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Low-frequency seismic source for monitoring volcanic activity

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Quantitative monitoring of magma movement is essential for the prediction of volcanic eruption. In many volcanoes seismic activity and crustal deformations are, generally, used to monitor the movement of magma. They reflect the movement of magma indirectly with the change in stress due to magma activity. Recently some method are tried to monitor the change in the physical property beneath volcanoes in more direct way. For example, electromagnetic method are used to monitor the resistivity change (Utada et al. 2007), and cosmic-ray muon radiography are used to monitor the change in mass structure (Tanaka et al. 2007) beneath volcanoes.

We have tested the method using active seismic sources that have been developed under the concept of ACROSS system. The seismic sources we used so far to generate seismic wave with the aid of centrifugal force by the rotation of eccentric mass. The seismic source can generate larger forces in higher frequency because the force is proportional to the square of the rotational velocity. Generally since volcanoes are highly heterogeneous and have strong scattering nature, it is preferable to use seismic wave of lower frequency to avoid the inherent characteristics of volcanoes. Therefore we tested a low frequency linear shaker that has been developed by Kajima Corp. to check the applicability to the volcano monitoring. The linear shaker generates vibration with the linear movement of large mass that is driven by a motor. As the force is proportional to the acceleration of the mass, it can generate lower frequency much easier than a rotational source.

We deployed the linear shaker at Awaji ACROSS test site and operated for 8 days. The linear shaker has an advantage over rotational shaker in the aspect of generating low-frequency signal. However, we worried about the repeatability of signal and robustness of the system before. To clarify the problem on the practical use of the shaker to volcano field we have tested the shaker by generating various forms of signal. The signal was recorded with the seismometers in deep borehole and accelerometers near the shaker. We have assured that the shaker can be robust enough for our purpose and can produce accurate signal with good repeatability. Michishita et al. (JPGU meeting 2009) shows the methodology of volcano monitoring by means of an inversion technique, and revealed that the use of low-frequency source is feasible for the detection of magma movement in a volcanic conduit. Since the shaker is originally designed to use in test the building structure, modification of design for volcano monitoring is necessary.