Supplementary Material
"Cyclical variations of fluid sources and stress state in a shallow megathrust zone mélange"

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Cathodoluminescence analysis of calcite veins

Selected polished thin sections of fault rocks of the Vidiciatico thrusts were examined using a CITL 8220 MK3 equipment (operating at ~17 kV and 400 µA) at the Department of Earth Sciences of the University of Torino. The calcite in shear and extensional veins has luminescence ranging from bright orange to reddish orange. All sets of veins include calcite having different luminescence. In several cases, calcite cementing the two perpendicular sets of extensional veins, has very similar appearance under the cathodoluminescence (Fig. SM1a, c). Sometimes, antitaxial fault parallel veins show instead a zoning in luminescence arranged symmetrically with respect to the median line (Fig. SM1b). The luminescence of shear veins is homogeneous across crack and seal increments and microtransforms, and is similar to the luminescence in extensional veins in the wall rock (Fig SM1d).

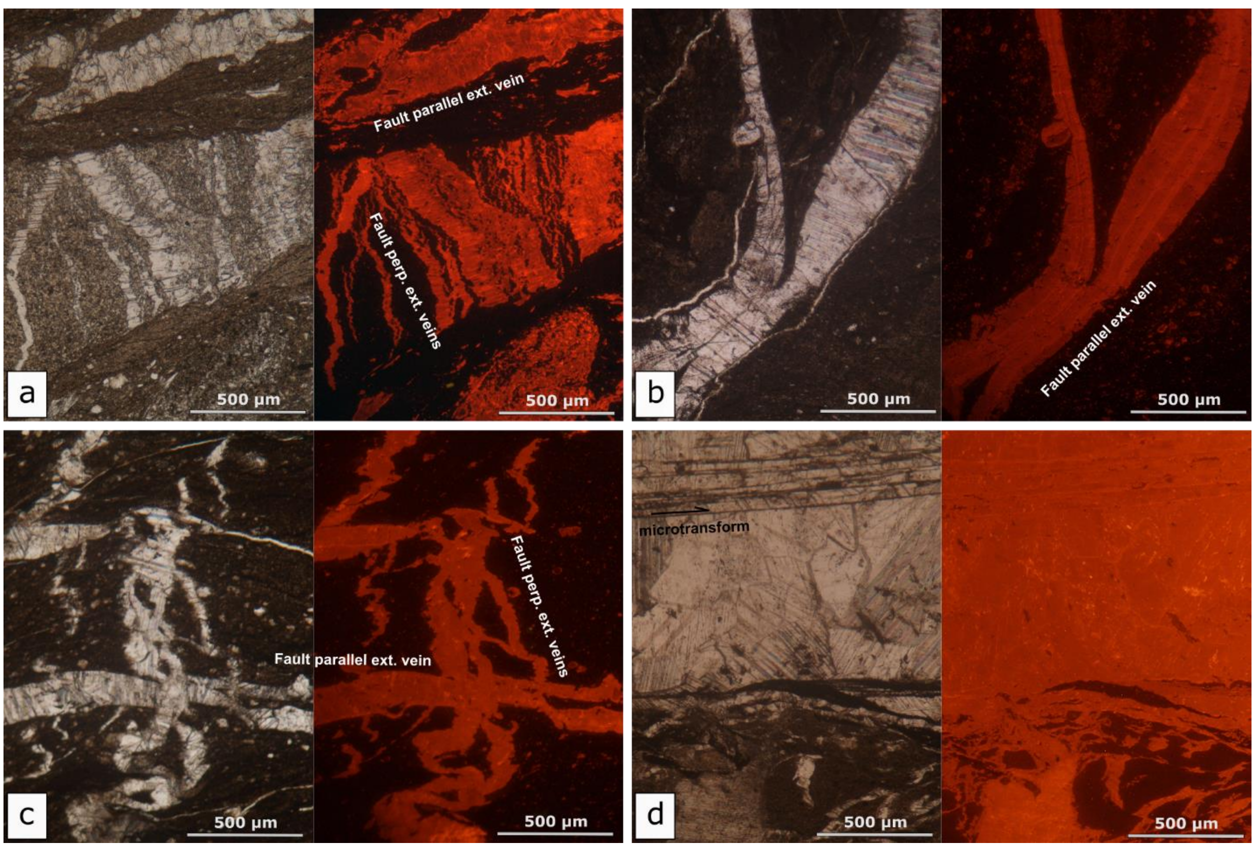

Figure SM1. Plane polarized and cathodoluminescence micrographs of veins of the Vidiciatico Thrust. (a) A fault parallel and several fault perpendicular veins confined within a rigid lithon. Calcite crystals have elongated blocky texture, and a dark orange luminescence with light spots in both vein sets. (b) Detail of a fault-parallel vein with a zoning in luminescence symmetric with respect to the median line. (c) Shortened and folded fault perpendicular