preparatory commission for the comprehensive nuclear-test-ban treaty organization

CTBTO PREPARATORY COMMISSION

CTBTO Spectrum

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Who we are

The Comprehensive Nuclear-Test-Ban Treaty bans all nuclear weapon test explosions. It opened for signature in New York on 24 September 1996 and enjoys worldwide support.

The CTBTO Preparatory Commission was established to carry out the necessary arrangements for the implementation of the Treaty and to prepare for the first session of the Conference of the State Parties to the Treaty after its entry into force. It consists of all States Signatories and the Provisional Technical Secretariat.

Inside this issue

Forensic seismology and CTBT verification

By Professor Paul G. Richards
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The word 'forensic' means the application of scientific methods and techniques to the investigation of a crime. Various courts of law have developed standards of what it means to present objective technical evidence, derived from forensic studies. Such courts provide a framework, developed over decades, in which others will evaluate that evidence, to see if indeed a crime has been committed, and perhaps to identify the perpetrators.

In the context of Comprehensive Nuclear-Test-Ban Treaty (CTBT) verification, for a Treaty that is not yet in effect, it is not yet clear what will constitute persuasive evidence of a Treaty violation, nor how in practice such evidence will be prepared, or presented, or assessed. An underlying question here is: who will need to be persuaded? But with more than 2000 nuclear weapon test explosions conducted from 1945 to 1996, there are plenty of examples of what signals might be expected from a CTBT violation – that is, from a nuclear explosion conducted by a Signatory State – if a test explosion were conducted in the same fashion as most tests to date, that is, without attempts at concealment. And we can reasonably speculate what are the challenges to monitoring, if a test were to be conducted with an effort at evading the attention of monitoring systems.

continued on page 6

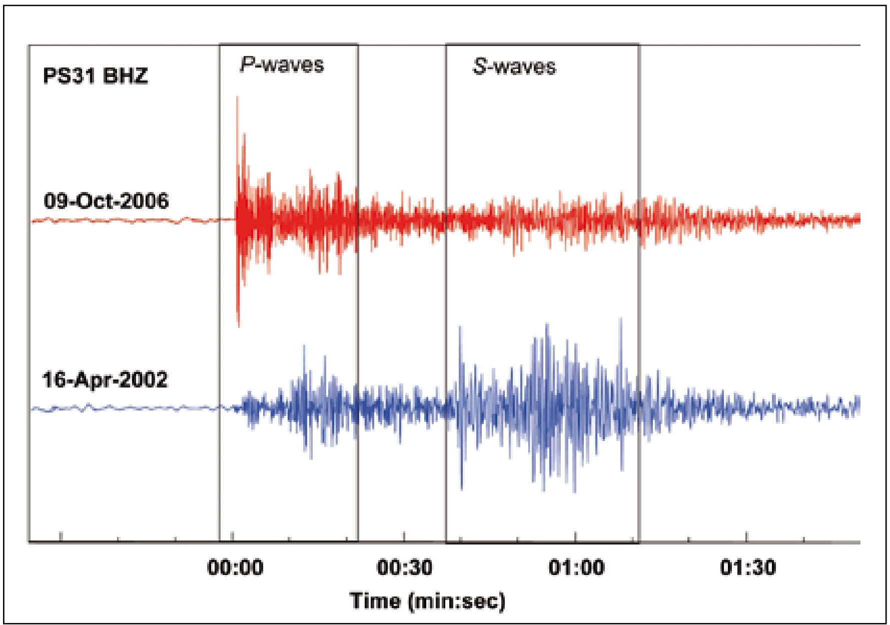

FIGURE 1: SEISMOGRAMS FROM PRIMARY SEISMIC STATION PS31, REPUBLIC OF KOREA. THE UPPER TRACE SHOWS THE WAVEFORM FOR THE ANNOUNCED NUCLEAR EXPLOSION IN THE DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA ON 09-OCT-2006, MB=4.1. THE LOWER TRACE IS FOR A CLOSE-BY SHALLOW EARTHQUAKE, MAGNITUDE MB=3.9. THE EXPLOSION GENERATES A LARGE P-WAVE AND PRODUCES LITTLE S-WAVE ENERGY RELATIVE TO THE EARTHQUAKE.

Notes & quotes

Promoting the CTBT at the NAM Summit

The CTBTO Preparatory Commission was invited to participate with 'guest status' at the XIV Summit of the Non-Aligned Movement (NAM), held in Havana, Cuba, from 11 to 15 September 2006.

The Non-Aligned Movement has been a staunch supporter of the CTBT. Out of the 118 NAM countries, 102 have signed the Treaty and 69 have ratified it. Facility Agreements have been concluded with 13 countries. The CTBTO Preparatory Commission has sent delegations to all the major NAM meetings.

The CTBTO Executive Secretary, Mr Tibor Tóth, met with high-level representatives from the following countries: Colombia, Cuba, Dominica, Guatemala, Lesotho, Mozambique, the Philippines, and Trinidad and Tobago.

In all of his contacts, Mr Tóth explored ways and means to promote signature and ratification of the Treaty and offered assistance by the Provisional Technical Secretariat. He also underlined the political and technical benefits of the verification regime, including its potential scientific and civil applications. In addition, he reported about the status of ratification and the build-up of the International Monitoring System network, and mentioned the opportunities for training and e-learning for Member States.

