F.A.S. *PUBLIC INTEREST REPORT*

Journal of the Federation of American Scientists (FAS)

Volume 50, Number 6 November/December 1997

Anatomy of a False Alarm: Silence Follows Hyped Leaks

Government leaks of alarming, semi-digested and inaccurate intelligence information have occurred regularly over the last half-century. Somehow the subsequent report of a false alarm never gets the same press attention.

This process has survived the Cold War, and now threatens to disrupt the peace building process, as shown by this brilliant review of the Russian nuclear-test-that-never-was by the distinguished geologist Lynn R. Sykes of Columbia University. Because very small earthquakes can now be picked up by seismic arrays designed to monitor the negotiated but unratified Comprehensive Test Ban Treaty, small earthquakes near nuclear test sites will sometimes be mis-identified as tests. And because weapons laboratory activity at the test site can arise from (unprohibited) subcritical tests, it is only too easy in cases of coincidence to put 2 and 2 together to get something that is not foursquare. Hopefully this incident will help, rather than hurt, the upcoming ratification of the nuclear test ban by revealing how sensitive are the instruments of its verification, and by inoculating the body politic against future misapprehensions.

Small Earthquake Near Russian Test Site Leads to U.S. Charges of Cheating on Comprehensive Nuclear Test Ban Treaty

By Lynn R. Sykes

On August 28 the *Washington Times* carried a lead story "Russia suspected of nuclear testing." It was followed up the next day by the *Washington Post* and the *New York Times*, the latter with the headline "U.S. Suspects Russia set off Nuclear Test." In the body of those and other press reports, however, the nature of event on August 16--whether it was a nuclear explosion or an earthquake at or near the Russian Arctic nuclear test site at Novaya Zemlya--was expressed as being still in doubt. Nevertheless, remarks quoted in the press like "this one certainly had characteristics that at least would lead some to believe that there had been an explosion that caused the event" emphasized the likelihood of a clandestine nuclear explosion. Officials in Moscow were quoted as strongly denying having tested a nuclear weapon. They maintained that the event was a small earthquake in the Arctic Ocean to the east of Novaya Zemlya.

This is the first allegation by U.S. officials of cheating by Russia (or of any other country) since the Comprehensive Test Ban Treaty (CTBT) was adopted overwhelmingly by the UN General Assembly more than a year ago. Soon thereafter, the treaty was signed by all of the acknowledged nuclear weapon states--China, France, Great Britain, Russia, and the United States. It now has been signed by 146 countries. The widely publicized allegation comes at a very sensitive

Lynn R. Sykes is Higgins Professor of Earth and Environmental Sciences at the Lamont-Doherty Earth Observatory of Columbia University Palisades NY 10964. He has worked on and written about verification of nuclear testing for more than 30 years.

moment as President Clinton stated at the UN on September 22 that his administration would submit the CTBT to the Senate. Passage by the Senate is problematic since a 2/3 positive vote is need for U.S. ratification of the Treaty. The accusation of Russian cheating may well be the beginning of an acrimonious debate over the CTBT. The August event is likely to play a key role in debate about the verifiability of the Treaty.

The story in the *Washington Times* appeared 12 days after the event of August 16 and just as the Labor Day holidays were commencing. Since then, however, a strong consensus has developed among experts in the seismological communities in the U.S., the U.K., Norway and Canada who are concerned with nuclear verification that the event of the 16th was, in fact, a small earthquake. It was located in the Kara Sea section of the Arctic Ocean to the east of the two main islands of Novaya Zemlya and more than 100 km to the southeast of the Russian test site itself. Recent analyses of its seismic waves indicate that the event had the characteristics of an earthquake, not those of an explosion. This was evident once they were compared carefully against seismic records from known Russian nuclear explosions at the Novaya Zemlya test site that were conducted before Russia declared a moratorium on nuclear testing in 1990 and with those of an nearby earthquake in 1986. Nevertheless, more than a month after the latest event several top U.S. policy makers either were not aware of this scientific consensus or maintained that the nature of the event remained ambiguous.

This is the 4th of 5 small earthquakes near Novaya Zemlya since 1986 that has been cited by the U.S. Defense Department (DoD) as being of either suspicious or problematic origin in terms of nuclear verification. In each of those cases, intense special studies revealed that each was a small earthquake. Those conclusions, not being as sensational as the accusations, were neither carried by the press nor in the press reports on the 1997 event.

Visit the FAS website for further information about all FAS activities and projects.

http://www.fas.org/

The *FAS Public Interest Report* (USPS 188-100) is published bimonthly at 307 Mass. Ave., NE, Washington, D.C. 20002. Annual subscription $25/year.

Periodicals Postage Paid at Washington, D.C.

POSTMASTER: Send address changes to FAS, Public Interest Rep., 307 Massachusetts Avenue, NE, Washington, D.C. 20002.

The Federation of American Scientists (FAS), founded October 31, 1945 as the Federation of Atomic Scientists by Manhattan Project scientists, engages in research and advocacy on science- and-society issues, especially global security.

Current war and peace issues range from nuclear war to ethnic conflict and from nuclear disarmament to arms sales; sustainable development issues include disease surveillance, climate modification, poverty, food security and environment. FAS also works on human rights of scientists and on reductions in secrecy.

This article summarizes the scientific evidence bearing upon the nature of the 1997 event, attempts to decipher who in the U.S. Government knew what and when about the event, and analyzes how key Government agencies may have arrived at the erroneous conclusion that the Russians either did or may have cheated. It urges more careful U.S. analysis before accusations are prematurely leaked to the press and recommends several confidence building measures that would provide yet greater assurance of compliance (or lack thereof) with the Test Ban Treaty.

