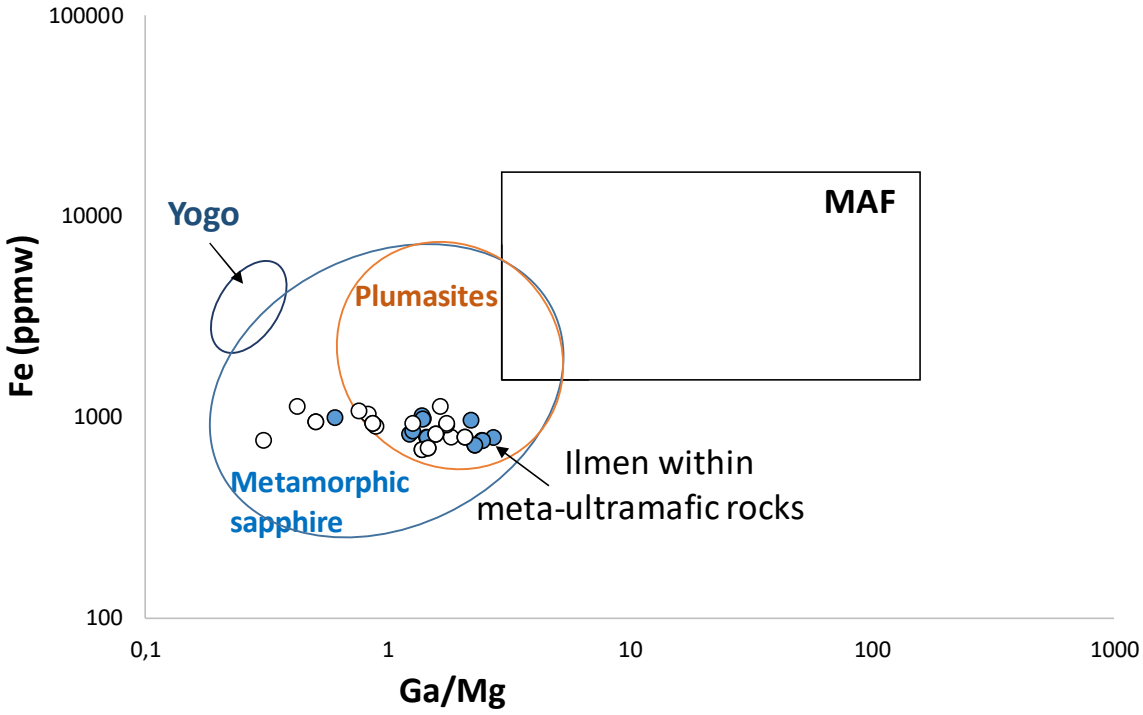

Figure S1. A plot of Ilmen sapphires within meta-ultramafic host rocks (blue-colored samples–bold blue circles, colorless samples–colorless circles) in a Fe *versus* Ga/Mg diagram showing boundaries for magmatic (MAF: Main Asian Field; magmatic sapphires in alkali basalt) and metamorphic sapphires, modified after [14,19].

Table S1. Description of sapphire-spinel samples used for WDS EMPA and LA-ICP-MS.

Sample	Dimensions (in cm)	Sapphire Color
1	0.7 x 0.4 x 0.7	Zonal, white and blue
2	1 x 0.4 x 0.7	Zonal, white and blue
3	1.2 x 0.9 x 0.7	Zonal, white and blue
4	1 x 1 x 0.7	Zonal, white and pale-blue
5	1 x 1.3 x 0.7	White

Table S2. Mineral assemblage and mode of minerals in the thin-sections.

