THE Al_2SiO_5 VEINS AND SEGREGATIONS OF THE SILVRETTA THRUST SHEET: STRUCTURAL AND METAMORPHIC IMPLICATIONS FOR A CARBONIFEROUS HISTORY

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Study of Al_2SiO_5 veins and segregations in basement leads to several informations, concerning conditions of formation, (i. e. the interactions of tectonics, petrology and fluid infiltration), and evolution of the country rocks (recorded by quartz microstructures, aluminosilicates and fluid inclusions).

In the Silvretta thrust sheet (Autroalpine domain in the Eastern Alps), such veins and segregations occurred in metapelites and paragneiss. Structural and metamorphic study in the southern part of the thrust sheet indicate a polyphase evolution under amphibolite facies. D1 is evidenced by a penetrative schistosity S1, but poorly constrained by metamorphic and geochronological data. Intensity of the main deformation D2 varies across the Silvretta. In the Eastern part (Flüelapass area), D2 related to parasitic folds (open to tight), an axial plane schistosity S2, a mineral and stretching lineation L2 marked by plagioclase and micas. In the Western part (Pischa area), S2 is penetrative with a few isoclinal folds preserved and the mineral and stretching lineation L2 (indicated by staurolite, andalusite, plagioclase and micas) is always E–W. Following D2, foliation boudinage structures and extensional crenulation cleavage (D3 extensional structures) developed and stressed a strong E–W stretching direction. According to mineral phase relationships, an anticlockwise P–T–t path is associated to D2 and D3 phases (T_{max}: 550°C, P_{max}: 0.5–0.6 GPa; FREI et al., 1995). Direct dating of core, rim, and bulk staurolite fractions yielded, within error, identical single-mineral Pb–Pb and U–Pb ages of ca. 310±10 Ma (BIINO & PROSPERT, 1996). This age was interpreted as a staurolite formation age dating the prograde part of a Variscan path. The staurolite age is a few Ma older than white-mica Rb–Sr and K–Ar ages, it suggests that the whole evolution was fast (ca. 20 Ma). With respect to the tectonic evolution, quartz-andalusite (±kyanite) veins and segregations occur in 4 structural settings:
- (1) lenses and boudins concordant to S2 (in both areas)
- (2) aggregates within or connected to faults crosscutting S2 (in the Flüelapass area)
- (3) segregations in boudin necks (in the Pischa area)
- (4) vertical veins crosscutting S2 (in both areas)

In type 1 and 2 veins, andalusite is overgrown by fibrolitic sillimanite. Quartz grains show undulose extinction, deformation bands and deformation lamellae but only in type 1 veins, quartz underwent dynamic recrystallisation localised in high strain areas (e. g. boudin necks affected by D3 structures). These results imply two main veining episodes, the first one (1 and 2) is coeval to D2 and the second one (3 and 4) is related to D3 and/or post-dates the main deformations.

Fluid inclusion study (microthermometric data at CRPG-CNRS, Vandoeuvre-lès-Nancy, and at Mineralogisch-Petrographisches Institut, Bern; Raman Spectrometry analysis at CREGU, Vandoeuvre-lès-Nancy) combined with microstructural observation has been performed on the quartz from types 1, 3 and 4 quartz-andalusite (±kyanite) veins.

In the type 1 veins, two main generations of fluid inclusions can be distinguished:
- CH_4–N_2 (Vcn) fluid inclusions have variable size, are abundant, organised in clusters (Vcn1), and planes subparallel (Vcn2) and perpendicular (Vcn3) to S2. Vcn2 fluid inclusions planes crosscut quartz grains but are destroyed by recrystallisation illustrated by decrepitation textures. The temperature of homogenisation ranges considerably from -100.0 °C to -159.0 °C for approximately constant composition of CH_4 = 87–82 % and N_2 = 18–13 %. A variation of molar volume from 60 to 39 cm^3/mol was calculated. According to re-equilibration textures (annular shape) and geometric relationships, the older fluid inclusions (Vcn1 and Vcn2) recorded an increase in pressure of ca. 0.2–0.3 GPa. Late Vcn3 fluid inclusions are located in quartz grains within fractured andalusite. They have the lowest density.

- saline water (L_{w-s}) two phases fluid inclusions are small and trapped in late planes subperpendicular (L_{w-s1}) or at 45° oblique (L_{w-s2}) to S2. The ice melting temperature (Tm) varies between -17.4 and -31.0 °C. Gas phase is composed of 80 % CH_4 and 20% N_2.

In type 3 segregations and type 4 veins, the same fluid inclusion generations have been recognized but aqueous fluid inclusions are too small to be measured. CH_4–N_2 (Vcn) fluid inclusions contain a single phase and rarely less than 5% of a discrete aqueous phase. They have a constant composition (70–82% CH_4 and 30-18% N_2) and molar volumes between 55 and 62,5cm^3/mol which indicate low density fluids.

Therefore, according to the CH_4–N_2 fluid inclusions in all vein types, the second generation of veins and segregations do not record any burial. This conclusion provides important consequences on the host rock tectonic history. During D2, a first generation of quartz-andalusite (±kyanite) veins and segregations formed and recorded an increase of pressure of 0.2–0.3 GPa. Then, a rapid uplift occur and produce the second generation of veins and segregations. This evolution is in good agreement with the petrological results (BIINO & PROSPERT, this volume).

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