The Ordered Network Structure of $M \geq 8$ Earthquakes and its Prediction for the Ordered Pair Great Earthquakes in Mainland China

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According to the statistical data, a total of 23 $M \geq 8$ earthquakes occurred in Mainland China from 1303 to 2012. The seismic activity of $M \geq 8$ earthquakes has showed an obvious self-organized orderliness. It should be remarked especially that there were three ordered pairs of $M \geq 8$ earthquakes occurred in West China during 1902 – 2001, of which the time interval in each pair of two earthquakes was four years. This is a unique and rare earthquake example in earthquake history of China and the world. In the guidance of the information forecasting theory of Wen-Bo Weng, based on previous research results, combining ordered analysis with complex network technology, this paper focuses on the summary of the ordered network structure of $M \geq 8$ earthquakes, supplements new information, constructs and further optimizes the 2D- and 3D-ordered network structure of $M \geq 8$ earthquakes to make prediction research. At last, a new prediction opinion is presented that the future ordered pair of great earthquakes will probably occur around 2022 and 2026 in Mainland China.

Key words: Mainland China; Informational Ordered Network Structure; Ordered Pair Great Earthquakes; Prediction of $M \geq 8$ Earthquake.

1. Introduction

China is not only a seismically active country, but also a great earthquake-prone country. Earthquake prevention and disaster reduction in the economic and social development of China is the most critical and urgent task we are facing. Seismic activity is the basic material for earthquake prediction research. An earthquake with magnitude 8 or larger is a very rare event, which may occur once in decades or even centuries. Thus, the research is extremely complicated and difficult, and is necessary to have a long-term data accumulation to find out the regularity of seismic activity. China has a very long history. Strong earthquakes take place frequently and seismic zones are widely distributed. The time duration of the historical records lasted for more than 4300 years from the 23rd century B.C. to now, which is the longest and the most abundant in detail all over the world. Dao-Yi Xu et al. made a deep study on the temporal orderliness of $M \geq 8$ earthquakes [1 – 5] and proposed the network hypothesis of earthquake occurrence and concept of self-organized network [6, 7]. In 2010, Xu, Men, and Deng [8] firstly proposed the network structure of $M \geq 8$ earthquakes in Mainland China. Since the 1990s, the author has concentrated on the prediction research of earthquake, flood, and other natural disasters, particularly devoting to studying the orderliness of severe natural disaster and its ordered network structure, and achieved a number of important results, such as the $M \geq 7$ strong earthquakes in Xinjiang and the northern Tibetan Plateau region [9 – 11], the $M \geq 6$ earthquakes in the Jiangsu-South Yellow Sea region [12 – 14], as well as the Changjiang (Yangtze) River big floods [15 – 17]. In 2011, the author deeply researched on the construction of ordered network of $M \geq 8$ earthquakes occurred in Mainland China and its prediction [18]. As a continuation of [18], with a supplement of new information, this paper constructs in detail and perfect the ordered network structure of $M \geq 8$ earthquakes in Mainland China. Besides that, we make a prediction on $M \geq 8$ earthquakes in Mainland China, to push forward the study on $M \geq 8$ earthquakes.

2. Risk Probability Assessment of the Future $M \geq 8$ Earthquakes in Mainland China

According to [19–21], during the past 710 years from 1303 to 2012, 23 $M \geq 8$ earthquakes occurred in Mainland China (see Table 1), which means once about 30.9 years in average. From the beginning of the 21st century to now, $M \geq 8$ earthquakes occurred twice in West China. They are the Kunlunshan $M8.1$ earthquake on November 14, 2001 and the Wenchuan $M8.0$ earthquake on May 12, 2008. Especially the Wenchuan earthquake brought extremely great losses to China: a total of about 500 000 km^2 disaster area, 46.25 million quake-stricken people, among them 87 150 people died or lost. The direct economic loss is about 845.1 billion Renminbi (RMB). After the Wenchuan earthquake in less than three years, the Tohoku $M9.0$ super-great earthquake occurred near the east coast Honshu in Japan at 13:46 on March 11, 2011 (Beijing time) (Measured by China Earthquake Networks Center (CENC), its epicenter was at longitude 142.6°E, latitude 38.1°N, and focaldepth was 20 km). This severe event shocked the whole world. People start to concern about the risk of the future $M \geq 8$ earthquakes in Mainland China.

Through the conversion, a tropical year is 365.2422 days; a tropical month is 30.44 days. In Table 1, the shortest time interval of two adjacent $M \geq 8$ earthquakes is 11 days, which means 0.028 a (between the 1833 Nielamu earthquake on August 26 in Xizang and the 1833 Songming earthquake on September 6 in Yuannan). And the longest time interval is 144.3 a (between the 1411 Dangxiong earthquake in Xizang and the 1556 Huaxian earthquake

Table 1. Catalogue of $M \geq 8$ earthquakes in Mainland China from 1303 to 2012.

