

Supplementary information

Methane-hydrogen-rich fluid migration triggers seismic failure in subduction at forearc depths

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Affiliations

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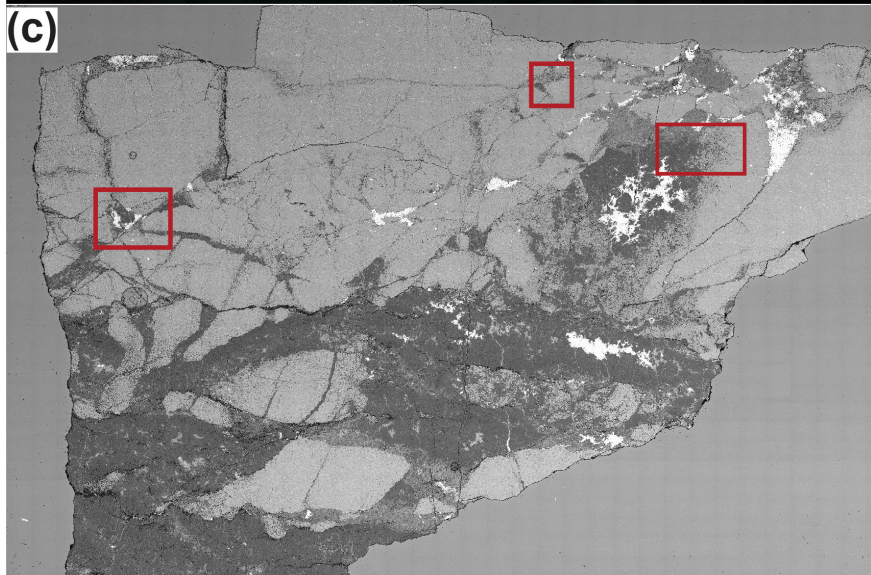
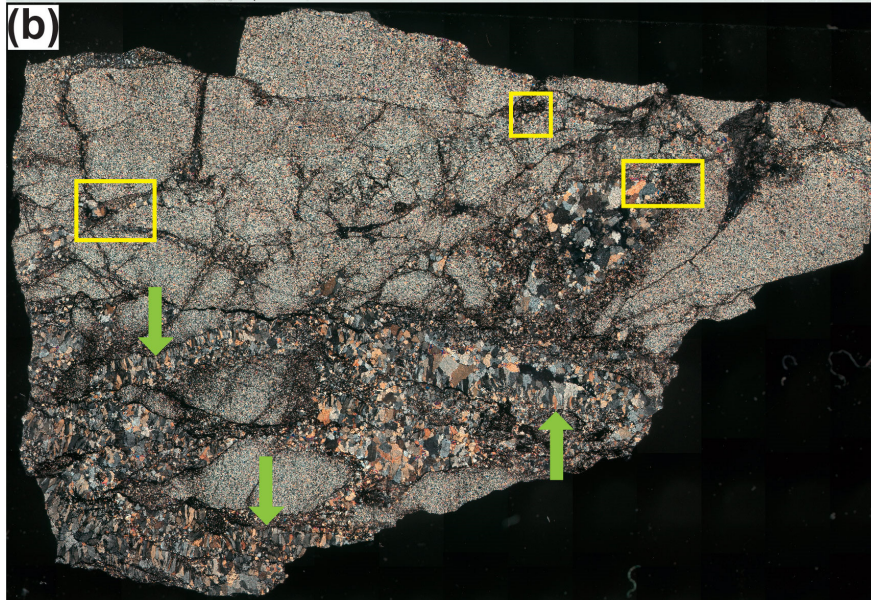
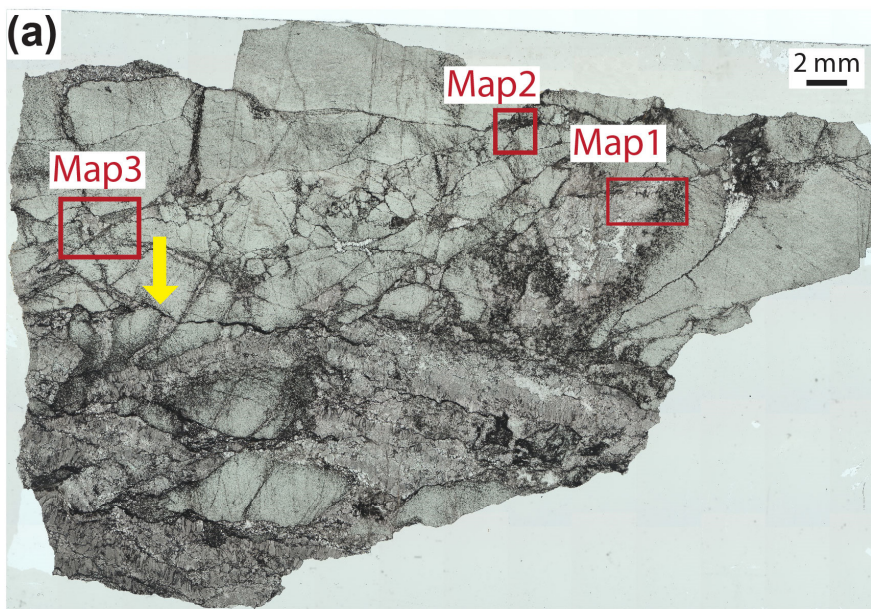
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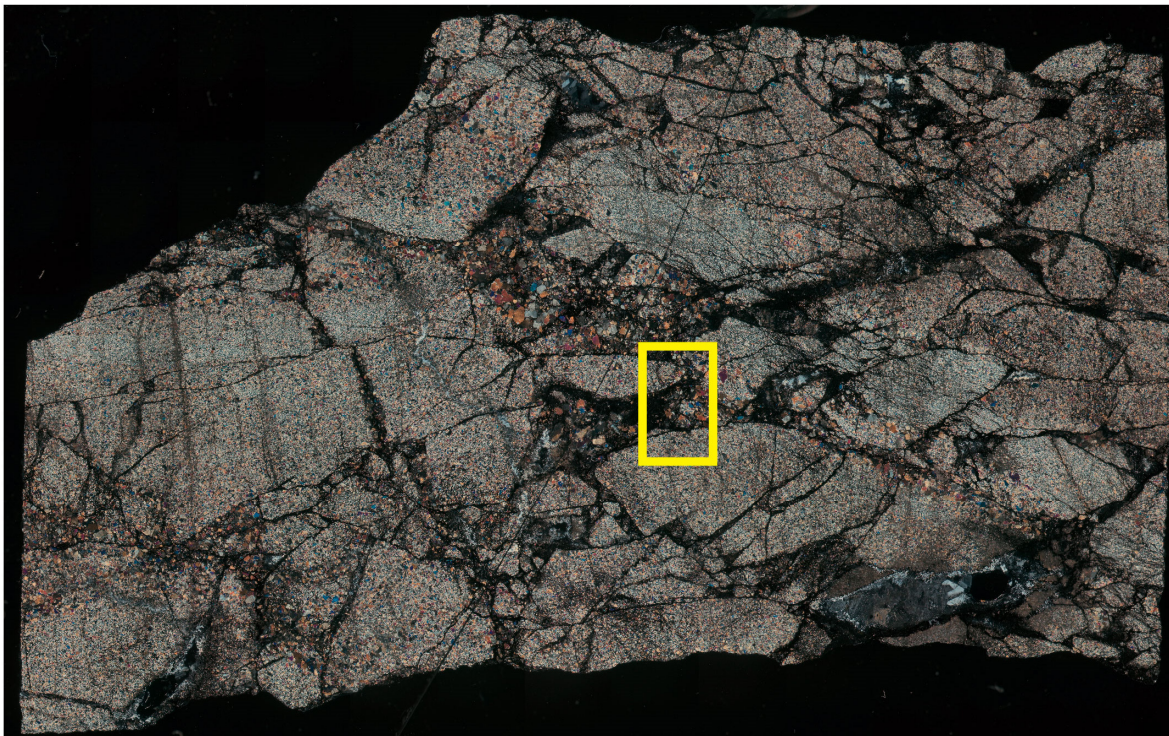
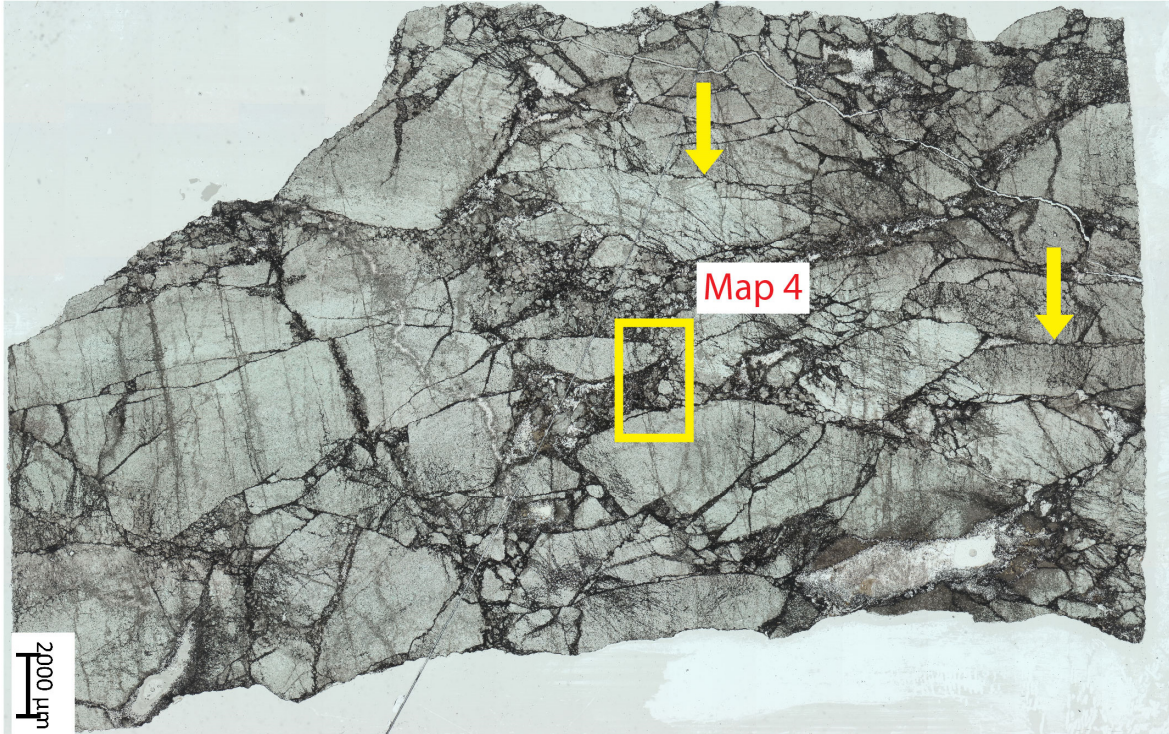
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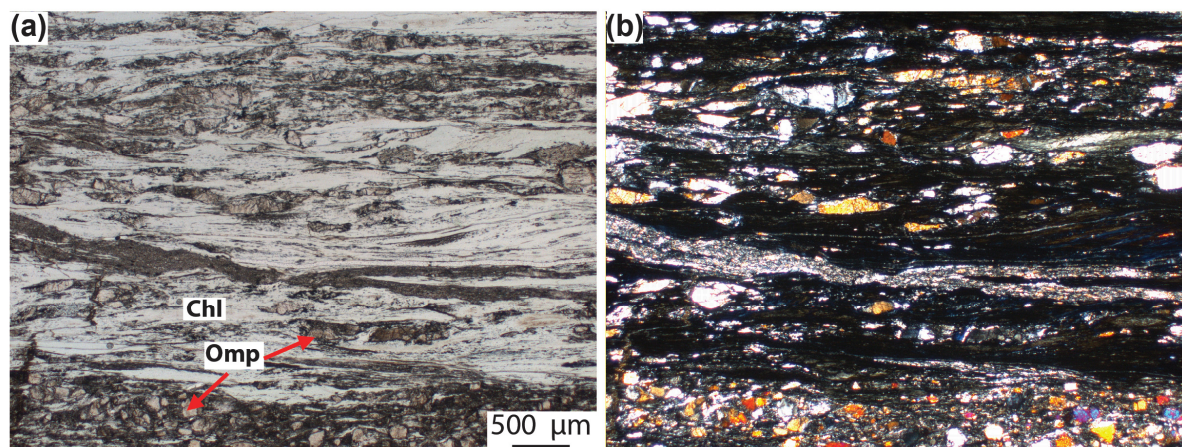
*francesco.giuntoli@unibo.it , *alberto.vitaleb@unibo.it



