Focus — On Seismic Verification

Focus is our column for secondary school students. We welcome your comments and suggestions for future topics.

Seismology

Seismology is the science of studying vibrations in the earth's crust. Vibrations occur during earthquakes or during smaller, less noticeable tremors. They also occur during underground explosions of nuclear devices. Any earthquake, tremor or explosion that causes vibrations is called a seismic event.

When a seismic event occurs, shock waves are transmitted through the earth. The waves are of two types: body waves, which travel quickly through the earth's mantle; and surface waves, which travel more slowly through the earth's crust. These waves can be detected and analyzed by equipment located up to 10,000 km away from where the event took place. By comparing the measurements of each series of waves, and the time between when they are received, seismologists can often determine where the event occurred and whether the event was an earthquake or an explosion.

The device used to measure vibrations in the earth's crust is called a seismometer. A seismometer usually takes the form of a metal canister, about 20 cm in diameter and 20 cm high, lined with a coil of wire. Inside the coil, suspended from the top of the canister by a spring, is a permanent magnet that is free to move up and down within the coil. The canister is buried in solid rock and any vibration in the earth will cause it to move up and down. The magnet, however, will tend to stay where it is, and the relative motion will induce a weak electrical current in the coil. This current is amplified and recorded on a moving roll of paper or on magnetic tape. It thus forms the basic measurement of a seismic event.

Nuclear Testing

A treaty called the Partial Test Ban Treaty (PTBT), signed in 1963, forbids the countries that signed it to explode nuclear devices in the atmosphere, in outer space or under water. This means that the only place these countries are allowed to explode nuclear devices is underground. Countries may want to explode nuclear devices for a variety of reasons: to test nuclear weapons; to test the effects of nuclear explosions on other equipment; or to study the nuclear explosion process.

Many countries, including Canada, think that all nuclear explosions should be banned. Since countries would then no longer be able to test nuclear weapons by exploding them, the development of new, more sophisticated kinds of nuclear weapons would be difficult. A ban would also make it hard for countries that do not have nuclear weapons to develop them.

Seismic Verification

Canada has been active with other countries in seeking a Comprehensive Test Ban Treaty (CTBT). Such a treaty would ban all nuclear explosions in all environments (including underground) for all time. Canada participates in the talks related to a CTBT at the Conference on Disarmament in Geneva.

The ability to effectively verify a CTBT is very important to progress toward one. No country that has nuclear weapons is likely to give up its right to test and improve its nuclear arsenal unless it can be sure that other countries will be living up to a similar commitment.

The verification of a possible future CTBT will have to rely a lot upon seismologists, and their ability to detect and identify underground nuclear explosions. Seismic verification could act as a "trip wire." This means that if seismologists detected what they thought was a nuclear explosion, other means of verification could then be used to see whether or not the event was indeed an explosion.

Problems with Seismic Verification

Although seismic events can be monitored with considerable accuracy, there are still some problems with using seismology to verify a CTBT. For example, countries can try to hide their nuclear explosions by testing nuclear devices in an area that is prone to earthquakes. Or, they can try to disguise the wave pattern of the nuclear test, so that it blends in with the seismic background noise usually found in the area. If an underground test is carried out in a large enough existing underground cavity, the seismic effects of the test will be muffled and distorted.

In addition, a huge number of seismic events occurs each year — over 10,000. It may not be practical to monitor and analyze all of them, and then re-analyze the ones that look suspicious using additional data from other sources. On the other hand, the attempt to do so could well discourage illegal nuclear testing by providing a good chance that potential treaty offenders would be caught.

Another problem is that nuclear weapon technology is constantly evolving, and one of the most dramatic trends is the movement toward smaller bombs. This means that future nuclear weapon tests will likely involve relatively smaller explosive devices and will therefore be far more difficult for seismologists to detect and pinpoint.

Efforts Continue

Despite all these problems, a lot of international research is underway to see just how effective an international seismic monitoring network might be in verifying a CTBT. Canada is playing a major role.

The most important international forum for the discussion of seismic verification techniques is the Group of Scientific Experts (GSE) associated with the Conference on Disarmament in Geneva. This is a group of seismological experts from many countries, including Canada. In January 1990, the GSE will begin a large experiment to exchange and process detailed seismic data provided by a number of seismic stations from countries around the world. A Canadian, Dr. Peter Basham of Energy, Mines and Resources Canada, is the global coordinator for the experiment. Canada's newly-modernized seismological array at Yellowknife will provide data for the experiment.

Conclusion

While experiments like the GSE's are crucial to the task of designing a seismic