一般講演
# 岩盤力学
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[3411-17-07] Prevention of Giant Earthquakes by Underground Nuclear Explosions

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Methods for imminent earthquake prediction have never been established so far. Even if a prediction method was established, it could not significantly reduce infrastructure damages although it could slightly reduce the number of fatality. On the other hand, prevention of earthquake, if a method could be developed, could reduce not only the number of fatality but also infrastructure damage to an almost negligible level. This might be possible by exploding the present nuclear warheads underground because a report from Russia pointed out that no earthquakes more than or equal to M8.3 occurred during the period in which the underground nuclear explosions were taken place. We statistically tested whether the explosions prevented giant earthquakes (more than or equal to M8) or not and found that the necessary condition was satisfied. The mechanism of the prevention is discussed, and the necessary yield to prevent giant earthquakes and how long the human could prevent giant earthquakes by the present nuclear warheads are estimated.

1. Introduction

Methods for imminent earthquake prediction have never been established so far. Even if a prediction method was established, it could not significantly reduce infrastructure damages although it could slightly reduce the number of fatalities. On the other hand, prevention of earthquakes, if a method could be developed, could reduce not only the number of fatalities but also infrastructure damages to an almost negligible level. This might be possible by exploding the existing nuclear warheads underground because a report from Russia pointed out that no $M \geq 8.3$ earthquakes occurred during the period in which the underground nuclear explosions were taken place. The relationship between underground nuclear explosions and giant earthquakes ($M \geq 8.0$) is shown first and the mechanism of the prevention is discussed. Necessary yield to prevent giant earthquakes and how long the human could prevent giant earthquakes by the existing nuclear warheads are estimated as well as the cost of the prevention.

2. Underground nuclear explosions and giant earthquakes

A Russian study claimed that no $M \geq 8.3$ earthquakes occurred during the period in which underground nuclear tests were carried out (source: https://jp.sputniknews.com/science/20150725634763/). Unfortunately, the detail of the study is not known because we could not succeed to access the original article. However, lists of the underground nuclear tests and giant earthquakes can be obtained from http://www.johnstonsarchive.net/nuclear/tests/ and http://earthquake.usgs.gov/earthquakes/search/, respectively. We examined the relationship between them by ourselves expanding the lower limit to $M \geq 8$ and found that less giant earthquakes occurred during the period in which underground nuclear tests were carried out (Fig. 1).

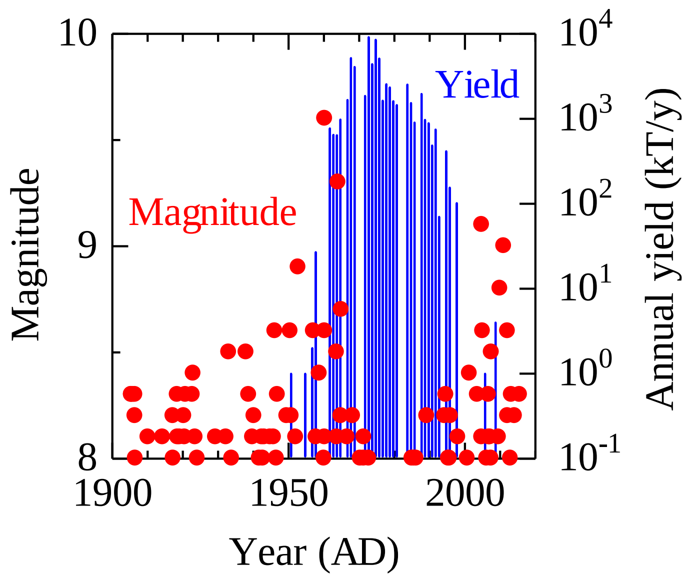

Fig. 1 Magnitude of giant earthquakes and annual yield of underground nuclear tests from 1900 to 2016.

The probability of the null hypothesis assuming that there was no Granger causality from annual yield or number of underground nuclear tests to annual seismic energy or number of giant earthquakes was calculated with a statistic package software R (https://www.r-project.org/). Granger causality does not mean usual causality. For example, it can be said that there is Granger causality from a time series A to a time series B if B can be predicted with A better than only from the auto correlation of B. If the probability is less than 0.05, the null hypothesis is rejected and it can be statistically said that the necessary condition of the existence of Granger causality from underground nuclear explosion to occurrence of giant earthquakes is satisfied.

