

Gold and Tin Mineralization in the Ultramafic-Hosted Cheoeum Vent Field, Central Indian Ridge

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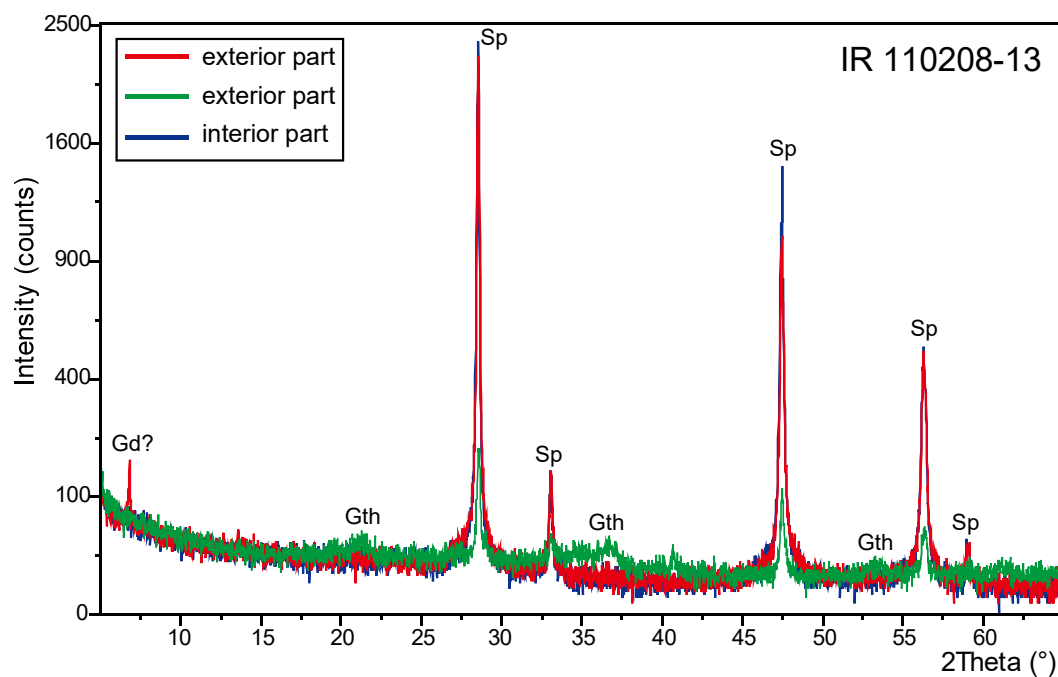
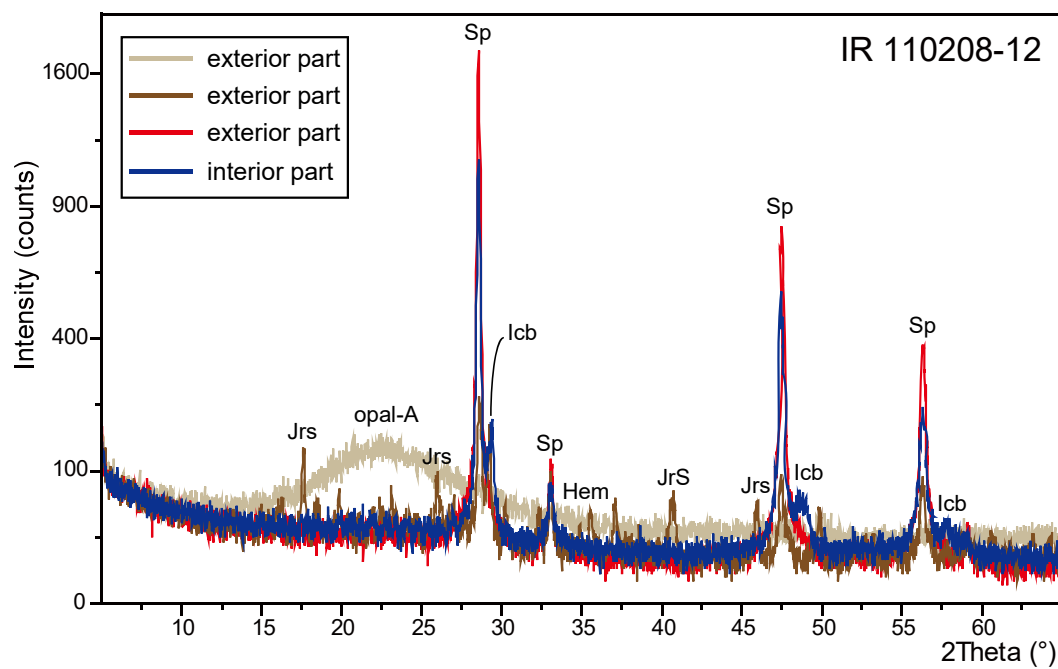
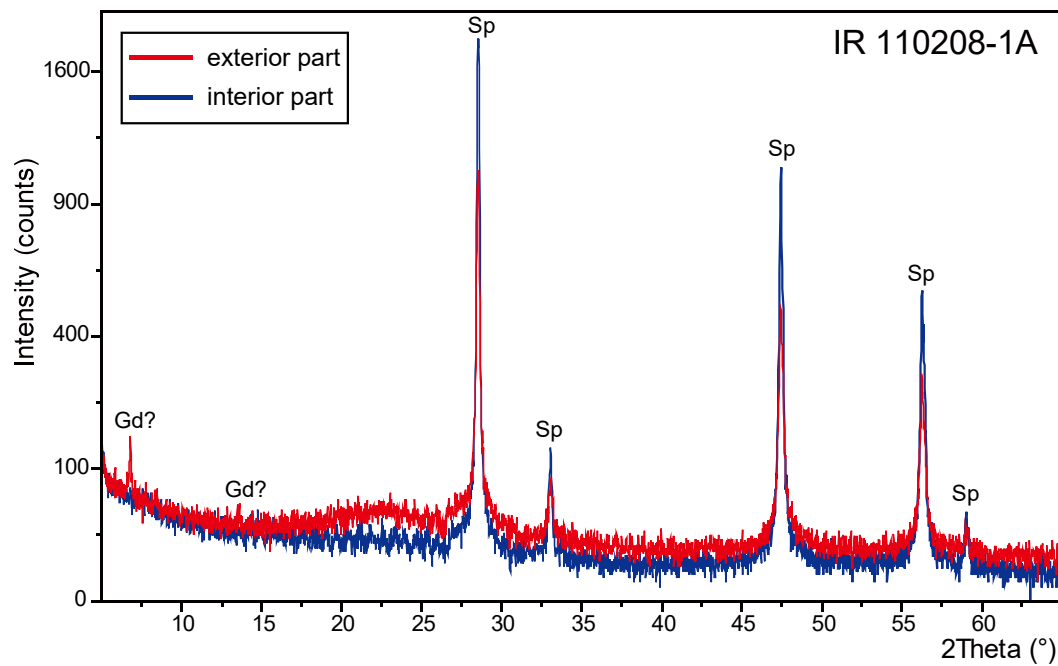


