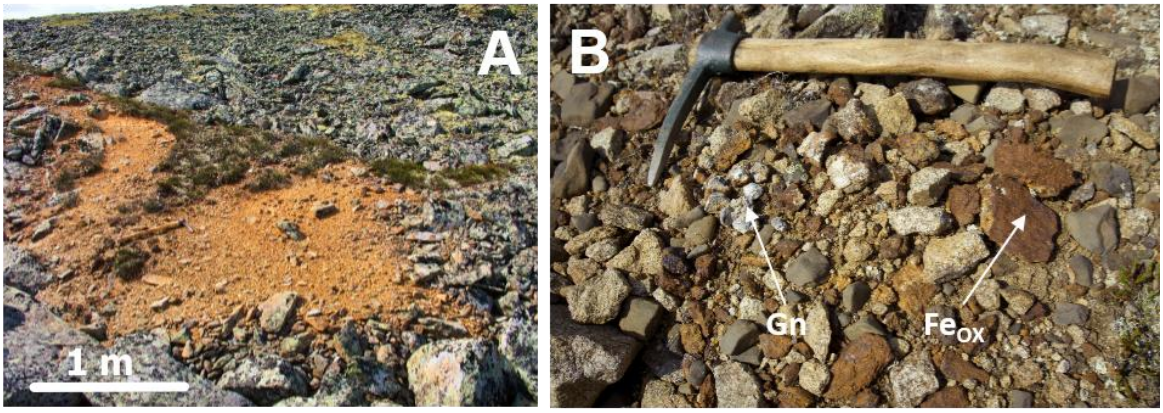
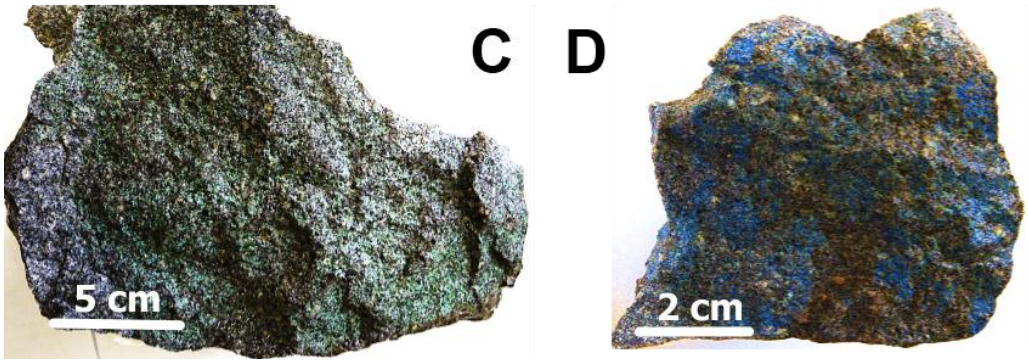
Supplement 1.1-1.5

The Kis-Kuel Fe-Cu-Au±(Ag, Mo, Bi) deposit, Eastern Yakutia (Russia) – a link between Iron Oxide Copper-Gold and Intrusion Related Gold systems

Aleksey V. Kostin

Supplement 1.1 Prospecting features for IOCG-style ore mineralization at the Kis-Kuel plato. A - Bright-red permafrost heaving in granodiorites with crushed pieces of led-silver ore (grab sample 6259: Cu-0.012%; Pb-23.1%; Zn-1.76%; Ag-3680 g/t). B - Bright brown permafrost heaving in granodiorites with pieces of oxidized galena and IOCG ore. C and D – malachite and azurite in thin fractures in diorites, located near IOCG ores.





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Supplement 1.2 Representative analyses of diorites and granodiorites from the Kis-Kuel intrusive.

