Earthquake Studies of the Active Geosphere: Faulting, Seismic Structures, and Tsunamis"

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1. INTRODUCTION

The Kyoto University Active Geosphere Investigations for the 21st Century Centers of Excellence (KAGI21) is a research and educational program that integrates a wide range of fields in geophysics. The study of earthquakes is an important part of this program and includes field investigations, laboratory experiments, and theoretical modeling. A large part of the focus of the whole KAGI21 research effort is on the role of water and observations of temperature in geophysics, and this also applies to the earthquake studies. Traditionally temperature measurements and estimates of water have not been used widely in seismological studies, so these studies represent exciting new areas of research.

2. TEMPERATURE MEASUREMENTS ON THE CHELUNGPU FAULT, TAIWAN

Following the September 21, 1999 Chi-Chi earthquake (Mw7.6), the Taiwan Chelungpu-fault Drilling Project drilled two boreholes which penetrated the fault at depths of about 1100 m in the northern part of the rupture zone. During the earthquake, this portion of the fault had a large amount of slip, 5 to 6 meters. The boreholes provided the rare opportunity to make temperature measurements in a fault zone with large slip from a recent earthquake. These type of observations are important to measure the amount of frictional heat that occurred at the time of the earthquake. To carry out the high resolution measurements, we developed borehole tools that contained quartz and platiumn resistance thermometers. Using these instruments, precise temperature measurements were recently carried out in one of the boreholes from March to September 2005, six years following the earthquake.

The results showed a small temperature increase (0.06°C) across the fault, which is interpreted to be representative of the frictional heat generated when the two sides of the fault move relative to each other at the time of the earthquake. In order to improve the interpretation of the temperature signature, we modeled the temperature distribution across the fault, including water flow and the spatial distribution of thermal conductivity. The modeling results imply an upper bound of the estimated heat generated by the earthquake, and indicate a very low level of friction at the time of the earthquake.

The estimated temperature and frictional heat produced during the earthquake provide information on the dynamic process of faulting. These results are used in understanding the physical mechanisms that are needed to cause the low friction on the fault that allow large earthquakes to occur.

3. 3-D STRUCTURE OF THE SLAB AND LOW-FREQUENCY EARTHQUAKES

The recent discovery of an unusual type of earthquake that contains only low-frequency seismic waves and is associated with subduction zones, has sparked interest in the structure of the subducting slab and the associated processes. These low-frequency earthquakes have been inferred to indicate water movement that is rising from the slab. Because these types of earthquakes are small and difficult to observe, their exact location relative to the subducting slab and their mechanism is still not fully known. We used a tomographic inversion to determine the P and S wave structures in the western Shikoku and Bungo Channel regions of western Japan. The velocity model clearly images the high velocity subducting slab and we can see its spatial relation to the position of the low-frequency earthquakes, which were relocated using the new 3-D model. Under western Shikoku the low-frequency earthquakes occur at depths close to the plate interface, while under the adjacent Bungo Channel region to the west, there is a clear depth separation with the low-frequency events occuring 10 to 20 km above the plate interface. Our interpretation is that the low-frequency events are occurring in a region above the slab interface. This region is characterized by a high ratio of the P-wave velocity to S-wave velocity, which may indicate the presence of water. The depth separation between the slab and the position of the low-frequency earthquakes varies depending on the region and may reflect the difference in the way the water is rising from the slab.

4. OBSERVATIONS OF THE WEST JAVA TSUNAMI EARTHQUAKE ON JULY 17, 2006

A tsunami earthquake (Mw 7.7) occurred south of Java on July 17, 2006. The event produced relatively low levels of high-frequency radiation and local felt reports indicated only weak shaking in Java. The KAGI21 International Summer School was being in Bandung, Indonesia when this earthquake occurred, so we were able to go quickly to the coastal area where the large tsunami occurred. We found that there was no ground motion damage from the earthquake but there was extensive damage and loss of life (over 600 people) from the tsunami along 250 km of the south coasts of Western and Central Java. An inspection of the area showed extensive damage to wooden and unreinforced masonry buildings that were located within several hundred meters of the coast. Since there was no tsunami warning system in place, efforts to escape the large waves depended on the reaction of people to the earthquake shaking, which was only weakly felt or not felt at all in the coastal areas.

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James Mori has been a Professor at the Disaster Prevention Research Institute, Kyoto University since 1999. His prior career experience includes, Seismologist at the Rabaul Volcano Observatory, Papua New Guinea (1984-1988), Research Seismologist with the US Geological Survey (1988-1992), Regional Coordinator for the US Geological Survey Earthquake Program in Southern California (1992-1999). He received a BA degree from Oberlin College in 1978, MA from Columbia University in 1980 and PhD from Columbia University in 1984. He has over 80 journal publications on source studies of earthquakes, earthquake hazards, and volcanic eruptions.