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Interview with Ken Hoffman

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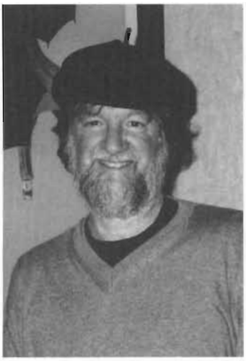

Ken Hoffman

Interview with Ken Hoffman

Professor of Physics

Kenneth A. Hoffman received a BA in Physics (1966), MA (1969) and PhD (1973) in Geophysics, all from the University of California at Berkeley. He has been on the faculty of the Physics Department at Cal Poly State University, San Luis Obispo, since 1974. Hoffman was elected Fellow of the American Geophysical Union in 1992, and has been an Editor of the *Journal of Geophysical Research: Solid Earth and Planets*, President of the Geomagnetism and Paleomagnetism section of the AGU; and Outstanding Professor of the California State University System. His primary research interest concerns the behavior of the paleomagnetic field during polarity transitions and excursions.

Moebius: Explain the difference between a physicist and a geo-physicist.

KH: Physics is the science of Nature in the broadest sense. Physicists study the behavior and properties of all matter. Geophysicists apply these principles to the Earth in order to gain a more thorough understanding of what it is and how it works.

Moebius: How did you become interested in earthquakes?

KH: Although not my chosen sub-discipline of research in geophysics, which happens to be paleomagnetism, from the very start of my graduate schooling I was interested in seismology. Seismology comprises a major part of geophysics, from theoretical study, such as elastic wave theory, to the real phenomenon of earthquakes themselves. Since my arrival at Cal Poly in 1974 I have consistently taught a non-majors course on earthquakes, Geology 205, which is a GE course with essentially no math involved; Geology 305, which is a seismology course principally for architecture engineering and earth sciences students and which involves more mathematics; and occasionally a senior-level course for Physics majors, Physics 410, which is entitled Physics of the Solid Earth, and involves a more sophisticated theoretical approach to seismology.

Moebius: What have we learned about earthquakes from the time you began to study them to the present?

KH: For one thing, it's because of our study of earthquakes that we know as much as we do about the Earth's interior. Since 1973, the year I received my doctorate, geophysicists started to use recordings of ground motion caused by the seismic waves generated by earthquakes to look inside the Earth in new ways and on a much finer scale. Because of the world-wide network that's set up to record seismic waves, we have much more data that can be analyzed. For example, after a major earthquake the entire Earth rings like a bell in hundreds of ways, and the timings of these oscillations tell us a lot about Earth's interior, from the surface to the center. Then came a kind of CAT scanning of the Earth by using recorded seismic wave data. It's actually called Seismic Tomography—and gives a 3-D view inside on a very fine scale. Of course, high-speed computers are involved in the analyses of the vast amounts of data needed to do tomographic studies. There now exists a rather good-sized international group of geophysicists dedicated to researching the Earth's deep interior, several of which who work on tomography in one way or another. These studies have given us a new understanding of variations in temperature and composition deep inside the Earth and what has come from this is exciting: clear evidence that the Earth is a holistic place where the surface affects the deep interior and vice versa.

Moebius: 1906 was a year of tremendous earth movement –Vesuvius, Ecuador, Chile. Again, the year of 2004 was a year of disasters—Iran, Sumatra. What are we to make of these observations?