No.	Dates Year-Month-Day	Time Interval (a)	Epicentral Latitude (°N)	Location Longitude (°E)	Magnitude (M)	Locality
1	1303-09-25	–	36.3	111.7	(8)	Zhaocheng and Hongtong, Shanxi
2	1411-10-08	108.037	30.1	90.5	(8)	Dangxiong, Xizang
3	1556-02-02	144.317	34.5	109.7	(8)[a]	Huaxian, Shanxi
4	1654-07-21	98.469	34.3	105.5	(8)	Tianshui, Gansu
5	1668-07-25	14.011	34.8	118.5	$(8\frac{1}{2})$	Tancheng, Shandong
6	1679-09-02	11.103	40.0	117.0	(8)	Sanhe, Hebei
7	1695-05-18	15.711	36.0	111.5	(8)[b]	Linfen, Shanxi
8	1739-01-03	44.417	38.8	106.5	(8)	Yinchuan, Ningxia
9	1812-03-08	73.181	43.7	83.5	(8)	Nileike, Xinjiang
10	1833-08-26(A)	21.466	28.3	85.5	(8)	Nielamu, Xizang
11	1833-09-06(B)	0.028	25.0	103.0	(8)	Songming, Yuannan
12	1879-07-01	45.837	33.2	104.7	(8)	Wudou, Gansu
13	1902-08-22	23.142	39.9	76.2	$8\frac{1}{4}$	Atushi, Xinjiang
14	1906-12-23	4.336	43.5	85.0	8[c]	Shawan, Xinjiang
15	1920-12-16	13.981	36.7	104.9	$8\frac{1}{2}$	Haiyuan, Ninxia
16	1927-05-23	6.435	37.7	102.2	8	Gulang, Gansu
17	1931-08-11	4.218	47.1	89.8	8	Fuyun, Xinjiang
18	1950-08-15	19.010	28.4	96.7	8.6	Chayu, Xizang
19	1951-11-18	1.259	31.1	91.4	8	Dangxiong, Xizang
20	1976-07-28	24.694	39.4	118.0	7.8 – 8.2	Tangshan, Hebei
21	1997-11-08	21.278	35.2	87.3	7.9 – 8.0	Mani, Xizang
22	2001-11-14	4.017	36.2	90.9	8.1	Kunlunshan, Qinghai
23	2008-05-12	6.494	31.0	103.4	8.0	Wenchuan, Sichuan

Note: Revised by Table 1 in [8, 18], [a] $8\frac{1}{4}$ revised by [20], [b] $7\frac{3}{4}$ revised by [20], [c] 7.7 revised by [20].

Table 2. Cumulative probability of $M \geq 8$ earthquakes in Mainland China.

Time interval (a)	4.5	6.5	11	14	16	19	21.5	23	25	46	73
Up to year –	2012	2015	2019	2022	2024	2027	2029	2031	2033	2054	2081
Cumulative probability (from the beginning of 1303)	0.23	0.32	0.36	0.45	0.50	0.55	0.64	0.68	0.73	0.77	0.82
Cumulative probability (from the beginning of 1654)	0.26	0.37	0.42	0.53	0.58	0.63	0.74	0.79	0.84	0.89	0.95

in Shanxi). We rearrange the time interval sequence according to the order of increasing magnitude of the numbers as $x_{(1)} \leq x_{(2)} \leq \ldots \leq x_{(n)}$, Thus the empirical distribution function of cumulative probability is as follows:

$$F_n(x) = \begin{cases} 0, & x < x_{(1)}, \\ \frac{k}{n}, & x_{(k)} \leq x < x_{(k+1)}, \quad (k = 1,2,\ldots,n-1), \\ 1, & x \geq x_{(n)}. \end{cases} \tag{1}$$

By statistical analysis based on formula (1), the cumulative probability of time interval of adjacent $M \geq 8$ earthquakes is listed in Table 2.

Due to the age, some records of $M \geq 8$ earthquake may be omitted in the 350 years from 1303 to 1654. So we calculate the cumulative probability of the whole sequence beginning in 1303 as well as the main sequence beginning in 1654 to make a comparison. According to Table 2, from the Wenchuan earthquake to the end of 2012, the cumulative probability of $M \geq 8$ earthquake in Mainland China is about $0.23 \sim 0.26$; $0.32 \sim 0.37$ by the end of 2015; $0.36 \sim 0.42$ in July, 2019; $0.45 \sim 0.53$ in July, 2022; $0.50 \sim 0.58$ in July, 2024; $0.55 \sim 0.63$ in July, 2027; and $0.64 \sim 0.74$ by the end of 2029. If the interval is 25 a, the cumulative probability of earthquake occurrence in 2033 would be as high as $0.73 \sim 0.84$. Thus, we can make some easy assessment of the risk of $M \geq 8$ earthquake in Mainland China after the M8.0 Wenchuan earthquake.

