Geoethics

Ethical Challenges and Case Studies in Earth Sciences

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Chapter 10

When Scientific Evidence is not Welcome…

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Abstract

This chapter concerns interactions in the 1980s between the technical community and the Reagan administration. Reports to the US Congress from the executive branch of government had stated that the Soviet Union was "in likely violation" of the bilateral Threshold Test Ban Treaty (TTBT), which had been negotiated between the USA and the USSR in 1974 and which imposed a limit of 150 kilotons for the explosive yield of any underground nuclear weapons test conducted by these two countries after March 1976.

The TTBT had led to the need for making estimates of explosive yield, and several methods came into use of which the most prominent was based on seismology. In the specialized work of estimating explosive yield from analysis of the strength of seismic signals, the expert community became convinced that it was inappropriate to claim that the Soviets were cheating on this arms control treaty.

In a revealing TV interview, Assistant Secretary of Defense Richard Perle stated with reference to the opinion of seismologists on the size of the largest Soviet tests, "It's not a question of scientific evidence. It's a question of scientists playing politics."

This chapter discusses Mr Perle's claim here, from a personal perspective: why I became involved; briefly, what was the scientific evidence; and, most importantly, to what degree was it true that scientists were playing politics? Mr. Perle stated, "I didn't much care what their answer was. It doesn't have any profound bearing on our policy."

To maintain a good professional reputation in the face of allegations of being biased because of a policy issue, an expert must be diligent to establish key facts and to defend them as bulwarks that may influence policy, with the potential to discredit policy makers who mischaracterize them. Seismological methods for measuring the size of the largest Soviet tests were endorsed by the results of two special nuclear explosions conducted in 1988 for which intrusive methods of monitoring were allowed.

The TTBT was eventually ratified in 1990 (by President G.H.W. Bush). Seismology continues to play a role in policy debates with reference to the much more important Comprehensive Test Ban Treaty of 1996.

1. This is Lamont-Doherty Earth Observatory Contribution number 7823.

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Policy issues that have a strong technical component, rooted in the geosciences, include responses to the prospect of climate change, national security decisions on dual use technologies,[2] and options for nuclear arms control where there is an underlying need for consensus on technical aspects of monitoring capability. This chapter describes the treatment of a specific arms control policy issue that arose in the Reagan Administration (1981–1989). The technical component was very simple. It boiled down to an understanding of the relationship between the energy released by an underground nuclear explosion (UNE) and the *P*-wave magnitude of the seismic signals generated by the explosion. And because of the forcefully expressed opinions of a person speaking for the Administration, we are able to see in this case, very clearly, an unwelcome reaction to a conclusion that was strongly held by the technical community, and also some of the consequences of how this particular technical issue played out in the policy arena.

In the 1980s, the US Congress required annual reports from the executive branch of government on the Union of Soviet Socialist Republics' compliance with arms control agreements. Some of these reports stated that the Soviet Union was "in likely violation" of the bilateral Threshold Test Ban Treaty (TTBT), which had been negotiated between the United States and the Union of Soviet Socialist Republics in 1974 and which imposed a limit of 150 kilotons (kt)[3] on the explosive yield of any underground[4] nuclear test explosion conducted by these two countries after March 1976.

Many methods of estimating nuclear explosive yield have been developed using remote observations—going back to the very first nuclear test explosion, of July 1945 (Trinity), in the atmosphere. Nuclear testing moved underground in later years and estimates of explosive yield began to be made using seismological methods. And then with the TTBT it became necessary to interpret yield estimates in the political context of assessing compliance with a formal arms control treaty.

The basic seismological observations were not seriously in dispute and were as follows: The largest underground explosions conducted by the United States at the Nevada Test Site (NTS), at yields that were reported by US agencies to be somewhat less than the 150 kt threshold, had seismic magnitudes of about

2. "Dual use" in this context means, military and civilian, for example, with reference to satellites.
3. In this context, a kiloton is an energy unit, originally taken as the energy released by exploding 1000 tons of TNT, but today the formal definition is 1 kiloton = a trillion calories (~4.2 trillion joules). So, 1 g (of TNT equivalent) is 1000 calories.
4. In 1963, the Limited Test Ban Treaty, sometimes called the Atmospheric Test Ban Treaty, had banned nuclear testing in the oceans, in the atmosphere, and in space. It did not ban nuclear testing underground.