Sample	Rock Type	Mineral and Mode (vol. %)	Number of Studied Thin-Sections/ Wafers
418-3	Actinolite rock	Actinolite ~ 90, Anthophyllite ~ 7, Ore mineral ~ 3	1
418-4	Black tack-bearing meta-ultramafic rock	Talc ~ 95, Ore mineral ~ 5	1
418-6	Ferruginous meta-ultramafic rock	Quartz ~ 30-50, Olivine ~ 5-10, Carbonate ~ 25-45, Chlorite ~ 10, Talc ~ 5-10	1
418-7	Enstatite meta-ultramafic rock	Enstatite ~ 95, Talc ~ 3, Serpentine (chrysotile-asbestos) ~ 2, Ore, clinopyroxene – acc.	1
418-9	Actinolite "broken" rock	Amphibole – 100	1
418-10	Brown micaceous rock	Vermiculite – 100	1
418-11	Contact micaceous rock	Vermiculite – 100	1
418-12	Micaceous lenses with corundum (sapphire)	Vermiculite 70-90, Corundum 10-25, spinel up to 5	24
418-13	Corundum-spinel-tourmaline lenses	Spinel ~ 40, Anorthite ~ 40, Muscovite ~ 20	1
418-14	Silicified rock	Muscovite 40-80, Quartz 20-60	1

Table S3. Minerals identified in association with the sapphire.

Mineral Groups	Major Minerals	Minor Mineral (Syngenetic Inclusions)	Accessory Minerals (Syngenetic Inclusions)
Oxides/ Hydroxides	Spinel – gahnite series	Microlite group Uraninite Allanite-Dissakisite Diaspore (protogenetic inclusion)	Vigezzite-fersmite Rutile Baddeleyite (protogenetic inclusion)
Silicates/ Alumo-silicates	Muscovite Clinochlore Amesite Anorthite	Zircon (epigenetic inclusions)	Hyalophane Celsian Pargasite Aluminotschermakite
Chlorites/ Borates/ Phospates		Apatite group (epigenetic inclusions) Monazite-(Ce)	Marialite Dravite (in association with corundum)
Nickel, lead Arsenates/ Sulfides		Millerite Maucherite Nickeline	Heazlewoodite Galena Gersdorffite

Table S4. Texture relationship of minerals found in association with sapphire.

Corona Minerals Around Sapphire	Minerals in Association with Sapphire	Minerals Found along Fractures and Cavities	Inclusions
Spinel–gahnite series Muscovite Clinochlore Amesite	Feldspar group minerals Muscovite Dravite Heazlewoodite	Clinochlore Amesite Apatite group Zircon Diaspore Monazite-(Ce) Hyalophane Celsian Baddeleyite	Microlite group Uraninite Allanite-Dissakisite Diaspore Vigezzite-fersmite Rutile Pargasite Aluminotschermakite Marialite Galena Gersdorffite Millerite Maucherite Nickeline

Table S5. Chemical composition of spinel and gahnite.

Oxide (wt. %)	Spinel									Gahnite
MgO	18.37	18.13	18.72	19.21	19.42	18.98	18.0	19.04	20.59	8.26
Al_2O_3	66.92	67.29	66.91	66.74	66.8	66.91	66.35	66.48	67.83	62.01
FeO	12.45	13.16	12.76	11.81	11.87	12.09	13.04	12.89	11.04	7.11
NiO	0.27	0.3	0.36	0.3	0.27	0.21	0.65	0.36	0.44	bdl
ZnO	2.14	2.08	1.88	2.33	2.36	2.35	2.57	1.56	1.12	22.21
MnO	0.18	0.12	0.1	0.15	0.13	0.11	0.14	0.2	0.11	-
CoO	0.08	0.16	0.08	0.08	0.07	0.14	0.28	0.1	0.07	-
Total	100.49	101.37	100.86	100.68	100.96	100.88	101.16	100.68	101.19	99.59
Atomic Number	**Recalculated on 4 Oxygen**									
Mg	0.69	0.68	0.70	0.72	0.73	0.71	0.68	0.72	0.76	0.34
Al	1.99	1.99	1.99	1.98	1.98	1.98	1.98	1.98	1.98	2.03
Fe	0.26	0.28	0.27	0.25	0.25	0.25	0.28	0.27	0.23	0.16
Ni	-	-	-	-	-	-	0.01	-	-	-
Zn	0.04	0.04	0.03	0.04	0.04	0.04	0.05	0.03	0.02	0.45

Table S6. Chemical composition of muscovite and clinochlore.