The probability values were more than 0.05 which means that the null hypothesis was not rejected although some of them were not so large (Table 1). Therefore, it can be statistically said that no Granger causality was found from underground nuclear tests to occurrences of the giant earthquakes. However, it is apparent that seismicity was restrained when the annual yield of the underground nuclear explosions was more than 1 MT/y (Fig. 2). The mechanism of the restraint would be induction of small earthquakes due to vibration from underground nuclear explosions thereby relieving the strain energy for giant earthquakes. Manga et al. (2012) explained that one of the causes of induction of smaller earthquakes in far fields by large earthquakes would be change in permeability due to transient stress disturbances.

Table 1 Probability of the null hypothesis.

Underground nuclear explosions	Giant earthquakes	
	Annual number	Annual seismic energy
Annual number	0.132	0.27
Annual yield	0.120	1.00

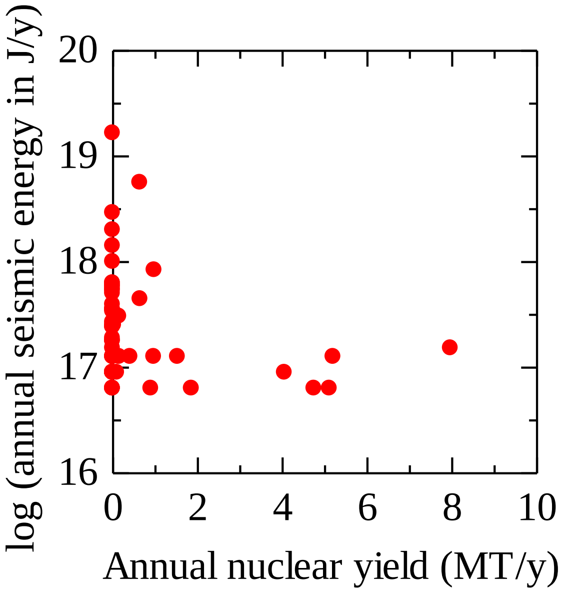

Fig. 2 Relationship between annual nuclear yield and annual seismic energy from 1900 to 2016.

Comparing the locations of nuclear tests (Fig. 3) and giant earthquakes (Fig. 4) from 1900 to 2016, nuclear tests and giant earthquakes are found in the same area for only Alaska. It is remarkable that five giant earthquakes occurred during 70 years before the nuclear tests in Alaska but only rather small one occurred during 50 years after the tests (Fig. 5). This also implies the prevention of giant earthquakes by underground nuclear explosions.

3. Prevention of giant earthquakes by underground nuclear explosions

Let us assume that the underground nuclear explosions prevented the occurrences of the giant earthquakes and propose to explode the existing warheads in US, Russia, UK etc. underground to prevent giant earthquakes. The total yield of existing 25900 warheads is 7000 MT (http://www.johnstonsarchive.net/). The minimum yield to prevent giant earthquake is 1 MT/y as stated before. However, let's assume that 2 MT/y is used to make sure the reduction of the giant earthquake occurrences. And then the existing nuclear warheads can be used for 3,500 years.