A few key people within the government were responsible for leaking misleading and outdated information to the press about the event. Data provided by the International Monitoring System for the CTBT as well as those from other unclassified seismic stations in several countries that are not formally a part of treaty monitoring provided enough information to make a clear judgment that the small event of August 16 was, in fact, an earthquake and not a clandestine nuclear explosion. The successful identification of five small events on and near Novaya Zemlya as earthquakes demonstrates the effectiveness of verification technologies. This conclusion still needs to be conveyed to U.S. policy makers, many of whom lack the resources to arrive at or obtain independent judgments about scientific and technical data related to verification of the CTBT. Once allegations of clandestine nuclear testing were passed up governmental chains of command, it became difficult later for high officials to state that the allegations were false.

International Monitoring System for the Test Ban Treaty

The International Monitoring System (IMS), the International Data Center (IDC) and the U. S. National Data Center played key roles in recording and analyzing data from the August 16 event. The present status of each is described as background before the event itself is discussed.

Verification was a major item of debate during the negotiations for the nuclear test ban treaty in Geneva in 1995 and 1996. The 1963 Limited Test Ban Treaty (LTBT) put an end to nuclear tests in the atmosphere, space and underwater by each of the signatories but it did not prohibit underground testing. France and China, who did not sign the LTBT, did test in the atmosphere after 1963 but each eventually decided to conduct their nuclear tests solely underground as well. The CTBT prohibits nuclear explosions of any size, i.e. any nuclear yield, in all environments. The United States wisely insisted in the negotiations that several networks of sensors be installed around the world to ensure that a clandestine nuclear explosion in any environment would be detected and identified quickly. The treaty adopted by the UN incorporates U.S. proposals for global networks with four types of sensors: seismological, underwater sound (hydroacoustic), infrasound, and radionuclide.

The CTBT Treaty and its verification protocol set up and specify an International Monitoring System, communication networks, an International Data Center, confidence-building measures, institutional arrangements for consultation and clarification, and procedures for requesting and carrying out on-site inspections of events thought by one or more parties to be either clandestine nuclear explosions or events of ambiguous origin.

The seismological portion of the IMS grew out of three experiments in data exchange arranged by the Group of Scientific Experts (GSE) of the UN's Committee on Disarmament. The final technical test of the IMS known as GSETT3 (Group of Scientific Experts Technical Test 3) has been in continous operation since January 1, 1995. Once the CTBT enters into force the seismic portion of the IMS is specified to consist of 50 primary stations distributed globally (Figure 1) and 120 auxiliary stations (Figure 2). There are 40 primary and 81 auxiliary stations now operating; 2 additional primary and 8 auxiliary stations are scheduled to be operational by the end of 1997. Most of the primary stations consist of arrays

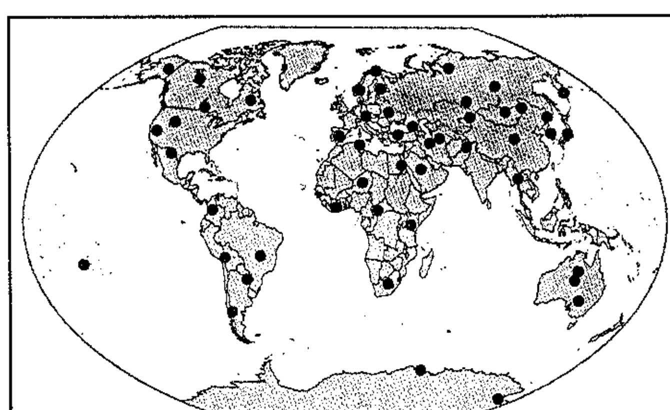

Figure 1 *Primary seismic stations of the International Monitoring System for the Comprehensive Test Ban Treaty.*

of seismometers designed to increase the signal-to-noise ratio. Primary and auxiliary stations must meet requirements for low levels of earth noise and for reliability as established by the GSE.

A continuous flow of seismic data in digital form from the primary stations is transmitted in near real time to the International Data Center, which is now located in Arlington Virginia but soon will be moved to a permanent site in Vienna, Austria. Seismic arrivals are identified by computer, are associated with specific events and then a preliminary location and size of each event are determined. Once an event is identified, auxiliary stations are interrogated automatically, their data for that event are retrieved and are then incorporated into improved estimates of location, origin time and size--typically within a few hours. Data for each event are then reviewed by seismologists at the IDC for accuracy and consistency; a reviewed event bulletin (REB) is produced in about 2 days.

The REB, the final product of the IDC, contains estimates of locations, origin times and sizes (seismic magnitudes) for each identified event as well as parameters for each station that recorded it such as arrival times of seismic waves and their amplitudes. The REB is accessible over the world-wide web and is available to national data centers for their use in assessing compliance with the CTBT.

During the CTBT negotiations the United States and some other countries insisted that the IDC should *not* issue statements about the nature of detected events, i.e. whether they were earthquakes, small chemical explosions or nuclear explosions. That concept was incorporated in the treaty and its verification protocol. Thus, the IDC assembles and distributes data but is not permitted to make a judgment or a statement about the nature of events like that of August 16. Judgments of that type are reserved to individual governments.

