

Electronic Supplementary Material

for the article

Origin and evolution of gold-bearing fluids in a carbon-rich
sedimentary basin: a case study of the Algamarca
epithermal gold-silver-copper deposit, northern Peru

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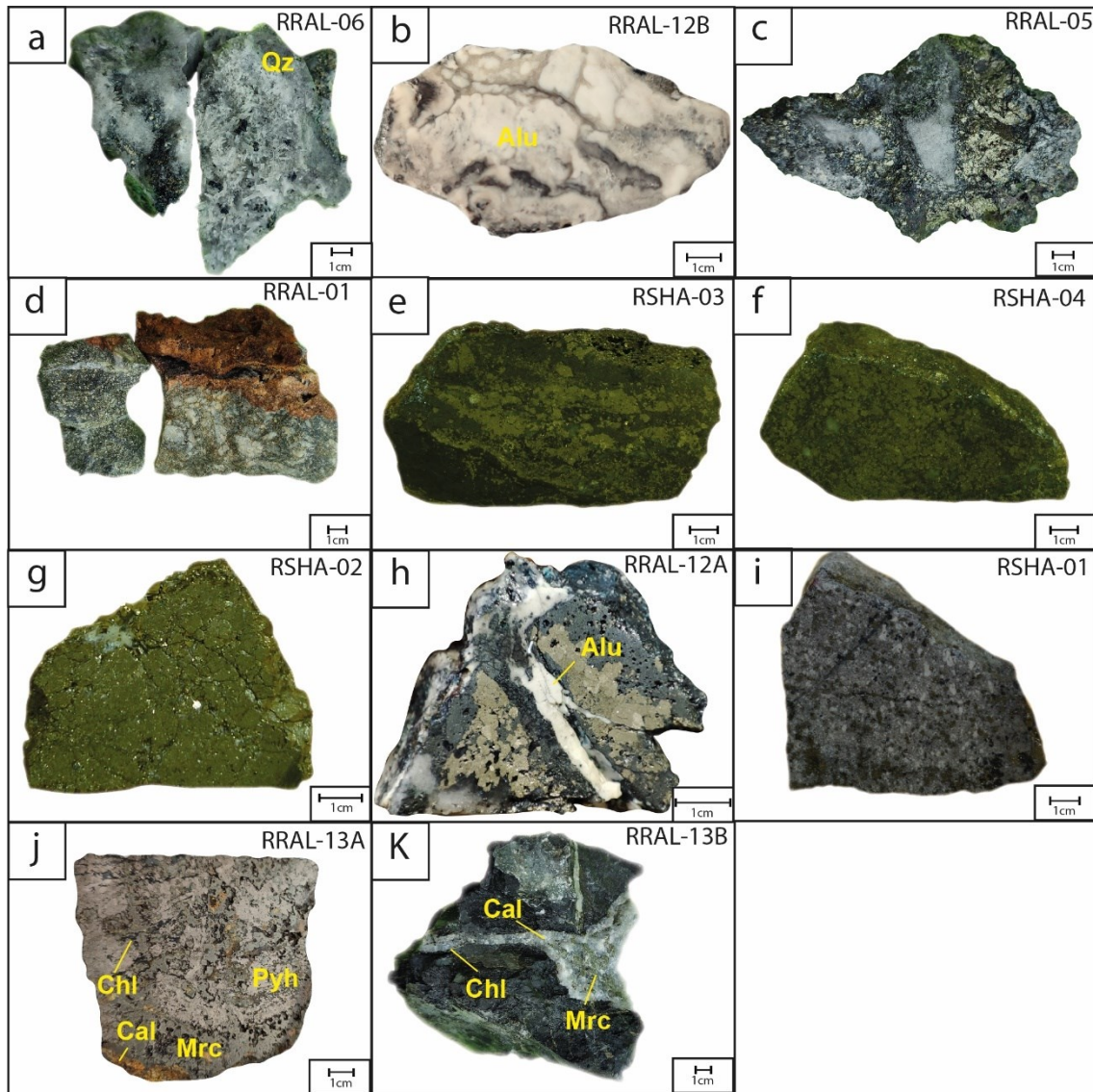


Fig. A1. Representative hand specimens, labeled by their sample numbers (displayed in the upper right corner). (a) Centimetric hydrothermal quartz crystals from the Concepción vein showing a crustiform texture. (b) Colloform alunite from Lucy vein. (c) Typical mineral assemblages of the Lucy vein matrix formed by pyrite-quartz-tennantite-tetrahedrite accompanied by clasts of quartzite from the Chimú Formation. (d) Hydrothermal breccia from the Choloque vein with clasts of quartzite and matrix of quartz and pyrite, partially oxidized. (e) Typical ore mineral assemblage of tennantite-pyrite-chalcopyrite from the Alisos vein. (f) Typical ore mineral assemblage of chalcopyrite-quartz-tetrahedrite-pyrite from the San Blas vein. (g) Massive pyrite, with minor baryte (white) from the San Blas vein. (h) Pyrite and tennantite-tetrahedrite from stage B, both crosscut by an alunite vein from stage C, Lucy vein. (i) Pre-ore diorite intrusive rock with abundant disseminated pyrite. (j) Massive pyrrhotite was replaced by marcasite. Chlorite and calcite are mainly in the contact between pyrrhotite and marcasite. (k) Veins of calcite-marcasite with narrow chlorite halo. In all figures, mineral abbreviations follow Warr (2021).