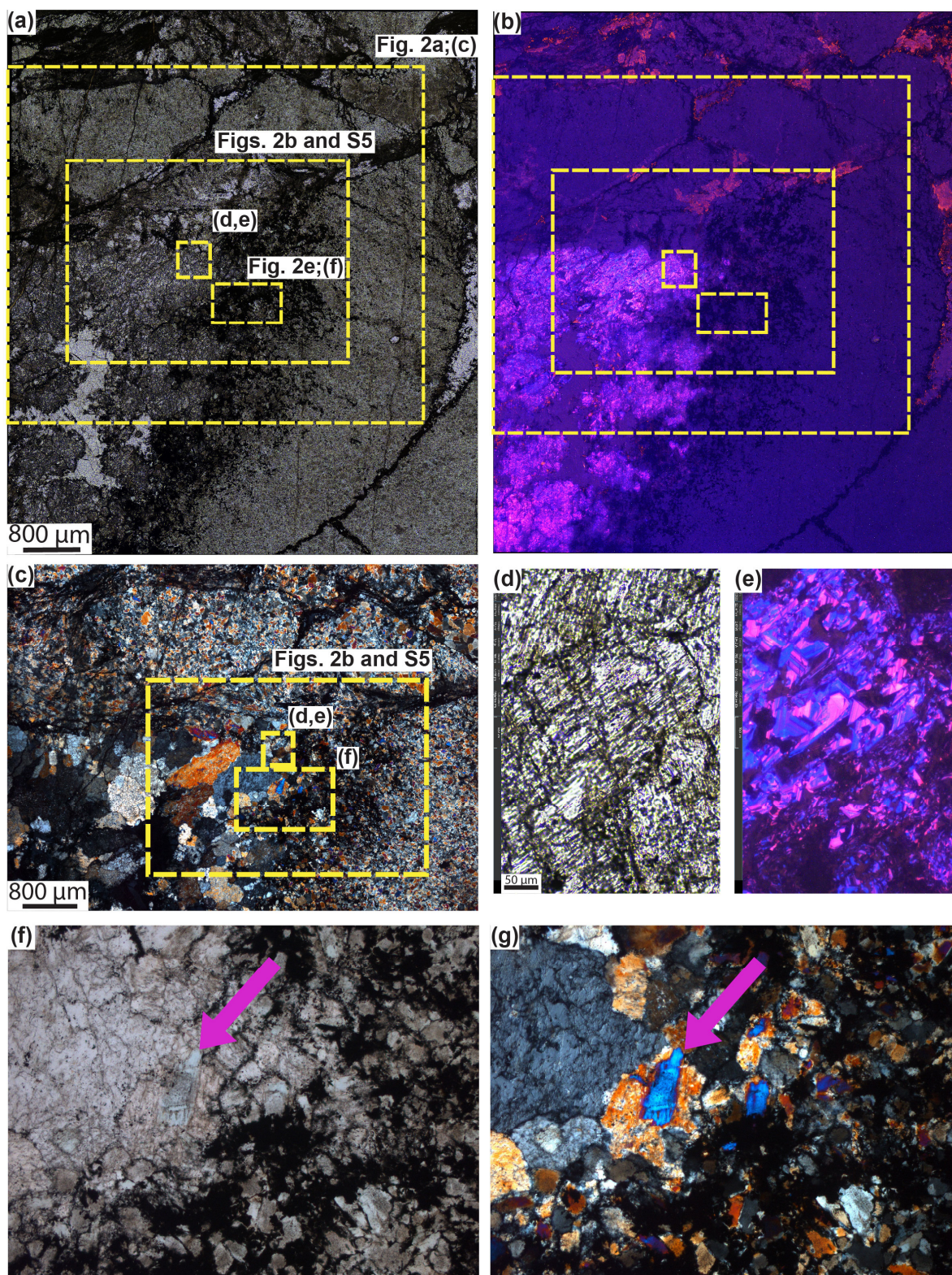
Supplementary Figure 1. Thin section scan of brecciated omphacitite with X-ray map locations. The dilational breccia shows predominantly a granular equant growth of jadeite in the matrix, with locally syntaxial growth (green arrows). Compenetrated clasts show graphite-enriched stylolitic structures (yellow arrow). Garnet seems to grow in the innermost part of the dilational matrix. (a) Plane- (b) crossed polarized light and (c) BSE image.



