

Harmony of deterministic and stochastic approaches in seismology and volcanology: Dream Forever of late Prof. Keiiti Aki

Kiyoshi Yomogida[1]

[1] Earth and Planetary Sci., Hokkaido Univ.

This presentation covers my personal prospects of the great contributions of late Prof. Keiiti Aki, who passed away on 17 May 2005 at the age of 75, and their developments at present and in future. Because of several other presentations in this special session, this focuses on those that are uncovered by them.

Two books that he read at his youth seem to have affected his fundamental style of researches in his life: Wiener (1947) and Ewing, Jardetzky & Press (1957). It was in the 1950s that the classic seismology had been just established based on a one-dimensional earth model and a point source model by Jeffreys, Gutenberg, Bullen, Richter and so on. He was seeking a new kind of science, and found some hints in the two books. From Wiener, he learned how to find useful information from apparently random data, recognizing the importance of stochastic approaches. His first work was the estimation of underground structure with microtremors recorded by a small seismic array. This made him interested in volcanic tremors and seismic explorations.

The book of Ewing et al. was linked with his encounter of Dr. Press at California Institute of Technology where he worked as a postdoc. He repeatedly mentioned his deep impact when Dr. Press showed him a beautifully dispersed surface-wave record. It was the exact time that he believed in the applicability of deterministic approaches to seismology. He immediately obtained important results of earth structure and seismic source as a fault motion (double couple force). The most famous was the first measurement of seismic moment for the 1964 Niigata earthquake. His researches on structure were extended to the implication of transverse anisotropy beneath Japan. It is amazing that he considered it because transverse anisotropy is still the key issue in dynamics of the solid earth. He devised a method to measure surface wave phase velocities with multiple stations. Due to the recent deployment of very dense seismic networks such as Hi-net, this approach is revived as a powerful tool.

The mainstream of deterministic approaches was the synthesis of seismograms with a one-dimensional earth model and a finite fault model as well as the comparison with data after low-pass filtering. His deterministic approaches, however, went far beyond it. He attached the problem of lateral heterogeneities, still a main issue in seismology, including response of irregular interfaces as well as free oscillations. He studied near-fault strong motion data of the 1966 Parkfield earthquake, because he knew complex path and site effects and source effects can be revealed only by that kind of seismic data. This provided the first firm bridge between seismology and earthquake engineering. Referring to exploration studies, on the other hand, he developed many new ideas, such as detection of free oscillation peaks by stacking and seismic inversion problems, including travel-time tomography and moment-tensor inversion of surface waves. In the field of fault mechanism, he initiated source dynamics based on stress on a fault and fracture criteria.

Later in his life, he observed that the deterministic approaches had been developed smoothly by many researchers, and decided to concentrate himself on stochastic approaches in which many unsolved problems remained. Of course, he had made much progress in these approaches, such as scaling-law of seismic sources only with the assumption of similarity among earthquakes. The seismicity pattern follows power laws, implying its non-linearity, excluding the impossible of prediction in any conventional manners. This did not disappoint him but excited him that a completely new branch of science named 'forecast' is ahead with seismology and volcanology as its pioneers. This contribution to society was indeed his ultimate dream. In order to partially fulfill this dream of him, we must seek for the harmony of deterministic and stochastic approaches as the key of its success.