Evolution of strong motion seismology in this quarter century: From specific barrier model to strong motion prediction recipe

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The late Dr. Keiiti Aki had established the foundation of the strong motion seismology in early 80's, which was the starting point of its everlasting evolution for a full quarter century thereafter. According to the late Dr. Aki, there were three important results contributed to the establishment. First is the validity of the kinematic model proved by the observed record at Parkfield. Second is the site characteristic evaluation for a horizontally heterogeneous structure. Third is the proposal of the scaling law of omega-square model and the so-called specific barrier model. The late Dr. Aki's approach always started from the analysis of observation, then went to the model construction by his unrivaled physical intuition, and ended by the verification of hypothesis, which was also applied to strong motion seismology.

The first result comes first from the simulation by the Haskell model in the infinite medium by Aki (1968), and was fortified later by Bouchon and Aki (1977) and Bouchon (1979). This first validation was the origin of all the subsequent development of source inversions. Research on the source inversion went to the heterogeneous source process quickly, and through the experience of the San Fernando earthquake of 1971, and the Imperial Valley earthquake of 1979, reached the golden age of the source process inversion in late 80s and 90s.

The second result also started in Aki and Larner (1970) almost at the same period. Even the calculation of the Aki-Larner method was not easy and the Aki team also carried out comparative study by using a two-dimensional finite difference method (Boore et al., 1971). This was also a forerunner for today's flourishment of the finite difference method. After basin-induced surface waves were observed simultaneously in Japan and the U.S. in 1975 and later proved theoretically by Bard and Bouchon in 1980, the importance of the basin effects was gradually recognized. When the Michoacan, Mexico earthquake happened in 1985, the world's researchers noticed the very long, monotonous later phase observed inside the Mexico City basin. Although the cause of the later phase haven't been settled yet, the basin-induced surface waves has been attracting researchers' interest ever since. The validity of theory has been verified in many basins as long as a detailed basin structure is constructed.

The third result originally came from Aki (1967). The feature of this problem was the stochastic aspect of the source and hence its primary target was a source spectrum, not a waveform. The biggest question from late 70s to early 80s was how to fill the gap between the global stress drops (long-period spectrum) and the local stress drops (short-period spectrum) in a scaling law. Aki (1979) tried to explain the source heterogeneity by the barrier model, and then proposed the specific barrier model in Papageorgiou and Aki (1983), in which they tried to establish the scaling law of all the microscopic parameters. The research on the asperity model was advanced in parallel by Das and Madariaga, and then it was proved that the multiple asperity model can also fill the spectrum gap as the specific barrier model (Boatwright, 1988, Aki, 1992).

The inconsistency of the first deterministic model and the third stochastic model was resolved by the great success of the empirical Green's function method (Irikura, 1986). It is shown that the characterized source model simplified from the heterogeneous source of the inversion can reproduce observed strong motions quite wel (e.g., Kamae and Irikura 1998). Now the strong motion prediction recipe is proposed (Irikura and 2005), in which both the macroscopic and microscopic parameters of the source are systematically defined, and its practical application has already started. We believe that almost all the aspects of the recipe have the origin in the strong motion seismology started by the late Dr. Aki one quarter century ago.