MINERALOGY, TEXTURAL CHARACTERISTICS AND MINERAL CHEMISTRY OF REMOBILISED SULPHIDES AND SULPHOSALTS IN THE RÄVLIDEN NORRA VMS DEPOSIT, SKELLEFTE DISTRICT, NORTHERN SWEDEN

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1. Introduction: remobilisation and local geology

- Remobilisation is the translocation of pre-existing mineralisation during prograde and retrograde metamorphism (Fig. 1).

- The resulting textures and structures are an interplay between the response of competent and uncompetent material to the same P, T conditions.

- Remobilisation of sulphides can potentially form new mineralisations from a precursor. However, as the distance between precursor and product mineralisation increases, the difficulty of linking them becomes more difficult. (Marshall and Gilligan, 1993; Marshall et al., 1998; Marshall and Spry, 1998).

The aim of this poster is to document meso- and micro-scale remobilisation textures in the Rävliden Norra (RN) VMS deposit and the implications of remobilisation processes to relative mineral enrichment within the deposit.

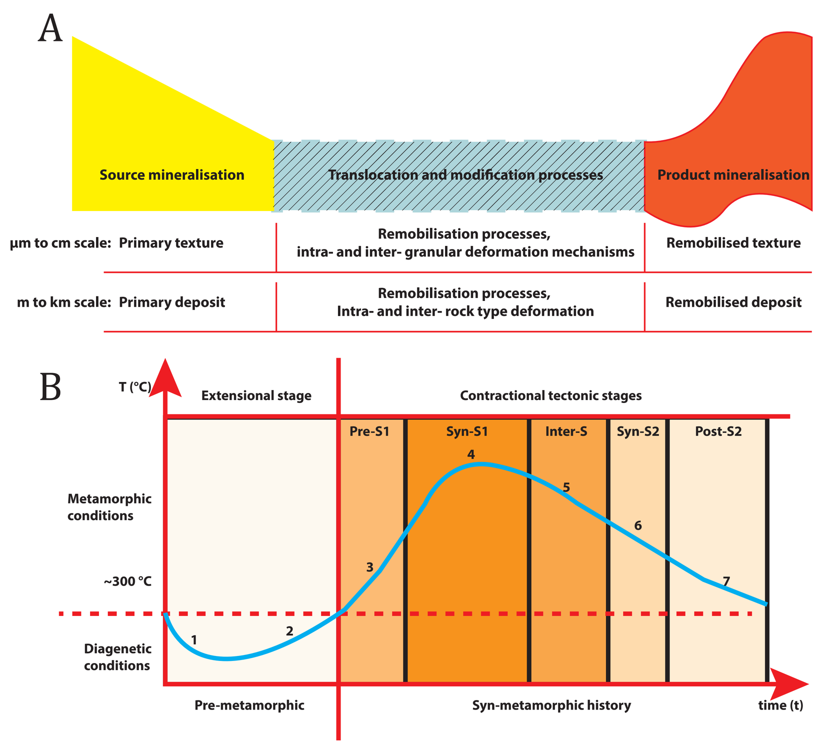


Fig. 1. A. Conceptual representation of remobilisation. B. Schematic interaction of ore genesis in the framework of diagenesis and metamorphism (Marshall and Gilligan, 1993; Marshall et al., 1998).