Fig S1 (ESM 1) X-ray diffraction data for the hydrothermal chimney from the CVF. Abbreviations: Ccp=chalcopyrite; Gd=gordaite; Gth=goethite; Hem=hematite; Icb=isocubanite; Jrs=jarosite; Sp=sphalerite.

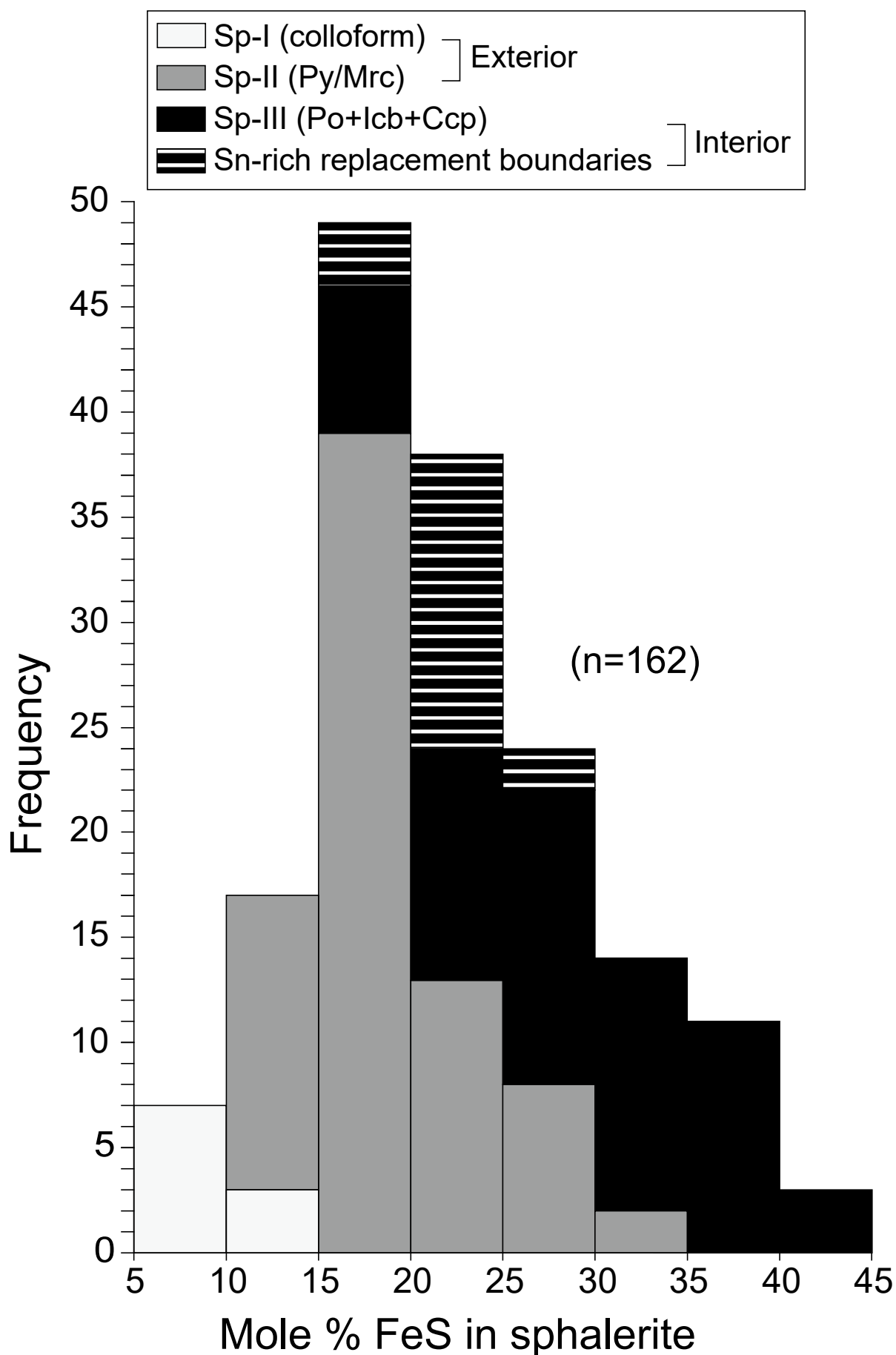


Fig S2 (ESM 1) Histogram of mol.% FeS contents in sphalerite according to the mineral assemblages present. Abbreviations: Ccp=chalcopyrite; Icb=isocubanite; Mrc=marcasite; Po=pyrrhotite; Py=pyrite; Sp=sphalerite. Roman numerals indicate the generation stage, which is related to the texture and mineral assemblages present.

