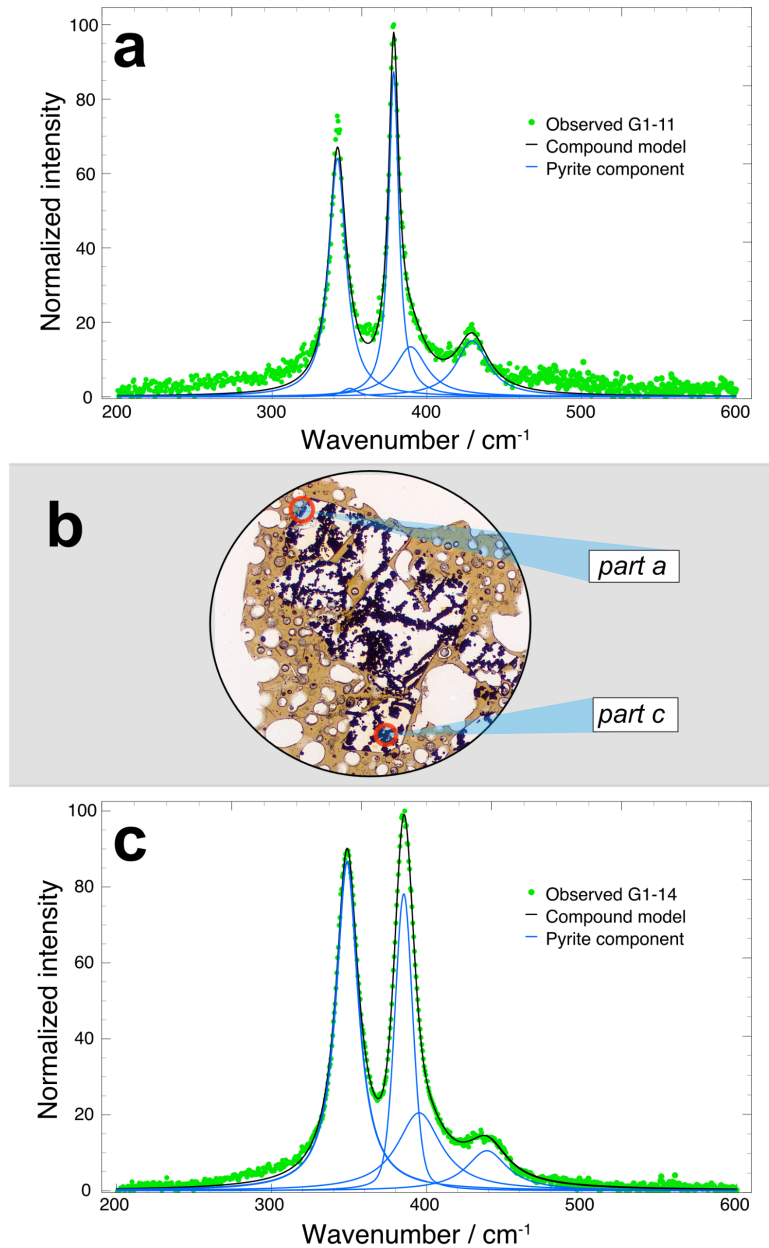
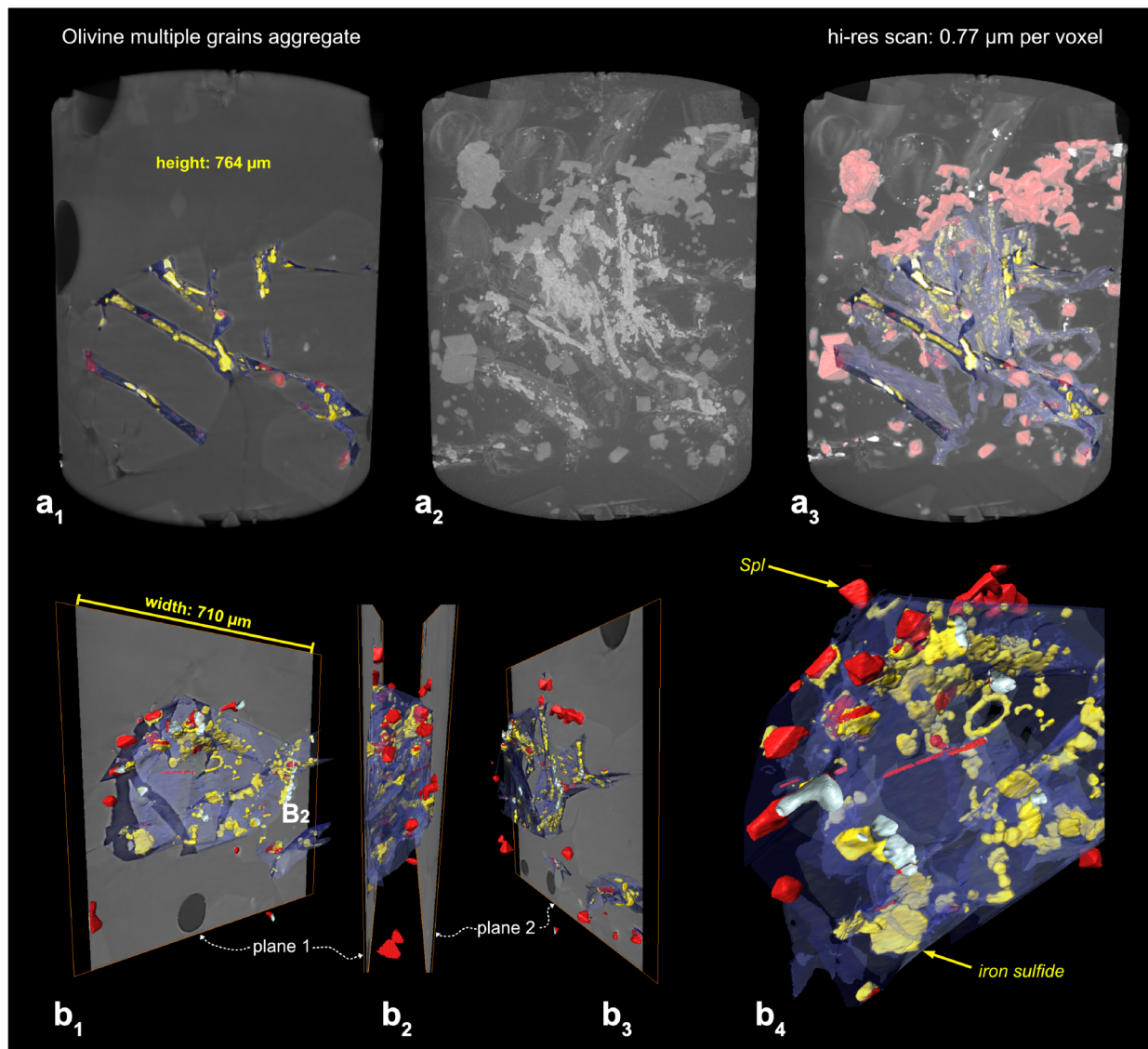