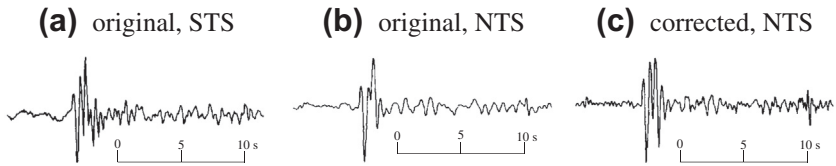

FIGURE 1 Here are three seismograms, showing about 15 s of the seismic signal at the station code named as EKA in Scotland, all with the same timescale. Seismograms are recordings of ground motion at a particular site as a function of time. In each case, the wave has traveled to EKA through the Earth's deep interior from an underground nuclear explosion several thousands of kilometers away. (a) is the signal at EKA, as originally recorded from an underground nuclear explosion at the Semipalatinsk Test Site (STS). (b) is the signal at EKA, as originally recorded from an underground nuclear explosion at the Nevada Test Site (NTS). (c) is a corrected version of (b), as described in the text. *Adapted from Douglas (1987).*[7]

5.6–5.7. The Soviet Union after March 1976 conducted its largest underground tests mostly at the Semipalatinsk Test Site in Kazakhstan, at magnitudes that steadily attained higher and higher values over a few years, and that by the early 1980s were up at around magnitude 6.1.[5] Since magnitude scales are logarithmic on a base of 10, this difference meant that the amplitude of signals recorded from the largest Soviet underground explosions were about $10^{0.4}$ or $10^{0.5}$ larger than the signals recorded from NTS. Since this factor is approximately 2.5–3, an assumption that the magnitude–yield relationship was the same for the Nevada and Semipalatinsk test sites led straightforwardly to estimates of the yield for the largest Soviet tests that were roughly three times greater than the largest tests in Nevada.[6]

But from the early 1970s to the mid-1980s, a growing body of evidence emerged from seismology that the magnitude–yield relationship was not the same for the two test sites. For example, there was the observation that for stations on shield regions, at distances of several thousands of kilometers from Nevada or Kazakhstan, the signals from Soviet explosions had significantly higher frequency content than those from US explosions. This feature is described in Figure 1, which shows three seismograms. The first signal, at a station in Eskdalemuir, Scotland, with code name EKA, is from an underground nuclear explosion on June 30, 1971, of magnitude 5.9, at the Semipalatinsk Test Site. The second signal, also recorded at EKA, is from an underground nuclear explosion in granite on June 2, 1966, of magnitude 5.6, at the Nevada Test Site.

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5. Several different magnitude scales are in use by different agencies, and typically they report slightly different values for the same seismic event, whether it is an earthquake or an explosion. The different values arise because of the use of slightly different measurement techniques and use of data from different seismographic networks.

6. If it were further concluded that the yields of deployed Soviet nuclear weapons were three times larger than had been estimated, then there would be consequences for an evaluation of the effectiveness of a Soviet first strike.

7. Douglas, A., Differences in upper mantle attenuation between the Nevada and Shagan River test sites: can the effects be seen in *P*-wave seismograms? Bull. Seismol. Soc. Am. 77, 270–276, 1987.

Although the two test sites are at comparable distances from the recording station in Scotland, these seismograms are significantly different. The first, with its signal from Kazakhstan, contains higher frequencies than the second, with its signal from Nevada. From this and a broad range of other evidence, it is concluded that beneath the test site from which the higher frequencies are not observed, there must lie an attenuating region.

Furthermore, we can quantify the amount of this attenuation by modeling the way in which the original seismograms differ across the whole spectrum of frequencies. When the high-frequency components are restored to make the attenuated signal (from Nevada) match the unattenuated one, the outcome is as shown in the third seismogram of Figure 1.

The amount of the correction needed to make the seismograms (a) and (c) in Figure 1 look similar turns out to have an effect on the amplitude of the signal in the band of frequencies where the magnitude is measured. In this case, it was found that the effect of attenuation beneath the Nevada Test Site had reduced the size of the signal (b) recorded at EKA by about 0.3 magnitude units.