Sample	6224	6231	6268	6269	6270	6271	6281	6282
Majorelements (wt %)								
SiO_2	59.59	58.04	57.91	58.5	58.21	59.1	58.26	55.85
TiO_2	0.85	0.9	1.04	0.92	0.89	1.01	0.95	1.1
Al_2O_3	17.17	17.54	17.17	17.03	16.75	16.56	17.26	18.37
Fe_2O_3	0.83	0.6	1.12	0.94	0.79	0.65	0.56	0.7
FeO	4.99	5.3	5.51	5.07	5.36	5.49	5.64	6.11
MnO	0.1	0.11	0.1	0.11	0.11	0.12	0.13	0.14
MgO	3.72	3.79	4.29	4.27	4.56	3.99	3.92	5.17
CaO	5.61	6.42	6.59	6.11	6.34	6.14	6.25	6.82
Na_2O	3.57	3.72	3.18	3.18	3.22	3.09	3.01	2.94
K_2O	2.75	2.38	1.99	2.25	2.33	2.34	2.2	1.81
H_2O^-	0.18	0.18	0.1	0.1	0.18	0.24	0.14	0.14
H_2O^+	0	0.12	0.25	0.18	0.37	0.46	0.49	0.34
LOI	0.69	0.79	0.49	0.64	0.48	0.67	0.47	0.28
P_2O_5	0.16	0.17	0.18	0.17	0.17	0.25	0.22	0.27
S	0.08	0.02	0.05	0.05	0.01	0.02	0	0
F	0.16	0.11	0.15	0.2	0.13	0.11	0.09	0.08
Trace elements (ppm)								
Rb	58.17	48.63	36.85	55.61	50.44	53.29	47.97	40.89
Sr	565.36	612.12	618.51	632.58	658.17	593.74	679.75	719.85
Y	24.37	21.95	21.66	22.67	20.82	21.28	24.20	23.05
Zr	30.54	25.33	37.30	30.95	51.33	33.72	39.72	27.50
Nb	15.09	13.86	14.16	14.16	14.11	14.90	13.44	15.42
Cs	1.31	1.25	0.66	1.23	1.13	1.03	0.98	1.11
Ba	768.34	679.85	749.27	790.65	729.12	791.59	744.96	657.08
La	39.82	34.17	35.39	44.38	45.50	46.62	35.29	33.36
Ce	74.64	67.03	68.08	82.60	87.91	88.64	66.07	68.47
Pr	8.96	7.80	8.01	9.58	9.74	9.70	7.90	7.72
Nd	33.43	31.71	31.44	36.03	36.24	36.68	32.97	31.39
Sm	6.12	4.65	5.93	5.95	5.90	6.67	5.85	6.17
Eu	1.35	1.45	1.35	1.45	1.49	1.57	1.50	1.69
Gd	5.90	5.33	5.51	5.88	5.75	5.70	5.83	5.70
Tb	0.80	0.70	0.76	0.77	0.69	0.76	0.76	0.77
Dy	4.47	4.09	4.07	4.29	4.24	4.14	4.68	4.70
Ho	0.91	0.83	0.83	0.83	0.76	0.76	0.86	0.86
Er	2.64	2.31	2.24	2.44	2.23	2.36	2.46	2.40
Tm	0.37	0.30	0.28	0.31	0.33	0.31	0.32	0.32
Yb	2.28	2.06	2.14	2.13	2.04	1.83	2.35	2.18
Lu	0.37	0.29	0.29	0.30	0.28	0.30	0.34	0.29

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Hf	0.89	0.77	1.13	1.03	1.26	1.00	1.31	0.88
Ta	0.61	0.57	0.63	0.66	0.61	0.62	0.60	0.62
Th	8.99	6.73	6.10	9.18	8.47	9.01	7.53	6.88
U	1.36	1.17	1.00	1.34	1.48	1.16	1.18	1.33
ΣREE	182.05	162.73	166.31	196.93	203.10	206.04	167.18	166.01
Eu/Eu*	0.69	0.89	0.72	0.75	0.78	0.78	0.79	0.87
Zr/Hf	34.51	32.83	32.88	30.03	40.88	33.80	30.42	31.13
Y/Ho	26.78	26.50	26.16	27.41	27.33	27.94	28.00	26.88

