A unique long-period earthquakes and swarm activities preceding the eruption at Asama volcano in 2004

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On September 1, 2004, a middle-scale eruption occurred at Mt. Asama. The first eruption occurred on 20:02 and was the largest in the volcanic activity of this time. Before the eruption, two broadband seismographs (CMG-3T) installed at east (KAH2) and west (KAC2) crater rim of Mt.Asama, and we observed unique long-period (about 5sec) volcanic earthquakes. The signals are so feeble that we can hardly recognize them even at the second nearest station from the summit crater. By means of deconvoluting the frequency characteristics of 1s period seismograph, we ascertained that the unique earthquakes had been occurring at least about a year before then, September 5, 2002.

The earthquakes have very unique waveforms and can be categorized in 3 types. Most frequently observed events have impulsive waveforms with high frequency components and upward movement (type1). The typical duration of one pulse is 3-4 s, longer duration explained as overlapping of simple plural events. We then roughly estimated the source location of the events by their particle motions. Horizontal particle motions point to the direction of the vent the first motion being outward from the vent. The depths of type1 events are very shallow just beneath the vent, about 200 meters beneath the crater summit. Very-long-period tremor followed by a relatively large high frequency event with its period becoming shorter with its attenuation observed intensively in May and June, 2004 (type2). Horizontal particle motions point to the direction of the vent the first motion being outward from the vent. Source depth is estimated to be 400 meters beneath the crater summit, a little deeper than that of type1. Some of the unique events are supposed to reflect the preparation process of coming eruption. Relatively long-period tremors with long durations and relatively small amplitudes being scarcely observed (type3). They are not monotonous in their frequency and tip of the waveform is sharp and some events are accompanied with high frequency small events soon after the point of its peak. The sharp waveform suggests that some non-linear dynamics takes part in these events. Horizontal particle motions point to the direction of the vent. Source depth is estimated to be 400 meters beneath the crater summit, the same depth as type2.

We examined the daily frequency of the type1 events, and found that the vicissitudes of the unique events are parallel to that of normal volcanic earthquakes until the beginning of July. The unique events became sporadically observed and completely ceased after August 24 while the number of normal volcanic earthquakes increased dramatically, and then Mt. Asama erupted on September 1. On the time of deviation, there observed an expansion in continuous GPS observation between two diastrophic observatory stations at the north and south of Mt.Asama [Aoki et al., 2004], suggesting that the intrusion of magma plays some role in stopping the activity of the unique events. Possible origin of type1 is the intensified pressure caused by some fluid running into somewhat space in and around the vent. The cessation before the eruption might be explained as the drying up of the fluid to cause the intensified pressure.

We selected 55 events and applied DD algorithm to get the details of the hypocenter distribution of the preceding swarm. The source distribution shows eastward inclination from the summit. On the extension line of the sources, there is the seismic source of the long-period event occurring on October 28, suggesting that a vent exists on the line. Possible process is that the long-period event on October 28 was due to a magma supply from a magma chamber around the source, and then through the vent on the line, the magma went upward to cause the following eruption. The magma supply lead to the eruption on November 14.