Long swarms and short swarms

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Many earthquake swarms at volcanoes last several months, then have a sharp uptick in rate in the hours before eruption. Examples include 2006 Augustine, 8.5 months then 10 hours; 1992 Spurr, 10 months then 4 hours; 1994 Rabaul, 1 year then 27 hours; 2008 Kasatochi, 6 weeks then 2 days; and 2011 Puyuehue Cordon Caulle, 5 weeks then 2 days. For the well studied Augustine case, broadband data showed that very long period (VLP) energy accompanied 221 of 722 located earthquakes in the 10 hours before the first explosive eruption on 11 January 2006. This was revealed by low-pass filtering and the period of the VLP signal was 50 sec. The Augustine broadband stations were campaign instruments at distances of 2-3 km from the vent. No similar VLP energy has been found in events during the 8.5 month long swarm. Okmok volcano had a short swarm only lasting 5 hours prior to its 12 July 2008 eruption. Low-pass filtering of data from broadband station OKSO, 10 km from the vent, showed that 23 of 42 located events had VLP energy with a period of 30-40 sec. Events from Kasatochi volcano were scanned on station ATKA. Here the broadband station is much farther away at 88 km but the earthquakes in the short swarm 7 August 2008 were much larger with many M>3 events. The station suffered data gaps so only a few hours of data were scanned but numerous events were observed with VLP energy starting just after the P phase. Low-pass filtering showed VLP energy with a period of 10-12 sec. No VLP energy has been found in events of the preceding 6 week long swarm. These observations at three different volcanoes suggest that the short swarms represent a different process than the long swarms. The long swarms likely reflect pressure increases in the surrounding country rock caused by increasing magma pressure. The short swarms in contrast, appear to represent discrete pulses of magma injection at shallow depths. For all three volcanoes the earthquakes looked like typical volcano-tectonic (VT) earthquakes on short-period stations. This demonstrates that broadband stations are needed at close distances to be able to make the needed observations. The short swarms are very short, a few hours to 2 days, and have important implications for hazards assessments. It is not known how commonly the long swarm-short swarm pairs occur and the false alarm rate is also not known.