Asbestos-like actinolite crystallisation during late regional variscan exhumation in the South Armorican Massif (France)

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Introduction

During the last decades, asbestiform actinolites were often studied in order to understand their petrological, optical or tectonometamorphic specificities [e.g., 1, 2, 3, 4, 5, 6, 7]. Nevertheless, to our knowledge, there is no study about tectonic and metamorphic origin of non-asbestiform hornblende breaking up into asbestos-like actinolite (ALA). In this study, we focus on such a purpose for two occurences of ALA identified by the BRGM during natural asbestos hazard mapping in the South Armorican Massif (France).

Geological setting, sampling and field observations

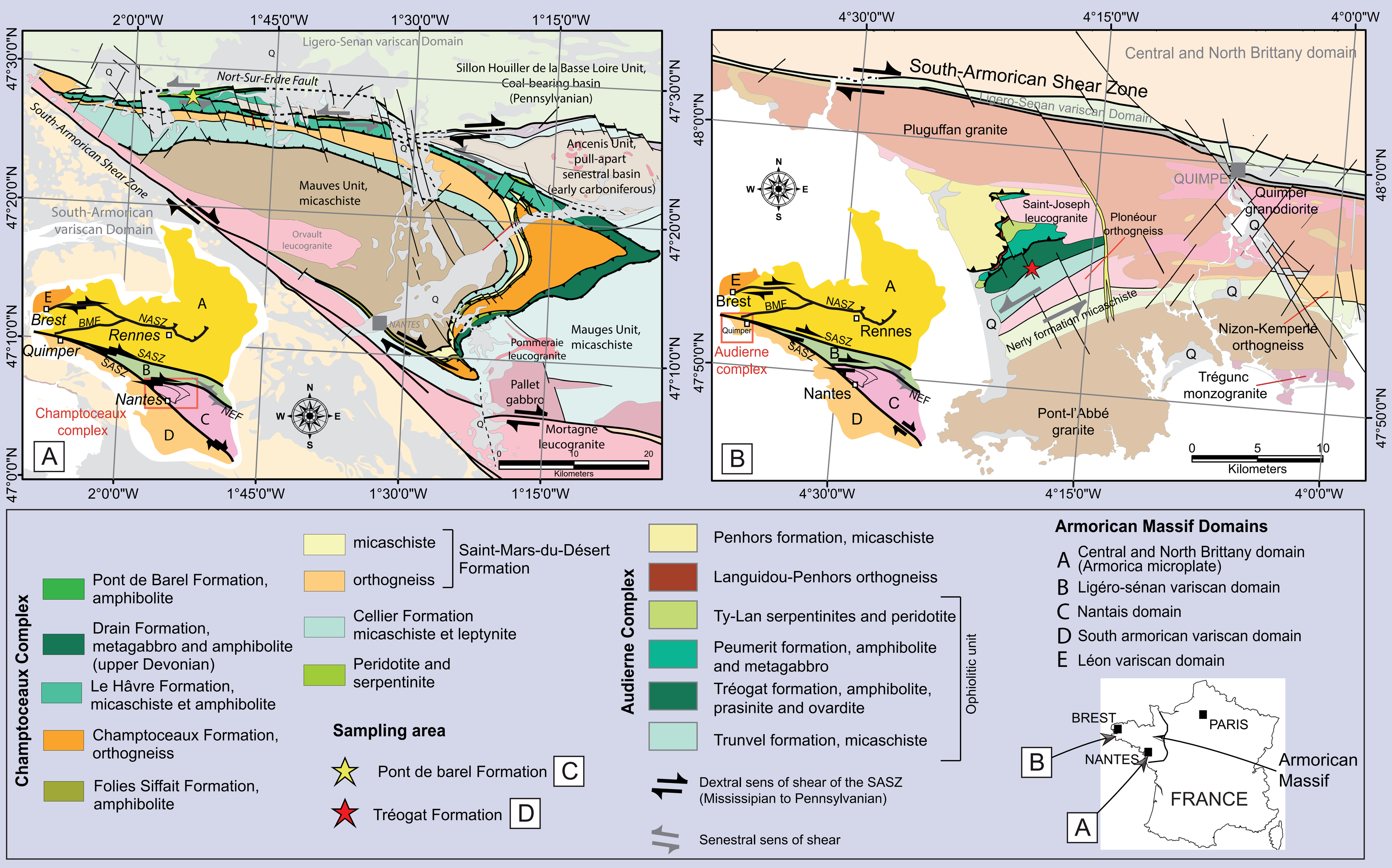


Fig. 1 - Geological setting and localisation of the studied areas. Modified after [8].

