Supplementary Materials

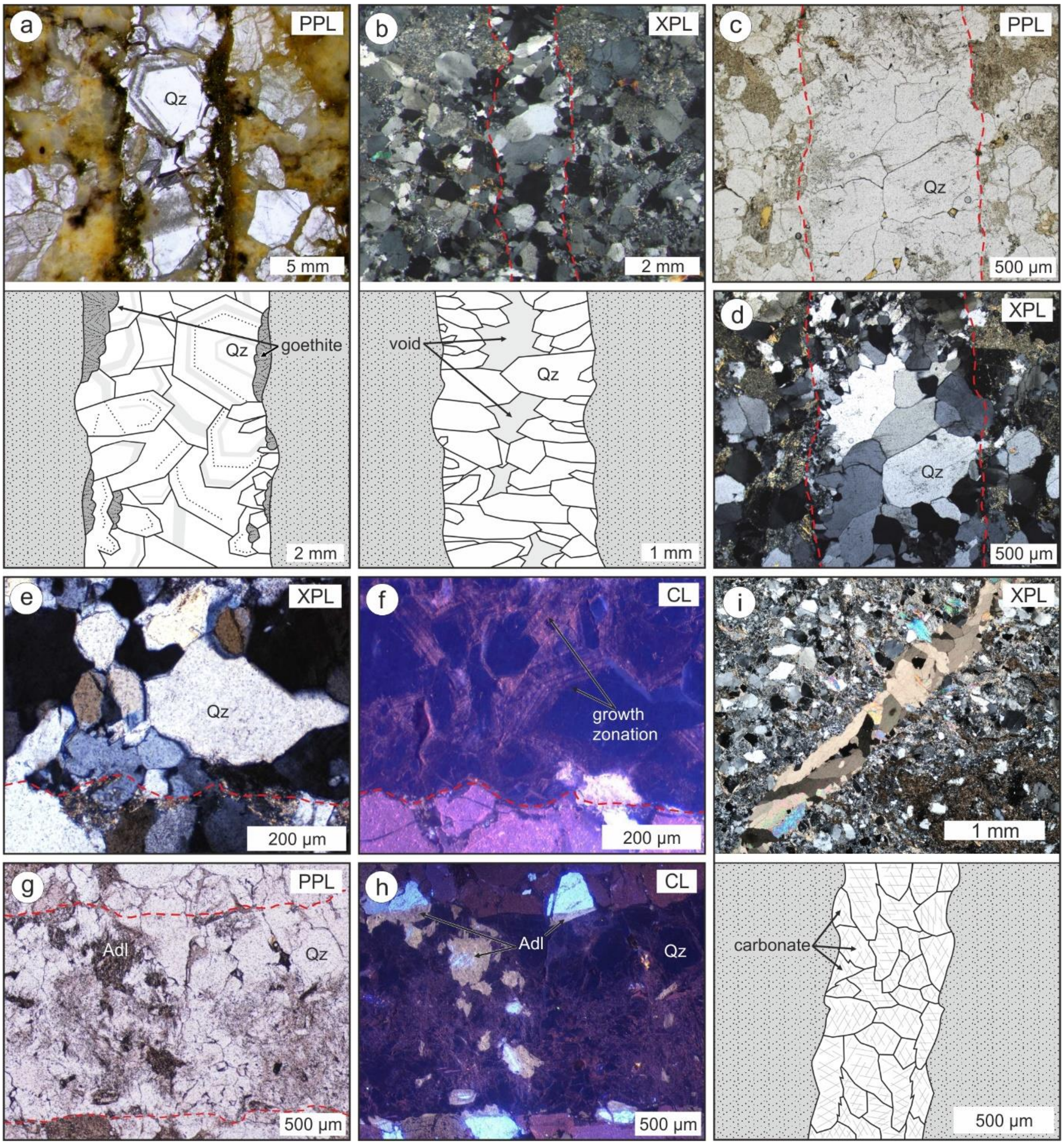

Figure S1: Typical blocky vein types of Téseny Sandstone. (a) Blocky quartz vein with euhedral quartz (Qz) crystals and goethite together with morphological sketch of this vein type (borehole T–5, 60.8 m). (b)–(d) Elongate blocky quartz veins together with morphological sketch of this vein type (samples T–7/1, 148.8 m and T–7/3, 150.6 m, respectively). (e) and (f) Characteristic fine-scale growth zonation patterns of quartz crystals of blocky textured quartz vein indicated in CL image. (g) and (h) Anhedral adularia (Adl) grains with turbide internal habit in the elongate blocky quartz vein type (sample T–7/3, 150.6 m). Detrital K-feldspar grains with a bright blue CL in the host sandstone are partially or totally replaced by brown-luninescent adularia in the vein. (i) Blocky textured carbonate (dolomite) vein and its morphological sketch (borehole Bm–1, 973.8 m). Other abbreviations: PPL = plane-polarized light; XPL = crossed polars; CL = cathodoluminescence image.

