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A MODEL FOR PERIODICAL SIGNALS OBSERVED AT SATSUMA-IWOJIMA VOLCANO, JAPAN

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Satsuma-Iwojima volcano is an active volcanic island located south of Kyushu, Japan. Huge amount of volcanic gas has long been emitted from the summit crater. Ash eruptions from the summit crater and high fumarolic activity in the summit area suggest an existence of shallow hydrothermal system and magma body.

A broadband seismic observation conducted at Satsuma-Iwojima in 1997 reveals unusual features in the seismic activity in the island. The most interesting feature in the broadband seismic data is an existence of highly periodical signals in various frequency bands. In the intermediate frequency band of 1-40Hz (IMF), the periodical feature appears as an amplitude modulation of volcanic tremor. The amplitude modulation consists of alternately increasing and decreasing phases. The increasing and decreasing phases last roughly 15 min and 30 min, respectively. In the frequency band higher than 40Hz (HF), a periodical amplitude modulation is also seen but in different manner. The amplitude modulation in HF band is perfectly synchronized with the amplitude modulation in IMF band but is characterized by an abrupt amplitude increase followed by gradual amplitude decay. The amplitude decay period lasts about 15 min. In the frequency band lower than 0.2Hz, very-long-period (VLP) seismic pulses are observed. The occurrences of VLP pulses are synchronized with regular amplitude modulations in IMF and HF bands. These VLP pulses have pulse width of roughly 5 sec and all the pulses have almost identical waveforms. The amplitude modulations in IMF and HF bands and the occurrence of VLP pulses are perfectly synchronized and have fairly regular intervals of 46-50min suggesting a spatially fixed and undestructive repetitive seismic source.

We perform waveform inversions to investigate the source mechanism of the VLP pulses assuming a point source embedded in a medium with a realistic topography of the volcanic edifice. The results of the waveform inversions indicate that the observed VLP pulses are well explained by the rapid expansion of an inclined cylindrical source beneath the summit crater at the very shallow part with seismic moment of 10^11 Nm.

We propose a model consisting of a water pocket just beneath a shallow aquifer and a narrow path that connects the water pocket to the ground surface. Water is supplied from the aquifer above through low permeable rock surrounding the pocket. The pocket and the path to the surface are connected through a valve. The pocket is heated by magma or high temperature volcanic gas.

Occurrences of VLP pulses correspond to sudden vaporizations of overheated water in the pocket. Sudden pressure increase due to evaporation in the pocket opens the valve and initiates outflow of vapor from the pocket. This corresponds to the outbreak of HF tremor. Vapor flow through narrow constricted path excites HF tremor. Once the pressure in the pocket reduced to the certain level, the valve is closed and the outflow of the vapor is terminated. The envelope of the IMF tremor consists of two curves. A convex curve to facing upwards lasting for 15 min followed by a convex curve facing downwards lasting for 30 min. This characteristic is seen in an electric circuit consisting of a resistance and a condenser when a pulse shaped voltage is imposed on the circuit. If we consider that the pulse-shaped voltage, the resistance and the condenser correspond to the pressure imposed on the narrow path, the path with narrow constrictions and a small gas pocket along the path, then the characteristic envelope of tremor amplitude modulation in IMF band is explained. Repetition of above-mentioned process explains the periodicity seen in the seismic data.