Kinematic GPS analysis gives new insights on the origin of the very-long-period seismic signals at Miyake-jima volcano during the caldera formation

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Miyake-jima is an active basaltic stratovolcano that is located 200km south of Tokyo, Japan. Its eruption event in 2000 was remarkable in that the large caldera was formed at the summit in approximately one month. During the caldera forming stage, very-long-period (VLP) seismic pulse waves with a duration of about 50-s that were accompanied by the step-like inflation were repeatedly recorded. Based on the broadband seismometer data, the piston model is proposed in which a vertical piston of solid materials in the conduit is intermittently sucked into the magma chamber located 3-5 km beneath the edific. In this study, we used the kinematic displacements from the continuous GPS observation to obtain additonal insights on the source mechanism of the pulse waves.

We calculated the kinematic displacements of 15 GPS stations on Miyake-jima that were in operation at that time at 30 sec interval. Then we extracted the displacements associated with each event using 20-hour time window centered at the occurrence of the event, and stacked the whole time series to obtain mean displacement time series.

The obtained time series contain: 1) step-like displacements associated with the pulse waves, 2) exponential decay following the events with time constant of approximately half-day, and 3) steady linear displacements indicating continuous contraction of the edifice. The type one displacements can be attributed to the simultaneous inflation of an mogi-type spherical pressure source located at the depth of 3.6 km under the edifice, and the opening of the nearby vertical dike whose top is at the depth of 2.3 km. The type two displacements can be interpreted as the pressure adjustment at the type one source by the outflow of the magma driven by the pressure difference between the type one source and surrounding area. The type three displacements can be interpreted as the steady outflow of the magma from the type one source.

The above results support the ``piston model" for the source of the pulse waves. However, it seems that the pressure increases by the collapse of the piston are not adjusted by the steady magma outflow as the ``piston model" suggests but by the pressure-driven magma outflow. The steady magma outflow instead seems to be responsible for the long-term shrinkage of the edifice observed at that period.