U.S. National Data Center

The Air Force Technical Applications Center (AFTAC) operates the U.S. national data center for the CTBT. Soon after the U.S.S.R. detonated its first nuclear explosion in 1949, AFTAC was assigned the task of operating a secret network of sensors of a variety of types that were installed in various countries. The system is called the Atomic Energy Detection System (AEDS). Its products and assessments of seismic events as being nuclear explosions or earthquakes have been and remain classified. AFTAC combines the data flow from the IMS with those from its classified stations. It also obtains other seismic data though bilateral agreements. Several of the former AEDS stations in other countries now provide unclassified data to the IMS.

Under the Treaty, the United States (and other countries) also are permitted to utilize their own so-called National Technical Means. These include satellite imagery, sensors on satellites to detect nuclear explosions in the atmosphere and space, and other intelligence methods.

Evidence that Event of August 16 was an Earthquake

Location of Event at Sea The international network of seismic stations to monitor the CTBT in northern Europe and adjacent oceanic areas is complete and has been in operation for several years. Figure 3 shows IMS and other seismic stations relevant to this discussion in the area surrounding the Russian test site on Novaya Zemlya. Stations consisting of multiple sensors, i.e. arrays, are indicated by solid triangles. A large and sensitive seismic array in southern Norway called Norsar has operated since 1970. Funds for its operation and research on its data have come from the Norwegian government and the U.S. Department of Defense. DoD later provided funds for additional seismic arrays in northern and southern Norway (ARCESS and NORESS), Finland (FINESS), Spitsbergen (SPITS) and Germany (GERESS). Sweden has operated a small but very sensitive array at Hagfors (HFS) for several decades. The Russian stations APA and NRI are part of the IMS.

The event of August 16 was recorded by the various IMS stations in Figure 1 with the exception of ARCESS, which was being repaired following a power surge. Fortunately, the seismic coverage in the area has some redundancy. The Finnish station KEVO near ARCESS recorded the event, as it had previous nuclear explosions at the Novaya Zemlya test site. Its data are important for the identification of the 1997 event as an earthquake. KEVO is not one of the designated IMS stations. Its recording of that and previous events points out the great value of drawing upon data from supplementary stations like it when a

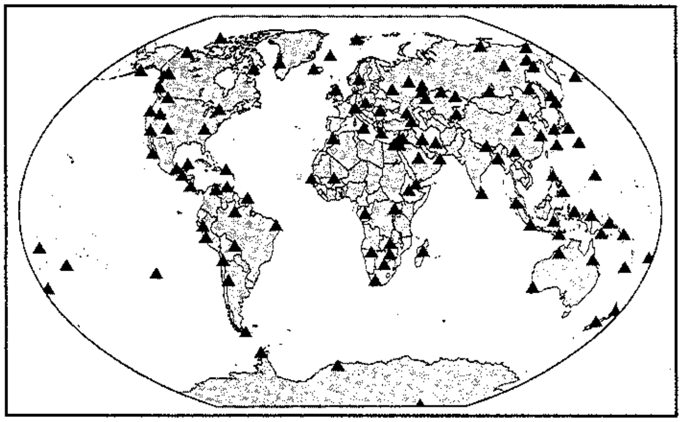

Figure 2 *Auxiliary seismic stations of the International Monitoring System.*

"problem event" arises. SOD also recorded the 1997 event and some earlier nuclear explosions. Likewise, a new small seismic array at Amderma, which also is not part of the IMS, should provide key additional data for events near Novaya Zemlya as it did for a small earthquake in 1995. Norwegian and Russian seismologists have worked out an arrangement for exchanging data, such as those from Amderma, APA and stations in Scandinavia.

Locations obtained by the IDC and by the Norwegian seismological center Norsar place the August 16 event more than 100 km (62 miles) southeast of the underground nuclear test site at Novaya Zemlya. The IDC location is shown in Figure 4. On September 15 the Associated Press reported results of a classified study by AFTAC of September 4 about the event. It quotes a Pentagon spokesperson ``It is a seismic event approximately 130 kilometers (81 miles) southeast of the test sites [sic] and is located offshore.'' Thus, the three agencies each places the event at sea and well to the southeast of the test site.

On August 21 Dr. Frode Ringdal, the Director of Norsar and probably the world's foremost expert on small seismic events in and near Novaya Zemlya, sent a long fax message about the event of August 16 to Dr. Ralph Alewine, Director of the Pentagon's Nuclear Treaty Programs Office within the Office of the Secretary of Defense. Alewine was the only scientist quoted by name in the initial article in the *Washington Times*. That fax, which was distributed widely, contains the received date and time stamped on all pages. Ringdal states "Thus the event appears to be quite confidently located offshore and at least 100 km from the test site." This and other information in the fax, including copies of seismograms, were available in Alewine's office a week before the article appeared in the *Washington Times*, which quotes him by name.

Size of 1997 Event The *Washington Post* for August 29 gives the seismic magnitude of the event as 3.8. Quoting Pentagon officials, the *Washington Times* on the 28th states "initial data on the event produced 'high confidence' that the activity detected was a nuclear test equivalent to between 100 tons and 1,000 tons of TNT. The relatively small size would be consistent with tests used to determine the reliability of a nuclear weapon . . .such as a scaled-down test of a warhead primer." The Reviewed Event Bulletin of the IDC gives a seismic magnitude, mb, of 3.9, obtained by averaging readings from two stations. Magnitude is proportional to the log of the amplitude of seismic waves.