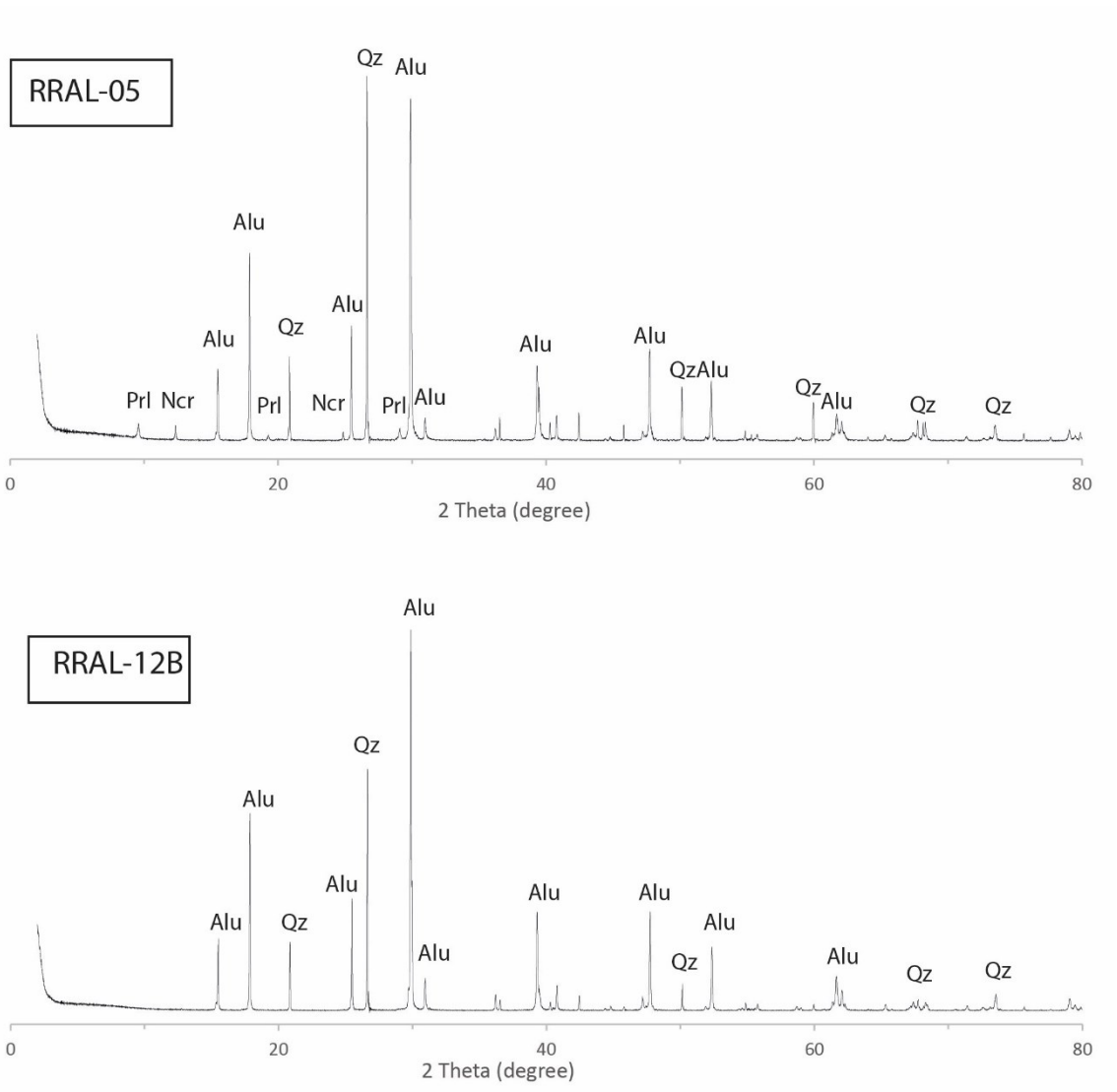


Fig. A2. XRD patterns of gangue minerals from Stage C for two indicated samples.

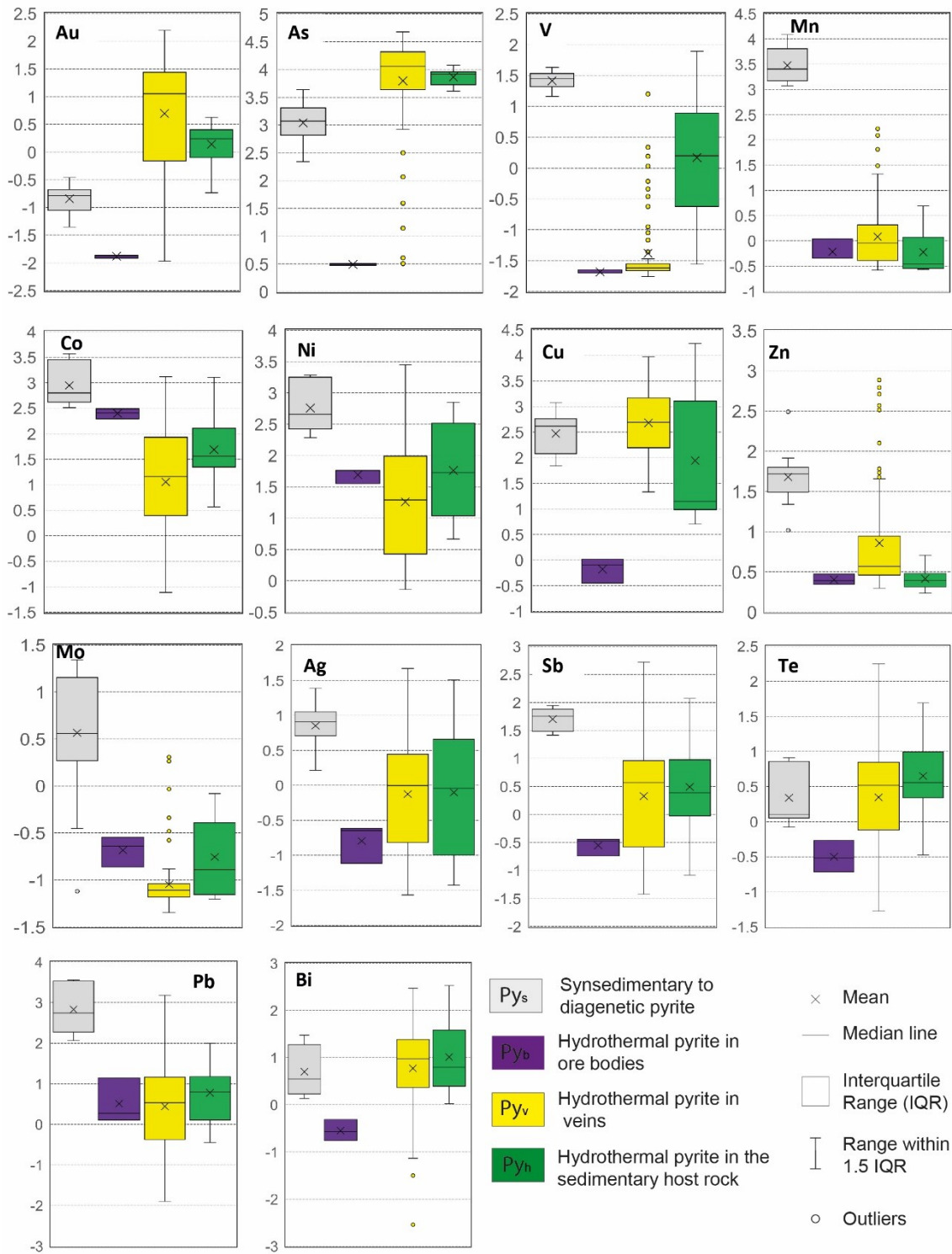


Fig. A3. Box plot comparison of the content in \log_{10} (ppm) of elements analyzed by LA-ICPMS in the different pyrite types from the Algamarca deposit.

