Cinna Lomnitz's Contributions to Seismology

Alejandro Nava P.
Lomnitz student
Departamento de Sismología
División Ciencias de la Tierra, Cicese
Ensenada, Baja California, México

Recounting Cinna Lomnitz's contributions to seismology is not easy, because they are many, span more than 61 years, and range over many fields. I will try to give a summary description of his principal contributions and, since listing all his production would need many pages, the years in parentheses correspond to the publication of related papers, and the bibliography contains only some of his most important papers.

Besides being intelligent and enthusiastic, Cinna had the oportunity of studying or practicing under some of the most important pioneers of seismology: Beno Gutenberg, Hugo Benioff, and Charles Richter. Thus, Cinna made his mark very early in his career with work he did for his PhD thesis on the viscoelastic behavior of igneous rocks in 1955-1956; he obtained a relation later named "Lomnitz's Law" by Sir Harold Jeffreys, and worked on the Q quality factor. This work was so important that Richter invited him to work at Caltech.

This interest on the behavior of rocks and soil would be retaken in later years (1962, attenuation), (1971, creep, microfractures), and after the destructive Michoacán, Mexico, earthquake of 1985, he studied the non-linear behavior of clays (1987, 1995, 1999, 2004), and the existence of seismic gravity waves in sediments (1970, 1989, 1990, 1991, 1996, 2000). He recognized thet surface waves were a major factor in causing damages and wrote several papers about surface waves (1970, 1991, 2008).

Together with waves in sediments, he was interested in waves in general, and he discovered the plate waves generated by the 1980 Huahuapan de León earthquake (1982, 1985), waves that may have played an important role in the 1985 catastrophe in Mexico City, together with the liquefaction and non-linear effects mentioned above (2002).

Perhaps because in 1964 he became director of the seismic network of the University of California, Berkeley, in northern California, Cinna was interested in seismic networks, and one of his larger achievements was the creation of the Mexican Continental Aperture Seismic Network (RESMAC), which was a state of the art, digital, telemetered network with stations designed and built in the Institute of Research on Applied Mathematics and Systems (IIMAS), UNAM (1975-1976). This network was later transferred to the Institute of Geophysics (IGF), UNAM, and was integrated with the Mexican Seismological Service Network (SSN). He also participated, with Jim Brune, in the creation of the Gulf of California Seismological Network (1976,1970), now operated by CICESE. Finally, due to his interest in the response of the sediments in the valley of Mexico, he installed a seismic network in the sediments of the Texcoco basin (1996, 1999, 2002, 2004, 2005, 2006).

Together with seismic networks, Cinna was interested in the associated problem of earthquake location. He worked on travel-time anomalies, a quadratic regression method for estimating epicenters, and explained a systematic error in the Jeffreys-Bullen travel-time tables (all in 1969), he questioned the accuracy of travel-time tables, and the effects of lateral inhomogeneity (both in 1971), and developed schemes for hypocentral location (1977 three papers, 1980). He considered the overparametrization of location algorithms (1980), stated an uncertainty principle in earthquake locations (1982), wrote about "how not to locate earthquake epicenters" (2001), and stated three theorems in earthquake location (2006, 2008).

To Cinna every large earthquake was an opportunity to find new things about the earthquake cycle and the earthquake generation process; he studied every large earthquake that occurred, mostly in North, Central, and South America. He studied the 1958 Maipo valley earthquake (1960, 2015), San Salvador 1965 (1966), Peru 1966 (1968), Peru 1970 (1970, 1971), Santiago 1647 (1983), Huahuapan de León, Mexico, 1980 (1985), Popayán, Colombia, 1983 (1985), Michoacán, Mexico, 1985 (1985, 1986, 1990, 1995). He explored the triggering of earthquakes by seismic waves (1966).

Cinna was one of the first seismologists to accept the Plate Tectonics paradigm, and he contributed several papers on the subject: seafloor spreading in Chile (1969), ocean-continent interaction in Mexico and Chile (1971), tectonics of the gulf of California (1970), a discontinuity in subduction zones (1972), and, of course, his book on "Earthquake Tectonics and Seismic Risk" (1974). He was interested in knowing the structures of the active tectonic zones where earthquakes occurred: Andes (1962), California (1967), Mexico and Chile (1971), southern Mexico (1975), Oaxaca, Mexico (1986).

Possibly Cinna's most important contributions were on the field of seismic hazard and forecasting, as shown by his books Global Tectonics and Earthquake Risk (1974), Seismic Risk and Engineering Decisions (1976, 1981), and Fundamentals of Earthquake Prediction (1994). Although he was a good friend of Sergei Fedotov the originator of the seismic gap concept, he had a very critical position about seismic gaps (1979); and we found that seismic gaps could appear by chance with a significant probability (1983). Cinna knew that argumentation is good for science, and liked to make statements that would evoke strong responses; an example is his paper on seismic gaps "What is a gap?" (1982), and he had a wonderful knack for finding, even in the most vitriolic criticism to his papers, something that supported his claims; an example is his answer to a paper that criticized the above mentioned paper: "I am grateful to Habermann et al. for providing another illustration of my claim that the concept of seismic gaps is confusing" (1983).

An important tool of seismic forecasting is statistical seismology, and Cinna contributed amply on this subject; his first contribution was an observation that the mean magnitude is stable through an aftershock episode (1960). Cinna was well aware of the need to consider the stochasticity in the earthquake process and was one of the first to consider Poisson-distributed processes with Gumbel type distributions for the largest magnitudes (1966 two papers, 1973). He found evidence that transitions of seismicity in neighboring regions are not completely random (1967). Introductions to the statistical aspects of seismic forecasting can be found in his books Global Tectonics and Earthquake Risk (1974), Fundamentals of Earthquake Prediction. (1994), and Seismic Risk and Engineering Decisions (with Emilio Rosenblueth, 1976). In this respect, another of Cinna's contributions was the siring of his son Jorge Lomnitz-Adler who died prematurely after a dazzling career in which he made several important contributions on his own and with Cinna (1978, 1979, 1981, 1982). Although fully aware of its limitations (1996, 2002), Cinna was a firm supporter of earthquake forecasting (1988), and was willing to consider efforts in this respect (1988, 2006).

Being a philanthropic person, Cinna was very much concerned about the disastrous aspects of large earthquakes, and wrote extensively on this subject (1970, 1997, 2001, 20012); he was particularly concerned about the siting of nuclear plants (1981, 2005). Before the 1985 earthquake Cinna was already worried about the risk in Mexico City and during a trip to Japan he searched for support for an institution devoted to disaster prevention; after the 1985 earthquake, his efforts resulted in the creation of the National Center for Disaster Prevention (CENAPRED). Cinna was concerned about the fact that the most probable interval before a large earthquake was zero!, so that we wrote about how an exponential interval distribution should be interpreted (2015). Cinna was productive to very end, as evidenced by a paper in which he is a co-author and is currently undergoing revision.

Other contributions of Cinna to seismology were his unselfish support to young (and callow) would-be scientists who, thanks to him, were given the opportunity to carry out graduate studies at renowned institutions, and his labors as editor of Geofísica Internacional to which he devoted an inordinate amount of time and effort.

In conclusion, it can be said without doubt that if Mexico gave Cinna a home and an environment in which he could flourish, he more than repaid it with his numerous achievements and contributions. We all will surely miss him.

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Ensenada, Baja California, Mexico