The IDC, which is a source of data to national data centers, however, does not make corrections for what is commonly known in seismology as "station bias." It only reports uncorrected magnitudes. Ringdal recognized about 15 years ago that magnitudes calculated for small events often were systematically too high. For large events some seismic stations, such as many of those in Scandinavia, consistently record seismic amplitudes much larger than the average obtained from a very large number of stations. As the size of an event decreases, usually only those few stations with higher than average amplitudes record the event and, hence, report a magnitude. For example, the Norsar array typically recorded amplitudes about 3 times larger than the average and the Hagfors array 10 times larger for nuclear explosions at the former test site of the U.S.S.R. in eastern Kazakhstan. Those biases resulted in magnitudes that were 0.5 and 1.0 times larger than the average. The yields of those explosions would have been vastly overestimated if they were based on uncorrected magnitudes at those two stations. The phenomenon of magnitude bias is widely recognized and is corrected for by AFTAC and many others who attempt to make unbiased estimates of the size of small events.

Large amplitudes of this type resulted from low attenuation (efficient propagation) of seismic waves along paths from eastern Kazakhstan to Scandinavia. For those paths the crust and upper mantle of the earth near both source and receiver are geologically very old, which results in very efficient transmission of seismic waves. The same is true for paths from

Novaya Zemlya to Scandinavia. The 1997 event occurred close to the 1986 earthquake (Figure 4) for which Marshall et al. used station corrections to obtain mb = 4.26. I used ratios of the seismic amplitudes for the 1986 and 1997 events at three Scandinavian stations to obtain mb = 3.25 for the 1997 event. Thus, it was about a factor of 10 smaller in amplitude than the 1986 earthquake.

Using that corrected magnitude and assuming (incorrectly) that the 1997 event was an underground nuclear explosion at Novaya Zemlya, the calculated yield drops to about 50 tons (0.05 kilotons), much smaller than the 100 to 1000 tons reported by the *Washington Times*. The smaller apparent yield is significant since it is well below the minimum yields needed to reliable test a boosted fission primary for a nuclear weapon.

If the event had been a nuclear explosion in the water, its yield would have been smaller, about 10 tons since explosions in water couple very efficiently into seismic waves. While tiny by the standards of nuclear weapons, such a yield is much larger than that of chemical explosions set off at sea for seismic exploration for petroleum.

Identification of Event from Seismic Waves The *Washington Times* quotes Alewine "We do have information that a seismic event with explosive characteristics occurred in the vicinity of the Russian nuclear test range at Novaya Zemlya on August 16." The article goes on to state "The Pentagon official explained that the explosive characteristics were based on seismic signals that created 'very sharp' waves on detection equipment. Waves associated with an earthquake 'do not appear quite so suddenly'." The last quote is misleading and represents poor seismological practice in seismic identification. Identification, often called discrimination, has been the prime topic of research in nuclear verification for almost 40 years. An experienced analyst does not simple look at a seismogram and pronounce that it is explosion-like, especially at the regional distances of many of the stations that recorded the event of August 16. Various seismic waves are characterized by "very sharp" signals when they are sampled near maxima in the radiation patterns of earthquakes.

Identification is performed best by comparing seismograms at a given station for a new event with those of known previous nearby explosions and earthquakes. The earthquake source differs appreciably from that of an explosion in that the former involves shearing motion along a fault. Consequently, earthquakes typically generate larger shear (S) waves than explosions when the two sources are normalized by the size of the compressional first-arriving (P) waves.

The array station ARCESS in northern Norway (Figure 3) has one of the best signal-to-noise ratios for events on and near Novaya Zemlya. It was also placed in operation early enough to record nuclear explosions at Novaya Zemlya in 1988 and 1990. Ringdal compared the ratio of S/P waves at that array for two explosions and three more recent small events. The latter have consistently larger ratios than the nuclear explosions, in accord with those three events being earthquakes. Two of those three events were located more than 200 km north of the test site (Figure 4).

Since ARCESS was not operating on August 16, the nearby station KEVO can be examined in the same way. In his fax to Alewine, Ringdal compares the record at KEVO for the 1997 event with those from three previous nuclear explosions at Novaya Zemlya. The event of 1997 also exhibits a higher S/P ratio than the nuclear explosions, again being indicative of its being an earthquake. British seismologists obtained a similar result for KEVO and for another station in Finland. My colleagues Richards and Kim of Columbia performed a quantitative analysis of the S/P ratio as a function of frequency at KEVO. That ratio for the 1997 event is significantly higher than that for three nuclear explosions at Novaya Zemlya. Their result is in excellent accord with recently published work by them using the same methodology wherein they found good separation between those ratios for explosions and earthquakes elsewhere. Thus, careful analyses of seismograms indicate that the event of August 16 was an earthquake at a high level of confidence.

One misleading quote in the *Washington Times* states "monitoring equipment also indicated the depth of the suspected test was zero -- which does not fit with an underwater earthquake." Since data from stations very close to the event were not available, the depth was arbitrarily fixed at zero, not calculated, a common practice for small shallow earthquakes with a similar distribution of recording stations. The data likely would be consistent with an event anywhere in the outer 30 km of the earth. Thus, the depth used does not permit identification as either an explosion or earthquake. For larger shallow events depth can be calculated more accurately. A careful comparison of the seismic waveforms of the nearby events of 1986 and 1997 may permit the depth of the 1997 event to be ascertained.

Why did Some Responsible U.S. Officials Conclude that the 1997 Event was a Nuclear Explosion?

The *Washington Times* stated that satellite photographs of the Russian test facility prior to August 16 indicated the movement of trucks and other activities that in the past were seen prior to nuclear test explosions. The *Washington Post* of August 29 remarks that intelligence satellite data indicated that Russian scientists had been unusually active at the test site in the preceding few months. It states further "Technicians there have been flying around in helicopters, lowering equipment, plugging test holes and stringing cables for diagnostic equipment, according to several sources. Victor Mikhailov, Russia's minister of atomic energy, visited the site several weeks ago. Russian officials have explained that they are conducting or preparing to conduct 'sub-critical' nuclear tests, in which chemical explosions are used to blow apart fissile material but no nuclear chain reaction occurs."