Sample	6283	6290	6291	6303	6206	6207	6208	6232
Major elements (wt %)								
SiO_2	59.06	60.86	57.61	59.69	66.73	68.09	67.84	67.89
TiO_2	0.91	0.88	1.04	0.91	0.53	0.5	0.48	0.5
Al_2O_3	16.87	16.83	17.09	17.09	15.66	15.49	15.18	15.49
Fe_2O_3	0	0.56	1.08	0.56	0.41	0.23	0.28	0.5
FeO	5.5	4.76	5.23	5.21	2.46	2.34	2.82	2.51
MnO	0.12	0.11	0.13	0.13	0.04	0.05	0.06	0.04
MgO	3.63	3.3	4.78	3.53	1.74	1.59	1.73	1.68
CaO	6.22	5.58	6.2	6.06	2.96	3.27	2.85	2.88
Na_2O	3.28	3.56	3.02	3.17	3.09	2.95	3.11	3.07
K_2O	2.32	2.39	2.46	2.32	4.62	4.5	4.3	4.57
H_2O^-	0.04	0.12	0.1	0.12	0.24	0.28	0.19	0.28
H_2O^+	0.48	0.21	0	0.23	0.57	0.28	0.59	0.52
LOI	0.83	0.68	0.78	0.43	0.42	0.68	0.21	0.39
P_2O_5	0.24	0.24	0.21	0.24	0.11	0.12	0.11	0.1
S	0.03	0.02	0.03	0	0.04	0.01	0.01	0.04
F	0.1	0.14	0.2	0.14	0.15	0.13	0.15	0.15
Trace elements (ppm)								
Rb	45.06	60.91	62.13	55.59	105.24	103.75	110.39	107.09
Sr	752.66	632.13	717.85	685.02	595.62	579.05	456.35	447.11
Y	21.02	20.21	24.74	22.28	27.18	31.49	30.20	21.53
Zr	54.58	21.01	27.55	24.17	48.85	52.46	54.28	49.88
Nb	15.33	17.94	18.63	15.76	22.06	21.75	19.31	22.73
Cs	1.28	1.39	1.75	1.29	2.14	1.40	1.66	1.73
Ba	774.54	713.05	971.57	717.84	1048.72	960.44	907.82	891.43
La	35.78	35.37	39.21	36.50	84.59	95.05	79.92	51.75
Ce	69.65	76.73	83.67	75.15	159.35	176.33	119.41	97.88
Pr	8.10	8.71	9.89	8.63	18.35	18.55	15.15	10.61
Nd	34.07	33.25	39.87	33.83	66.61	64.32	57.52	39.24
Sm	6.03	5.78	7.10	5.95	9.87	9.61	8.47	6.27
Eu	1.69	1.61	1.87	1.81	1.44	1.43	1.15	1.08

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Gd	5.40	5.30	6.51	5.64	8.47	8.88	7.60	5.94
Tb	0.75	0.75	0.85	0.77	1.08	0.99	0.96	0.76
Dy	4.49	4.54	5.39	4.84	5.78	5.72	5.43	4.26
Ho	0.82	0.81	0.97	0.84	1.01	1.11	1.09	0.81
Er	2.10	1.91	2.53	2.40	2.89	3.02	2.87	2.24
Tm	0.30	0.27	0.34	0.33	0.40	0.39	0.42	0.32
Yb	2.00	1.85	2.38	2.27	2.77	2.98	2.76	2.07
Lu	0.28	0.27	0.32	0.34	0.38	0.42	0.41	0.29
Hf	1.60	0.74	1.02	0.90	1.69	1.52	1.76	1.71
Ta	0.69	0.79	0.84	0.72	1.28	1.22	1.10	1.21
Th	7.03	8.64	8.66	7.46	25.07	29.73	22.82	22.97
U	1.04	1.26	1.85	1.36	3.46	2.66	2.72	2.60
ΣREE	171.46	177.13	200.90	179.32	362.97	388.80	303.15	223.52
Eu/Eu*	0.90	0.89	0.84	0.96	0.48	0.47	0.44	0.54
Zr/Hf	34.02	28.33	27.11	26.93	28.88	34.52	30.88	29.16
Y/Ho	25.55	24.84	25.52	26.39	26.87	28.29	27.77	26.68