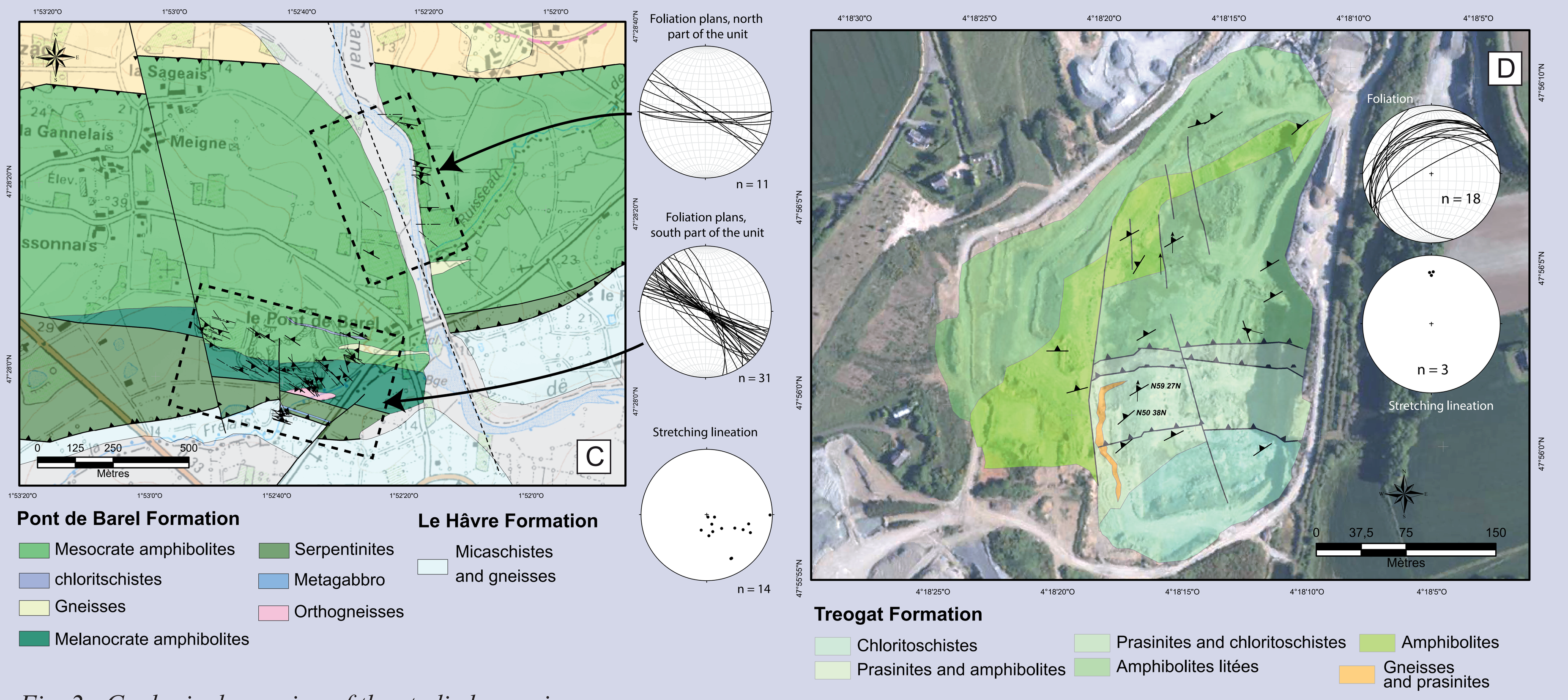


Fig. 2 - Geological mapping of the studied quarries

Studied rocks were collected within two Variscan ophiolitic formations (Tréogat and Pont de Barel Formations, South Armorican Massif, Western France), mainly composed of amphibolites, and which recorded amphibolite to greenschist facies metamorphism.

The natural asbestos-like actinolite occurrences are closely related with the development of tectonic structures such as extension veins, tension gashes, σ and δ-type boudins. Theses structures are systematicaly sealed by plagioclase due to metamorphic fluid precipitation.

Observations of the Kinematic criteria point to a sinistral strike-slip shearing for Pont de Barel formation and to a sinistral transtensive shearing for the Tréogat formation, which is consistent with the late regional variscan exhumation of the South Armorican Terrane.

Under the microscope, actinolite displays acicular to fibrous shape. Fibrous microtexture can be divided in two types: flexible and tensed. The flexible type displays the characteristics of Natural Occurring Asbestos (NOA).

SEM observations show that asbestos-like actinolite originates from the fragmentation of hornblende crystallographic plan. Fragmentation starts first along the (110) plans and continue along both the (100) and (110) plans.