The United States conducted two sub-critical nuclear test underground at the Nevada Test Site (NTS) in 1997. Plutonium is involved in those experiments as is the firing of the chemical explosives in a nuclear weapon. Probably similar equipment to that used for secure transport of fissile materials and for monitoring past nuclear tests also is used by both the U.S. and Russia for sub-critical tests. Such tests are not prohibited by the CTBT even though some argue that they violate the spirit of the Treaty. Ironically, a small earthquake, somewhat larger than the August 16 event, occurred at NTS as the U.S. was preparing to conduct its second sub-critical test.

These press reports indicate that intelligence data as well as seismic observations were involved in the accusations of Russian clandestine nuclear testing. While much information remains classified, the following scenario of U.S. response to the event of August 16 can be reconstructed from press reports and unclassified data. The Russians were preparing to conduct a sub-critical test (or may have already completed such a test) when a small earthquake occurred off the coast of Novaya Zemlya. Some official(s) in the Defense Department and perhaps in the intelligence community jumped to the conclusion that the earthquake was a nuclear explosion.

The story then was leaked to the *Washington Times* and published 12 days after the event. By that time, however, the fax from Ringdal in Norway had already been in Alewine's office a week, indicating the event was more than 100 km from the test site. Also, the seismograms in his fax for the station KEVO indicated that the event had the characteristics of an earthquake and not those of an explosion. Nevertheless, Alewine and others furnished information to the *Washington Times* that was out of date by at least a week and was misleading and deceptive.

The AP story on the classified AFTAC report of September 4 "indicates the tremor was probably a natural earthquake." Sometime in early September an aftershock was identified that occurred 4 hours after the August 16 event. Nevertheless, as of September 22, when President Clinton spoke at the UN, high U.S. officials still claimed that the event may have been either an explosion or an earthquake.

As the reality of an offshore location became evident, however, some invoked a number of old and discredited evasion scenarios including either conducting a small nuclear explosion at the test site immediately after the earthquake or detonating two small nuclear devices (one at the time of mainshock and another at that of the aftershock). In the latter scenario the Russians are assumed to have emplaced the two nuclear weapons sometime earlier in holes drilled into the seafloor.

In a follow-up story on August 30, Bill Gertz, the National Security Correspondent of the *Washington Times*, states "Suspicions that Russia secretly carried out a small underground nuclear test two weeks ago have raised new questions about whether the signed but unratified test ban treaty can be verified effectively." I think that discrediting the verifiability of the CTBT is the overriding motive for the leaks to the press about a suspicious nuclear test on August. I have long thought that questions of verifiability would be central to the debate about the ratification of the CTBT.

Alewine and others in the Defense Department argued for many years that the U.S.S.R. had detonated nuclear explosions far in excess of the 150-kt limit of the bilateral Threshold Test Ban Treaty (TTBT) of 1974. Soon after the TTBT was signed, two leading seismologists at AFTAC, Thomas Eisenhauer and Robert Zavadil, found evidence from seismic surface waves indicating the official formula used by the U.S. to estimate yields of Soviet nuclear explosions from P waves gave calculated yields that were too large. They were strongly opposed by AFTAC and other DoD officials. I was a member of an AFTAC panel that reviewed their work and other methodologies for estimating yields of Soviet explosions in the late 1970s. When a majority of the panel concluded that the existing formula, in fact, was generating yields that were too large, the panel was never asked to meet again. Testing above the limit of the TTBT was one of several arms control agreements the U.S.S.R. was accused of violating during the Reagan and Bush eras.

Questions of Soviet cheating on the TTBT were allowed to simmer and remain unresolved for a decade until Congress authorized its Office of Technology Assessment to conduct a study of both Soviet compliance with the TTBT and verification of a CTBT. The OTA Report of 1988 found no evidence that the Soviet Union had detonated nuclear explosions above the 150-kt limit of the TTBT. The issue was finally resolved when the U. S. and the U.S.S.R. each conducted a nuclear explosion with a yield close to the threshold and allowed the other to monitor it very close to the shot point.

While research on seismic verification of underground nuclear testing had gone on since 1958, the status of verifying a CTBT and the TTBT were not reviewed by an independent agency until the 1988 OTA study. Throughout the past 40 years agencies that have opposed a CTBT have had to walk a fine line between working to acquire excellent intelligence information but at the same time arguing that data and instrumentation were not good enough to verify a CTBT.

At one point in the yield debate, an AFTAC official stated that they had not been "tasked" to work on improved estimates of yield. I am very concerned that the present debate about Russian compliance with the CTBT resembles the long arguments about the yields of Soviet nuclear explosions under the TTBT. For example, AFTAC has shown little interest in incorporating seismic data from supplementary seismic stations such as very sensitive ones in Kazakhstan, many of which recorded the August 16 event and previous small earthquakes near Novaya Zemlya. Alewine's office has gained control of most funding for seismic research on verification of the CTBT and has driven the Air Force Office of Scientific Research and the Phillips Lab of the Air Force out of the field.

In contrast, for nearly 40 years a small group of British seismologists who work on seismic verification has conducted and published excellent studies of a few key problem events, such as demonstrating that a seismic event at the eastern Kazakhstan test site in March 1976 was a small earthquake. They have taken a strong scientific and problem-solving approach as have the Norwegians. Intense studies of a few key "problem events" does advance the field of nuclear verification. The *New York Times* article of August 29 states "An administration official, speaking on condition of anonymity, said Britain and Norway, for example, also saw the data [on the event of August 16] and had not suspected a nuclear explosion." Thus far, the U.S. Government has taken a different position on that event than its two NATO allies, Norway and the U.K, each of whom have some of the most knowledgeable seismic verification teams.