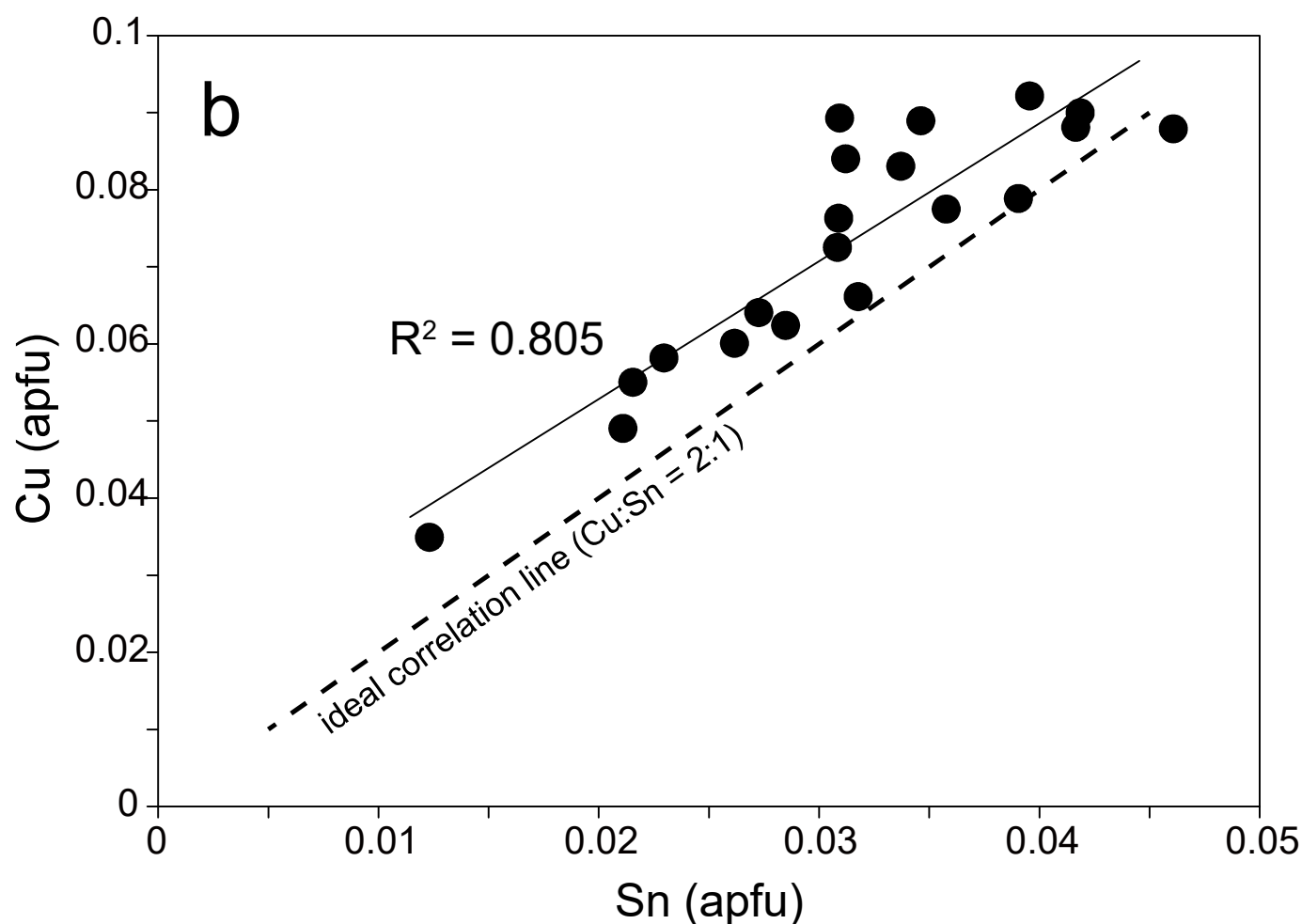
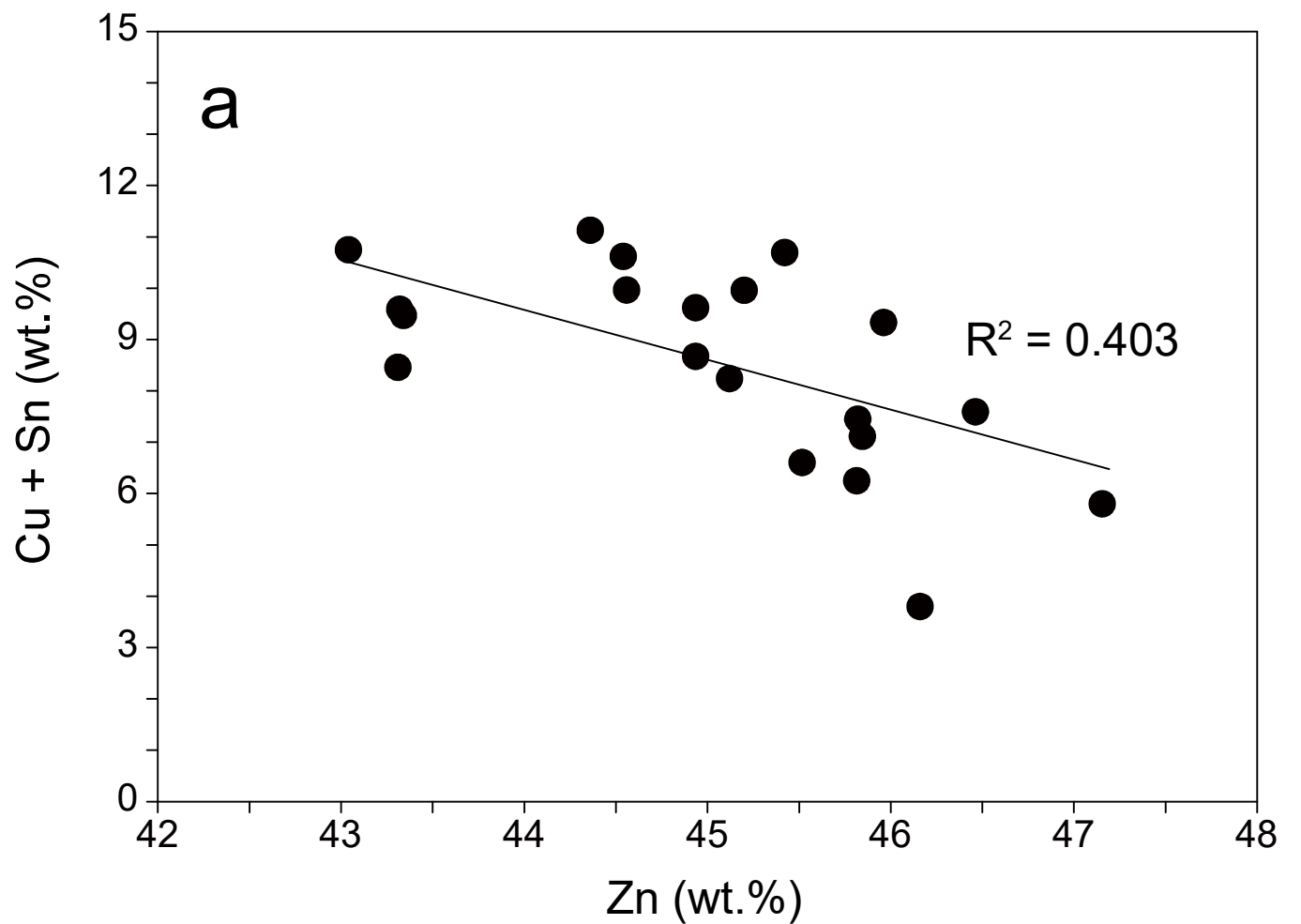


