Special Compaction Phenomenons in a Magmatic Crust

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Melting and melt ascent in the continental crust is an important process contributing to its structural and compositional evolution. Its physics of thermo-mechanical two-phase flow of matrix and fluid, e.g. rock and melt, the phase change and compositional alteration and the numerical realization is in progress; new results are presented.

The approach is based on the conservation equations of mass, momentum, and energy for melt and solid, respectively, and includes a simplified binary melting model, as well as compaction of the solid matrix. Dislocation creep power law parameters of quartzite or granite determine a weak or strong rheology, plasticity is included. We assume meta-greywacke as the initial rock type for solidus and liquidus definition. Their chemical composition, i.e. the enrichment or depletion in SiO_2 of the advected silicic melt and solid, is tracked.

The model layout intends to allow fundamental study of magmatism in a thick continental crust. Therefore, we apply a 50 km high square 2D box with reflective vertical sides; it is assumed to dip into the lower crust where a bottom heat flux serves for energy to generate melt. The code FDCON is based on the Finite Element Method in an Eulerian formulation.

Model families are performed to find sensitive parameters, to understand the physical behaviour and implies limits of geologically interpretable results. As controlling input parameters the bottom heat flow, the Retention number, e.g. melt mobility, and the matrix strength have been varied.

The scope of results allowed to figure out typical characteristics and behaviour of melting and freezing, of flow patterns, matrix movement, compaction or decompaction and depletion or enrichment. Several successive phases, during which distinctive stages appear, are identified; they are not complete for the various models.

One of the phases comprises a special compaction mechanism we call CATMA, an acronym for "**C**ompaction/decompaction **A**ssisted **T**wo-phase flow **M**elt **A**scent". In a late stage of diapiric ascent and formation of a wide plume head of high porosity (80 to 100%) melt accumulates at the top and continuously rises by heating the overburden, decompacting the roof matrix and segregating upwards by two-phase flow. The highly molten layer in the head develops melt channels where the vertical segregation velocity varies, this generates a wavy instability at the top boundary of the magma body. The freezing melt front is no more flat and separated melt pillows shape out. These penetrate into the overburden, forming flat melt bodies or sills until they freeze. This CATMA mechanism causes an additional melt ascent of several km. Modifications of the advection scheme can enhance this phenomenon up to the formation of a chain of curls around the top melt front.

The models show that diapirism is not the dominating process of melt migration in the crust. Melt additionally segregates by two-phase flow and accumulates beneath the solidus of the stiff upper crust. A new process called CATMA which also may be interpreted as "micro-stoping" allows further ascent and finally, when cooled down, strongly enriched zones may be interpreted as granitic layers. Clearly, the "simple" models have limitations, but they are successful in understanding better melt migration in the crust and the consequences as structural features and compositional particularities.