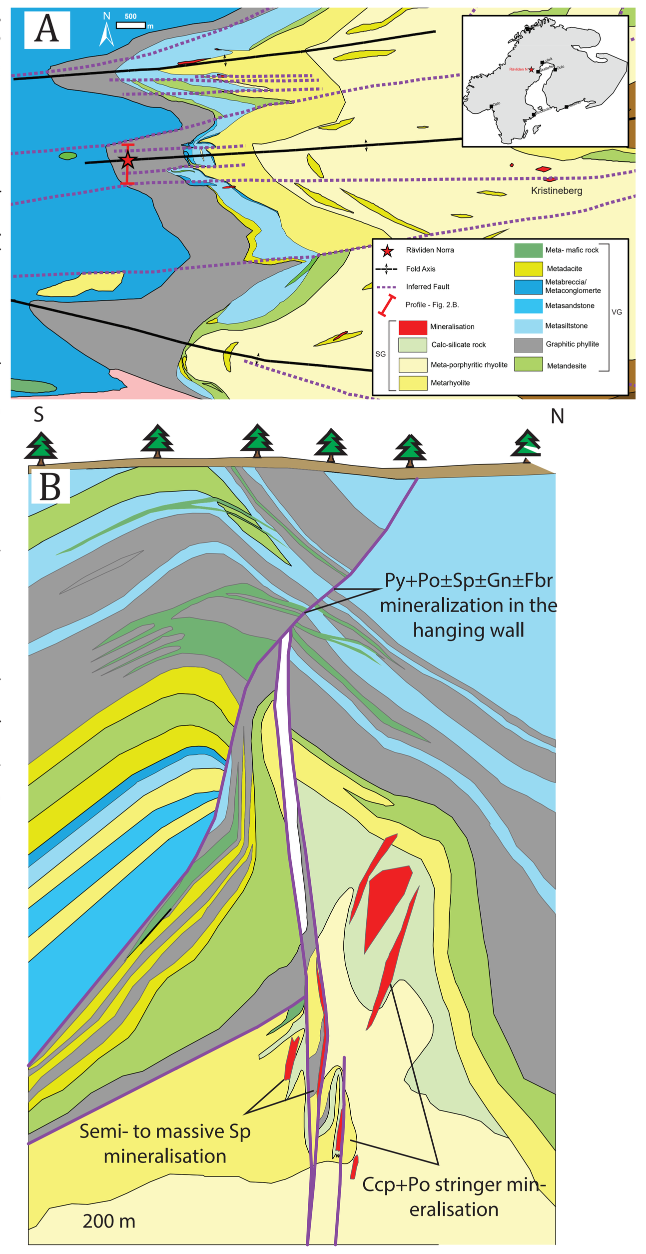


Fig. 2. A. Geological map of the Kristineberg area with the location of RN. B. Geological profile looking west (map and profile modified after Jansson and Persson (2014)). VG: Vargfors group, SG: Skellefte group.

- RN is hosted at the transition between metavolcanic rocks from the Skellefte group and metasedimentary rocks of the Vargfors group (Fig. 2., Fig. 3.).

- Three main mineralisation types have been identified (Fig. 4 - 6):

- Pyrite + pyrrhotite mineralisation with sphalerite, galena and freibergite in the hanging wall.
- Semi- to massive sphalerite with galena, pyrrhotite, freibergite and boulangerite associations.
- Chalcopyrite + pyrrhotite stringers associated with pyrite and minor sphalerite.

- Freibergite is the main silver-bearing mineral in all mineralisation types. Minor Ag-minerals include: hessite, electrum, allargentum, native silver, and rare pyrargyrite, pyrostilpnite, argentopyrite, sternbergite and stephanite.

- The deposit has been subjected to greenschist to lower amphibolite metamorphism imposing a faulted antiform geometry to the host rocks of the mineralisation (Fig. 3).

