# Synchrotron X-ray imaging for characterizing chrysotile asbestos

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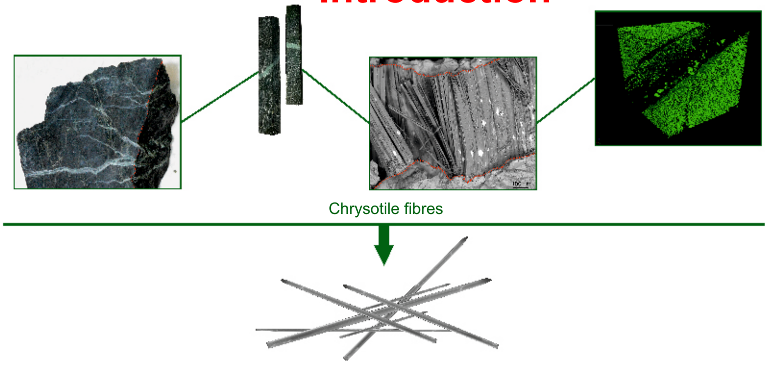
## Introduction

Over the last decades, many studies have been conducted on rocks containing Naturally Occurring Asbestos (NOA) to determine the potential health risks to exposed neighboring populations. Serpentinite rocks are formed by the low-temperature hydration of ultramafic rocks (i.e. peridotite, pyroxenite), during which olivine and pyroxenes are transformed into serpentine minerals (chrysotile, lizardite and antigorite). Serpentinization is accompanied by abundant veining marked by different generations of vein-filling serpentine, which induces a decrease in density.




Crack-and-seal mechanismis invoked for veins formation, which requires three successive stages:
i) space opening at a rate linked to the stress/strain overall regime
ii) the transfer of elements to the vein in the presence of a fluid
iii) a vein-filling episode of mineral crystallization

Serpentine veins in hydrated peridotite are particularly abundant and display a vast and complex variety of textures and morphologies. This variety reflects numerous mechanisms of vein formation and fluid conditions recorded by various serpentine mineral assemblages (Andréani et al., 2007). It is worth remembering that the dominant type of serpentine infill is the fibrous one (e.g. chrysotile, protoserpentine, polygonal serpentines).

## Results

The SR-µCT results are consistent with those obtained through PLM, SEM/EDS and EPMA examination. SR-µCT revealed that serpentine veins could be discriminated in massive serpentinite rocks while, routine techniques such as PLM and SEM can only be used for surface observations or to a maximum depth of a few hundred microns.

. In this work we present results obtained by the application of high-resolution X-ray computed microtomography which provided a realistic visualization of the 3D shapes and orientations of veins that can be quantified through the extraction of parameters such as volume fraction, size distributions, orientation and connectivity. Furthermore, the phase-contrast mode allowed to detect the crystals with chemical composition different from the serpentinite group minerals (e.g., magnetite).

### Macroscopic characterization

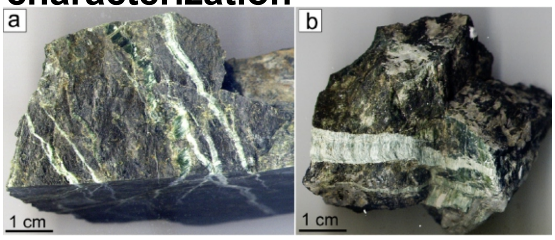
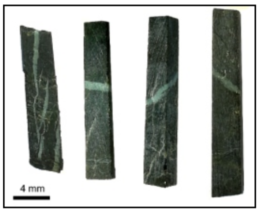



Fig. 1. Vein network developing inside massive serpentinite; a) vivid green serpentine veins; b, V-




### Petrographic characterization

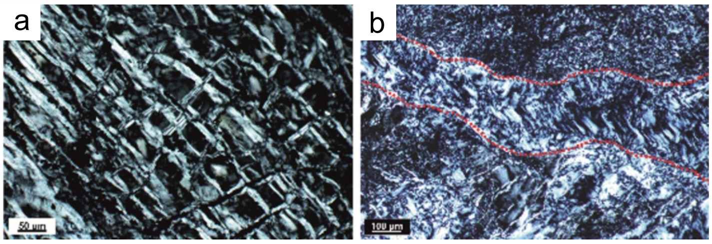



Fig.2. Photomicrographs of main features of serpentinite rocks. a) detail of mesh-like texture of serpentine (crossed polarizers); b) kink-banded serpentine veins within the mesh-like matrix (crossed polarizers).

