THE LOMA PRIETA EARTHQUAKE: LESSONS LEARNED

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BEFORE THE

SUBCOMMITTEE ON SCIENCE, RESEARCH AND TECHNOLOGY

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Mr. WALGREN. Thank you, Congresswoman Pelosi. And the Chair now recognizes the gentlewoman from California, Congresswoman Boxer.

Ms. BOXER. Thank you very much, Mr. Chairman. I want to say, along with my colleague, Mrs. Pelosi, how pleased we are that you are here. Congresswoman Pelosi's district in San Francisco suffered the brunt of it. In my area, we were very fortunate, a few cracks, a few problems, but nothing as dramatic or horrendous as that which happened in the Marina district.

Very briefly—I do not have a formal statement. I want to say that human beings deal with natural disasters by learning from them. We do the best that we can. And I know it is in that spirit that you come here. We will learn from this disaster and we will handle the next one better, wherever it strikes, whatever state in the Union.

I would like to point to one positive factor, and this speaks to what Congress can do. About 12 years ago, my predecessor, Congressman John Burton, asked Congress to fund earthquake proofing of the Golden Gate Bridge. And this was a very costly and difficult job to do, but it was done. And I just want to note that that bridge stood tall and proud, and has absolutely no damage whatsoever. We understand that maybe the earthquake did not come near there. But the fact of the matter is that we do have to look at our bridges, we have to look at our infrastructure as we look to getting ready for the next disaster, wherever it happens in this country. It is an investment that I really believe that we must make.

Thank you very much, Mr. Chairman.

Mr. WALGREN. Thank you, Congresswoman Boxer. Let me introduce to you the first panel of witnesses we have. Dr. Don Anderson, the president of the American Geophysical Union; Dr. William Ellsworth, a research seismologist with the U.S. Geological Survey; and Dr. Tom McEvilly, director of the Earth Sciences Division at Lawrence Berkeley Laboratory, and Chairman of the National Earthquake Prediction Evaluation Council.

Gentlemen, we are pleased you are here. You may know of our ground rules. We are going to create a record of this hearing. Written statements will be reproduced in that record as a matter of course. You can feel free to take from your submissions to the committee in whatever way you feel will most effectively emphasize and communicate the thoughts that you would like to stress. So let me invite you then to give us in your views. We will start in the order in which I introduced you to the record with Dr. Anderson.

STATEMENT OF DR. DON L. ANDERSON, PRESIDENT, AMERICAN GEOPHYSICAL UNION AND PROFESSOR OF GEOPHYSICS, CALIFORNIA INSTITUTE OF TECHNOLOGY

Dr. ANDERSON. Thank you, Mr. Chairman. Thank you for having your meeting in conjunction with the American Geophysical Union. You came to the right place at the right time. We know a lot about this earthquake and most of the geophysicists who worry about earthquakes and study earthquakes are probably here in this room right now.

THE LOMA PRIETA EARTHQUAKE: LESSONS LEARNED

Statement of

Don L. Anderson

to the

U.S. House of Representatives
Subcommittee on Science, Research and Technology

December 4, 1989
San Francisco, California

Mr. Chairman and Members of the Subcommittee:

Thank you for inviting me to testify. My name is Don L. Anderson and I am Professor of Geophysics at Caltech and President of the American Geophysical Union.

Let me say at the outset that we do not completely understand earthquakes and therefore we cannot predict them, on the short term, in any socially meaningful way. It is the consensus of the geophysical community, however, that we are getting closer to defining seismic hazards in a very general sense, and that we know what to do to greatly increase our understanding of earthquakes and the processes which lead up to them. What we are missing is a high dynamic range, broadband ground motion database and this requires a large investment in modern instrumentation. Understanding earthquakes is part of the larger problem of understanding the Earth and we have not yet made the required investment in facilities and basic research. We will continue to be surprized by ozone holes, droughts, global warmings, El Ninos, earthquakes and so on until we acknowledge that it is in our best interests to understand the planet we live on. Understanding the Earth, including the tectonic forces that culminate in earthquakes, should be as high a priority as understanding the atom, the human genome, the cosmos and the solar system, and this means a commitment to fundamental research and to modern observatories and instrumentation.