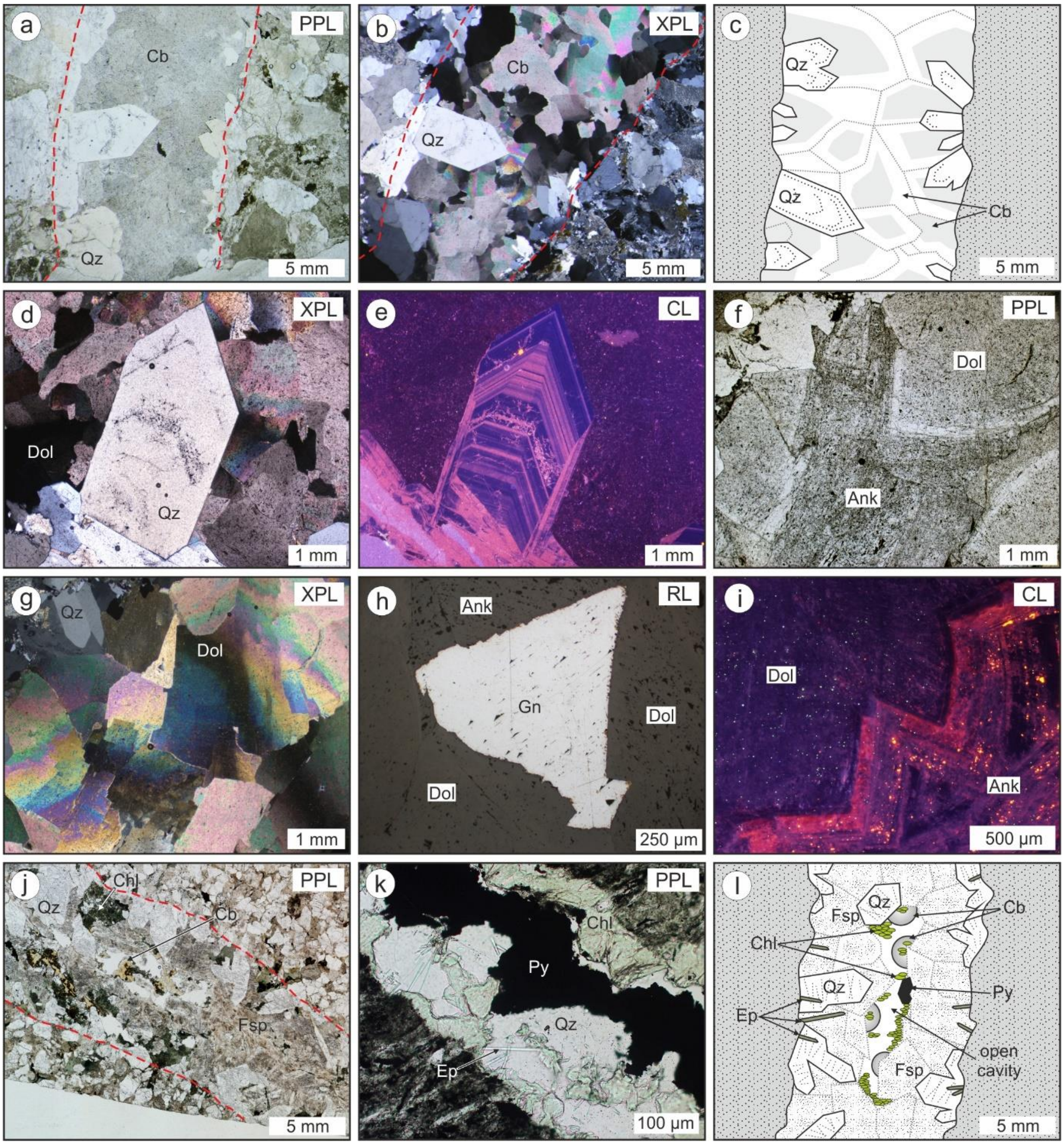

Figure S2: Characteristic polymineralic blocky vein types of Téseny Sandstone. (a)–(c) Quartz-carbonate vein type and its morphological sketch (borehole Bm–1, 875.0 m). (d) and (e) Euhedral quartz crystal deposited on the vein wall exhibiting fine-scale growth zoning indicated by fluid inclusion assemblages (borehole Bm–1, 875.0 m). (f) Petrographic characteristics of different carbonate phases can be found among the euhedral quartz crystals in the quartz-carbonate vein type. Note the curved crystal faces of the dolomite. (g) Dolomite crystals with sweeping extinction (borehole Bm–1, 875.0 m). (h) Subhedral galena crystal with typical triangular pits (borehole Bm–1, 875.0 m). (i) In the quartz-carbonate vein type, a distinct pattern of luminescence zoning representing different carbonate generations is observed. Note the calcite solid inclusions with bright orange CL within the ankerite zones. (j)–(l) Characteristic appearances of quartz-silicate-carbonate veins together with the morphological sketch of this vein type (sample T–3/1, 95.3 m and borehole Bm–1, 1290.5 m, respectively). Abbreviations: Qz = quartz; Cb = carbonate; Dol = dolomite; Ank = ankerite; Gn = galena; Chl = chlorite; Fsp = feldspar; Ep = epidote; Py = pyrite; PPL = plane-polarized light; XPL = crossed polars; CL = cathodoluminescence image; RL = reflected light.