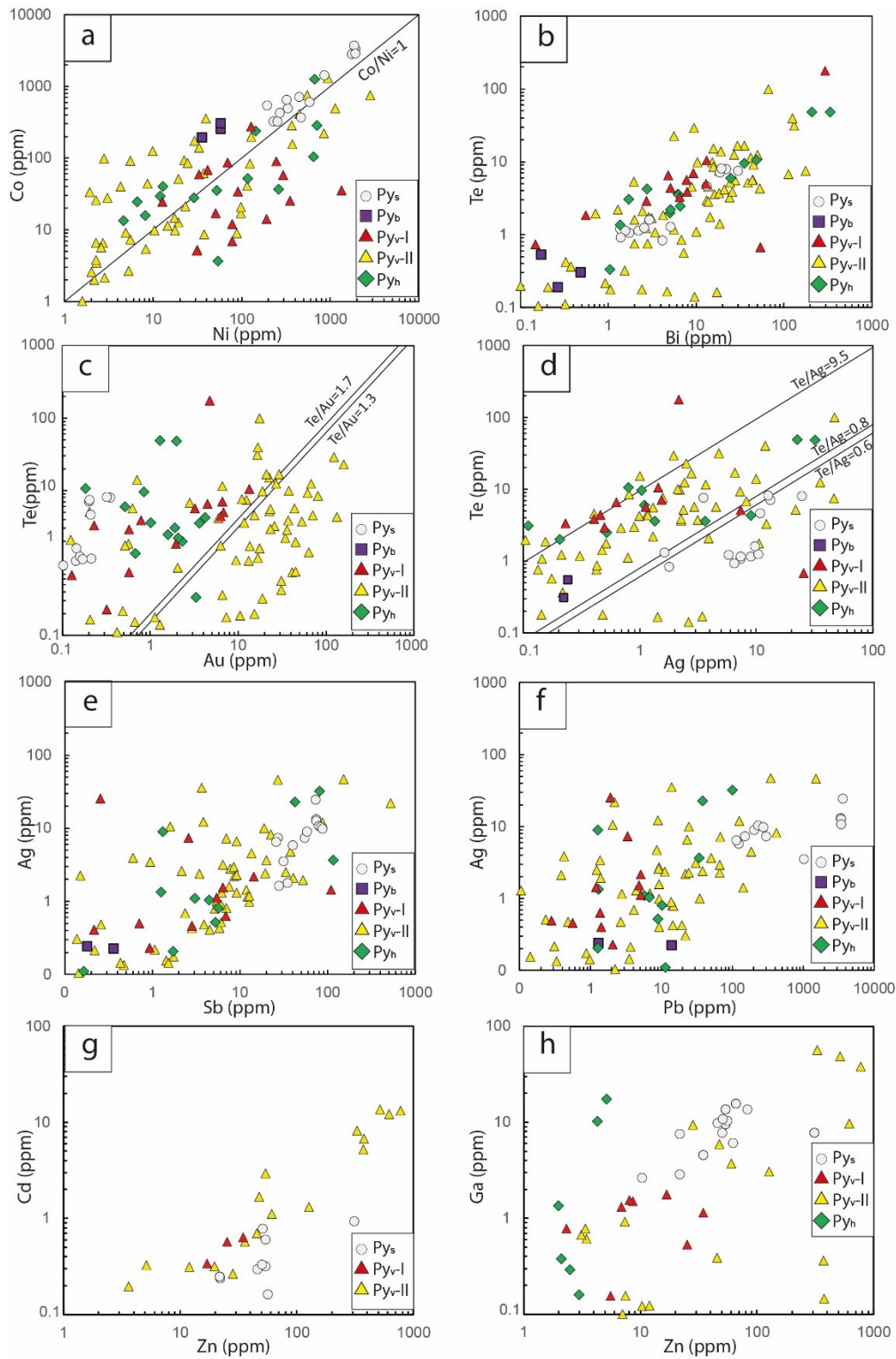


Fig. A4. Scatter diagrams of traces elements in all the types of pyrite from the Alamarca deposit. Abbreviations for pyrite types are the same as in Table 2. (a) Co vs. Ni. (b) Te vs. Bi. (c) Te vs. Au. (d) Te vs. Ag. (e) Ag vs. Sb. (f) Ag vs. Pb. (g) Cd vs. Zn. (h) Ga vs. Zn. The lines in Fig. A4c, d represents the ratios of common Au-Ag tellurides: calaverite ($Te/Au=1.3$), petzite ($Te/Au=1.3$ and $Te/Ag=0.8$), sylvanite ($Te/Au=1.7$ and $Te/Ag=9.5$), and hessite ($Te/Ag=0.6$).

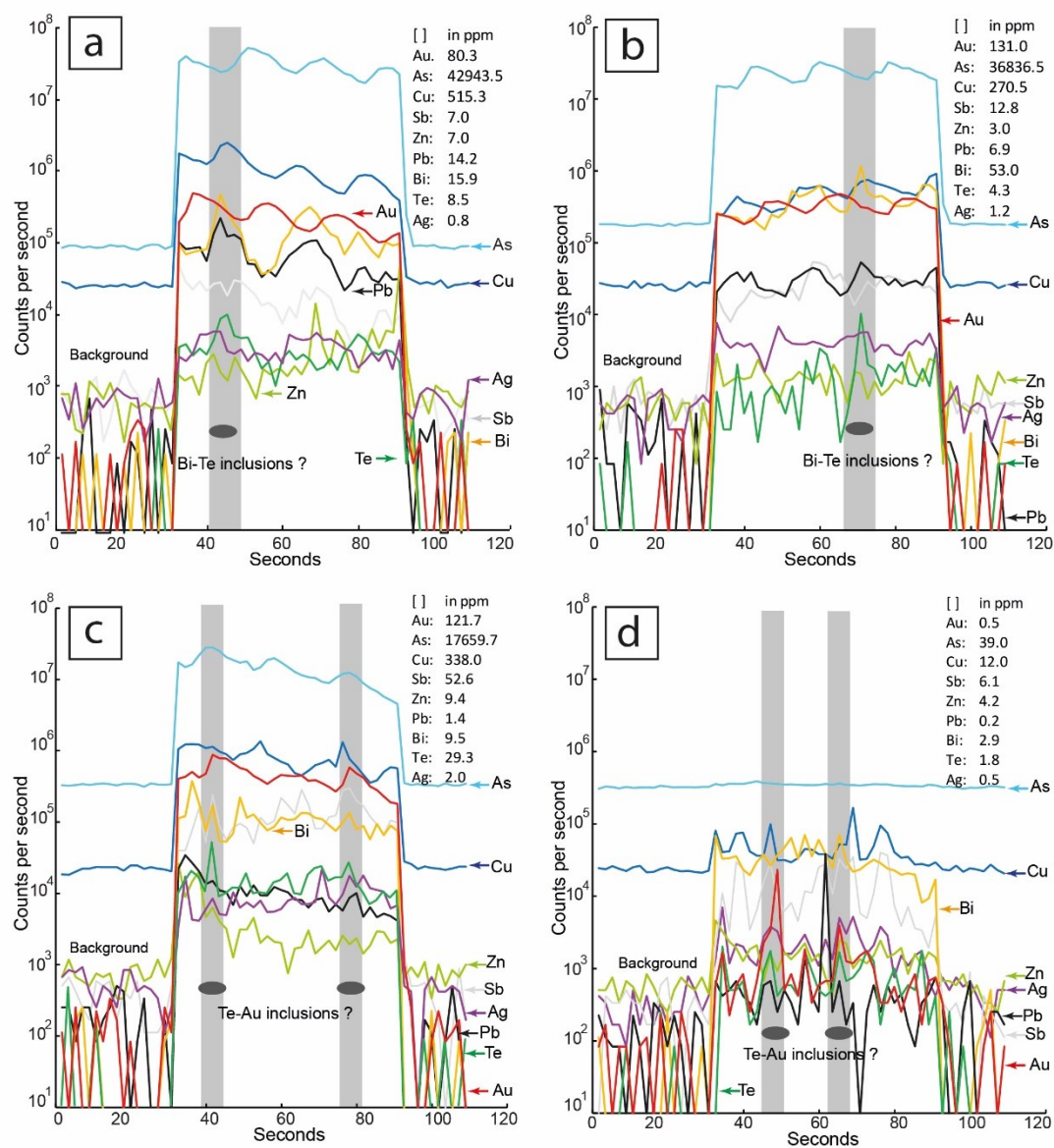


Fig. A5. LA-ICPMS signals for selected elements obtained from spot analyses of hydrothermal pyrites in veins. The spiky peaks highlighted in gray indicate the presence of inclusions. (a) Py_v-II_b from the Concepción vein, (b) Py_v-II_e from the Lucy vein, (c) Py_v-II_b from the San Blas vein, and (d) Py_v-II_c from the San Blas vein.