extensional veins crosscutting fault parallel veins having the same luminescence. (d) A shear vein, including several microtransform surfaces on top, has the same bright orange luminescence as the extensional veins in the wall rock (bottom).

2D orientation of structural elements in thin section

Four thin sections cut perpendicular to the foliation and parallel to the calcite slickenfibers on shear veins were chosen to trace the orientation of the following structural elements: (i) foliation planes, (ii) fault parallel extensional veins, (iiii) fault perpendicular extensional veins, (iv) crack and seal increments and (v) microtransforms. The structures were traced as polylines on thin section scans loaded in an ArcMap 10.6 project in a custom reference frame scaled in millimeters. The polylines were split into 0.1 mm long segments (Fig. SM2), whose orientations served to build the rose diagrams shown in Fig. 2. In this way, the histogram of the orientations of the segments is normalized by length. In order to plot together different sets of structures for each sample, the bins' height is normalized using the pdf (probability density function) instead of the number of segments. According to the Matlab ® user manual, the height of each bar is: (number of observations in the bin)/(total number of observations * width of bin).

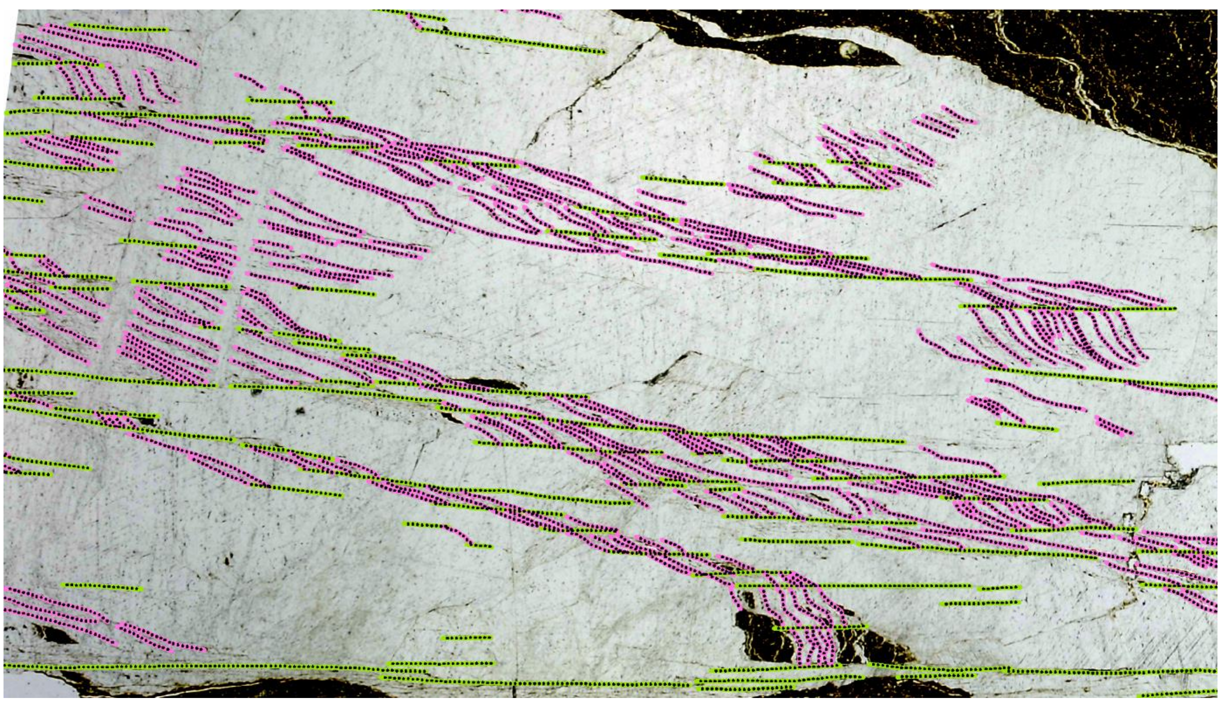

Figure SM2. Example of line drawing on thin section AC15, where microtransforms are in green and crack and seal increments in pink. The dark spots indicate where the lines are split into 'unitary' segments.

