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Continuous deflation and plate spreading at the Askja volcanic system, Iceland: Constrains on deformation processes from finite element models using temperature-dependent non-linear rheology

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Iceland is located on the mid Atlantic ridge, where the spreading rate is nearly 2 cm/yr. The high rate of magmatism in Iceland is caused by the interaction between the Iceland hotspot and the divergent mid-Atlantic plate boundary. Iceland hosts about 35 volcanoes or volcanic systems that are active. Most of these are aliened along the plate boundary. The best studied magma chamber of central volcanoes (e.g., Askja, Krafla, Grimsvötn, Katla) have verified (suggested) a shallow magma chamber (< 5 km), which has been model successfully with a Mogi source, using elastic and/or elastic-viscoelastic half-space. Maxwell and Newtonian viscosity is mainly considered for viscoelastic half-space. Therefore, rheology may be oversimplified. Our attempt is to study deformation of the Askja volcano together with plate spreading in Iceland using temperature-dependent non-linear rheology. It offers continuous variation of rheology, laterally and vertically from rift axis and surface. To implement it, we consider thermo-mechanic coupling models where rheology follows dislocation flow in dry condition based on a temperature distribution. Continuous deflation of the Askja volcanic system is associated with solidification of magma in the magma chamber and post eruption relaxation. A long time series of levelling data show its subsidence trend to exponentially. In our preliminary models, a magma chamber at 2.8 km depth with 0.5 km radius is introduced at the ridge axis as a Mogi source. Simultaneously far field of rift axis stretching by 18.4 mm/yr (measured during 2007 to 20013) is applied to reproduce plate spreading. Predicted surface deformation caused of combined effect of tectonic-volcanic activities is evaluated with GPS during 2003-2009 and RADARSAT InSAR data during 2000 to 2010. During 2003-2009, data from the GPS site OLAF (close to the centre of subsidence) shows average rate of subsidence 19±1 mm/yr relative to the ITRF2005 reference frame. The MASK (Mid ASKJA) site is another GPS station at the top of predicted centre of magma chamber correlates well with OLAF site at 500 m distance from MASK. Average subsidence rates derived from GPS measurements show comparable rate derived from InSAR data. Velocities derived from InSAR show that the yearly maximum subsidence rates in the Askja caldera decrease linearly. The optimized pressure decrease in the magma chamber from the model follows an exponential decay, with P (MPa) = 2.0177 EXP(-0.0176x), where x is the numbers of years (1,2,3 .. 10). However total ramp pressure drop during this period (10 years) is 4 MPa and additional 4.68 MPa pressure drop may be caused of rheological relaxation.