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Indications of subsurface mass movement in the Katla volcano in Iceland during 1997-2007, revealed by evolution of earthquake locations and geothermal activity within the caldera, as well as crustal deformation around the caldera rim.

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Katla is an ice covered volcano in South Iceland, located at the southern end of the Eastern Volcanic Zone. It is one of Iceland's most active volcanoes, with 1-2 eruptions per century. With the latest volcanic eruption occurring in 1918, the volcano is considered due for another eruption. During seismic recording history in Iceland, which spans over 50 years, the volcano has been seismically active and since the installation of the national digital seismic network (SIL) in 1991, over 14 thousand earthquakes have been recorded. Most of the seismicity is located under the volcano's western flank, but nearly 3 thousand of the earthquakes originate withinin the caldera itself. Improved location accuracy of the caldera seismicity and it's temporal relation to observed geodetic signals around the caldera, as well as to subglacial geothermal activity manifested in depressions (ice cauldrons) on the ice surface is the focus of our research, and our contribution to the study of mass movement in volcanoes within the VOLUME project.

Although improving through time, location accuracy of most events in Katla has been rather poor. This is due to noisy conditions at the nearest seismic stations, emergent onsets of arrivals, high attenuation along some paths and sparcity of recording sites

during the first half of the SIL period. With the increasing number of stations located within 30 km distance, lateral location accuracy has improved somewhat, but vertical locations have remained higly inaccurate, with the majority of the events clustering at the surface. The main cause of this inaccuracy is the inappropriateness of the standard velocity model (SIL) used for the locations. An improved velocity model is constructed by combining the lower crustal part of a well determined model for wave propagation in south Iceland with an average of the velocity structure obtained for the upper crust in the caldera. In this model, location accuracies improve drastically and events are distributed throughout the crust. 1500 events from the caldera, with clear phases and good signal to noise ratios are selected for re-picking of arrival times and subsequent relative location.

Temporal evolution of the relocated seismicity shows greatly increased seismicity during 2002-2004, with activity peaking in 2002. Furthermore, spatial distribution of the activity suggests that a small influx of magma may have occurred in 1998, when seismicity, extending from 20 km depth to the upper crust, is confined to a rather small region in the NE part of the caldera. The following two years, the seismicity is moderate, but increases dramatically in 2002, when the earthquakes fall under the NE caldera rim, as well as along an apparent N-S line through the center of the caldera and again extending into the lower crust. West of this line, hardly any earthquakes are located in the 2-5 km depth range. Seismic activity decreases somewhat in 2003 and 2004, but the same pattern prevails; hardly any earthquakes are in the 2-6 km depth interval in the western half of the caldera. During 2005-2007 seismicity continues to decrease, and the aseismic region is preserved.

The increased seismic activity coincides with a period of expansion shown in GPS observations around the caldera, where horizontal and vertical expansions of up to 2 cm/yr were observed during 2001-2004 and subsequently modeled by a Mogi source around 5 km depth in the NE part of the caldera. The location is approximately at the bottom of the aseismic region, but approximately 2 km east of it.

Areas of increased geothermal activity are revealed by ice cauldrons on the glacier surface, due to icreased ice melting underneath. Several such cauldrons are located within the Katla caldera. Profiles crossing the main depressions have been monitored twice a year since 1999, by radar altimeter from aircraft. The profiles reveal cauldrons forming, increasing and decreasing during the period. The year following the possible magmatic influx as revealed by seismicity in 1998, three cauldrons formed on the ice surface, one of which drained in a sudden glacial flood in July 1999. Overall the cauldron developments indicate increased geothermal output within the caldera during 2001-2003, and somewhat increased during 2003-2005, in general agreement with the seismicity. In addition some of the cauldrons along the NE caldera rim are associated with spatial clusters in the seismicity.