In the Karakoram Shear Zone, NW India, leucogranitic dykes form an extensive, varied and complex network, linking the Pangong Range anatectic terrane with leucogranites of the Karakoram Batholith. The network is characterized by continuous and interconnected leucosomes and dykes, with only rare cross-cutting relationships, forming dyke swarms and more chaotic injection complexes. This meso- to macroscale complex network is also reflected at microscale, where fine-grained granitic material form semi- to continuous corridors, narrow (10−100 µm) to wide (>0.5 mm) channels that links together and form an extensive network branching around large grains. We suggest, that the large grains represent early formed solid granitic framework that was later invaded by a new melt batch that exploits microfractures in between and through the framework forming crystals giving rise to this interconnected network. Once formed, the magma channels remained open either intermittently or continuously and the new melt batches migrated through following predominantly grain boundaries along an S-C fabric related to syn-magmatic shearing. Importantly, leucogranites in this network, carry an isotopic signature intermediate between the two main anatectic rocks in the source, suggesting efficient homogenization. This hybrid signature results from the microscopic interaction between previously crystallized magmatic rock and new magma batch, through local equilibration. Final composition of these leucosomes and magmatic bodies is a result of the accumulation of magma residue which in turn depends on compositional changes of magma influx, P–T conditions, and the interaction of new magma with early crystallized magmatic products.