



Supplement of

Luminescence dating approaches to reconstruct the formation of plaggic anthrosols

Jungyu Choi et al.

Correspondence to: Jungyu Choi (jungyu.choi@wur.nl)

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Section S1. Data for dose rate calculations

Table S1. Data for dose rate calculations

Sample	Depth (cm)	Water Content (%)	Organic Content (%)	²³⁸ U (Bq/kg)	²³² Th (Bq/kg)	⁴⁰ K (Bq/kg)	Beta (Gy/ka)*	Gamma (Gy/ka)*	Cosmic (Gy/ka)	Dose rate (Quartz) (Gy/ka)	Dose rate (Feldspar) (Gy/ka)**
NCL-1117134	22	12.0 ± 3.0	3.9 ± 1.0	11.9 ± 0.2	10.1 ± 0.6	211.7 ± 5.5	0.56 ± 0.03	0.32 ± 0.02	0.27 ± 0.01	1.16 ± 0.04	2.10 ± 0.10
NCL-1117133	31	12.9 ± 3.2	3.3 ± 0.8	9.6 ± 0.2	9.9 ± 0.5	192.8 ± 4.8	0.49 ± 0.03	0.29 ± 0.02	0.26 ± 0.01	1.05 ± 0.03	1.99 ± 0.10
NCL-1117132	41	14.5 ± 3.6	3.8 ± 0.9	10.6 ± 0.2	10.4 ± 0.5	212.3 ± 5.1	0.53 ± 0.03	0.31 ± 0.02	0.25 ± 0.01	1.09 ± 0.04	2.03 ± 0.10
NCL-1117131	50	14.2 ± 3.5	3.3 ± 0.8	11.3 ± 0.2	11.2 ± 0.5	221.1 ± 5.2	0.55 ± 0.03	0.33 ± 0.02	0.24 ± 0.01	1.13 ± 0.04	2.07 ± 0.10
NCL-1117130	60	11.5 ± 2.9	3.3 ± 0.8	12.4 ± 0.2	11.1 ± 0.5	228.2 ± 5.8	0.58 ± 0.03	0.33 ± 0.02	0.23 ± 0.01	1.15 ± 0.04	2.09 ± 0.10
NCL-1117129	70	12.2 ± 3.1	3.3 ± 0.8	12.6 ± 0.2	10.8 ± 0.5	229.7 ± 5.4	0.59 ± 0.03	0.35 ± 0.02	0.23 ± 0.01	1.17 ± 0.04	2.11 ± 0.10
NCL-1117128	81	14.3 ± 3.6	3.8 ± 0.9	12.6 ± 0.2	11.3 ± 0.5	232.2 ± 5.8	0.58 ± 0.03	0.35 ± 0.02	0.22 ± 0.01	1.17 ± 0.04	2.11 ± 0.10
NCL-1117127	96	12.3 ± 3.1	2.9 ± 0.7	11.0 ± 0.2	10.7 ± 0.5	211.9 ± 5.0	0.60 ± 0.03	0.36 ± 0.02	0.22 ± 0.01	1.18 ± 0.03	2.12 ± 0.10
NCL-1117126	101	11.5 ± 2.9	2.9 ± 0.7	10.3 ± 0.2	9.3 ± 0.5	208.5 ± 4.2	0.53 ± 0.03	0.30 ± 0.02	0.21 ± 0.01	1.06 ± 0.03	2.00 ± 0.10
NCL-1117125	112	7.8 ± 2.0	1.7 ± 0.4	8.1 ± 0.2	6.7 ± 0.4	202.7 ± 4.8	0.52 ± 0.03	0.29 ± 0.01	0.21 ± 0.01	1.03 ± 0.03	1.97 ± 0.10
NCL-1117124	123	6.2 ± 1.6	1.5 ± 0.4	7.9 ± 0.2	7.3 ± 0.5	212.9 ± 5.1	0.56 ± 0.03	0.31 ± 0.02	0.21 ± 0.01	1.08 ± 0.03	2.02 ± 0.10
NCL-1117123	142	5.8 ± 1.4	1.6 ± 0.4	7.7 ± 0.2	8.3 ± 0.5	227.8 ± 5.3	0.60 ± 0.03	0.34 ± 0.02	0.20 ± 0.01	1.15 ± 0.03	2.09 ± 0.10
NCL-1117122	165	5.4 ± 1.4	1.2 ± 0.3	7.7 ± 0.2	8.9 ± 0.5	254.7 ± 5.7	0.66 ± 0.03	0.35 ± 0.02	0.20 ± 0.01	1.21 ± 0.04	2.15 ± 0.10

