

Supplement Table S1. Compositions of the different generations of arsenopyrite in Laozuoshan gold deposit (Data from EPMA, wt.%)

Stage	No.	Co	Ag	Fe	S	Zn	Au	Cu	Ni	As	Total	Fe*	As*	S*	Data source
Apy-1	L-7D-2	2.08	<mdl	33.18	18.70	<mdl	<mdl	<mdl	0.04	47.70	101.69	0.328	0.351	0.321	Meng et al., 2020
	LDK-4-2	1.09	<mdl	33.98	18.84	<mdl	0.02	<mdl	0.26	47.99	102.18	0.331	0.349	0.320	
	L-7B-2	4.19	<mdl	30.09	18.48	<mdl	0.02	<mdl	0.75	47.75	101.29	0.307	0.364	0.329	
	L-7B-5	2.99	<mdl	31.97	18.97	<mdl	0.01	<mdl	0.21	46.67	100.83	0.320	0.349	0.331	
	L-7B-6	2.96	<mdl	32.07	18.53	<mdl	0.01	<mdl	0.09	47.58	101.24	0.321	0.355	0.323	
	L-7B-11	2.82	<mdl	32.17	18.06	<mdl	<mdl	<mdl	0.10	49.02	102.17	0.321	0.365	0.314	
	L-7D-14	2.92	<mdl	31.71	17.64	<mdl	<mdl	<mdl	0.37	49.41	102.05	0.319	0.371	0.310	In this study
	LDK-1-3	0.08	<mdl	34.43	17.49	<mdl	0.03	<mdl	0.09	48.05	100.18	0.342	0.356	0.302	
	LDK-1-5	0.23	<mdl	34.08	16.93	<mdl	0.04	<mdl	0.06	49.21	100.55	0.340	0.366	0.294	
	LDK-1-6	0.21	<mdl	34.57	17.56	<mdl	0.02	<mdl	0.04	47.63	100.04	0.343	0.353	0.304	
	LDK-1-7	0.34	<mdl	33.81	16.57	0.01	0.02	<mdl	0.09	50.71	101.55	0.337	0.376	0.287	
	LDK-1-8	1.74	0.01	32.90	17.25	0.01	<mdl	<mdl	0.02	48.36	100.28	0.332	0.364	0.303	
	LDK-1-9	0.35	<mdl	34.28	17.64	<mdl	0.02	<mdl	0.09	49.24	101.62	0.337	0.361	0.302	
	Max.	4.19	0.01	34.57	18.97	0.01	0.04	<mdl	0.75	50.71	102.18	0.343	0.376	0.331	
	Min.	0.08	<mdl	30.09	16.57	<mdl	<mdl	<mdl	0.02	46.67	100.04	0.307	0.349	0.287	
	Average	1.69	0.00	33.02	17.90	0.00	0.02	0.00	0.17	48.41	101.21	0.329	0.360	0.311	
	S.D.	1.40	0.00	1.35	0.76	0.00	0.01	0.00	0.20	1.06	0.76	0.011	0.009	0.013	
Apy-2	LZS-3-1	0.29	<mdl	34.86	19.29	<mdl	<mdl	<mdl	0.01	46.03	100.47	0.339	0.334	0.327	Meng et al., 2020
	LZS-3-3	0.07	<mdl	35.10	19.21	0.02	<mdl	<mdl	<mdl	45.51	99.90	0.343	0.331	0.326	
	LZS-3-4	0.13	<mdl	35.46	19.52	0.01	0.01	0.01	<mdl	45.81	100.94	0.342	0.330	0.328	
	LZS-3-33	0.19	<mdl	35.09	19.63	<mdl	0.01	<mdl	<mdl	46.87	101.78	0.337	0.335	0.328	
	LZS-3-36	0.29	<mdl	34.75	19.34	<mdl	<mdl	<mdl	<mdl	45.95	100.32	0.338	0.334	0.328	