3. An Overview of Ordered Network of $M \geq 8$ Earthquakes in Mainland China

3.1. Seismic Regular and Informational Ordered Network of $M \geq 8$ Earthquake in Mainland China

'System' is an abstract concept, it can be used to study the characteristics of many things. To be distinguished with other things, a system has a scope and boundaries, which denotes close. That means closure of a system is greater than openness. So it can hardly describe complex research object. 'Network' has a strong image, it has no fixed boundary, or the boundary is fuzzy, and it can extend without restriction, its open degree is often greater than the closure, so it is more suitable to describe those complex things which are not included in the system, especially multi-contact complex things [22]. In recent years, complex networks have become a new subject to study complex systems, and received great attention from scholars at home and abroad. The analysis method of complex networks has been widely used in various fields, many natural, social or artificial systems can be studied and described by various networks.

The so-called ordered network is an ordered set of nodes and their connections. Here, the node is the great earthquake sample and the connection between two nodes is the time interval of great earthquakes, that is the order parameter τ value, which is used to describe the interaction between great earthquakes. In the construction of great earthquake ordered network, we usually only focus on the ordered connection of line length (time interval) between the nodes, but do not care about the location of the node, the form of line (straight or curved). And the fact that whether they intersect with one another, and so on. The specific location and connection properties do not depend on the specific form called the topological properties of a network, its structure is called the network topology structure. Therefore, the great earthquake ordered network is a complex network with topology structure.

The structure, function, and impact factors of a network are always changing. Specially, we use a network to describe some important contact methods: One is the long range correlation. In a network, nodes and lines with long distance can contact closely, while blanks and nodes with short distance contact rarely. The other one is the combination of continuity and discreteness. Blank means discrete while nodes and lines are continuous. It has great value in explaining leaping contact [22]. A network hypothesis of great earthquake, which regards the earthquakes as a multi-level, multi-factor, multi-dimensional network nodes, is helpful for us to research the regularity of seismic activity and the informational orderliness from the overall and dynamic perspective [6, 7]. Therefore, we can build the two-dimensional (2D) or three-dimensional (3D) ordered network of great earthquakes based on the topology of ordered network. Sometimes, it is difficult to summarize by only one figure, we must build a few figures in detail. To make sure the temporal association of earthquake samples, some samples can be repeated [9 – 12, 18].

For convenience, each great earthquake is denoted by its occurred year. There are 23 $M \geq 8$ earthquakes and 22 years in Table 1 (two great earthquakes with magnitude 8 in 1833 are recorded as one year). Thus, we will get $C_{22}^2 = 231\,\tau$ values of time interval by pair-

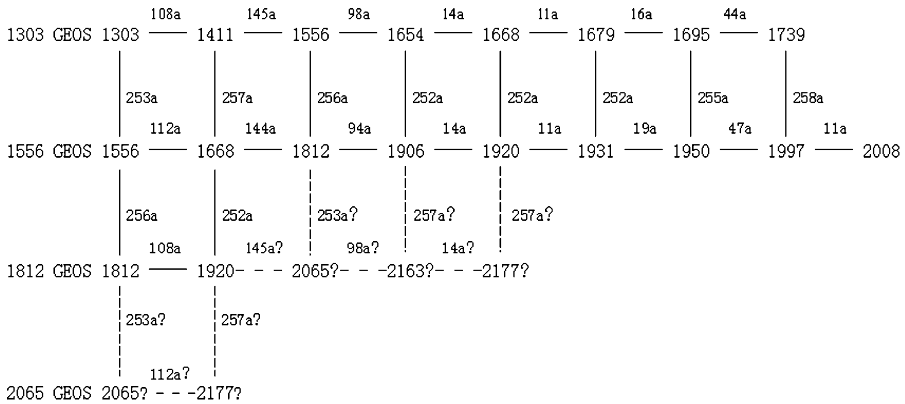

Fig. 1. Ordered network structure of $M \geq 8$ earthquakes during 1303 – 2012 in Mainland China. (Dotted line for prediction and followings are the same.)

wise subtraction. As statistical analysis shows, $M \geq 8$ earthquakes in Mainland China have obvious orderliness. The main intervals are 252 ∼ 258a, 108 ∼ 112a, 94 ∼ 98a, 44 ∼ 48a, 24 ∼ 25a, 16 ∼ 19a and 11 ∼ 14a, among which 252 ∼ 258a is the most frequent and important.

Figures 1 and 2 show the ordered network structure of $M \geq 8$ earthquakes during 1303 – 2012 in Mainland China. Xu et al. [8] divided the earthquakes into three great earthquakes order series (GEOS) and one great earthquake order sub-series (GEOSS). In Figure 1, each GEOS is named by the first great earthquake year, so that we have the 1303 GEOS, 1556 GEOS, and 1812 GEOS, respectively (2065 GEOS, that is for prediction). It seems that the horizontal interval between two events in each row is disorganized. But in each column, all vertical intervals are 252 ∼ 258a, which is surprisingly regular. In Figure 1, the total duration of the first real column, 1303 – 1556 – 1812, is 509 a. So as the second one, 1411 – 1668 – 1920. Obviously, it is not accidental. It shows the great regular pattern of $M \geq 8$ seismic activity in Mainland China. Figure 2 is the construction figure of GEOSS, which shows nice symmetry and orderliness too.

