Characterising As-Bi-Co-Cu-bearing minerals at Scar Crags and Dale Head North, Lake District, UK.

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Supplementary Material:

Other minerals chemistry

At Scar Crags a single minute grain of electrum was identified and analyses returned an Au/Ag ratio of ~85/15. A mineral tentatively identified as (Pb)-bismuth-telluride seemingly contained a few wt.% of Se and up to 16 wt.% Pb, but readings of 3–5 wt.% oxygen (likely oxidation of the highly unstable telluride) compromise the value of this data. Readings of up to 9 wt.% oxygen accompanied invariably all EDS analysis results of native bismuth, bismuthinite, and bismuth-tellurides and bismuth-selenides. Near stoichiometric wittichenite seemed to overgrow a bismuth-selenide. A mineral identified as ferroskutterudite contained > 20 wt.% Fe and < 8 wt.% Co. Tetrahedrite showed up to 6 wt.% Zn.

The apatite present in samples from DHN contained ~4 wt.% F. Cassiterite, rutile, and stannite seemed to host 1–2 wt.% of Fe, yet, readings of 1-2 wt.% Fe even in zircon, flagged the possibility of mixed-analyses with the underlying Fe-rich chlorite, due to very minute size of the aforementioned crystals (< 20–30 μm). The minerals tentatively identified as parisite or synchysite and xenotime yielded EDS spectra from which software calculation returned up to 31 wt.% Ce, 18 wt.% La, and 13 wt.% Nd for the former, and 25 wt.% Y, 1 wt.% Gd, 3 wt.% Dy, and 5 wt.% Yb for the latter (Fig. S1).

Chlorite elemental composition analyses returned magnesium contents < 3–4 wt.%, with Fe > 29–30 wt.%, and very rarely ~ 1 wt.% Mn.

Semi-quantitative chemical compositions of these minerals are reported in Table S2.