Many studies of this type have been done, using sources and seismographic recording stations all over the world.[8] Several other lines of argument[9] have also pointed to the conclusion that Nevada signals were being attenuated more than was the case for signals from Semipalatinsk. When this extra attenuation was quantified, the Union of Soviet Socialist Republics, like the United States, appeared to be observing a yield limit, which was about 150 kt, in its underground nuclear testing program.

The first evidence for differences in attenuation began to emerge in the early 1970s.[10] The general subject of how to estimate yield by seismological means was vigorously pursued for 15 years, culminating, as we shall see, in 1988. Within the US research community, which was well funded from the 1960s to the 1980s by Department of Defense agencies seeking to improve monitoring capability, there developed a widening acceptance of the conclusion that teleseismic signals from sources in the tectonically active western United States (including NTS) were attenuated more than was the case for sources in stable continental regions such as northern Kazakhstan (including the Semipalatinsk Test Site).

I did not participate directly in this research but was well aware of it through contacts at Caltech (my grad school in the late 1960s) where my advisor was

8. For a detailed study of the method summarized in Figure 1, see Der, Z., McElfresh, T., Wagner,R., Burnetti, J., 1985. Spectral Characteristics of P waves from Nuclear Explosions and Yield Estimation. Bull. Seismol. Soc. Am., 75, 379–390. Also note some important errata, given in the same year at vol. 75, 1222–1223.

9. Another piece of evidence was the seismic magnitude of the 80-kt US nuclear test LONGSHOT conducted in the Aleutians, for which the magnitude was significantly greater than would be expected on the basis of magnitude-yield relations for a nuclear test in Nevada.

10. For example, Filson, J., Frasier, C.W., 1972. Multisite estimation of explosive source parameters, J. Geophys. Res. 77, 3303–3308.

Charles Archambeau, and at the Lamont-Doherty Earth Observatory of Columbia University (which has employed me since 1971) where I have followed the work of my colleague, Lynn Sykes (more on Archambeau and Sykes, below). From 1971 to 1984, my career followed a conventional academic track that had little to do with public policy issues, but then in 1984, I took a leave of absence for a year and became a visiting scholar at the US Arms Control and Disarmament Agency, specifically in a unit that participated in writing the President's annual Report to Congress on Soviet compliance with arms control treaties. For me, this was a fascinating opportunity to see professional worlds very different from my own—academia—and to see how they dealt with highly specialized technical issues, which in one or two cases I was encouraged to understand (most importantly, yield estimation using seismological methods). For the most part, I found a willingness to listen to technical arguments and to bring relevant information to bear on the subject at hand. But sometimes, there was hostility, and in making this point we can examine the openly expressed views of a senior policy maker, the Assistant Secretary of Defense for International Security Policy, Richard Perle. His views were televised on May 9, 1986, by KRON, the National Broadcasting Company affiliate in San Francisco, as part of its evening news broadcast in a segment prepared by KRON's "Target 4" unit, when Perle was interviewed by an experienced investigative reporter, Rollin Post.

Let me give excerpts from this interview, which is available on YouTube,[11] and which is (perhaps unfortunately) framed as "Perle versus the experts" who in this case include two seismologists from academia, Charles Archambeau and Lynn Sykes, and Willard (Jim) Hannon of Lawrence Livermore National Laboratory.

Introduction: *The Administration says, that the Soviets have tested weapons more powerful than agreed to in 1974. But have they? … Our investigative unit spent the last month looking into it. They found the Administration is ignoring evidence that the Soviets never cheated….*

Rollin Post: *What you are about to hear, now, is a story of political ideology and scientific truth, and what happens when the two come into conflict. It's also a story of Soviet-American tensions and nuclear weapons. The key players in this drama are an Assistant Secretary of Defense named Richard Perle, and a group of seismologists who have spent much of their careers working for the government.*

The issue; has Richard Perle, because of his distrust of the Soviets, deliberately rejected and suppressed evidence?…

[Cut to Perle: *Baloney. It's not a question of scientific evidence, it's a question of scientists playing politics!*]

11. The interview is available as an 8-min clip on YouTube, via http://www.youtube.com/watch?v=MfjG1hE0Qfg (or, search YouTube on Richard Perle + experts).