Figures 1 and 2 highly summarize and accurately describe the occurrence and development regularity of $M \geq 8$ earthquakes in Mainland China in recent 710 years, which contain extremely rich connotation.

According to the two figures, not only the Kunlunshan M8.1 earthquake in 2001 and the Wenchuan M8.0 earthquake in 2008 can be predicted, but also the future $M \geq 8$ earthquakes in Mainland China can be predicted.

3.2. Prediction Examples: The 2001 Kunlunshan M8.1 Earthquake and the 2008 Wenchuan M8.0 Earthquake

With the similar genetic cut and copy technology in biological engineering, based on the GEOS in Figures 1 and 2, we construct the 3D-ordered network structure which can predict the 2001 Kunlunshan M8.1 earthquake (Fig. 3) and the 2008 Wenchuan M8.0 earthquake (Fig. 4).

In Figure 3, there are three quadrilaterals whose opposite sides are almost equal, which is obviously symmetry and regular. There are three order parameters (or time intervals) in Figure 3: 25 a (24 a), 50 a(49 a), and

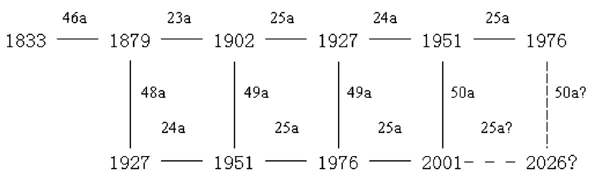

Fig. 2. Ordered network structure of the 1833 GEOSS and its prediction sketch.

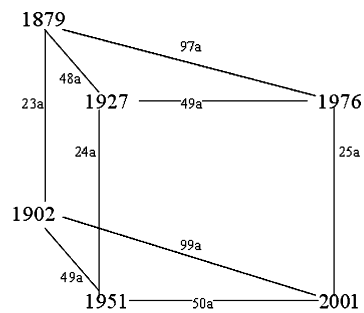

Fig. 3. Sketch of prediction for the 2001 Kunlunshan M8.1 earthquake by using a 3D-ordered network.

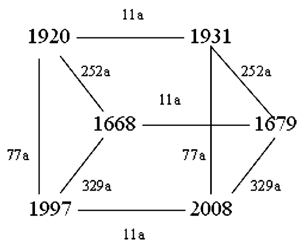

Fig. 4. Sketch of prediction for the 2008 Wenchuang $M8.0$ earthquake by using a 3D-ordered network.

99 a (97 a), of which 25 a is the most basic one, and the others of its relationship of two and four times, respectively. And therefore they are significant for prediction. Figure 3 shows the time regularity of the 2001 Kunlunshan $M8.1$ earthquake.

Also, in Figure 4, there are three quadrilaterals whose opposite sides are almost equal. The intervals are 11 a, 77 a, 252 a, and 329 a, which play an important role in prediction. 11 a is the foundation. Figure 4 shows the time regularity of the 2008 Wenchuan $M8.0$ earthquake. If combined with the ordered network structure of $M \geq 7$ strong earthquakes in the northern Xizang Plateau, the 2008 Wenchuan $M8.0$ earthquake would be predicted successfully.

4. Constructing the Ordered Network Structure of $M \geq 8$ Earthquakes and the Prediction

It is necessary to note that the 1833 GEOSS is not isolated. It is related to the 1303 GEOS and 1556 GEOS. Just as Figure 5 shows, the opposite side of each quadrilateral is equal, which is very symmetrical and regular.

Six $M \geq 8$ earthquakes in West China from 1902 to 2001 in Table 1, which occurred in three pairs, should be remarked especially. They are the 1902 Atushi earthquake and the 1906 Shawan earthquake in Xinjiang, the 1927 Gulang earthquake in Gansu and the 1931 Fuyun earthquake in Xinjiang, the 1997 Mani earthquake in Xizang and the 2001 Kunlunshan earthquake in Qinghai, respectively. Also, they can be called the ordered pairs of $M \geq 8$ earthquakes in this paper. Each pair of two earthquakes had a time interval of 4 a. Among them, three great earthquakes belong to the 1556 GEOS, the other three belong to the 1833 GEOSS. As such short as one hundred years, three pairs of $M \geq 8$ earthquakes have taken place, which is very unique and rare earthquake example not only in China but also in the world history of earthquake.

4.1. Construction of 2D-Ordered Network Structure and the Prediction

To dig out the ordered regularity from disordered great earthquake series, this paper also uses the similar manner. Taking the three pairs of $M \geq 8$ earthquakes as nodes, by connecting and pasting, the 2D-ordered network structure can be constructed (Fig. 6 a, b). In the two figures, the opposite sides of each quadrilateral are equal, which are well regular. Based on the two figures, not only the 2001 Kunlunshan $M8.1$ earthquake can be predicted, but also the future earthquakes, which means that a new ordered pair of $M \geq 8$ earthquakes will occur in 2022 and 2026 in West China. (In this paper, each great earthquake is named by its occurred year, where the prediction error is ± 1a, and followings are the same.)

