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UA Researcher Uses Forensic Seismology to 'Fingerprint' Mysterious Explosions

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If you think seismology concerns only earthquakes and plate tectonics, think again.

Terry Wallace represents a different breed of seismologist, that of forensic seismologist. By using seismic stations as “little ears to the ground,” Wallace continues to push the forefront of forensic seismology by studying the sinking of submarines, industrial explosions, nuclear weapons testing, landslides, and other unidentified phenomena that leave their mark by shaking the ground.

Wallace, a geosciences professor at the University of Arizona, says that seismographic records can provide the tools necessary to reconstruct a sequence of events on land or in the ocean.

“Seismological tools and theory can be used as constraints to tell when an accident occurs or something that’s not accidental, like a nuclear explosion. We can then put behind that some ideas of how big an explosion might be, or if it’s a landslide, how big the landslide might have been, or how far the rocks have fallen, for example,” he explains.

Wallace will talk about it at the 2002 American Geophysical Union meeting in San Francisco. He is a panelist at the 11 a.m. Dec. 8 news conference entitled “Forensic Seismology: Deciphering Exotic Seismic Sources and Man-made Events." Other panelists include Steve Taylor of Los Alamos National Laboratory in New Mexico, David McCormack of Geological Survey Canada based in Ontario, and Keith Koper of St. Louis University. The session will focus on how seismic data can be used by the government, insurance companies or other agencies.

Also, Wallace will present some of his research findings at 9:50 a.m. Dec. 9. His talk, entitled “Forensic Analysis of Seismic Events in the Water; Submarines, Explosions and Impacts," will specifically address his seismic studies of ocean events, such as the sinking of the Russian Kursk submarine on Aug. 12, 2000, in the Barents Sea.

“A few years ago we looked at the Kursk sinking data and developed a scenario, almost in real time, of what happened. We came up with a scenario of two explosions, where the first was probably a misfire, and the second was either a warhead detonating or fire-related when the warship hit the ocean bottom. This turned out to be almost exactly what the Russians eventually released in a report of July this year," Wallace says.

“The fact that we looked at this one event and could see so many things has spurred me to go back and look at other underwater events and see how well we understand them," he adds.

Other underwater events that Wallace will discuss include the sinking of the U.S. Scorpion submarine near the mid-Atlantic ridge in 1968, the sinking of another Russian sub in the Baltic in 1989, and the sinking of a large oil derrick in the North Sea that produced a 3.5-magnitude earthquake when it hit the ocean floor.

Wallace collects data from about 3,600 different seismic stations located around the world for his seismic research. An estimated 10,000 high-quality seismic stations exist worldwide, but many do not make their data public. Most of the stations monitor earthquake activity, while others keep track of nuclear explosions or are used in classified work.

“These stations are looking for a particular thing, but they also continuously record all this other information that can be really interesting,“ Wallace says.

Most of the seismic data Wallace uses to reconstruct earth-shaking events he collects from land-based seismic stations. Even occurrences that take place deep in the ocean register on these seismometers, largely due to the nature of water.

“Water is a marvelous thing to make seismic noise in,” Wallace says. “It doesn’t seem like it should be, but it turns out that water is much more compressible in a recoverable way than is earth. So we can transmit signals through water much farther before they go into the land and come up to the land-based seismometers.”

Water seismometers, or hydrophones, are even more sensitive to water rumblings than are the land-based versions. “Using a hydrophone in the water, we can see the explosion of one stick of dynamite anywhere in the world. That’s how quiet the oceans are. So if you are going to hide something, don’t do it in the water,” Wallace says.

This ability to monitor phenomena occurring in the water with extreme sensitivity and accuracy is why a network of water-based seismometers is not publicly accessible, as is the network of land-based seismometers. Most information from the huge network of water siesmometers is classified, Wallace says. In fact, modern seismology evolved because of national interest in what seismic information says about international activities, from nuclear arms testing to submarine trafficking.

Wallace explains, “Seismology is really important for modern plate tectonics, discovering where plate boundaries are. However, all these things came about from the desire to use seismology to monitor nuclear tests. In the early 1950s, we realized that seismology could play a key role in telling us what the Russians were doing. So in 1959 the U.S. pushed to build a huge seismic network all around the globe – called the worldwide seismic network – and at the same time developed seismologists in universities here at home. This network led to the discovery of many of the important things in plate tectonics, but it’s deeply rooted in the desire to use seismology as a monitoring tool.”

Although analyzing seismic data for monitoring purposes has long been practiced, Wallace and colleagues continue to refine the art. For example, he explains, “Using seismic signals from a station in Chile, we did an experiment where we can see trucks drive by, or when they drove up and drove beyond. But then I began to characterize the signals and tell the differences between them. Now I can tell which way the trucks are going. I can look at the signal size and see how the signal built up to begin to get an estimate of how much the trucks weigh.”

“This is an example of what forensic seismology can be," he adds. "Here it is a sentinel that is actually telling you where the traffic is going and how much it weighs.”

For now, public land-based seismometers provide Wallace with enough information to track earth-shaking events. He and others in his lab continuously collect data from these seismic stations and characterize notable seismic events to compile a portfolio of incidents.

“The whole research effort for my group is to develop as big a portfolio as possible. This way, when we see an industrial accident where a fireworks factory blows up or a gasoline tank blows up, we have all the different kinds of seismic records we can get from that and we have characterized them. Then the next time something like that happens, we have some experience to draw from. We’ve got some fingerprints left over to help us understand what is happening,” Wallace says.