Asbestos-like actinolite crystallisation during late step of the main deformation event

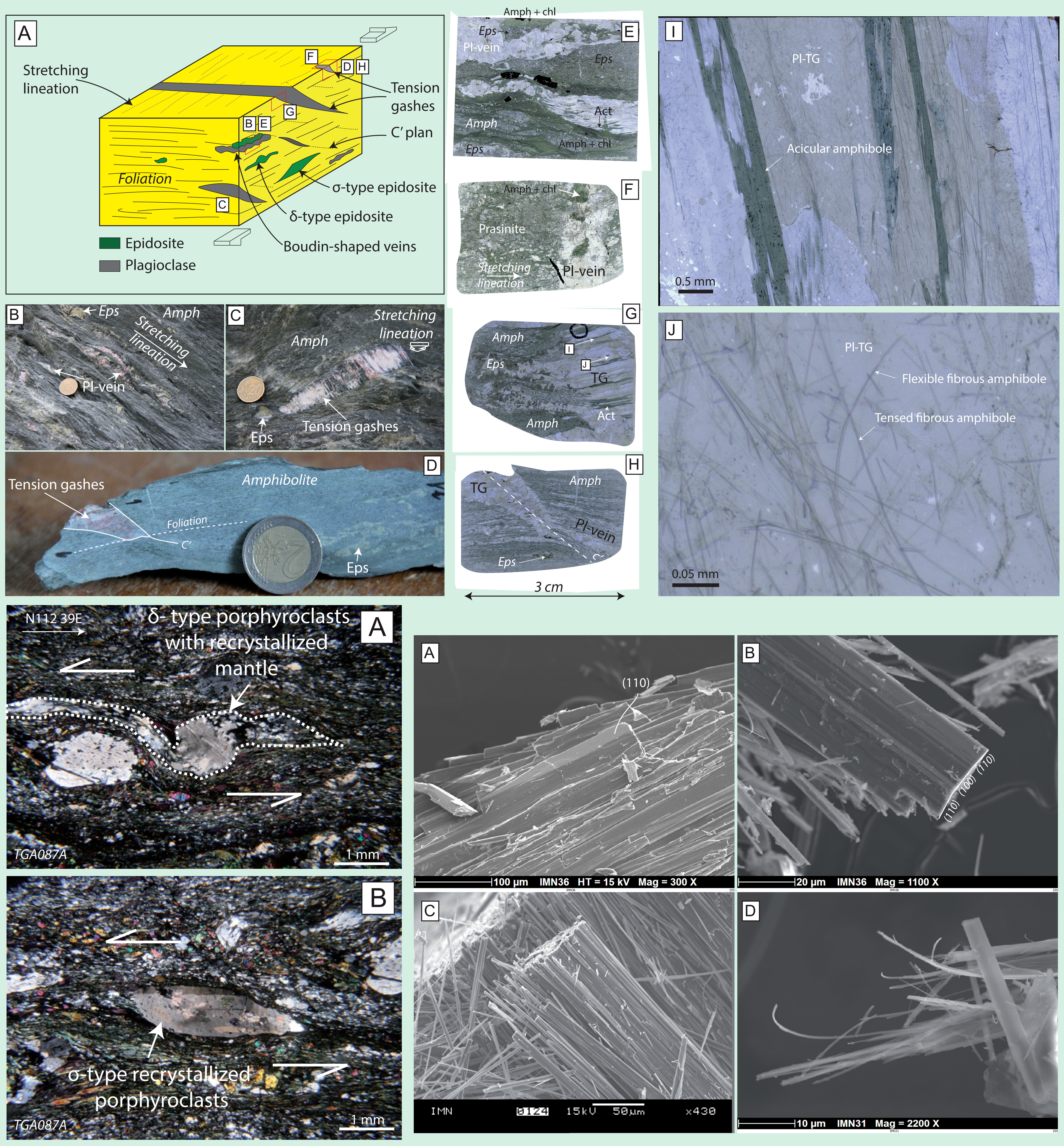
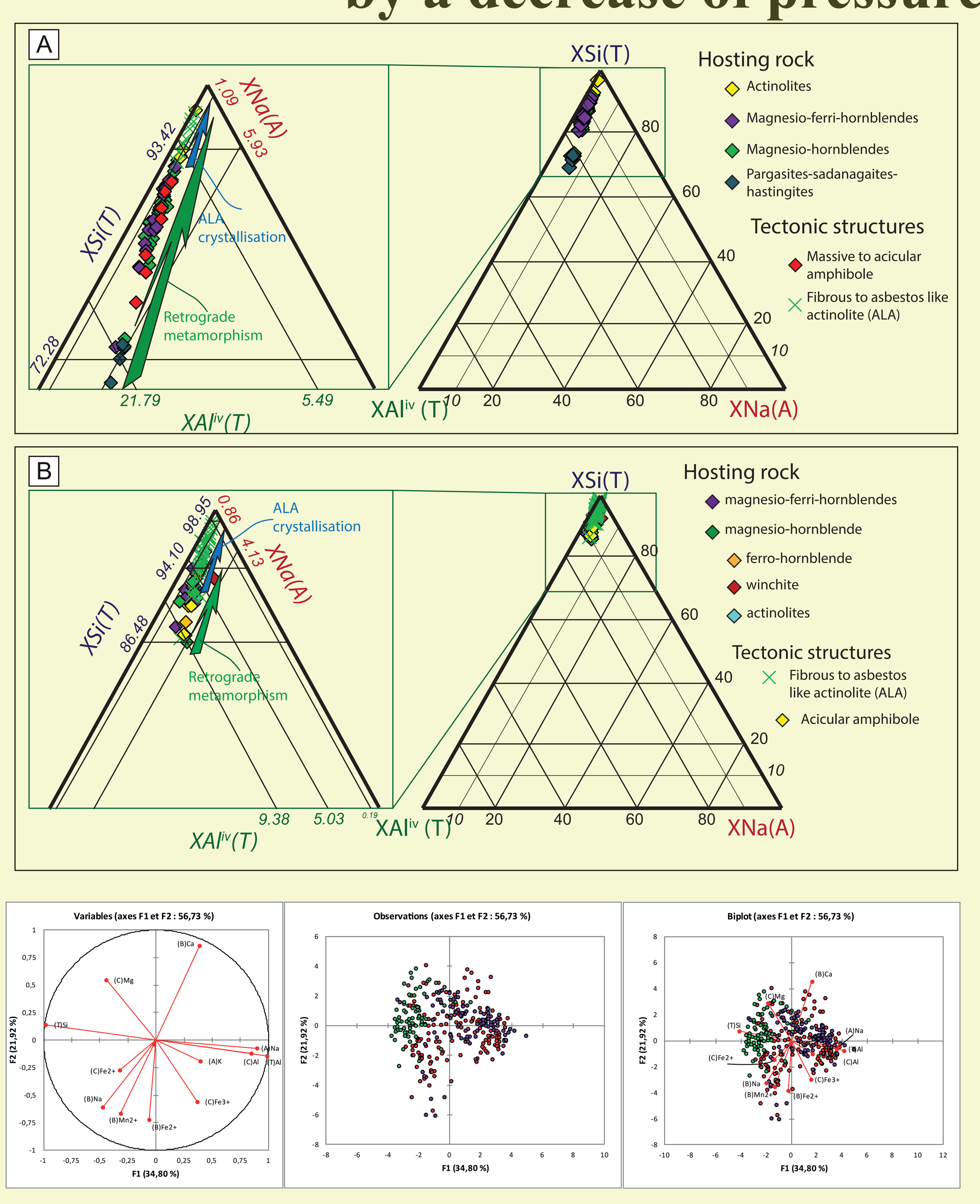