What have we learned from the numerous earthquakes that have hit California in the past five years? We have learned that every earthquake is different. Some occur on deep faults or folded structures and not on mapped faults. Some do not even break the surface. Some were preceded by smaller events which alerted us that something was happening. We have confirmed that the geology of Northern and Southern California are different and, perhaps, different research and prediction strategies need to be adopted. We have confirmed that the density and quality of instrumentation is woefully inadequate and therefore we cannot pretend that we have an earthquake prediction program. For most of the State of California (and things are worse in the other western states, Alaska, the midcontinent and the east) there is little tectonic and seismological data being collected and high quality data, by modern standards, is only being collected at a few sites.

The Loma Prieta earthquake was approximately a magnitude of 7 and because of the simplicity of the seismograms that it wrote we call it a "simple seven" or a smooth event. It appears to have been a smooth break and the major motions were over in 6 seconds. In contrast, the Armenian earthquake was a complex event and strong shaking lasted 10 times longer. Although building practices in California are superior to those in Armenia there is little doubt that an Armenian type earthquake at Loma Prieta would have been a much greater disaster than the Loma Prieta earthquake itself. Let me also remind you that the Loma Prieta earthquake was not really very big nor was it very close to San Francisco. We were lucky. Other California earthquakes are not so simple, and have larger motions or longer durations, even if smaller in magnitude. The 1906 San Francisco earthquake was also relatively smooth and simple. Many earthquakes in Southern California are not. There is no reason why these more destructive earthquakes cannot occur closer to heavily populated areas than they have in the past 50 years.

I would like to emphasize that although we are a long way from being able to predict the time and place of earthquakes, there is a great deal that seismologists can do to reduce the hazards of living in California. Before building codes can be realistic and before earthquake engineers can design safe structures it must be understood what ground motions can be expected at a given location. This involves an understanding of what happens at the epicenter of an earthquake and what happens to an earthquake wave as it propagates to the surface. With arrays of modern instruments, recording continuously, this kind of information slowly accumulates as more and more earthquakes, small and large, are analyzed. A safe structure must be in harmony with its environment. For example, a building that may resist a large earthquake if built on a hill in Los Angeles County may fall down if built in the middle of the Los Angeles Basin. This is because a basin has its own resonances and may amplify a seismic wave of a given period. This is what happened in Mexico City. This kind of information results from geophysical research but is taken into account only crudely by building codes and engineers. Engineers do worry,of course, about whether the site is on mud or on "hard rock" but I'm talking about large scale geological features.

