From “Mineralogy and Geochemistry of Turquoise from Tianhu East, Xinjiang, China”
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APPENDIX 1

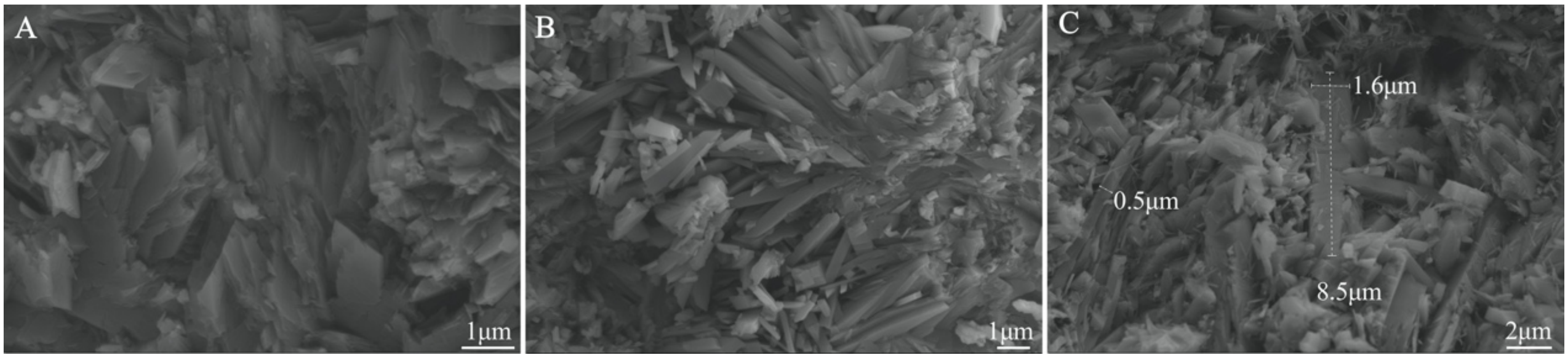

Figure S-1. Various microstructures of Tianhu East turquoise observed by FESEM. A: Platy microcrystals. B: Long columnar microcrystals stacked radially. C: Tiny columnar microcrystals attached to larger columnar ones.

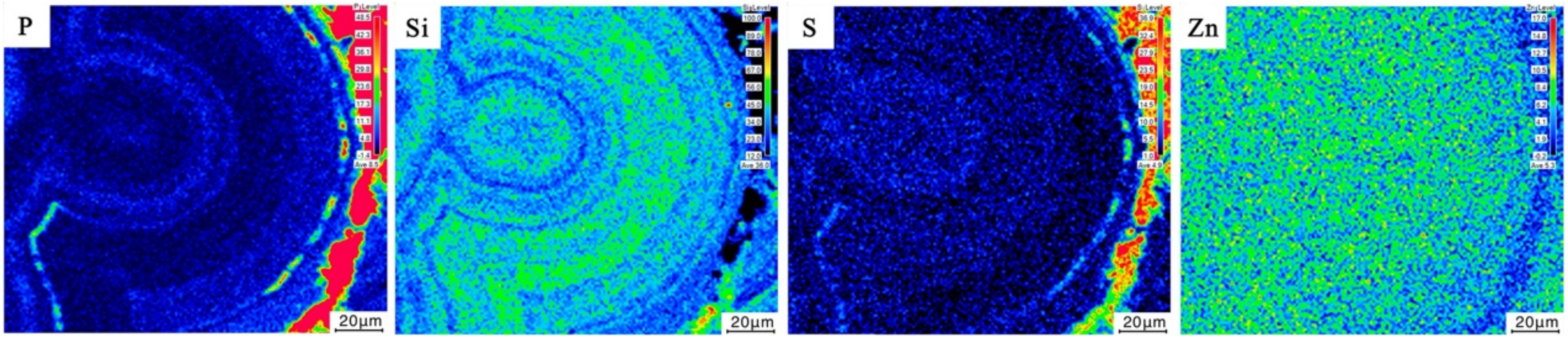

Figure S-2. Goethite showed distinct oscillatory zonings in BSE images, and EPMA element mapping revealed variations in phosphorus, silicon, sulfur, and zinc contents. Images by Ling Liu.