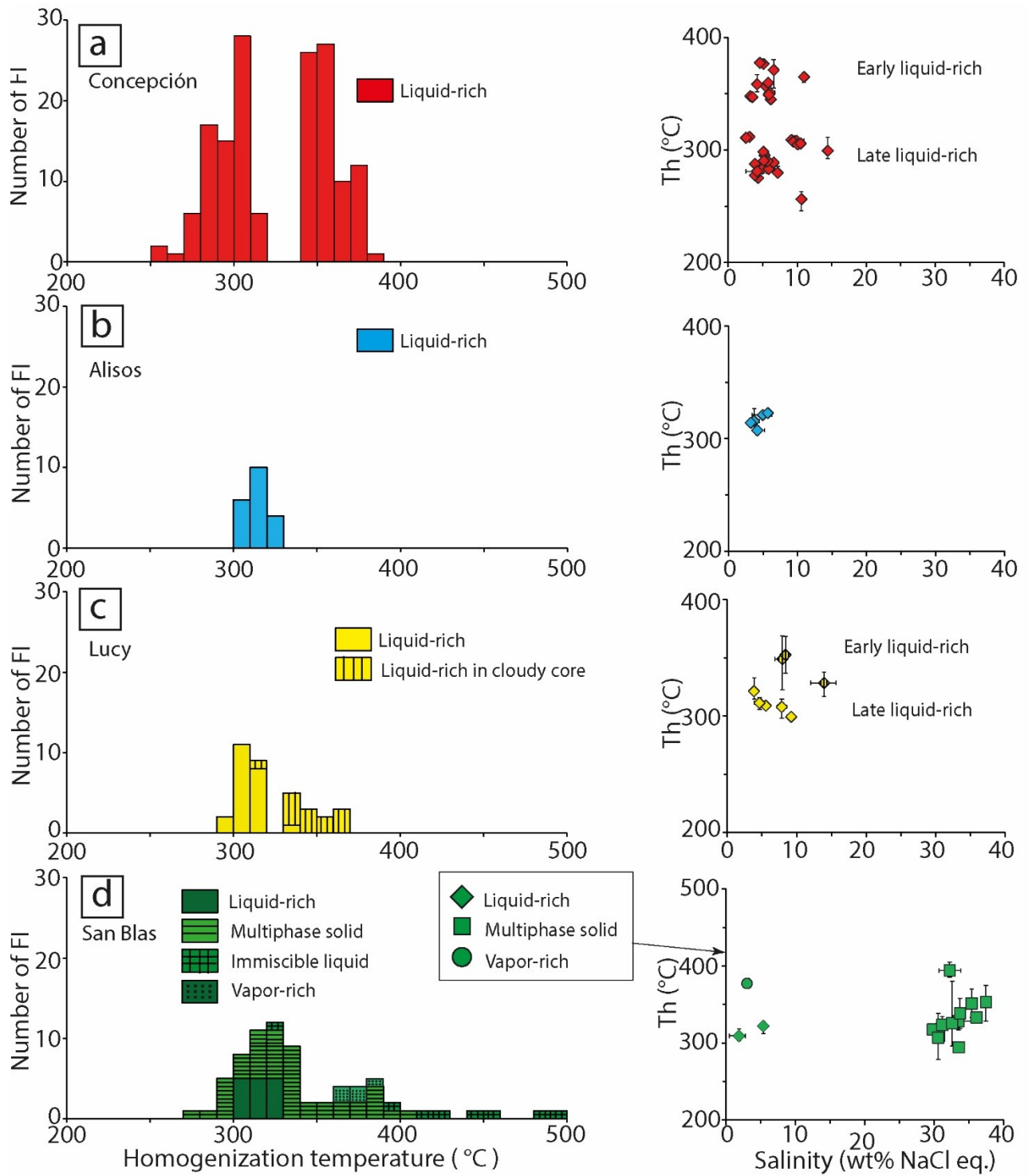


Fig. A6. Frequency vs. temperature of homogenization and temperature of homogenization vs. salinity for the Algamarca veins. The error bars correspond to the minimum and maximum value for each fluid inclusion assemblage.

Table A1. Representative EPMA analyses of different hydrothermal pyrites types. Including the chemical composition and structural formulas.

Stage	Stage A		Stage B										d.l.		
Mineral	Pyrite in veins		Pyrite in veins										Pyrite in the host rock		
	Py _v -I		Py _v -II _a		Py _v -II _b		Py _v -II _c		Py _v -II _d		Py _v -II _e		Py _h		
Sample	RSHA-04	RSHA-04	RRAL-06	RRAL-06	RRAL-06	RSHA-02	RRAL-06	RRAL-05	RRAL-05	RRAL-06	RSHA-01	RRAL-06	RRAL-01A	RRAL-01A	
#	47		3		8		27		25		74		5	10	
As (wt%)	0.22	1.15	0.15	0.15	3.77	2.58	2.02	b.d.l.	0.53	2.77	0.12	2.56	0.16	1.12	0.06
S	53.54	52.46	53.17	53.17	50.68	51.63	52.11	53.79	53.99	51.67	53.14	51.78	53.88	52.63	0.06
Fe	47.67	47.52	47.13	47.13	46.65	46.46	46.69	47.13	47.88	46.83	47.59	46.68	47.34	47.19	0.07
Sb	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	0.03
Cu	n.m.	n.m.	n.m.	n.m.	n.m.	b.d.l.	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	
Total	101.45	101.14	100.46	100.46	101.11	100.67	100.82	100.93	102.4	101.28	100.85	101.02	101.40	100.94	
As (apfu)	0.00	0.02	0.00	0.00	0.06	0.04	0.03	0.00	0.01	0.04	0.00	0.04	0.00	0.02	
S	1.98	1.96	1.99	1.99	1.92	1.95	1.96	2.00	1.98	1.94	1.98	1.95	1.99	1.97	
Fe	1.02	1.02	1.01	1.01	1.02	1.01	1.01	1.00	1.01	1.01	1.02	1.01	1.00	1.01	
Total	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	

= number of electron microprobe analyses, d.l. = detection limit in wt%, b.d.l.= below detection limit, n.m. = not measured. Abbreviations for pyrite types are the same as in Table 2.

