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Fluid-assisted nucleation and growth of myrmekite during development of ductile shear zones in metagranites

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The development of myrmekite during progressive mylonitization of granites under lower amphibolite facies and fluid-present conditions was investigated by means of microstructural and geochemical analysis of samples collected along strain gradients of continuous shear zones. Primary aim of the study is to add further information on the role of stress, strain and fluid phase in myrmekite formation. The studied samples belong to the Gran Paradiso Pennine nappe of the Western Alps. The samples consist of weakly deformed porphyric granites (WDG), foliated granites (FG), representative of intermediate strains, and mylonites (MG). Most of the magmatic K-feldspar (K-feldspar1) consists of perthitic microcline with abundant lamellae and patches of albite derived by exsolution. Since the earliest stage in the deformation sequence (WDG) perthites are commonly recrystallized to a fine-grained aggregates inside K-feldspar1 and albite grains show an incipient- to pervasive re-equilibration to oligoclase at their rims. K-feldspar clasts also contain deformation bands consisting of an aggregate of albite and/or recrystallized K-feldspar. In WDG, quartz-oligoclase myrmekites are common and preferentially occur inside K-feldspar1 (e.g. along perthites, albitic rims and fractures), instead than along the outer boundary. They almost invariably develop at albite/K-feldspar boundaries oriented at a high angle to the inferred incremental shortening direction. In FG and MG myrmekites are no more selectively developed at “high angle interfaces” but occur almost pervasively along all internal perthites and fractures. As the K-feldspar is progressively dismantled along microshear zones, exploiting the fine grained aggregates along original fractures and perthites, the nucleation and growth of new myrmekites tend to occur preferentially at the periphery of small K-feldspar clasts that are more and more free of internal reaction interfaces.

The small clasts in mylonites appear completely mantled by myrmekites without a clear relationships to the kinematic axes of the shear zone. Geochemical modelling indicates that the myrmekites formed by cationic exchange in the presence of a fluid phase. In Al-Si-conservative models the myrmekite-forming reaction results in a net negative volume change of 8.5%. Based on microstructural observations, we infer that this negative volume change produces porosity, which promotes continue fluid influx to the reaction sites and myrmekite growth. We suggest that the preferred nucleation of myrmekite inside the K-feldspar1 reflects the presence of perthites providing (i) numerous reaction interface, and (ii) local high strain energies due to lattice mismatch between K-feldspar and albite. Microstructural evidences suggest a direct role of elastic strain in promoting myrmekite nucleation at the early stages of K-feldspar1 consumption. Once most of the available internal sites have been consumed by progressive grain size reduction and myrmekite development, preferred nucleation occurs along outer sites and is basically driven by the enhanced fluid/K-feldspar interaction. We therefore infer that the main factors controlling myrmekite development might change during the evolution of the deformation and be influenced by the pre-mylonitic configuration of K-feldspar.