Behaviour of allanite during mylonitisation and implications for U-Th-Pb dating: case study at the Mt Mucrone, Italy

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Allanite occurs in meta-granodiorite showing different amounts of strain, from undeformed (a) to mylonitic (f). This body intruded the polycyclic Sesia basement at Permian times and underwent HP metamorphism and ductile deformation during the Alpine convergence. We study the effects of deformation on allanite U-Th-Pb apparent ages.

In the mylonitic rock allanite forms mm-size angular grains in a strongly recrystallised matrix and shows exclusively Permian ages, eventhough the grains are intimately linked to Alpine deformation and metamorphism. These grains occur in mm-sized lenses around which the mylonitic foliation flows. In addition to allanite, these lenses are composed of randomly oriented phengite and Ca-rich garnet (up to 30wt%). During mylonitisation these allanite grains were mechanically shielded by a robust mineral (epidote) that subsequently broke down to garnet and phengite.

The undeformed rock gives insight into allanite forming reaction. Relics of Permian magmatic monazite are found exclusively in the undeformed samples where the magmatic textures and minerals are largely preserved. Coronas of allanite, thorite and apatite surround monazite relics indicating the reaction: monazite + plagioclase + fluid ---> allanite + apatite + thorite. These textures are located at the contact where magmatic biotite and plagioclase breakdown to form the HP assemblage phengite and garnet.

Alpine allanite is found in the undeformed rock. It is much smaller (ca. 200 μm), present fragmented textures with satellite neocrystals, is rich in Sr (up to 2wt%) and has a positive Eu anomaly. In medium strain rocks small (< 20 μm) Sr-rich rims around Permian allanite can be found. This indicates that Alpine allanite crystalisation is clearly associated to plagioclase breakdown (plagioclase + H2O ---> jadeite + zoisite + quartz) and must have been triggered by local fluid present conditions.

The interpretation of these complex textures, microstructures and ages needs superposition of at least two events. At Permian times, mm-sized allanite rimed by epidote most probably formed in late magmatic fractures associated to fluid circulation. At Alpine times, these fractures play the role of precursor heterogeneities where ductile deformation is localized. Allanite in the mylonite is mechanically and chemically shielded during the Alpine event.

Allanite is a robust chronometer. However in case of superposition of deformation events, its Pb isotope composition may not record all the events seen by the rock. Reworking of old structures during the Alpine orogeny has to be taken into account when interpreting ages on allanite in deformed rocks. A deeper look into textures and structures – that can be misleading at a first glance – is necessary to understand the significance of U-Th-Pb in situ ages in polycyclic rocks.