The effect of Seiche on the great flood in the Liangzhu area 4300 years ago

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Abstract

This paper attempts to use the Seiche phenomenon to explain a huge flood that occurred in the Liangzhu region of Zhejiang Province in the middle and lower reaches of the Yangtze River 4,300 years ago. According to the available archaeological evidence, the height of this flood reached about 100 meters. The cause of this Seiche phenomenon is the dam failure of glacial lakes formed in the Tarim and other basins in the western plateau of China after the end of the last glacial period. This paper estimates that if the dam of the Tarim Basin, which is filled with glacial lake water, fails, the flood water can easily flow into the East China Sea through the Hexi Corridor, causing geological disasters such as earthquakes, leading to a chain of dam failure effects in other basins in the west, and then more massive floods. The potential energy of the floods generated by the dam failure of these glacial lakes is enough to cause Seiche standing waves up to 150 meters high and 5 kilometers in wave length in places such as the East China Sea. Such a high amplitude Seiche standing wave may be the cause of the great flood in the Liangzhu area 4,300 years ago. Considering that the current global climate is rapidly warming and may cause more severe flooding, this paper also estimates that if a 30-kilometer radius of Greenland ice sheet dissolves and dumps into the ocean, the potential energy carried by this ice sheet will propagate to the North Sea in northern Europe, potentially causing Seiche standing waves with amplitudes of up to 50 meters. This Seiche standing wave can last for months, or even years. This will have a very serious impact on the countries bordering the North Sea and require our attention.

1 Introduction

4,300 years ago, there was a great flood in the Liangzhu region of Zhejiang, China [1,2]. The scale of this great flood was very large. According to the available archaeological evidence, the depth of this great flood reached a maximum depth of about 100 meters and lasted for several decades.

This was about 7,000 years after the end of the last glacial age. At this time, the sea level has

been stable for thousands of years, so even a small fluctuation in the global climate can cause the global average sea level to fluctuate by about 1 meter. Such small sea level fluctuations did not cause a large enough flood to inundate the ancient city of Liangzhu, so there was another reason for the flood that inundated the ancient city of Liangzhu.

At present, if we look at the topographic map of the western plateau of China, we can see that there are many basins on and near the western plateau. Including the Jungar Basin, the Sichuan Basin and the Tarim Basin. The total area of these basins reaches 1.2 million km^2. The largest of these basins is the Tarim Basin. The area of the basin reaches 400,000 km^2, and the depth of the basin can reach 2,000 m. Therefore, if the entire western plateau covers millions of km^2 of ice sheet glaciers during the last glacial maximum, when these glaciers dissolve, some of the glacial meltwater will flow to the lower east. However, a large portion of glacial meltwater remains in these basins of the Western Plateau, and form of so-called glacial lakes. The current Qinghai Lake is probably one of the remaining glacial lakes after the glacier melted.

But the dams of these glacial lakes are naturally formed, so they are also very unstable. After 7,000 years, the dams of these glacial lakes have failed. This process of rout can be cascading. In other words, the dam failure of one of the larger glacial lakes caused an earthquake, which in turn led to the dam failure of other glacial lakes one after another. Eventually, almost all of the glacial lake water flowed through the collapsed levees to the east and into the East China Sea and other oceans.

Judging from the topography of the existing western plateau, the Tarim Basin produces the largest amount of water. Most of this glacial meltwater flows east through what is now the Hexi Corridor and eventually into the East China Sea via the Bohai Sea. We can also note that there is a

so-called Wakhan corridor in the Tarim Basin that reaches Afghanistan. This also means that part of the glacial meltwater that year also washed into Afghanistan and then flowed into the India Ocean. But given the width and length of the Wakhan Corridor, these glacial meltwater flows should be only a fraction of the glacial meltwater stored in the Tarim Basin. Therefore, the floods in places such as Afghanistan are relatively small. This is why we have relatively few records and sites that show that there was a flood in this area. Of course, the geological disasters caused by the huge collapse of glacial lakes in the Tarim Basin will certainly affect the western Iran plateau and other regions, and this impact may include the dam failure of other glacial lakes in the Iran plateau and other locations. However, the scale of glacial lakes in these areas should be much smaller than those in the western plateau of China, so the scale of the flooding caused by dam failure of these small glacial lakes will naturally be relatively small. This may also be the reason why the Great Flood is recorded in the Bible as lasting only 40 or 150 days and then receding.