Fig S3 (ESM 1) Chemical compositions of sphalerite focused on the Sn-rich replacement boundaries shown in Fig. 7. (a) Plot of (Cu + Sn) versus Zn showing a negative correlation. (b) Plot of Cu versus Sn (apfu) showing a 2:1 correlation for Cu:Sn.

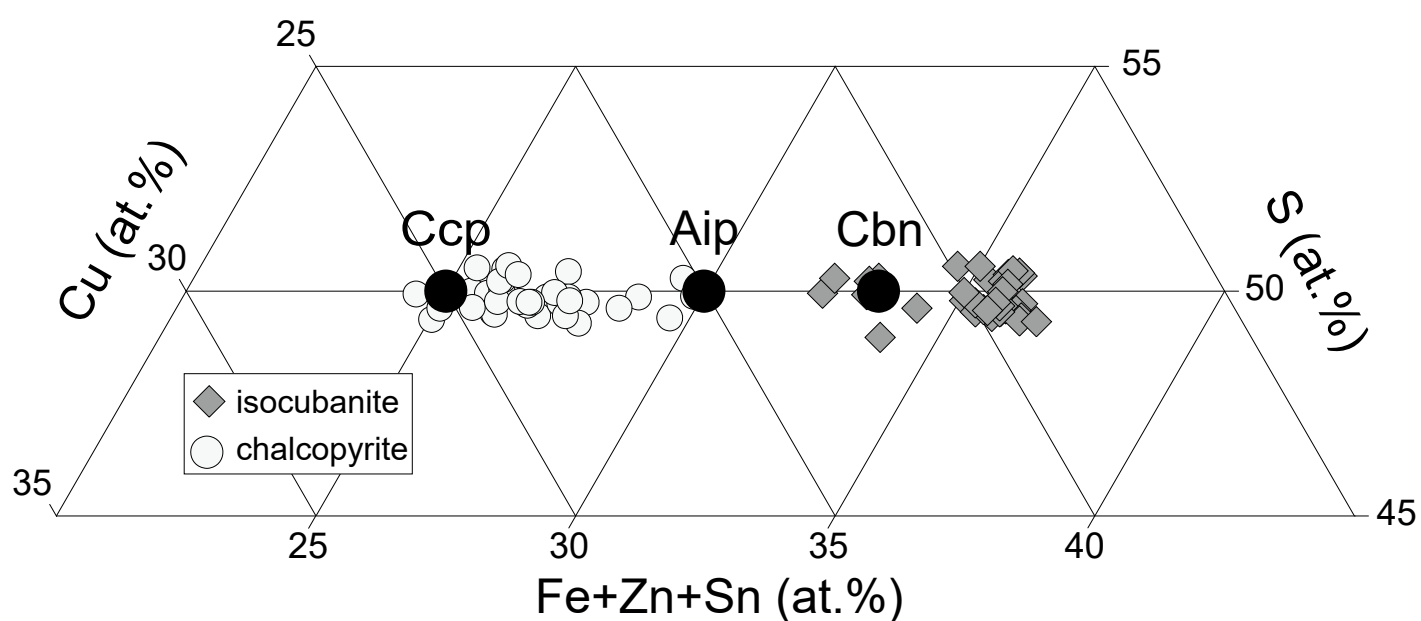


Fig S4 (ESM 1) Fig. 10 Cu sulphide data plotted on a Cu–(Fe + Zn + Sn)–S diagram. Black circles are theoretical compositions of chalcopyrite (Ccp; CuFeS_2), cubanite (Cbn; CuFe_2S_3), and altered isocubanite phase (Aip: $\text{Cu}_2\text{Fe}_3\text{S}_5$).