Supplementary Figure 2. (a) Thin section scan of mosaic brecciated omphacitite with X-ray map 4 location. Yellow arrows highlight graphite-enriched stylolitic structures. (a) Plane- (b) crossed polarized light.

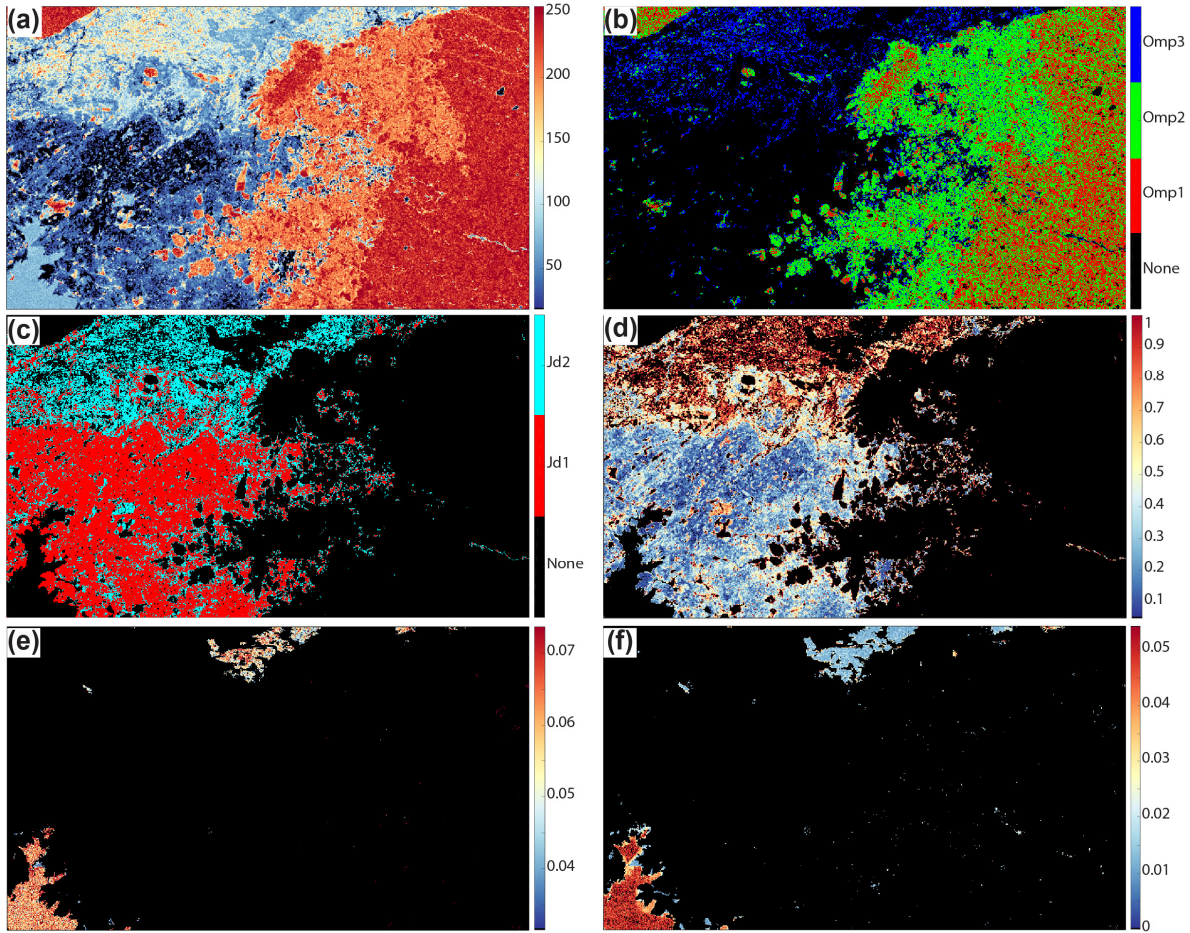


Supplementary Figure 3. Omphacitite breccia overprinted by a mylonitic foliation rich in chlorite.

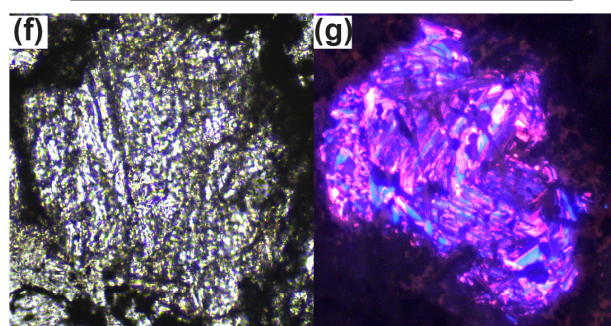
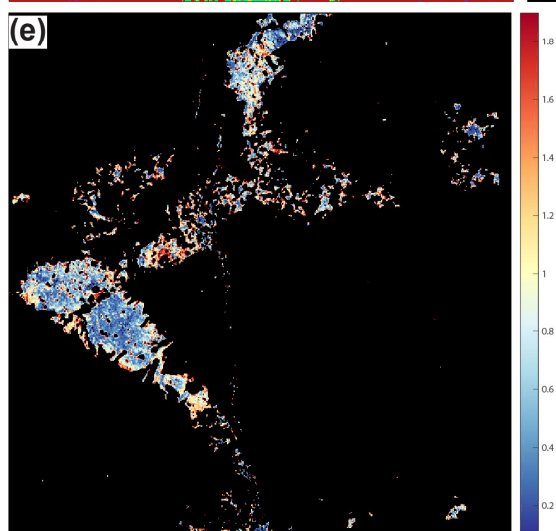
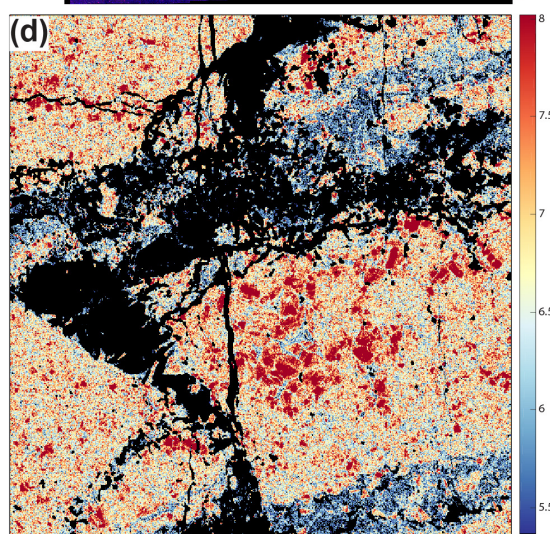
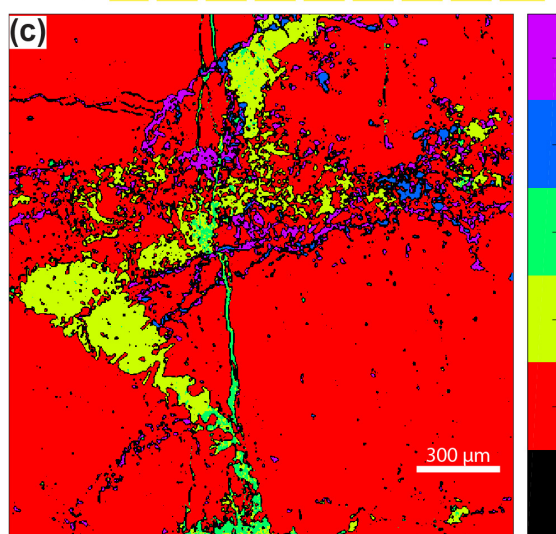
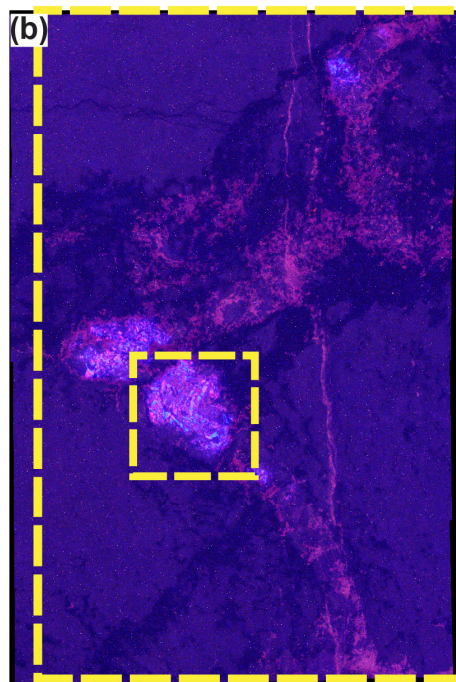
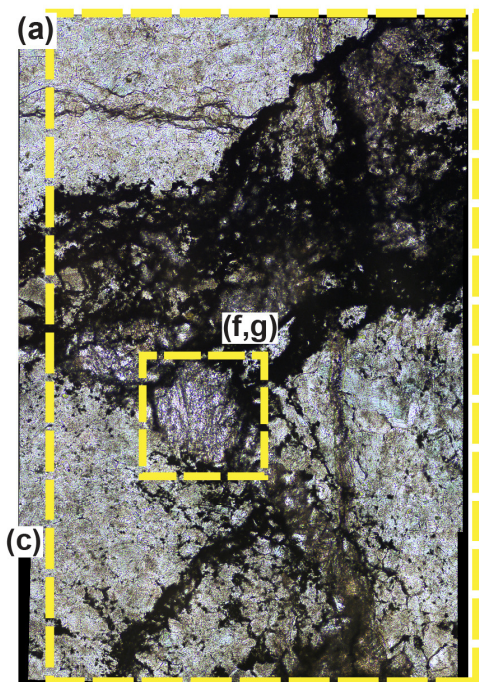