Other Small Earthquakes on and near Novaya Zemlya

The event of August 16, 1997 is, in fact, the 4th of 5 small seismic events on and near Novaya Zemlya that has been declared to be either a suspicious or a problem event by officials of the U. S. Defense Department. After detailed study, all 5 subsequently were identified as earthquakes. Novaya Zemlya and surrounding waters is an area of low natural earthquake activity, a so-called intraplate region in the parlance of plate tectonics. Its level of natural activity is somewhat lower than that of the 300 km by 300 km region centered on New York City.

Several small seismic events occurred near the shot points of two megaton-size underground nuclear explosions in 1973 and 1974 and were undoubtedly either earthquakes triggered by the explosions themselves or signals resulting from the collapse of underground cavities created by those explosions. Otherwise, no earthquake had ever been detected on or near Novaya Zemlya until the occurrence of a small event on August 1, 1986. An official of the Defense Advanced Research Projects Agency (ARPA), Dr. Alan

Ryall, concluded that the 1986 event could not be identified positively and that the large 90% confidence region associated with its location included land areas of Novaya Zemlya. ARPA previously directed the nuclear verification office for DoD. The event occurred at a time the U.S.S.R. had stated that it was observing a self-declared moratorium on nuclear testing. Ryall's 90% confidence region, however, did not include the Soviet underground test site, which occupies a very small area of Novaya Zemlya (Figure 4).

In 1989 three British seismologists published a detailed study of the 1986 event. Based on a number of criteria, they concluded that it was an earthquake at a depth of 24 km within the crust. By carefully calibrating travel times of seismic waves in the region, they obtained the location shown in Figure 4 and a much smaller 90% confidence region that was entirely at sea. Their revised seismic magnitude, mb, of 4.26, which was corrected for station bias, was smaller than ones based on uncorrected and fewer values of mb. The depth of 24 km is important since it indicates the event was of natural origin. (Most underground nuclear explosions have been detonated at depths shallower than 1.5 km; the deepest, at a depth of about 4 km. With the exception of one super-deep well to 13 km, the deepest wells drilled reach depths of 10 km.)

Figure 4 shows four subsequent small events in and near Novaya Zemlya with their seismic magnitudes in parentheses. The smallest of these, the event of January 1996, was featured twice in the *Washington Times* by Bill Gertz under the headlines "U.S. Officials suspect Russia staged nuclear tests this year" and "Perry cites evidence of Russian nuke test." William J. Perry was then the Secretary of Defense. An anonymous source was quoted as saying "It was a low-yield test in mid-January". As in the *Washington Times* article of August 28, the two stories on the 1996 event inferred that the intelligence community based their suspicions on observed activities at the Novaya Zemlya test site that were similar to those seen during a nuclear weapons test. The reports occurred at a critical time in the test ban negotiations and at a time Russia had announced that it was following a moratorium on nuclear testing (but not necessarily on sub-critical tests).

In his first article on the 1997 event Gertz states that U.S. officials were unable to prove the 1996 event was a nuclear test at Novaya Zemlya. Nevertheless,

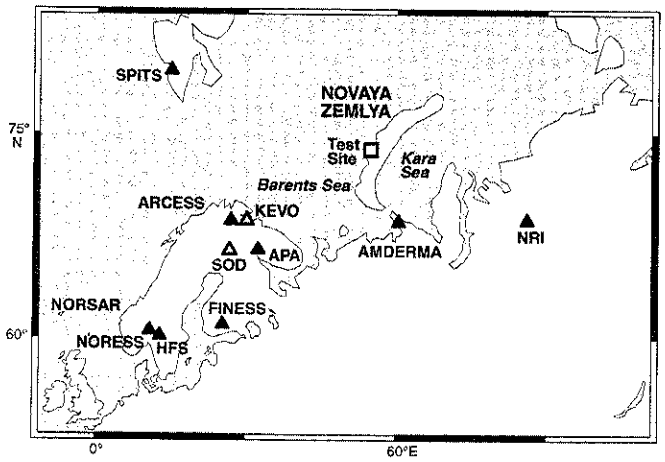

Figure 3 *Seismic stations in northern Europe relevant to studies of seismic events at Novaya Zemlya.*

the *Washington Post* article of August 29, 1997 states "After raising concerns with Moscow about another suspicious signal in early 1996, the Clinton administration determined that it had been caused by an earthquake." We need to know the basis for the latter determination. As stated earlier, Ringdal showed that the small events of 1992, 1995 and 1996 in Figure 4 had S/P ratios at the ARCESS seismic array that differed appreciably from those of past nuclear explosions at the Russian test site. Fisk obtained a similar result for the 1992 event.

In 1993 ARPA hired several consulting firms to examine the 1992 event, probably at a cost of several million dollars. While special studies of "problem events" do advance the subject of nuclear verification, it is questionable if so much money should have been spent on an event so small. Residents of California will recognize that an earthquake of magnitude 2.7 is a very small event, one that is rarely felt by anyone. In his executive summary of 1993 about the 1992 event, Ryall states that its magnitude was appropriate for a fully-decoupled 1 kiloton nuclear test. This begs the question Is fully decoupled or highly decoupled nuclear testing possible at Novaya Zemlya?