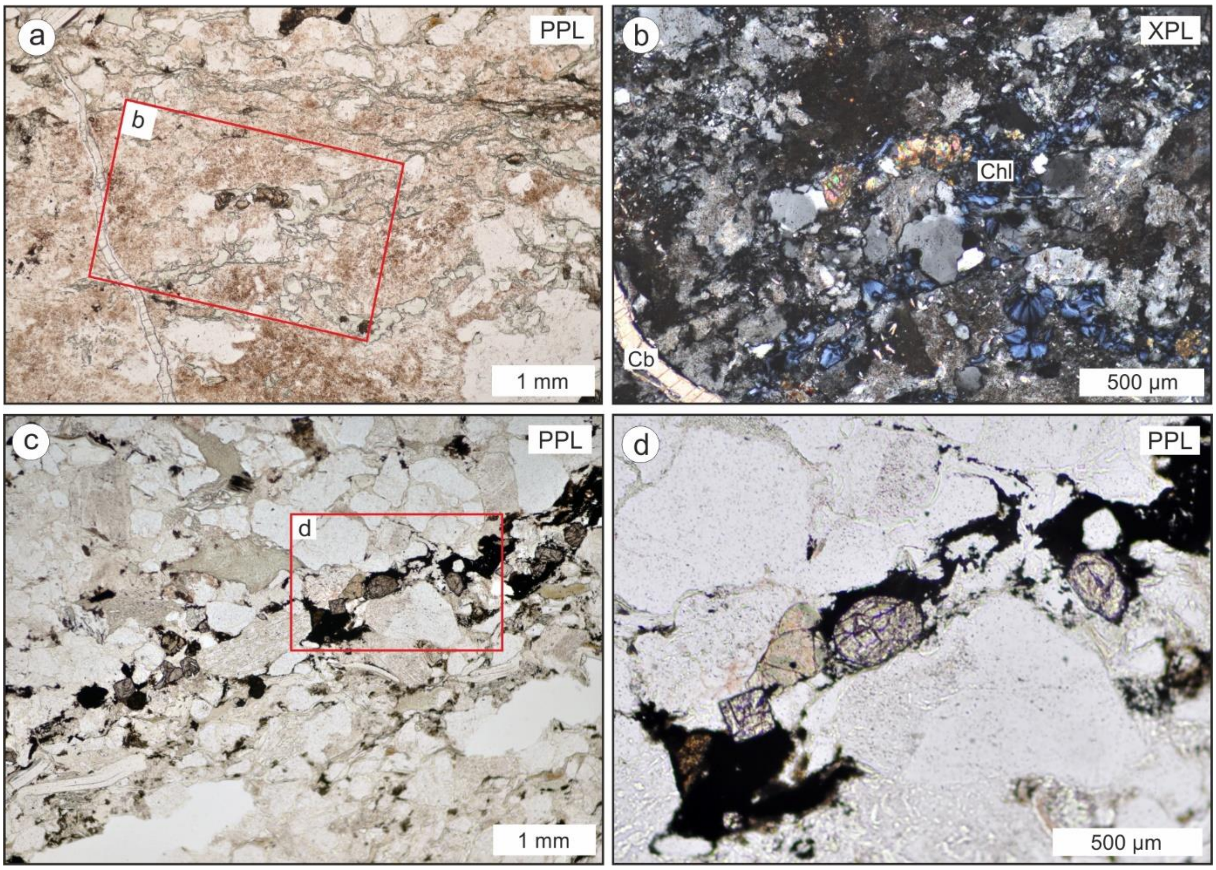

Figure S3: Characteristic polymineralic blocky vein types of Téseny Sandstone. (a)–(d) In the lowermost part of the Pennsylvanian section (borehole Bm–1 1062.1 m, covered thin section), organic material, chlorite, and/or pyrite are accompanied by euhedral monazite and/or xenotime crystals. *Note*: crosscutting relationships are also visible (hematite-rich alkali feldspar dominant vein → veins with chlorite + monazite/xenotime → carbonate vein). Abbreviations: Cb = carbonate (calcite); Chl = chlorite; PPL = plane-polarized light; XPL = crossed polars.