* Water and grain size attenuated

** Internal dose rate calculated as 0.89 ± 0.09 Gy/ka based on the assumptions of internal concentrations of K (12.5 ± 0.5 %/ppm) and Rb (400 ± 100 %/ppm)

Section S2. Luminescence dating protocols

Table S2. Luminescence dating protocol used for small-aliquot quartz OSL measurements.

Step	Action	Measured
1	Beta dose (or Natural dose)	
2	10s preheat to 200°C	
3*	20s blue stimulation at 125 °C	L_n/L_i
4	Beta test dose	
5	10s preheat to 180°C	
6*	20s blue stimulation at 125 °C	T_n/T_i
7	40s blue bleach at 210°C	
8	Repeat step 1-7 for a range of doses (incl. zero and repeat dose)	
Extra 1	Repeat step 1-7 with added infrared bleach at 30°C prior to step 3	

* The first 0-0.5 s integration interval was used for analysis, and the subsequent 0.5-1.76 integration interval was used for early background subtraction.

Table S3. Luminescence dating protocol used for single-grain feldspar pIRIR measurements.

Step	Action	Measured
1	Beta dose (or Natural dose)	
2	120s preheat to 200°C	
3*	2s single-grain IR laser stimulation at 50°C	L_n, L_i (IRSL ₅₀)
4*	2s single-grain IR laser stimulation at 175°C	L_n, L_i (pIRIR ₁₇₅)
5	Beta test dose	
6	120s preheat to 200°C	
7*	2s single-grain IR laser stimulation at 50°C	T_n, T_i (IRSL ₅₀)
8*	2s single-grain IR laser stimulation at 175°C	T_n, T_i (pIRIR ₁₇₅)
9	300s IR stimulation at 210 °C	
10	Repeat step 1-9 for a range of doses (incl. zero and repeat dose)	

* The 0.17-0.23 s integration interval was used for analysis, and the 1.29-1.62 s integration interval was used for background subtraction.