Oxide (wt. %)	Muscovite	Clinochlore				
MgO	0.29	24.21	26.91	23.46	30.1	24.22
Al_2O_3	38.21	19.87	20.31	28.05	24.45	18.81
SiO_2	45.35	37.59	33.51	30.68	28.45	30.5
K_2O	10.78	0.55	0.62	1.00	bdl	0.12
CaO	0.40	0.39	0.65	0.19	bdl	0.23
FeO	0.14	4.01	4.19	4.77	4.38	5.05
F	0.17	0.23	0.09	Bdl	bdl	0.21
Total	95.77	87.21	86.54	88.46	87.78	79.4
Atomic number	Rec.on 10 O, 2 OH and 2 F	Recalculated on 10 O and 8 OH				
Mg	0.03	3.35	3.8	3.23	4.23	3.75
Al	3.25	2.18	2.30	3.05	2.71	2.30
Si	3.28	3.49	3.18	2.83	2.68	3.17
K	0.99	0.07	0.07	0.11	-	0.02
Ca	0.03	0.06	0.07	0.12	-	0.02
Fe	-	0.31	0.33	0.37	0.35	0.44

Table S7. Chemical composition of feldspar group minerals and marialite.

Oxide	Hyalophane		Celsian		Anorthite	Marialite	
Na_2O	Bdl	bdl	-	-	-	6.79	7.14
MgO	-	0.25	0.83	0.47	-	-	
Al_2O_3	21.31	20.79	29.35	29.02	37.32	24.30	24.76
SiO_2	58.48	58.67	34.41	35.18	42.50	51.31	51.09
K_2O	12.60	12.64	0.34	0.40		bdl	0.25
CaO	bdl	bdl	-	-	19.24	11.09	10.82
FeO	bdl	bdl	0.58	0.52	Bdl	bdl	bdl
BaO	6.67	6.18	33.63	32.97	-	-	-
Cl	-	-	-	-	-	1.76	1.72
Total	99.06	98.53	99.14	98.56	99.06	95.25	95.78
Atomic number	Recalculated on 8 O					Recalculated on 49 atoms	
Na	-	-	-	-	-	1.96	2.06
Mg	-	0.02	0.07	0.04	-	-	-
Al	1.22	1.19	2.04	2.01	2.05	4.24	4.34
Si	2.83	2.84	2.03	2.07	1.98	7.65	7.60
K_2O	0.78	0.78	0.03	0.03	-	-	0.05
Ca	-	-	-	-	1.21	1.77	1.73
Fe	-	-	0.03	0.03	-	-	-
Ba	0.13	0.12	0.78	0.76	-	-	-
Cl						0.44	0.43

Table S8. Chemical composition of apatite group minerals.

Oxide	1	2	3	4	5	6
SiO_2	0.1	0.11	0.08	0.08	0.08	0.1
P_2O_5	40.35	41.65	42.01	42.33	41.81	42.88
CaO	53.38	54.75	54.79	54.95	55.04	55.53
FeO	0.11	0.11	0.06	0.10	0.14	0.15
La_2O_3	bdl	0.11	0.21	0.07	0.16	0.1
Ce_2O_3	0.14	0.08	0.19	0.13	0.06	0.13
SrO	0.14	bdl	bdl	0.11	bdl	0.19
F^-	1.38	1.19	1.53	1.64	1.74	2.47
Cl^-	2.38	2.7	2.17	1.99	1.99	0.73
Total	98.05	100.76	101.2	101.5	101.12	102.36
Atomic number	Recalculated on 12 O and 1 (F,Cl)					
Si	-	-	-	-	-	-
P	3.11	3.11	3.12	3.13	3.11	3.13
Ca	5.20	5.19	5.16	5.15	5.19	5.14
Fe	-	-	-	-	0.01	0.01
La	-	-	-	-	0.01	-

Table S9. Chemical composition of zircon and monazite-(Ce).

