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V. CONCLUSION TOWARD THE KEY STONE PROJECT

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ABSTRACT

The main purpose of CRL's 5-year "Western Pacific Very Long Baseline Interferometer (VLBI) Network project" is to precisely measure the movement of the four tectonic plates under and around Japan: the North American Plate, the Pacific Plate, the Philippine Sea Plate, and the Eurasian Plate. This should help us learn how and why large earthquakes occur around the Japanese Islands, and our recent activities and achievements of the project are summarized in this special issue. The experience gained in this project provides the basis for a Tokyo Metropolitan Crustal Deformation Monitoring Program using space geodetic measurements and called "Keystone Project." This program will use both VLBI systems and Satellite Laser Ranging systems to monitor the three-dimensional displacement of four sites within the Metropolitan Tokyo region.

There are Japanese islands above the Pacific plate, the Eurasian plate, the Philippine Sea plate, and the North American plate. Because earthquakes occur very often in these islands, a VLBI network with a station on each plate should be constructed so that the relative motions of these plates can be monitored in order to obtain information that might be useful for the long-term prediction of earthquakes. We obtained a special fund from our government to construct such a network with a 30 m class antenna station at Kashima (supposedly on the North American plate) and two 10 m class antenna stations, one at Minamidaitojima (on the Philippine Sea plate) and one at Minamitorishima (on the Pacific plate).

In 1987, CRL purchased three antenna systems from USA: the 34 m antenna at the Kashima main station and 10 m and 11 m antennas for the remote islands. The 34 m antenna has a surface accuracy of 0.17 mm (rms), enabling it to be used at millimeter wavelengths. Ten low-noise radio-astronomy-frequency-band receivers (from 300 MHz to 43 GHz) are installed on the antenna, which replaced the 26 m antenna which had previously played the main role in CRL's international and domestic VLBI experiments. This 26 m antenna also has S/X band receivers and has been used for international VLBI experiments since 1984. Beside 34 m, 26 m antenna will play the important roles for international connection for our next new project. A 3 m antenna, the world smallest VLBI station, was also developed for mobile experiments. These antennas were completed in 1988, and have been the key stations for monitoring plate motion around Japan.

Our papers describe the performance of CRL's VLBI antennas and gives details of the new VLBI system including many new methods to calibrate for the accuracy of our results.

After the antenna system was checked in 1989, one antenna was transported to Minamitorishima (Marcus Reef), which is the only Japanese territory on the Pacific Plate, and the first VLBI experiment involving both Minamitorishima and Kashima was performed in July 1989. The following experiments using only the Japanese domestic VLBI network detected the clear movement of the Pacific Plate. For the Philippine Sea Plate, the 3 m antenna station was moved to and used for a

VLBI experiment with the Kashima 34 m antenna in 1990. In the same year, the 25 m antenna of the Shanghai Observatory joined in our Western Pacific VLBI Network as the reference station on the Eurasian Plate.

Space geodetic techniques such as VLBI, SLR, and the Global Positioning System (GPS) can monitor the global crustal motion or regional deformation with a precision better than a few centimeters. VLBI and GPS measure the baseline vectors, and VLBI is more suitable for longer baselines. SLR, however, measures the absolute geocentric position. VLBI and SLR play complementary roles to improve the three-dimensional precision of the global geodesy.

Based on both these progress of the space geodetic techniques and our experiences of The Western Pacific VLBI Network Project, we are now proceeding with the Tokyo Metropolitan Crustal Deformation Monitoring Program, called the "Keystone Project (KSP)," using space geodetic measurements. This project uses both VLBI and SLR to monitor the three-dimensional displacement of four sites around the Metropolitan Tokyo region. This region is on the edge of the North American Plate (or Okhotsk microplate) and also very near the boundaries of three other plates: Pacific Plate, Philippine Sea Plate, and Eurasian Plate. Thus, Tokyo region is situated above the very dangerous triple-layered structure of these three plates. It is now an urgent subject to monitor the preseismic signals of "the earthquake occurring directly under Metropolitan Area (EDUMA)."

VLBI and SLR are expected to make it possible to measure the horizontal relative displacements and the absolute vertical positions (with regard to the Earth's gravitational center) with a precision better than 1 cm, and this program will play a basic role for earthquake prediction in this area.

GPS geodetic networks now have been established mainly by Geographic Survey Institute (GSI) and the National Institute for Disaster Prevention and Earth Science (NIED). GSI and CRL have established the Metropolitan Diamond Cross (MDX) VLBI funded by the Science and Technology Agency of Japan, and two 3.5 m VLBI antennas have also been installed by GSI. These background also encouraged CRL to promote the new KSP to observe the crustal deformation around the Tokyo Metropolitan area. The Keystone Project is sensitive enough to measure both Type-1 (inner-plate earthquakes just beneath the surface) and Type-2 (occurring on the surface of Philippine Sea Plate) EDUMA in the southern Tokyo Metropolitan area and to measure Type-1 EDUMA in the northern Tokyo Metropolitan area.

Thus we will use and apply our global precise geodetic potential prepared by the Western Pacific VLBI Network to the urgent requirement for the earthquake prediction of our near-step Tokyo Metropolitan Area.