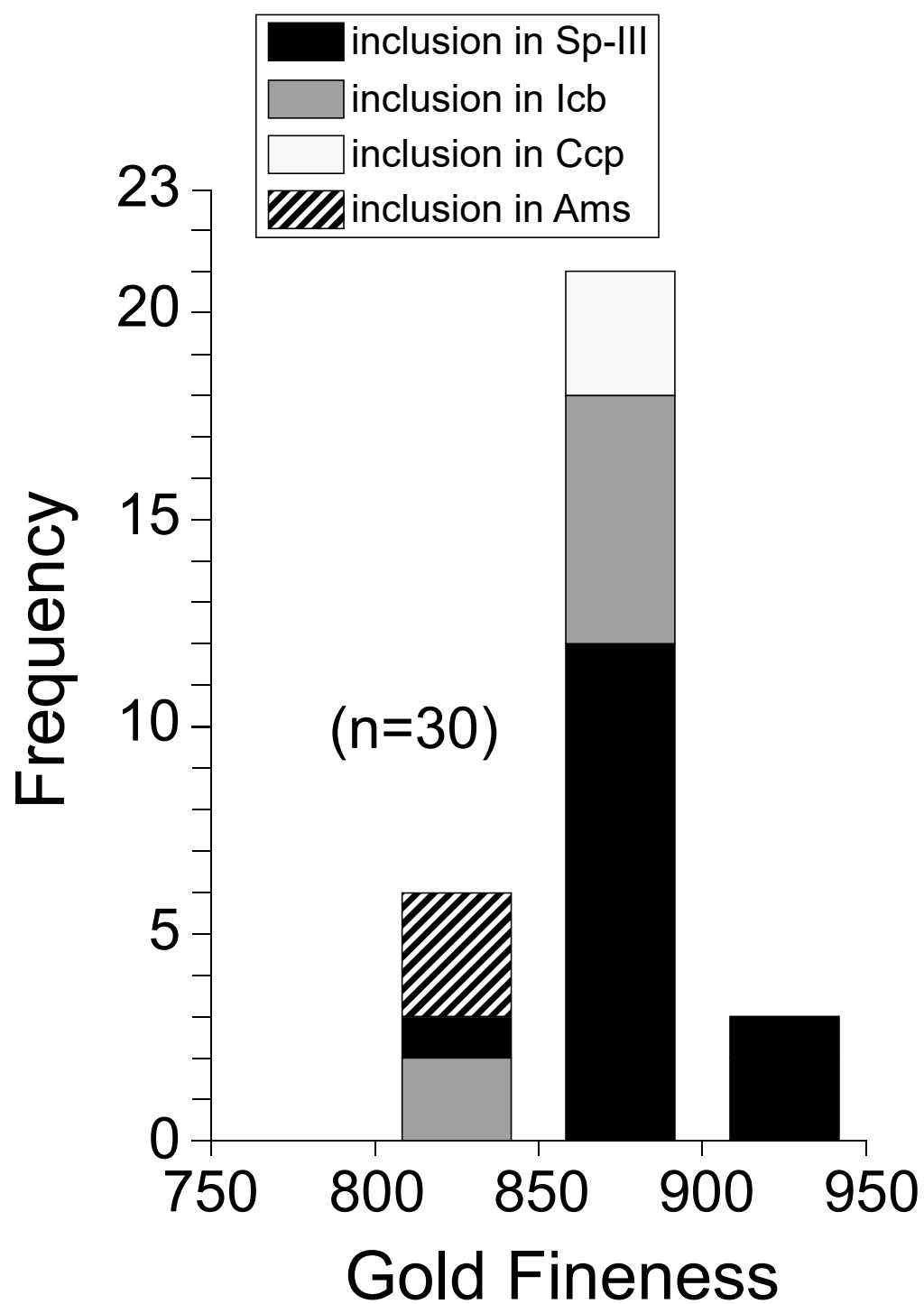


Fig S5 (ESM 1) Fig. 11 The range of gold fineness with respect to electrum mode of occurrence. Abbreviations: Ams=amorphous silica; Ccp=chalcopryite; Icb=isocubanite; Sp=sphalerite.