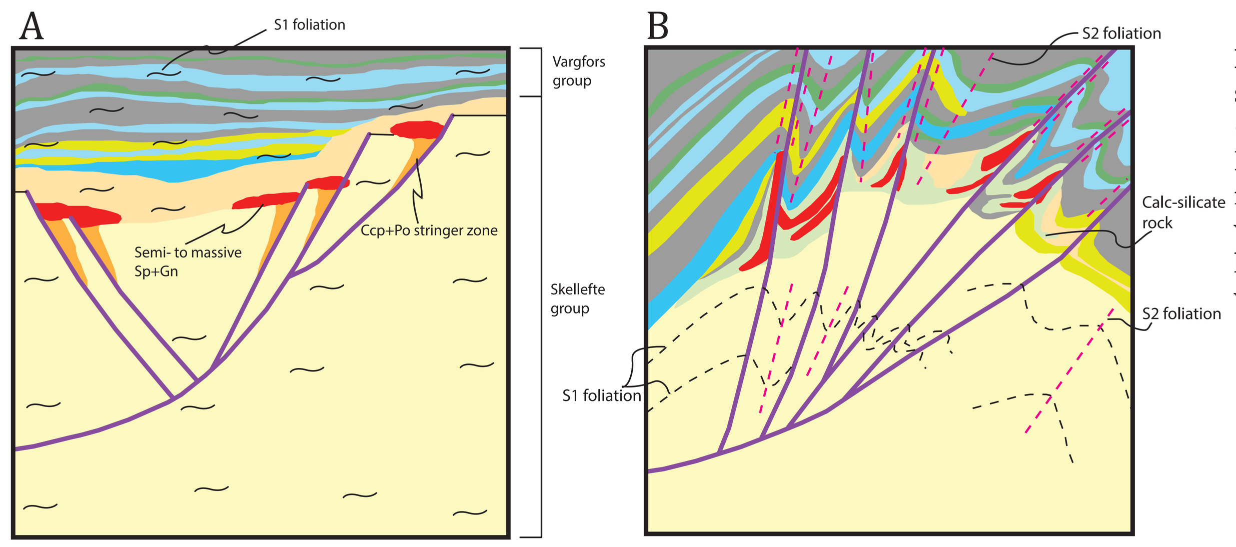


Fig. 3. A and B represent a schematic evolution model (modified after Jansson and Persson, 2014). After primary mineralisation (A) the volcanosedimentary rocks and ore lenses experienced deformation with tight folding and faulting (B).

Abbreviations: Gn: Galena; Sp: Sphalerite; Ccp: Chalcopyrite; Po: Pyrrhotite; Hess: Hessite; Bl: Boulangerite; Fbr: Freibergite; Dys: Dyscrasite; Tr: Tremolite; Act: Actinolite; Qz: Quartz; Fsp: Feldspar; Plg: Plagioclase; Chl: Chlorite; Cal: Calcite; Zeo: Zeolites

2. Textures and mineralogy

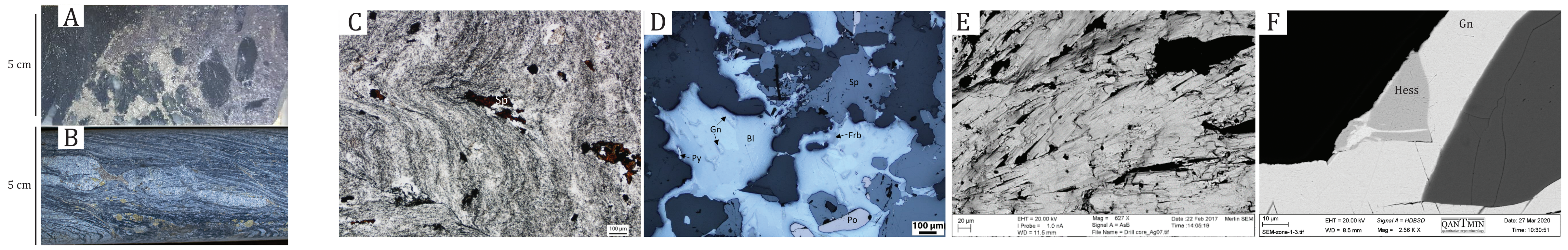


Fig. 4. Hanging wall mineralisation. A. Sulphide-cemented breccia. B. Boudinage with pyrrhotite filling tension gaps between boudins C. sphalerite grains aligned to a fold axis of crrenulation foliation of graphitic phyllite. D. Galena hosting freibergite and boulangerite. E. BSE image of tabular stephanite. F. BSE image of hessite in galena.

