RARE METAL SKARN MINERALIZATION IN THE BERGGIESSHÜBEL, PÖHLA AND OELSNITZ DISTRICTS / ERZGEBIRGE-VOGTLAND (GERMANY)

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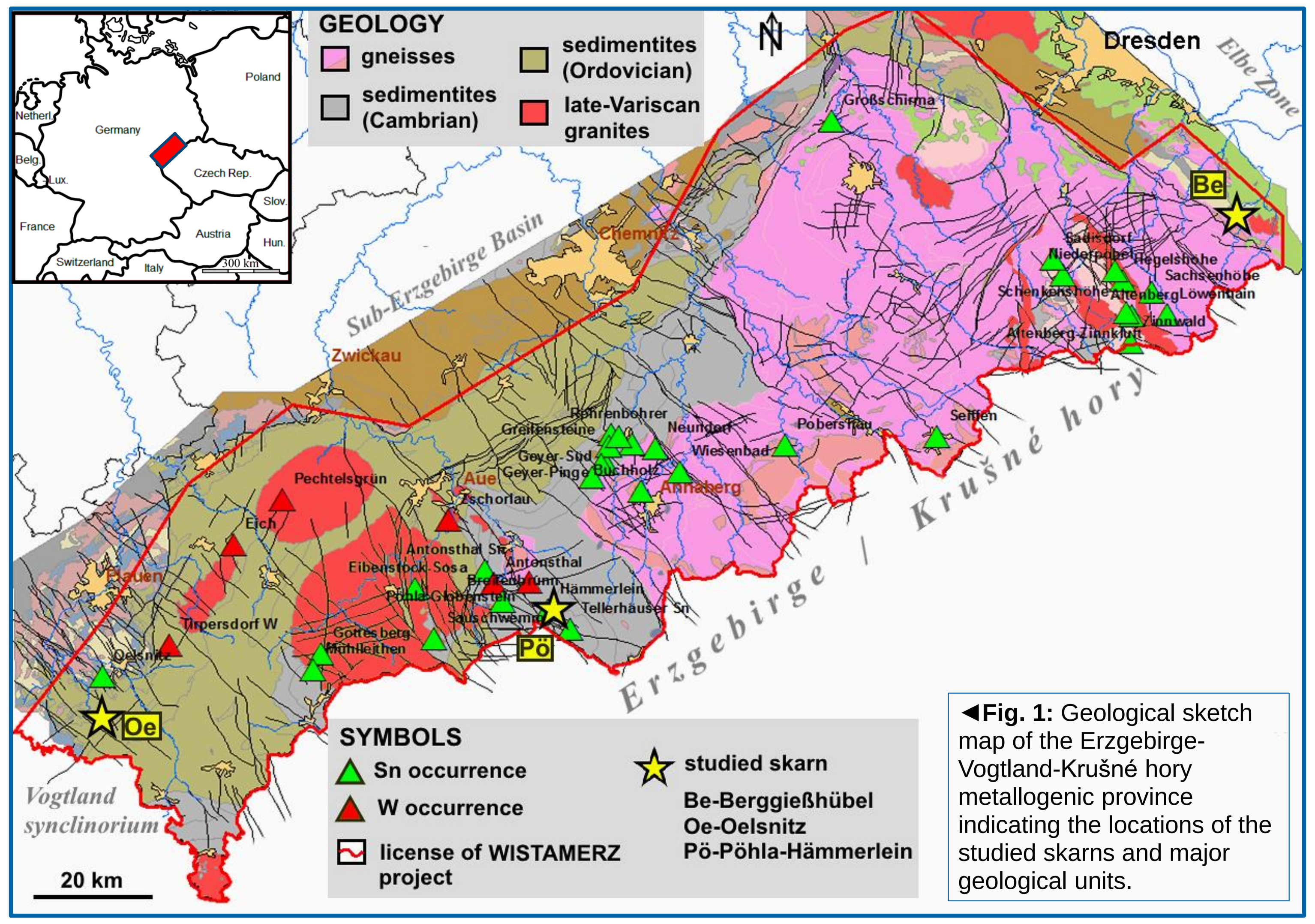
Introduction – Polymetallic skarn deposits in the Erzgebirge-Vogtland metallogenic province were mined since the 15th century (Berggießhübel/Elbe Zone: Fe, Cu, Zn; Breitenbrunn, W-Erzgebirge: Fe; Oelsnitz, Vogtland synclinorium: Fe; see Fig. 1) and explored in the 20th century for Fe, Zn, Sn, W, and In (Pöhla, W-Erzgebirge: Fe, Sn, W, In; Oelsnitz and Zobes, Vogtland synclinorium: Fe, Sn and W). The investigated skarn ore bodies of Berggießhübel, Pöhla-Hämmerlein and Oelsnitz are hosted by different stratigraphic horizons of varying lithology (see Figs. 1, 2 and Tab. 1). During late-Variscan times (320-300 Ma), different post-collisional granites and rhyolitic dikes as well as lamprophyres intruded into these metamorphic rocks. Some of them are possibly associated with the genesis of skarns and relatively younger rare metal mineralization (Baumann et al. 2000, Seifert 2008 and references therein).