	LZS-3-38	0.04	0.03	35.53	19.40	<mdl	<mdl	<mdl	<mdl	46.14	101.13	0.343	0.332	0.326	
	LZS-3-17	0.09	<mdl	34.79	18.80	0.01	0.17	0.01	<mdl	48.45	102.36	0.336	0.348	0.316	In this study
	Max	0.29	0.04	35.53	19.63	0.02	0.17	0.01	0.01	48.45	102.36	0.343	0.348	0.328	
	Min	0.04	<mdl	34.75	18.80	<mdl	<mdl	<mdl	<mdl	45.51	99.90	0.336	0.330	0.316	
	Average	0.16	0.01	35.08	19.31	0.00	0.03	0.00	0.00	46.39	100.99	0.340	0.335	0.326	
	S.D.	0.10	0.02	0.31	0.27	0.01	0.06	0.01	0.00	1.00	0.86	0.003	0.006	0.004	
Apy-3	LZS-9T-03	6.83	<mdl	26.51	17.92	<mdl	<mdl	<mdl	1.20	49.42	101.87	0.280	0.390	0.330	
	LZS-9T-05	5.60	0.04	28.35	17.79	0.01	0.17	<mdl	0.51	50.15	102.63	0.293	0.386	0.320	
	LZS-9T-11	6.92	<mdl	27.10	18.20	<mdl	<mdl	<mdl	0.58	49.17	101.96	0.284	0.384	0.332	
	LZS-9T-17	2.91	0.02	31.16	18.51	<mdl	0.18	<mdl	0.33	48.67	101.77	0.313	0.364	0.323	
	LZS-9T-20	0.60	<mdl	33.69	18.54	<mdl	<mdl	<mdl	0.01	48.72	101.55	0.329	0.355	0.316	In this study
	LZS-9T-25	5.02	<mdl	27.30	17.52	<mdl	0.02	<mdl	1.93	50.36	102.15	0.286	0.394	0.320	
	LZS-9T-28	1.29	<mdl	29.20	17.24	<mdl	0.02	<mdl	2.11	50.62	100.47	0.301	0.389	0.310	
	LZS-9T-35	4.14	0.05	29.34	18.16	<mdl	0.08	<mdl	0.97	50.07	102.79	0.299	0.380	0.322	
	Max	6.92	0.05	33.69	18.54	0.01	0.18	0.00	2.11	50.62	102.79	0.329	0.394	0.332	
	Min	0.60	<mdl	26.51	17.24	<mdl	<mdl	<mdl	0.01	48.67	100.47	0.280	0.355	0.310	
	Average	4.16	0.01	29.08	17.98	0.00	0.06	0.00	0.95	49.65	101.90	0.298	0.380	0.322	
	S.D.	2.39	0.02	2.39	0.46	0.00	0.08	0.00	0.75	0.75	0.72	0.016	0.014	0.007	
Apy-4	L-8A1-3	0.18	<mdl	33.69	19.29	<mdl	0.02	<mdl	0.98	46.42	100.58	0.331	0.340	0.330	
	L-8A1-9	0.31	<mdl	34.04	19.88	<mdl	0.05	<mdl	0.09	46.18	100.55	0.330	0.334	0.336	Meng et al.,
	L-8B-5	0.08	<mdl	35.33	20.09	<mdl	<mdl	<mdl	0.18	46.68	102.36	0.336	0.331	0.333	2020
	L-8B-3	0.05	<mdl	34.93	19.59	<mdl	<mdl	0.01	0.56	46.62	101.75	0.336	0.335	0.329	
	LZK-6-1-2	0.04	0.01	34.22	19.53	<mdl	<mdl	<mdl	0.29	45.79	99.88	0.334	0.333	0.332	In this study
	Max	0.31	0.01	35.33	20.09	<mdl	0.05	0.01	0.98	46.68	102.36	0.336	0.340	0.336	

Min	0.04	<mdl	33.69	19.29	<mdl	<mdl	<mdl	0.09	45.79	99.88	0.330	0.331	0.329
Ave.	0.13	0.00	34.44	19.67	0.00	0.01	0.00	0.42	46.34	101.02	0.334	0.335	0.332
S.D.	0.11	0.00	0.67	0.31	0.00	0.02	0.00	0.36	0.36	1.00	0.003	0.003	0.003

Notes: <mdl – under minimum detection limit; S. D. – standard deviation; Fe*-Fe (at.%) in arsenopyrite; As*-As (at.%) in arsenopyrite; S*-S (at.%) in arsenopyrite.

