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Thermal perturbation, mineralogical assemblage and rheology variations induced by dyke emplacement in the crust

Alessio Lavecchia
Simula School of Research and Innovation, Fornebu, Norway (alessio@simula.no)

Our model consists of a two-dimensional physical model simulates the thermal perturbation induced by a sequence of basaltic dykes along a crustal section. Each dyke has a thickness of 1 km, a length equal to the minimum crustal thickness and an initial temperature of 1200 °C. The model assumes a temperature-dependent thermal conductivity throughout the crust; while radiogenic heat production is expressed by an exponential decay law. One dyke intrudes every 1 Myr, reaching a maximal thickness of 10 km at 10 Myr, similar to dyke sequence thicknesses registered in rift areas, such as in the Afar.
We find peaks in the thermal perturbation of the crust in our model at the emplacement of the first dykes and have a diminishing effect subsequently, with almost no effect after reaching approximately 5 km of thickness. The thermal peaks are reached faster in the upper crust than in the lower crust and have a sharper cooling profile. It testifies the heat retention in the lower crust and suggests that metamorphic reactions are favoured here. Temperature reached exceeds the muscovite and biotite dehydration points in the lower crust, likely allowing an extensive crust partial melting. The thermal perturbation becomes negligible after ≈5 Myr in the lower crust and after ≈6 Myr in the upper crust. The eventual phase changes are strictly dependent on the duration of the thermal peaks; however they are unlikely to occur after ≈2.5 Myr from the beginning of the emplacement in the lower crust and ≈3 Myr in the upper crust.
Subsequent results include metamorphic reactions relative to a MnKFMASH system and take into account the disappearance of chlorite, appearance of garnet and staurolite, disappearance of staurolite, appearance of allumosilicate and muscovite and biotite dehydration reactions, assuming every phase as composed by pure end-members. The enthalpies of reaction are calculated and considered in the total thermal balance. Subsequently, variations in mineralogical associations with temperature are used to obtain the averaged values of rheological parameters for the whole crust. We then calculate the variation in the rheological behaviour during the simulation time and highlight the importance of including metamorphic reactions in such calculations.