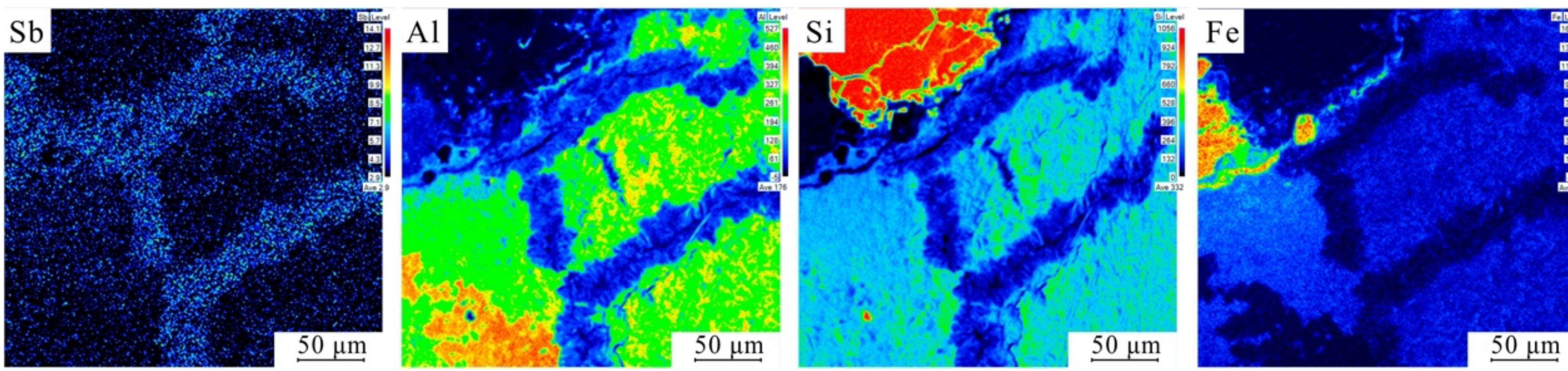

Figure S-3. EPMA element mapping of the antimony, aluminum, silicon, and iron contents distributed in the apatite's vermicular form. Images by Ling Liu.