4.2. Construction of 3D-Ordered Network Structure and the Prediction

4.2.1. Ordered Network Structure of Quadrangular and its Prediction

Also with the application of the preceding method, taking the three pairs of great earthquakes as nodes, by connecting and pasting, a 3D-ordered network structure like a triangular prism can be constructed, as the real line parts of Figure 7. There are three quadrilaterals in Figure 7, 1902 – 1906 – 1927 – 1931, 1902 – 1906 – 1997 – 2001, and 1927 – 1931 – 1997 – 2001. Their opposite sides are equal, which are very symmetrical. The triangular

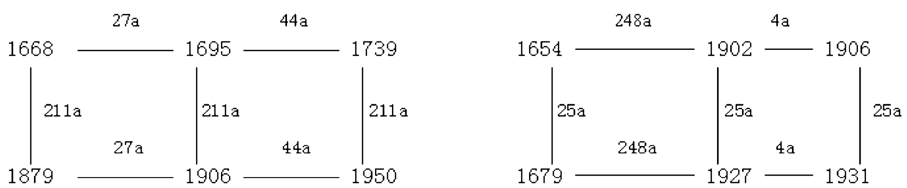

Fig. 5. Order relation between the 1833 GEOSS and the 1303 GEOS or the 1556 GEOS.

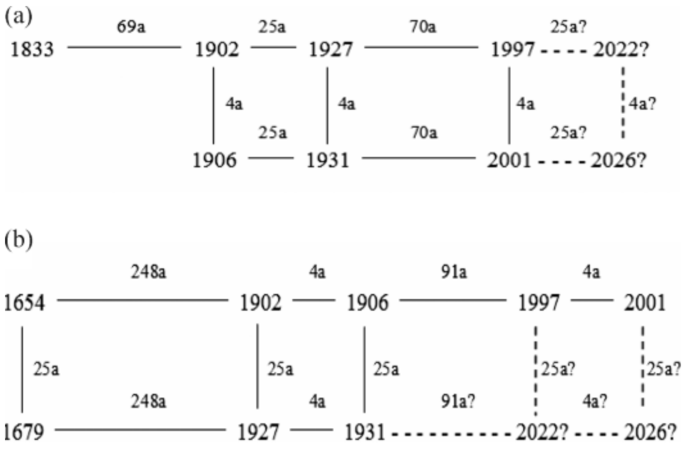

Fig. 6. Sketch of prediction for the ordered pair of $M \geq 8$ earthquakes by using a 2D-ordered network.

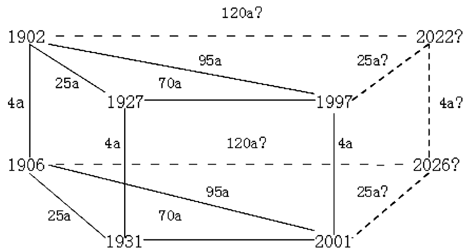

Fig. 7. Sketch of prediction for the ordered pair of $M \geq 8$ earthquakes by using a quadrangular network.

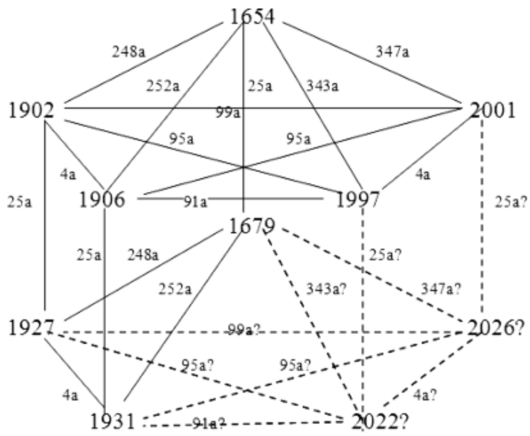

Fig. 8. Sketch of prediction for the ordered pair of $M \geq 8$ earthquakes by using a five prism network.

prism network structure composed of the three quadrilaterals shows the coupling relation between the GEOS and the GEOSS. According to the real line parts of Figure 7, the 2001 Kunlunshan $M8.1$ earthquake can be predicted. By extending, a quadrangular ordered network structure composed of real and dotted lines can be constructed. Thus, in the future a new pair of $M \geq 8$ earthquakes can be predicted based on the quadrangular ordered network. It means that a new ordered pair of $M \geq 8$ earthquakes will happen around 2022 and 2026.

4.2.2. *Ordered Network Structure of Five Prism and its Prediction*

With the same method, by choosing some earthquake events in the 1833 GEOSS and 1303, 1556 GEOS, a prediction sketch of 3D-ordered network structure like a five prism can be constructed (Fig. 8).

