ARE NUCLEAR EXPLOSIONS CAUSING EARTHQUAKES AND KILLING MILLIONS OF PEOPLE?

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Introduction

In the Saint John, N.B. *The Telegraph-Journal* of 25 February, 1989 and also last fall, a geography professor, Dr. Gary Whiteford at the University of New Brunswick is quoted as stating that "nuclear bomb tests are shaking the earth's crust and may be responsible for earthquakes that have killed millions".

This is a most serious charge to make and must be examined by knowledgeable scientists. This proposition or hypothesis is so full of possible costly consequences that it must be tested. Seismologists are the most suitable professionals to undertake this because they have contributed to the data Whiteford is using and understand the limitations and shortcomings of those data.

In science, whenever a new hypothesis is proposed, it is customary to present it to ones peers for evaluation and criticism. However, it is also customary to do this before a suitable audience that is knowledgeable on the subject. In this case, that audience is seismologists and geophysicists. It could be done in two ways, either by attending one of the biannual meetings of the, for instance, "Seismological Society of America", "American Geophysical Union" or "Canadian Geophysical Union", or by submitting one's findings for publication in the appropriate scientific journal for review and publication. Such hypotheses should not be first given to the press because the matter cannot be examined properly when not enough information is supplied. Although Whiteford has chosen that path, we will not do likewise. We will send a copy of this rebuttal to Whiteford and hope that he will answer our rebuttal of his hypothesis, by submitting his data and interpretation in writing to us or another suitable forum.

Whilst we cannot prove with 100% certainty that nuclear explosions do not cause earthquakes, because one can not prove things that are false, we will attempt to dismantle Whiteford's arguments and show that it is nearly impossible for this hypothesis to be valid.

Man made structures and activities indeed cause earthquakes. In Canada, three hydroelectric reservoirs generated earthquakes during or after their filling: Manic 3, La Grande 2 and 3. The investigations into these activities have been published in the Canadian Journal of Earth Sciences and the Bulletin of the Seismological Society of America (BSSA). One point is important: the earthquakes occur right under the reservoir. Coal mines in Nova Scotia generate so called "bumps"; metal ore mines in Ontario cause "rockbursts"; potash mines in Saskatchewan induce small earthquakes. These seismic events are caused by the underground cavities created by the mining. Again, all this earthquake-like activity is right in the mines. In Colorado and New York State, waste water was pumped under very high

pressure deep into the ground and generated earthquakes. These events also occurred within a kilometer or so of the injection wells.

Finally, the near and far field effects of nuclear explosions have been described in many articles in the BSSA. See Massé (1981) for a summary and Toksöz and Kehrer (1972) for ratio of energy release of the explosion and triggered earthquake. The salient facts are that they do release tectonic strain (strain in the rocks of the earth's crust) that is, an earthquake is triggered but with three important limitations:

1. the time - it always occurs within seconds of the explosion
2. the distance - it is always within a few kilometers of the explosion
3. the energy released by the triggered earthquake is usually smaller compared to that of the explosion itself. Only rarely was it larger for a few small explosions.

Toksöz and Kehrer (1972) determined the energy ratio for 24 nuclear explosions to the triggered earthquake; for only three of them are the earthquakes significantly larger than the explosions. "Pile Driver" has the largest triggered earthquake magnitude of 6.4 for an explosion of M 5.6. However, the largest explosion, M=6.8 ("Cannikin") in Kamchitka triggered an earthquake of 6.6. More important is the fact that neither the explosions nor the triggered earthquakes have killed anybody since they are always set off sufficiently far from population centers.

In the following part we will critically analyse the two arguments that Whiteford is quoted as using in support of his hypothesis. The first is his observation that from 1900 to 1950 there were mostly fewer than 100 earthquakes of magnitude 6 per year and from 1950 to the present there was usually more than 100 such earthquakes per year. The second is that a Soviet Central Asia nuclear explosion on a Friday generated an earthquake 2 days later near Tokyo, killing one person. In support of our argument we will also talk about the energy released by earthquakes because that is a much more reliable indictor of long term strain release by earthquakes.