Supplementary Figure 4. (a) Detail of the contact between omphacite clasts and matrix, plane-polarized light. (b) CL image highlighting jadeite grains located in the matrix with pink and light blue colours, and garnet with orange and blue colours. (c) Detail of (a) and same area of Fig. 2a, crossed-polarized light. Note the different grain size between smaller omphacite grains in the clasts and larger

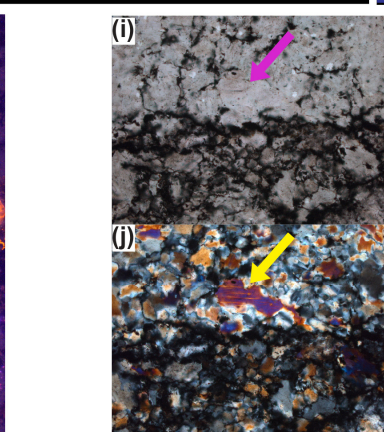
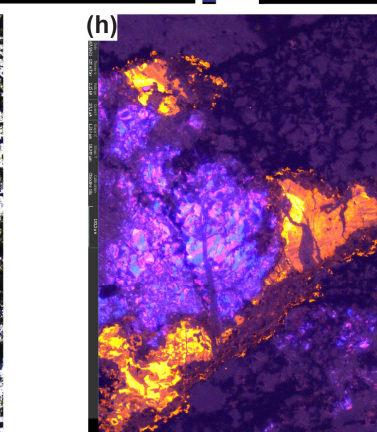
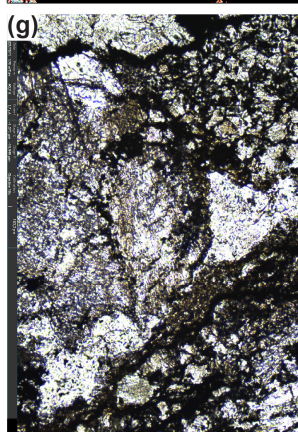
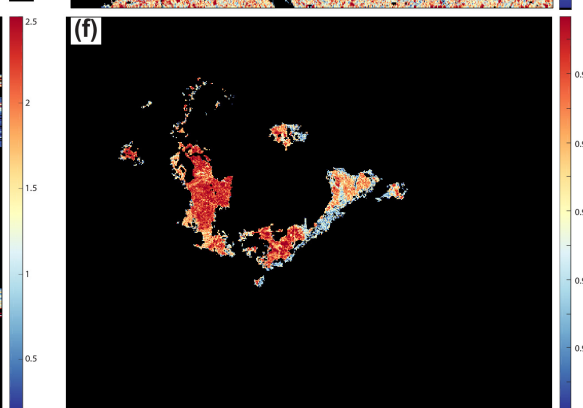
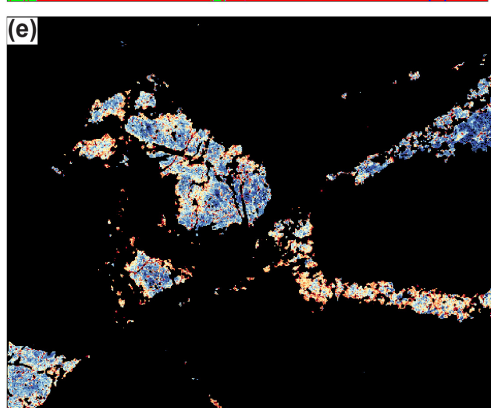
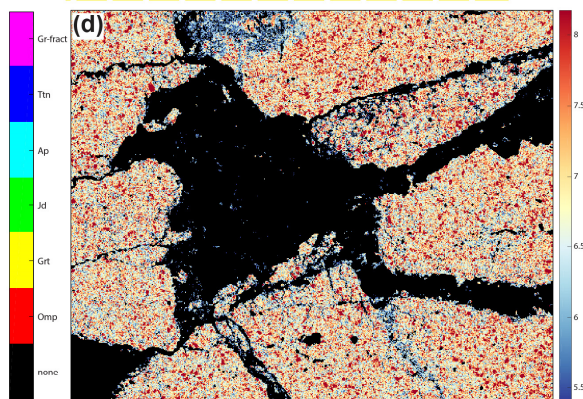
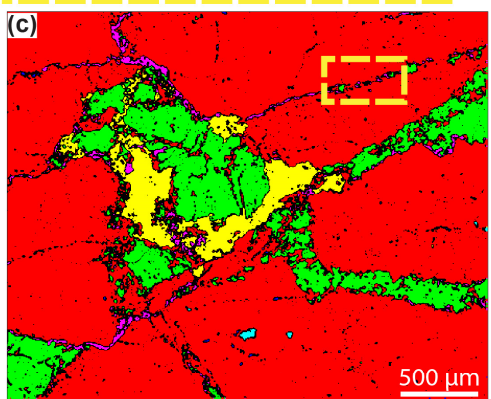
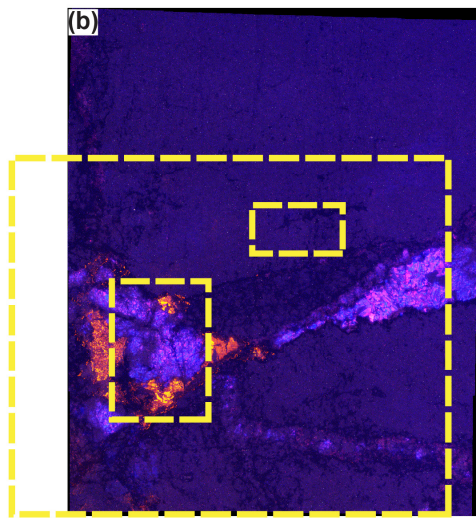
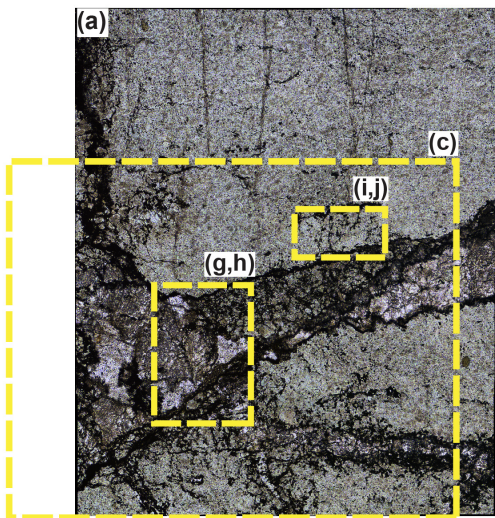
jadeite grains in the matrix. (d,e) Detail of jadeite grains displaying oscillatory growth zoning, plane-polarized light and CL image, respectively. (f,g) Detail of (c). The arrow highlights a grain of omphacite generation 1 and 2 overgrown by jadeite (see text for discussion and compare with Supplementary Fig. 5b and c).