Methods – The current study comprised microscopic investigations and geochemical analyses. Optical microscopy was complemented by SEM-EDS and mineral liberation analysis (MLA, cf. Fig. 5x). Bulk skarn ores were geochemically analyzed by ALS Minerals, Romania (code CCP-PKG01) and sulfide separates were analyzed by Actlabs, Canada (code UT1). Sulfide mineral chemistry was supplemented by $\delta^{34}S$ isotopic studies (University of Münster, VCDT standard).

Results – The studied skarns are characterized by a pyroxene-garnet (andradite-grossular series)-epidote(-titanite)-magnetite-sphalerite I mineralization (in bulk ore Zn up to 24 wt.%) (Figs. 3, 4, 5). It is overprinted by veinlet- and micro-fissure controlled cassiterite(-helvine)-chalcopyrite-sphalerite II-arsenopyrite-fluorite-quartz-chlorite mineralization. Skarn bulk samples exhibit considerable concentrations of Sn, W, Zn, Cu and In (see Tab. 1). Moreover, significant concentrations of Li, Rb and Cs have been detected within the bulk skarn ores: Berggießhübel (n=13), Li: 30 (3-120) ppm, Rb: 100 (2-820) ppm, Cs: 10 (1-45) ppm; Pöhla-Hämmerlein (n=54), Li: 150 (10-400) ppm, Rb: 100 (5-1,000) ppm, Cs: 50 (5-300) ppm; Oelsnitz (n=11), Li: 55 (10-240) ppm, Rb: 50 (2-185) ppm, Cs: 5 (1-20) ppm. Zinc, Cu and In are concentrated within a sulfidic, sphalerite-dominated mineralization (see Tab. 1).

Discussion – The geochemical data obtained during the present study demonstrate mineralogical and geochemical similarities between the investigated skarn occurrences (Tab. 1). All skarns are spatially associated with late-Variscan granite intrusions but hosted by stratigraphically different units. Relatively high contents of "indicator elements" for Sn-greisen like Be, Cs, Li, Rb, Sn and W can be discussed as link between Sn-W and In mineralization in skarns and post-magmatic fluid-systems of the Sn(-W)-polymetallic association in the Erzgebirge (300-315 Ma), further indicated by $\delta^{34}S$ analyses of sulfides (see Tab. 1).