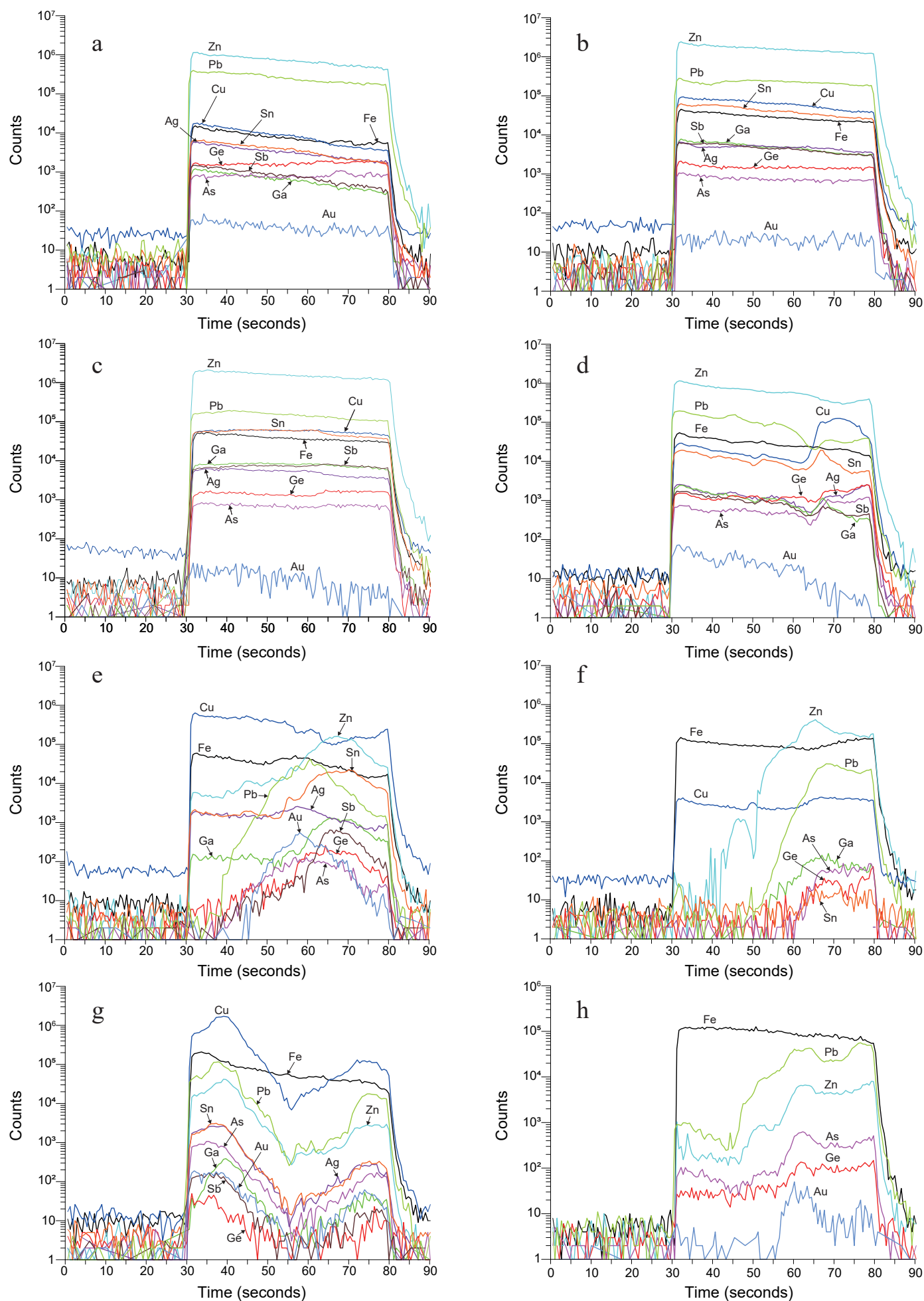


Fig S6 (ESM 1) Representative time-resolved LA-ICP-MS depth profiles for selected elements in the dominant sulfide minerals. Sphalerite mostly has flat depth profiles indicative of solid solution regardless of the mineralisation stage. (a) Colloform sphalerite (Sp-I) in the exterior zone. (b) Massive sphalerite (Sp-II) in the exterior zone. (c) Main-stage sphalerite (Sp-III) in the interior zone. Some profiles show irregularities with respect to (d) sphalerite, (e) isocubanite, and (f) pyrrhotite. (g) Mixture of covellite and pyrrhotite show that spikes of most trace elements are confined to covellite. (h) Mrc-II showing spikes typical of its depth profile.