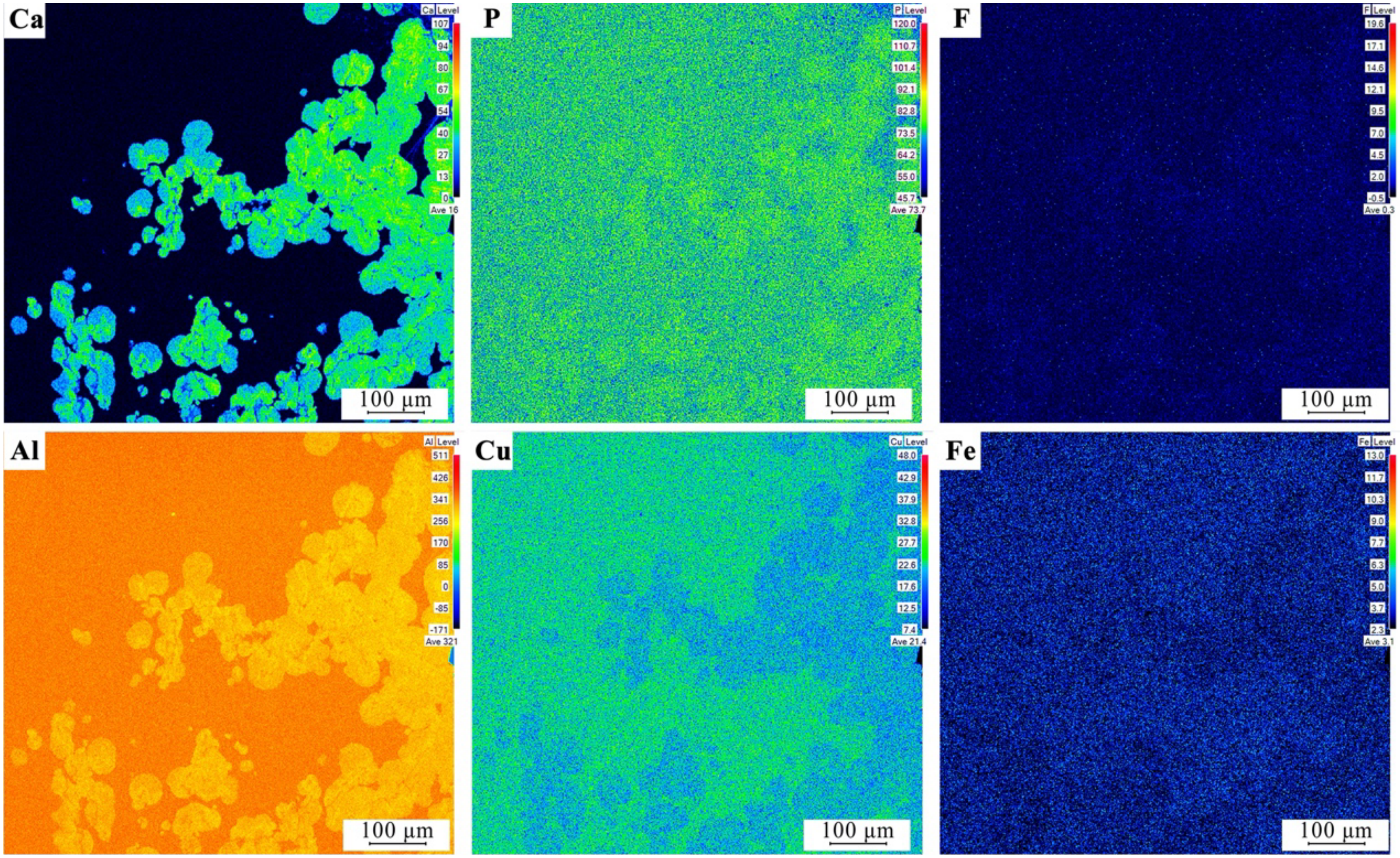

Figure S-4. EPMA element mapping results show variations in the contents of calcium, phosphorus, fluorine, aluminum, copper, and iron between the turquoise portion and the round inclusions. Images by Ling Liu.

Table S-1. Chemical composition (in wt.%) of Tianhu East turquoise, analyzed by EPMA.