Section S3. Radial plots of single-grain feldspar pIRIR measurements

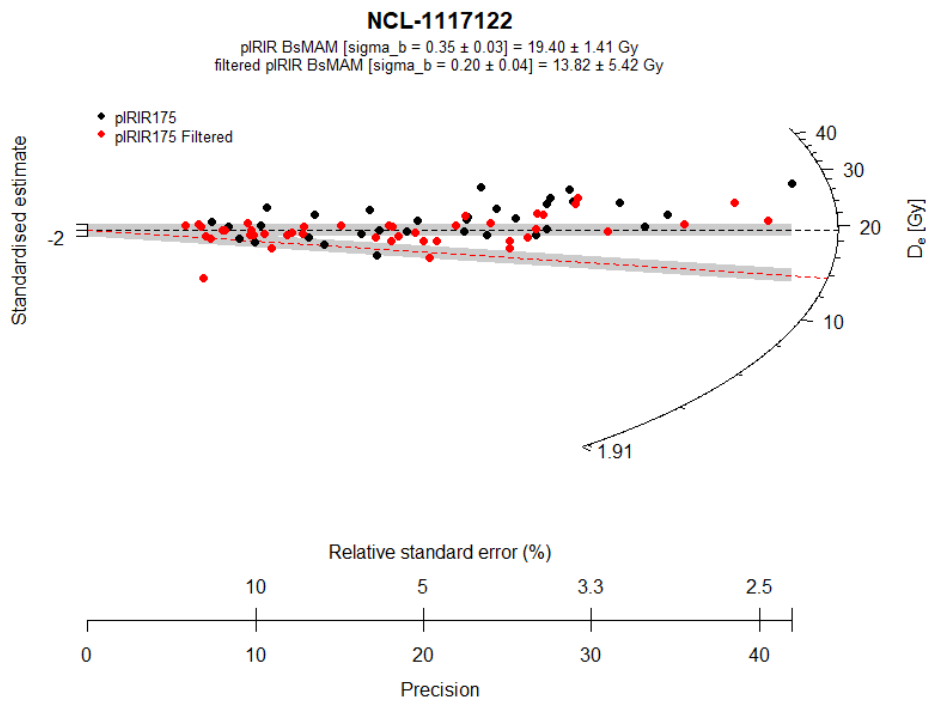


Figure S1. Radial plot of equivalent dose obtained from single-grain feldspar pIRIR measurement of NCL-1117122. The black dotted line indicates the BsMAM result of the total dataset, and the red dotted line indicates the BsMAM result of the filtered dataset. The σ_b values applied for each BsMAM are indicated in the figure.

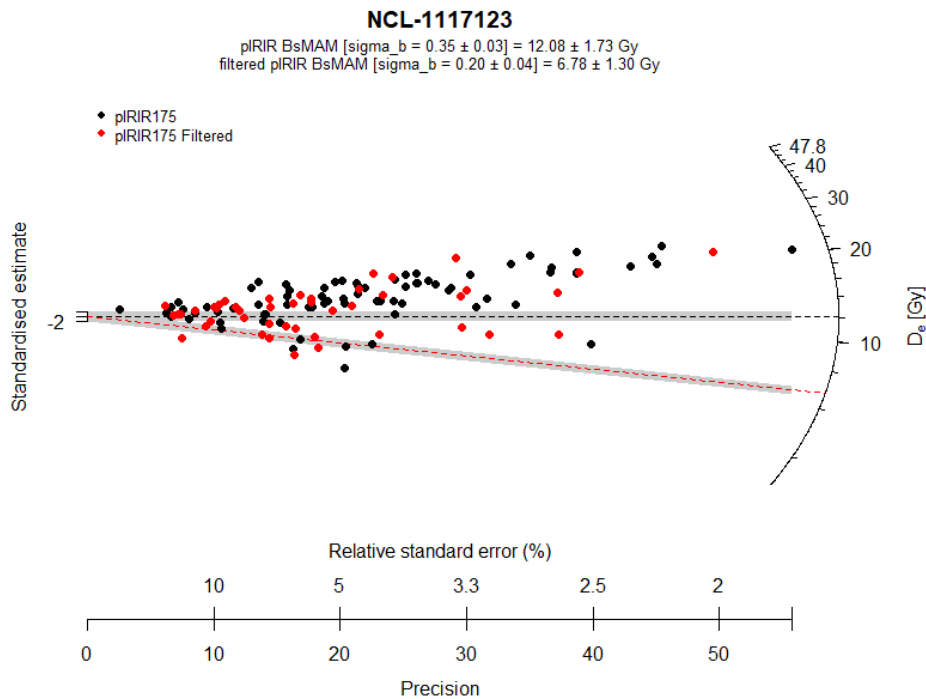
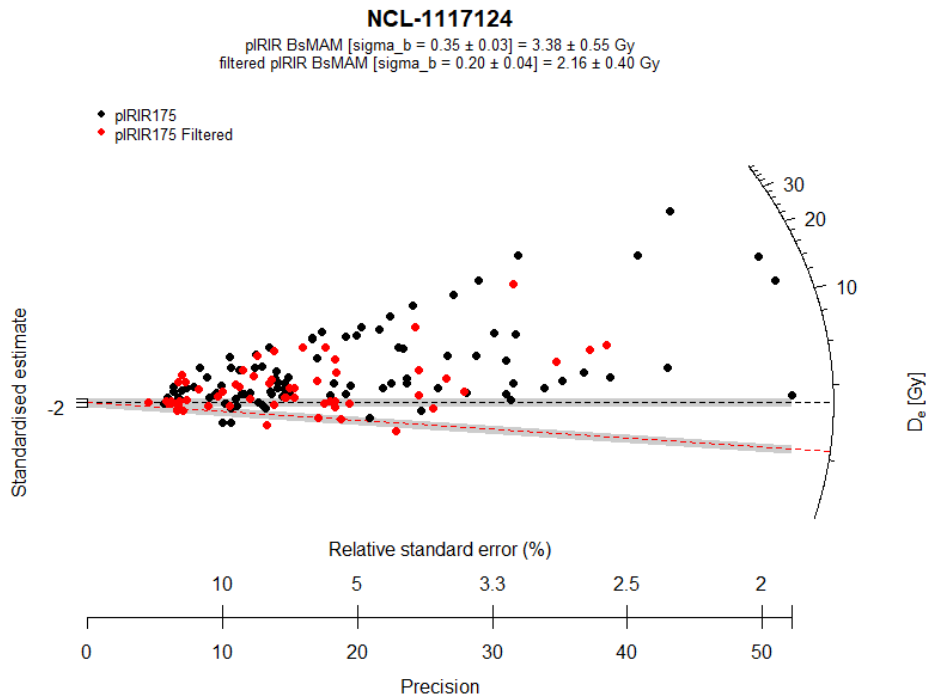