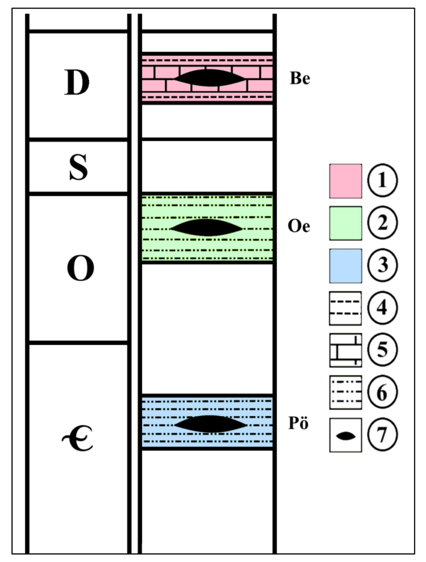
References:
BAUMANN L (1995) Die prävariszischen Vererzungen des Erzgebirges – eine Übersicht. Freiberger Forschungshefte C454: 9-64
BAUMANN L, KUSCHKA E, SEIFERT T (2000) Lagerstätten des Erzgebirges. Enke im Georg Thieme Verlag, Stuttgart, 300 pp.
SEIFERT T (2008) Metallogeny and Petrogenesis of Lamprophyres in the Mid-European Variscides. IOS Press, Amsterdam, 303 pp.



◄**Fig. 1:** Geological sketch map of the Erzgebirge-Vogtland-Krušné hory metallogenic province indicating the locations of the studied skarns and major geological units.

►**Tab. 1:** Compilation of major geological and geochemical features of the studied skarn occurrences.

▼**Fig. 2:** Lithostratigraphic and lithologic classification (after Baumann 1995) of the studied skarn occurrences Berggiesshübel (Be), Oelsnitz (Oe) and Pöhla-Hämmerlein (Pö). Stratigraphy of host rocks: 1-Devonian (D), 2-Ordovician (O), 3-Cambrian (Є); lithology of host rocks: 4-Volcanoclastics, 5-Meta-carbonate, 6-Pelite; 7-Skarn-bearing horizon.



Locality	Berggiesshübel	Pöhla-Hämmerlein	Oelsnitz
Metamorphic host rocks	marble, volcanoclastics (Devonian)	two-mica schist, marble, meta-rhyolite (Cambrian)	clay shale (Ordovician)
Late-Variscan magmatic rocks	Markersbach granite	Eibenstock granite	Eichigt-Schönbrunn granite (not exposed)
Mineralization	early – late Sn, (W) – Cu, Zn, In	early – late Sn, (W) – Zn, Cu, In	early – late Sn, W, (Be) – Zn, Cu, In
Geochemistry bulk rock skarns Ø (min-max)	n=13 Sn: Ø 840 (10-2,700) ppm W: Ø 40 (2-150) ppm Zn: 0.1 - >1.0 wt.% Cu: 0.002 - >1.0 wt.% In: Ø 25 (0.2-95) ppm	n=54 Sn: Ø 1.5 (0.1-8.2) wt.% W: Ø 65 (5-270) ppm Zn: Ø 8.2 (0.1-16.2) wt.% Cu: Ø 0.6 (0.1-5.1) wt.% In: Ø 150 (0.01-1,750) ppm	n=11 Sn: Ø 900 (400-2,400) ppm W: Ø 915 (3-4,250) ppm Zn: Ø 1.6 (0.1-5.3) wt.% Cu: Ø 0.02 (0.01-0.06) wt.% In: Ø 35 (5-130) ppm
Geochemistry skarn-hosted sphalerite concentrates Ø (min-max)	n=1 Fe: 4.2 wt.% Cu: 0.36 wt.% Sn: 15 ppm In: 140 ppm Cd: >0.2 wt.% Ga: 3 ppm Ge: 0.2 ppm	n=14 Fe: Ø 8.8 (5.9-13.9) wt.% Cu: Ø 0.57 (0.01-5.54) wt.% Sn: Ø 140 (2-1,080) ppm In: Ø 720 (50-4,700) ppm Cd: Ø 0.37 (0.29-0.45) wt.% Ga: Ø 1.1 (0.7-4) ppm Ge: Ø 0.2 (0.1-0.7) ppm	n=3 Fe: Ø 2.4 (2.3-2.6) wt.% Cu: Ø 0.14 (0.07-0.24) wt.% Sn: Ø 12 (4-20) ppm In: Ø 200 (110-280) ppm Cd: > 0.2 wt.% Ga: Ø 1.0 (0.9-1.5) ppm Ge: Ø 0.4 (0.1-0.9) ppm
$\delta^{34}S$ (skarn-hosted sulfides)	-1.8 ‰, Ccp, n=1 0.3 ‰, Sp, n=1	0.0 ‰ – 1.2 ‰, Sp, n=15 0.1 ‰ – 1.6 ‰, Apy, n=6 0.0 ‰ – 0.2 ‰, Ccp, n=4 1.5 ‰ – 1.7 ‰, Py, n=3	5.3 ‰ and 5.8 ‰, Sp, n=2