Samples used for REE in situ analyses and locations of the analysed spots

In the following Figs SM3, SM4, SM5, SM6 and SM7 enlarged reproductions of the thin section scans of the samples selected for REE analyses (Fig. 3 of the main text) are provided, showing the spots of Rare Earth Element LA-ICP-MS analyses. The corresponding geochemical data are provided in Table SM8.

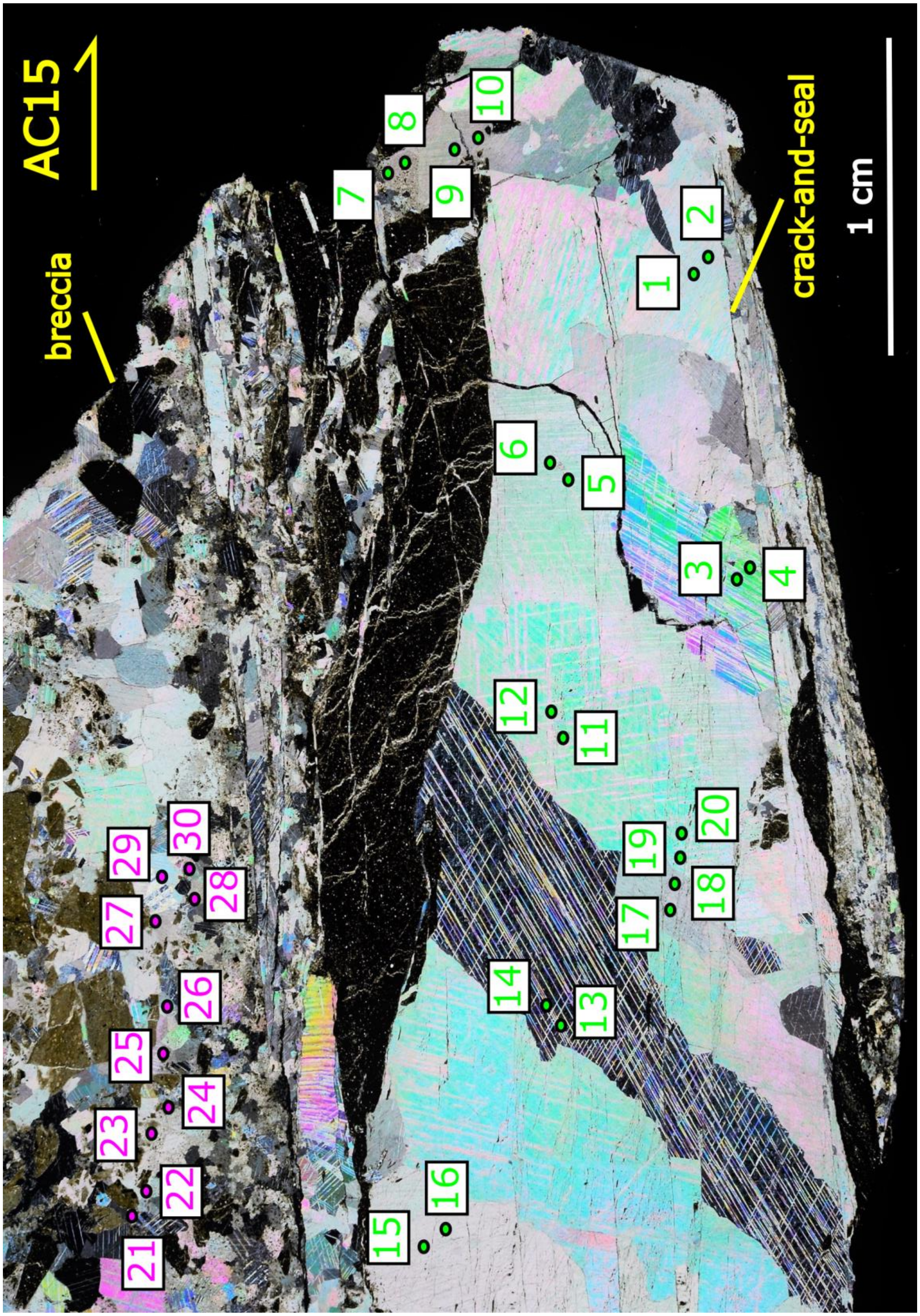