**Figure S1.** Occurrence and connectivity of voids inside a volcanic ash particle (3D X-ray microscopy, XRM). (a) The highly-connected pore space (blue) in this particle spans over several olivine crystals, all embedded in glass matrix. (b) Volume rendering of this particle, virtually cut by plane for visualization of the multiple olivine grains aggregate. (c) Location of a high-resolution scan (see Fig. S3) inside this particle.



**Figure S2.** (a) Raman spectra at the location G1-11 of the sample 22841, as labeled in figure 6. The fitted five Pseudo-Voigt components correspond to pure pyrite. (b) Location of G1-11 and G1-14 depicted in thin section (plain polarized light). (c) Raman spectra at the location G1-14. The resolved Pseudo-Voigt components correspond to pure pyrite, however with a broader lineshape along with a global blue shift.



**Figure S3.** High-resolution XRM scan of a volcanic ash particle, showing the microfabric of olivine dissolution and  $\text{FeS}_2$  precipitation processes, with particular consideration of spinel occurrence. Spinel (red) exhibits euhedral to subeuhedral crystal morphologies, irrespective of the fabric context: either in volcanic glass, or olivine material unaffected by dissolution, or overgrown by  $\text{FeS}_2$  (yellow) where in contact with dissolution-induced cavities (transparent blue). (a) Visualization of the spatial distribution of spinel,  $\text{FeS}_2$  and void space within the cylindric VOI:  $a_1$  opaque volume rendering of olivine/glass;  $a_2$  maximum intensity projection;  $a_3$  semitransparent volume rendering of olivine/glass. (b) Visualization of Spl,  $\text{FeS}_2$  and void between to virtual cropping planes. For location of the high-resolution scan inside the volcanic ash particle please refer to supplementary figure S1.