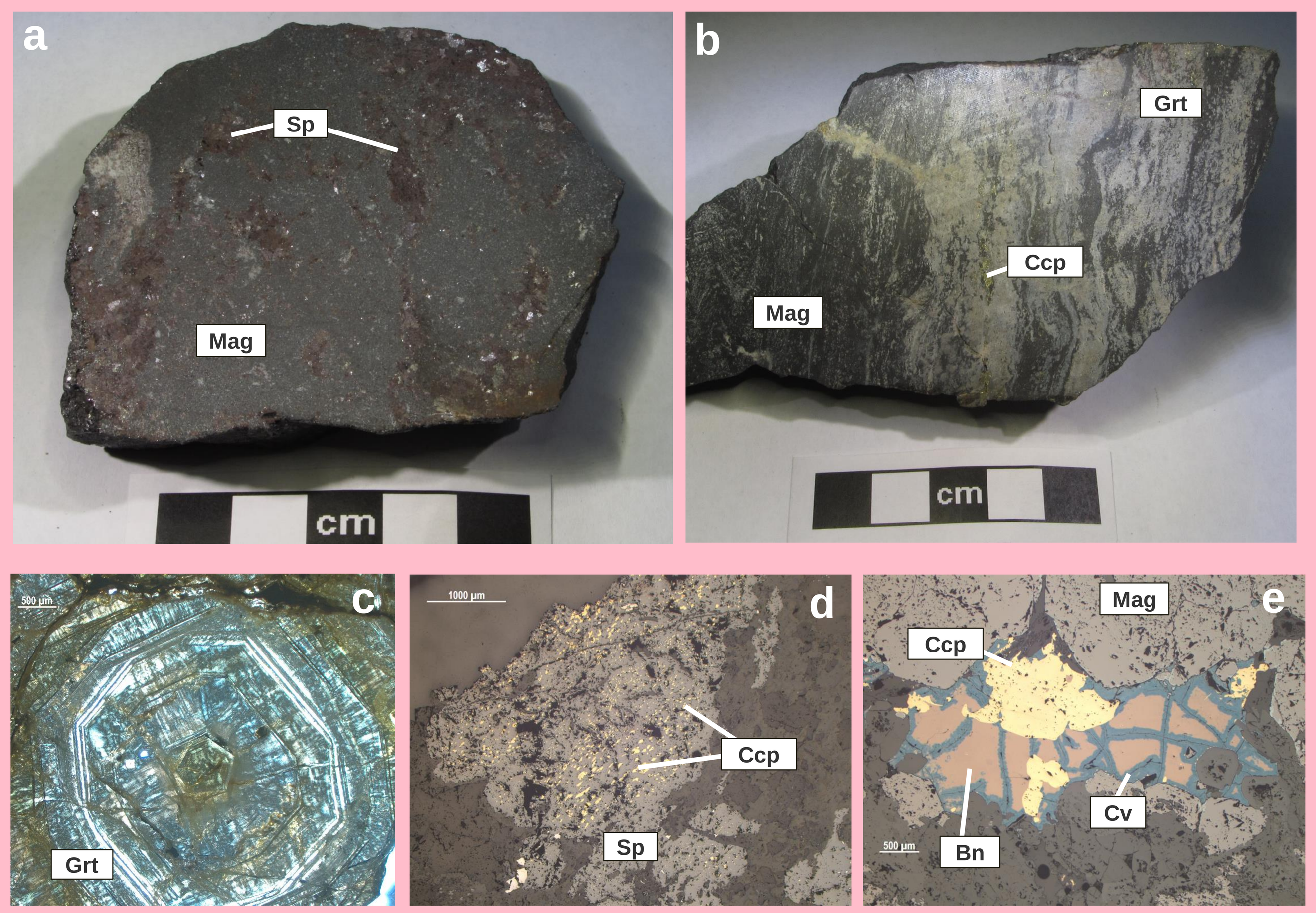


Fig. 3: Mineralogical features of the occurrence Berggießhübel. **a**-Sp-Mag-rich skarn, hand specimen, sample MSS1; **b**-Mag-Grt-rich skarn with Ccp impregnation, hand specimen, sample MGS21; **c**-euhedral Grt crystal showing anomalous optical properties and oscillatory zoning, transmitted light, sample MGS20; **d**-Sp exhibiting flame-like Ccp exsolution structures, reflected light, sample MSS2; **e**-Cu-rich mineralization with Ccp, Bn and Cv in a Mag-silicate-matrix, reflected light, sample MGS16.