Supplement Table S2. Compositions of gold in Laozuoshan gold deposit (Data from EPMA, wt.%)

Stage	Sample	Co	Ag	Fe	Bi	S	Au	Zn	Te	Cu	Sb	Ni	As	Total	Name	Date Source
Au-1	L-7B-4	-	15.08	0.10	-	0.16	82.49	<mdl	-	<mdl	-	<mdl	0.01	97.84	Electrum	Meng et al., 2020
	L-7B-13	-	14.90	0.76	-	0.23	81.53	<mdl	-	<mdl	-	<mdl	<mdl	97.42	Electrum	
	L-7D-3	-	14.54	0.34	-	0.27	86.93	<mdl	-	0.55	-	<mdl	<mdl	102.63	Electrum	
	L-7D-16	-	17.45	0.25	-	0.07	84.16	0.01	-	<mdl	-	<mdl	0.01	101.95	Electrum	
	LZS-7T-07	<mdl	14.37	0.06	0.73	<mdl	84.93	0.02	0.06	<mdl	<mdl	0.03	0.04	100.25	Electrum	In this study
	LZS-7T-03	<mdl	13.91	0.11	0.71	<mdl	87.04	0.14	0.13	<mdl	<mdl	<mdl	<mdl	102.05	Electrum	
	LZS-7T-11	0.04	15.11	0.04	0.57	<mdl	82.98	0.02	0.10	<mdl	<mdl	<mdl	<mdl	98.87	Electrum	
	L-7B-3	<mdl	14.11	0.10	0.83	<mdl	87.27	<mdl	0.01	<mdl	<mdl	<mdl	0.03	102.35	Electrum	
	L-7B-8	<mdl	14.02	0.12	0.80	<mdl	84.99	0.01	0.09	<mdl	<mdl	0.02	0.02	100.07	Electrum	
	L-7B-9	<mdl	13.67	0.39	0.61	<mdl	83.90	0.01	0.16	<mdl	<mdl	0.01	<mdl	98.74	Electrum	
	L-7B-10	-	13.73	0.25	-	0.04	83.89	0.01	-	<mdl	-	0.01	<mdl	97.93	Electrum	
	L-7D-2	<mdl	14.00	0.36	0.65	0.01	85.35	0.01	<mdl	<mdl	<mdl	<mdl	0.03	100.42	Electrum	
	L-7D-6	<mdl	15.71	0.21	0.83	0.01	84.38	0.03	0.04	<mdl	<mdl	<mdl	<mdl	101.21	Electrum	
	L-7D-11	0.01	32.10	0.28	0.64	0.04	68.57	0.04	0.32	0.42	<mdl	<mdl	<mdl	102.43	Electrum	
	Max	0.04	32.10	0.76	0.83	0.27	87.27	0.14	0.32	0.55	<mdl	0.03	0.04	102.63		
	Min	<mdl	13.67	0.04	0.57	<mdl	68.57	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	97.42		
	Everage	0.01	15.91	0.24	0.71	0.06	83.46	0.02	0.10	0.07	0.00	0.01	0.01	100.30		
	S.D.	0.01	4.77	0.19	0.10	0.09	4.60	0.04	0.10	0.18	0.00	0.01	0.01	1.87		
Au-2	LZS-3-6	-	7.73	0.10	-	<mdl	90.38	<mdl	-	<mdl	-	<mdl	<mdl	98.21	Native gold	Meng et al., 2020
	LZS-3-21	-	7.33	0.03	-	0.34	89.87	0.01	-	<mdl	-	<mdl	0.10	97.68	Electrum	
	LZS-3-22	-	9.01	0.19	-	0.09	90.45	0.01	-	<mdl	-	<mdl	0.05	99.80	Native gold	
	LZS-3-1-1	<mdl	8.12	0.06	0.72	<mdl	90.18	<mdl	0.05	<mdl	0.00	0.03	0.08	99.23	Native gold	In this study
	LZS-3-2	<mdl	7.97	0.07	0.71	0.03	91.42	<mdl	0.02	0.02	0.00	0.01	0.04	100.29	Native gold	