Sample	6233	6259	6261	6262	6263	6265	6266	6267
Major elements (wt %)								
SiO_2	66.98	65.04	66.41	67.97	65.41	67.86	65.31	66.96
TiO_2	0.54	0.6	0.58	0.53	0.64	0.49	0.53	0.63
Al_2O_3	15.47	15.9	15.47	14.89	15.81	15.35	15	15.52
Fe_2O_3	0.68	0.93	0.59	0	0.73	0.2	0.79	0.44
FeO	2.75	2.84	2.89	3.2	3.07	2.79	3.01	3.12
MnO	0.03	0.08	0.05	0.06	0.06	0.07	0.04	0.08
MgO	1.62	2.12	1.81	1.63	2.21	1.62	1.45	1.53
CaO	3.09	3.5	3.18	3.21	3.46	3.02	2.93	3.67
Na_2O	3.19	3.54	3.72	2.79	3.19	3.07	2.64	2.95
K_2O	4.5	3.84	4.51	3.87	3.87	4.34	4.97	3.79
H_2O^-	0.16	0.22	0.1	0.1	0.12	0.22	0.14	0.14
H_2O^+	0.02	0.1	0.59	0.19	0.29	0	1.62	0.52
LOI	0.95	0.72	0.29	0.71	0.55	0.47	0.55	0.41
P_2O_5	0.13	0.13	0.1	0.2	0.12	0.1	0.1	0.21
S	0.08	0.03	0.03	0	0.04	0.07	0.1	0
F	0.15	0.15	0.15	0.11	0.17	0.16	0.15	0.12
Trace elements (ppm)								
Rb	96.52	90.26	92.92	114.75	92.66	105.14	114.37	93.53
Sr	465.32	548.41	497.55	439.57	602.50	434.70	404.60	590.12
Y	22.74	23.85	24.48	25.21	26.93	24.73	21.37	23.05
Zr	33.39	26.20	37.53	57.44	40.90	48.42	52.20	37.93
Nb	19.47	19.05	18.97	21.19	20.51	19.81	17.48	19.73

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Cs	1.84	1.95	1.63	1.89	1.35	1.74	2.00	1.53
Ba	869.17	977.45	948.55	952.83	953.19	793.54	779.47	955.23
La	57.23	62.91	61.16	60.88	60.97	67.13	60.23	61.23
Ce	109.49	114.46	117.28	114.46	119.36	128.30	111.60	119.84
Pr	12.21	12.61	12.98	12.90	13.36	14.40	12.32	12.98
Nd	43.06	46.50	47.99	45.40	49.16	51.67	44.98	46.94
Sm	7.00	7.31	7.27	7.55	7.99	7.71	7.13	7.67
Eu	1.10	1.33	1.05	1.10	1.36	1.12	1.00	1.40
Gd	6.19	7.38	6.31	6.84	6.88	7.14	6.30	6.67
Tb	0.82	0.93	0.87	0.90	0.92	0.91	0.77	0.88
Dy	4.43	4.59	4.65	4.81	5.22	4.66	4.28	4.81
Ho	0.82	0.91	0.91	0.92	0.99	0.97	0.85	0.90
Er	2.47	2.46	2.61	2.71	2.74	2.55	2.37	2.40
Tm	0.32	0.33	0.33	0.37	0.38	0.35	0.30	0.33
Yb	2.19	2.27	2.38	2.50	2.54	2.53	2.16	2.15
Lu	0.33	0.33	0.35	0.35	0.35	0.34	0.29	0.32
Hf	1.20	0.97	1.34	1.82	1.56	1.70	1.78	1.37
Ta	1.00	0.93	0.99	1.16	1.08	1.11	0.96	0.99
Th	18.75	15.50	19.08	22.75	18.18	24.37	24.01	17.58
U	2.64	2.20	2.47	3.56	1.76	1.45	3.52	1.92
ΣREE	247.68	264.31	266.14	261.69	272.23	289.77	254.57	268.51
Eu/Eu*	0.51	0.56	0.47	0.47	0.56	0.46	0.46	0.60
Zr/Hf	27.94	27.02	28.07	31.64	26.19	28.40	29.33	27.64
Y/Ho	27.61	26.10	27.02	27.44	27.24	25.44	25.18	25.59

