CRUSTAL DEFORMATION AROUND TOKYO AREA OBSERVED BY THE KEYSTONE NETWORK IN THE SUMMER OF 2000

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Abstract

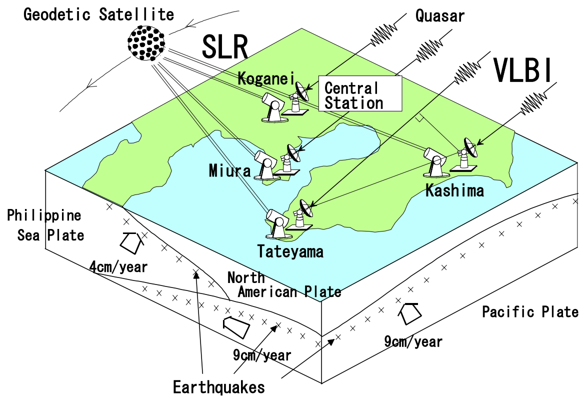
Since1996, crustal deformation has been observed at the four sites in the Tokyo metropolitan area using the space geodetic techniques. The program is named Keystone project (KSP). At the end of June in 2000, volcanic and seismic events started at Izu islands south of Tokyo. Following the event, extraordinary crustal deformation was observed not only around the Izu islands, but also at the Keystone network, where the closest site is over 100 km away from the Izu islands. Until the end of August, both the volcanic and seismic activities were high. Between Kashima and Tateyama, the baseline length changed over 2 cm/month, which is the largest change among the Keystone stations. The obtained data by real-time VLBI was provided to the related national institutes and to the public via internet. This is the first case that VLBI system observed the full process of crustal deformation together with GPS and SLR. It is explained that the crustal deformation was caused by the dyke intrusion event at Izu islands. The data was used to estimate the volcanic model.

Key Words: Keystone project, crustal deformation, real-time VLBI, dyke intrusion

１． Introduction

The Keystone Project (KSP) was planned to monitor the crustal deformation among the Tokyo area using the most advanced space geodetic techniques (Figure 1) [1]. Since1996, geodetic results have been regularly produced from the four VLBI stations using the data recording systems. The VLBI observation system is designed to be automated for a regular use [2]. Since June in 1997, real-time VLBI (very long baseline interferometry) observations started in the Keystone network based on the high speed network with the cooperation with NTT. The received data from the radio sources at each Keystone station is sent to the central station at Koganei with 256 Mbps data rate via optical fiber network for a real-time data processing [3]. At the Keystone stations, VLBI, SLR (Satellite Laser Ranging) and GPS (Global Positioning System) facilities are placed within c.a. 100 m distance. Furthermore, the GPS receivers at Koganei and Kashima are elements of the nationwide GPS network operated by the Geographical Survey Institute (GSI). As an integrated space geodetic network [4], its performance is also studied by the collocation of the systems for the future international geodetic network.

Figure 1. Network of the Keystone Project.



2. VLBI system utilizing high-speed network

The four Keystone stations are connected by an optical fiber network for a high-speed data link. The ATM (asynchronous transfer mode) communication is adopted in the KSP. The data is transferred at 256 Mbps which is equivalent to the maximum data recording rate of the K-4 system. Hence, the design of data processing system is almost the same as the one for data recording system. It is a unique system in the world. It is advantageous to the quick data delivery, the reliable operation, and the little man-power. The VLBI geodetic solution is available about 30 minutes after the last observation of the 24 hours session.

3. Crustal Deformation Observed before June 2000

It took three years to construct the four Keystone observation stations. Using a part of observation network which is completed, the VLBI test observation was conducted in 1994. Since then, the system was adjusted and improved mostly by changing the observation schedule, frequency set, recording bandwidth and reference frames. By the evaluation of repeatability for VLBI geodetic solutions, it was concluded that a 2-mm level repeatability in baseline length was confirmed [5].

By the geodetic results before June 2000, the crustal deformation due to the plate motion is clearly seen as a linear trend in the baseline length evolution of KSP network (e.g. Figure 5) .

4. Crustal Deformation Observed after June 2000

On June 26 in 2000, earthquake swarm started at the Miyake island about 150 km south of Tokyo. On June 27, volcanic activity started (Figure 2). As is depicted in Figure 3 (Courtesy Environment Information Technology Group in CRL), the large scale volcanic eruption was observed by an airborne Synthetic Aperture Radar (SAR) in X-band. The seismic activities are shown in Figure 4. It is understood the activity was high in July and August. Following these activities, we detected the extraordinary crustal deformation in the Keystone network (Figure 5). According to Koyama's estimation [6], beginning of the crustal deformation coincides with the time when the earthquake swarm began. We changed the frequency of regular VLBI observations from every two days to every day (July 22-November 11). In the baseline connected to Tateyama, length change was most significant.