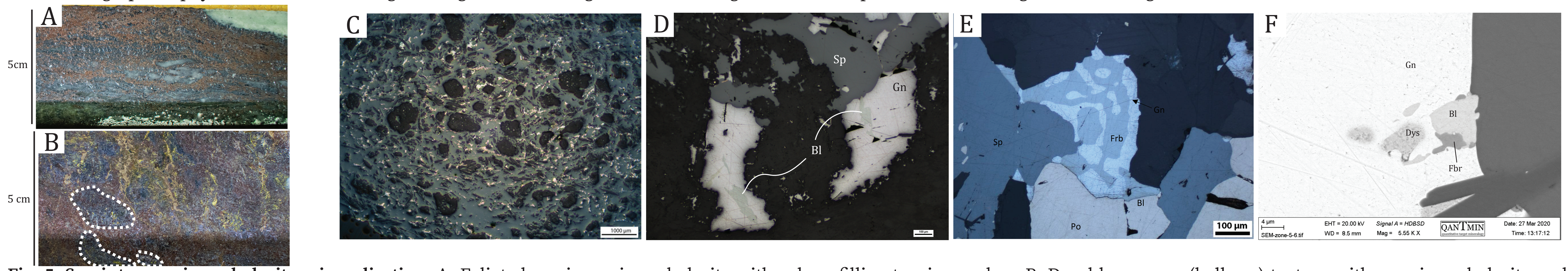


Fig. 5. Semi- to massive sphalerite mineralisation. A. Foliated semi-massive sphalerite with galena filling tension gashes. B. Durchbewegung (ball-ore) texture with massive sphalerite and tremolite-skarn clasts being cut by chalcopyrite+pyrrhotite veins. C. Micro-scale durchbewegung texture with massive sphalerite matrix and pyrrhotite+galena filling pressure shadows around clasts. D. Sphalerite + galena + boulangerite piercement veins. E. 'Myrmekitic'-alike intergrowth between freibergite and galena. F. BSE image showing common inclusions in galena: dyscrasite, boulangerite and freibergite.

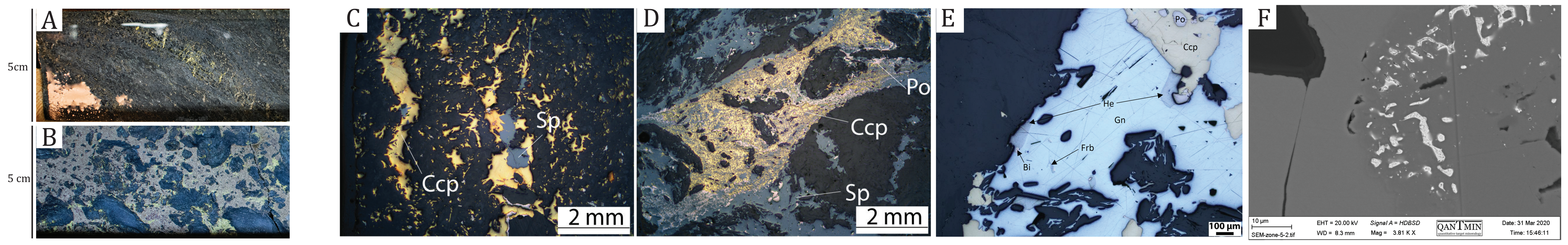
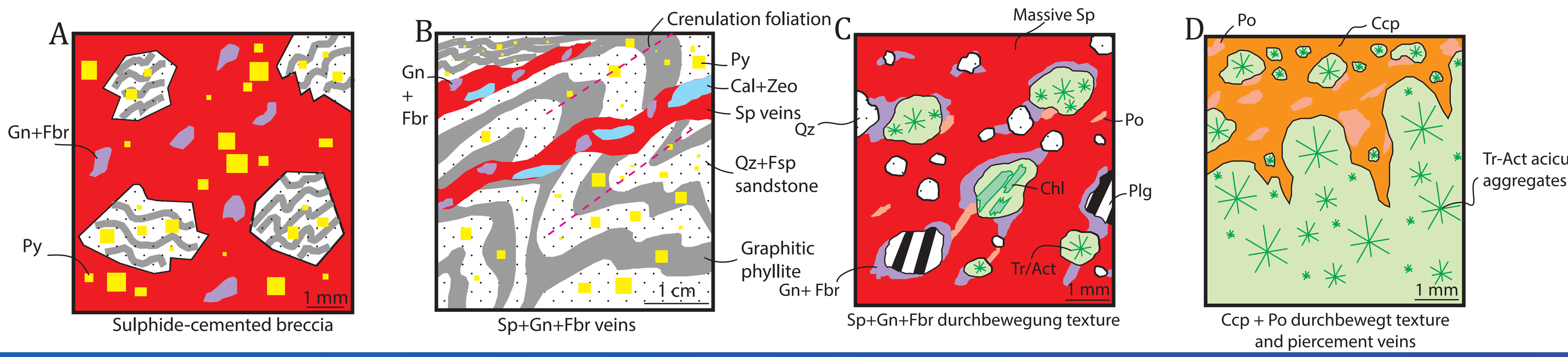