Whiteford's observation that there were fewer magnitude 6 earthquakes listed in the catalogue before 1950 than after that date is true. However, in seismological circles this phenomenon is referred to as "incompleteness". In short, what that means is as follows. Because there were very few seismograph stations in the world in the early part of the century, very few earthquakes were detected and their locations computed and magnitudes estimated. The biggest earthquakes fared best and nearly all were located. The smaller the events, the more likely it is that they were not located. Even today, hundreds of earthquakes with magnitude less than 3 may escape detection in many parts of the world

because seismograph stations are not sufficiently near to them. In Fig. 1 are shown the number of seismograph stations in the world since the turn of the century. Up to 1951 the number is estimated; after that they are known. In Fig. 2 are the number of earthquakes located by the International Seismological Center and its predecessor. It is clearly evident that the number of earthquakes goes up with the number of stations.

In Fig. 3 I have plotted at the bottom the annual number of magnitude 8 and larger earthquakes. Not only are there fewer by year since the fifties, there are also many years when there are none compared to before the fifties. These are the events that we consider to be "complete". Because of their size they are known from their effects if not from seismograph recordings. This is therefore proof that the number of big earthquakes has gone down since the time nuclear testing began. In the center of Fig. 3 I have plotted all the annual number of earthquakes between magnitudes 7.0 and 7.9. In the first decade of 1900 there were about 5 per year, then it rose to 20 after 1920 with a peak in the forties of nearly 40. Since that time, the number has steadily decreased to about 10.

Finally, the yearly number of earthquakes between magnitudes 6.0 and 6.9 have been plotted as circles also in Fig. 3. Until 1907 one was recorded. The number rose starting after 1920 with a very sharp peak of 160 in 1933. The numbers decreased during the war years. Between 1950 and 1960 the number rose again reaching an absolute maximum between 1960 and 1965. During that time we also see a low of about 60. Between 1970 and the present the numbers oscillate between 90 and 130. The magnitude range 6.0 to 6.9 is a good example of the incompleteness problem, certainty until 1930. If one wanted to blame the peak between 1960 to 1965 on nuclear explosions, one would be forced to do the same in the early 1930s. Since that predates even the Hiroshima event, Whiteford's hypothesis is in great difficulty.

Dr. H. Kanamori (1977) determined the annual number of shallow earthquakes with magnitude 7 and larger (see Fig. 4), they clearly decrease since 1945. The shallow earthquakes are important in this discussion since they are the ones that kill people. The deep ones are much smaller in number and are often so far from the earth's surface that they do not cause significant damage.

Before passing on to Whiteford's second argument, we would like to discuss the energy released by earthquakes. The energy of an earthquake is determined simply from its magnitude M by the equation $\log E = 11.8 + 1.5\ M$ (Richter, 1958). Kanamori calculated the yearly energy for all the earthquakes (Fig. 5). Because of the form of the equation it is evident that an increase of one unit in magnitude leads to an increase of 31 in energy and 2 units to an increase of 961 in energy (roughly 1000). This observation leads to two

points. One, the total energy comes mainly from the largest events and, two, one magnitude 8 earthquake has as much energy as 1000 magnitude 6 earthquakes. Referring to Fig. 5 from Kanamori (1977), it is evident that the energy is highest around 1900 in spite of the incompleteness of the data. Furthermore, the energy decreases even for a time period when the contribution from magnitude 6 earthquakes is complete.

Since the underground nuclear explosions commenced in the 1950's one could argue that they were responsible for decreasing the world-wide yearly energy release, although I believe the cause lies elsewhere.

Lastly, we will consider the argument of Whiteford that a nuclear explosion caused an earthquake two days later. Both earthquakes and nuclear explosions are similar in that they set off disturbances in the earth that travel away from the source in a symmetrical and predicatable manner. The first disturbance is a P–wave and the second is an S–wave. These two are the ones that are always responsible for the shaking of the ground that causes damage near the epicenter. These are followed by many combinations of P– and S–waves and finally surface waves. The latter because of their very long periods have much less potential for inflicting damage. Moreover, the speed of propagation of these P– and S–waves varies only as a function of the distance between two points on the earth's surface and they are predictable in that one can determine their time of arrival to within a few seconds. Let us assume that the distance between central Asia and Tokyo is exactly 6111.1 km or 55.00° then the P–wave arrives 9 minutes, 35 seconds after the explosion and the S–wave 17 minutes, 17 seconds after. Here I estimated the distance since I do not know the exact latitude and longitude of the explosion or earthquake. However, about six weeks after the events occurred the coordinates are published and we could use them to calculate the distance to a fraction of a degree and then we could calculate the exact arrival times of the P– and S–waves at that particular place. The point is that if we want to blame an earthquake on the arrival of P–waves from an explosion, then the earthquake has to occur within a few seconds of the calculable and known arrival time of the P–wave. If it occured a few seconds earlier or later then it was not caused by the P–wave. We can argue similarly for the S–wave. These waves decrease very rapidly in amplitude once they have travelled a distance of about 1/4 of the earth's circumference away from the explosion and the slower S–wave accomplishes that in about 27 minutes. Therefore, about half an hour after the explosion the ground motion generated by them is miniscule, and detectable only by seismographs, and one would not expect them to trigger any earthquakes.