Baseline length change of the Koganei-Tateyama and Kashima -Tateyama since the beginning of 2000 is shown in Figure 6 and 7.

The geodetic results obtained by real-time VLBI system was provided to the Meteorological Agency in Japan and national committees for earthquake research. Moreover, it was put on the Keystone Web site. These

Figure 2 Volcanic eruption at Miyake island (August 10, 2000). Courtesy Asia Air Survey Co., Ltd.

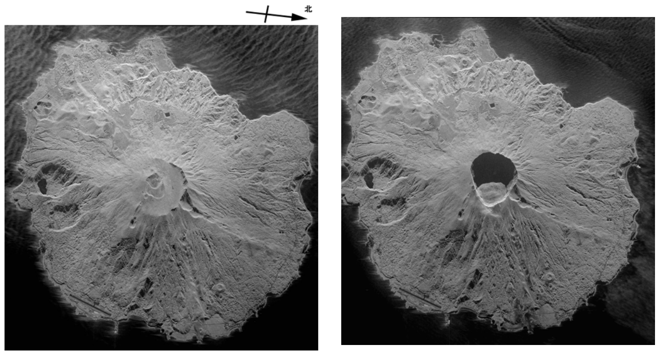


Figure 3 Miyake-island observed by an airborne Synthetic Aperture Radar (SAR) in X-band
(Left: 2000/July/6, Right: 2000/Aug./2).
Size of the crater is EW:1370m, NS:1360m, Depth:410m.

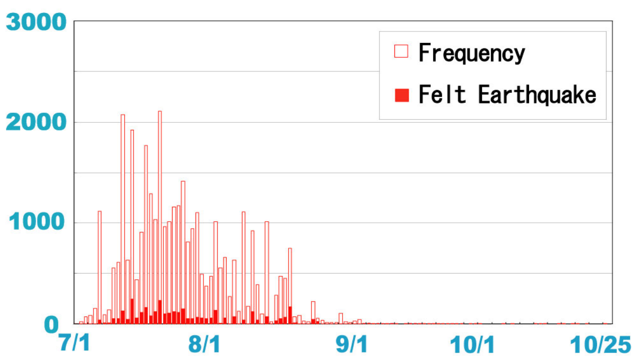


Figure 4 Frequency of Earthquakes at Miyakejima (Courtesy JMA).

results contributed to understand the status of on-going volcanic and seismic activities. The seismic activities almost stopped at September, 2000.

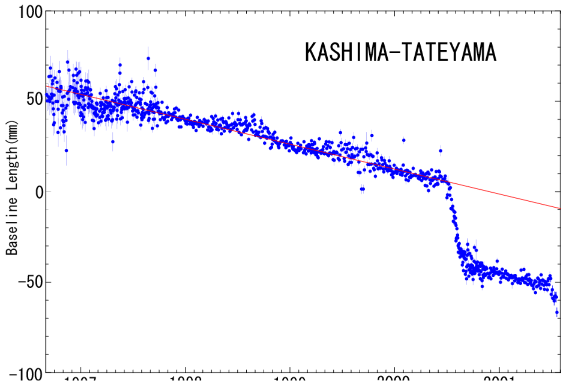


Figure 5 Baseline length between Kashima and Tateyama since 1996.

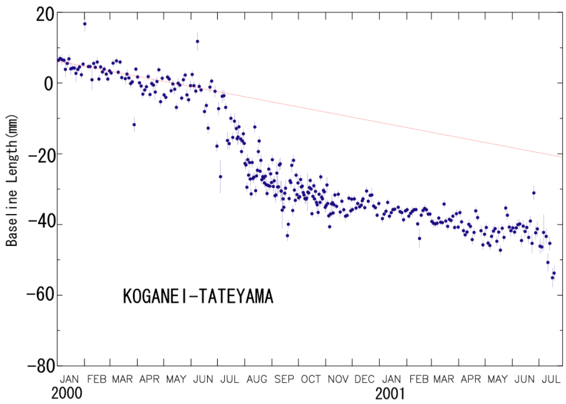


Figure 6 Baseline length between Koganei and Tateyama since 2000.