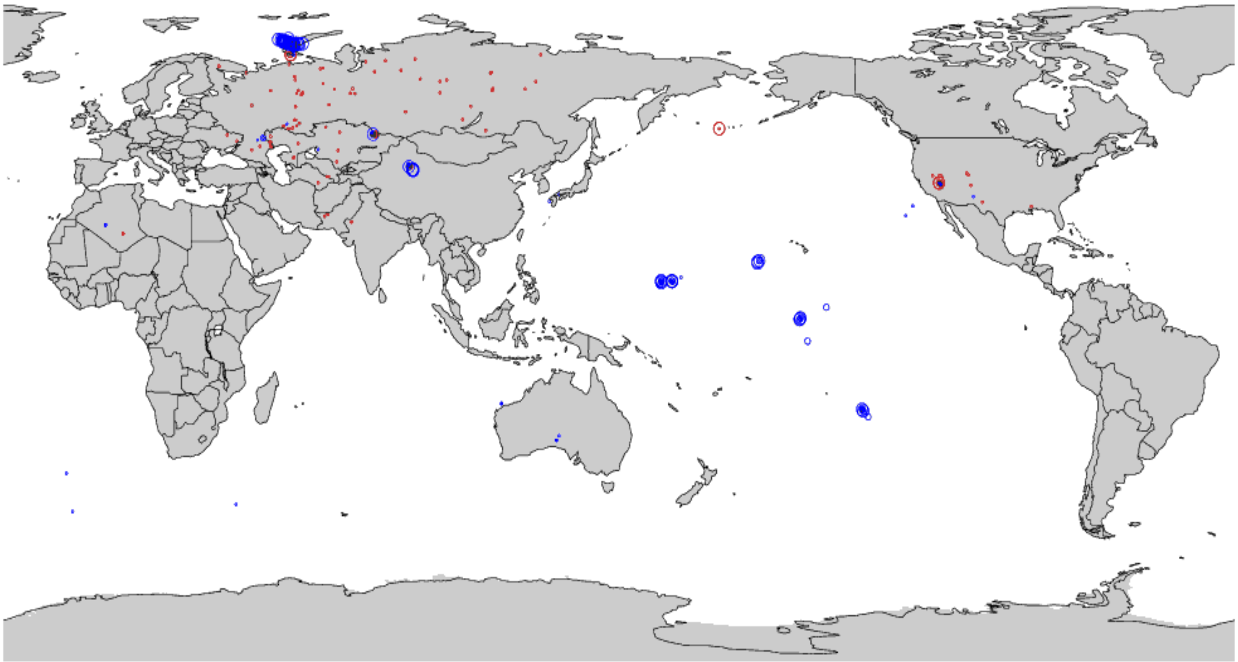

Fig. 3 Locations of underground nuclear explosions (red) and atmospheric nuclear explosions (blue).