	Max	<mdl	9.01	0.19	0.72	0.34	91.42	0.01	0.05	0.02	0.00	0.03	0.10	100.29	
	Min	<mdl	7.33	0.03	0.71	<mdl	89.87	<mdl	0.02	<mdl	<mdl	<mdl	<mdl	97.68	
	Everage	0.00	8.03	0.09	0.71	0.09	90.46	0.00	0.04	0.00	0.00	0.01	0.05	99.04	
	S.D.	0.00	0.62	0.06	0.01	0.14	0.58	0.01	0.02	0.01	0.00	0.01	0.04	1.09	
Au-3	LZS-9T-07	0.22	0.61	1.67	0.71	0.01	98.43	0.01	<mdl	<mdl	0.01	0.07	0.05	101.79	Native gold
	LZS-9T-02	0.16	45.02	1.21	0.65	0.20	51.77	0.01	0.09	<mdl	<mdl	0.06	0.41	99.57	Electrum
	LZS-9T-04	0.15	42.62	1.90	0.42	0.04	55.58	<mdl	0.43	<mdl	<mdl	0.06	0.05	101.24	Electrum
	LZS-9T-10	0.15	19.14	0.99	0.49	0.06	78.69	0.03	0.19	<mdl	<mdl	0.02	0.02	99.79	Electrum
	LZS-9T-14	0.07	46.55	0.91	0.47	0.05	52.71	<mdl	0.04	<mdl	<mdl	0.06	0.07	100.94	Electrum
	LZS-9T-19	<mdl	38.72	0.09	0.48	<mdl	58.35	<mdl	0.42	<mdl	<mdl	<mdl	0.01	98.09	Electrum
	LZS-9T-27	0.06	33.90	0.96	0.43	0.04	62.00	0.09	0.35	<mdl	<mdl	0.09	0.04	97.95	Electrum
	LZS-9T-30	0.29	42.46	4.18	0.49	0.88	50.26	<mdl	0.37	<mdl	<mdl	0.14	1.88	100.92	Electrum
	LZS-9T-31	0.13	35.66	1.03	0.48	0.01	62.99	0.05	0.42	<mdl	<mdl	0.05	0.04	100.85	Electrum
	LZS-9T-33	0.09	46.12	0.69	0.33	0.05	50.23	0.01	0.45	<mdl	<mdl	0.01	0.10	98.07	Electrum
	Max	0.29	46.55	4.18	0.71	0.88	98.43	0.09	0.45	<mdl	0.01	0.14	1.88	101.79	
	Min	<mdl	0.61	0.09	0.33	<mdl	50.23	<mdl	<mdl	<mdl	<mdl	<mdl	0.01	97.95	
	Everage	0.13	35.08	1.36	0.50	0.13	62.10	0.02	0.27	0.00	0.00	0.06	0.27	99.92	
	S.D.	0.08	14.61	1.11	0.11	0.27	15.38	0.03	0.18	0.00	0.00	0.04	0.58	1.45	

In this study

Notes: <mdl – under minimum detection limit; S. D. – standard deviation; “-” – untested

Supplement Table S3. Compositions of the Bi-minerals in Laozuoshan gold deposit (Data from EPMA, wt.%)