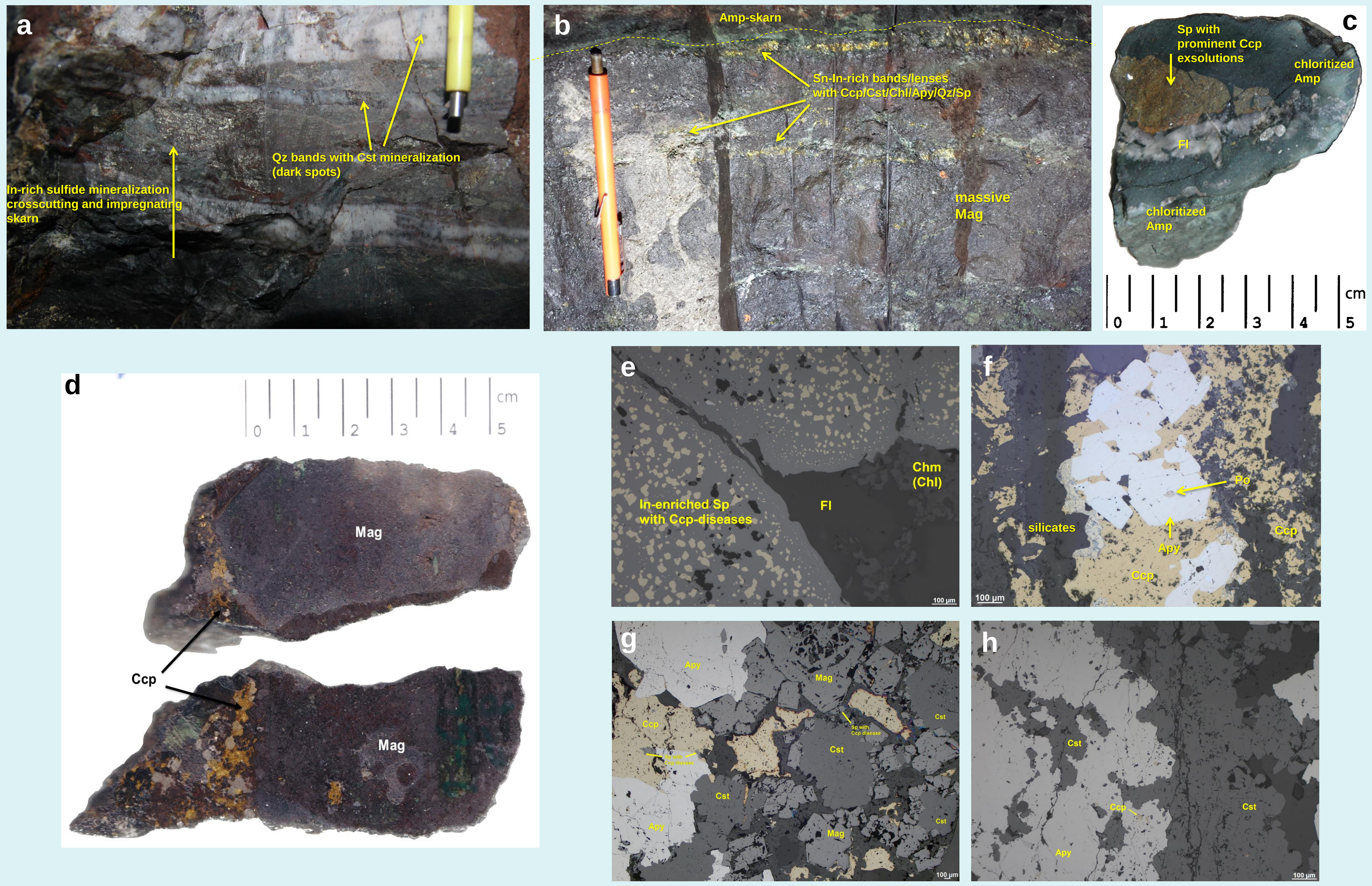


Fig. 4: Mineralogical features of the deposit Pöhla-Hämmerlein. **a**-Abundant cassiterite in quartz bands, crosscut by In-rich sulfides (Ccp, Sp). Location: drive 214; **b**-Sn-In-rich mineralization in bands and layers embedded within and crosscutting massive Mag lenses, bordered by Amp-skarn at the hanging wall contact. Location: drive 2-6b; **c**-Sp lens with prominent Ccp exsolutions, and adjacent Fl-(Qz), embedded in Chl- Amp-skarn, sample 926e230; **d**-Sn-In-rich lens with sulfide-mineralization hosted in massive Mag, sample 2-6b-ccp-1; **e**-Closeup of Sp crystals adjacent to minor Fl from a lens hosted in chloritized Amp. Sp shows abundant Ccp exsolutions and is slightly enriched in In. Polished section, reflected light, sample 926e230-3; **f**-Closeup of a sulfide-bearing veinlet consisting of mostly Ccp and Apy, with minor Po, Chl and Fl, crosscutting massive Mag and Amp-skarn. Polished section, reflected light, sample 4-M5AB-6; **g**-Typical mineral assemblage of Sn-In-rich lenses hosted within massive Mag lenses. Smaller Sp grains show strong Ccp exsolutions. Cst occurs as aggregates of smaller crystals. Polished section, reflected light, sample 2-6b-ccp-1; **h**-Intergrowth of abundant Cst and Apy crystals in a larger veinlet crosscutting massive and only slightly martitized Mag. Polished section, reflected light, sample 2-6b-1B-4.