Table A2. Representative EPMA analyses (in wt% and atomic units) of sedimentary pyrite and other indicated sulfide minerals from veins and ore bodies.

Mineral Sample #	Syndimentary to diagenetic pyrite		Sulfides in ore bodies						Sulfide in veins from Stage B						d.l.
	Py _s		Py _b		Po		Mrc		Ttr		Tnt		Ccp		
	RRAL-03	RRAL-03	RRAL-13A	RRAL-13A	RRAL-13A	RRAL-13A	RRAL-13A	RRAL-13A	RSHA-04	RSHA-04	RSHA-03	RSHA-02	RSHA-04	RSHA-04	
	12		10		4		10		23		6		12		
As (wt%)	0.08	0.22	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	1.73	2.91	18.67	20.40	b.d.l.	b.d.l.	0.06
S	53.34	51.94	52.6	53.03	39.05	39.18	53.05	52.5	25.21	26.04	28.16	28.43	34.65	34.85	0.06
Fe	47.48	46.81	47.72	47.62	61.72	61.12	47.7	47.25	5.12	5.45	6.19	8.29	30.27	30.48	0.07
Sb	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	26.22	24.74	2.35	0.79	b.d.l.	b.d.l.	0.03
Cu	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	38.12	37.93	43.75	42.42	34.80	34.70	0.05
Ag	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	1.35	1.58	b.d.l.	b.d.l.	b.d.l.	b.d.l.	0.2
Zn	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	1.73	1.65	1.05	0.32	b.d.l.	b.d.l.	0.2
Bi	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	0.3	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	0.3
Total	100.9	98.98	100.35	100.66	100.77	100.3	100.75	99.75	99.80	100.30	100.17	100.65	99.72	100.03	
As (apfu)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.38	0.64	3.67	3.98	0.00	0.00	
S	1.98	1.98	1.97	1.98	1.10	1.12	1.94	1.94	12.89	13.27	12.93	12.96	1.98	1.99	
Fe	1.02	1.02	1.03	1.02	1.00	1.00	1.00	1.00	1.50	1.59	1.63	2.17	0.99	1.00	
Sb									3.53	3.32	0.28	0.09	1.01	1.00	
Cu									9.83	9.75	10.13	9.76	0.00	0.00	
Ag									0.21	0.24	0.00	0.00	0.00	0.00	
Zn									0.43	0.41	0.24	0.07	0.00	0.00	
Bi									0.03	0.00	0.00	0.00	0.00	0.00	
Total	3.00	3.00	3.00	3.00	2.10	2.12	2.94	2.94	28.80	29.23	28.88	29.04	3.98	3.99	

= number of electron microprobe analyses, d.l. = detection limit in wt%, b.d.l.= below detection limit, n.m. = not measured. Abbreviations for minerals follow Warr (2021) and for pyrite types are the same as in Table 2

Table A3. Representative LA-ICPMS analyses (in ppm) of minerals from the Algamarca deposit.