In summary, if we want to blame an earthquake as having been triggered by a P–wave or an S–wave of an explosion, then the earthquake has to occur within a few seconds of the calculable arrival of these waves otherwise no triggering occurred.

Whiteford claims that the earthquake in Tokyo occurred two days after the explosion. There are simply no waves, known to seismologists, in the earth from such an event that take two days to arrive with sufficient energy to trigger an earthquake. Therefore this argument is not valid and can be excluded.

Seismologists and other earth scientists have for some years been curious about the possibility that a large earthquake in one location may be able to trigger at a later time in a distant location another large earthquake. There have been unsuccessful attempts to invoke some sort of very slow–moving "strain wave propagation". This is a quite valid area of enquiry. However, large earthquakes, e.g., magnitude 7 and 8, release strain many orders of magnitude larger than that of the largest nuclear explosions. So, until it is possible to show that large earthquakes might be able to trigger other distant large earthquakes later in time, it is futile to attempt to demonstrate the same for the orders or magnitude smaller explosions.

In summary, we have shown that the apparently lower yearly number of magnitude 6 earthquakes between 1900 and 1950 than between 1950 and the present is due simply to the incompleteness of the data and not due to nuclear explosions. Furthermore, we have shown that the annual number of large earthquakes, of magnitude 7 and over, has in fact decreased since 1945. The total yearly energy released had a maximum in 1900 and decreases ever since taking a sharp down turn in 1950 when nuclear testing started. All of this contradicts and invalidates Whiteford's arguments. We have shown that explosions usually trigger only very small earthquakes near the source. Finally, we have shown that if one wants to blame triggering of earthquakes on the waves with the largest amplitude generated by an explosion then the triggering has to occur within a few seconds of the passage of these waves.

The above evidence most strongly argues against nuclear explosions triggering earthquakes that in turn kill people. We strongly suggest to Whiteford that he reexamine his interpretation and inference that millions of people may have been killed indirectly by explosions. We recomment that further discussion be carried out through a scientific forum.

References

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Massé, R.P. Review of seismic source models for underground nuclear explosions, Bull. Seism. Soc. 71, 1249-1268, 1981.

Richter, C.F. Elementary seismology, W.F. Freeman and Co., San Francisco, 786 pp., 1958.

Toksöz, M.N. and H.H. Kehrer Tectonic strain release by underground and nuclear explosions and its effect on seismic discrimination, Geophys. J.R. astr. Soc. 31, 141-161, 1972.

Figure Captions

Fig. 1 World–wide number of seismograph stations. Before 1960 they are known stations after that they are the stations actually used.

Fig. 2 Number of earthquakes located by the International Seismological Centre and its predecessors.

Fig. 3 Annual number of earthquakes extracted from the National Earthquake Information Centre data GT8 = greater than magnitude 8; GT7LT8 = greater than magnitude 7 and less than magnitude 8; GT6LT7 = greater than magnitude 6 and less than magnitude 7.

Fig. 4 Annual number of shallow earthquakes with magnitudes 7 and larger (Kanamori, 1977). The dashed curve shows the unlegged 5–year running average.

Fig. 5 Seismic wave energy released in earthquakes computed from the surface wave magnitude M_S through the Gutenberg–Richter energy versus magnitude relation. The dashed curve shows the unlagged 5–year running average (Kanamori, 1977).