By cutting Figure 8, we can get nine rectangles, shown in Figure 9. Three real line rectangles in row one are completed. Their opposite sides are symmetrical and equal, which shows very stable symmetry structure and nice orderliness.

According to the property that opposite sides are equal in a rectangle, it can be predicted that two $M \geq 8$ earthquakes will occur in 2022 and 2026 by the six rectangles ordered networks in row two and row three of Figure 9, respectively. It means that based on the five prism ordered network structure, the future ordered pair of $M \geq 8$ earthquakes which will probably occur around 2022 and 2026 can be predicted.

4.2.3. *Ordered Network Structure of Triangular Prism and its Prediction*

Cutting the five prism in Figure 8 along the corresponding diagonal in top and bottom side, we can get six triangular prisms. They are listed in Figure 10.

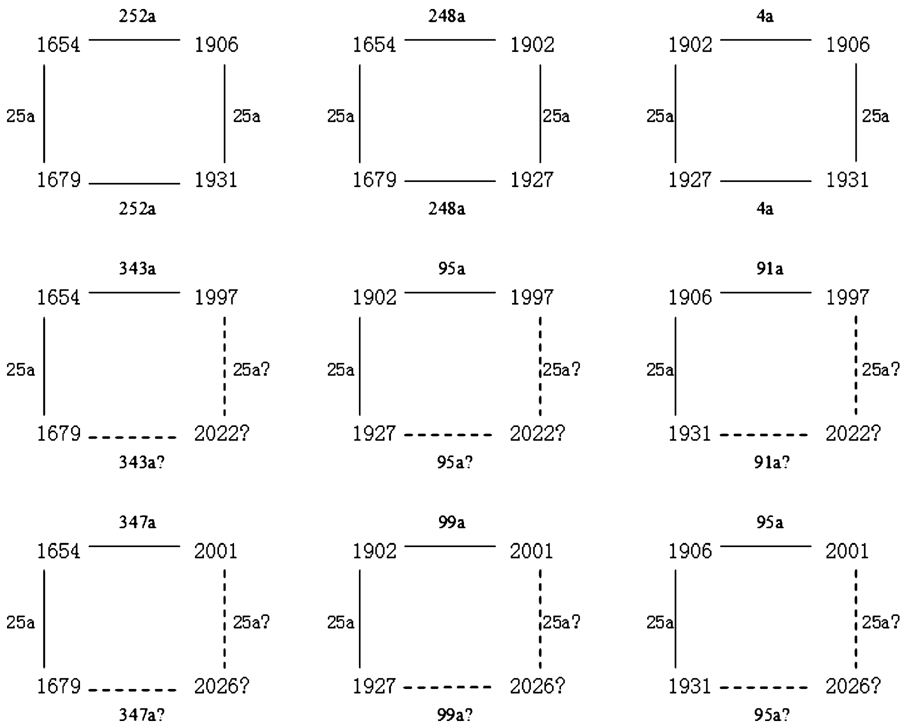

Fig. 9. Nine rectangles with stable and symmetrical structure in Figure 8.

Similarly according to the rectangle rule, we can predict that an $M \geq 8$ earthquake will probably occur around 2022 and 2026 by using the two triangular prisms in Figure 10a,b and Figure 10c,d respectively. At the same time, we can also predict that two $M \geq 8$ earthquakes will probably occur around 2022 and 2026 by using the two triangular prisms in Figure 10e,f.

4.3. Combinatorial Prediction

(i) Choose some great earthquakes in Table 1, let $x_1 = 1833$, $x_2 = 1879$, $x_3 = 1951$, $x_4 = 1976$, $x_5 = 1997$, $x_6 = 2001$, the three-variable commensurable formulas are as following:

$$
\begin{aligned}
x_6 + x_5 - x_4 &= 2001 + 1997 - 1976 = 2022\,, \\
x_5 + x_4 - x_3 &= 1997 + 1976 - 1951 = 2022\,, \\
x_4 + x_2 - x_1 &= 1976 + 1879 - 1833 = 2022\,, \\
x_3 + x_3 - x_2 &= 1951 + 1951 - 1879 = 2023\,.
\end{aligned}
$$

That means that the time node 2022 is definitely not accidental. An $M \geq 8$ earthquake will probably occur around 2022.

(ii) Figure 2 shows the network structure of 1833 GEOSS. According to it, an $M \geq 8$ earthquake will probably occur around 2026. Choose six great earthquakes in the 1833 GEOSS, let $y_1 = 1879$, $y_2 = 1902$, $y_3 = 1927$, $y_4 = 1951$, $y_5 = 1976$, $y_6 = 2001$. Six three-variable commensurable formulas can be generated:

$$
\begin{aligned}
&y_6 + y_5 - y_4 = 2026\,, \quad y_6 + y_3 - y_2 = 2026\,, \\
&y_6 + y_6 - y_5 = 2026\,, \\
&y_5 + y_4 - y_2 = 2025\,, \quad y_6 + y_4 - y_3 = 2025\,, \\
&y_5 + y_5 - y_3 = 2025\,.
\end{aligned}
$$

That also means that the time node 2026 (2025) is definitely not accidental. An $M \geq 8$ earthquake will probably occur around 2026.

