**SUPPLEMENTARY MATERIAL**

**Non-conventional pressure estimates by using transmission electron microscopy coupled with**

**energy-dispersive spectroscopy (TEM-EDS): testing on submicrometer white mica from low-grade metapelites**

Edoardo Sanità1, Maria Di Rosa1, Enrico Mugnaioli1, 2

1 Dipartimento di Scienze della Terra, Università di Pisa, Pisa, Italy.

2 Centre for Instrument Sharing of the University of Pisa (CISUP), Università di Pisa, Italy

\*Corresponding author: Prof. Enrico Mugnaioli

Università di Pisa

Dipartimento di Scienze della Terra, via Santa Maria 53, Pisa, Italy,

e-mail: [enrico.mugnaioli@unipi.it](mailto:enrico.mugnaioli@unipi.it)

**Data acquisition and reduction**

A Multipurpose JEOL JEM-F200 TEM, equipped with a Schottky FEG source and a windowless SDD EDS detector with an effective area of 100 mm2 and working at 200 kV, was used for TEM-EDS analyses. Data acquisition and analysis were performed with the JEOL *Analysis station software* included in the TEM-EDS device. All acquisitions were performed in STEM mode with the following setting: emission current of 77.78 A, a 40 μm CL aperture, a probe size of 6, an acquisition area of ~50 nm2 (see the white boxes of Figure 2 in the main text), and a time of 60 s. The counts per second (cps) ranged between 4000 and 15000 with a death time never higher than 30% and the sample was tilted of 15° around the X axis (tilt-X) to maximize the EDS gain.

The chemical analysis of Wm crystals grown on the S1 foliation were used to perform the *P* estimates. The data processing of the raw TEM-EDS chemical analysis was performed using the absorption correction procedure described in Conconi et al. (2023) based on electroneutrality criterion (van Cappellen and Doukhan, 1994), in which H contribution is taken into account by using a reduced oxygen valence for structural formula recalculation (as suggested in Sanità et al., 2024a). According to Sanità et al. (2024a), only the chemical analysis that show charge balance within a scatter of +/-0.04 e- after the absorption correction were considered. Among these, we choose the chemical analysis of Wm for which TiO2+MnO < 0.5 weight percent (wt.%) is respected (in accord with Vidal and Parra, 2000).

***P* estimates**

The Phg-Qz-wt method (Dubacq et al., 2010) is based on the de-hydration of white mica to refine the thermodynamics status of water content in the A-site which is mainly a *T*-sensitive reactions. The strategy used is as follows: *i*) For each sample, *P* estimates were computed using a fixed *T* corresponding to the average value of the temperature range estimated by Meneghini et al. (2023) and Sanità et al. (2024b), which is 215 °C for ULI3aT, 225 °C for ULI8T, 265 °C for ULI14T and 250 °C for ULI22aT; *ii*) the H2O activity (aH2O) was set to 0.8 due to the presence of calcite in each sample (Frassi et al., 2023, Sanità et al., 2024b). Each estimated *P* value was computed by optimizing the percentage of Fe3+ content range, this expresses like XFe3+ = Fe3+/Fe2+ + Fe3+, with an input *X*H2O steps (empty circles in the Figure 4 in the main text). The XFe3+ ratio for white mica is thus optimized in the models to satisfy the convergence criteria. When a single *X*H2O value is found to be the optimized solution for a given sample and for a specific XFe3+ range, this is takes into account to estimates the *P* conditions. Among these, the *X*H2O value supported by the most robust statistics (95% of confidence) in each sample will be used to estimate the *P* range of formation for the investigated Wm.

**Reference**

Conconi, R., Ventruti, G., Nieto, F. and Capitani, G., 2023. TEM-EDS microanalysis: Comparison among the standardless, Cliff & Lorimer and absorption correction quantification methods. *Ultramicroscopy*, **254**, 113845.

Dubacq B., Vidal, O. and De Andrade V., 2010. Dehydration of dioctahedral aluminous phyllosilicates: thermodynamic modelling and implications for thermobarometric estimates. *Contribution to Mineralogy and Petrology*, **159**, 159-174.

Frassi, C., Di Rosa, M., Farina, F., Pandolfi, L. and Marroni, M., 2023. Anatomy of a deformed upper crust fragment from western Alpine Corsica (France): insights into continental subduction processes. *International Geology Review*, **65**, 40-60.

Lanari, P., 2012. P-T mapping in metamorphic rocks. Applications to the Alps and the Himalaya. Ph.D. Thesis, University of Grenoble, 544 pp.

Lanari, P., Vho, A., Bovay, T., Airaghi, L. and Centrella, S., 2019. Quantitative compositional mapping of mineral phases by electron probe micro-analyser. *Geological Society, London, Special Publications*, **478**, 39-63

Meneghini, F., Di Rosa, M., Marroni, M., Raimbourg, H. and Pandolfi, L., 2023. Subduction signature in the Internal Ligurian units (Northern Apennine, Italy): Evidence from P–T metamorphic peak estimate. *Terra Nova*, **36**, 182-190

Sanità, E., Conconi, R., Lorenzon, S., Di Rosa, M., Capitani, G. and Mugnaioli, E., (2024a). Application of an improved TEM-EDS protocol based on charge balance for accurate chemical analysis of sub-micrometric phyllosilicates in low-grade metamorphic rocks. *Clay and Clay Minerals*.

Sanità, E., Di Rosa, M., Marroni, M., Meneghini, F. and Pandolfi, L., 2024b. Insights into the Subduction of the Ligure-Piemontese Oceanic Basin: New Constraints from the Metamorphism in the Internal Ligurian Units (Northern Apennines, Italy). *Minerals*, **14**, 64.

van Cappellen, E. and Doukhan, J.C., 1994. Quantitative transmission X-ray microanalysis of ionic compounds. *Ultramicroscopy*, **53**,343-349.

Vidal, O. and Parra, T., 2000. Exhumation paths of high‐pressure metapelites obtained from local equilibria for chlorite–phengite assemblages. *Geological Journal*, **35**, 139-161.