In a 1996 review paper on decoupled nuclear testing I argued that large decoupling factors could be obtained only for explosions with yields in excess of 1 kiloton when they were detonated in huge cavities constructed in salt domes. The decoupling factor is the amplitude ratio of a well-coupled, non-evasive explosion to that of one of the same yield detonated so as to decouple or muffle the size of its seismic waves. Large cavities constructed in hard rock and used for clandestine nuclear tests are likely to leak bomb-produced radioactive isotopes to the surface by way of joints and faults. Hard rock contains such imperfections on a scale of meters and larger. A cavity with a radius of about 28 meters and at a depth of 1 km in salt is needed to fully decouple a 1 kiloton nuclear explosion. No salt domes are known beneath Novaya Zemlya. Since few people live there and mining is rare, attempts to create a large cavity in any rock type should be readily observable with satellite imagery.

The United States stated in a working paper for the CTBT negotiations that it desired a monitoring capability of "a few kilotons, evasively tested." Hence, whether large decoupling factors (like 70 times) can be achieved or not by a potential evader drives monitoring perceptions. A few kilotons tested with a decoupling factor of 70 times corresponds to an mb of about 3.0. A capability better than that is being achieved now for Novaya Zemlya. Probably decoupling factors no larger than a factor of two, however, are possible at that test site for yields of a few kilotons. An explosion of that size would correspond to mb 4.0. Thus, of the 5 small earthquakes in and near Novaya Zemlya of the last 11 years, only that of 1986 was large enough to have an mb value comparable to that of an explosion of a few kilotons evasively tested.

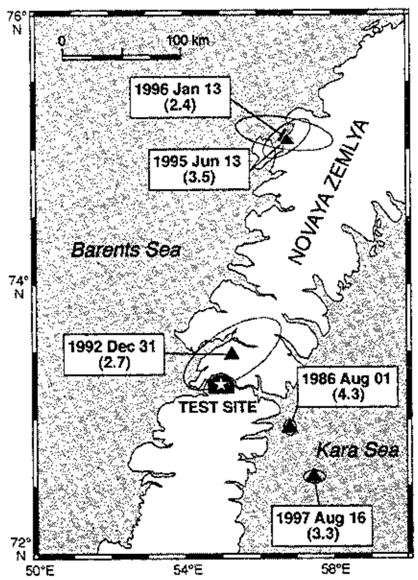

Figure 4 *Locations and their 90% confidence limits for 5 small earthquakes on and near Novaya Zemlya. The seismic magnitude, mb, is shown in parentheses beside the date of each event. Results for 1997 event from IDC; that for 1986 from Marshall et al.; others from Ringdal.*

The real question that needs to be debated is Were any of the subsequent small events on or near Novaya Zemlya large enough to constitute cheating of military significance if they had been explosions? Leaking stories to the press about the smallest event, that of mb 2.4 of 1996, appears to be making a mountain out of a molehill, especially when the event was located more than 200 km from the Russian test site. Further analysis showed that it was an earthquake.

Working in Novaya Zemlya: the Dominant Influence of Climate

The Novaya Zemlya test site at latitude 73° N is farther north than the northernmost point in Alaska. It is a frigid, largely mountainous region where polar bears are more numerous than humans. Much of its northern half is covered by glaciers. The rest is just emerging from the last glacial age. It is dark continuously for several months there and winter lasts a long time. Except for glacial action, the last major geological event in the area occurred more than 250 million years ago. This rules out one suggestion made in a Pentagon press briefing that the event of August 16 might have been an underwater volcanic eruption.

The Soviet Union conducted its largest nuclear explosions at Novaya Zemlya prior to the entry into force of the Threshold Treaty in 1976. Many of those explosions appear to have been tests of nuclear weapons that could not be conducted at full yield at the more accessible test site in eastern Kazakhstan. Likewise, the United States was forced to go to remote Amchitka Island in the western Aleutians to conduct its largest underground nuclear explosion to avoid causing damage in Las Vegas if it had been detonated at the Nevada Test Site.

The U.S.S.R. has published information on 42 underground nuclear explosions conducted at Novaya Zemlya. All but two were detonated between July 27 and Nov. 7. None were conducted between Dec. 4 and May 7. This pattern is obviously connected to the long, harsh winter conditions in Novaya Zemlya. Why didn't some officials in the United States at least stop to ask Doesn't it seem unlikely that Russia would detonate tiny nuclear explosions--those of Dec. 31, 1992 and Jan. 13, 1996 and the smallest events detected thus far--in the midst of severe Arctic winter conditions? Fortunately, seismic networks strongly support the most obvious explanation, i.e. they were small earthquakes.

Conclusions

I have presented several lines of evidence that the seismic event of August 16, 1997 was a small earthquake. It occurrence was not unique since it was the 5th known small earthquake to occur on or near Novaya Zemlya since 1986. In four of those cases officials of the Defense Department stated soon after their detection that each was either a suspicious nuclear explosion or an event of ambiguous origin. In each case special studies of the locations and wave character indicate that they were earthquakes, not explosions.

Information on the events of 1996 and 1997 were leaked to the *Washington Times* and headlined as suspicious nuclear explosions. The 1996 earthquake occurred at a critical time in the negotiations for the Test Ban Treaty and the latest as the Treaty was about to be conveyed to the Senate for ratification. Much misinformation was given to the press in conjunction with the stories that appeared on August 28 and 29. Information that the event was located well at sea and at least 100 km from the test site was available in the Nuclear Treaty Programs Office of DoD a week before the story broke in the *Washington Times.* While the role of the intelligence agencies in this affair remains classified, the press reports cite what they claim is detailed intelligence information bearing upon a nuclear origin. It seems likely that preparations were being made to conduct a sub-critical experiment at the test site at roughly the same time a small earthquake occurred offshore. An uncritical and rushed judgment was made that the earthquake was a nuclear explosion.