In the Final Document of the Summit Meeting, the Heads of State or Government stressed "the significance of achieving universal adherence to the CTBT, including by all nuclear weapon States, which should contribute to the process of nuclear disarmament." They reiterated that "if the objectives of the Treaty were to be fully realized, the continued commitment of all States Signatories, especially the nuclear weapon States, to nuclear disarmament would be essential." ■

Forensic seismology and CTBT verification …

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continued from cover page

Nuclear explosion monitoring entails a series of steps, beginning with detection of signals (did a particular station detect anything?) and association (can we gather all the different signals, recorded by different stations, that originate from the same 'event'?). The next steps involve making a location estimate and an identification (did it have the characteristics of an earthquake, a mining blast, a nuclear weapon test?). Then follow the steps of yield estimation (how big was it?) and attribution (if it was a nuclear test, what country carried it out?).

Many different technologies contribute to nuclear explosion monitoring, with seismology playing a major role in monitoring the underground and underwater environments of a possible nuclear test.

It is intrinsically difficult to do this work because there are so many events generating seismic signals. The International Seismological Centre, located in Berkshire, United Kingdom, provides the most thorough documentation of global seismicity. Its bulletin, published about two years in arrears, now reports several hundred events per day, most of them very small earthquakes occurring in well-monitored regions. Because the CTBT is a comprehensive ban on nuclear testing, all seismic events are potentially suspect and require some level of attention. But though monitoring is difficult, extensive resources are applied to do the work.

The fact that so many events are detected and located should not be seen so much as a problem in monitoring, but rather as a testament to the sensitivity of monitoring networks, which continue to improve in part because of ever-increasing needs to study earthquake hazards. The work of monitoring – for both earthquakes and explosions – is done in practice by hundreds of professionals who process the vast majority of seismic events routinely, and who also look out for the occasional events that in the context of CTBT verification exhibit interesting characteristics, and which may then become the subject of special studies.

These special events have stimulated the development of effective new discrimination techniques and a better appreciation of overall monitoring capability. Examples include a mine collapse in 1989 in Germany and two such collapses in 1995 (in Russia and in the United States); a small earthquake of magnitude 3.5 and its smaller aftershock in 1997 beneath the Kara Sea near Russia's former nuclear test site on Novaya Zemlya; and two underwater explosions in 2000 associated with the loss of a Russian submarine in the Barents Sea; the series of nuclear explosions carried out by India and Pakistan in 1998; and the nuclear test conducted by the Democratic People's Republic of Korea (DPRK) on 9 October 2006.

The mining collapses were seismically detected all over the world, and caused concern because their mix of surface waves and body waves as recorded at great distances from the source appeared explosion-like using the classical Ms: mb discriminant. In this method, the strength of surface waves (Ms) is compared with that of body waves (mb). For seismic sources of a certain size, as determined by their mb value, surface waves are significantly stronger for shallow earthquakes than they are for an underground explosion.

But a careful analysis of regional waves from these events showed that although the surface waves were quite weak, and in this respect seemed explosion-like, they had the wrong sign. Therefore the motion at the source was implosive (the ground had moved inward toward the source), rather than explosive. Indeed, mining collapses are an implosion

continued on page 19

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continued from page 6

210 KT ATMOSPHERIC NUCLEAR TEST EXPLOSION ‘TRUCKEE’ CONDUCTED BY THE UNITED STATES ON 9 JUNE 1962 AT 15:37 GMT, 10 MILES SOUTH OF CHRISTMAS ISLAND, A NON SELF-GOVERNING TERRITORY OF AUSTRALIA.

phenomenon, and it was important to learn that their implosive nature could be reliably determined from seismic recordings.

The Kara Sea earthquake was too small to apply the Ms: mb discriminant (the surface waves were too small to measure reliably). This event showed the importance of accurate locations, and of using spectral ratios of regionally (from distances less than about 1500 km) recorded P (pressure) and S (shear)-waves to discriminate small events. This method exploits the fact that for explosions, P-waves are typically stronger than S-waves. Therefore the ratio of P to S amplitudes can be used to distinguish the type of event (see Figure 1 on cover page).

The North Korea nuclear test is of interest as an example of a nuclear explosion that was promptly detected globally, though its yield has been estimated as less than one kiloton. This event required regional seismic data in order to determine that indeed an explosion had been carried out and that the signals were not from an earthquake.

Some of these special events were associated with press releases by government agencies that, on technical issues, such as assessments of the difficulty of discrimination, and yield values, differed from work being reported by individuals in the monitoring community. At present there is no good open forum for experts in the monitoring community to have their work assessed, to see if a consensus can be developed on how to characterize a particular special event. This problem of discrepancies between government press releases and expert commentary is compounded by rules imposed by some monitoring agencies that prevent their experts from speaking to the press at times of intense public interest in a current story, such as the assessment of the North Korean test of October 2006.

But these are short-term issues, and in practice the record of analysis of special events over the last ten years is that a consensus on each of the special events has eventually emerged. In fact, the best seismological data to resolve a specific monitoring issue has sometimes come from stations that are not part of any treaty-monitoring network. The contribution from such stations is often made in the context of routine analysis already done by dedicated networks and data centres. Typically, it is found that the data from such networks, and in particular the location estimate, provide guidance on what additional stations might be contacted to provide additional data.

Though we do not yet know in detail what future procedures will be adopted in the evaluation of forensic evidence, if the CTBT were in effect and a Treaty violation were to be indicated, we already have experience derived from special events. This shows that the combined capabilities of the CTBTO monitoring networks and of numerous other stations that may also gather relevant data permit monitoring of nuclear explosions down to very low levels of yield, with very high confidence. ■

Biographical note

Prof Paul G. Richards was born in the United Kingdom and has lived in the United States since 1965, where he has taught at Columbia University since 1971. He is a seismologist, co-author of the advanced text “Quantitative Seismology” (translated into Russian, Chinese, and Japanese), and co-discoverer of the super-rotation of the earth’s inner core. ■

Photo courtesy of Lamont-Doherty Earth Observatory