Post, voice over (with images of underground nuclear tests, and of Nixon and Brezhnev signing the bilateral TTBT): *The argument concerns scientific testing of nuclear weapons. In 1974, the United States and the Soviet Union agreed to a treaty that said each side could test nuclear weapons as long as the explosion didn't exceed a hundred and fifty kilotons….*

Perle: in a clip from the MacNeil-Lehrer Report /1986 March 24/ *I've looked carefully at the evidence, and have concluded, as President Reagan did, that there is significant evidence that the Soviets have violated the hundred and fifty kiloton threshold.*

Post: *This has been the position of the Administration since 1983, a position formed and spearheaded by Assistant Secretary of Defense Richard Perle. But it has also caused a rebellion among the very scientists that the Defense Department relies on to estimate the size of the Soviet tests.*

So deep has been the controversy that last year the Defense Department secretly convened three groups of experts who monitor Soviet tests. They are seismologists, the same people who measure the size of earthquakes.

Target 4 has interviewed three of those seismologists, and they all said the Soviet Union has not violated the 1974 test ban treaty.

One of them is Dr. Charles Archambeau, who has been monitoring the Soviets since the Eisenhower Administration.

[Cut to Archambeau: *At present, there is no evidence that the Soviets have tested over 150 kilotons—none whatsoever.*]

Another is Professor Lynn Sykes, who negotiated the test ban treaty for the Nixon Administration: *The treaty itself, it states, that…neither country shall test above 150 kilotons. And I have no evidence that indicates to me that the Soviets have done that.*

Post: *Dr. Willard Hannon heads seismic monitoring for the Lawrence Livermore National Laboratory*

[Cut to Jim Hannon: *I don't believe the evidence supports a militarily significant violation.*]

The man who ultimately receives this advice is Richard Perle. His position is far different.

Perle: *The best experts available, spent years studying this, and came to the conclusion that it was likely the Soviet have violated the 150 kilotons…*

Post: *There are seismologists…who have written, for instance, Dr. Charles Archambeau—I think you know…him—wrote "at present, there is no evidence the Soviet have tested over 150 kilotons, none whatsoever."*

Perle: *Well, with all due respect…he's wrong. There's lots of evidence. He may not be persuaded on the basis of the evidence, but to say there's no evidence is flatly wrong.*

Post: *Dr. Sykes, of Columbia, says that the Soviet Union has not violated a 150 kilotons limit of the threshold treaty as alleged. He's wrong?*

Perle: *He's entitled to his opinion. He's a professor sitting up at Columbia.*

Post: *But he is an authority on the issue, isn't he?*

Perle: *Well, all the seismology enables you to make an estimate of the yield of the event… Even by that standard alone, there is evidence that suggests the Soviets have violated it, your experts, notwithstanding.*

Post: *They were your experts at one time. They worked for the Defense Department.*

Perle: *There is other evidence, as well…of a sensitive and classified nature.*

Mr. Perle would only say, that the other evidence involves satellite and electronic surveillance…but Target 4's investigation learned that Mr. Perle had already convened a panel of experts which looked at this other evidence, and rejected it.

Post: *You had a Defense Intelligence Agency study, not very long ago, for precisely that, to evaluate seismic and non-seismic ways of determining what the Soviets are doing, and they still came up with the conclusion that seismology, was the most accurate way.*

Perle: *They came to the conclusion that…of the many ways of estimating yield, seismology was the single most important—and I happen to agree with that.*

Post: *Even after acknowledging seismology as the best indicator, Mr. Perle then rejects it.*

Perle: *I didn't much care what their answer was. It doesn't have any profound bearing on our policy.*

Post: *Target 4's also uncovered evidence that Mr. Perle improperly tried to manipulate intelligence agencies in a biassed direction. Example, a Perle letter to the Air Force when its intelligence unit asked seismologists to advise on Soviet tests. According to sources who have seen the letter, it said: "The intelligence community is trying to undermine the Administration's position. My Department will control this area." I asked Perle about the letter:*

There was a letter I understand, that you wrote on April the 15th, of last year, to General Fats who is the Air Force Assistant Chief of Staff, I think…

