***Imperial Prize and Japan Academy Prize to:***

Kazushige Obara
Professor, Earthquake Research Institute,
The University of Tokyo

for "Discovery of Deep Low-Frequency Tremor at Subducting Plate Interface and Development of Slow Earthquake Seismology"

***Outline of the work:***

The research achievement of Dr. Kazushige Obara is summarized as the discovery of a new type of earthquake phenomenon called a "slow earthquake" and the subsequent creation of a new research field known as the "science of slow earthquakes." Similar to an ordinary earthquake, a slow earthquake is caused by fault slip; however, the fault slip speed in the latter is much slower than that in the former.

Dr. Obara was responsible for constructing a data acquisition and processing system for the high-sensitivity seismograph network (Hi-net) deployed by the National Research Institute for Earth Science and Disaster Prevention (NIED) after the 1995 Hanshin–Awaji Great Earthquake Disaster. Based on the daily monitoring of continuous seismograph data obtained from 800 seismic stations to verify the status of the system, Dr. Obara found a strange seismic tremor lasting for a long time with a very weak amplitude and a dominant frequency component lower than that of an ordinary earthquake. This tremor is now known as a "deep low-frequency tremor."

Given that the usual detection and location method for ordinary earthquakes cannot be applied to the tremor analysis because of the lack of clear P or S wave, which are usually associated with ordinary earthquakes, Dr. Obara conceptualized a new method to detect and locate tremors. This new method is based on the cross-correlation analysis of the envelope shapes of seismic signals observed at many pairs of neighboring stations. Dr. Obara then clarified the source distribution of the tremor along a length of 600 km parallel to the strike of the subducting Philippine Sea Plate in southwest Japan. The most impressive point is that the tremor is at the downdip edge of the Nankai megathrust earthquake's anticipated rupture area. Therefore, the tremor is expected to be related to the occurrence of a major earthquake. The paper published in *Science* in 2002, which discussed the discovery of the tremor, has had a significant impact on the global solid Earth science community. Following its publication, surveys of tremors were initiated in many locations across the world.

After the discovery of the tremor, Dr. Obara worked on finding other related phenomena associated with the tremor by cooperating with young researchers. In the process, he successfully discovered a short-term slow slip event, which had a very slow speed slip at the plate interface with a duration of several days, along with deep very low-frequency earthquakes with a dominant period of several 10-s bursts. These slow earthquake phenomena occurred simultaneously

in space and time, and their focal mechanisms were estimated to be reverse faulting along the plate interface. Because these phenomena are all characterized as fault slips with slower speeds compared with ordinary earthquakes, they are included in the "slow earthquake" family. In other words, Dr. Obara succeeded in identifying various members of slow earthquake phenomena and elucidating an entirely new perspective on slow earthquakes.

Moreover, Dr. Obara discovered a shallow, very low-frequency earthquake at the shallower side of the megathrust seismogenic zone along the plate interface near the Nankai trough. This finding indicated that the Nankai major earthquake seismogenic zone is sandwiched by shallow and deep slow earthquakes along the dipping plate interface. When slow earthquakes occur, the stress at the slow earthquake source area is released but is then built up at the major earthquake source area. Therefore, slow earthquake activity might be related to the occurrence of large earthquakes. For 20 years since the publication of the first paper on the discovery of tremors in 2002, Dr. Obara and his co-authors have published seven significant papers in *Science*. These research results are applied to disaster mitigation policies formulated by the Japanese government for the coming Nankai trough major earthquake.

Theoretically speaking, the discovery of several types of slow earthquakes by Dr. Obara drastically changed our perceptions of earthquakes. Based on the new image of earthquakes derived from Dr. Obara's work, the newly created research field named "science of slow earthquakes" is expected to deepen our understanding of the earthquake phenomenon through multidisciplinary and interdisciplinary approaches.

Based on his outstanding contributions to science and research, Dr. Obara has received several awards from Japan, including the Seismological Society of Japan Award in 2018 and the Medal with Purple Ribbon in 2022. He also received distinctions from the US scientific community, including being recognized as an American Geophysics Union Fellow in 2013 and a Gutenberg Lecturer by the American Geophysics Union in 2015.

## List of Main Publications


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