Stress response of volcano-tectonic seismicity - tidal response (2)

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After the historical discovery that an abrupt increasing the seismicity was followed by the eruption at Usu volcano in 1910, volcanic seismicity is recognized to be one of the most reliable observations to predict volcanic eruptions. The seismicity prior to eruptions has many temporal patterns. In some cases, seismicity increases divergently just before the eruptions, and it has a quiescence in a few days before eruption in the other cases. The relation among the observed seismicity and physical conditions inside of volcanoes is still unsolved even the volcanic seismicity is well operationally used for hazard estimation of volcanic eruptions. Induvial earthquake may be partly controlled by accidental effects because it is caused by fracture of the rock. However, seismicity is a statistical value, and it thought to have a robust information to present the condition inside of volcanoes. We studied the relation among stress rate and seismicity change around volcanoes based on rate and state friction (RSF) law proposed by Dieterich (1994), and found out that the seismicity can be well explained by the law in the case of the stress changes by magma storage as well as ones by the great earthquake far from volcanoes. Furthermore, we found tidal response of volcanic seismicity at Izu-Oshima volcano. In this presentation, we will present the results of statistical test and tidal response changed in 2013.

Schuster’ s test is well used for testing the tidal response of seismicity. It is based on the 2D random walk theory. Firstly, we use this test to demonstrate the seismicity correlate with earth and ocean tide. In this method, absolute value of stress generated by tide is not considered and we applied chi-square test as follows. Bins of tidal stress value is dived as that each bin has the same time interval of tidal stress ranges, the number of earth quakes in each bin (stress range) should be show Poisson’ s distribution. Whether earthquakes occur randomly or not can be checked by chi-square test.

As mentioned before, we checked the volcanic earthquakes occurring at shallow region beneath Izu-Oshima caldera during 2004 and 2016. The null hypothesis that the earthquakes occur randomly are rejected with high confidence for the earthquakes occurring after 2013, but it cannot be rejected earthquakes before 2012. Supposing various focal mechanisms for the earthquakes, the result is not changed because the normal stress component acting on fault surface is dominant. Therefore, we tentatively use the volumetric tidal stress, that is equivalent to pressure acted on the fault planes. The earthquakes after 2013 occurred when the tidal volumetric stress is near the local maxima (extension). It means that earthquakes prefer to activate in maximum condition of the Coulomb failure function.

We will discuss that temporal change of tidal response of the seismicity. At very active volcanic zone of ocean bottom in West Pacific Rise, seismicity increased when tidal volumetric stress becomes local maxima distinctly (Stroup at al., 2007). In fact, as decreasing effective normal stress acting on the fault plane becomes low, the tidal response of seismicity becomes distinct and earthquakes prefer to occur in maximum extensional tidal stress. We have found out that the volcanic earthquakes at shallow occurring beneath Izu Oshima caldera, are affected by stress changes generated by magma storage in the reservoir located at the depth of 5km. And the seismicity after 2011 was greater than the expected value calculated using RSF model. The both fact show that the effective normal stresses at fault planes decreased in 2011 or 2013, and kept low value until the present. One of the most feasible reasons of the low effective normal stress is increasing pore pressure beneath the hypocenter zone located just above estimated pressure source of magma reservoir.

Izu Oshima volcano repeats eruptions every 30-40 years, and latest eruption occurred in 1986. It passed over 30 years. The above observations probably caused by uprising of volatile component from magma

reservoir, and it makes the pore pressure at the hypocenter zone increases, and decrease effective normal stress on the fault planes of the volcanic earthquakes after 2011 or 2013. This is one of the possible precursory phenomena of next volcanic eruption. And we would like to exaggerate the volcanic seismicity is very sensitive to stress in this case.

Keywords: volcano-tectonic earthquakes , seismicity, tidal response, active volcano, volatile component