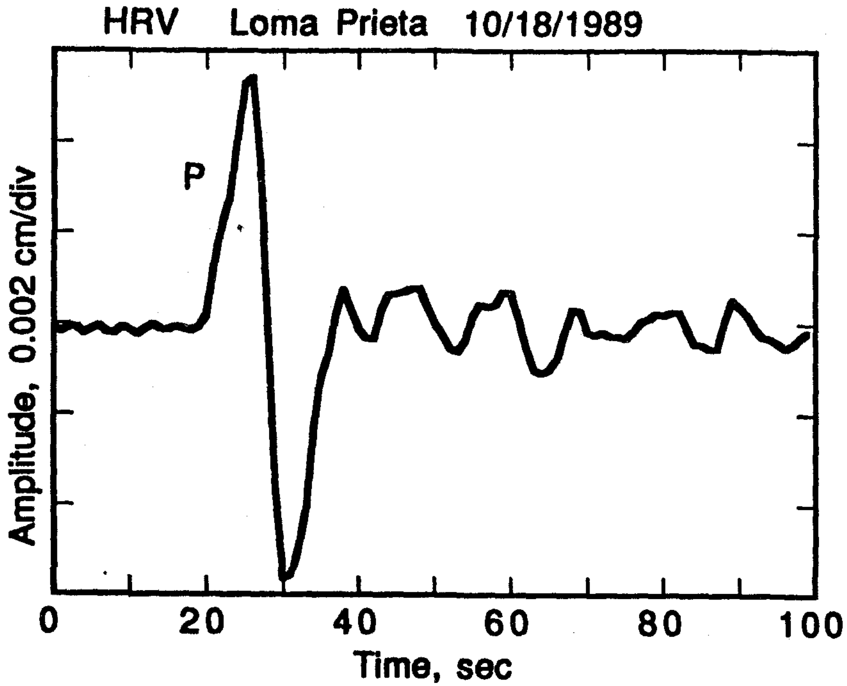
The seismic hazard, particularly in Southern California, is not restricted to the San Andreas fault. It is difficult and expensive to adequately instrument California so that the events that occur between and just before all major earthquakes can be trapped and analyzed. At the moment, funds are only adequate to instrument one section of one fault and to test only one type of theory about prediction. On the other hand, with an array of modern broadband, high-dynamic range digital instruments, spread across the state, there is hope that very small, slow precursors that may precede large earthquakes can be detected. I should emphasize that we know how to instrument an area to optimize our understanding of earthquakes and to trap the kinds of signals that may occur before earthquakes. I will call this a "research array". This is in contrast to a "prediction array". The prerequisites for earthquake prediction include the continuous operation of a research array for some years, an adequately funded research program and a few large earthquakes. Only after we have the prerequisites can we talk about installing instruments to routinely predict earthquakes. Only then will we know what to look for.

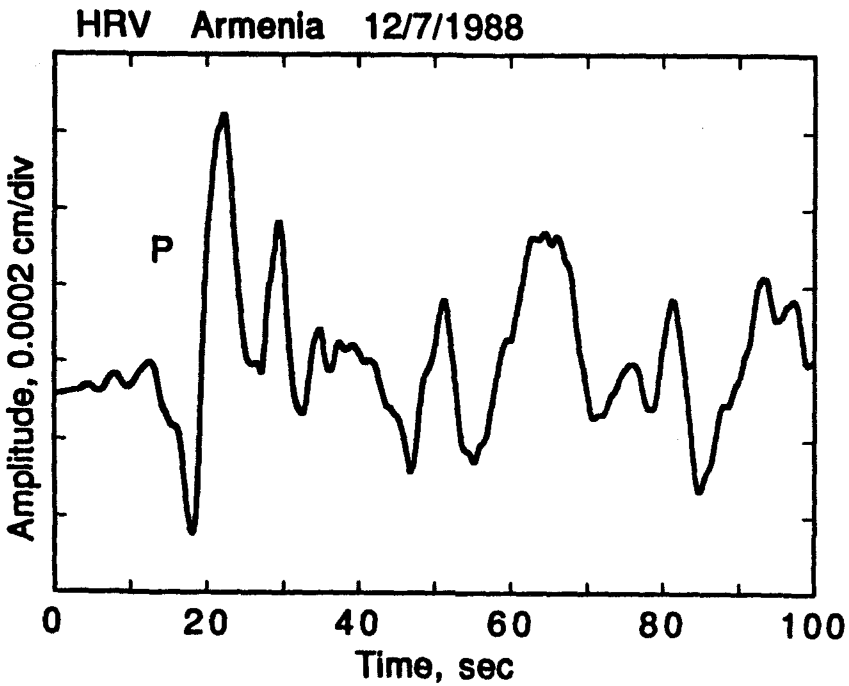
The research array, however, will allow us to learn more about earthquakes and can be used to rapidly communicate post-, and possibly, pre-earthquake information to public officials and the general public. Seismology has become a very sophisticated science. There are literally dozens of scientific papers, written in the months following every major earthquake, which give a great deal of information about the nature of the event, the damage pattern and the distribution of ground motions. With modern instruments and computers this type of analysis can be condensed into minutes and the seismologists can provide public officials with data from networks of instruments and interpretations in the critical period immediately after the event. Possible precursors can also be evaluated. Even while the research array is in its learning mode it can be providing important information to the public. I should remind you that seismologists can use seismic waves to peer deep into the Earth. They do not rely on surface breaks or information about preexisting faults.