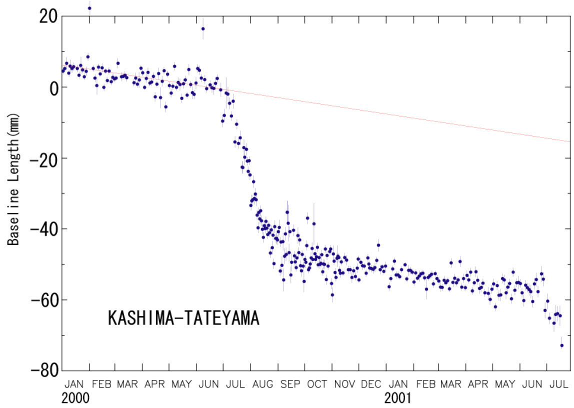


Figure 7 Baseline length between Kashima and Tateyama since 2000.

5. Interpretation

Between June 26 and September 15, the velocity of Tateyama was 2.5 cm/month and 1.5 cm/month for Miura referenced to Kashima (Figure 8). It is quite large compared to the annual velocity (1.4 and 1.3 cm/month respectively) observed in last three years. The event is interpreted as a dyke intrusion at the Izu islands. We analyzed the data referring the model parameters by Nagoya University for calculating the displacement field. Dyke width and tensile opening values are modified in this study. The data is analyzed by MICAP-G software [7] based on Okada dislocation model. Estimated parameters of Dyke is Length: 20km, Depth：3-15km, Tensile: 5m. From the estimated model, field of displacement is calculated (Figure 9). It is understood that Kashima –Tateyama baseline is most sensitive among the six baselines in the Keystone network.

6. Summary

Crustal deformation in the Tokyo area has been observed by the Keystone geodetic network since 1996. Before June 2000, crustal deformation caused by the plate motion was observed. During the volcanic event at Izu islands, crustal deformation due to dyke

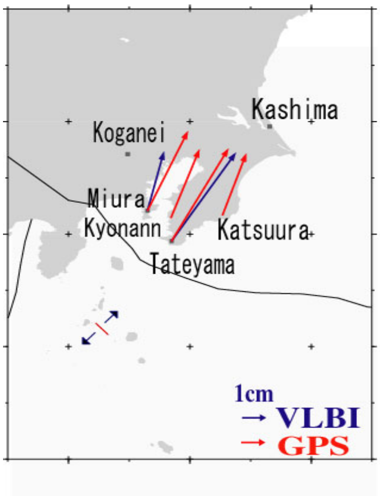


Figure 8 Site velocity after the event (June 26 – Sept. 15 , 2000)

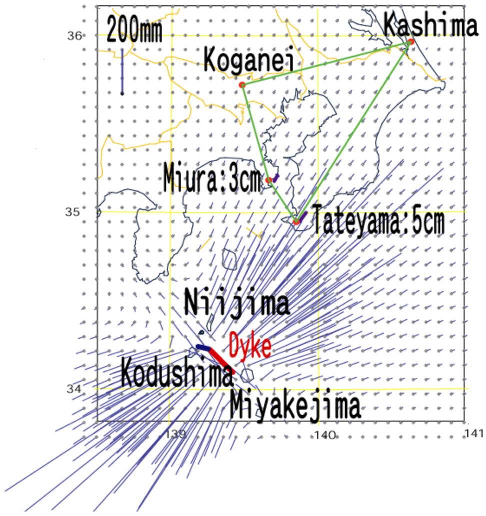


Figure 9 Displacement calculated by the estimated model.

intrusion was dominant. Full process of crustal deformation was firstly observed by the VLBI and other space geodetic techniques. It was a valuable opportunity. Monitoring of crustal deformation is continued to investigate the after-effect.

It was planned to terminate the project at the end of March, 2001 (end of FY2000) since the Keystone project is time-limited. However, we had a special event before the project termination. We received formal requests from IAG (International Association of Geodesy), IVS (International VLBI Service for Geodesy and Astrometry), Liason committee of geodesy under the Science Council of Japan, JMA (Japan Meteorological Agency), GSI to continue the observation at least one year. Hence, it is decided to extend the project one year. In spite of the above decision, Miura station was closed at the end of 2000 as we planned because the contribution of Miura was smaller than Tateyama in this event. The Tateyama station will be also closed at the end of 2001. The antenna and optical telescope of the above two stations are arranged to be transported to the Universities and other institutes in Japan for VLBI and other research works. The system both at Koganei and Kashima will be used also for the R&D experiments.

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