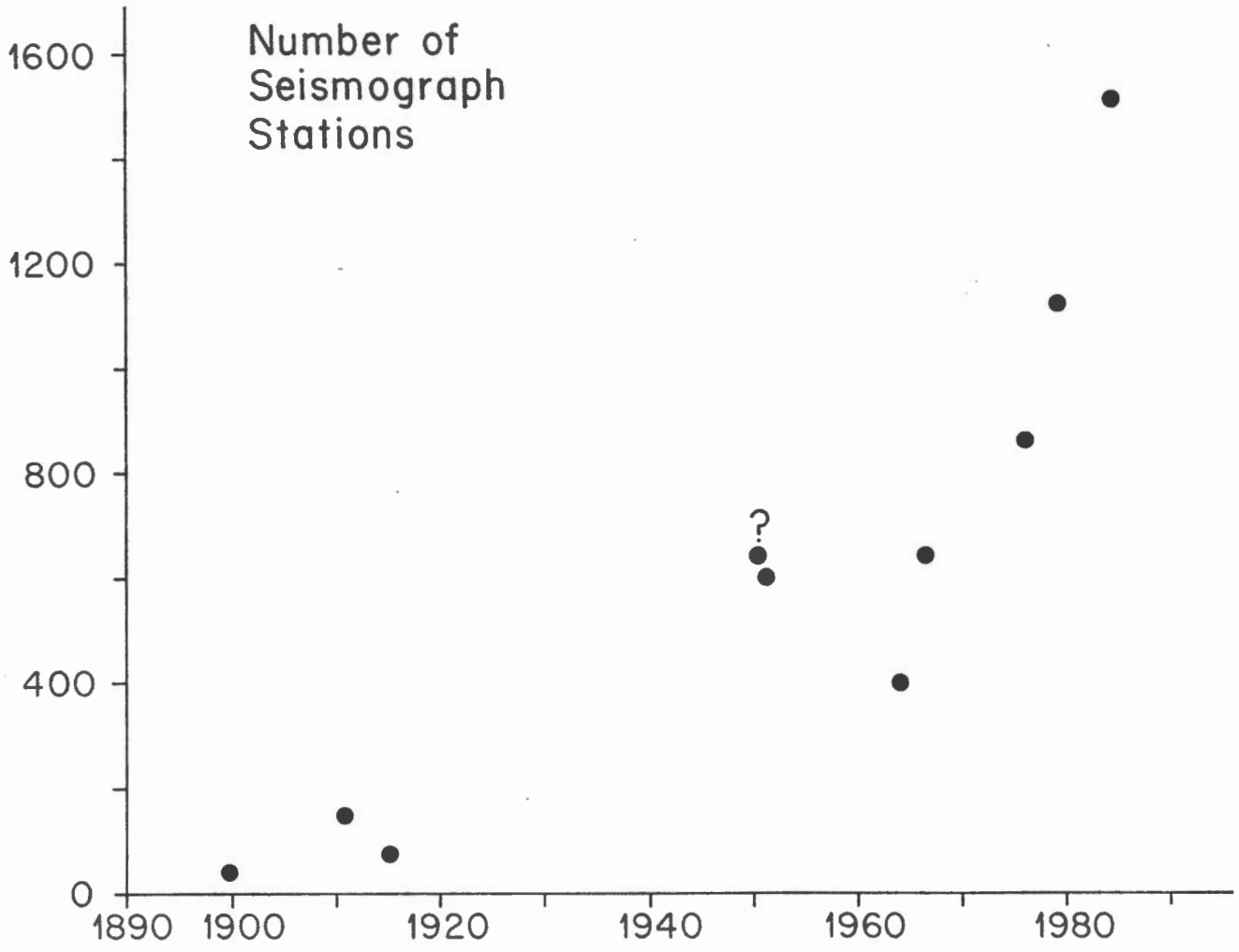
Number of
Seismograph
Stations
1600
1200
800
400
0
1890
1900
1920
1940
1960
1980
?