Perle: *I don't remember the exact words of the letter, but my concern, as I've expressed throughout this interview, which is that…we have tended—I think wrongly—to exclude the non-seismic evidence that bears on the estimation of the yield of Soviet tests.*

Post: *When you cut through these disagreements you find that the real issue may be more personal and political than scientific.*

Perle: *They're all seismologists! They're a bunch of seismologists feathering their own nests. Well, look, seismologists have dominated this field since the beginning, it's how they make their living. The day that it is concluded that we can get along without attributing the importance to seismology that we do, some of these fellows are going to be looking for jobs.*

Archambeau: *The scientific opinion is close, to, I'd say to unanimous. Right now Mr. Perle finds it extremely difficult to find any scientist that will defend the DOD/Perle position. And that's because, there just aren't any, that believe it.*

Sykes: *I think one view that is often put forth…is that arms control agreements are not in the best interest of the United States. That the Soviets will cheat. And then attempt to have a self-fulfilling prophecy, by coming up with a procedure, an incorrect one, that indicates to them that the Soviets have cheated.*

I am writing about this interview almost 30 years later, and still find it fascinating for the direct expression of views. The title of this chapter is "When scientific evidence is unwelcome…" and for the present example, we can be more complete: "When scientific evidence is unwelcome, shoot the messenger!" (In this case, the seismologist.)

The scientists see the technical issue as clear cut (especially Charles Archambeau, with his statement "… there is no evidence that the Soviets have tested over 150 kilotons—none whatsoever"), whereas in Mr. Perle's view: "It's not a question of scientific evidence, it's a question of scientists playing politics!"

In practice, policy makers must act in situations where knowledge is incomplete. But this is not an excuse to make up one's own reality. Was Mr Perle right, in saying that scientists were playing politics here?[12] To the extent that a scientist personally becomes convinced that a certain technical conclusion is correct and is being misrepresented, is there not an obligation—if the issue is important—to push harder? This, to me, is the central ethical issue. One must avoid the temptation to embarrass a policy maker who may not be aware of the strength of the evidence against his or her position, but surely there is a responsibility to stand up for technical conclusions if they are being misrepresented.

Though not the most important of arms control treaties, the TTBT received extensive attention in the late 1980s in part as a bargaining chip between the Reagan Administration and the US Congress, which had several members wanting to see the TTBT ratified and then to see progress on negotiating a Comprehensive Test Ban Treaty. The Reagan Administration agreed to submit the TTBT for Senate advice and consent to ratification, but then stunned senior Senators, after making that submission of the TTBT, by taking the position that even if the Senate voted its consent to ratification, the President would not ratify it, at least until its verification provisions were improved.

Most remarkably, with the appointment of Mikhail Gorbachev as General-Secretary in the Union of Soviet Socialist Republics, a breakthrough was achieved on the issue of TTBT verification, when a pair of "Joint Verification Experiments" (JVEs) were conducted in the summer of 1988 according to new protocols negotiated between the two superpowers in the preceding months. These experiments were a significant part of the opening up of the Soviet Union, and presumably would not have happened if there had not been challenges concerning TTBT compliance. One of the experiments was a special nuclear explosion carried out by the United States on the NTS, and the

12. In March 1987, he resigned from his position in the Department of Defense.

other was a reciprocal explosion by the Union of Soviet Socialist Republics on the Semipalatinsk Test Site. It was agreed ahead of time that these two explosions would be in the yield range between 100 and 150 kilotons and that each side could bring monitoring equipment right on to the other side's test site to monitor the host country's nuclear explosion close up. This agreement was remarkable in view of the decades of history of operations at the superpowers' nuclear test sites, some of the most highly protected and secretive installations in the world, where explosions larger than the totality of all World War II explosions were conducted, in part as an expression of Cold War competition.[13] Special equipment was installed for the two JVEs to measure the strength of each blast deep underground as a hydrodynamic shock wave,[14] using sensors in a vertical hole going down hundreds of meters, parallel to the shaft in which the nuclear device was emplaced. The monitoring system was thus deployed at distances going down to just a few tens of meters away from the exploding device.