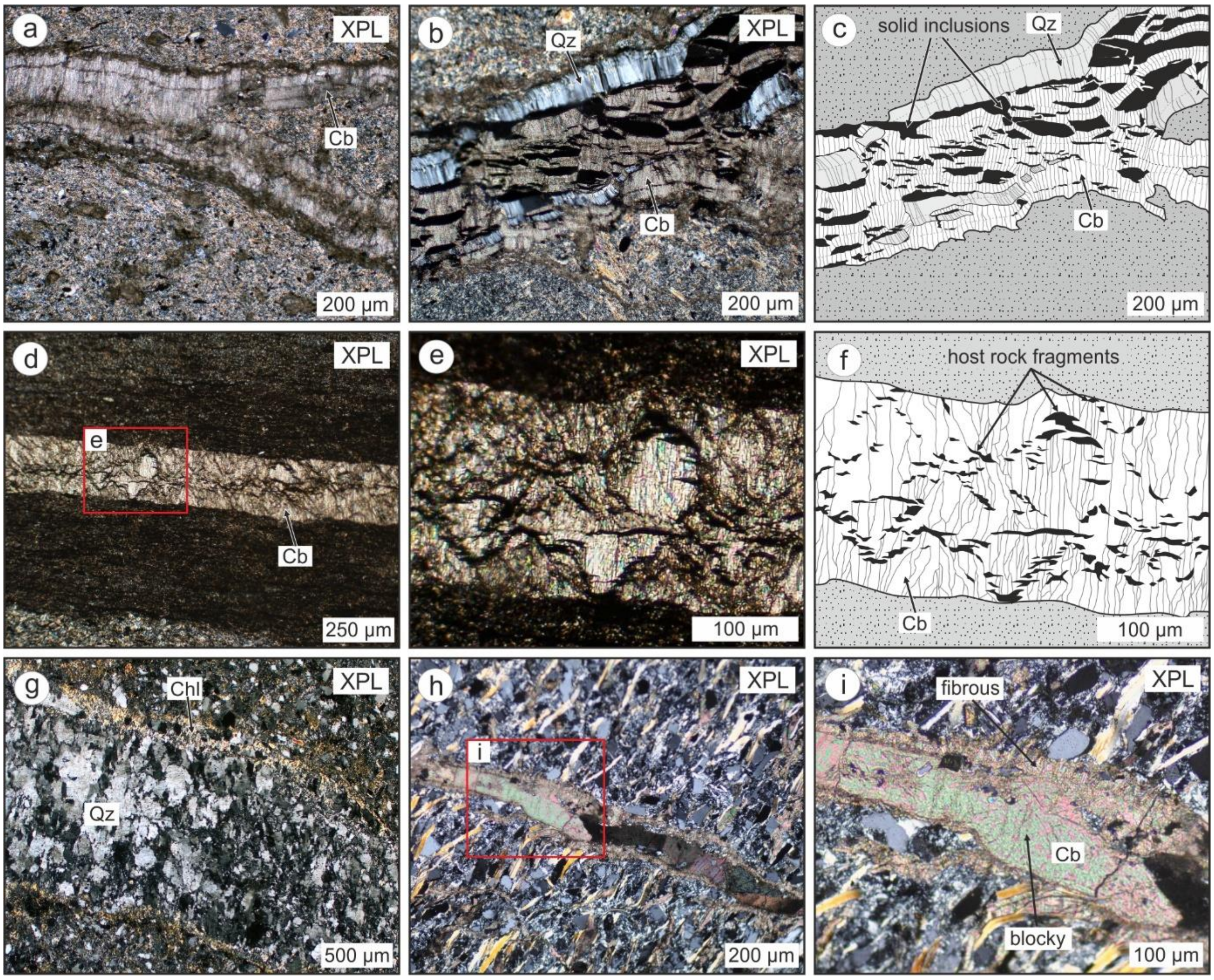

Figure S4: Fibrous, stretched, and polytextured vein types of Téseny Sandstone. (a)–(c) Fibrous carbonate and quartz-carbonate veins with antitaxial growth morphology (borehole Bm–1, 927.0–929.4 m). (d)–(f) Fibrous carbonate vein with typical sinusoidal host rock fragments (borehole Bm–1, 901.5–904.2 m). (g) Stretched quartz vein with small amount of chlorite on the vein wall (borehole Bm–1, 1224.7 m). (h) and (i) Polytextured carbonate vein with fibrous texture on the vein wall and blocky one in the middle part of the vein (borehole Bm–1, 1027.6 m). Abbreviations: Cb = carbonate; Qz = quartz; Chl = chlorite; XPL = crossed polars.

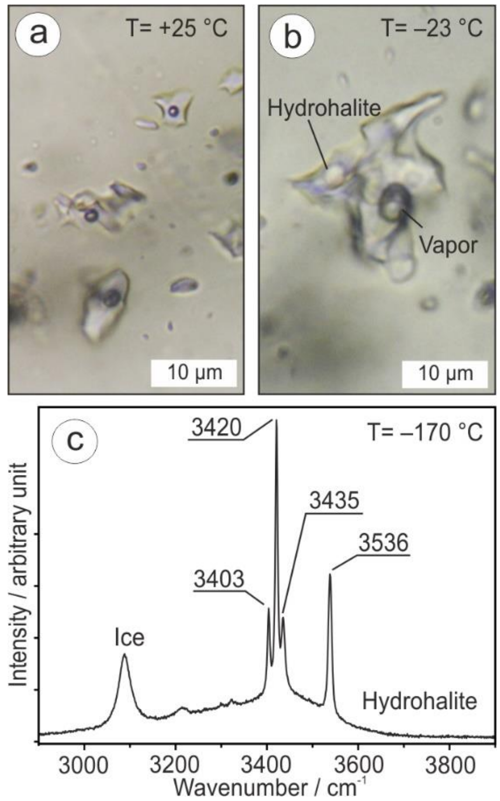

Figure S5: Fluid inclusion petrography and microthermometry. (a) Two-phase liquid dominant fluid inclusions in the QP1 FIA. (b) Hydrohalite crystal in a primary inclusion from the QP1 assemblage. (c) Raman spectrum of the hydrohalite and ice assemblage (borehole T–5, 60.8 m).

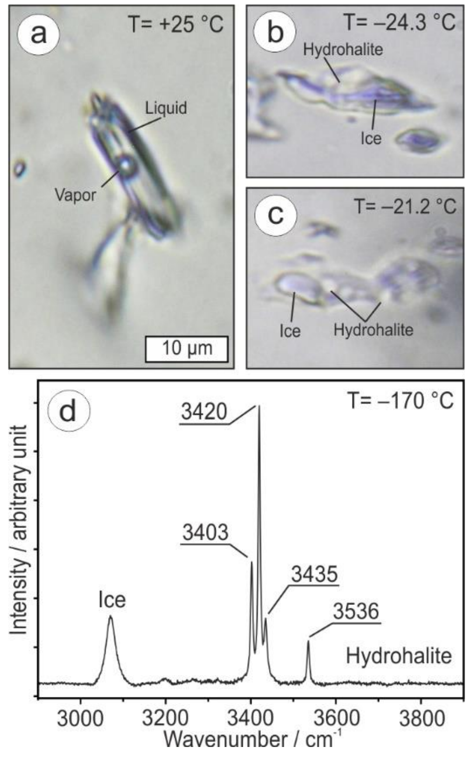

Figure S6: Fluid inclusion petrography and microthermometry. (a) Liquid dominant primary fluid inclusion from the QCP3 FIA of quartz. (b) Phase equilibria among liquid, vapor, ice, and hydrohalite in a FI of the QCP1 FIA. (c) Metastable phase equilibria in a QCP2 inclusion. (d) Representative Raman spectrum of hydrohalite and ice from a primary FI of quartz from a quartz-carbonate vein (borehole Bm–1, 875.0 m).