Fig. 1

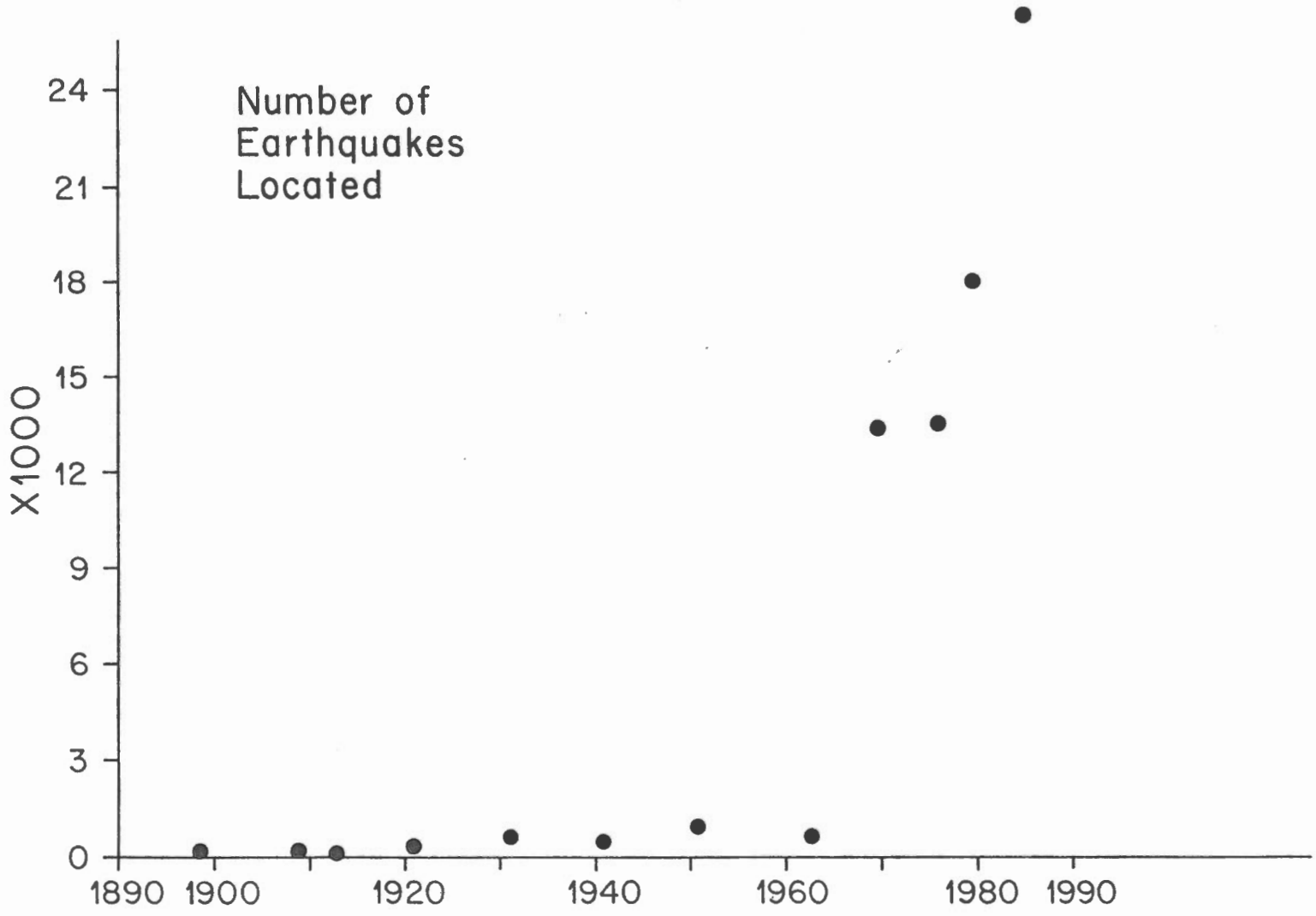
Number of
Earthquakes
Located
X1000
24
21
18
15
12
9
6
3
0
1890
1900
1920
1940
1960
1980
1990

