Seismic characteristics of the Hekla volcano and its surroundings, Iceland

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Abstract — The volcano Hekla is located in south Iceland at the junction of a transform segment, the South Iceland seismic zone, and a ridge segment, the Eastern volcanic zone, of the mid-Atlantic plate boundary. Hekla is one of the most active volcanoes in Iceland, with at least 18 eruptions during the last 1100 years. In recent decades it has had relatively small eruptions, approximately once in a decade, most recently in 1991 and 2000. During non-eruptive periods Hekla is virtually aseismic, and does not give long-term or intermediate-term precursory warnings before its eruptions. Eruption-related seismicity starts 25–80 minutes before its onset. Hundreds of small volcano-tectonic earthquakes (magnitude < 3), related to magma intrusion, occur during the first hours when the eruption is violent and explosive. This seismicity soon diminishes, along with the eruptive activity. Subsequent eruptive activity consists mainly of lava effusion and occasional gas bursts associated with very few earthquakes. Volcanic tremor, continuous low-frequency vibration of the ground, starts simultaneously with the eruption, and continues throughout it. It is most vigorous during the explosive onset, and decreases along with the eruptive activity. The few earthquakes at Hekla and its immediate vicinity during non-eruptive times are small (magnitude < 2), and apparently not related to the Hekla volcano itself. They follow a distribution similar to the events of the South Iceland seismic zone. They form two north-south lineaments analogous to the seismic zone faults, and occur mainly at depths of 8–12 km. Thus seismically the Hekla area has a dual nature: on one hand the seismicity is ruled by the tectonics of the South Iceland seismic zone, and on the other hand by the internal processes of the volcano. Transform zone tectonics dominate during the non-eruptive periods. The volcano-related seismicity of Hekla is almost exclusively associated with eruptions. Volcanic tremor has never been recorded during non-eruptive periods.

INTRODUCTION

The two most recent eruptions of Hekla occurred in January 17–March 11, 1991 and February 26–March 8, 2000. These events produced a rather similar amount of eruptives of basaltic-andesitic composition, 0.15 km³ (Guðmundsson et al. 1992) and ~0.2 km³ (Höskuldsson et al. submitted), respectively. Both eruptions had a short-lived initial Plinian phase and were most vigorous in the first hours. Effusion of lava began at the same time as the explosive activity, or shortly after. Initially, large segments of fissures were active, but the eruptions became more localised during the later phases. In both cases, lava production was largest during the first days of activity. Seismically, the eruptions were very similar. No long-term precursory seismicity was detected. The onset of each eruption was accompanied by an initial swarm of hundreds of small volcano-tectonic earthquakes (Mₜ < 3) which increased in magnitude towards the onset of the eruption, few earthquakes in the later phases and continuous low-frequency volcanic tremor with dominant frequencies at 0.7–0.9 Hz (Soosalu and Einarsson 2002; Soosalu et al. 2003, 2005).