A large amount of meltwater from the glacial lake flowing eastward accumulates in the East China Sea, which is surrounded by dams formed by the present-day Japan archipelago and the Ryukyu Islands, forming a Seiche resonance phenomenon. This Seiche oscillation wave carries all the energy left behind by the meltwater from the glacial lake and causes seawater to pour into the lower reaches of the Yangtze River and the North China Plain, causing a flood of more than 100 meters high. In September 2023, the Seiche wave generated by a landslide caused by the melting of glaciers in the Dickson Fjord in Greenland lasted for nine days [3]. In such a large area of the East China Sea, it is very likely that the false tide standing waves that form in the sea water will last for more than 100 years. This caused the ancient city of Liangzhu to be submerged in water for 100 years. A splendid civilization was completely interrupted.

2 Seiche

The Seiche effect is a standing wave of water vibration that is formed in a relatively small area of closed or semi-closed due to an earthquake or some other factor. This vibrating standing wave of water will last for a longer time. Current records and studies show that in September 20023, the Seiche effect of Dickson Fjord in eastern Greenland caused a tsunami of up to 200 meters high and lasting up to nine days [3]. Therefore, when these Seiche phenomena occur in the East China Sea in eastern Asia or the Persian Gulf in Central Asia, they should last longer, possibly from 40 days to about 100 years. This is a good explanation for the continuous great floods that occurred in various parts of the country 4,300 years ago.

3 The formation of the East China Sea and the role of Seiche

From the satellite images on the existing network map, it can be seen that the topography of the middle and lower reaches of the Yangtze River Plain and the North China Plain in eastern China is very low-lying, while in the east of China, the East China Sea, the Yellow Sea, the Bohai Sea, etc., the water depth is only about 20 to more than 1000 meters. Therefore, considering the long-term erosion of seawater and subsidence, it can be assumed that the East China Sea, the Yellow Sea and the Bohai Sea should be a plain swamp land for at least a long time. At least that's the case during the last glacial maximum. If the East China Sea and other places are plain swampy areas, then the Japan archipelago and the Ryukyu Islands should be the coastline of this plain area. So we can assume that after the end of the last glacial maximum, it was only the external sea level that rose, and that most of the glaciers in the western plateau of China dissolved, but the vast majority of the

meltwater from these glaciers remained in the glacial lakes of the western plateau. Therefore, the amount of glacial meltwater that actually enters the current East China Sea area is relatively small. As a result, the Japan archipelago and the Ryukyu Islands remained a continuous coastline long after the end of the last glacial maximum. It can block the inflow of ocean water from the outside Pacific Ocean, thus ensuring that the entire East China Sea, the Yellow Sea, and the Bohai Sea remain a swamp with many lakes for thousands of years after the end of the last glacial period. And there may have been some ancient civilizations active around this swamp.

By 4,300 years ago, this situation had changed, and a large number of glacial lakes in the western plateau of China began to burst their dams, resulting in a large amount of glacial meltwater accumulated in the Tarim Basin pouring down along the Hexi Corridor to the middle and lower reaches of the Yellow River, and then forming huge floods. The earthquake caused by the dam failure of the glacial lakes in the Tarim Basin may also lead to the dam failure of the glacial lakes accumulated in the Qaidam Basin and the Sichuan Basin. Eventually, all of these glacial lakes of more than 1 million square kilometers began to pour out into the middle and lower reaches of the Yellow River and the Yangtze River, and were blocked by the dikes of the Japan archipelago and the Ryukyu Islands in the East China Sea, preventing them from continuing to flow into the vast Pacific Ocean, thus forming a very powerful Seiche phenomenon in the East China Sea.

This huge Seiche carries a very large amount of energy, and in a relatively short period of time, in the relatively low-lying areas of the middle and lower reaches of the Yangtze River Plain in China's North China Plain, a flood area with a depth of about 100 meters has been formed.

Due to the oscillation of the standing wave of Seiche, the continuous back and forth of the flood has washed away all the relics of human civilization on the one hand, and on the other hand,

it has also given the surviving refugees the opportunity to take canoes, rafts and other water vehicles to escape from the middle and lower reaches of the Yangtze River and enter Erlitou, Sanxingdui and other places to rebuild a new civilization.