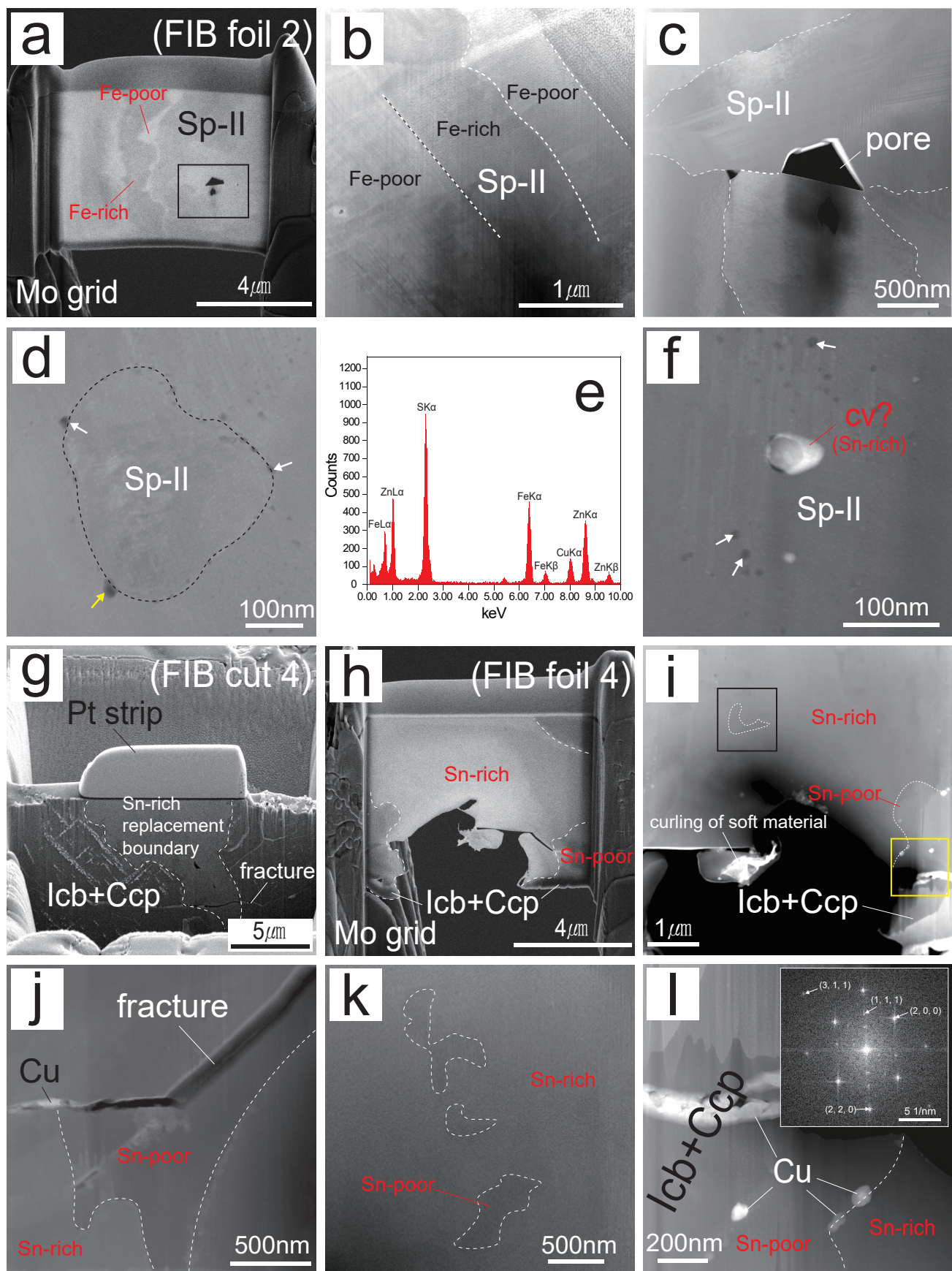


Fig S7 (ESM 1) Focused ion beam-SEM and HAADF-STEM images of ion-milled samples obtained from the Sn-rich zone of (a–f) Sp-II and (g–l) Sn-rich replacement boundaries in the interior zone of the chimney. (a) Sp-II with no inclusions in a FIB-SEM image. (b) Fe zonation that is generally characteristic of Sp-II. (c) A number of aggregate grains (black box in A). (d) Cu-rich sphalerite inclusion (white arrows) intermittently observed along grain boundaries (dotted black line). (e) EDS spectrum of a Cu-rich sphalerite inclusion marked by yellow arrow in (d). (f) Translucent phase around Cu-rich sphalerite inclusions with a composition close to that of covellite exhibiting Sn enrichment. (g) The positions of the focused ion beam slices. (h) Focused ion beam slices with no inclusion phase. (i–k) Sn-rich and -poor parts in replacement boundaries. Sn enrichment is not associated with any inclusion phase. (l) Native Cu along fractures and grain boundaries of sulphide minerals (yellow box in i). The inset is a fast Fourier transform (FFT) pattern of native Cu. Abbreviations: Ccp=chalcopyrite; cv=covellite; lcb=isocubanite; Po=pyrrhotite; Sp=sphalerite.

