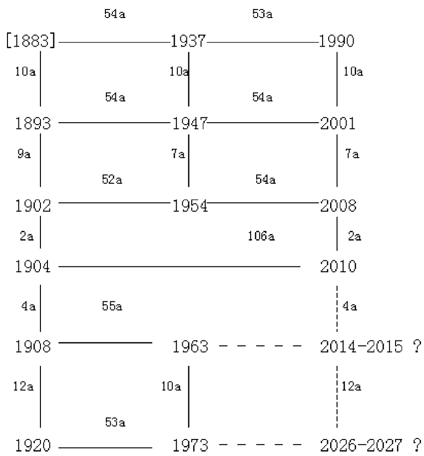

Fig. 7. Sketch of prediction for 3 great earthquakes (the Kunlunshan *M8.1* earthquake, Wenchuan *M8.0* earthquake, Yushu *M7.1* earthquake) since the 21st century and the future $M \geq 7$ earthquakes in this region.

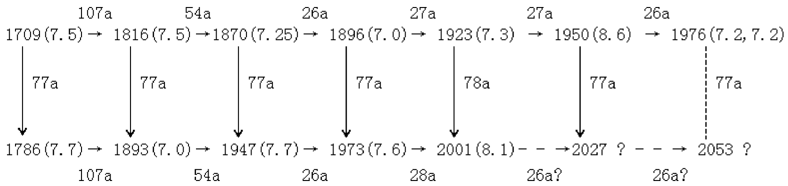

Fig. 8. Relationship of ordered values between 107a, 54a, 27a, and 77a (dotted line for prediction).

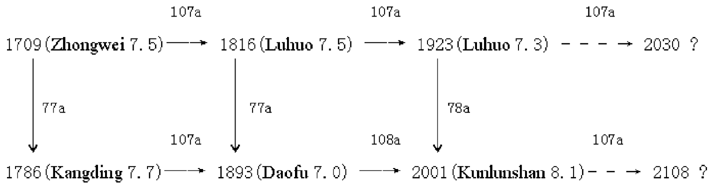

Fig. 9. Structure of ordered values of 107a and 77a (dotted line for prediction).

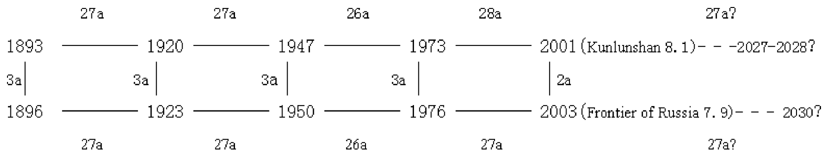

Fig. 10. Transfer relation of $M \geq 7$ earthquakes in the large triangle region of West China. (Note: This *M7.9* earthquake occurred in September 27, 2003 in the Frontier of Russia, Mongol, and China.)

quake in 1902 to the Wenchuan *M8.0* earthquake in 2008 with the interval of 106a, and the forth one transfers from the Daofu *M7.0* earthquake in 1904 to the Yushu *M7.1* earthquake in 2010 with the interval of 106a. That means that the interval values of 53 ∼ 54a and 106 ∼ 107a have a greater significance in the prediction and a higher credibility. Thus, we can presume that the fifth horizontal line starting from the year 1908 and the sixth one starting from the year 1902, plus the interval value 106 ∼ 108a separately, can be calculated as future earthquake nodes. That is, the future $M \geq 7$ earthquakes may occurred in the northern Xizang Plateau around 2014 – 2015 and 2026 – 2027. Figures 8 and 9 reveal the structural relationship between the interval values of 26 ∼ 27a, 53 ∼ 54a, 106 ∼ 107a, and 77 ∼ 78a, which indicates that $M \geq 7$ earthquakes might occur around 2027 and 2030.

In particular, $M \geq 7$ earthquakes occurred regularly with the intervals of 53 ∼ 54a or 26 ∼ 27 not only in the Xizang Plateau, but also in a far-reaching area, for example the large triangle region in West China, Southeast Asia, and South America [26]:

i) Figure 10 shows the transfer relation on $M \geq 7$ earthquakes in the large triangle region (Qinghai, Xizang, and Xinjiang) of West China. The stability of the network structure in this region can not be guaranteed at present time, further researches are still needed.

ii) 53 years after the Assam *M8.6* earthquake in India on June 12, 1897, a *M8.6* earthquake struck Chayu in Xizang of China on August 15, 1950. Another 54 years later, a *M8.7* (*Mw9.0*) earthquake occurred in Indonesia on December 26, 2004.

iii) 54 years after the Ecuador *M8.8* earthquake on January 31, 1906, a *Mw9.5* earthquake struck Chile, South America on May 22, 1960. Another 50 years later, a *M8.8* earthquake occurred again in Chile on February 27, 2010.

The structure with the same interval indicates quite homogeneous medium, which means there might be dynamic process control in a larger scale of the deep Earth, that is ordered activity of the Xizang Plateau–Burma–Indonesia [27, 28]. The interval of 53a or 54a is a multiple of 27, certainly a multiple of 9, which shows that it is not accidental for information transferred by the interval values.

