Time Series Analysis of Volcanic Earthquakes at Satsuma Iwo island

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Satsuma Iwo island is an active volcano located in the south of Kyushu, Japan. Several types of volcanic seismic events are observed at this volcano; those are A-type (high frequency), B-type (low frequency), C-type (monochromatic) and volcanic tremor. We performed the time series analyses for the B-type earthquakes, which are characterized by low frequency seismic waves (about 1.5 Hz). The data used in this study were collected between November 2000 and July 2001 by a broadband seismometer located in 250m south of the crater of Iwo dake (the eastern part of Satsuma Iwo island). The B-type earthquakes had a nearly constant waveform throughout the whole observation period, suggesting that they occur at a fixed locality by a fixed mechanism. The average time interval of the B-type earthquakes is about 1300s, which is much longer than the duration of each event (5s). Because of the difference in the time scales (i.e. those of duration of each event and interval), the B-type earthquakes are regarded as a point process.

We statistically analyzed the time series of the B-type earthquakes from the view point of stochastic point process. The whole time series includes at least eight continuous periods in which the occurrences of the B-type earthquakes are relatively stationary. We examined each of these stationary time series on the correlation of two successive intervals of the earthquakes using Speaman's Rank Correlation Coefficient and the function form of the time interval distribution. In practice, six probability distributions are fitted to the observed histograms of the intervals of the B-type earthquakes. These probability distributions are Exponential, Weibull, Gamma, Normal, Lognormal, and Inverse-Gaussian distributions. They are known to be explained by simple stochastic processes. We used the maximum likelihood method to determine the parameters that make the six probability distributions fit the best to the observed time series of the B-type earthquakes. The goodness of fit of these six probability distributions is assessed by Akaike's Information Criteria (AIC) and several statistical tests, such as Kolmogorov-Smirnov test.

The results show that two successive intervals of the B-type earthquakes have no correlation and that Lognormal distribution is the best fit for the observed interval distribution; Exponential distribution is rejected by these statistical tests. These mean that the examined time series of the B-type earthquakes can not be regarded as Poisson process. In other words, the B-type earthquakes do not occur 'at random', but occur following some causal mechanism. The observed interval distribution shows a remarkable scarcity of interval less than 300 seconds; the probability of occurrence of B-type earthquake is smaller just after each event. These facts may indicate that it takes some time for energy causing a new B-type earthquake to be restored.