Sample	6272	6278	6279	6286	6292
Major elements (wt %)					
SiO_2	66.2	66.36	67.42	67.54	67.06
TiO_2	0.62	0.62	0.62	0.52	0.52
Al_2O_3	15.29	15.47	15.48	15.69	15.26
Fe_2O_3	0	0.24	1.08	1.08	0.83
FeO	3.79	3.25	2.91	2.55	2.4
MnO	0.08	0.07	0.06	0.05	0.05
MgO	1.78	1.74	2.25	2.08	2.02
CaO	3.22	3.57	3.33	3.02	3.13
Na_2O	3.22	3.06	2.55	2.32	3.01
K_2O	4.18	3.6	3	3.32	4.11
H_2O^-	0.18	0.1	0.18	0.22	0.2
H_2O^+	0.4	0.51	0.38	0.57	0.65
LOI	0.6	0.46	0.39	0.46	0.15
P_2O_5	0.21	0.21	0.11	0.11	0.04

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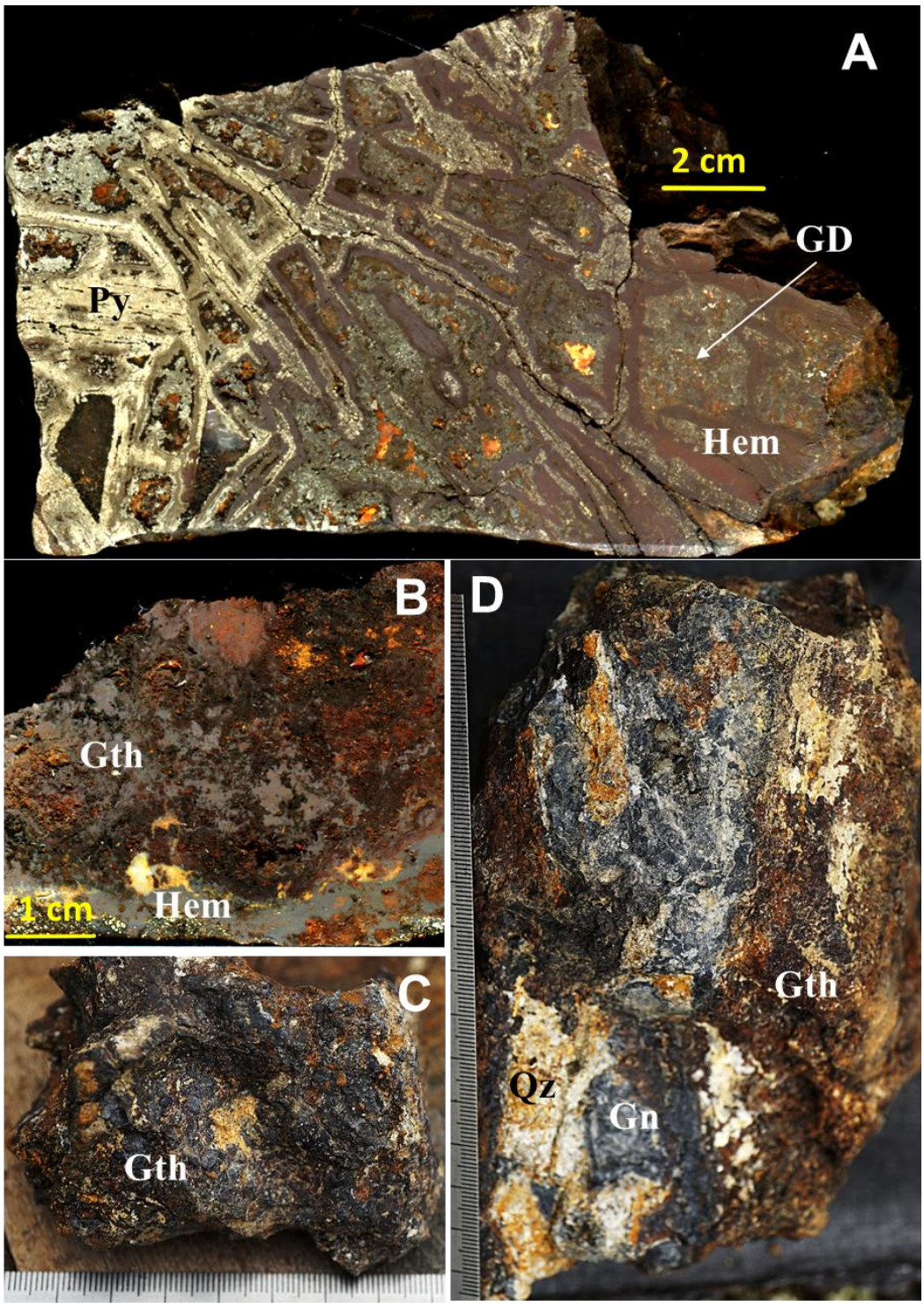
S	0	0	0.04	0.03	0.09
F	0.13	0.12	0.16	0.17	0.16
Trace elements (ppm)					
Rb	108.72	94.67	99.21	110.51	47.35
Sr	466.44	638.76	573.34	533.66	890.43
Y	26.45	23.21	29.61	26.26	10.67
Zr	44.38	31.63	54.76	50.85	178.32