Oxide	Zircon		Monazite			
SiO_2	31.88	32.57	6.74	4.00	-	2.86
ZrO_2	61.66	64.49	-	-	-	-
HfO_2	4.73	3.16	-	-	-	-
P_2O_5	0.16	bdl	28.75	40.38	29.70	25.81
CaO	0.28	0.26	8.25	7.09	0.38	6.63
FeO	bdl	bdl	-	1.71	-	0.93
La_2O_3	0.06	0.07	10.09	10.05	21.92	21.06
Ce_2O_3	0.08	bdl	29.07	23.11	37.53	29.44
Pr_2O_3	-	-	4.49	2.92	3.44	4.58
Nd_2O_3	bdl	0.09	7.27	8.77	4.25	4.49
Sm_2O_3	-	-	bdl	-	-	-
ThO_2	bdl	bdl	4.04	-	1.80	3.31
UO_2	0.75	0.28	bdl	-	-	-
Total	99.71	101.07	98.70	98.03	99.02	99.11
Atomic number	Recalculated on 4 O					
Si	1.00	1.00	0.24	0.13	-	0.11
Zr	0.94	0.97	-	-	-	-
Hf	0.04	0.03	-	-	-	-
P			0.86	1.08	1.00	0.85
Ca	0.01	0.01	0.31	0.24	0.02	0.28
Fe	-	-	-	0.05	-	0.03
La	-	-	0.13	0.12	0.32	0.30
Ce	-	-	0.38	0.27	0.54	0.42
Pr	-	-	0.06	0.03	0.05	0.07
Nd	-	-	0.09	0.10	0.06	0.06
Sm	-	-	-	-	-	-
Th	-	-	0.03	-	0.02	0.03
U	0.01	-	-	-	-	-

Table S10. Chemical composition of sulphide minerals.

Element	Millerite				Galena	Maucherite		Nickeline		Gersdorffite
S	35.20	33.56	34.62	34.85	13.37	0.61	0.61	0.76	-	19.50
As	-	2.05	-	-	-	47.32	47.43	54.18	55.15	42.37
Fe	2.40	11.48	20.56	20.74	-	0.74	2.06	0.78	0.75	3.15
Co	0.99	-	2.77	0.57	-	-	-	-	-	12.76
Ni	60.71	52.92	41.92	43.84	-	50.92	49.84	43.83	43.48	21.80
Pb	-	-	-	-	86.02	-	-	-	-	-
Total	99.30	100.00	99.87	100.00	99.39	99.59	99.94	99.55	99.37	99.58
Atomic number	Recalculated on 1 S					Recalc. on 8 S+As		Recalc. on 1 S+As		Recalc. on 1 S
S	1.00	0.97	1.00	1.00	1.00	0.23	0.23	0.03	-	1.00
As	-	0.03	-	-	-	7.77	7.77	0.97	1.00	0.93
Fe	0.04	0.19	0.34	0.34	-	0.16	0.42	0.02	0.02	0.09
Co	0.02	-	0.04	0.01	-	-	-	-	-	0.36
Ni	0.94	0.84	0.66	0.69	-	10.67	10.42	1.00	1.01	0.61
Pb	-	-	-	-	1.00	-	-	-	-	-

Table S11. Chemical composition of allanite-(Ce) group minerals.

