Ground Deformation Cycles in a Magma-effusive Stage, Sub-Plinian and Vulcanian Eruptions at Kirishima Volcanoes, Japan

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Volcanoes display several kinds of explosive eruptions, such as Plinian, sub-Plinian, Vulcanian, and Strombolian. The dynamics of explosive eruptions is one of most fascinating subjects in volcano physics. The Kirishima volcanoes lie at the southern rim of the Kakuto caldera in the southern part of the Kyushu Island and consist of twenty small andesitic stratovolcanoes and pyroclastic cones. The Shinmoe-dake volcano, one of pyroclastic cones, started a magmatic eruption at 15:29 (JST) on 26 January 2011. During the early period of volcanic activity at the Shinmoe-dake volcano in 2011, sub-Plinian eruptions, a magma effusion, and Vulcanian eruptions, occurred sequentially. The initial period from 26 January to 10 February could be divided into three stages: a sub-Plinian stage (26-27 January), a magma-effusive stage (28-31 January), and a Vulcanian stage (1-10 February). A different kind of tilt motion accompanied each stage. Here, we clarify the characteristics of the tilt motions and of their time sequences, presenting a new image of triggering process of Vulcanian eruptions. The sub-Plinian and the Vulcanian eruptions at the Shinmoe-dake volcano were preceded by inflations at shallow depths near the summit. The inflation-deflation cycles were also recorded during the magma-effusive stage with a typical period of one hour, synchronized with volcanic tremors or long-period events. Almost all Vulcanian eruptions were preceded by trapezoidal inflations, whose durations systematically lengthened as time progressed, and were followed by various time sequences of tilt motions, which became progressively more complicated throughout the frequent Vulcanian eruptions. In spite of the complicated time sequences of the preceding inflations, we have revealed the clear linearity with a constant gradient of 0.45 between the logarithm of the preceding durations versus elapsed time for each sub-stage. These observations can be consistently explained based on the assumption that a Vulcanian eruption is induced by a catastrophic rupture of the closed magma frame due to overpressure caused by magma degassing, and the degassing from magma declines exponentially with time.