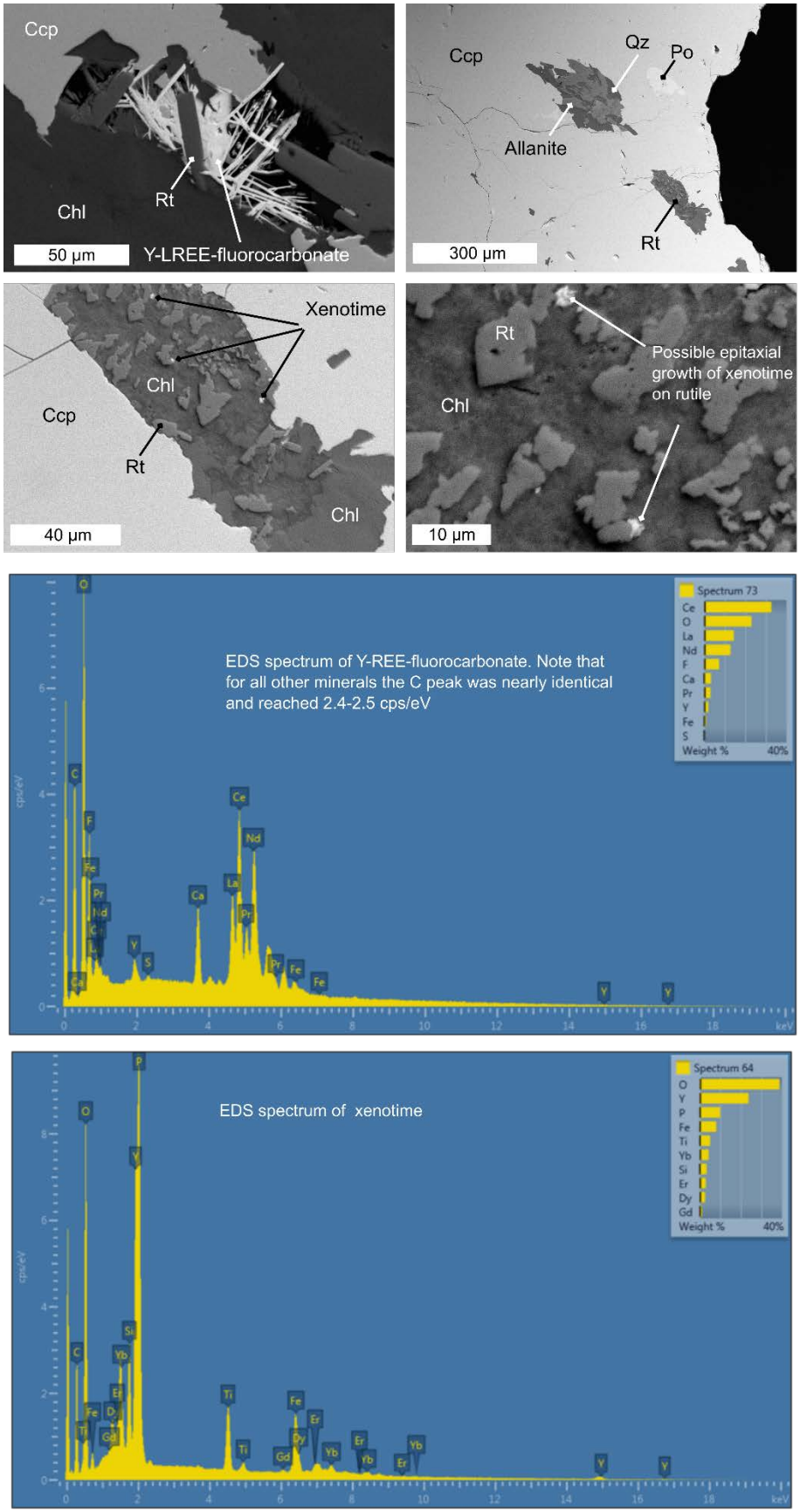


Fig. S1: Backscattered electron images and EDS spectra of very rare minerals found in Dale Head North samples. Ccp: Chalcopyrite, Chl: Chlorite, Po: Pyrrothite, Rt: Rutile, Qz: Quartz.