4. Discussion on the Genesis of Wenchuan and Yushu Earthquakes

(i) Currently, for some earthquake specialists, accelerated subduction, collision, and extrusion of the India plate with the Eurasia plate results in the Wenchuan

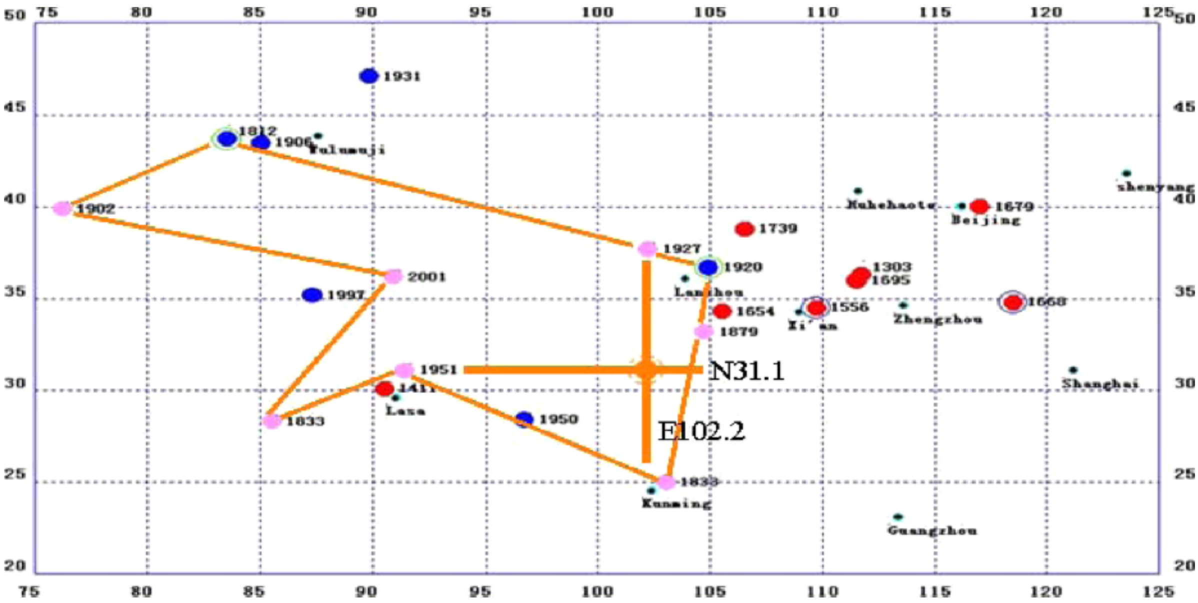

Fig. 11 (colour online). Prediction for the epicenter of the Wenchuan *M8.0* earthquake (Drawn by Geng Qingguo).

M8.0 earthquake. Usually, subduction of plates lasts as long as a few hundred thousand years. But the Wenchuan earthquake is a typical intraplate earthquake [29], and it doesn't occur at plate boundaries. According to great earthquakes recorded chronologically, the India plate is travelling farther north. Earthquakes of $M \geq 7$ occur in Burma or Yunnan firstly, 1–3 years later, it travels gradually north. However, no earthquake occurred as a signal in Burma before the Wenchuan earthquake.

(ii) Si-Guang Li, a well-known geologist, presented two large systems before, one is in Asia and the other is from the West Bank of North America to the Caribbean in Central America [30]. The former system extends from the Xizang Plateau–Burma to Indonesian island arc, which controls earthquakes in West China in Xu's opinion. Both the Wenchuan earthquake and the Yushu earthquake are closely related to the system. For example,

i) A *M8.1* earthquake struck Kunlunshan in the northern Xizang Plateau on November 14, 2001, which indicates seismic activity at the head of the Xizang Plateau–Burma–Indonesia system. About three years later at the end of the system, a *M8.7* earthquake struck Sumatra in Indonesia on December 26, 2004.

ii) At the end of the system, a *M8.7* and a *M8.6* earthquake occurred in Sumatra on December 26, 2004 and March 29, 2005, respectively. Six months later, a *M7.8* earthquake struck Pakistan on October 8, 2005 (the head).

iii) Eight months after the Sumatra *M8.6* earthquake on September 12, 2007 (the end), a *M8.0* earthquake occurred in Wenchuan of China on May 12, 2008 (the head).

iv) The *M7.1* earthquake in southwestern Sumatra on March 6 and the *M7.8* earthquake in northern Sumatra on April 7, 2010 indicate seismic activity of the tail system. A week later, on April 14, the Yushu *M7.1* earthquake occurred (the head).

The four examples above show that an earthquake is not isolated or random. It concerns not only a local fault system, but also a process of change in dynamic conditions of a large scale in deep earth [27]. It takes about three years for seismic activities at the head of the Xizang Plateau–Burma–Indonesia system to affect the tail, while 18 months for the tail to affect the head, which offer a precious opinion for prediction of $M \geq 7$ earthquakes in the Xizang Plateau.