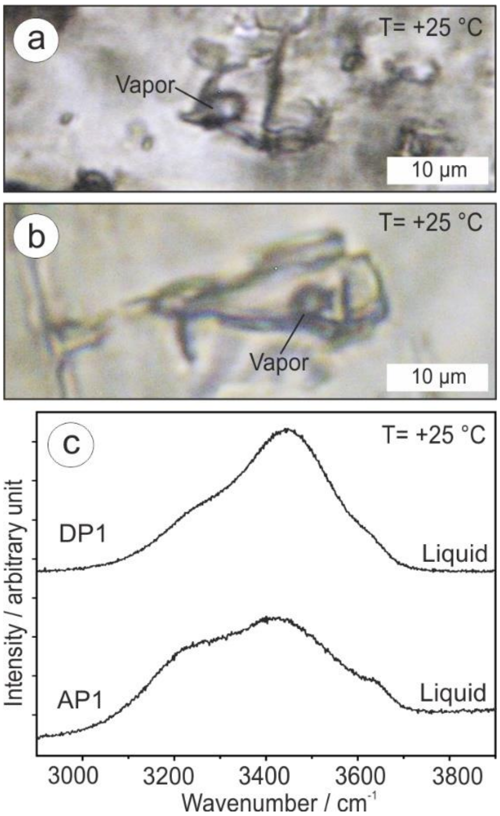

Figure S7: Fluid inclusion petrography and microthermometry. (a) Representative primary inclusion (DP1) of the dolomite phase. (b) Fluid inclusion in the AP1 assemblage, showing tapered tips in the grow direction of the crystals. (c) Characteristic Raman spectra of fluid inclusions at T_{lab} from the DP1 and AP1 fluid inclusion assemblages (borehole Bm–1, 875.0 m).

Table S1: Chemical composition of the studied carbonate phases of the selected quartz-carbonate veins. Abbreviations: Dol = dolomite; Ank = ankerite.

	CaO [mass%]	MgO [mass%]	MnO [mass%]	FeO [mass%]	$CaCO_3$ [mass%]	$MgCO_3$ [mass%]	$MnCO_3$ [mass%]	$FeCO_3$ [mass%]
Dol 01	28.2	16.4	1.5	6.8	49.1	39.7	2.0	9.2
Dol 02	27.3	17.3	1.4	6.8	47.3	41.6	1.9	9.2
Dol 03	28.0	16.7	1.5	6.5	48. 7	40.3	2.0	9.1
Dol 04	26.1	18.5	1.5	6.4	45.0	44.5	2.0	8.6
Dol 05	26.4	18.7	1.4	6.2	45.3	44.7	1.7	8.3
Dol 06	26.4	18.6	1.4	6.3	45.4	44.4	1.7	8.5
Dol 07	26.1	19.0	1.2	6.1	44.8	45.4	1.6	8.2
Ank_{Mn} 01	25.2	10.5	5.3	12.0	46.8	28.1	7.8	17.4
Ank_{Mn} 02	26.6	10.1	5.5	11.7	48.6	26.3	8.1	17.1
Ank_{Mn} 03	25.2	11.5	5.4	11.3	46.6	29.5	7.6	16.3
Ank_{Mn} 04	25.2	11.4	5.0	11.6	46.6	29.3	7.4	16.8
Ank_{Mn} 05	25.7	11.4	4.1	12.2	47.4	29.2	5.9	17.5
Ank_{Mn} 06	26.2	11.9	4.5	10.6	47.9	30.3	6.6	15.2
Ank_{Mn} 07	25.1	13.6	4.1	10.2	45.5	34.2	5.9	14.4
Ank_{Fe} 01	26.7	9.3	2.0	15.8	49.8	24.2	3.0	23.0
Ank_{Fe} 02	25.0	13.6	2.2	12.3	45.2	34.2	3.2	17.4
Ank_{Fe} 03	26.9	8.9	3.4	14.6	50.4	23.2	5.1	21.3
Ank_{Fe} 04	27.7	11.2	1.8	13.0	50.5	28.3	2.7	18.5
Ank_{Fe} 05	25.4	11.2	2.5	14.5	46.9	28.7	3.6	20.9
Ank_{Fe} 06	26.7	12.9	1.8	11.9	48.2	32.5	2.6	16.8
Ank_{Fe} 07	26.0	14.1	1.8	11.3	46.7	35.1	2.5	15.8

Table S2: Semi-quantitative chemical composition of the studied galena samples. Abbreviations: Gn = galena; <LOD = below the limit of detection.

	Pb [mass%]	S [mass%]	Bi [mass%]	Se [ppm]	Ag [ppm]	Sn [ppm]	Sb [ppm]
Gn 01	90.0	8.1	0.5	3500	2900	1900	<LOD
Gn 02	87.6	10.7	0.5	1400	2800	1800	<LOD
Gn 03	89.0	8.4	1.3	<LOD	4100	2900	<LOD
Gn 04	86.8	10.1	1.4	5100	4300	2500	<LOD
Gn 05	83.1	15.3	0.9	1900	2200	<LOD	1300
Gn 06	83.4	14.5	1.1	1400	3400	1300	<LOD
Gn 07	83.6	13.9	1.1	5100	3700	1100	<LOD

Table S3: Stable isotope composition (in per mil) of the studied carbonate phases of the selected quartz-carbonate veins. Abbreviations: Dol = dolomite; Ank = ankerite.