To the east, the coastline formed by the Japan archipelago and the Ryukyu Islands was constantly impacted by the oscillation of the Seiche standing wave of the sea, and the seawater erosion continued to occur, and the effect gradually weakened, and finally after a hundred years, most of the Ryukyu Islands subsided, causing a huge earthquake, and the Seiche standing wave energy in the East China Sea was released. Eventually, in the middle and lower reaches of the Yangtze River and northern China, the floodwaters eventually receded.

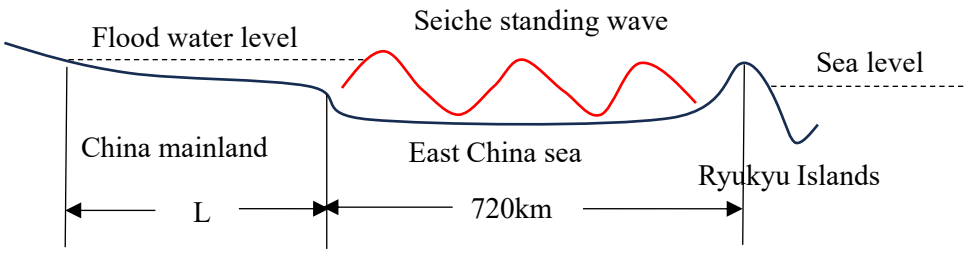

Fig. 1. Seiche standing wave in east China sea

Fig. 1 shows the phenomenon of floods flowing from Chinese mainland to the East China Sea and then being blocked by the Ryukyu Islands, forming standing waves in the East China Sea.

4 Simple estimates

For water waves, the standing wave's wave equation can be expressed as

$$f(x) = 2Acoskxcos\omega t$$

In this way we can calculate the total energy formed by this standing wave as

$$E = \frac{1}{2} M \omega^2 A^2 \quad (1)$$

In the above equation, A is the amplitude, k is the wave vector, ω is the oscillation frequency, and M is the mass of the seawater. It can be seen that the energy of the Seiche standing wave is proportional to the square of the product of amplitude and frequency.

However, the amplitude of the Seiche standing wave is limited by the depth of the seawater. In other words, the amplitude of the standing wave of the seawater should not be greater than the depth of the seawater, otherwise the water molecules will create a very large friction force on the seabed and consume the remaining energy. The depths of the East China Sea, the Yellow Sea and the Bohai Sea are not the same, and the maximum depth of the East China Sea is currently an average of 340 meters, which also means that the amplitude of the Seiche standing wave will not exceed 340 meters. Considering other factor limitations, the amplitude of the standing wave is A=150 meters.

For the sake of simplicity, let's just consider that the glacial lake water accumulated in the Tarim Basin flows into the East China Sea over a period of 100 years. According to the Tarim Basin of the Western Plateau with an area of 400,000 square kilometers and an average depth of 2,000 meters, the water storage of the glacier lake can reach $8 \times 10^{17} kg$, and the mass of the glacier lake water discharged into the glacier lake reaches $8 \times 10^{15} kg$ per year according to the flow rate of 1/100 of the downstream after the dam failure of the glacier lake, which can be compared with the current water volume of the Yangtze River flowing into the ocean is about $1 \times 10^{15} kg$. So the amount of this flood is still quite large. Therefore, with the amount of water flowing out of the Yangtze River and other rivers, the annual flood flowing into the East China Sea will reach about $10^{16} kg$ after the dam failure of the glacial lake in the western plateau

According to the average altitude of 3,000 meters above sea level in the western plateau, the

potential energy of the annual flood into the ocean is

$$E = mgH \approx 10^{16} \times 9.8 \times 3000 \approx 3 \times 10^{20}(J)$$

The mass of the water of east China sea is

$$M \approx 2.62 \times 10^{18} kg$$

If all these potential energies are converted into the energies of the Seiche standing wave in the East China Sea, then the above parameters can be substituted into equation (1) to obtain them

$$f = \frac{\omega}{2\pi} = \sqrt{\frac{2E}{M}} \frac{1}{2\pi A} \approx 0.012(Hz)$$