(iii) According to Figures 7 and 8, the above six $M \geq 8$ earthquakes (1902, 1906, 1927, 1931, 1997, and 2001) occurred in three pairs and orderly. The time interval between the first and second pair of $M \geq 8$ earthquakes is 21a and the four nodes can be connected to form a quadrangle: 1902 – 1906 – 1927 – 1931 (showing the above part of Fig.11). Based on comparative analysis of the symmetry and orderliness, if the time interval between the the future fourth pair and the third

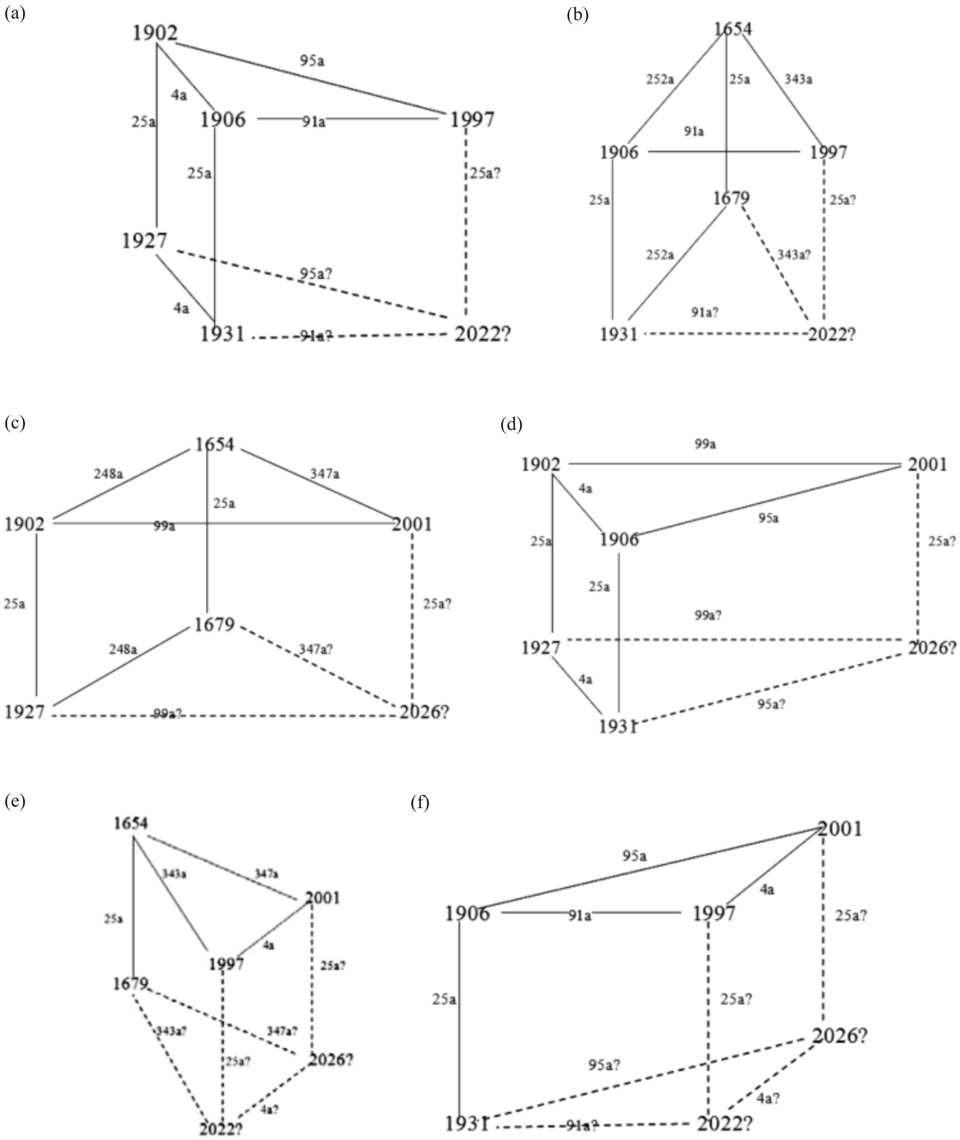

Fig. 10. Sketch of prediction for the ordered pair of $M \geq 8$ earthquakes by using triangular prism networks.