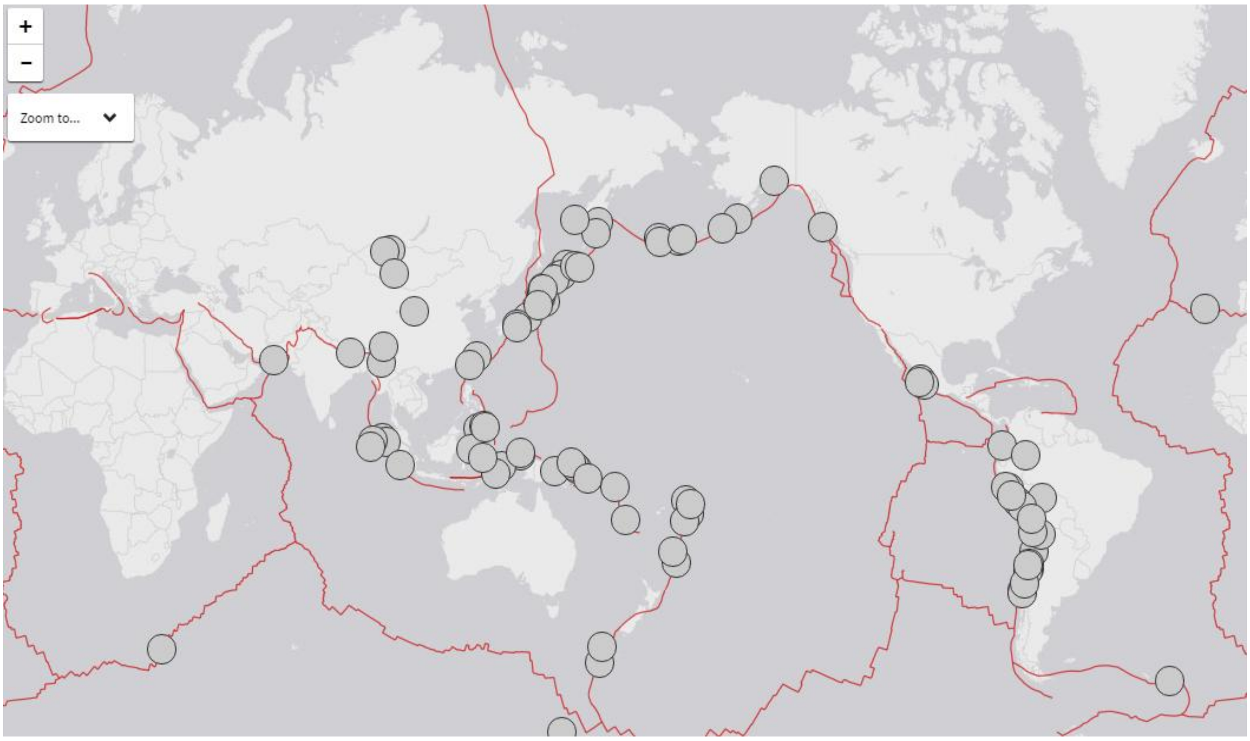

Fig. 4 Giant earthquakes between 1900 and 2016.

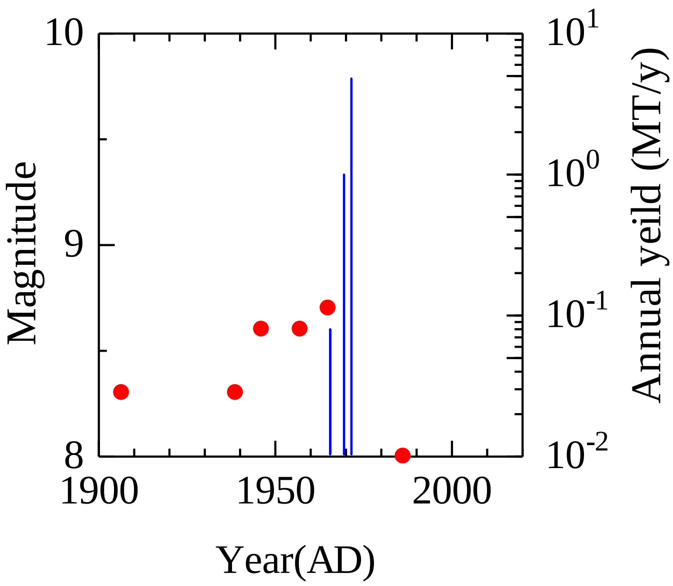

Fig. 5 Annual yield of underground nuclear explosions and magnitude of giant earthquakes in Alaska.

The cost of the recent underground nuclear test by North Korea was estimated to be ca. 5 million USD/test by South Korea (http://www.sankei.com/world/news/161005/wor1610050062-n1.html). The cost of the proposed method, if the 2 MT/y is divided into 10 tests, can be estimated as 50 million USD/y. On the other hand, the property damages by giant earthquakes listed in Wikipedia are 235 billion USD for Tohoku 2011, Japan, 86 billion USD for Sichuan 2008, China and 15-30 billion USD for Chile 2010 between 1906 and 2012. This means that the total property damage is at least 336 billion USD in 107 years or ca. 3 billion USD/y. The cost of the prevention is less than 1/60 of the earthquake damage.

The biggest possible risk of the proposed method would be an unexpected induction of giant earthquakes instead of preventing them. Deliberate investigation should be made before the practice of the method of course.

4. Concluding remarks

It was apparent that underground nuclear explosions more than 1 MT/y prohibited the occurrences of giant earthquakes although the causality was not statistically proven. Prevention of giant earthquakes by exploding the existing nuclear warheads was proposed. Cost is less than 1/60 of giant earthquake damages. Risk is the possible unexpected induction of giant earthquakes. The biggest problem would be obtaining the social consensus. However, it is worth to further consider this method because it would significantly contribute the world peace by not only preventing giant earthquakes but also by disarming the nuclear weapons.

References

Manga, M., Beresnev, I., Brodsky, E. E., Elkhoury, J. E., Elsworth, D., Ingebritsen, S. E., Mays, D. C. and Wang, C.-Y. (2012), Changes in Permeability Caused by Transient Stresses: Field Observations, Experiments, and Mechanisms, Rev. Geophys., Vol. 50, RG2004, doi:10.1029/2011RG000382