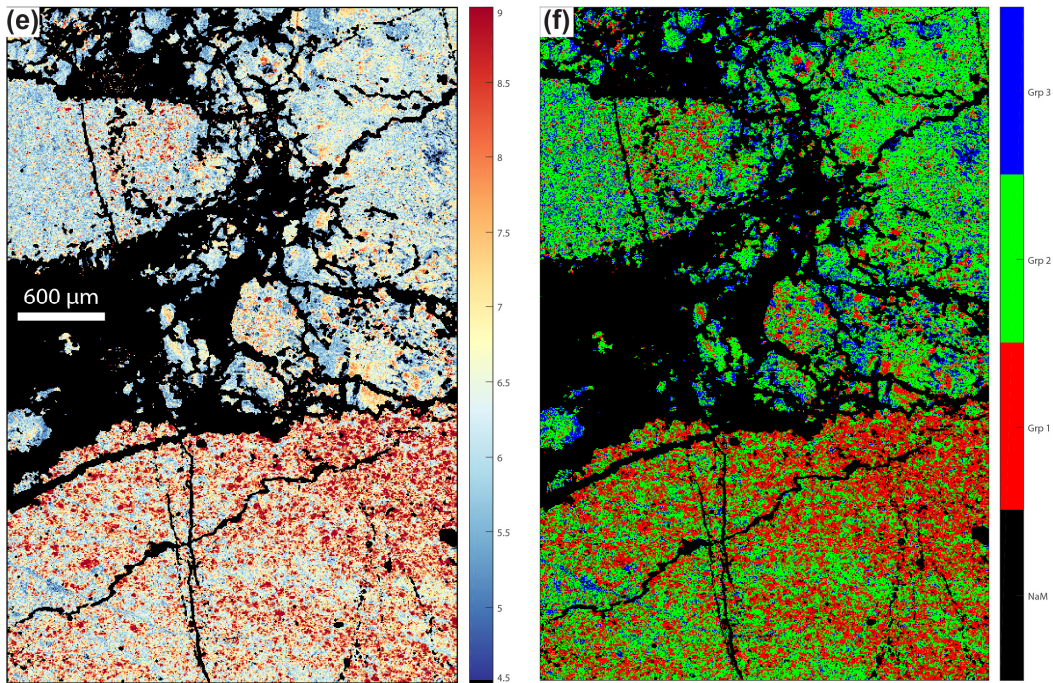
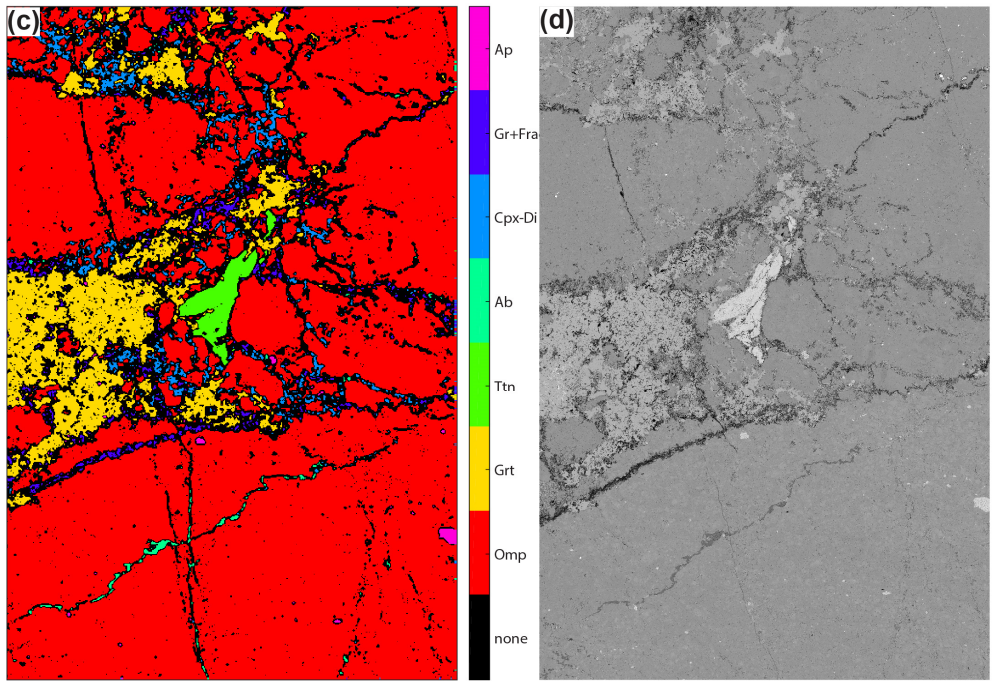
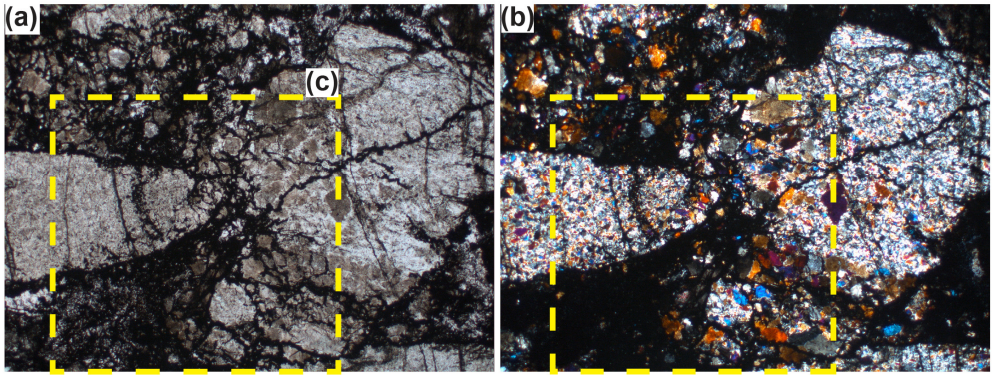
Supplementary Figure 5. Complementary insets of standardized X-ray map 1 shown in Fig. 2d (see location in Supplementary Fig. 1). (a) Fe counts per second highlighting the relations between omphacite, jadeite and garnet. (b, c) Classification of jadeite and omphacite generations, respectively (see text for explanation). (d) FeO weight % in jadeite. (e, f) Garnet X_{Grs} and X_{Adr} maps, respectively.



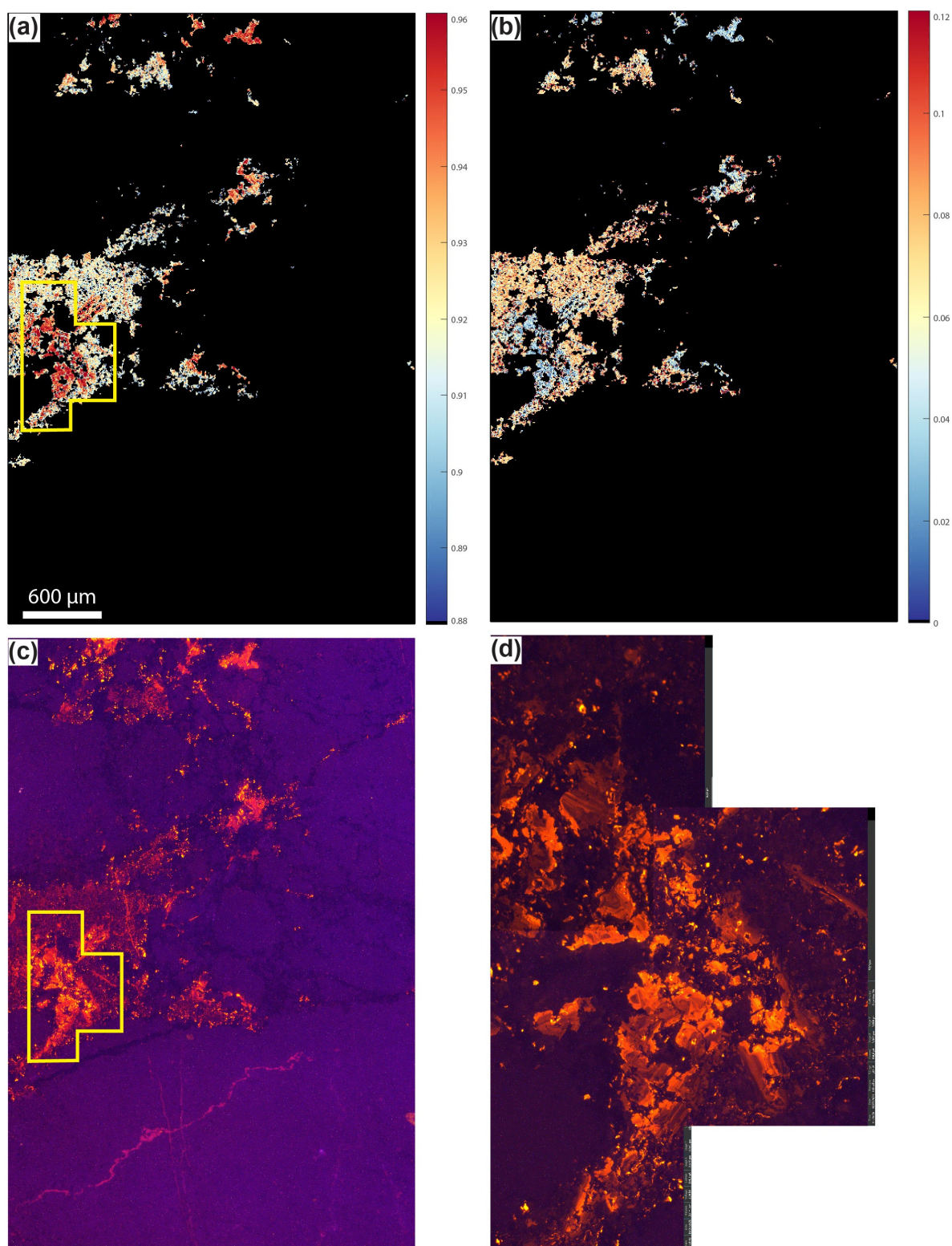
Supplementary Figure 6. X-ray Map 2 (see location in Supplementary Fig. 1). (a,b) Plane- polarized light and CL image, respectively. X-ray map 2: (c) colour coded for the different mineral phases. Gr-fract: graphite-coated fractures, Ttn: titanite, Ab-Fract: later albite fracture, Jd: jadeite, Omp: Omphacite. (d,e) FeO weight % in omphacite and jadeite, respectively. (f,g) Detail of jadeite in the matrix; plane- polarized light and CL image, respectively.