Fig. 6. Chalcopyrite + pyrrhotite mineralisation. A. Chalcopyrite filling tension gashes in clorite schist. B. Pyrrhotite+chalcopyrite durchbewegung (ball-ore) texture. Clasts are made of tremolite calc-silicate rock. C. Chalcopyrite+sphalerite piercement veins in tremolite calc-silicate rock. D. Micro-scale durchbewegung texture with matrix composed of chalcopyrite, pyrrhotite and sphalerite. E. Freibergite, hessite and bismuth hosted by galena. F. BSE image of dyscrasite inclusions in pyrrhotite.

Fig. 7. Schematic cartoons of common textures that are the result of remobilisation process in the hanging wall (A and B) and ore lenses (C and D) at RN. A. Sulphide-cemented breccia with clasts of graphitic phyllite. B. Sphalerite+galena+freibergite veins. C. Durchbewegung (ball-ore) texture with massive sphalerite matrix and clasts composed of silicates. D. Durchbewegung and piercement veins of chalcopyrite and pyrrhotite.



3. Mineral chemistry

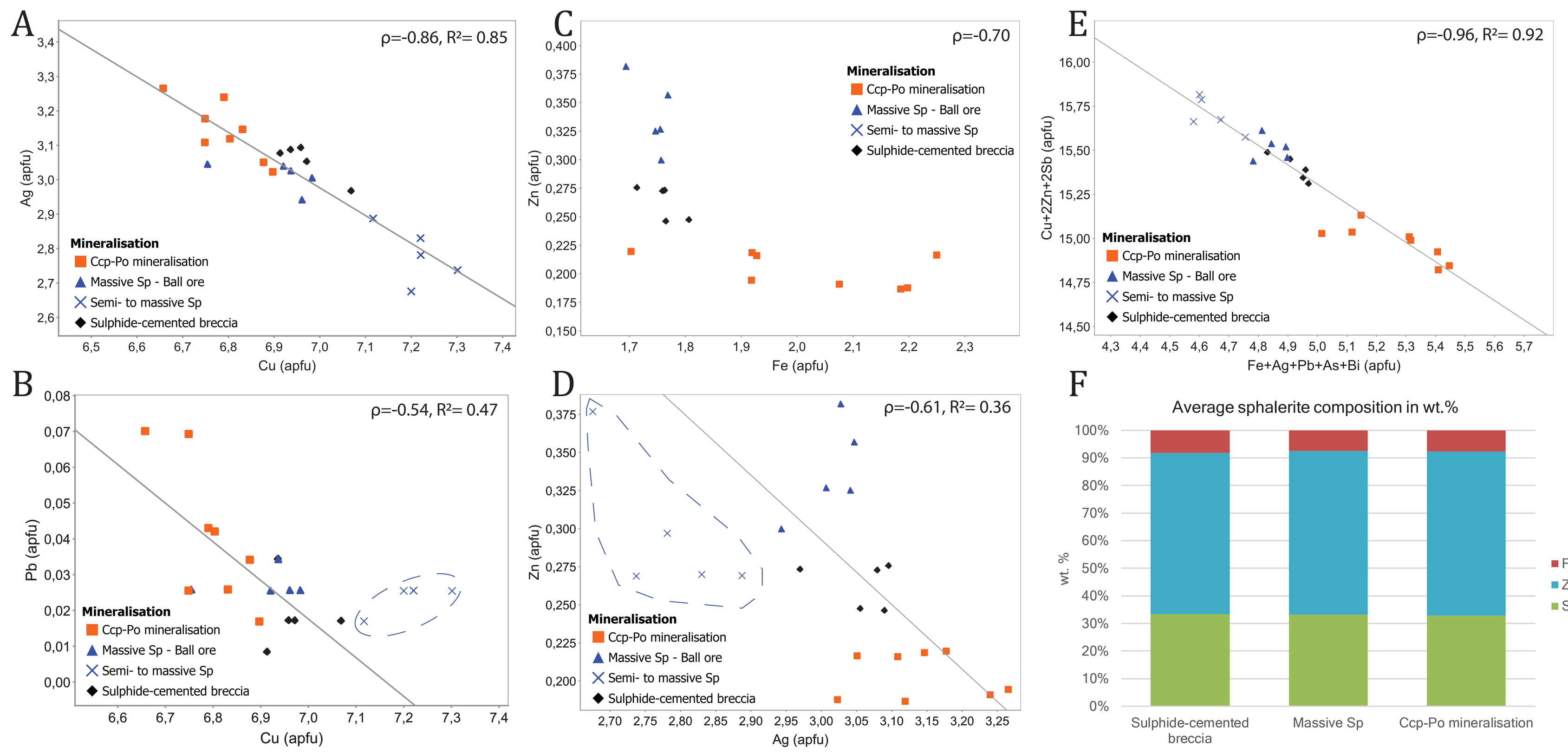


Fig. 8. Scatterplots of elements in freibergite structure from the three main mineralisation types at Rävliden Norra (A-E). The data was adquired with a JXA-8530F JEOL field emission microprobe at Uppsala University. Number of spots: 23. A. Silver vs. Cu in apfu. B. Lead vs. Cu in apfu. C. Zinc vs. Fe in apfu. D. Zinc vs. Ag in apfu. E. Copper+2Zn+2Sb vs. Fe+Ag+Pb+Bi in apfu. ρ: Spearman correlation coefficient. F. Stacked bar graph for average Fe, Zn and S in sphalerite. Number of spots: 22.

- Inverse correlation between Ag and Cu apfu (atoms per formula unit) is related to substitution of Ag and Cu in the molecular structure of Freibergite (George et al., 2017; Moëlo et al., 2008; Riley, 1974).
- Correlations in Fig.8.A-E. are explained by coupled substitutions of (Ag, Cu), (Fe, Zn, Pb), and (Sb, As, Bi), in the A, B, C and X sites of the tetrahedrite group general structural formula $A_6(B,C)_6X_4Y_{12}Z$ (George et al., 2017; Moëlo et al., 2008).