Figure SM3. Sample AC15, including a shear vein (green spots) and a breccia shear vein (pink spots). Calcite was analyzed in both domains, as detailed under the column 'Vein Type' in Table SM8.

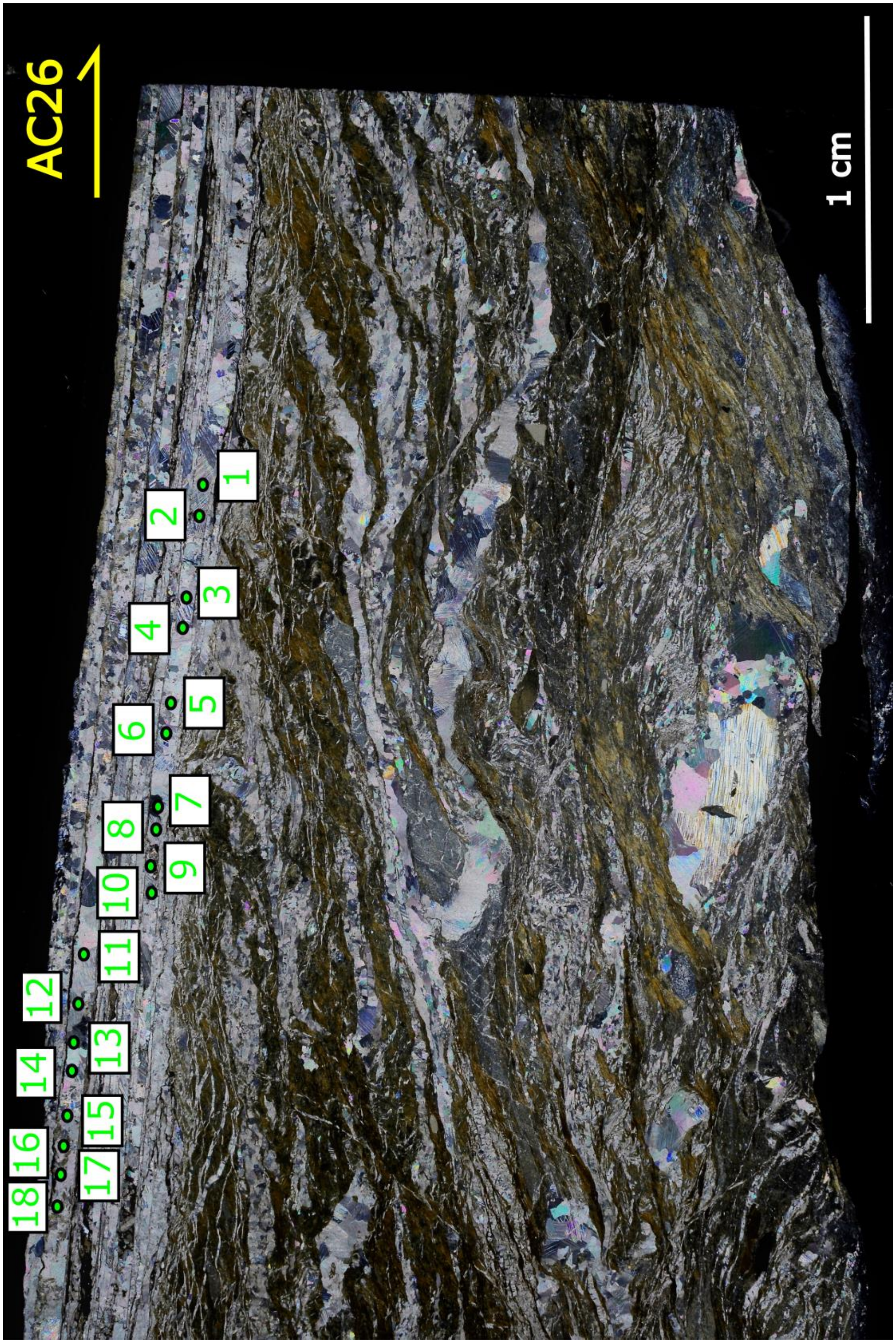

Figure SM4. Sample AC26, collected along the main thrust fault surface (Figs 1b, 2a), including a shear vein on top (green spots) and a complex network of polydeformed extensional veins. Only the main shear vein was analysed.