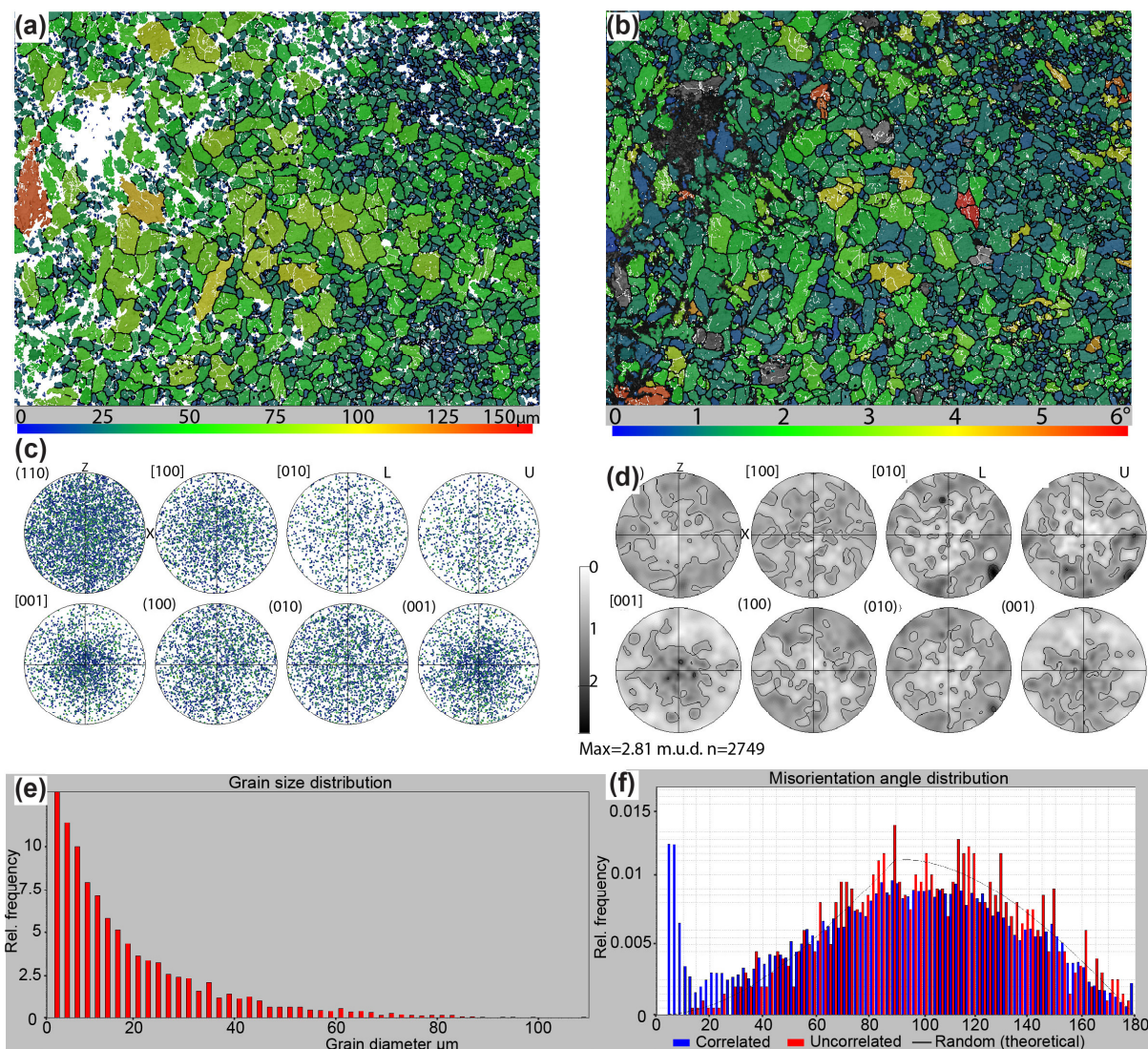
Supplementary Figure 7. Detail of the contact between omphacitite clasts and matrix and X-ray Map 3 (see location in Supplementary Fig. 1). (a,b) Plane- polarized light and CL image, respectively. (c-f) X-ray map 3: (c) colour coded for the different mineral phases. Gr-fract: graphite-coated fractures, Ttn: titanite, Ap: apatite, Jd: jadeite, Grt: garnet, Omp: Omphacite. (d,e) FeO weight % in omphacite and jadeite, respectively. (f) Garnet X_{Grs} . (g, h) Detail of jadeite and garnet in the matrix; plane- polarized light and CL image, respectively. (i,j) Omphacite grain in the omphacitite clast close to a graphite-coated fracture displaying twinning (see text for discussion).



Supplementary Figure 8. X-ray Map 4 (see location in Supplementary Fig. 2). (a,b) Detail of the contact between two omphacite clasts. Plane and crossed-polarized light, respectively. (c,f) X-ray map 4: (c) colour coded for the different mineral phases. Ap: Apatite, Gr-fra: graphite-coated fractures, Cpx-Di: retrograde Diopside-rich clinopyroxene, Ttn: titanite, Ab-Fract: later albite fracture, Omp: Omphacite. (d) BSE image. (e) FeO weight % in omphacite. (f) Classification of omphacite generations (see text for explanation).



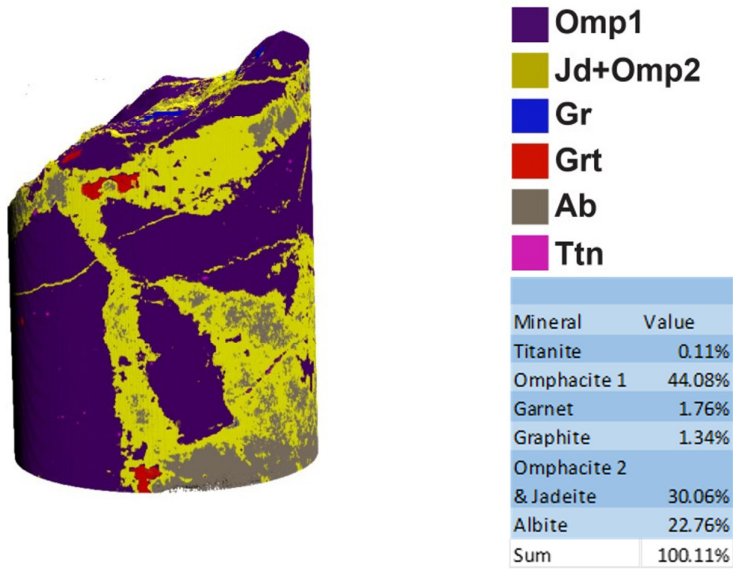
Supplementary Figure 9. Continuation of X-ray Map 4 (see location in Supplementary Fig. 2). (a) Garnet X_{Grs}, (b) X_{Adr}, and (c, d) CL images highlighting a core to rim zoning.