Oxide	1	2	3	4	5	6	7
MgO	3.51	3.08	3.33	1.49	3.71	4.21	3.68
Al_2O_3	22.57	22.96	22.99	22.64	20.87	19.97	19.77
SiO_2	35.86	35.80	36.11	36.42	36.18	35.68	37.20
CaO	12.59	12.79	12.72	13.98	9.86	9.81	9.57
FeO	3.76	3.96	4.24	6.38	3.29	3.73	3.96
Y_2O_3	-	-	-	bdl	-	-	-
La_2O_3	4.27	4.23	4.45	1.83	7.56	6.84	6.45
Ce_2O_3	10.78	11.06	10.86	7.48	13.63	14.23	13.80
Pr_2O_3	1.35	bdl	bdl	bdl	bdl	1.90	bdl
Nd_2O_3	2.82	2.58	2.67	5.24	1.62	1.25	1.30
Sm_2O_3	-	bdl	bdl	bdl	-	-	-
ThO_2	-	-	-	-	bdl	bdl	bdl
Total	97.51	96.46	97.37	95.46	96.72	97.62	95.73
Atomic number	Recalculated on 12 O and 1 OH						
Mg	0.45	0.40	0.43	0.19	0.49	0.56	0.49
Al	3.11	2.36	2.34	2.33	2.19	2.10	2.08
Si	2.31	3.12	3.12	3.18	3.22	3.19	3.32
Ca	1.17	1.19	1.18	1.31	0.94	0.94	0.91
Fe	0.27	0.29	0.31	0.47	0.24	0.28	0.30
La	0.14	0.14	0.14	0.06	0.25	0.23	0.21
Ce	0.34	0.35	0.34	0.24	0.44	0.47	0.45
Pr	0.04	-	-	-	-	0.06	-
Nd	0.09	0.08	0.08	0.16	0.05	0.04	0.04

Table S12. Chemical composition of amphibole group minerals.

Oxide	Pargasite			Aluminotschermakite					
Na_2O	2.81	2.31	2.55	2.17	2.25	2.08	2.05	2.21	1.99
MgO	18.48	16.95	17.26	16.88	17.15	16.85	16.77	16.83	17.99
Al_2O_3	17.34	18.24	19.13	19.26	18.50	19.31	19.31	18.85	19.19
SiO_2	44.07	43.95	42.72	42.82	43.53	43.04	43.26	44.03	43.15
K_2O	bdl	0.26	0.25	0.22	0.29	0.23	0.25	0.29	0.29
CaO	11.68	12.41	12.12	12.18	12.36	12.24	11.89	12.45	11.61
MnO	-	-	-	bdl	-	Bdl	-	-	-
TiO_2	bdl	-	bdl	-	bdl	Bdl	-	bdl	-
Fe_2O_3	3.07	3.79	3.75	4.00	3.88	3.85	3.50	3.88	3.73
Cl^-	bdl	bdl	0.21	bdl	0.21	Bdl	bdl	0.17	bdl
Total	97.45	97.91	97.99	97.53	98.17	97.60	97.03	98.71	97.95
Atomic number	Recalculated on 22 O and 2 OH								
Na	0.75	0.62	0.68	0.58	0.60	0.56	0.55	0.59	0.52
Mg	3.78	3.50	3.55	3.48	3.53	3.46	3.46	3.45	3.64
Al	2.81	2.98	3.11	3.14	3.01	3.14	3.15	3.05	3.07
Si	6.05	6.09	5.90	5.92	6.01	5.94	5.99	6.04	5.86
K	-	0.05	0.04	0.04	0.05	0.04	0.04	0.05	0.05
Ca	1.72	1.84	1.79	1.80	1.88	1.81	1.76	1.83	1.69
Fe	0.35	0.43	0.44	0.46	0.45	0.45	0.40	0.45	0.43
Cl	-	-	0.04	-	0.04	-	-	0.03	-

Table S13. EDXRF (wt. %) and ICP-MS (ppmw) analyses of host rocks from 418 mine.