Considering that this is a shallow water wave, its wave velocity can be used by a formula

$$c = \sqrt{gd} \approx 58.3 m/s$$

In the above equation, *g* is the acceleration due to gravity, *d* is the depth of the sea, and *c* is the wave velocity. In this way we can find the wavelength as

$$\lambda = 4970m$$

From the above estimates, it can be seen that even if the dam of the glacial lake in the Tarim Basin bursts, only the water of the glacial lake can form an oscillating standing wave with a wave amplitude of 150 meters and a wavelength of 4.97 kilometers in the East China Sea. The energy loss of this standing wave is small and hence it can last for a long time. And a wave amplitude of 150 meters means that a flood of up to 100 meters can be formed along the eastern coast of China. This would better explain why the great floods that occurred along China's eastern coast 4,300 years ago were so deep and lasted so long.

5 A not optimistic forecast

The global climate is warming rapidly. Due to the glaciers of the western plateau of China, only a small part of the Himalayas remain. Therefore, even if it is completely dissolved, it will not have too serious an impact on the middle and lower reaches of the Yangtze River. However, the current situation in Greenland is very similar to that in the western plateau of China 4300 years ago. According to the available datas, the western plateau of China covered about 2.5 million square kilometers of glaciers during the last glacial maximum. Greenland now covers more than 1.8 million square kilometres of glaciers. This also means that as the global climate continues to warm, the continued dissolution of Greenland's glaciers is inevitable. If global temperatures rise by about 6°C, Greenland's glaciers can be expected to melt completely.

However, we can also note that Greenland is surrounded by the sea and is low-lying. This also means that Greenland's melting ice flows into the ocean more easily. Of course, since the thickness of the glacier reaches several kilometers, the entire dissolution process is not linear. In other words, it is not as much ice that is dissolved as much glacial meltwater will flow out. In fact, like the western plateau of China, the altitude of central Greenland is relatively low. Therefore, there are many glacial lakes that can store glacial meltwater. Much of the meltwater from the dissolved glaciers is temporarily stored in these glacial lakes. This can play a role in regulating the amount of glacier dissolution. In other words, if the temperature rises more, there will be more meltwater in the glacial lake. When the temperature drops, there will be less meltwater in the glacial lake. This limits the amount of meltwater flowing out of Greenland's glaciers. Much of the evidence now suggests that Greenland's glacier bottoms are dissolving severely. This should reflect the effect of

this glacial lake.

However, if humans do not tighten the control of global temperature rise now, the capacity of these glacial lakes on Greenland is limited, and when the glaciers dissolve to a certain extent, the glacial lakes will lead to dam failure, and then export a huge amount of glacial meltwater to the ocean at one time, thus causing a rapid nonlinear rise in sea level. This non-linear rise could be devastating.

One of these disasters is the possibility of a tsunami in the North Sea of Europe that can be tens of meters high and may last up to a year or two. and has a fatal impact on United Kingdom, Denmark and other places.

Fig. 2. Seiche standing wave in North Sea of UK

As can be seen in Figure 2, if a huge ice sheet in eastern Greenland slips into the ocean, its enormous energy will be transferred to the North Sea through seawater waves. The North Sea is in a semi-closed state, so this energy accumulates in the North Sea, forming Seiche standing waves. Considering that the average depth of the North Sea in United Kingdom is about 96 meters, the

amplitude of the Seiche standing wave can be as high as about 50 meters. In other words, a tsunami can form up to 50 meters high. In contrast to the India Ocean tsunami, the North Sea tsunami was caused by the Seiche standing wave. As a result, the energy cannot be released in other directions, but can only rush towards land. So it will last a very long time. For example, months or even years. And the back and forth of the waves of the sea water rubbing against the land can cause even more serious damage.