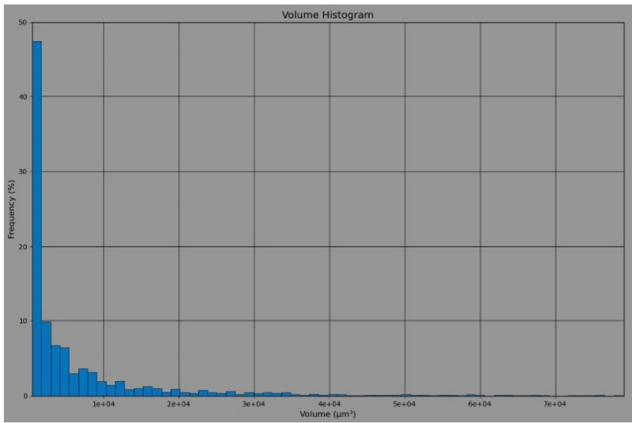
Supplementary Figure 10. Complementary insets of EBSD map of omphacite grains located inside the clast (compare with Fig. 2,f). (a) Grain size map. (b) Grain orientation spread (GOS) map; the grains show numerous low-angle boundaries and relative low GOS values except a few grains, with values up to 6°. (c,d) Pole figures and contoured pole figures of the crystallographic orientation data of omphacite showing that no CPO is present. 2749 data points (one-point-per-grain). n = number of grains. Half width 10° and cluster size 5°, maximum value is given. Lower hemisphere of the stereographic projection, if not specified. (e, f) Histogram of grain size and misorientation angle distribution, respectively.

X-ray Microscopy (XRM) statistical data

#1_4a2



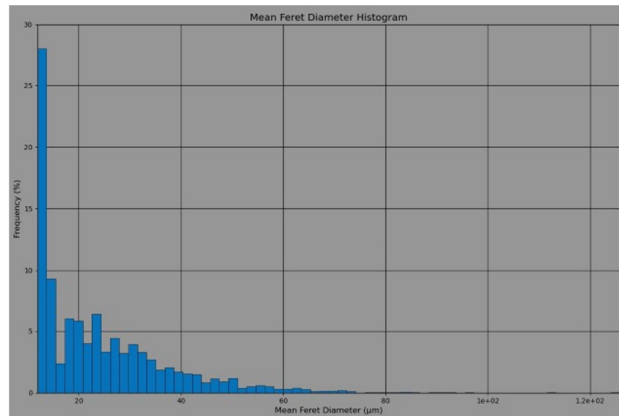
#1_4a2 – Volume
Titanite



Volume Histogram statistics

- Min: 526.74 µm³
- Max: 3,955,823.76 µm³
- Mean: 12,894.62 µm³
- Standard dev: 84,268.18 µm³

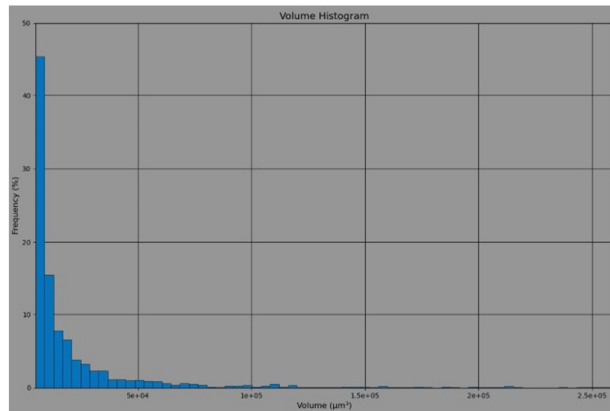
#1_4a2 – Mean Feret Diameter Titanite



Mean Feret Diameter Histogram statistics

- Min: 11.90 μm
- Max: 303.91 μm
- Mean: 26.10 μm
- Standard dev: 19.90 μm

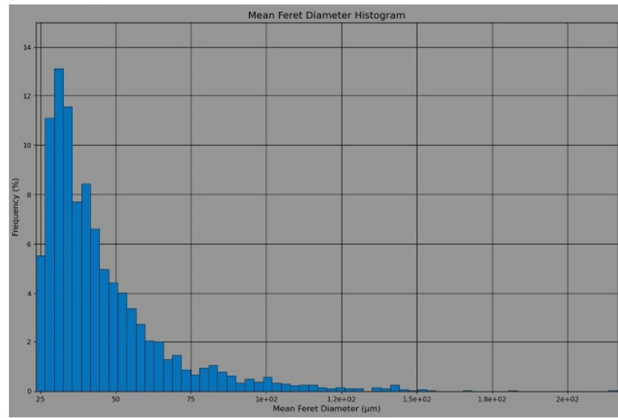
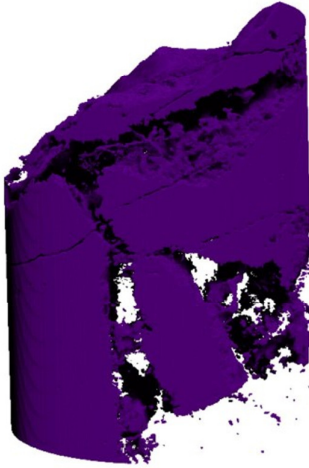
#1_4a2 – Volume Omphacite 1



Volume Histogram statistics

- Min: 4,740.67 μm^3
- Max: 17,400,603,631.49 μm^3
- Mean: 6,463,548.46 μm^3
- Standard dev: 333,152,386.87 μm^3

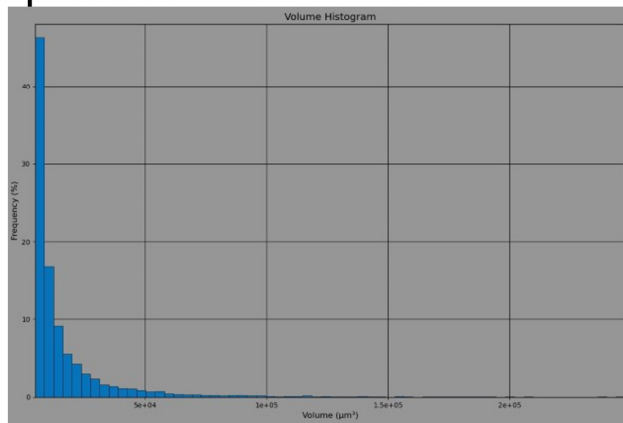
#1_4a2 – Mean Feret Diameter Omphacite 1



Mean Feret Diameter Histogram statistics

- Min: 23.47 μm
- Max: 4,307.83 μm
- Mean: 52.19 μm
- Standard dev: 93.51 μm

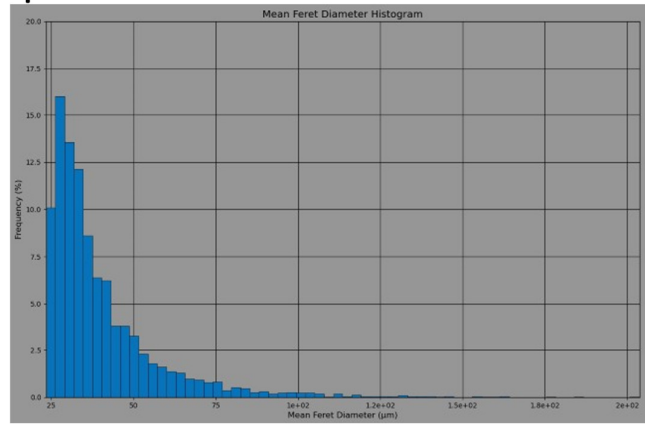
#1_4a2 – Volume Omphacite 2 & Jadeite



Volume Histogram statistics

- Min: 4,740.67 μm^3
- Max: 11,870,067,046.10 μm^3
- Mean: 2,406,371.69 μm^3
- Standard dev: 168,036,015.74 μm^3