Mineral	Type	Structure	Sample	Au	As	V	Mn	Co	Ni	Cu	Zn	Ga	Se	Mo	Ag	Cd	In	Sn	Sb	Te	W	Pb	Bi
Pyrite	Py _s		RRAL-03	0.3	1,100	30	1300	3300	1900	1,100	66	16	98	11	25	b.d.l.	0.03	2	73	8	0.08	3,600	22
	Py _s		RSHA-13	0.06	2,200	43	1700	550	190	70	54	14	4	3	6	0.3	0.02	0.6	40	1	0.1	120	1
	Py _s		RSHA-13	0.2	2,500	30	6600	500	330	120	51	11	6	22	9	0.8	0.03	0.4	58	1	0.1	200	2
Pyrite	Py _b	Ore bodies	RRAL-13	b.d.l.	b.d.l.	b.d.l.	1	260	58	1	2	b.d.l.	b.d.l.	0.3	0.1	b.d.l.	b.d.l.	b.d.l.	0.3	0.2	0.01	2	0.3
	Py _b	Ore bodies	RRAL-13	b.d.l.	b.d.l.	b.d.l.	b.d.l.	200	35	1	2	b.d.l.	2	0.2	0.2	b.d.l.	b.d.l.	b.d.l.	0.2	0.5	b.d.l.	1	0.2
	Py _b	Ore bodies	RRAL-13	b.d.l.	b.d.l.	b.d.l.	b.d.l.	310	58	b.d.l.	3	b.d.l.	2	0.1	0.2	b.d.l.	b.d.l.	b.d.l.	0.4	0.3	b.d.l.	14	0.5
Pyrrhotite	Po	Ore bodies	RRAL-13	b.d.l.	17	b.d.l.	b.d.l.	230	54	b.d.l.	2	b.d.l.	2	b.d.l.	0.3	b.d.l.	b.d.l.	b.d.l.	0.3	1	b.d.l.	4	0.8
	Po	Ore bodies	RRAL-13	0.04	b.d.l.	0.2	14	240	40	1	2	0.2	3	b.d.l.	0.6	b.d.l.	0.03	0.5	1	b.d.l.	b.d.l.	6	1
Marcasite	Mrc	Ore bodies	RRAL-13	b.d.l.	b.d.l.	b.d.l.	2	300	65	1	3	b.d.l.	2	0.2	0.1	b.d.l.	b.d.l.	b.d.l.	0.4	0.8	0.02	3	0.5
	Mrc	Ore bodies	RRAL-13	b.d.l.	b.d.l.	0.05	1	300	68	1	3	b.d.l.	2	0.2	0.2	0.1	b.d.l.	b.d.l.	0.5	0.2	0.05	3	0.2
Pyrite	Py _{r-1}	San Blas vein	RSHA-04	4	15,700	b.d.l.	65	7	78	270	6	0.2	44	b.d.l.	0.6	b.d.l.	0.02	b.d.l.	7	7	b.d.l.	1	5
	Py _{r-1}	San Blas vein	RSHA-04	5	17,100	b.d.l.	9	17	51	1,840	35	1	52	b.d.l.	2	0.6	0.3	19	14	180	0.03	5	290
Pyrite	Py _{r-II_a}	Concepción vein	RRAL-06	19	6,700	b.d.l.	b.d.l.	b.d.l.	32	1,800	520	48	9	b.d.l.	2	14	18	490	9	10	0.03	22	15
	Py _{r-II_a}	Concepción vein	RRAL-06	7	2,800	b.d.l.	2	b.d.l.	15	2,000	330	56	10	b.d.l.	4	8	20	390	20	12	b.d.l.	50	42
Pyrite	Py _{r-II_b}	Concepción vein	RRAL-06	41	27,800	b.d.l.	b.d.l.	280	370	21	3	b.d.l.	14	b.d.l.	0.4	b.d.l.	0.03	b.d.l.	3	0.8	b.d.l.	15	3
	Py _{r-II_b}	Concepción vein	RRAL-06	67	34,300	b.d.l.	1	5	32	950	50	6	23	b.d.l.	2	2	2	74	20	13	0.04	38	50
	Py _{r-II_b}	San Blas vein	RSHA-02	122	17,700	0.2	b.d.l.	13	19	340	9	0.1	22	b.d.l.	2	b.d.l.	0.03	b.d.l.	53	29	0.05	1	9
Pyrite	Py _{r-II_c}	Concepción vein	RRAL-06	23	20,200	0.3	2	750	550	470	3	0.1	21	b.d.l.	1	b.d.l.	0.03	b.d.l.	5	15	0.03	35	16
	Py _{r-II_c}	Concepción vein	RRAL-06	45	21,600	b.d.l.	b.d.l.	120	10	120	3	b.d.l.	21	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	2	b.d.l.	2	0.7
	Py _{r-II_c}	San Blas vein	RSHA-02	0.5	40	b.d.l.	2	10	10	12	4	b.d.l.	11	b.d.l.	0.5	b.d.l.	b.d.l.	b.d.l.	6	2	b.d.l.	0.2	3
Pyrite	Py _{r-II_d}	Concepción vein	RRAL-06	23	20,600	2	b.d.l.	7	3	65	3	b.d.l.	11	b.d.l.	0.9	b.d.l.	0.04	b.d.l.	6	3	600	14	13
	Py _{r-II_d}	Lucy vein	RRAL-05	62	27,200	b.d.l.	6	b.d.l.	b.d.l.	180	36	b.d.l.	16	b.d.l.	7	0.6	0.1	0.9	7	9	0.01	68	45
	Py _{r-II_d}	Concepción vein	RRAL-06	29	17,350	b.d.l.	21	176	29	136	9	0.06	22	b.d.l.	2.8	b.d.l.	0.03	b.d.l.	8	17	b.d.l.	9	35
Pyrite	Py _{r-II_e}	Lucy vein	RRAL-05	64	21,900	b.d.l.	b.d.l.	0.4	b.d.l.	150	4	b.d.l.	10	b.d.l.	0.5	0.2	0.03	b.d.l.	4	1	0.01	3	19
	Py _{r-II_e}	Concepción vein	RRAL-06	31	28,400	b.d.l.	b.d.l.	197	128	52	3	b.d.l.	16	b.d.l.	b.d.l.	b.d.l.	0.05	b.d.l.	b.d.l.	0.4	b.d.l.	0.5	0.3
	Py _{r-II_e}	Alisos vein	RSHA-03	0.7	800	b.d.l.	165	15	17	3,700	28	9	72	b.d.l.	10	0.3	4	67	19	14	0.08	24	19
Pyrite	Py _h core	Choloque vein	RRAL-01A	0.2	6,100	3	b.d.l.	100	650	11	2	1	35	b.d.l.	0.8	b.d.l.	b.d.l.	b.d.l.	6	11	0.8	10	49
	Py _h core	Choloque vein	RRAL-01A	0.5	4,700	3	4	4	54	400	2	0.3	39	b.d.l.	1	b.d.l.	b.d.l.	b.d.l.	3	6	5	6	25
	Py _h core	Choloque vein	RRAL-01A	2	11,900	78	5	1300	670	17,100	5	17	67	0.7	32	b.d.l.	0.05	1	82	49	76	100	340
Pyrite	Py _h rim	Choloque vein	RRAL-01A	3	11,600	b.d.l.	b.d.l.	25	7	13	2	b.d.l.	8	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	0.4	0.3	0.05	0.4	1
	Py _h rim	Choloque vein	RRAL-01A	1	7,100	6	1	36	52	62	3	b.d.l.	11	0.7	4	b.d.l.	b.d.l.	b.d.l.	120	4	9	34	6
	Py _h rim	Choloque vein	RRAL-01A	2	8,400	6	b.d.l.	13	5	10	2	0.1	9	0.3	0.2	b.d.l.	0.03	0.4	2	2	23	1	5
Arsenopyrite	Apy	San Blas vein	RSHA-01	5	424,100	6	b.d.l.	b.d.l.	3	870	11	0.1	21	0.9	0.9	0.4	1	1	200	3	83	3	5
	Apy	San Blas vein	RSHA-01	0.6	450,000	110	1	0.3	1	56	2	0.1	16	b.d.l.	0.3	b.d.l.	0.3	0.3	230	3	77	2	10
	Apy	San Blas vein	RSHA-04	320	417,400	b.d.l.	b.d.l.	120	350	55	b.d.l.	b.d.l.	160	b.d.l.	0.1	b.d.l.	0.6	b.d.l.	26	1200	b.d.l.	0.1	13
Tennantite	Tnt	Alisos vein	RSHA-03	0.04	84,400	b.d.l.	23	9	b.d.l.	106,700	5,400	5	30	3,300	530	180	5	17,500	8,200	28	0.05	110	310
	Tnt	Alisos vein	RSHA-03	0.04	87,200	b.d.l.	24	9	b.d.l.	133,200	6,500	4	35	3,100	600	210	5	17,100	8,900	39	0.07	0.5	450
Tetrahedrite	Ttr	San Blas vein	RSHA-04	0.06	30,400	b.d.l.	770	2	b.d.l.	298,900	29,100	10	89	b.d.l.	10,200	745	8	0.6	200,200	60	b.d.l.	0.2	2,360
	Ttr	San Blas vein	RSHA-04	0.05	31,700	b.d.l.	700	2	b.d.l.	305,300	29,200	12	83	b.d.l.	9,800	760	9	0.9	205,700	59	b.d.l.	0.4	2,500
Chalcopyrite	Ccp	San Blas vein	RSHA-04	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	317,400	32	91	33	b.d.l.	3	b.d.l.	15	1,100	2	5	b.d.l.	0.9	1
	Ccp	San Blas vein	RSHA-04	0.1	b.d.l.	0.04	2	b.d.l.	b.d.l.	317,600	14	14	36	b.d.l.	2	b.d.l.	11	320	3	4	0.04	1	0.7

b.d.l. = below detection limit.

Table A4. Pearson correlation coefficients for all bivariate trace element combinations in hydrothermal pyrite from the Algamarca veins (Py_v). Weak (light gray), moderate (medium gray) and high correlation (dark gray) are high.