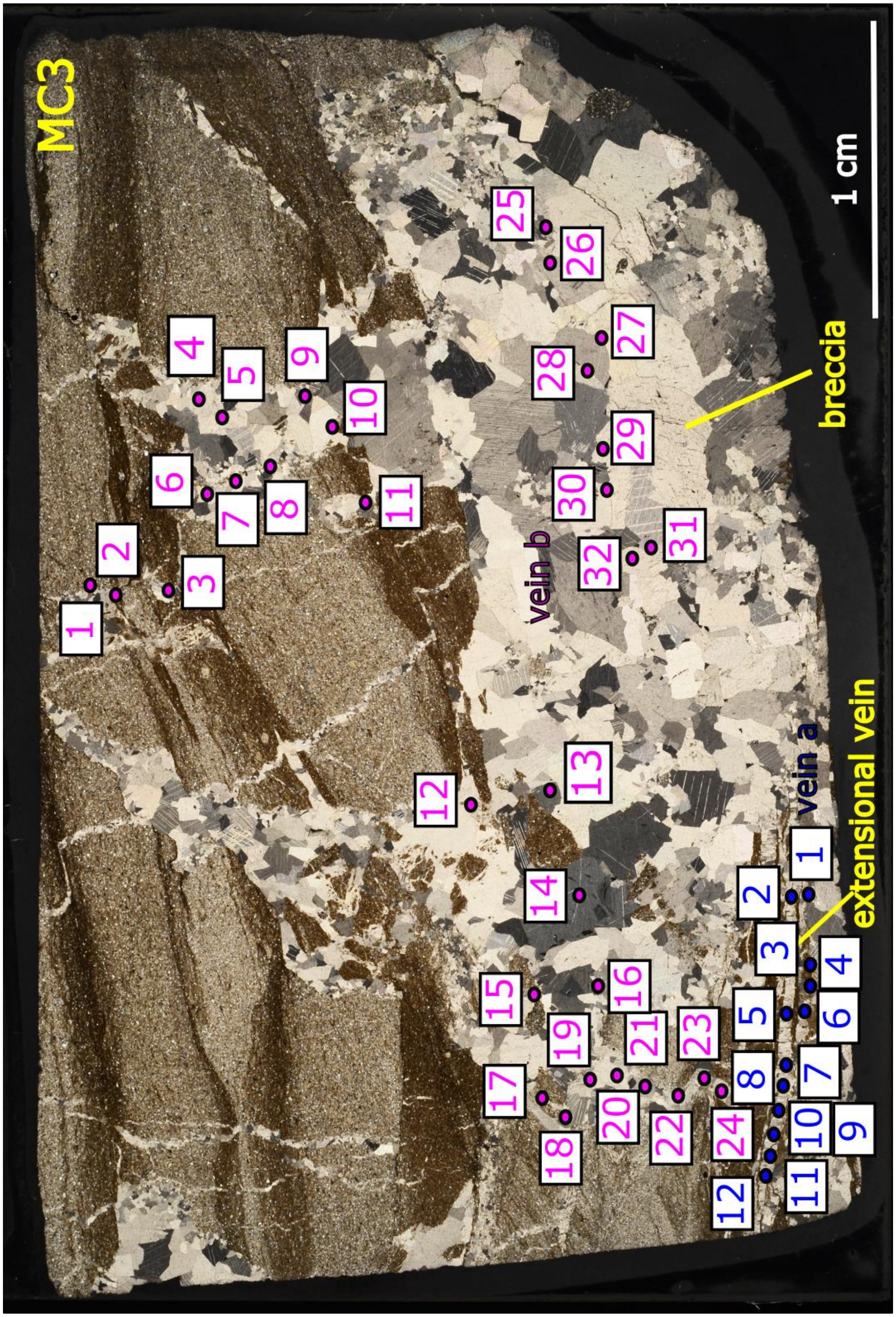

Figure SM5. Sample MC3, collected from a dilational jog (Figs 1b, 2b), including a breccia shear vein domain (vein b, pink spots), crosscutting a fault-parallel extensional vein (vein a, blue spots).