What does a research array consist of? It consists of 50 to 100 broadband, high dynamic range digital seismometers, dispersed over California, connected to one or more central data processing facilities but also accessible by dial-up and satellite links. I am restricting my comments to California but similar stations should be installed on Alaska, Hawaii and other high risk areas. Each site should have strong motion instruments and GPS (Global Positioning Satellites) geodetic receivers. This mix of instruments assures that useful information will be obtained during and between events, regardless of their size. The research array is in addition to conventional microearthquake arrays and clusters along certain fault segments. The excellent seismological research centers in California need to be adequately funded and involved in the planning and implementation of the program. These centers should be expanded into Data Centers and Earthquake Research Centers, with a mission to understand earthquakes and to disseminate information to the public. Any new thrust in California should also make it possible for non-Californians to participate since there will be plenty of data and work to go around. Modern broadband research arrays also need to be installed in other earthquake prone areas. What is needed is a partnership between federal, state and local governments, industry and university scientists. What is really needed is an understanding by the public and the politicians that in places like California earthquakes have built the mountains, the valleys and the coastlines and that earthquakes will continue to happen. The more we understand them the less we have to fear from them.

Earthquakes are just one reminder of how the planet we live on can surprize us and how it will continue to surprise us until we understand it. They also remind us that in any program of Global Change or any mission to Planet Earth we must strive to understand the whole Earth, including the atmosphere, oceans, surface and interior. Crash programs on ozone holes, global warming, global change, earthquakes and so on, may be productive but a long term committment to the support of basic research in the Earth Sciences, through NSF, NASA, USGS, NOAA and so on, and involving the best minds in universities and government laboratories, is cheaper and is an investment in the habitability of our Planet. These programs must involve the solid Earth and oceans as well as the atmosphere.

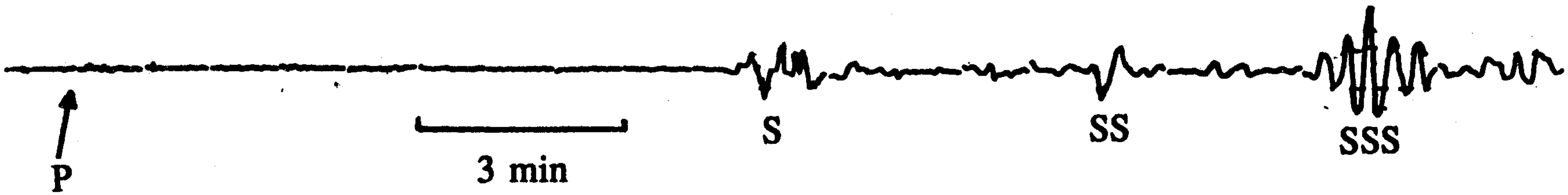
Comparison Between Loma Prieta and Armenia Earthquakes





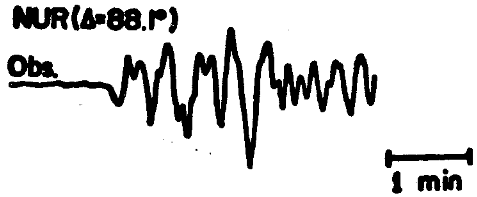
1906 San Francisco Earthquake

Uppsala Wiechert N-S



1976 Guatemala Earthquake

WWSSN



1989 Loma Prieta Earthquake

OBN Wiechert (Simulated)