Nb	21.56	19.58	21.69	22.92	8.68
Cs	1.91	1.72	1.48	1.63	3.84
Ba	1008.77	920.35	978.96	970.64	170.05
La	65.88	61.28	63.90	65.71	53.02
Ce	120.30	121.59	116.77	125.14	107.62
Pr	13.14	13.71	13.05	13.52	12.12
Nd	47.97	47.70	50.83	48.95	45.73
Sm	7.84	7.90	8.47	8.16	7.00
Eu	1.27	1.40	1.46	1.36	2.16
Gd	7.01	6.69	7.57	7.11	4.73
Tb	0.93	0.87	0.99	0.91	0.51
Dy	4.82	5.08	5.69	5.26	2.23
Ho	0.92	0.86	1.09	0.92	0.40
Er	2.67	2.30	3.12	2.75	1.17
Tm	0.37	0.33	0.42	0.38	0.17
Yb	2.45	2.18	2.88	2.54	1.29
Lu	0.37	0.28	0.39	0.35	0.21
Hf	1.31	1.20	1.83	1.68	4.15
Ta	1.13	0.95	1.25	1.19	0.29
Th	23.32	20.26	24.97	22.61	13.16
U	3.38	2.91	3.02	2.93	9.84
ΣREE	275.94	272.18	276.63	283.06	238.37
Eu/Eu*	0.52	0.59	0.56	0.55	1.15
Zr/Hf	33.89	26.33	29.87	30.33	42.97
Y/Ho	28.79	26.93	27.24	28.43	26.86