This experience shows that existing international seismic monitoring stations as supplemented by data from other key stations did provide sufficient information to identify not only the most recent event but also four previous small events as earthquakes. Unfortunately, as of late September high officials in the U. S. Government still had not acknowledged this and were claiming that the 1997 event had not been determined to be either an explosion or an earthquake. If these statements of ambiguity continue, the Test Ban Treaty likely will fail to win ratification in the Senate.

Clearly, investigations are needed both within the executive and legislative branches of the government to ascertain who misled both the press and public officials about the nature of the event. A technically sophisticated, thorough, non-ideological, and honest review process needs to be established within the government for CTBT verification that involves a variety of agencies with test ban responsibilities. For more than 40 years several DoD officials in nuclear monitoring have been strong opponents of a CTBT even though they were charged with either using or improving verification methods. The August 16 event demonstrates that this subject now has such serious foreign policy consequences that those with the hidden agenda of opposing a CTBT cannot be allowed to make poor and rushed technical judgments and then leak them to the media. The United States risks crying wolf too many times. We need to save our credibility for the case of a possible nuclear explosion that is a breach of the Treaty. Two NATO allies who possess outstanding groups in seismic verification did their "homework" on the 5 Novaya Zemlya events and showed that they were not of nuclear origin. They did this with fewer people and less funding than the United States. While instruments and identification methods performed well for the August 16 event, the human part of the system in the U.S. did not. We need the help of the Defense Department and the intelligence agencies in verifying a CTBT but we must insist on analyses with the highest standards.

Confidence Building Measures Several confidence building measures could help prevent false alarms under the CTBT regime. These could be a combination of bilateral and multinational agreements. This is especially important as long as the Treaty remains unratified, which is likely to be so for at least several years until all 44 stipulated countries that have the capacity to produce fissile materials sign and ratify the Treaty. While much of the International Monitoring System (IMS) is likely to be in operation before then, provisions for on-site inspections do not formally become effective until the Treaty enters into force.

1. Conduct announced chemical explosions with yields of about 20 to 50 tons at the Nevada, Novaya Zemlya and Lop Nor test sites with observers present from the countries involved in the agreements. This would permit calibration of the locations of seismic events detected at and near those sites. More importantly, it would allow those sensitive stations of the IMS that were placed in operation after the last nuclear explosions in various areas to be calibrated so that their data can be used more effectively for identification of future events. The United States has plans to conduct chemical explosions in that size range at the Nevada Test Site. Chemical explosions of that size at Novaya Zemlya would undoubtedly arouse

U.S. suspicions if U.S. witnesses were not present. Chemical explosions for calibration purposes, in fact, were conducted in 1997 at the former test site in eastern Kazakhstan.

2. Exchange data on past chemical explosions and earthquakes at and near those three test sites. At least two large chemical explosions are known to have been conducted at the Novaya Zemlya test site. NTS and Lop Nor have higher levels of natural earthquake activity than Novaya Zemlya.

3. Arrange for rapid exchange of data from seismic and other stations that are not part of the IMS when a "problem event" occurs.

4. Install seismic stations at or near each of those three test sites whose data can be transmitted to other parties in near real time.

5. Consider halting sub-critical experiments at all test sites to avoid their being mistaken for a nuclear explosion of small yield. Whether China would join such a venture is unknown.

Data Availability in the U.S. The accessibility of the Reviewed Event Bulletin of the IDC permitted U.S. seismologists outside of AFTAC to quickly access the location and size of the event of August 16 once it was announced in the press. Identifying an event as either an explosion or earthquake (other than by a location at sea), requires access to seismograms, a level of data above that contained in the REB. As the U.S. national data center for the CTBT, AFTAC has stated for more than two years its intention to make seismic data from the unclassified stations of the IMS publicly available. Thus far, however, AFTAC only makes data available for three U.S. seismic stations. In 1996 a report published by the National Academy of Sciences/National Research Council strongly recommended that unclassified data from the IMS be made available to U.S. scientists. Those data are available to users in many other countries. The CTBT protocol only stipulates that data from the IDC be distributed to all national data centers for the CTBT that request them. The national data centers for the United States and Russia have standing orders to obtain all data transmitted to the IDC. Many U.S. seismologists were unable to get unclassified data on the August 16 event through the U.S. national data center.

Fortunately, the data from KEVO, Finland, a non-IMS station whose data were critical in identifying the August 16 event as an earthquake, were readily available through the data center operated by the U.S. consortium for seismology called IRIS. The field of seismology, which has been involved in earthquake studies for nearly 100 years, has a long tradition of international data exchange, much like that for weather information. Seismic data have multiple uses--nuclear test verification, quick and accurate location of damaging earthquakes so as to permit rapid emergency response and studies of the interior of the earth and the physics of the earthquake source. It would be a tragedy if unclassified seismic data from other countries were not available in the United States when a major earthquake disaster strikes somewhere else in the world and U.S. response to the disaster were delayed. Hopefully, the experience with the seismic event of August 16 will finally result in easy access to unclassified seismic data.

FAS PUBLIC INTEREST REPORT (202) 546-3300
307 Mass. Ave., N.E., Washington, D.C. 20002
Return Postage Guaranteed
November/December 1997, Volume 50, No. 6

Periodicals
Paid at
Washington, D.C.