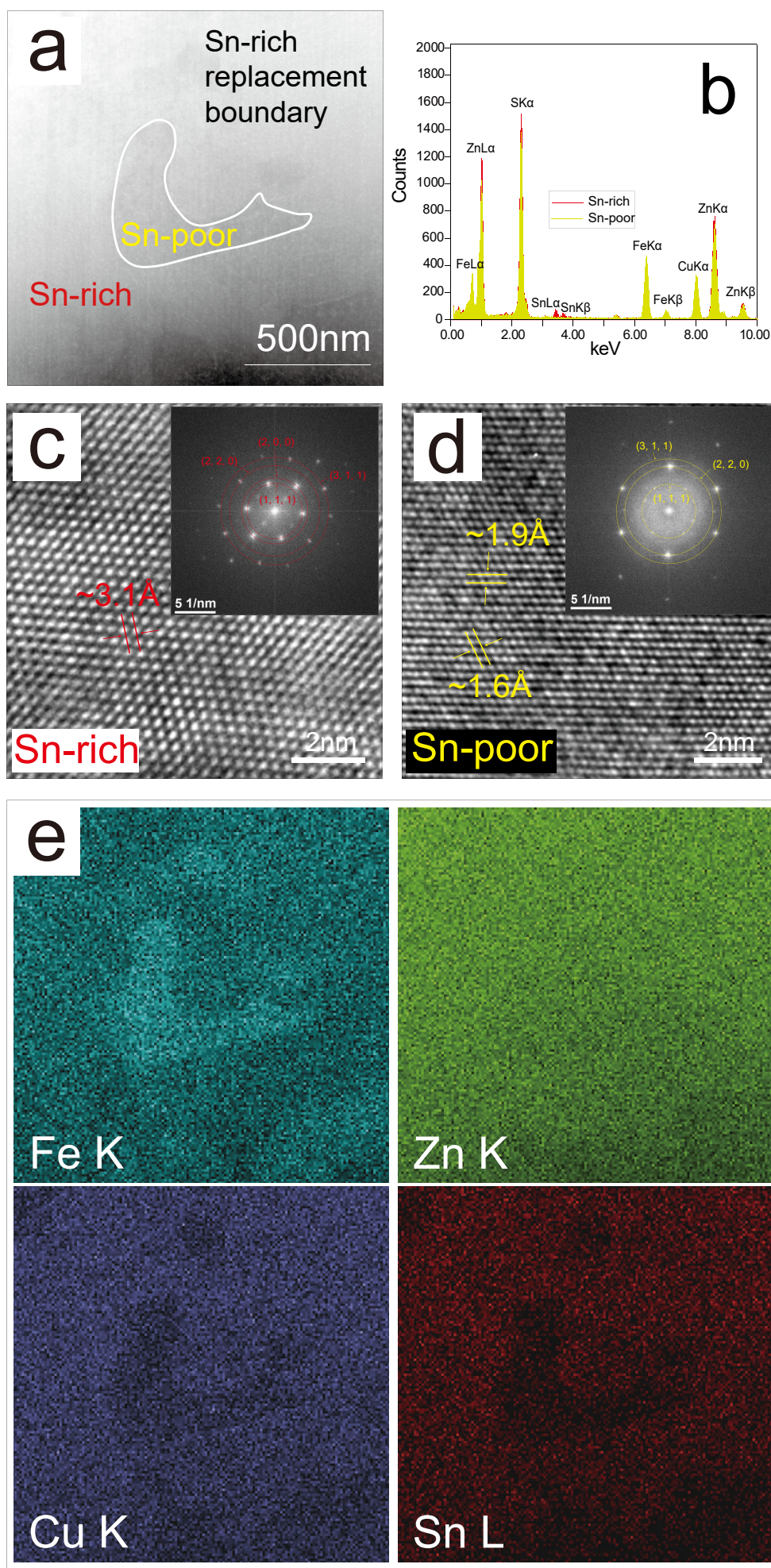


Fig S8 (ESM 1) (a) HAADF-STEM image of the black box outlined in Fig S7i. (b) EDS spectra of the Sn-rich and -poor regions shown in (a). (c) High-resolution (HR) TEM image of a Sn-rich part in (a). The inset is the corresponding fast Fourier transform (FFT) pattern. (D) HR-TEM image of a Sn-poor part in (a). The inset is the corresponding FFT pattern. (e) STEM EDS element maps (Fe, Zn, Cu, and Sn) showing that Sn is positively correlated with Cu and negatively correlated with Fe.

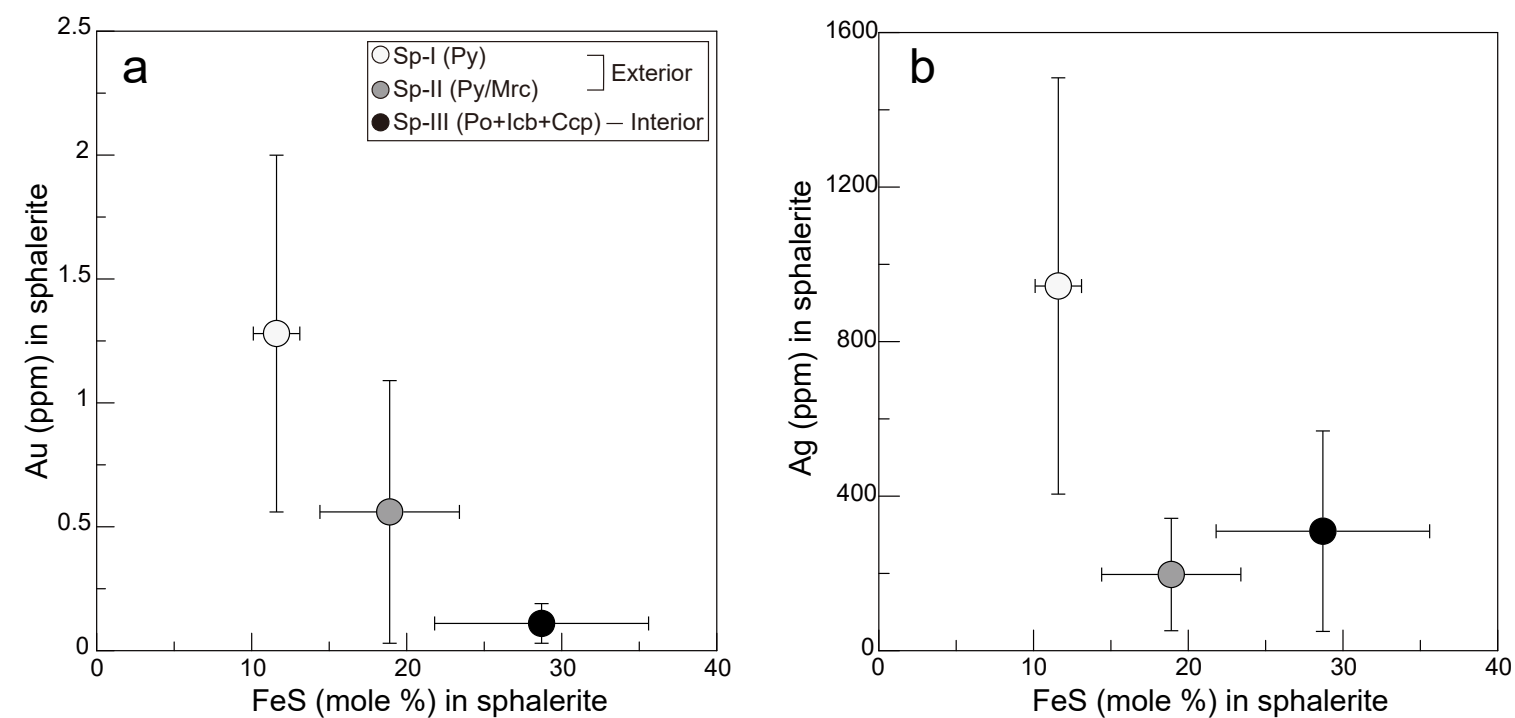


Fig S9 (ESM 1) Plots of invisible (a) Au and (b) Ag concentrations versus FeS contents for sphalerite according to the mineralization stage (average values). Error bars are 1σ standard deviation. Abbreviations: Ccp=chalcopyrite; Icb=isocubanite; Mrc=marcasite; Po=pyrrhotite; Py=pyrite.; Sp=sphalerite.