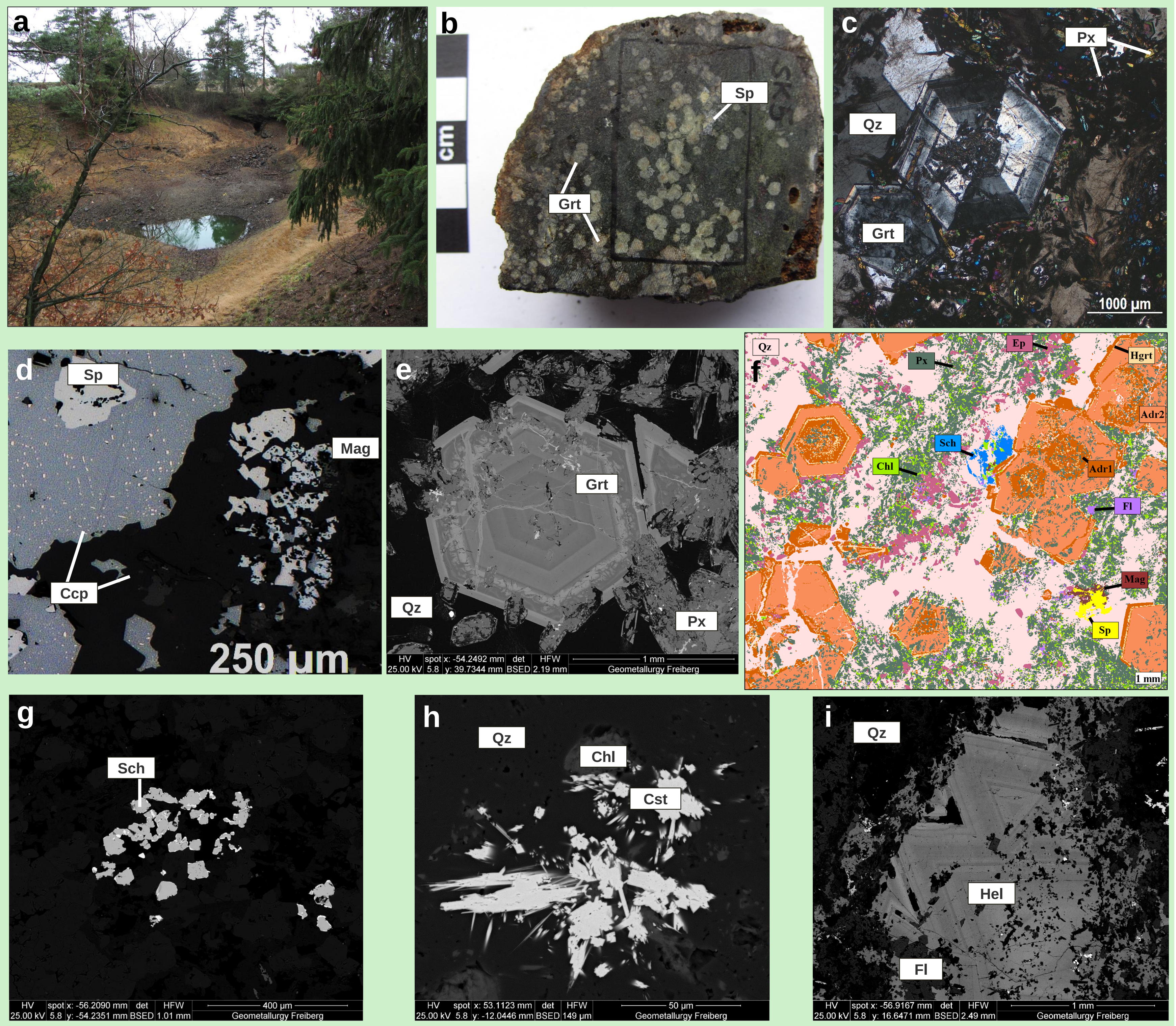


Fig. 5: Mineralogical features of the occurrence Oelsnitz. **a**-Outcrop of former "Ludwig Fundgrube" magnetite open pit near Oelsnitz; **b**-Hand specimen of Grt-rich skarn rock with Sp impregnation, euhedral Grt crystals exhibit zoning; sample SK5; **c**-Grt crystal exhibiting "hourglass-like" optical extinction patterns, in a Qz-Px-matrix; thin section, transmitted light, crossed polars, sample SK5; **d**-Sp with crystallographically oriented Ccp exsolutions, polished section, reflected light, sample LU01; **e**-Grt exhibiting intense zoning caused by varying chemical composition, thin section, BSE image, sample SK1; **f**-GXMAP of a Grt-rich coarse grained skarn section, sample SK5, false colors. Adr1 is Al-dominated whereas Adr2 exhibits elevated Fe-content; **g**-Subhedral Sch crystals with rims of stolzite (?), probably representing pseudomorphs of stolzite after Sch, thin section, BSE image, sample WS4; **h**-Cassiterite aggregate of acicular crystals up to 100 µm in quartz matrix, thin section, BSE image, sample WS3; **i**-Euhedral crystal aggregate of helvine with distinct chemical zoning, overgrowth on subhedral granular Fl, thin section, BSE image, sample SK22.

Mineral abbreviations – Adr-andradite, Amp-amphibole, Apy-arsenopyrite, Chl-chlorite, Chm-chamosite, Ccp-chalcopyrite, Cst-cassiterite, Ep-epidote, Fl-fluorite, Grt-garnet, Hel-helvine, Hgrt-hydrous garnet, Mag-magnetite, Po-pyrrhotite, Px-pyroxene, Py-pyrite, Qz-quartz, Sch-scheelite, Sp-sphalerite.

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