	Au	As	V	Mn	Co	Ni	Cu	Zn	Ga	Se	Mo	Ag	Cd	In	Sn	Sb	Te	Pb	Bi
Au	1																		
As	0,6	1																	
V	-0,1	0,0	1																
Mn	-0,1	-0,1	0,0	1															
Co	0,0	0,1	0,0	-0,1	1														
Ni	-0,1	-0,1	0,0	0,0	0,6	1													
Cu	-0,1	-0,2	0,0	0,1	0,2	0,2	1												
Zn	-0,1	-0,1	0,0	0,0	-0,1	-0,1	0,2	1											
Ga	-0,1	-0,1	0,0	0,0	-0,1	-0,1	0,1	0,7	1										
Se	0,0	-0,2	-0,2	0,3	0,0	0,0	0,2	0,0	0,0	1									
Mo	-0,1	-0,1	0,6	-0,1	0,2	0,2	0,4	0,0	0,0	-0,2	1								
Ag	-0,1	-0,1	-0,1	0,1	0,0	0,0	0,4	0,3	0,0	0,3	0,0	1							
Cd	-0,1	-0,1	0,0	0,0	-0,1	-0,1	0,2	1,0	0,8	0,0	0,0	0,3	1						
In	-0,1	-0,1	0,0	0,1	-0,1	0,0	0,1	0,8	0,9	-0,1	0,0	0,0	0,8	1					
Sn	-0,1	-0,1	0,0	0,0	-0,1	0,0	0,1	0,8	0,8	0,0	0,0	0,0	0,9	1,0	1				
Sb	0,0	-0,1	0,0	0,1	-0,1	-0,1	0,5	0,4	0,0	0,2	-0,1	0,4	0,3	0,0	0,0	1			
Te	0,1	0,0	-0,1	0,1	0,0	-0,1	0,2	0,1	0,1	0,5	-0,1	0,3	0,1	0,0	0,1	0,2	1		
Pb	-0,1	-0,1	0,0	0,0	-0,1	-0,1	0,0	0,3	0,0	0,1	0,0	0,6	0,2	0,0	0,0	0,1	0,1	1	
Bi	0,0	0,0	-0,1	0,2	-0,1	-0,1	0,1	0,3	0,1	0,2	-0,1	0,4	0,2	0,1	0,1	0,1	0,7	0,5	1

Table A5. Microthermometric results of immiscible-liquid fluid inclusion assemblages (FIAs) in quartz of stage A from the San Blas vein. For each microthermometric parameter, the average values are given, while the number of analyzed fluid inclusions are in brackets.

Sample	Type	Th (°C)	Tm _(CO₂) (°C)	Tm _(clath) (°C)	Th _(CO₂) (°C)
RSHA-04	C	>370 (5)	-66.8 ± 1.3 (3)	10.6 ± 2.1 (3)	29.2 ± 0.3 (3)
RSHA-04	I	498 (1)	-66.2 (1)	10.1 (1)	29.5 (1)
RSHA-04	I	327 (1)	-65.8 (1)	10.3 (1)	30.0 (1)
RSHA-04	C	404 ± 17 (2)	-65.9 ± 1.1 (3)	9.1 ± 4.3 (2)	30.9 ± 0.4 (3)
RSHA-04	C	444 ± 25 (3)	-66.5 ± 0.5 (3)	9.8 ± 1.7 (3)	31.0 ± 0.1 (4)

Th = homogenization temperature, Tm_(CO₂) = melting temperature of solid CO₂, Tm_(clath) = melting temperature of clathrate, Th_(CO₂) = homogenization temperature of CO₂, C = cluster, I = isolated.

Table A6. Element concentration obtained by LA-ICPMS for 15 fluid inclusion assemblages from the Algamarca veins.