### SEM/EDS characterization

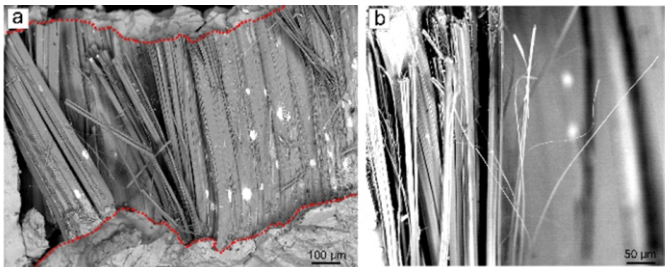



Fig. 3. SEM images of vein infill by chrysotile fibres bundles (a); note the splitting of compact fibres into thinner fibrils; b) chrysotile fibre bundles with their typical wavy appearance. Note the flexibility of the single fibrils.

### EPMA characterization

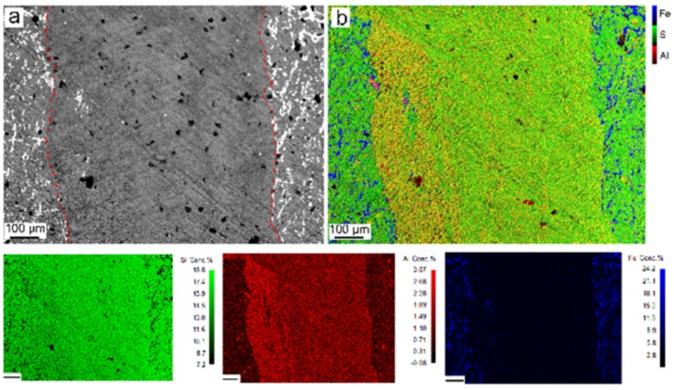



Fig. 4. X-ray element maps (WDS) of Fe, Al and Si on serpentinite vein

### SR-µCT

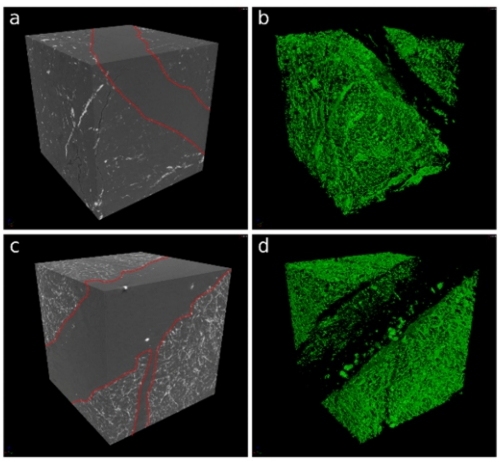



Fig. 5. Volume rendering of extracted VOIs with highlighted contact lines (dashed red) between veins and matrix. The spatial distributions of the veins are shown as empty spaces between the matrix (in green).

## Concluding remarks

We have investigated the serpentine vein infill, which crosscuts massive serpentinite bodies cropping out in the Gimigliano-Mount Reventino Unit (Calabria, Southern-Italy). Obtained data allowed to evaluate i) the geometric interface between serpentine-fibrous infill veins and the matrix; ii) the percentage of serpentinization; iii) the percentage of fibrous minerals in massive serpentinite rocks. Moreover, the fibrous form of the chrysotile contained in the veins can be observed without disturbing fibre size. Chrysotile occurs within serpentinite rocks as respirable fibrous phase infill (particles with length N 5 µm, width b 3 µm, length/width ratio N 3:1). Therefore, the sizes of the chrysotile fibres analyzed corresponded with the size of regulated asbestos.