KH: One has to be careful not to read too much into these, likely, coincidences. It is true that under the surface tectonic plates is a kind of "mushy" area called the asthenosphere. It has been hypothesized that, on occasion, it may act as a means to project the effects of some violent earth activity to areas far away triggering other events. Maybe. Yes, the Landers earthquake in 1992 (7.4 magnitude) centered near Yucca Valley, likely triggered another earthquake, of magnitude 6, not far away, but on a completely different fault near Big Bear. On the other hand, it is important to understand that large earthquakes occur every year. However, from the media we are much more likely to learn about those occurrences that had disastrous effects on people and structures. But, similar events to, say, the size of the recent earthquakes in the middle-east also occur elsewhere, oftentimes unnoticed by the public. Understanding the energy released by certain earthquakes may also help in answering this question. You mention 1906. Well, the San Francisco earthquake of 1906 is now believed to have had a magnitude of about 7.8. I would estimate from this that it would take about 150, plus-or-minus, San Francisco earthquakes to release the same amount of energy as one 2004 Sumatra earthquake, which was a 9.1. In 1960 and 1964 the two largest earthquakes ever recorded, each several times larger than even Sumatra, occurred. But we don't talk about triggering effects around the world due to them. So, I'm highly skeptical about any special importance given to any one year of events and disasters.

Moebius: How close are we to predicting earthquakes?

KH: Not very close. In order to measure various types of phenomena that may take place prior to an earthquake at that particular site—changes in the ground that might then alert us to an impending earthquake—we would have to have measurement devices of all kinds placed and working at that exact place. Even if there was money to do this along all major and potentially lethal faults, which there certainly isn't, there is no reason to believe that we could make a meaningful prediction. And even if we could, what would happen? What would likely happen if seismologists told people living, say, in the San Francisco Bay Area, or in the Los Angeles basin, that an earthquake, possibly a large one, was likely to occur in, well, about a month? Would everyone buy a ticket for a European vacation? Would they even close-up their shops? I think the more likely scenario would be litigation taken against those that made such a prediction—for economic reasons—especially if the earthquake either didn't happen or did, but caused little damage. What is done today is not prediction, but is earthquake forecasting, where we estimate the probability of the occurrence over the next 30 years of a particular size earthquake on a particular fault. For example, the US Geological Survey and other scientists now conclude there is a 62% probability of at least one magnitude 6.7 or greater quake, capable of causing widespread damage, to strike the San Francisco Bay region before 2032. Forecasts definitely can alert us to matters that need to be attended to, especially with regard to strengthening existing structures, in those areas most likely to experience a large earthquake. For example, the first such forecasting, made in the early 1980s, pointed to Loma Prieta and what occurred in 1989 was about a magnitude 7 earthquake, which caused fatalities and major damage all around the Bay.

A lot of energy was released by the 1906 earthquake, and so, for the subsequent 50 years there were no moderate or larger earthquakes in the Bay Area. The same happened after the 1857 earthquake along the San Andreas fault in the Southland. Imagine that these situations are like a coiled up spring. When let go, for our case the fault ruptures big-time, the stored-up energy is released and the effects are great. Then it's quiet for a long time while the spring begins to coil up again due to tectonic stresses.

In the Southland, there are many blind-thrust faults, where the fault and the fault breaks during an earthquake, do not reach the surface. Some of the magnitude 6+ earthquakes in the San Fernando Valley between 1971 and 1994 were along faults that prior to the events were not known to exist. This type of fault adds considerable complexity to earthquake forecasting.

As for the size of past earthquakes, crucial to any forecast attempt, we now have a way to calculate magnitude which, unlike the Richter and other scales, is based on the physics of the process, on what happens to the ground. A number of past earthquake magnitudes have been recalculated in this new way. Some, like the 1906 San Francisco earthquake, were "demoted" from 8.2 to 7.8. But the very large ones, like Anchorage, Alaska, 1964, were found to be much larger. Its magnitude climbed from 8.6, a truly great earthquake, to 9.2, a humongous earthquake. The largest known earthquake that took place off the coast of

Chile in 1960 went from 8.5 to 9.5. In terms of energy release that's about 32 times larger than what we thought. The recent tsunami-producing, catastrophic Sumatra earthquake is the latest case of extreme fault rupture and energy release, measuring 9.1. We just don't know when or where the next super-great earthquake will occur.

Interview on behalf of Moebius *conducted by Mary Kay Harrington, Winter, 2006.*