- The composition of sphalerite presents little variations within the deposit (7.75 wt.% Fe in average). Metamorphic re-equilibration of sphalerite composition might have played a role assuming pre-metamorphic variations during ore deposition (Scott, 1983). Future studies of sphalerite from Rävliden Norra would confirm or falsify our hypothesis.
- Samples correspond to sulphide-cemented breccia in the hanging wall, massive sphalerite with ball-ore texture, semi-to massive sphalerite with foliated texture, and vein hosted chalcopyrite+pyrrhotite mineralisation.

4. Preliminary conclusions

- Sphalerite, galena and Ag-rich sulphosalts in the hanging wall of Rävliden Norra occurred insofar our observations, due to remobilisation from the massive sphalerite and chalcopyrite+pyrrhotite ore lenses during metamorphism of the volcanosedimentary sequence hosting the mineralisation.

- Freibergite is most commonly hosted in galena and presents a fairly homogenous composition with minor variations relative to mineralisation type. These variations are to a greater extent in the atomic content of Ag, Cu, and Fe, with Zn, Pb, Sb, Bi and As to a lesser extent. Coupled substitutions in the internal structure of freibergite are accounted as the main reason for such differences, being monovalent Ag by Cu the most clear trend. Moreover, freibergite from the chalcopyrite+pyrrhotite mineralisation contains more Ag than freibergite from the hanging wall and massive sphalerite. A probable hypothesis is that a pre-metamorphic zonation of freibergite compositions has been retained to some extent even after greenschist facies metamorphism. Alternatively, freibergite might have exolved from Ag-rich galena during metamorphism removing Ag in the presence of other mobile elements such as Fe, Cu or Sb (Johnson et al., 1986; Grant, 2009). This is evidenced by the close association between galena and freibergite, and other Ag-minerals as inclusions in galena (e.g. hessite, dyscrasite). However, EMPA data in galena is needed to confirm this hypothesis.

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