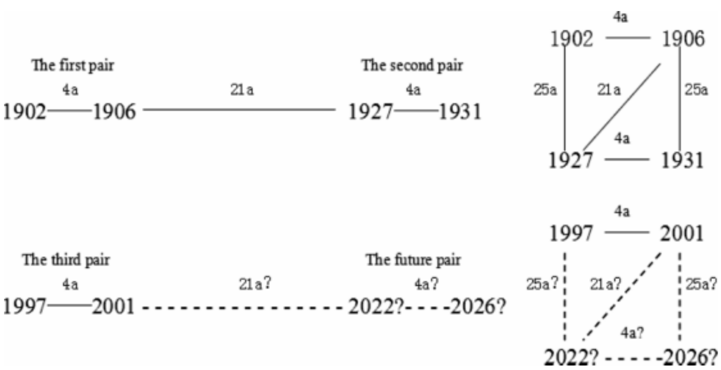

Fig. 11. Sketch of prediction for the future pair of $M \geq 8$ earthquakes based on the symmetry and orderliness.

pair of $M \geq 8$ earthquakes is also 21a, we will have another quadrangle with one real side and three dashed sides: 1997 – 2001 – 2022 – 2026 (showing the bottom part of Fig.11). The opposite sides of two quadrilaterals should be symmetrical and equal. According to Figure 11 in the light of these symmetrical features, we can predict that the future fourth pair of $M \geq 8$ earthquakes will occur around 2022 and 2026.

To sum up, a new ordered pair great earthquakes with an interval of 4a are very likely to occur around 2022 and 2026. Because the former three ordered pairs of $M \geq 8$ earthquakes all occurred in West China, so the future fourth pair great earthquakes will also be likely to occur in the western region of China.

5. Conclusion and Discussion

(i) Natural characteristics of things can be divided into two categories: order and disorder. And order can be divided into two parts: dominant and recessive. Dominant is apparent orderliness, such as four seasons in one year. Recessive means hidden orderliness [22]. Symmetry and nonsymmetry, or symmetry breaking, are basic attributes of nature. They are the identity and variation during the natural changes. The mutual dependence and transformation make up the colourful, complex, and lively images [23]. Symmetry means orderliness, simplicity, and inevitability. To explore the symmetry is to find orderliness in arbitrariness, to find simplicity in complexity, to find inevitability in haphazard [24]. Oderliness always comes together with disorder and it runs through human, biology as well as nature. Symmetry, commensurability, fractal self-similarity, informational orderliness etc. all belong to the category of orderliness. Exploring orderliness has a profound inspiration for us to recognize and study the development of human society and nature [25]. The event in a great earthquake chain is not isolated, but interrelated and interacted with coupling others before and after that, and thus forming a network, which is so-called the emergence. The network is a kind of recessive network [26 – 29]. $M \geq 8$ earthquakes in Mainland China show obvious self-organized temporal orderliness. The regular, symmetric network structure provides a new instance for network hypothesis. The 2D- and 3D-ordered network structure of $M \geq 8$ earthquakes in Mainland China in this paper digs out symmetrical, simple, and inevitable ordered information from disorderliness, complexity, and haphazard. It highly contains and reveals complexity and orderliness of $M \geq 8$ earthquakes in Mainland China for over the last 710 years. This is better for us to deeply understand the occurrence regularity of great earthquakes and so as to promote the prediction research of $M \geq 8$ earthquakes.

(ii) Now the era of big data is coming [30]. Big data is undoubtedly the hottest issue at present time. Some media claim that 2013 is the first year of big data. A predictor of the era of big data, Viktor Mayer-Schönberger, says that the essence of world is data. Big data will bring great era transformation. The change of thinking from causality to correlation is the key of big data, while the forecast based on correlation is the core. To find useful information from mass data, dig out the closet pattern, trend, and correlation, and reveal the natural and social phenomena, stronger data insight is required. From a very unique and deep perspective, he proposes three points about big data: not random sample but whole data, not exactness but hybridity, not causality but correlation. It is very worthy of studying and thinking carefully. Overall, the basic thought of big data is generally consistent with the information forecasting theory. The difference is that in the former the correlation is in a narrow sense, namely statistical correlation, while in the latter it is generalized, which includes not only the statistical correlation, but also commensurability, symmetry, fractal self-similarity, informational orderliness etc. What is more important, the information forecasting theory is more devoted to mining the regularity of severe disaster events (such as great earthquakes, big floods etc.) from a small number of effective data which could also help the advance of disaster prediction and new ideas.

(iii) Different from the complex and unrecognized traditional mathematical method, the ordered network structure is an intuitive, vivid, and easy method on the moderate term and long term prediction for $M \geq 8$ earthquakes. Though it is hard in the whole world, a great earthquake can be predicted. The results in this paper show again that the information forecasting theory by Wen-Bo Weng is effective to analyze and solve the leaping (especially long time and long distance) prediction of great earthquakes. It is generally known that the prediction of a $M \geq 8$ earthquake should be a gradual process, a system engineering. There may be false in above prediction. The subsequent short-term and imminent prediction should be based on the mid-and-long term prediction, combining multi-disciplinary and multi-channel with collaborative research to strengthen comprehensive study on a variety of impending seismic phenomena, to track and focus on the information of great earthquakes. By various means to discard the false and retain the true, narrowing forecast range, we can lock and capture the future great earthquakes in order to contribute to disaster prevention and reduction of mankind.

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