Phases	$\delta^{13}C$ (V-PDB) [‰]	$\delta^{18}O$ (V-PDB) [‰]	$\delta^{18}O$ (V-SMOW) [‰]
Dol 01	–5.78	–16.21	14.20
Dol 02	–5.77	–16.63	13.76
Dol 03	–6.04	–16.41	14.01
Dol 04	–6.15	–16.52	13.86
Ank_{Fe} 01	–5.64	–14.93	15.51
Ank_{Fe} 02	–5.61	–15.63	14.81
Ank_{Fe} 03	–5.39	–16.09	14.31

Table S4: Petrographic characteristics and microthermometric data of the studied fluid inclusions (individual measurement data). Abbreviations: T_n = nucleation temperature of ice; T_i = initial melting temperature of ice; T_m (Ice) = temperature of final melting of ice; T_m (Hh) = temperature of final melting of hydrohalite; T_h = temperature of homogenization; p_h = pressure of homogenization; QP = primary fluid inclusions trapped in quartz from quartz veins; QCP = primary fluid inclusions trapped in quartz from quartz-carbonate veins; DP = primary inclusions trapped in dolomite; AP = primary inclusions trapped in ankerite. *Note:* notation refers to the temporary sequence of the assemblages (from 1 to 4, respectively).

Fluid inclusion code	T_n [°C]	T_i [°C]	T_m(Ice) [°C]	T_m(Hh) [°C]	T_h [°C]	p_h [MPa]	ϕ_V	V_m [cm^3/mol]	Salinity			
									NaCl-H_2O	$CaCl_2$-H_2O	NaCl-$CaCl_2$-H_2O	
									NaCl eq, [mass%]	$CaCl_2$ eq, [mass%]	NaCl [mass%]	$CaCl_2$ [mass%]
QP1_01	–64.3	–51.2	–24.7	–5.7	-	-	-	-	-	-	17.4	9.2
QP1_02	–65.6	–52.3	–22.1	–12.0	105	0.502	0.11	18.81	-	-	22.3	2.8
QP1_03	–64.8	–51.8	–22.4	–15.3	109	0.489	0.11	18.99	-	-	21.1	3.7
QP1_04	–69.4	-	–22.5	-	145	-	-	-	-	-	-	-
QP1_05	–68.5	-	-	-	88	-	-	-	-	-	-	-
QP1_06	–64.0	–47.8	–21.0	-	92	-	-	-	-	-	-	-
QP1_07	–69.2	-	–23.7	-	123	-	-	-	-	-	-	-
QP1_08	–66.2	-	–24.0	–22.0	109	0.489	0.12	19.14	-	-	16.5	8.1
QP1_09	–66.8	–52.4	–24.0	–17.6	107.5	0.494	0.12	18.95	-	-	17.2	8.0
QP1_10	–64.2	-	–22.0	–16.7	108	0.492	0.11	18.92	-	-	21.9	2.6
QP1_11	–69.3	-	–22.8	-	128.6	-	-	-	-	-	-	-
QP1_12	–73.5	–51.7	–26.0	–6.0	117.5	0.465	0.13	19.25	-	-	15.2	11.7
QP1_13	–73.0	-	–22.6	-	100	-	-	-	-	-	-	-
QP1_14	–69.0	-	–24.7	–2.8	111	0.483	0.12	19.13	-	-	17.6	9.2
QP1_15	-	-	–24.2	-	118	-	-	-	-	-	-	-
QP1_16	-	-	–24.7	-	112	-	-	-	-	-	-	-
QP1_17	-	–52.8	–24.7	-	106	-	-	-	-	-	-	-
QP2_01	–66.8	-	–24.2	-	89	-	-	-	-	-	-	-
QP2_02	–68.5	-	–23.5	–9.0	73	0.605	0.09	18.48	-	-	19.4	6.6
QP2_03	–71.1	–51.8	–25.4	–6.5	84	0.576	0.11	18.84	-	-	16.1	10.6
QP2_04	–69.2	-	–23.1		86	-	-	-	-	-	-	-
QP2_05	–67.0	–49.7	–25.0	–13.0	63	0.617	0.09	18.57	-	-	16.0	10.02
QP2_06	–70.5	-	-	-	-	-	-	-	-	-	-	-