Stage	Sample	Co	Ag	Fe	Bi	S	Au	Zn	Te	Sb	Se	Total	Chemical Formula	Name
Bi-Te-1	L-7D-4	0.11	<mdl	1.22	63.21	0.05	<mdl	<mdl	36.63	<mdl	0.17	101.39	Bi _{1.05} Te	Tsumoite
	LZS-7T-06	<mdl	0.02	0.06	67.95	<mdl	<mdl	0.03	30.13	<mdl	0.29	98.49	Bi _{1.38} Te	Pilsenite
	L-7B-11	<mdl	<mdl	0.23	67.69	0.03	0.05	<mdl	29.90	<mdl	0.03	97.92	Bi _{1.38} Te	Pilsenite
	LZS-7T-08	<mdl	<mdl	0.53	63.96	4.81	0.13	0.01	30.33	<mdl	0.23	100.00	Bi _{2.04} Te _{1.58} S	Ingodite
	LZS-7T-02	<mdl	<mdl	0.10	65.09	5.04	<mdl	<mdl	28.47	<mdl	0.49	99.20	Bi _{1.98} Te _{1.42} S	Ingodite
	LZS-7T-05	<mdl	<mdl	1.11	68.60	5.29	<mdl	0.56	25.37	<mdl	0.54	101.47	Bi _{1.99} Te _{1.20} S	Ingodite
	L-7B-2	<mdl	<mdl	0.20	66.85	5.05	0.02	0.02	25.50	<mdl	-	97.65	Bi _{2.03} Te _{1.27} S	Ingodite
	L-7B-6	<mdl	0.03	0.23	67.68	5.11	<mdl	0.03	24.99	<mdl	-	98.07	Bi _{2.03} Te _{1.23} S	Ingodite
	L-7B-10	<mdl	<mdl	0.60	69.96	4.05	<mdl	<mdl	21.37	<mdl	1.20	97.18	Bi _{2.65} Te _{1.33} S	Ingodite
	LZS-7T-12	0.01	<mdl	0.15	73.13	2.64	0.10	0.03	21.83	<mdl	0.40	98.27	Bi _{4.25} Te _{2.08} S	Joséite-B
	LZS-7T-01	<mdl	<mdl	0.29	73.04	2.58	<mdl	0.03	22.10	<mdl	0.56	98.60	Bi _{4.35} Te _{2.15} S	Joséite-B
	LZS-7T-04	<mdl	<mdl	0.62	75.25	2.70	<mdl	1.20	21.78	<mdl	0.56	102.10	Bi _{4.28} Te _{2.03} S	Joséite-B
	L-7B-5	0.01	<mdl	0.14	73.84	2.33	<mdl	0.03	21.05	<mdl	1.26	98.66	Bi _{4.86} Te _{2.27} S	Joséite-B
	L-7B-12	<mdl	0.03	0.11	74.98	2.46	0.14	<mdl	20.87	<mdl	1.10	99.69	Bi _{4.67} Te _{2.13} S	Joséite-B
	L-7B-14	<mdl	0.02	0.10	74.52	2.65	0.04	<mdl	21.91	<mdl	0.28	99.52	Bi _{4.32} Te _{2.08} S	Joséite-B
	L-7B-15	<mdl	<mdl	0.19	74.04	2.66	<mdl	<mdl	21.50	<mdl	0.45	98.84	Bi _{4.26} Te _{2.03} S	Joséite-B
	L-7D-3	<mdl	<mdl	0.13	74.51	2.63	0.10	<mdl	21.21	<mdl	0.50	99.08	Bi _{4.34} Te _{2.03} S	Joséite-B
	L-7D-1	<mdl	0.03	0.12	75.09	2.64	0.03	<mdl	21.77	<mdl	-	99.67	Bi _{4.36} Te _{2.07} S	Joséite-B
	L-7D-7	0.03	0.06	0.14	75.02	2.63	<mdl	<mdl	21.27	<mdl	0.76	99.90	Bi _{4.37} Te _{2.03} S	Joséite-B
	L-7D-8	0.02	0.01	0.21	75.48	2.76	0.07	0.03	21.59	<mdl	0.23	100.39	Bi _{4.20} Te _{1.97} S	Joséite-B
	L-7D-12	<mdl	<mdl	0.17	75.68	2.70	0.13	0.07	20.94	<mdl	0.66	100.35	Bi _{4.30} Te _{1.95} S	Joséite-B
	L-7D-10	<mdl	<mdl	0.49	99.96	0.04	<mdl	0.01	<mdl	0.01	0.00	100.52	Bi	Native Bismuth
Bi-Te-2	LZS-3-9	<mdl	0.01	0.08	33.32	<mdl	64.26	<mdl	<mdl	<mdl	<mdl	97.67	Au _{2.05} Bi	Maldonite
	LZS-3-1-14	0.01	<mdl	0.02	33.06	0.01	65.01	0.02	<mdl	0.02	-	98.14	Au _{2.09} Bi	Maldonite

