Is the subsidence of Aso Caldera after the 2016 Kumamoto Earthquake of volcanic origin?

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Following the 2016 Kumamoto earthquake, significant subsidence was found to continue within the Aso caldera. Previous studies have speculated that this subsidence was of volcanic origin, with magma or aqueous fluids migrating from a previously unknown source in response to the earthquake. However, this conclusion may be disputed because they attributed the Aso caldera subsidence to an entirely volcanic origin. Notably, it is known that the 2016 Kumamoto earthquake caused significant viscoelastic deformation as well as afterslip. Therefore, this study aimed to reappraise the subsidence in the Aso caldera by considering viscoelastic deformation, afterslip, and volcanic deformation.

In this study, GNSS data from the Geospatial Information Authority of Japan (GSI), the Japan Meteorological Agency (JMA), and the National Research Institute for Earth Science and Disaster Prevention (NIED) were used. First, we corrected the GNSS time series of steady-state crustal deformation estimated using data from non-volcanic regions. We then calculated and corrected the viscoelastic deformation associated with the 2016 Kumamoto earthquake evaluated using the viscoelastic structure of Pollitz et al. (2017) and the source fault model of Kobayashi et al. Furthermore, using the above data, we simultaneously estimated the volume changes of the spherical volcanic deformation source as proposed by Nobile et al. (2017), and the afterslip on fault planes that extend the source faults of Kobayashi et al..

Figure 1 shows the contribution of each crustal deformation source at a GNSS station in the Aso caldera. The long-term subsidence trend is explained almost entirely by afterslip, indicating that the contribution of the volcanic deformation source to subsidence is negligible. Figure 2 shows a time series of volume changes of the volcanic deformation source. The volume of the volcanic deformation source stagnated in the long term, but tends to increase a few months before the eruption and then decrease after the eruption or in the middle of the eruption sequence. It seems that the volcanic deformation source was not significantly affected by the 2016 Kumamoto earthquake, and the pre-earthquake stagnation trend has continued as it was.

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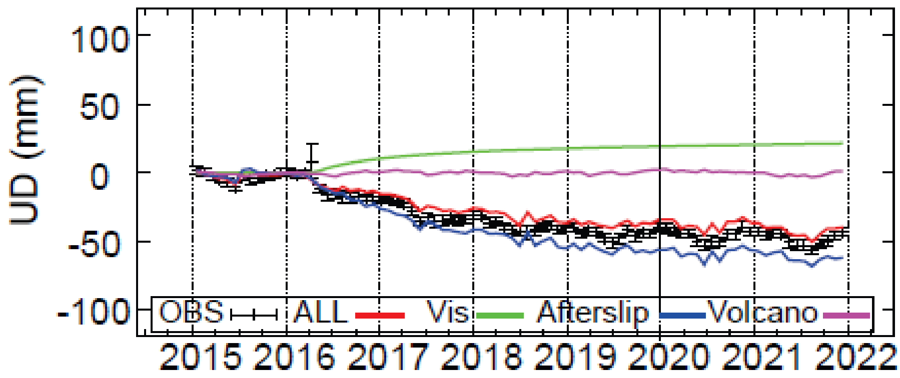

Figure 1: Vertical deformation at the GNSS station "Aso" and the contribution of each crustal deformation source. Green line indicates contribution of viscoelastic deformation, blue line indicates that of afterslip, and purple line indicates that of volcanic deformation sources. Red line denotes the sum of each contribution.

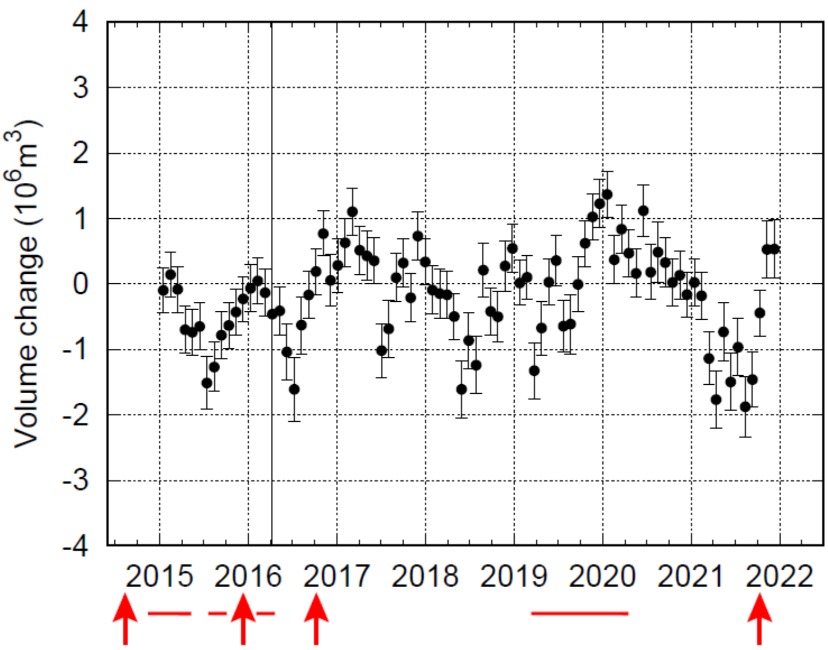

Figure 2: Estimated volume changes of the volcanic deformation source. Red lines and red arrows indicate periods of eruption.