QP2_07	–67.0	–52.1	–24.7	–11.5	65	0.616	0.09	18.55	-	-	16.8	9.4
QP2_08	–67.0	-	–24.6	–3.4	68	0.613	0.09	18.52	-	-	17.8	8.97
QP2_09	–68.6	–51.6	–25.0	-	74.3	-	-	-	-	-	-	-
QP2_10	–69.1	-	–25.3	-	83	-	-	-	-	-	-	-
QP3_01	–65.3	-	–23.0	–7.6	-	-	-	-	-	-	20.7	5.3
QP3_02	–67.5	-	–24.5	-	-	-	-	-	-	-	-	-
QP3_03	–62.1	-	–25.3	–6.7	-	-	-	-	-	-	16.2	10.5
QP3_04	–69.5	-	–25.0	–5.2	55.5	0.614	0.09	18.41	-	-	16.9	9.8
QP3_05	–72.3	-	-	-	63.5	-	-	-	-	-	-	-
QP3_06	–71.5	-	-	-	67	-	-	-	-	-	-	-
QP3_07	–74.7	–52.3	–27.0	-	55	-	-	-	-	-	-	-
QP3_08	–70.2	-	–25.0	–13.5	66	0.615	0.09	18.61	-	-	16.0	10.03
QP3_09	–72.1	-	–26.0	–8.3	68.5	0.613	0.1	18.70	-	-	15.0	11.8
QP3_10	–67.8	-	-	-	49.7	-	-	-	-	-	-	-
QP3_11	-	-	–23.5	–14.3	66.5	0.615	0.09	18.43	-	-	18.7	6.7
QP3_12	–62.8	–51.7	–24.0	–17.0	77	0.596	0.1	18.68	-	-	17.3	7.9
QP3_13	–62.8	-	-	-	-	-	-	-	-	-	-	-
QP3_14	–64.7	-	–23.5	-	59	-	-	-	-	-	-	-
QP3_15	–68.3	-	–24.0	-	-	-	-	-	-	-	-	-
QP3_16	-	-	-	-	62	-	-	-	-	-	-	-
QCP1_01	–76.8	-	-	-	66.4	-	-	-	-	-	-	-
QCP1_02	–80.3	–52.4	–23.6	-	76.3	-	-	-	-	-	-	-
QCP1_03	–72.0	-	–24.0	–16.0	99	0.523	0.11	18.984	-	-	17.5	7.9
QCP1_04	–81.6	–53.3	–22.8	–12.0	54.1	0.612	0.07	18.020	-	-	20.6	4.8
QCP1_05	–85.1	-	-		78	-	-	-	-	-	-	-
QCP1_06	–71.8	-	–23.7	–9.5	84.2	0.575	0.1	18.69	-	-	19.0	7.1
QCP1_07	–78.0	-	-	-	58	-	-	-	-	-	-	-
QCP1_08	–83.3	-	-	-	83	-	-	-	-	-	-	-
QCP1_09	–86.5	–52.9	–24.8	–3.5	127	0.45	0.13	19.34	-	-	17.4	9.4
QCP1_10	-	-	–25.4	–6.4	123	0.455	0.13	19.31	-	-	16.1	10.6
QCP1_11	–78.2	-	–22.8		102	-	-	-	-	-	-	-
QCP1_12	–76.0	-	–23.6	–10.0	152.6	0.506	0.14	19.70	-	-	19.1	6.8
QCP1_13	–70.4	-	–23.2		93.7	-	-	-	-	-	-	-
QCP1_14	-	-	–23.0	–1.6	88	0.562	0.1	18.58	-	-	21.2	5.2
QCP1_15	–72.0	-	–22.8	–7.5	109	0.489	0.11	18.96	-	-	21.2	4.7
QCP1_16	–62.5	-	-	-	92	-	-	-	-	-	-	-
QCP1_17	–80.4	-	–24.2	-	92.5	-	-	-	-	-	-	-
QCP1_18	-	-	–24.5	–15.0	91	0.552	0.11	18.90	-	-	16.7	9.0
QCP2_01	–62.0	-	–23.2	–6.7	65.3	0.616	0.08	18.24	-	-	20.4	5.8
QCP2_02	–63.8	-	–25.2	–8.5	46	0.59	0.08	18.33	-	-	16.2	10.3
QCP2_03	–67.4	-	–24.6	-	46.7	-	-	-	-	-	-	-
QCP2_04	-	-	-	-	71.6	-	-	-	-	-	-	-
QCP2_05	–71.8	–52.7	–24.3	–11.4	63.2	0.617	0.09	18.47	-	-	17.5	8.5
QCP2_06	-	-	–24.0	–13.6	60	0.617	0.08	18.40	-	-	17.8	7.9
QCP2_07	–65.0	-	-	-	-	-	-	-	-	-	-	-
QCP2_08	-	-	–22.8	–14.0	50.6	0.605	0.06	17.98	-	-	20.4	4.8