	HM001	HM002	HM003	HM004	HM005	HM006	HM007	HM008	HM009	HM010[a]	HM011	HM012	HM013	HM014	HM015	HM016	HM017	HM018	HM019	HM020	HM021	HM022	Detection limit
P_2O_5	34.40	35.29	35.38	35.28	34.26	36.54	36.20	36.29	35.54	34.96	34.64	35.81	35.71	34.77	36.05	34.77	35.59	35.23	34.37	34.42	33.67	30.74	0.044
SiO_2	bdl[b]	0.03	0.06	0.04	1.80	0.13	0.29	0.12	0.16	0.18	0.24	bdl	bdl	bdl	0.03	0.15	0.49	0.63	1.03	1.23	2.30	5.65	0.031
CuO	7.86	8.74	6.37	6.65	7.14	8.02	7.92	7.14	7.57	8.56	7.86	8.26	7.88	8.16	7.91	7.41	8.22	7.36	7.84	7.27	7.79	7.41	0.049
ZnO	0.13	bdl	0.53	0.56	0.19	0.09	0.18	0.27	0.12	0.13	0.13	0.33	0.28	0.32	0.25	0.21	bdl	bdl	0.07	0.14	0.15	0.08	0.061
CaO	0.08	0.05	0.06	0.09	0.10	0.14	0.20	0.14	0.11	0.08	0.08	0.16	0.16	0.09	0.14	0.11	0.10	0.07	0.09	0.09	0.28	0.38	0.018
Na_2O	0.16	0.10	0.10	0.12	0.15	0.15	0.14	0.24	0.15	0.07	0.14	0.16	0.11	0.14	0.16	0.21	0.18	0.15	0.15	0.17	0.29	0.52	0.020
K_2O	0.05	0.06	0.04	0.03	0.04	0.04	0.06	0.07	0.04	0.04	0.06	0.04	0.04	bdl	0.05	0.04	0.07	0.07	0.09	0.07	0.11	0.23	0.013
Al_2O_3	37.62	37.01	36.60	36.94	37.57	37.32	37.43	36.68	36.39	36.93	36.10	37.43	37.55	37.09	37.14	36.73	36.92	36.39	36.75	36.11	35.02	32.68	0.021
FeO[c]	1.60	2.65	2.31	2.14	0.76	1.87	2.03	2.91	1.52	1.57	1.83	1.66	1.96	2.88	1.80	1.87	2.17	2.12	2.52	2.65	4.06	5.67	0.037
H_2O[d]	18.09	16.03	18.57	18.15	17.98	15.70	15.55	16.14	18.41	17.49	18.92	16.14	16.31	16.53	16.48	18.51	16.21	17.97	17.09	17.86	16.33	16.63	—
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	—
Formula 16(O)+8 (OH)																							
P^{5+}	3.9449	3.9747	4.0746	4.0498	3.8938	4.0813	4.0408	4.0809	4.0872	3.9977	4.0262	4.0261	4.0206	3.9392	4.0685	4.0096	4.0056	4.0372	3.9015	3.9455	3.8129	3.5176	—
Si^{4+}	bdl	0.0039	0.0079	0.006	0.242	0.0168	0.0386	0.0157	0.0212	0.0243	0.0335	bdl	bdl	bdl	0.0041	0.0199	0.0654	0.0853	0.1377	0.166	0.3079	0.7641	—
Cu^{2+}	0.8039	0.878	0.6547	0.6812	0.7236	0.799	0.789	0.7168	0.7764	0.8735	0.815	0.8284	0.7913	0.8253	0.796	0.7623	0.8257	0.752	0.7942	0.743	0.7867	0.7564	—
Zn^{2+}	0.013	bdl	0.0527	0.0556	0.0192	0.0088	0.017	0.0262	0.0118	0.0128	0.0135	0.0323	0.0273	0.0313	0.0242	0.0209	bdl	bdl	0.0064	0.0141	0.0149	0.0076	—
Ca^{2+}	0.0109	0.0064	0.0087	0.0126	0.0147	0.0194	0.0277	0.0196	0.0159	0.0117	0.0119	0.0225	0.0224	0.0123	0.0204	0.0153	0.0147	0.0106	0.0135	0.0136	0.0396	0.0552	—
Na^{+}	0.0418	0.0266	0.0259	0.0302	0.0377	0.0394	0.0368	0.0618	0.0395	0.017	0.0381	0.0409	0.0284	0.0353	0.0414	0.0547	0.0461	0.0381	0.0398	0.0449	0.0747	0.1368	—
K^{+}	0.0088	0.0102	0.0069	0.0055	0.0074	0.0071	0.0094	0.012	0.0071	0.0071	0.0098	0.0059	0.0064	bdl	0.0085	0.0076	0.0124	0.0117	0.0151	0.0116	0.0189	0.0391	—
Al^{3+}	6.0049	5.8041	5.8683	5.9022	5.9439	5.8041	5.817	5.7432	5.8264	5.8783	5.8421	5.8575	5.8853	5.8495	5.8363	5.8967	5.7846	5.8055	5.8089	5.7614	5.5215	5.2059	—
Fe^{2+}[e]	0	0	0.2627	0.2428	0.0854	0.2068	0.194	0.2671	0.1726	0.0735	0.1498	0.0769	0.1314	0	0.2006	0.1159	0.1145	0.2395	0.0169	0.1733	0	0	—
Fe^{3+}[e]	0.181	0.2948	0	0	0	0	0.0296	0.0566	0	0.1041	0.0601	0.1077	0.0863	0.3226	0	0.0971	0.1262	0	0.266	0.1267	0.4544	0.6411	—

[a]Chemical formula of sample HM010: $(Cu_{0.8735}Zn_{0.0128}Fe_{0.0735}Ca_{0.0117}Na_{0.017}K_{0.0071})_{\Sigma=0.9956}(Al_{5.8783}Fe_{0.1041})_{\Sigma=5.9824}(P_{3.9977}Si_{0.0243})_{\Sigma=4.0220}O_{16}(OH)_8\bullet 4H_2O$

[b]bdl = below detection limit

[c]All iron was analyzed as FeO by EPMA.

[d]H_2O was calculated by the difference from 100%.

[e]Fe^{2+} and Fe^{3+} recalculated from total FeO after electrovalent difference method and assigned using ideal formula cations (11).

Table S-2. EPMA analysis (in wt.%) of atacamite and mixtures of turquoise and apatite.