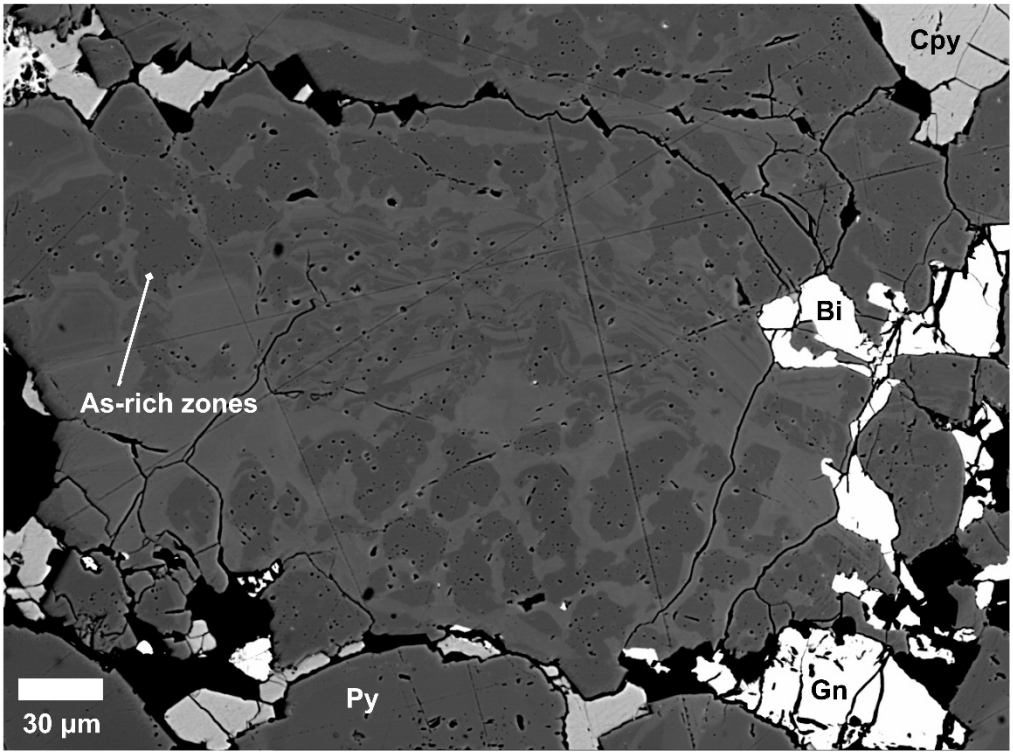
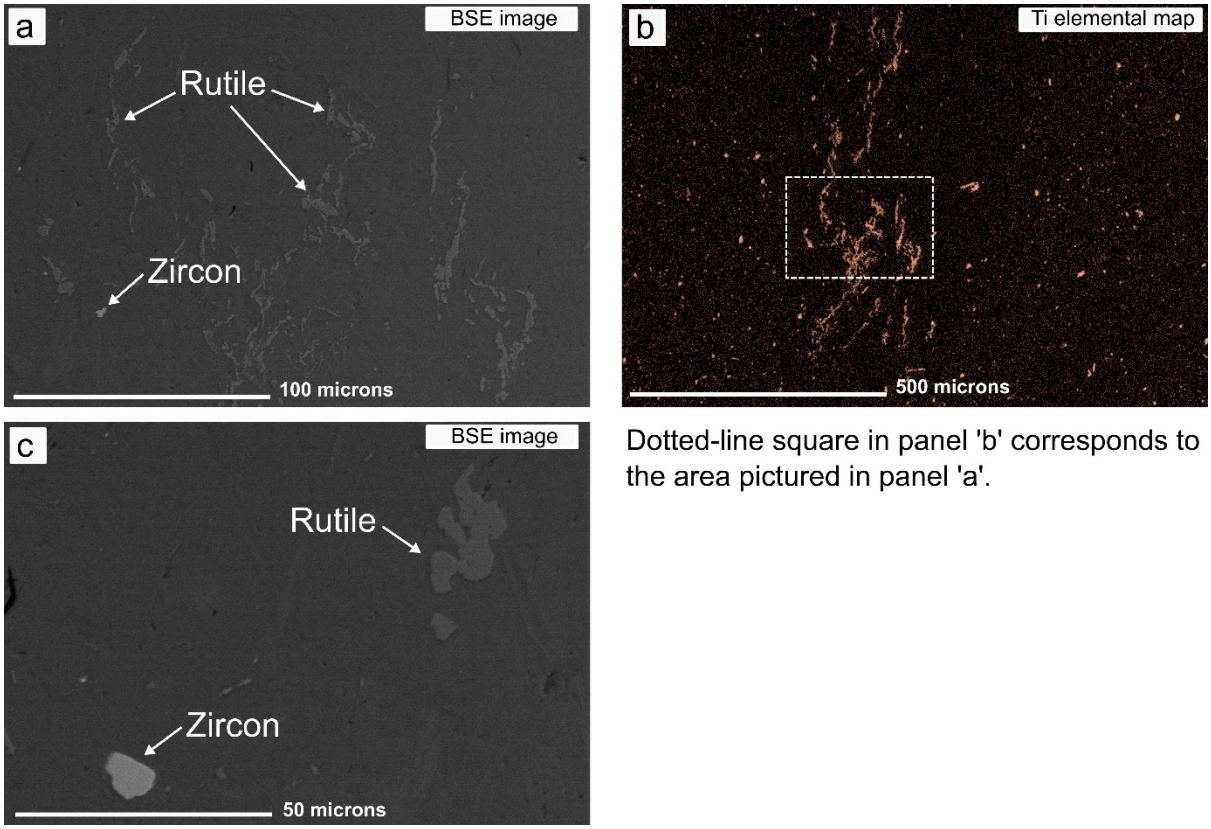


Fig. S2: Backscattered electron image of a sample from Dale Head North. Native bismuth (Bi) and galena (Gn) appear white, chalcopyrite (Ccp) is medium grey, and pyrite crystals are darker grey. Patchy darker zones inside pyrite are rich in arsenic (see section *Sulfides* in **Results** for further details).



Dotted-line square in panel 'b' corresponds to the area pictured in panel 'a'.

Fig. S3: Backscattered electron images (top left and bottom left corners) and titanium elemental distribution map (top right corner) of a sample from Dale Head North containing rutile and zircon (see sub-section *Dale Head North* in *Mineralogy and Petrography* of section **Results** for further details).