Fig. 2

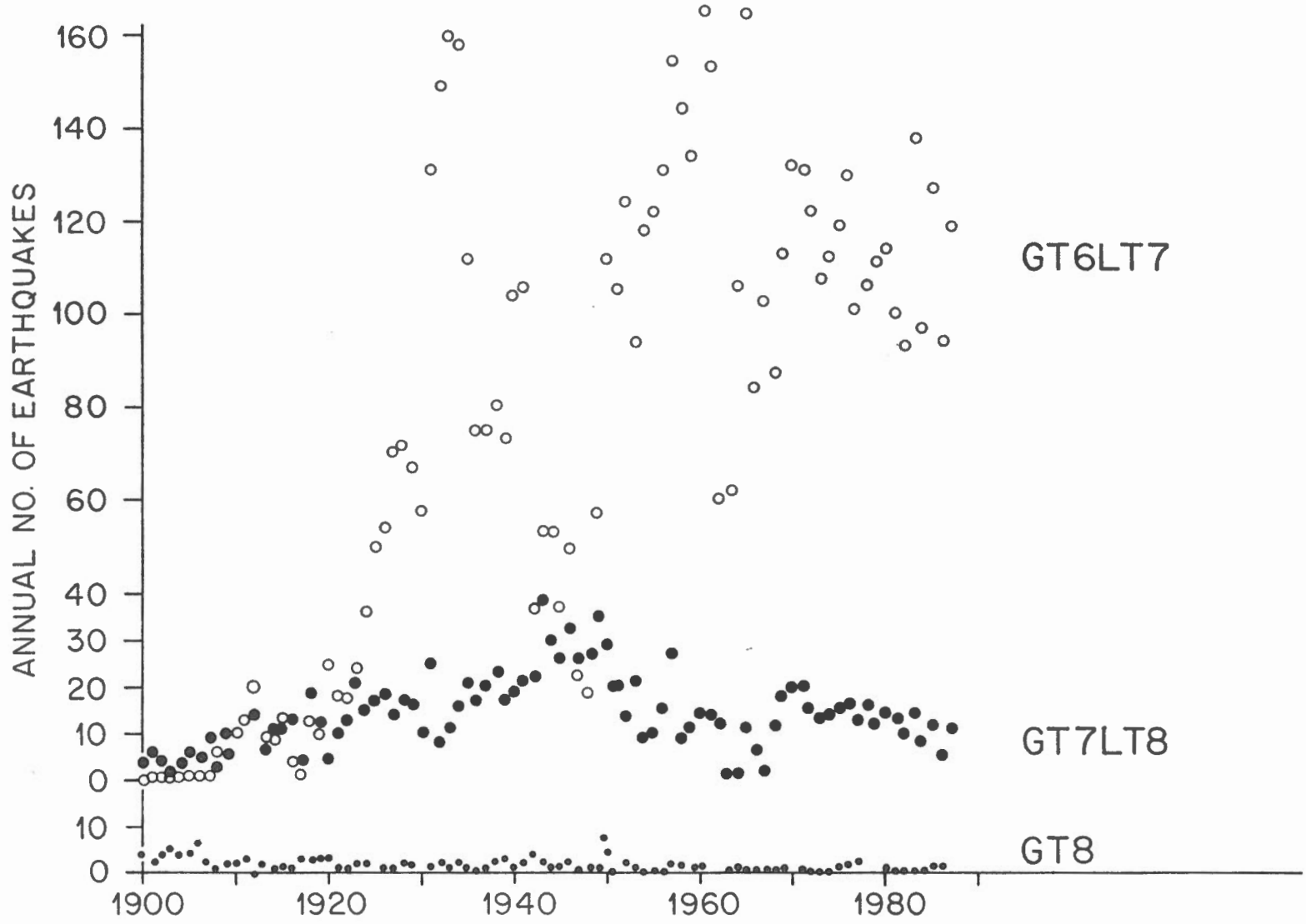
ANNUAL NO. OF EARTHQUAKES
160
140
120
100
80
60
40
30
20
10
0
10
0
1900
1920
1940
1960
1980
GT6LT7
GT7LT8
GT8