	Atacamite (3 spots)			Turquoise + apatite (2 spots)		Detection limit
				Transparent portion	Opaque portion	
Al_2O_3	bdl[a]	bdl	bdl	31.00	32.95	0.021
SiO_2	bdl	bdl	bdl	0.37	0.23	0.031
CaO	bdl	bdl	bdl	8.09	5.43	0.018
P_2O_5	bdl	bdl	bdl	34.21	35.51	0.040
F	—	—	—	0.91	0.46	0.152
Na_2O	bdl	bdl	bdl	0.22	0.14	0.019
CuO	71.59	71.17	70.68	6.73	7.18	0.064
FeO[b]	bdl	bdl	bdl	0.66	0.76	0.032
TiO_2	—	—	—	0.23	0.18	0.031
Cr_2O_3	—	—	—	0.36	0.39	0.046
Cl	12.84	12.99	12.92	—	—	0.006
H_2O[c]	15.57	15.84	16.40	17.22	16.78	—
Total	100	100	100	100	100	—

[a]bdl = below detection limit

[b]All iron was analyzed as FeO by EPMA. Spots 1, 2, and 3 of atacamite were analyzed in different locations.

[c]H_2O was calculated by the difference from 100%.

Table S-3. Chemical analysis (in wt.%) of minor minerals in Tianhu East turquoise, obtained by EPMA-EDS.

	Apatite (2 spots)		**Svanbergite**	**Apatite + svanbergite**	**Turquoise + svanbergite**	**Turquoise + apatite + svanbergite**	**Jarosite + turquoise**	
Na_2O	bdl[a]	1.86	bdl	bdl	bdl	bdl	bdl	bdl
Al_2O_3	0.32	bdl	42.17	11.59	36.93	35.66	25.7	27.1
SiO_2	bdl	bdl	bdl	1.21	4.84	2.64	bdl	bdl
P_2O_5	33.14	32.17	26.23	32.06	25.09	25.88	21.61	24.8
SO_3	3.93	3.65	8.11	3.94	4.01	4.8	15.95	14.06
K_2O	bdl	bdl	bdl	bdl	bdl	bdl	4.49	3.65
CaO	62.61	60.77	10.95	45.38	7.48	9.21	0.85	0.39
V_2O_5	bdl	bdl	0.67	bdl	bdl	bdl	0.58	bdl
Cr_2O_3	bdl	bdl	bdl	bdl	bdl	bdl	0.51	bdl
FeO	bdl	1.55	1.75	0.53	0.97	0.67	24.93	22.69
CuO	bdl	bdl	bdl	0.96	5.15	4.67	5.38	7.3
SrO	bdl	bdl	10.12	4.33	15.53	16.46	bdl	bdl
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

[a]bdl = below detection limit. Detection limits: 0.1–0.5 wt.%.

Table S-4. Chemical compositions (in wt.%) of apatite, mica, and pyrite in black shale at Tianhu East, analyzed by EPMA.

	Ap-1	Ap-2	Detection limit		Mca-1	Mca-2	Detection limit		Py-1	Detection limit
P_2O_5	41.023	41.154	0.0401	K_2O	10.956	10.399	0.0137	Ga	bdl[a]	0.0643
CaO	55.477	55.104	0.0196	CaO	0.024	bdl	0.0192	Cu	0.013	0.0402
SrO	bdl	bdl	0.0704	FeO[b]	0.617	0.609	0.0336	Sb	bdl	0.0296
FeO	bdl	bdl	0.0376	SiO_2	49.48	49.416	0.0302	In	bdl	0.0266
Na_2O	bdl	0.048	0.0166	Al_2O_3	30.609	31.213	0.0193	Cd	bdl	0.0244
MgO	bdl	0.033	0.0206	MgO	3.067	3.36	0.0192	Bi	bdl	0.0542
F	3.433	3.446	0.1251	Na_2O	0.063	0.079	0.0148	S	53.06	0.0056
SiO_2	0.176	0.18	0.0317	F	bdl	bdl	0.0978	Pb	bdl	0.0344
Cl	0.005	0.01	0.0046	TiO_2	0.222	0.307	0.0387	Fe	46.91	0.0207
SO_3	bdl	bdl	0.0270	Cr_2O_3	0.035	0.103	0.0029	Co	0.082	0.0216
MnO	0.069	0.07	0.0262	Cl	bdl	0.011	0.0039	Ni	bdl	0.0260
Ce_2O_3	0.095	bdl	0.0522	MnO	0.059	bdl	0.0241	Zn	bdl	0.0422
Total	100.281	100.069	—	Total	95.146	95.611	—	Total	100.2	—

[a]bdl = below detection limit

[b]All iron was analyzed as FeO by EPMA.