No	418-3	418-4	418-6	418-7	418-9	418-10	418-11	418-14	418-12	418-13	Miaskite*
	Meta-ultramafic Host Rocks								Corundum-Bearing Rock		
Major elements (wt. %)											
SiO_2	58.79	61.38	58.71	56.57	49.93	39.73	39.27	79.88	35.14	24.12	57.51
Al_2O_3	1.72	0.76	0.11	0.94	3.97	10.99	9.85	0.28	16.26	38.52	17.55
TiO_2	0.029	0.007	bdl	0.004	0.078	0.277	0.228	0.001	0.117	0.032	1.24
Fe_2O_3	4.53	3.53	4.3	8.02	2.9	3.49	5.11	1.16	3.44	9.5	1.90
MnO	0.144	0.091	0.038	0.154	0.072	0.029	0.086	0.021	0.024	0.086	0.21
K_2O	0.02	bdl	0.04	0.01	0.05	0.01	0.02	0.02	0.06	0.53	5.66
CaO	6.41	0.29	17.24	0.29	13.93	0.92	0.63	0.15	0.26	1.39	2.80
MgO	24.96	27.64	3.65	31.73	20.26	24.97	26.65	15.58	25.54	21.25	1.57
Na_2O	0.33	0.16	0.15	0.07	0.63	0.03	0.03	0.14	bdl	0.56	5.8
P_2O_5	0.02	0.017	0.056	0.024	0.025	0.016	0.019	0.021	0.068	0.276	0.24
S	bdl	bdl	0.016	0.028	0.009	0.006	0.011	0.013	0.027	0.035	-
L.O.I.	2.77	5.81	15.49	1.7	7.95	18.94	17.69	2.58	18.95	3.89	1.8
Total	100.00	99.99	99.99	100.00	99.99	100.02	100.03	100.00	100.03	100.56	99.48
Trace-elements (ppmw)											
Li	4.68	2.31	1.70	2.75	4.54	8.73	62.0	63.9	122	44.0	32
Be	0.78	0.20	0.33	0.105	0.40	1.26	1.39	1.31	1.14	2.65	3.0
Sc	7.64	1.44	6.31	2.22	6.58	12.7	7.84	6.97	5.94	1.57	3
V	35.4	11.0	26.6	16.3	28.0	72.9	75.4	78.3	56.6	15.2	78
Cr	1742	732	1259	427	1066	1310	3339	2253	77.2	26.2	8
Co	34.6	18.9	41.5	51.9	75.5	27.3	45.5	39.8	54.0	107	9
Ni	657	437	769	819	1437	591	1339	1190	1107	945	9
Cu	15.1	24.0	10.1	15.3	20.1	13.1	5.73	9.58	3.75	6.30	34
Zn	49.8	96.9	44.4	112	105	29.9	36.6	36.9	110	1257	87
Ge	1.18	0.22	0.54	1.02	1.18	1.26	0.93	0.88	0.92	0.75	-
As	bdl	120	bdl	9.12	bdl	bdl	0.60	bdl	bdl	22.4	-
Rb	0.59	1.24	0.34	0.92	0.32	0.50	2.01	2.28	2.54	17.0	114
Sr	19.8	9.19	7.06	67.2	12.6	47.5	33.5	14.3	29.7	136	1405
Y	6.68	0.36	0.21	0.59	0.169	14.1	0.99	1.42	2.49	1.47	20
Zr	3.80	bdl	bdl	bdl	0.23	5.99	47.3	67.5	29.1	107	77
Nb	8.44	0.89	1.78	0.35	0.32	11.6	36.0	30.1	34.6	6.44	188
Mo	0.031	0.47	bdl	0.152	0.60	bdl	bdl	bdl	bdl	0.23	1
Cd	0.31	0.038	0.082	0.161	0.042	0.52	0.048	0.117	0.035	0.130	-
Sn	1.21	0.83	0.154	0.38	0.21	2.31	0.73	0.54	0.46	2.82	-
Sb	1.23	0.26	0.34	0.47	0.068	0.055	0.121	0.061	20.2	0.51	-
Cs	0.125	0.81	0.150	1.32	0.078	0.138	0.90	1.04	1.27	1.66	-
Ba	113	106	31.8	203	109	42.4	22.1	40.0	999	128	1589
La	2.47	0.61	0.44	0.71	0.107	3.54	0.62	0.44	18.7	2.26	80
Ce	7.20	1.81	1.62	0.83	0.25	12.3	1.31	0.97	31.0	5.07	142
Pr	1.33	0.154	0.145	0.138	0.026	2.60	0.21	0.134	2.23	0.67	17
Nd	5.73	0.43	0.51	0.48	0.093	12.0	0.81	0.54	5.50	2.67	57
Sm	1.44	0.116	0.092	0.104	0.047	3.01	0.166	0.119	0.62	0.58	7.6
Eu	0.36	0.017	0.014	0.028	0.005	0.54	0.031	0.043	0.105	0.106	2.0
Gd	1.27	0.075	0.074	0.095	0.021	2.88	0.134	0.138	0.58	0.36	6.1
Tb	0.191	0.008	0.010	0.012	0.003	0.43	0.024	0.028	0.070	0.048	0.7