Fig. 3

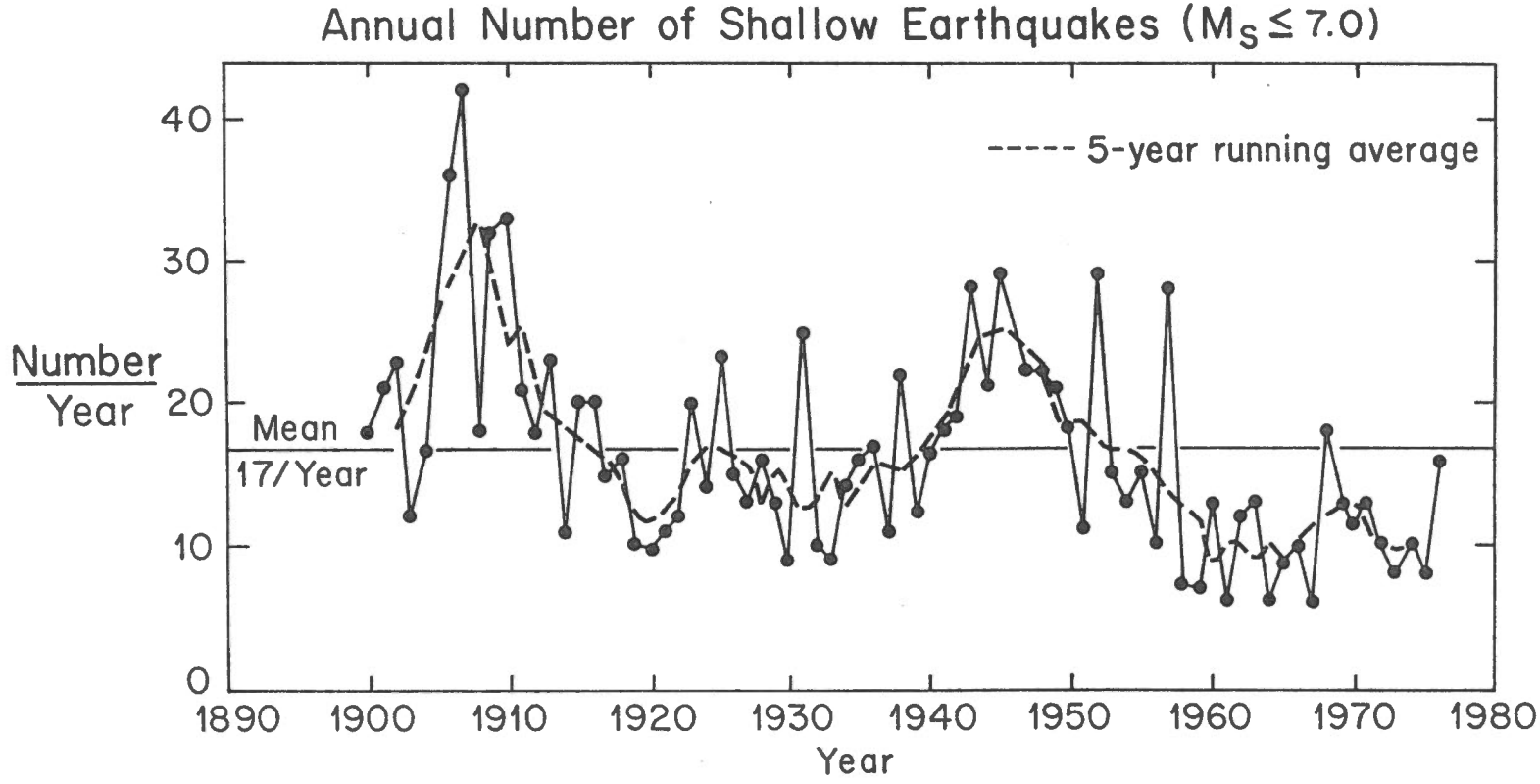
Annual Number of Shallow Earthquakes ($M_S \leq 7.0$)
----- 5-year running average
Number / Year
Mean
17/Year
0
10
20
30
40
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980
Year

Fig. 4

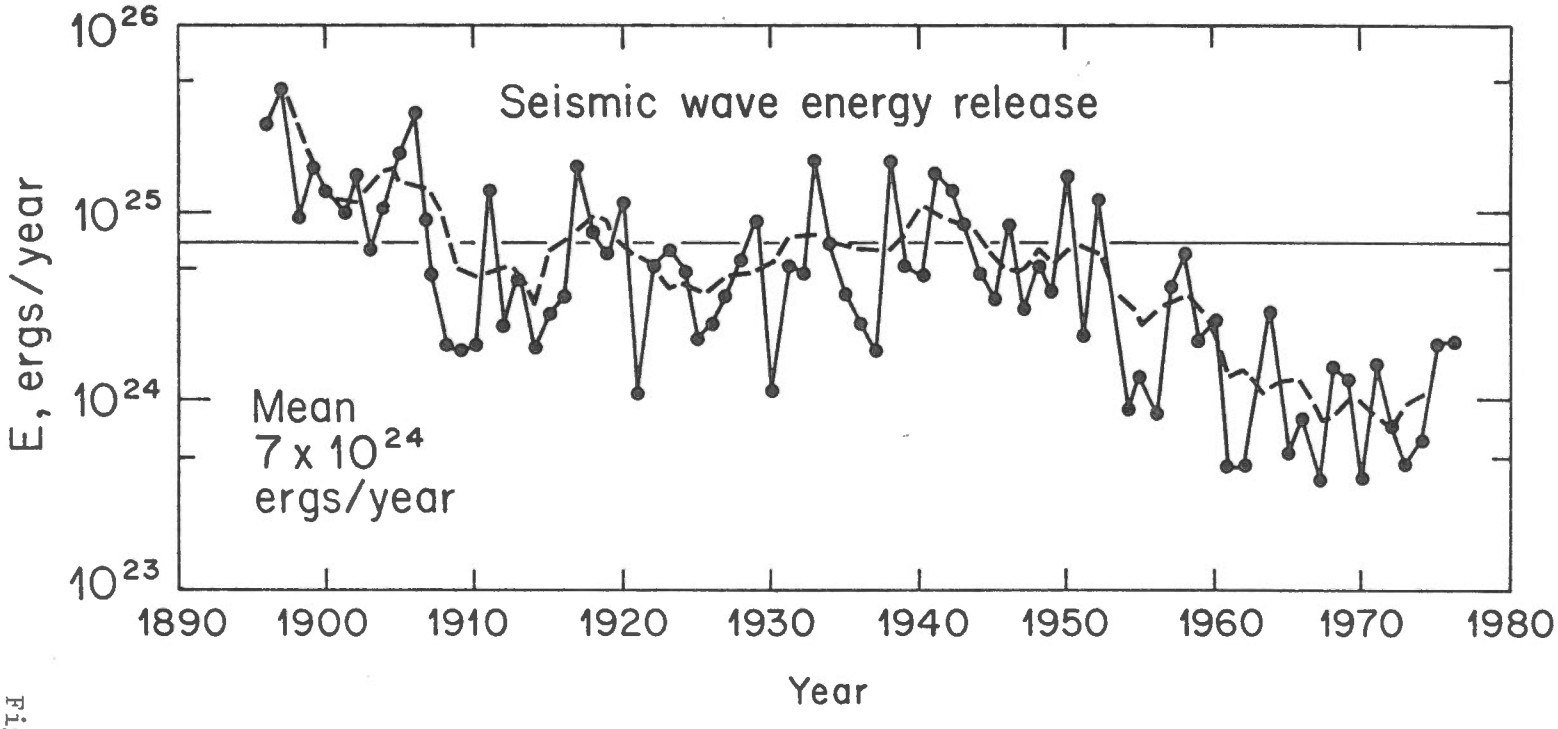
Seismic wave energy release
Mean
7 x 10^24
ergs/year
E, ergs/year
10^26
10^25
10^24
10^23
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980
Year