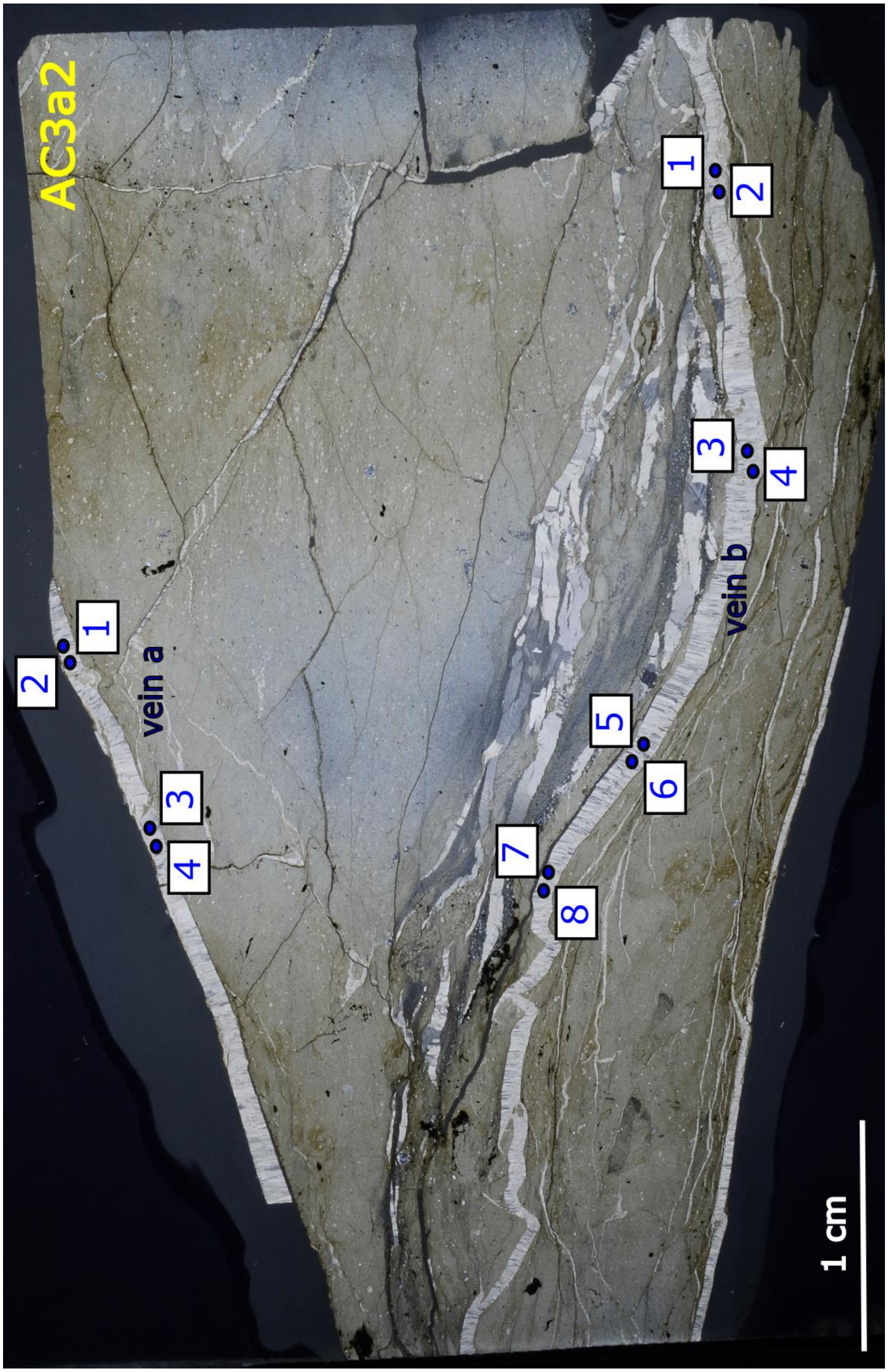

Figure SM6. Sample AC3a2, including two fault-parallel extensional veins (blue spots), vein a and vein b.