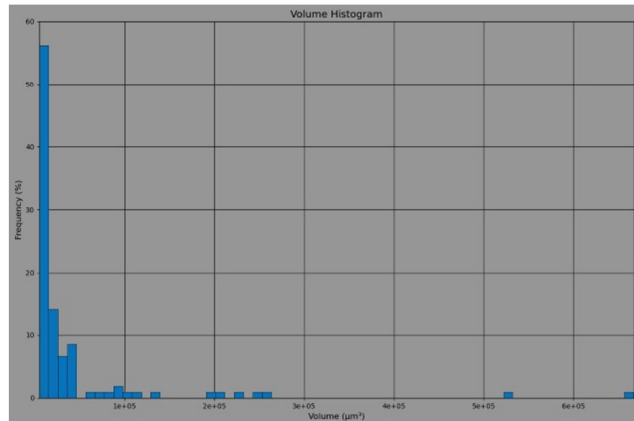
#1_4a2 – Mean Feret Diameter Omphacite 2 & Jadeite



Mean Feret Diameter Histogram statistics

- Min: 23.39 μm
- Max: 4,671.25 μm
- Mean: 42.44 μm
- Standard dev: 70.61 μm

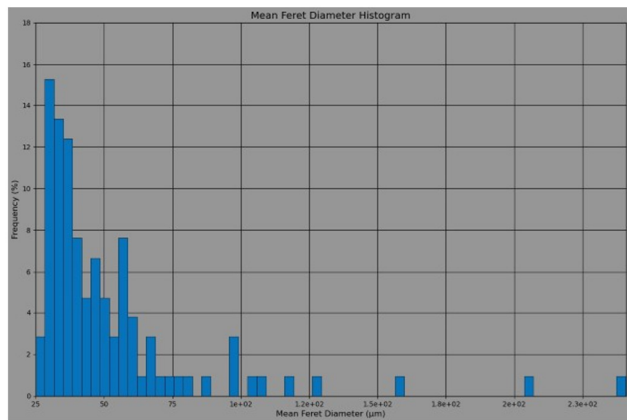
#1_4a2 – Volume Garnet



Volume Histogram statistics

- Min: 4,740.67 μm^3
- Max: 627,334,125.94 μm^3
- Mean: 6,065,461.71 μm^3
- Standard dev: 58,000,508.26 μm^3

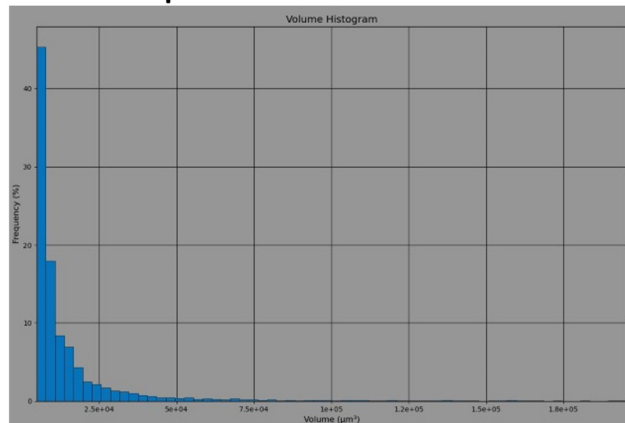
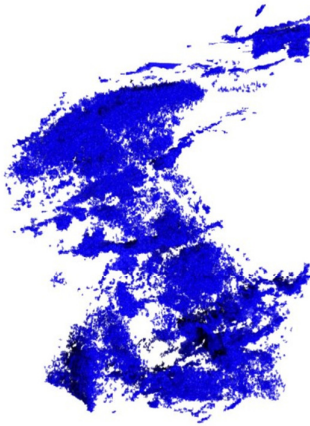
#1_4a2 – Mean Feret Diameter Garnet



Mean Feret Diameter Histogram statistics

- Min: 24.89 μm
- Max: 2,018.45 μm
- Mean: 94.42 μm
- Standard dev: 201.97 μm

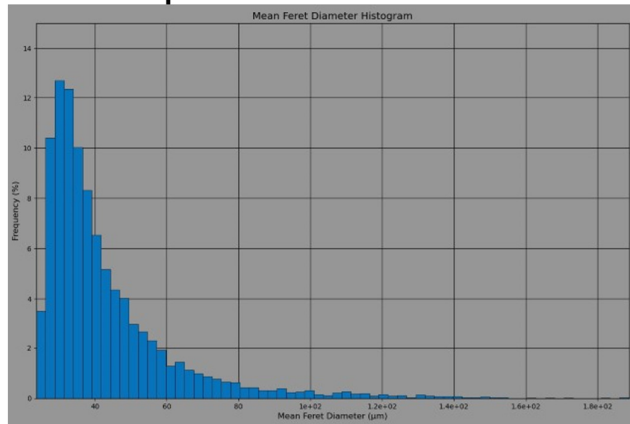
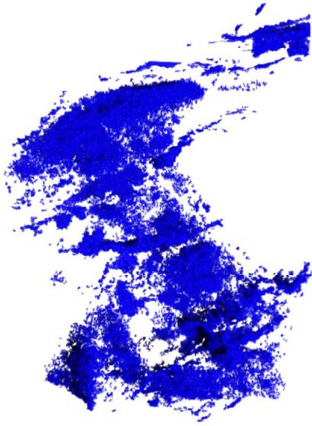
#1_4a2 – Volume Graphite



Volume Histogram statistics

- Min: 4,740.67 μm^3
- Max: 93,321,095.52 μm^3
- Mean: 67,510.61 μm^3
- Standard dev: 1,443,868.98 μm^3

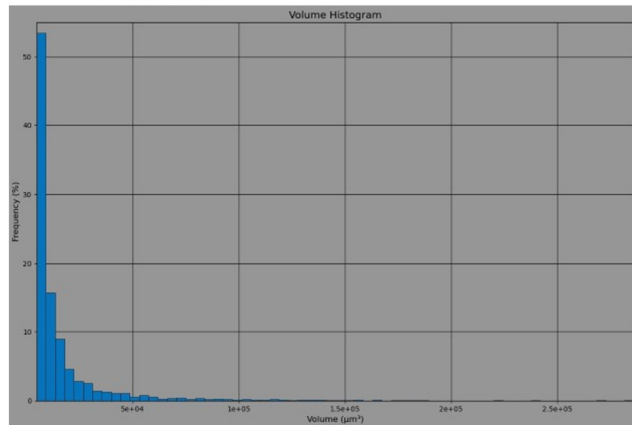
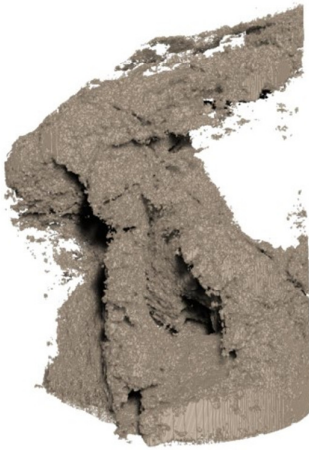
#1_4a2 – Mean Feret Diameter Graphite



Mean Feret Diameter Histogram statistics

- Min: 23.65 μm
- Max: 1,550.09 μm
- Mean: 47.04 μm
- Standard dev: 47.98 μm

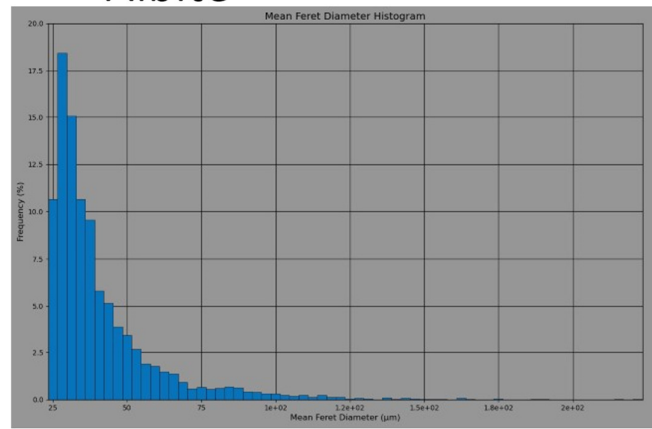
#1_4a2 – Volume Albite



Volume Histogram statistics

- Min: 4,740.67 μm^3
- Max: 8,969,916,751.63 μm^3
- Mean: 2,370,017.16 μm^3
- Standard dev: 144,902,045.25 μm^3

#1_4a2 – Mean Feret Diameter Albite



Mean Feret Diameter Histogram statistics

- Min: 23.44 μm
- Max: 4,590.19 μm
- Mean: 44.54 μm
- Standard dev: 80.67 μm