Textural and structural evidences for cumulative processes and layering in Svidnya pluton, Stara Planina Mountain, Bulgaria

Текстурни и структурни доказателства за кумулативни процеси и разслояване в Свидненския плутон, Стара планина, България

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Key words: layering, accumulation, potassic syenites.

Svidnya pluton comprises several plutonic bodies dispersed over small area. All previous works regard Sidnya pluton as built up by several pulses, assuming succession in emplacement of different magma portions. The more mafic clinopyroxene-biotite melasyenite (shonkinite) refers to the first intrusive phase, followed by the amphibole-aegirine syenites and quartzsyenites, regarded as a second intrusive pulse of evolved magma. Magmatic activity ends with the introduction of strongly peralkaline syeniteporphyritic and graniteporphyritic dykes. The whole spectrum of intrusive rocks observes only in the two biggest outcrops, namely in the west slope of the hill between Pessoko and Lilyako, and between the localities Rogo and Padalishte. Recently, some very melanocratic rocks – grimmerite and clinopyroxenite were described in Pessoko and their presence were explained as crystallization from ultrabasic magma. Contacts between the main intrusive phases — melasyenites (shonkinites) and quartzsyenites have never been described. Only the presence of different rock-types motivated the existence of successive magmatic events.

The new field observations on the west slope of the hill, between Pessoko and Lilyako, impose the idea that the transition from melanocratic to leucocrate rock-types is gradual. The amount of pinkish potassium feldspar regularly increase and biotite diminishes, the colour index changes from 50–40 (in mesocratic-melanocratic syenites) to 10–15 (in quartzsyenite). The change of modal composition is accompanied by the texture change from small-medium to coarse grained. The presented rock-types change gradually from the clinopyroxene-biotite melasyenite (shonkinite) and clinopyroxene-biotite-amphibole syenite (shonkinite) to amphibole-aegirirne-augite syenite and aegirine-amphibole quartzsyenite. Minor amount of granite occupies the highest part of Lilyako peak. Concomitant with the change of modal composition the chemical composition also shows regular evolution. SiO_2, Na_2O and K_2O increase and TiO_2, FeO, MgO, CaO, Ni, Cr regularly decrease on the Harker diagrams. Mineral composition of clinopyroxene and amphiboles present continuous trends from calcic to sodic-calcic and sodic species without missing crystallization intervals. These entire fields, geochemical and mineralogical data support the idea that plutonic rocks underwent in situ evolution. Processes of accumulation and fractional crystallization were responsible for the formation of the wide range of intrusive rock-types in Svidnya.

Structural and textural properties of the plutonic rocks evidence the processes of accumulation and crystal settling. In the most melanocratic varieties – clinopyroxene-biotite melasyenite (shonkinite) orientated structure is marked by the parallel disposition of tabular potassium feldspar. Sometimes pyroxenes and biotite tend to form a framework of touching crystals or continuous rows aligned parallel to the feldspars disposition. Magma clots of very mafic composition could be observed in this syenite. They are composed of clinopyroxene, biotite and apatite and show very fine-grained texture. Their blob-like form, fine-grained texture, sharp contacts with hosting syenites and the fact that are found in the bottom of the presumed magma chamber are in favour of the idea that they represent chilled, early crystallized mineral assemblage.

The aegirine-augit-amphibole syenite, outcropping on the west slope between the Svidnya River and Lilyako, presents orientated structure with magmatic lamination and modal layering. The leucocratic and melanocratic layers are defined as lamina (in the sense of Irvine, 1982) and are 1–5 mm thick. The later are composed of potassium feldspar and pyroxene + amphibole, as the planar orientation of tabular feldspars is best marked, mafic minerals show less pronounced orientation. Potassium feldspar and pyroxene are always euhedral, whereas amphibole is subhedral to anhedral. The texture of rocks implies on the idea that pyroxene and potassium feldspar are cumulus phases, whereas poikilitic amphibole represents intercumulus mineral. Post cumulus growth in the rocks is evidenced by the crystallization of intercumulus amphibole and by the presence of significant zoning in the minerals, namely in the pyroxene and potassium feldspar. The amount of trapped liquid in early cumulates can vary significantly, on the basis of textural particularities we consider that its amount is at around 15–25%.

Several processes can explain formation of the observed cumulates and layering. Density driven sedimentation, based on the Stocks law, is possible for mafic minerals plus apatite. The calculations yield settling velocities of $2.29*10^{-7}$ m/s for clinopyroxene and $7.03*10^{-8}$ m/s for biotite, 7.2 m/year and 2.22 m/year respectively. These values allow formation of 700–900 m thick cumulative pile for a reasonable time span. Simple crystal settling could also be responsible for the formation of monomineral rocks such glimmerites and pyroxenites, reported by Vladykin et al., (2001). Crystal settling of potassium feldspar is less obvious. Its density is comparable to the density of initial magma composition, so it will tend to float or it will be retained in the liquid. The fact that most mafic/basic rocks (found in the bottom parts of the magmatic chamber) K-feldspar content is less than in the initial magma implies that it was buoyant and therefore some crystals were able to migrate upward with moving magma. When K-feldspar reached its isostatic equilibrium with the hosted magma it started formation of rocks bearing significant K-feldspar content (aegirine-augite-amphibole syenite).

The modal layering occupies a restricted area of around 300 m^2 in the middle parts of the presumed magma chamber. The layers have limited lateral extension up to 20–30 m and several millimetres thickness, as the transition from layered to massive (unlayered) syenites, sometimes occurs in decimetre scale. These particularities could be interpreted as evidence for minute and essentially *in-situ* operating processes of layering formation. The most appropriate mechanism explaining similar modal layering is the oscillatory crystallization around the eutectic point under disequilibrium conditions. Thus, rhythmic changes in the composition of the melt provide a mechanism for repetitive crystallization and as a result the formation of layers with different modal composition. When the disequilibrium conditions ceased, the crystallization continues at eutectic point at equilibrium and massive (unlayered) syenites continue to form. The restricted area where the layering is observed and limited thicknesses of repetitive layers imply that oscillatory crystallization in disequilibrium has a short-time duration and limited space range.

Cumulative textures, igneous layering, mafic clots and ultramafic segregations can not be observed in all outcrops of Svidnya pluton, but only in the biggest body – between Pessoko and Lilyako. It can be easily explained in terms of the dimensions of the magmatic cameras of crystallization. This was the only one chamber big enough to keep the magma in liquid state for substantial period of time and hence to permit processes of differentiations. The other cameras were too small and the magma solidified quickly, before any differentiation taking place, thus they are representative for the initial liquid composition.