Specially, Qing-Guo Geng, who makes a great contribution to the prediction of the Wenchuan earthquake, proposed a viewpoint of the great earthquake knob conjugated with information of the occurrence time based on a research lasting 30 years. He suggests that the Wenchuan earthquake epicenter should be in the area enclosed by broken lines between the earthquake epicenters of 1812, 1833, 1879, 1902, 1920, 1927, 1951, and 2001. In fact, he is true. The Gulang *M8.0* earthquake (37.7° N, 102.2° E) on May 23, 1927 and the Dangxiong *M8.0* earthquake (31.1° N, 91.4° E) on November 18, 1951 are two conjugate-knob earthquakes of the Wenchuan *M8.0* earthquake (31.0° N, 103.4° E) on May 12, 2008 [31] (Fig. 11).

5. Conclusions

(i) The seismic activity of $M \geq 7$ earthquakes in the northern Xizang Plateau presents obvious temporal orderliness. The regular network structure offers a good example for network hypothesis. The analysis of network structure is a view image method for moderate term and long term prediction of great earthquakes, and it avoids the tedious analysis of a classic mathematical model. The successful prediction for the Wenchuan and the Yushu earthquake demonstrates that combining the informative forecasting theory of Wen-Bo Weng with the ordered network structure is an effective method for moderate term and long term leaping prediction of $M \geq 7$ earthquakes. According to this paper, we can make the prediction that the $M \geq 7$ earthquakes will occur around 2014 – 2015, 2026 – 2027, and 2030 in the northern Xizang Plateau. Experts are expected to pay attention to follow and focus on information of $M \geq 7$ earthquakes and minimize prediction scale by combining multi-disciplinary with multi-method, so that future $M \geq 7$ earthquakes can be captured.

(ii) The seismic activity of great earthquakes presents obvious spatial orderliness, too. In 1998, Xu and Ouchi studied the spatial orderliness and the geometric distribution of *M7* and *M8* earthquakes in Japan and Asia in depth [32, 33]. Also, we have studied spatial orderliness of $M \geq 7$ earthquake chains of China and Indonesia [34]. Xu and Zhang studied the same interval of $M \geq 7$ earthquakes in Qinghai, the results show that the Kunlunshan *M8.1* earthquake fills the grid of the diamond of western Qinghai (Fig. 9 in [35] and Fig. 1 in [36]). Accordingly, I proposed that there may be a $M \geq 7$ earthquake near the junction of the Kuma fault zone in the eastern part of the Xizang Plateau and the North-South seismic belt in [9].

(iii) We are now at the network times of 21st century. The network thought and theory have infiltrated into all aspects of nature science and social science [37 – 40]. Complex networks describe a wide range of complicated systems in nature and society, for example, transportation network, electric power network, internet, neural network in animals, protein network, and social network etc. The $M \geq 7$ earthquakes and their earthquake chains are the same. The single strong earthquake is like an ant or a neuron, and the strong earthquake chain network which is like an ant colony or a neural network consist of the single earthquake by coupling relationship between them. The adaptability showed by the population is much over the adaptability of a single unit, and the amount of information contained by the network of strong earthquake chains is much larger than that of a single strong earthquake. The formation mechanism of a strong earthquake is characterized by network features. Therefore, network technology is also applicable for the study of earthquake prediction. However, earthquake network is a dynamic, growing, and unbalanced evolving network, which constructs an appropriate model to fit and predict the actual process of self-organization and explore the formation mechanism and organization principle. Empirical study indicates [38] that many real networks, including information networks, social networks, and biology networks, have two basic properties – small world effect and scale-free characteristics. But the power law function $y(x) = cx^{\alpha}$ is scale invariant, which means that it is independent on the measure unit. The basic model of a scale-free network is named BA model, whose main evolving mechanisms are growth and preferential attachment. Its degree exponent is 3, while the one of most real networks is in $(1, 4)$. Growing network is a promotion of the BA model, which fixed the assumption that growth is balanced and preferential attachment is linear. Currently, evolving mechanism and model construction of networks is still a great topic. The network image of $M \geq 7$ earthquake chains in the northern Xizang Plateau is given in this paper. But the design of prediction function should be perfected, and the earthquake network structure of other regions of the Chinese Mainland should be studied further, too. In addition, no one has used complex networks for the study of earthquake prediction so far.

(iv) Prediction of great earthquakes is a difficult topic in the world. The instances above show that great earthquakes and great earthquake chains can be predicted by implementing scientific outlook on development, innovation, and combining multi-disciplinary, multi-department with multi-methods. The information forecasting theory by Weng is effective to analyze and solve leaping (especially long time and long distance) prediction of great earthquakes. Based on moderate term and long term prediction, by lowering threshold of target magnitude, minimizing temporal and spatial scale, following information of great earthquakes, and synthesizing prediction methods, great earthquakes can be predicted to contribute to disaster prevention and reduction. Severe earthquakes struck China so frequently that it is necessary to establish an early alert system. And the ordered network method we present here is effective for establishing an early alert system of great earthquake.

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