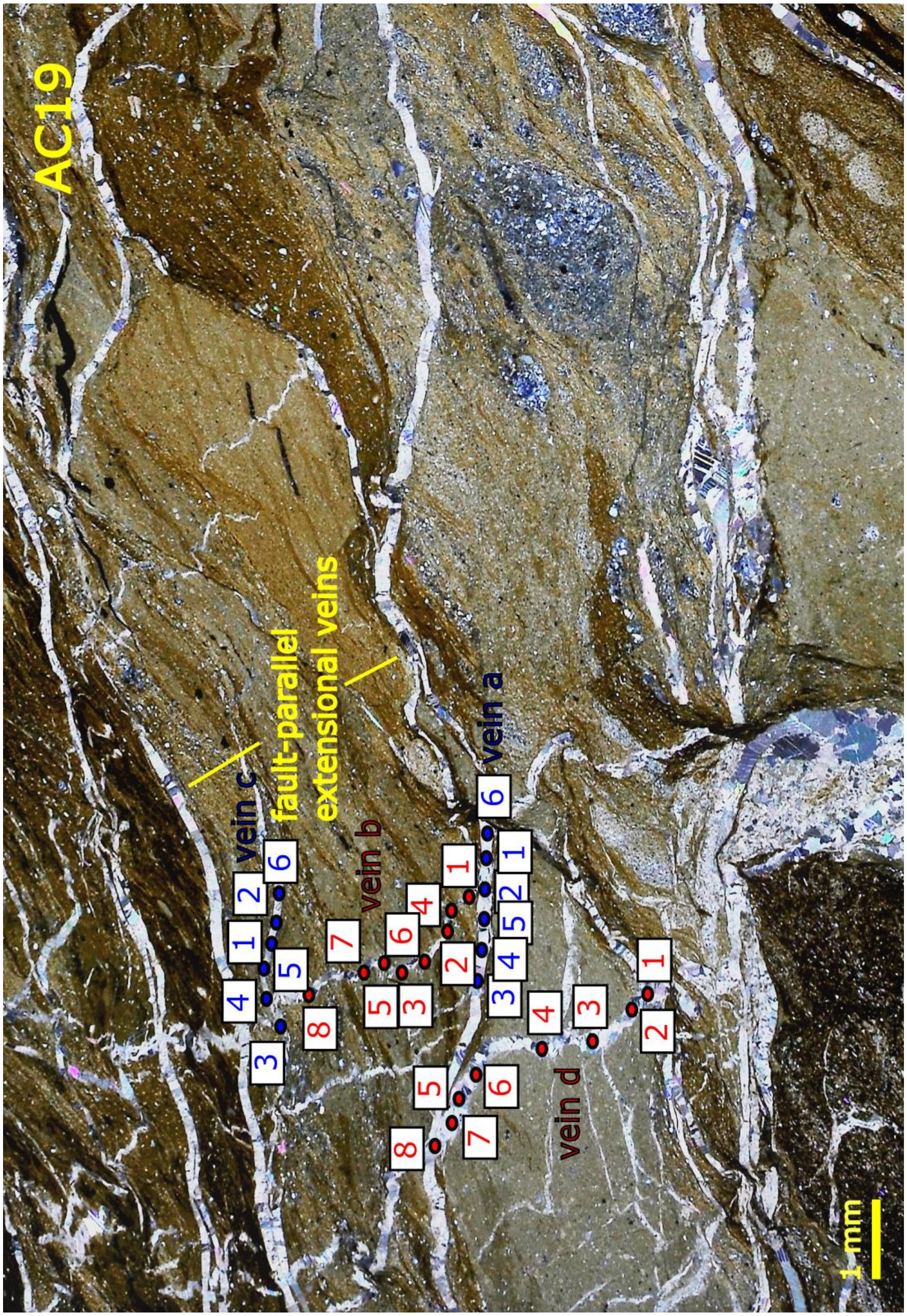

Figure SM7. Sample AC19, including mutually crosscutting fault-parallel and fault-perpendicular extensional veins. We analysed two fault parallel extensional veins (veins a and c, blue spots) and two fault-perpendicular extensional veins (veins b and d, red spots).

Table SM8

Table SM8 is available as separate .pdf and .csv files.