Fig. 5

Saint John The Telegraph-Journal Sat. Feb. 25, 1989

Professor sees new quake, bomb link

By SHAUN WATERS
Staff Writer

Last Friday Russian scientists triggered a nuclear bomb in Soviet Central Asia.

It was the size of the bomb dropped on Hiroshima in the Second World War and was meant to show observers what happens during an atomic explosion.

On Saturday, Dr. Gary Whiteford had a hunch. He phoned a Fredericton radio station and told them to watch the wires for news of an earthquake.

The next day a quake measuring 5.6 on the Richter Scale rumbled through Tokyo, Japan, killing one person.

That didn't surprise Whiteford. He just marked it down on a chart.

The grim coincidence between underground nuclear tests and earthquakes has become almost routine for the geography professor at the University of New Brunswick. The Toyko quake was the sixth coincidence since last August.

"I hate to cry wolf but I do get upset in a way," Whiteford said in an interview this week. "I phone some media now and they hang up on me or say 'give us something new or a different angle'. I don't know any other way to say it.".

Last fall Whiteford made headlines across North America with his theory that nuclear bomb tests are shaking the earth's crust and may be responsible for earthquakes that have killed millions. He has compiled coincidences going back almost half a century and is now working on a link to volcanic eruptions as well.

The United Nations has invited him to present his findings at a conference in April in Seattle, Wash.

He has just finished preliminary data on 6.0 earthquakes on the Richter Scale. That's the level where major damage starts and people panic. Whiteford calls them killer-quakes or mega-quakes.

He discovered that since 1950 when rigorous nuclear bomb testing began, there have been over 100 quakes that size every year except two.

One of the years where the number dropped below 100 was 1986 when the Soviet Union unilaterally stopped testing for a year. The lowest it ever went to was 78 and the highest ever was in 1956 when 214 6.0 quakes shook the earth.

That frequency compares dramatically to the pre-nuclear first half of the century. From 1900 to 1950 there were only eight years that recorded more than 100 6.0 quakes and one year dipped to as few as 17.

"If this trend continues into the next 10 years, we can obviously expect more deaths as more people encounter earthquakes," Whiteford said. "I feel like a straw in the wind. Nobody's listening and I think it's because it's not happening in our backyard."

Since starting his research Whiteford has become something of a fatalist.

The odds now for San Francisco rumbling apart are up to 20 per cent in the next 10 years and 50 per cent for a corner of Missouri.

"I think they are damn well blowing the planet apart and all I can say is 'don't be shocked or surprised' when a 6.0 quake happens near you," he said. "Maybe it's too simple. The same thing happened with continental drift. It was obvious the continents fit together but scientists had to look for a complex explanation."

For now, he'll plug away at trying to keep people alerted.

"It's my responsibility," he said. "I think these coincidences should be announced just like the weather forecasts.

"I wish they would stop testing for 10 years and then look back and see the evidence that something was going on."