*Miascite major and trace-element compositions are from [25]

Table S13 *Cont.*

No	418-3	418-4	418-6	418-7	418-9	418-10	418-11	418-14	418-12	418-13	Miaskite*
Dy	1.18	0.048	0.079	0.030	2.56	0.144	0.189	0.089	0.36	0.27	4.2
Ho	0.22	0.013	0.018	0.008	0.51	0.031	0.041	0.014	0.080	0.048	0.8
Er	0.65	0.041	0.122	0.018	1.36	0.092	0.128	0.040	0.22	0.138	2.2
Tm	0.090	0.004	0.008	0.003	0.188	0.012	0.020	0.004	0.027	0.023	0.3
Yb	0.55	0.047	0.059	0.027	1.18	0.118	0.171	0.058	0.169	0.132	2.1
Lu	0.084	0.005	0.005	0.007	0.177	0.013	0.033	0.007	0.026	0.023	0.3
Hf	0.29	0.048	bdl	0.033	0.32	1.87	2.72	bdl	1.22	7.28	1.3
Ta	0.87	0.24	0.023	0.121	0.93	3.94	3.99	0.041	21.4	0.85	20.4
W	0.116	0.29	1.31	0.24	0.080	0.154	0.103	0.128	0.092	0.36	-
Tl	0.073	0.24	0.066	bdl	0.040	0.21	0.22	0.048	0.71	0.086	-
Pb	6.35	12.4	10.6	11.3	6.61	2.74	11.7	28.3	5.50	11.5	12
Bi	0.005	bdl	bdl	0.86	bdl	0.056	0.166	0.013	bdl	0.093	-
Th	0.51	0.26	0.125	0.142	0.22	1.89	7.94	0.179	26.8	0.60	13
U	0.127	0.030	0.89	0.53	0.27	0.46	0.65	1.30	2.28	0.73	3.2

* Miascite major and trace-element compositions are from [25]

Table S14. Rb-Sr and Sm-Nd isotope measurements of sapphire-bearing rocks and muscovites associated with sapphire.

	418–12-1	**418–12-2**	**418–13-1**	**418–13-2**	**418-13-rock1**	**418-13-rock2**	**418-mica1**	**418-mica2**
Rb (ppmw)	2.02	2.15	15.4	15.4	23.0	30.3	1.56	2.73
Sr (ppmw)	9.50	9.05	124	127	308	251	5.30	4.81
$^{87}Rb/^{86}Sr$*	0.6158	0.6871	0.3598	0.3509	0.2156	0.3490	0.8505	1.6428
$^{87}Sr/^{86}Sr$	0.710460 ± 0.000008	0.710587 ± 0.000006	0.708836 ± 0.000004	0.708764 ± 0.000010	0.708254 ± 0.000008	0.708826 ± 0.000012	0.711371 ± 0.000008	0.714131 ± 0.000016
$(^{87}Sr/^{86}Sr)_{289}$	0.707919 ± 0.000026	0.707752 ± 0.000029	0.707357 ± 0.000015	0.707326 ± 0.000018	0.707368 ± 0.000012	0.707391 ± 0.000018	0.707873 ± 0.000036	0.707375 ± 0.000069
Sm (ppmw)		0.91	0.37					
Nd (ppmw)		8.45	1.83					
$^{147}Sm/^{144}Nd$		0.0648	0.121					
$^{143}Nd/^{144}Nd$		0.5122 ± 0.000008	0.5122 ± 0.000012					
ε^{Nd}		-7.8	-7.8					

*2σ errors for $^{87}Rb/^{86}Sr$ = 1% and for $^{147}Sm/^{144}Nd$ = 0.1%