From such near-in underground measurements, and an analysis to estimate the volumetric extent of the hydrodynamic shock wave, this nonseismic method applied to the JVE at Semipalatinsk on September 14, 1988, provided a yield estimate deemed accurate and that was indeed in the range 100–150 kt. Stations around the world provided measurements teleseismically, giving a seismic magnitude of 6.1 and thus comparable to the largest magnitudes of Semipalatinsk explosions since 1976, indicating that they too had been conducted in a way that respected the 150 kt limit of the TTBT. The reciprocal JVE had been conducted earlier at the NTS, on August 17, 1988, with a Russian team making its own close-in measurements of the shock wave from a large US underground nuclear test that was intended to be in the range 100–150 kt. (According to many news reports, the yield of this explosion somewhat exceeded 150 kt. Timerbaev[15] and news reports have given it as 180 kt.)

The TTBT eventually received the Senate's advice and consent in 1990, and it was ratified by President George H. W. Bush. The momentum/progress on that treaty may well have helped in the complicated process of reaching an agreement 6 years later on the text of the Comprehensive Nuclear Test Ban Treaty, finalized in 1996, about 40 years after such a ban first began to be discussed in the 1950s.

The JVEs of 1988 were a massive experiment[16] that enabled TTBT ratification and thus entry-into-force and that proved what seismologists had long

13. See, e.g., "A Review of Nuclear Testing by the Soviet Union at Novaya Zemlya, 1955–1990" by Khalturin, V.I., Rautian, T.G., Richards, P.G., Leith, W.S., 2005. Sci. Global Sec. 13, 1–42. More than 200 megatons of nuclear explosive energy was released in 130 tests at this site.
14. At the shot point of an underground nuclear explosion, rock is vaporized and a hydrodynamic shock spreads out, eventually slowing to become a linear elastic *P*-wave. The volume of rock within which the shock travels faster than the *P*-wave, is proportional to the explosion yield.
15. See http://www.pircenter.org/kosdata/page_doc/p1650_1.pdf.
16. The cost of the US share was about $28 million.

worked to demonstrate, namely, that for UNEs of around 150 kt at the Semipalatinsk Test Site the resulting seismic signals were about 0.4 magnitude larger than those from UNEs of around the same yield at the NTS.

In part, I suspect that the hostility shown by some members of the Reagan Administration to the TTBT, and, in a different way, to seismologists, was a reflection of their policy views on the much more important Comprehensive Test Ban Treaty. From this perspective, agreeing to TTBT was indeed a slippery slope that led to a CTBT.

Coming back to the issues raised by Rollin Post in his interview with Richard Perle: what can an expert do, to maintain a good professional reputation in the face of allegations of being biased because of a policy issue? Mainly, my advice is to be diligent to establish key facts, and to defend them if attacked. But do not become vulnerable by making a technical mistake, and do not become embittered over time if your views are not accepted. Just keep on pushing, if you are sure you are right.

Every person has to make his or her own choice as to the level of activism in pushing a point of view, and here I suppose that Mr Perle could have been right, in a limited sense, in saying this a question of scientists playing politics. I worked for years on technical issues surrounding the TTBT, and felt the need to get out the story that technical arguments were being treated in some quarters with contempt. So I was very glad to have had an opportunity to work with the people who prepared Rollin Post (whom I never met—nor have I met Mr Perle). Rollin Post certainly elicited some remarkable statements from Mr Perle.[17]

In my opinion, it does not work very well to claim that certain policy makers are behaving unethically. More important, is to monitor the behavior and the activities of the person for whom one most directly has responsibility, namely, oneself; and to stand up for the views of the expert community especially when it appears that those views are disparaged.

So then, was it ethical to set up Mr Perle by working with a very competent TV interviewer? I had heard secondhand of Mr Perle's views from several people, and it seemed important to bring these views out for a wider audience.

I am comfortable with having worked to place his opinions on the record.

17. "I didn't much care what their answer was. It doesn't have any profound bearing on our policy."…"They're all seismologists! They're a bunch of seismologists feathering their own nests. Well, look, seismologists have dominated this field since the beginning, it's how they make their living. The day that it is concluded that we can get along without attributing the importance to seismology that we do, some of these fellows are going to be looking for jobs."