Fig. 3 - Macroscopic, optical and SEM observations highlighting the to link between early steps of the retrograde deformation event (during which acicular hornblende crystallizes in extension veins showing fuzzy boundaries or in hosting rock) and the late step of the same deformation event (during which hornblende is downgraded into asbestos-like actinolite synchronous with felsic melt circulation and tectonic structures opening).

Asbestos-like actinolite crystallisation driven by a decrease of pressure



EPMA analyses show that Na-Al-Si metasomatism is associated with this fragmentation.

Temperature estimates of chlorite crystallization after hornblende are around 300°C for the Tréogat Formation and 200°C for the Pont de Barel Formation, suggesting that amphibole fragmentation can occur over a wide temperature range.

Additionally, Principal Component Analysis was performed using as variable the distribution of chemical elements between crystallographic sites.

Results show a clear correlation between actinolite Si(T) and hornblende Al(T), Al(C) and Na(A) crystallographic sites, suggesting that asbestos-like actinolite after hornblende fragmentation is due to a decrease in pressure within the tectonic structures, as Al in amphibole is pressure-dependent.

Conclusion

The purpose of this study was to constrain the tectonic and metamorphic origin of two ALA occurences from two ophiolitic mafic units of the South Armorican Massif. Both units recorded an amphibolite to greenschist facies retrograde regional-metamorphism during which acicular hornblende and, to a lesser extent, acicular actinolite crystallized. Or study shows that asbestos-like actinolite is closely related to tectonic structures that opened during the late step of the main deformation event and are sealed by metamorphic fluid precipitation. This study shows that asbestos-like actinolite originate from hornblende break-up starting first along the (110) plans and continue along both the (100) and (110) plans until acilular hornblende (or actinolite) becomes asbestiform actinolite. Regarding to the temperature of crystallisation of chlorite after hornblende, temperature does not seem to play an important role in hornblende break-up. However, Al-Na release suggests that this break up is due to a decrease of pressure. Such a P drop could be due to the tectonic structure opening, during which fluid pressure turned to supra-lithostatic allowing Na-Al metasomatism.

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