We can get a rough estimate of the energy that formed such a large Seiche standing wave. The total mass of the North Sea is $M \approx 5.75 \times 10^{16} kg$, and the wavelength of the wavelength is 50 km (the length of the wavelength is mainly related to energy. The input energy is smaller, and the wavelength is longer. vice versa), a standing wave with an amplitude of 50 meters, the wave velocity is $c = \sqrt{gd} \approx 31 m/s$. It can be calculated from equation (1).

$$E = \frac{1}{2} M\omega^2 A^2 \approx 0.5 \times 5.75 \times 10^{16} \times \left(2\pi \times \frac{31}{50000}\right)^2 \times 50^2 = 1.1 \times 10^{15} (J)$$

Then we take into account that the energy from the slide of a 30 kilometers radius Greenland ice sheet travels along a circular wave to the North Sea, and the energy is inversely proportional to the radius. Calculated at a distance of 3,000 km from Greenland in the North Sea, then the formation of such Seiche standing waves requires Greenland to release energy

$$E_t = E \times 10^5 = 1.1 \times 10^{20} (J)$$

For an ice sheet with a radius of 30 kilometers and a thickness of 2,000 meters, the difference in height from land to sea can also reach about 2,000 meters. then the potential energy it produces is

$$E_v = \pi \times 30000^2 \times 2000 \times 1000 \times 10 \times 2000 = 1.13 \times 10^{20} (J)$$

It can be seen that the energy of the two is comparable. In other words, if a glacial lake

underneath the ice sheet in Greenland fails, large chunks of the ice sheet could slip from the land into the ocean. An ice sheet about 30 kilometers in diameter slips into the ocean, causing a Seiche standing wave with a wavelength of 50 kilometers and an amplitude of 50 meters in the North Sea of United Kingdom. Such a Seiche phenomenon can lead to the formation of tsunamis up to several tens of meters high in coastal areas such as United Kingdom, Denmark, Netherlands, etc. This is indeed something that needs attention.

Unfortunately, passive protection measures against tsunamis are currently quite limited. In particular, the tsunami generated by the plains covering an area of more than 100,000 square kilometers. This can be seen in the disaster caused by the tsunami in the India Ocean of that year. Of course, we can also take a proactive approach, such as reducing the global temperature rise, which should stabilize Greenland's glaciers. And if the rise in global temperatures cannot be controlled, we can also keep an eye on changes in the Greenland ice sheet. In particular, pay attention to the amount of meltwater in the glacial lakes below the ice sheet. If it is found that these glacial lakes are at risk of dam failure, they can be manually excavated to release the meltwater from the glacial lakes, which is believed to alleviate the risk of glaciers sliding into the seawater.

6 Conclusions

From the above analysis, it can be seen that the Seiche phenomenon was the direct cause of the scale of the flood 4,300 years ago. The formation of this Seiche phenomenon may be due to the fact that the current Ryukyu Islands were still a relatively intact land mass, resulting in a relatively closed environment in the entire East China Sea. This would explain why such a large flood occurred more than 7,000 years after the end of the last glacial period . The indirect cause of the great flood 4,300

years ago was the presence of a large number of glacial lakes on the plateau of western China. These glacial lakes can now be seen in the topography of the Western Plateau of China. The Tarim Basin is the largest basin in the Western Plateau, reaching 400,000 square kilometers, which means that after the end of the last glacial period, glacial meltwater will be temporarily preserved in large basins such as the Tarim Basin. Another important topography is the Hexi Corridor and the Wakhan Corridor. These two corridors show the flow of floodwaters after the dam failure of the glacial lake in the Tarim Basin. It is clear from the width and scale of the Hexi Corridor that the flood flow caused by the dam failure in the Tarim Basin is very large. In this paper, we assume that the flow of flood water leaking through the Hexi Corridor is about 10 times the amount of water currently flowing out of rivers such as the Yangtze River. The estimates in this paper show that such a large flood carries a huge potential energy that can form a Seiche standing wave with an amplitude of up to 150 meters in the East China Sea. This provides a theoretical basis for the great flood 4,300 years ago. At the same time, the analysis in this paper also shows that the flood may have occurred mainly in eastern China, and the impact on other regions was relatively small.

In the current situation where the global temperature is rising and difficult to control, the analysis in this paper also allows us to make a prediction of the future disaster caused by the melting of Greenland's glaciers. According to this paper's estimates, if a huge ice sheet with a radius of 30 kilometers and a thickness of 2 kilometers in Greenland dissolves and falls into the ocean, it will have a catastrophic impact on the North Sea region of Europe. This catastrophe may be the formation of a tsunami as high as tens of meters, considering that this tsunami is caused by Seiche standing waves, the entire tsunami may last for months or even years, which needs to be paid enough attention. Of course, if some measures can be taken as soon as possible, it is still possible to reduce

the whole disaster.

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