LOI – Loss On Ignition

https://doi.org/10.21638/spbu07.2019.401

Supplement 1.3 Main types of Iron Oxide ores of KKBC. A – Sample 88113-B: breccia of granodiorite with hematite-pyrite cement, grades FeOtot- 50.8%, Cu –0.094%, Au 37.17g/t.B – Sample 88074: hematite-goethite cement of KKBC, grades FeOtot– 40.22%, Cu – 0.048%, Au – 31.61 g/t. C – Sample 88094: goethite-quartz cement of KKBC, grades FeOtot %, Cu %, Au – 15.84 g/t. D – Sample SR-010: galena in IOCG surrounding, grades Ag 1474 g/t, Pb– 71.5%; Quartz-IOCG ore – FeOtot – 21.0%, Cu – 0.004%, Au – 20.03 g/t (Hem – Hematite, Gth – Goethite, Py – Pyrite, Gn – Galena, Qz – Quartz, GD – Granodiorite).



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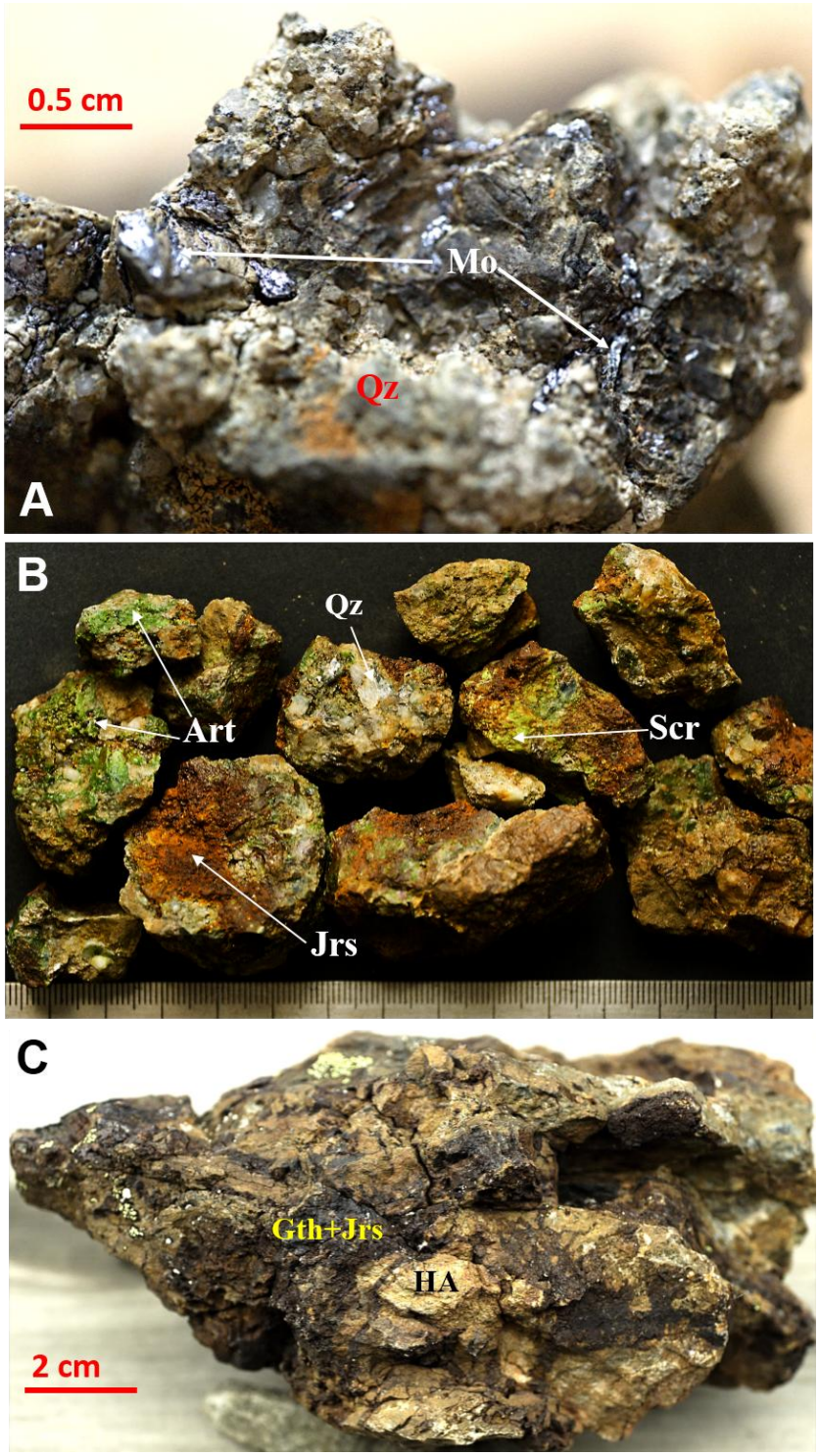
Supplement 1.4 Main types of Cu-Au-porphyry ore of KKBC. A – Sample 88100: quartz-molybdenite vein in Cu-Au-porphyry ore. B – Sample 88049: Cu-Au-porphyry ore – oxidized pieces from permafrost heavings in granodiorites, grades FeOtot – 33.42%, Cu – 3.57%, Ag – 329 g/t, Au – 64.48 g/t. C – Sample 88062: Breccia in hornfelse aureole of intrusive rocks, grades FeOtot – 24.86%, Ag – 38 g/t, Au – 23.46 g/t. (Mo – Molybdenite, Qz – Quartz, Art –Arthurite, Scr –Scorodite, Jrs – Jarosite,Gth+Jrs–Goethite+Jarosite, HA – Hornfelse aureole).