FIA	Type	S	Cl	B	Na	Mg	K	Ca	Mn
RRAL-06_3_1	Liquid-rich	8,900 ± 2,300 (6)	12,400 ± 9,000 (3)	1,500 ± 300 (6)	12,600 ± 1,200 (6)	40 ± 30 (5)	8,600 ± 700 (6)	2,700 ± 600 (4)	250 ± 40 (6)
RRAL-06_2_1	Liquid-rich	7,400 ± 1,100 (2)	11,300 ± 900 (2)	1,700 ± 200 (2)	17,200 ± 400 (2)	140 ± 140 (2)	11,500 ± 5,000 (2)	1,000 ± 200 (2)	430 ± 70 (2)
RRAL-06_1_1	Liquid-rich	3,800 ± 1,000 (2)	10,000 ± 3,400 (3)	800 ± 200 (3)	9,000 ± 500 (3)	150 ± 110 (2)	6,000 ± 1,200 (3)	1,600 ± 700 (3)	170 ± 20 (3)
RRAL-06_10_1	Liquid-rich	4,000 (1)	13,400 (1)	900 (1)	19,600 (1)	1,600 (1)	6,700 (1)	3,100 (1)	180 (1)
RRAL-06_10_2	Liquid-rich	2,100 (1)	37,200 ± 10,000 (3)	1,600 ± 200 (3)	28,100 ± 1,400 (3)	90 ± 40 (3)	18,000 ± 600 (3)	6,400 ± 2,000 (3)	1,600 ± 10 (3)
RRAL-06_6_1	Liquid-rich	8,500 ± 1,000 (2)	17,100 ± 2,700 (2)	800 ± 20 (2)	14,600 ± 200 (2)	290 ± 20 (2)	9,600 ± 500 (2)	1,400 (1)	1,100 ± 100 (2)
RRAL-06_13_1	Liquid-rich		39,000 (1)	1,400 (1)	25,100 (1)	420 (1)	19,000 (1)	5,000 (1)	2,100 (1)
RRAL-06_11_1	Liquid-rich	4,000 (1)	15,000 (1)	1,500 (1)	27,200 (1)	450 (1)	19,000 (1)	4,100 (1)	2,300 (1)
RRAL-06_11_2	Liquid-rich		70,000 ± 400 (2)	1,100 ± 50 (2)	21,900 ± 2,000 (2)	250 ± 90 (2)	14,000 ± 2,000 (2)	9,700 (1)	1,300 ± 140 (2)
RRAL-06_11_4	Liquid-rich	3,800 (1)	50,000 (1)	1,600 (1)	24,500 (1)	410 (1)	18,400 (1)	2,900 (1)	2,100 (1)
RRAL-06_11_6	Liquid-rich		31,000 (1)	1,900 (1)	35,000 (1)	570 (1)	27,000 (1)	9,800 (1)	2,200 (1)
RRAL-06_12_1	Liquid-rich	3,300 ± 300 (3)	21,800 ± 14,500 (2)	800 ± 80 (3)	9,500 ± 700 (3)	80 ± 10 (3)	5,700 ± 800 (3)	2,700 ± 1,300 (3)	200 ± 10 (3)
RRAL-04_2_1	multiphase solid	2,100 (1)	247,000 ± 14,000 (3)	550 ± 200 (3)	53,000 ± 5,000 (3)	130 ± 50 (3)	48,500 ± 7,800 (3)	7,000 ± 800 (3)	15,300 ± 1,000 (3)
RRAL-04_2_2	multiphase solid	6,000 ± 600 (2)	262,500 ± 10,000 (2)	400 ± 160 (2)	60,000 ± 6,000 (2)	460 ± 60 (2)	76,000 ± 5,000 (2)	6,000 ± 700 (2)	15,000 ± 3,200 (2)
RRAL-04_3_1	multiphase solid	3,000 (1)	270,000 ± 75,000 (3)	400 ± 50 (3)	75,000 ± 17,000 (3)	300 ± 90 (3)	72,000 ± 20,000 (3)	5,000 ± 1,400 (3)	16,400 ± 3,800 (3)
FIA	Type	Fe	Cu	Zn	As	Br	Rb	Sr	Mo
RRAL-06_3_1	Liquid-rich	1,900 ± 400 (6)	540 ± 60 (6)	140 ± 70 (6)	300 ± 80 (6)	n.m.	n.m.	5 ± 1 (6)	n.m.
RRAL-06_2_1	Liquid-rich	2,400 ± 400 (2)	560 ± 130 (2)	190 ± 20 (2)	200 ± 90 (2)	n.m.	n.m.	12 ± 1 (2)	n.m.
RRAL-06_1_1	Liquid-rich	800 ± 170 (3)	10 ± 1 (3)	50 ± 20 (3)	380 ± 90 (3)	n.m.	n.m.	11 ± 1 (3)	n.m.
RRAL-06_10_1	Liquid-rich	700 (1)	290 (1)	80 (1)		n.m.	n.m.	42 (1)	n.m.
RRAL-06_10_2	Liquid-rich	8,900 ± 600 (3)	20 ± 10 (3)	640 ± 60 (3)	200 ± 42 (3)	n.m.	n.m.	48 ± 4 (3)	n.m.
RRAL-06_6_1	Liquid-rich	2,900 ± 300 (2)	10 (2)	830 ± 30 (2)	120 ± 10 (2)	n.m.	n.m.	24 ± 1 (2)	n.m.
RRAL-06_13_1	Liquid-rich	10,700 (1)		1,000 (1)	220 (1)	n.m.	n.m.	44 (1)	n.m.
RRAL-06_11_1	Liquid-rich	12,800 (1)	20 (1)	1,000 (1)	270 (1)	n.m.	n.m.	52 (1)	n.m.
RRAL-06_11_2	Liquid-rich	4,900 ± 1,600 (2)		660 ± 30 (2)	100 (1)	n.m.	n.m.	31 ± 1 (2)	n.m.
RRAL-06_11_4	Liquid-rich	9,700 (1)		1,200 (1)	170 (1)	n.m.	n.m.	41 (1)	n.m.
RRAL-06_11_6	Liquid-rich	10,900 (1)	80 (1)	1,200 (1)		n.m.	n.m.	41 (1)	n.m.
RRAL-06_12_1	Liquid-rich	830 ± 70 (3)	20 ± 20 (3)	40 ± 5 (3)	340 ± 40 (3)	n.m.	n.m.	11 ± 1 (3)	n.m.
RRAL-04_2_1	multiphase solid	95,000 ± 10,000 (3)	70 (1)	8,200 ± 1,200 (3)	1,800 ± 200 (3)	550 ± 200 (1)	600 ± 100 (3)	74 ± 7 (3)	0.5 (1)
RRAL-04_2_2	multiphase solid	73,500 ± 4,400 (2)	6,900 ± 2,500 (2)	5,500 ± 600 (2)	2,000 ± 1,500 (2)	570 ± 130 (2)	800 ± 100 (2)	310 ± 2 (2)	0.3 (1)
RRAL-04_3_1	multiphase solid	79,000 ± 20,000 (3)	2,000 ± 2,000 (3)	5,800 ± 2,300 (3)	1,100 ± 1,000 (3)	500 ± 80 (2)	800 ± 200 (3)	270 ± 80 (3)	0.8 (1)
FIA	Type	Ag	Sb	Cs	Ba	Au	Pb	Bi	
RRAL-06_3_1	Liquid-rich	4 ± 3 (4)	145 ± 80 (5)	31 ± 4 (6)	n.m.		40 ± 20 (6)	n.m.	
RRAL-06_2_1	Liquid-rich	1 ± 1 (2)		46 ± 7 (2)	n.m.	0.2 (1)	52 ± 2 (2)	n.m.	
RRAL-06_1_1	Liquid-rich	0.2 (1)	45 ± 20 (3)	14 ± 3 (3)	n.m.		18 ± 3 (3)	n.m.	
RRAL-06_10_1	Liquid-rich	1 (1)		22 (1)	n.m.		30 (1)	n.m.	
RRAL-06_10_2	Liquid-rich	2.0 ± 0.3 (3)	70 ± 10 (3)	64 ± 4 (3)	n.m.		140 ± 20 (3)	n.m.	
RRAL-06_6_1	Liquid-rich	1 (1)	26 ± 3 (2)	11 ± 1 (2)	n.m.		290 ± 40 (2)	n.m.	
RRAL-06_13_1	Liquid-rich		390 (1)	18 (1)	n.m.		230 (1)	n.m.	
RRAL-06_11_1	Liquid-rich	1 (1)		17 (1)	n.m.		250 (1)	n.m.	
RRAL-06_11_2	Liquid-rich		150 (1)	12 ± 3 (2)	n.m.		200 ± 50 (2)	n.m.	
RRAL-06_11_4	Liquid-rich	2 (1)	6 (1)	18 (1)	n.m.		320 (1)	n.m.	
RRAL-06_11_6	Liquid-rich			20 (1)	n.m.		280 (1)	n.m.	
RRAL-06_12_1	Liquid-rich		20 (1)	16 ± 3 (3)	n.m.		20 ± 3 (3)	n.m.	
RRAL-04_2_1	multiphase solid	50 ± 20 (3)	1,900 ± 400 (3)	200 ± 30 (3)	100 ± 30 (3)		1,300 ± 100 (3)	110 ± 60 (3)	
RRAL-04_2_2	multiphase solid	100 ± 10 (2)	1,400 ± 770 (2)	225 ± 30 (2)	210 ± 5 (2)		1,300 ± 500 (2)	490 ± 20 (2)	
RRAL-04_3_1	multiphase solid	110 ± 60 (3)	900 ± 500 (3)	200 ± 70 (3)	200 ± 30 (3)		1,500 ± 600 (3)	370 ± 180 (3)	

Notes: The number of corresponding single measurements is in brackets. Data are reported as the assemblage average, with a standard deviation, n.m. = not measured.

Table A.7. Relevant Raman peak parameters and estimated temperatures from Raman spectra of carbonaceous material at the Algamarca deposit.

Sample	Analysis	Position (cm ⁻¹)					Area					FWHM	Area ratio	Estimated temperature (°C)	
		D4	D1	D3	G	D2	D4	D1	D3	G	D2			D1	RA1
RRAL-07	1	1215	1338	1521	1593	1610	58118	323058	51090	110599	40040	83	0.65	300	348
	2	1230	1338	1516	1593	1611	257913	810020	230738	363517	22683	86	0.63	293	323
RRAL-14A	1	1207	1333	1506	1593	1603	141804	718590	177509	273185	102037	109	0.61	243	291
	2	1205	1332	1507	1593	1603	275069	1058620	259769	456584	75651	114	0.63	233	315
	3	1202	1331	1508	1593	1603	233581	1072050	261730	452602	78045	114	0.62	232	308
	4	1207	1333	1506	1593	1604	105506	411466	94436	133517	87863	109	0.62	245	306
RRAL-14B	1	1204	1330	1511	1593	1603	251648	1225450	364442	537825	56424	113	0.61	234	288
	2	1205	1331	1511	1593	1603	296607	1040610	293744	458089	44465	114	0.63	232	314

Notes: FWHM = half width at half maximum, RA1 = (D1 + D4)/(D1 + D2 + D3 + D4 + G) area ratio, Tw = temperature estimated using the D1 width (FWHM) after Kouketsu et al. (2014), Ta = temperature estimated using the area ratio RA1 after Lahfid et al. (2010).

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