	LZS-3-1-16	0.01	<mdl	0.68	77.35	0.03	0.02	<mdl	19.97	<mdl	-	98.05	Bi _{2.37} Te	Hedleyite
	LZS-3-4	<mdl	0.01	0.19	80.07	<mdl	<mdl	<mdl	18.58	<mdl	0.10	98.96	Bi _{2.63} Te	Hedleyite
	LZS-3-1	0.04	<mdl	0.17	96.78	<mdl	<mdl	<mdl	<mdl	0.98	<mdl	97.97	Bi	Native Bismuth
	LZS-3-12	<mdl	<mdl	0.11	97.84	<mdl	0.04	0.01	<mdl	1.13	<mdl	99.12	Bi	Native Bismuth
	LZS-3-7	<mdl	0.03	0.07	98.14	<mdl	<mdl	<mdl	<mdl	0.31	0.02	98.58	Bi	Native Bismuth
	LZS-3-1-13	<mdl	0.03	0.04	97.55	<mdl	0.09	0.02	<mdl	0.41	-	98.14	Bi	Native Bismuth
	LZS-3-1-4	0.04	<mdl	0.54	99.47	<mdl	0.01	<mdl	<mdl	0.94	-	100.98	Bi	Native Bismuth
Bi-Te-3	LZS-9T-12	0.30	0.28	2.16	34.32	0.04	65.17	0.04	<mdl	<mdl	0.13	102.44	Au _{2.01} Bi	Maldonite
	LZS-9T-34	0.10	0.18	1.47	65.57	0.01	0.06	0.03	32.48	<mdl	0.14	100.05	Bi _{1.23} Te	Pilsenite
	LZS-9T-23	0.18	<mdl	0.85	75.34	2.50	<mdl	<mdl	19.41	<mdl	1.58	99.86	Bi _{4.62} Te _{1.95} S	Joséite-B
	LZS-9T-24	0.11	0.06	0.70	75.38	2.52	0.08	<mdl	19.15	<mdl	1.37	99.38	Bi _{4.60} Te _{1.91} S	Joséite-B
	LZS-9T-01	0.16	0.01	0.85	75.90	2.28	0.07	0.01	17.91	<mdl	2.82	99.99	Bi _{5.12} Te _{1.98} S	Joséite-B
	LZS-9T-15	0.02	<mdl	0.58	80.52	5.70	0.06	0.02	11.39	<mdl	0.73	99.01	Bi _{4.31} TeS _{1.99}	Joséite-A
	LZS-9T-13	0.11	0.09	0.60	97.01	<mdl	0.05	0.07	<mdl	0.02	<mdl	97.95	Bi	Native Bismuth
	LZS-9T-18	<mdl	0.07	0.34	99.84	<mdl	0.04	0.03	<mdl	0.09	0.02	100.43	Bi	Native Bismuth
	LZS-9T-29	0.19	0.01	2.22	99.86	0.02	<mdl	<mdl	<mdl	<mdl	<mdl	102.30	Bi	Native Bismuth
	LZS-9T-16	0.10	0.02	0.89	100.27	<mdl	<mdl	<mdl	<mdl	0.04	<mdl	101.33	Bi	Native Bismuth

Notes: <mdl – under minimum detection limit; “-” – untested