QCP2_09	-	-	-		70.1	-	-	-	-	-	-	-
QCP2_10	-	-	–23.0	–12.0	77	0.596	0.09	18.48	-	-	20.2	5.3
QCP2_11	-	-	-	-	72	-	-	-	-	-	-	-
QCP2_12	–61.0	-	-	-	82	-	-	-	-	-	-	-
QCP2_13	-	-	-	-	53	-	-	-	-	-	-	-
QCP2_14	-	-	–23.0	–11.5	71	0.609	0.08	18.37	-	-	20.2	5.3
QCP3_01	–59.1	–48.2	–23.8	–6.5	54.3	0.612	0.07	18.19	-	-	19.1	7.2
QCP3_02	-	-	-	-	-	-	-	-	-	-	-	-
QCP3_03	–52.1	-	–24.2	–9.6	66.8	0.615	0.09	18.50	-	-	17.9	8.2
QCP3_04	–51.6	-	-	-	56.4	-	-	-	-	-	-	-
QCP3_05	-	-	-	-	41.6	-	-	-	-	-	-	-
QCP3_06	-	-	–25.0	–12.3	57	0.616	0.09	18.48	-	-	16.1	10
QCP3_07	-	-	–25.7	–14.0	57.2	0.616	0.09	18.57	-	-	14.8	11.4
QCP3_08	-	-	-	-	-	-	-	-	-	-	-	-
QCP3_09	-	-	-	-	-	-	-	-	-	-	-	-
QCP3_10	-	-	-	-	-	-	-	-	-	-	-	-
QCP3_11	–80.3	-	-	-	67.3	-	-	-	-	-	-	-
QCP3_12	–70.3	–53.2	–25.3		58	-	-	-	-	-	-	-
QCP3_13	–71.4	-	–26.3	–7.5	62.5	0.617	0.1	18.65	-	-	14.6	12.3
QCP3_14	-	-	-	-	62	-	-	-	-	-	-	-
QCP3_15	-	-	–24.5	–8.5	78	0.593	0.1	18.69	-	-	17.5	8.6
QCP3_16	-	-	–25.0	–13.0	68	0.613	0.09	18.638	-	-	16.0	10
QCP3_17	-	-	–28.0	–25.0	56	0.615	0.1	18.725	-	-	10.3	15.6
QCP4_01	–59.0	–47.7	–24.0	–16.8	72	0.607	0.09	18.612	-	-	17.4	7.9
QCP4_02	-	-	–24.0	–17.2	74	0.603	0.09	18.647	-	-	17.3	7.9
QCP4_03	–51.7	-	-	–17.4	63	-	-	-	-	-	-	-
QCP4_04	-	-	–21.7	–11.0	54	0.612	0.04	17.55	-	-	23.6	1.6
QCP4_05	-	-	–22.0	–15.0	57	0.616	0.06	17.85	-	-	22.2	2.6
QCP4_06	-	-	–23.4	–17.4	67	0.614	0.09	18.46	-	-	18.5	6.5
QCP4_07	–78.2		-	-	62	-	-	-	-	-	-	-
QCP4_08	-		–24.2	-	58	-	-	-	-	-	-	-
QCP4_09	-		–23.7	-	66	-	-	-	-	-	-	-
QCP4_10	–80.3	–54.1	–22.4	-	52.2	-	-	-	-	-	-	-
QCP4_11	-		-	-	43.5	-	-	-	-	-	-	-
QCP4_12	-		-	-	42.7	-	-	-	-	-	-	-
QCP4_13	-		-	-	43.5	-	-	-	-	-	-	-
QCP4_14	-		-	-	54	-	-	-	-	-	-	-
QCP4_15	-		–23.7	–9.8	54	0.612	0.08	18.21	-	-	18.9	7.1
QCP4_16	-		–25.0	–15.0	47	0.594	0.08	18.37	-	-	15.8	10.1
DP1_01	-		–27.8	-	127	0.45	0.13	19.51	-	23.6	-	-
DP1_02	-		-	-	150	-	-	-	-	-	-	-
DP1_03	-		–25.8	-	157.6	0.539	0.15	19.86	-	22.8	-	-
DP1_04	-		–26.7	-	152	0.502	0.15	19.81	-	23.5	-	-
DP1_05	-		–28.0	-	135	0.45	0.14	19.61	-	24.0	-	-
DP1_06	-		-	-	158	-	-	-	-	-	-	-
DP1_07	-		–26.3	-	149	0.487	0.15	19.76	-	23.3	-	-

DP1_08	-	–26.5	-	158.5	0.546	0.15	19.88	-	23.2	-	-
DP1_09	-	-	-	154	-	-	-	-	-	-	-
DP1_10	-	–26.5	-	155	0.52	0.15	19.84	-	23.4	-	-
DP1_11	-	–27.2	-	143	0.464	0.14	19.70	-	23.6	-	-
DP1_12	-	–26.8	-	155	0.52	0.15	19.85	-	23.5	-	-
DP1_13	-	–28.6	-	154	0.514	0.15	19.86	-	24.2	-	-
DP1_14	-	–25.5	-	167	0.627	0.15	19.99	-	23.0	-	-
AP1_01	-	–2.2	-	106	0.499	0.06	18.96	3.7	-	-	-
AP1_02	-	–1.8	-	109	0.489	0.06	18.97	3.0	-	-	-
AP1_03	-	–2.0	-	85	0.572	0.05	18.72	3.4	-	-	-
AP1_04	-	–2.0	-	93	0.545	0.05	18.80	3.4	-	-	-
AP1_05	-	–2.3	-	98	0.527	0.06	18.87	3.9	-	-	-
AP1_06	-	–2.1	-	92	0.548	0.05	18.80	3.6	-	-	-
AP1_07	-	–1.7	-	81	0.585	0.04	18.66	2.9	-	-	-
AP1_08	-	–2.7	-	89	0.559	0.05	18.81	4.6	-	-	-
AP1_09	-	–1.6	-	100	0.519	0.05	18.85	2.7	-	-	-
AP1_10	-	–1.9	-	108	0.492	0.06	18.96	3.2	-	-	-
AP1_11	-	–2.5	-	87	0.566	0.05	18.78	4.2	-	-	-
AP1_12	-	-	-	83	-	-	-	-	-	-	-
AP1_13	-	-	-	91	-	-	-	-	-	-	-
AP1_14	-	-	-	92	-	-	-	-	-	-	-
AP1_15	-	-	-	89	-	-	-	-	-	-	-
AP1_16	-	-	-	96	-	-	-	-	-	-	-
AP1_17	-	-	-	103	-	-	-	-	-	-	-
AP1_18	-	-	-	90	-	-	-	-	-	-	-
AP1_19	-	-	-	61	-	-	-	-	-	-	-
AP1_20	-	-	-	97	-	-	-	-	-	-	-