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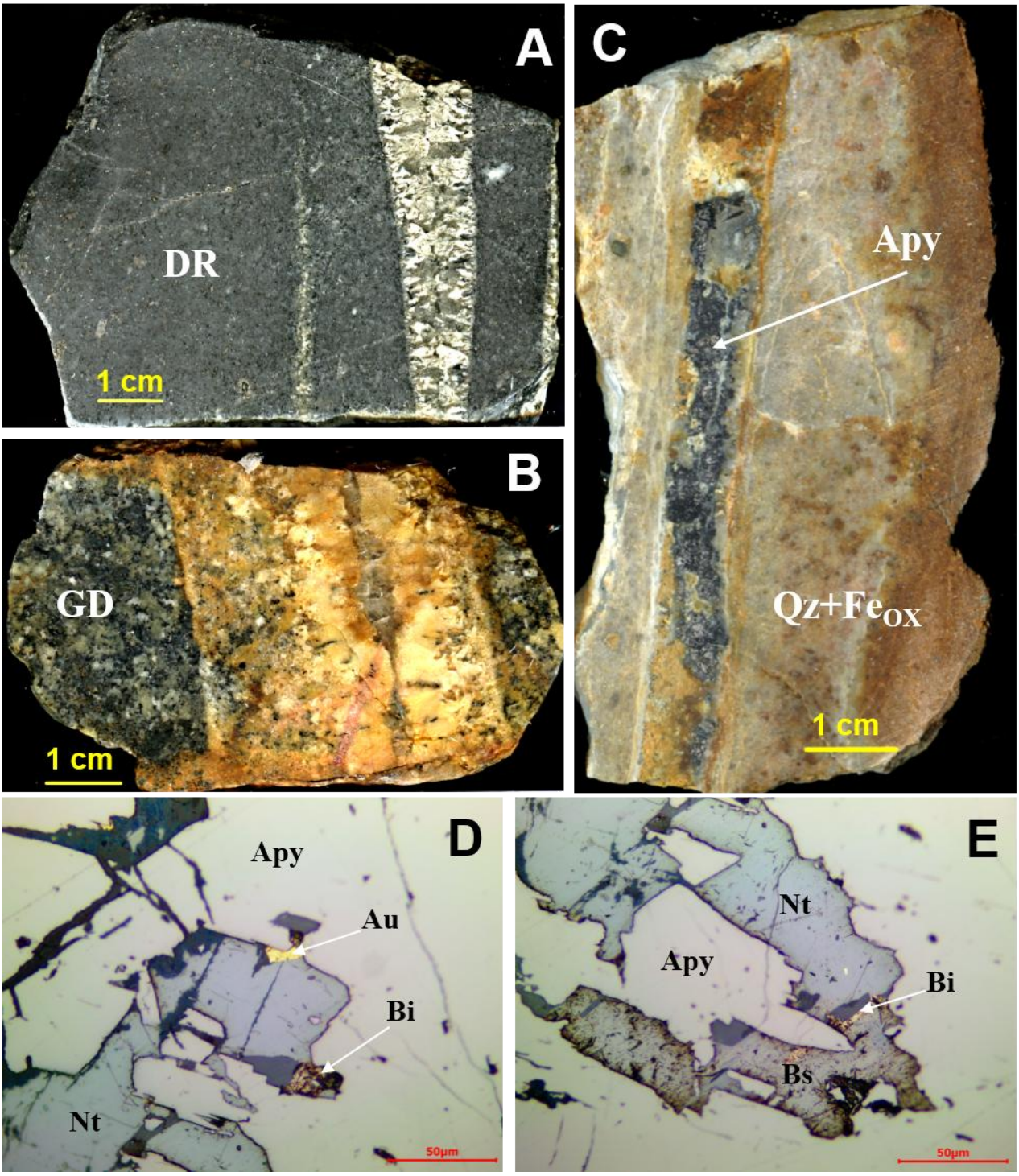
Supplement 1.5 Intrusion-hosted sheeted quartz veins of KKBC. A-B – Sample 88113. Typical gold-bearing sheeted quartz±feldspar±mica veins cutting diorite and granodiorite at the Kis-Kuel occurrence. C – Sample 88093-B. Gold-bearing sheeted vein with quartz-arsenopyrite and iron-oxide infill: grades FeOtot – 17.84%, Cu – 0.881%, Ag – 191 g/t, Au – 33.16 g/t. D and E – Sample 88093-B. Reflected-light photomicrographs of gold and bismuth minerals in arsenopyrite. (Qz+FeOX – Quartz + Iron oxides intergrowth, Apy – Arsenopyrite, Au – gold native, Bi – Bismuth native, Bs – bismite, Nt – neyite, DR – Diorite, GD – granodiorite).



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