Figure S2. Radial plot of equivalent dose obtained from single-grain feldspar pIRIR measurement of NCL-1117123. The black dotted line indicates the BsMAM result of the total dataset, and the red dotted line indicates the BsMAM result of the filtered dataset. The σ_b values applied for each BsMAM are indicated in the figure.



Figures S3. Radial plot of equivalent dose obtained from single-grain feldspar pIRIR measurement of NCL-1117124. The black dotted line indicates the BsMAM result of the total dataset, and the red dotted line indicates the BsMAM result of the filtered dataset. The σ_b values applied for each BsMAM are indicated in the figure.

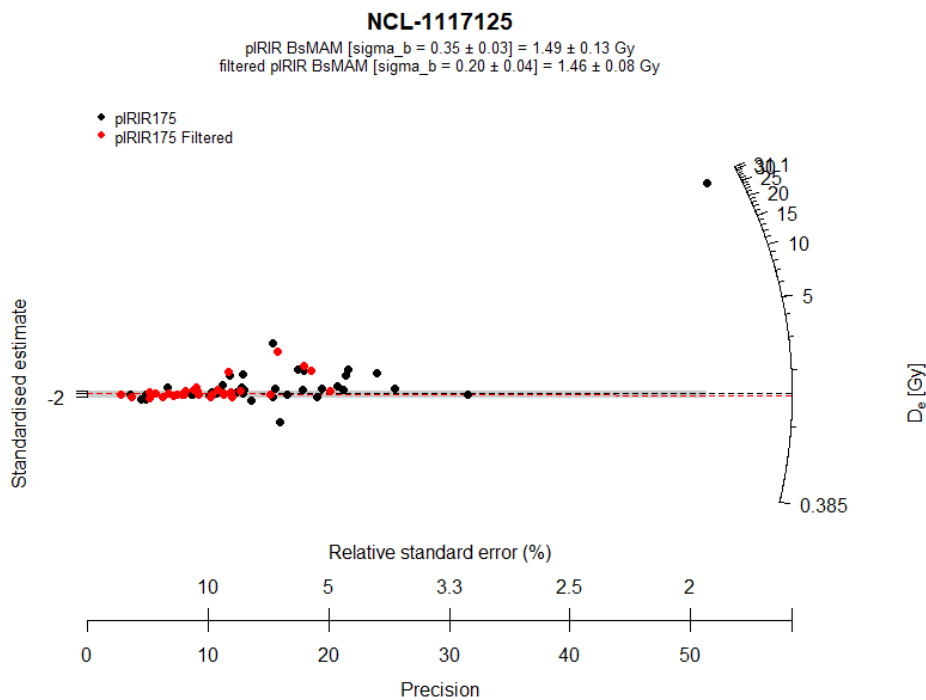


Figure S4. Radial plot of equivalent dose obtained from single-grain feldspar pIRIR measurement of NCL-1117125. The black dotted line indicates the BsMAM result of the total dataset, and the red dotted line indicates the BsMAM result of the filtered dataset. The σ_b values applied for each BsMAM are indicated in the figure.

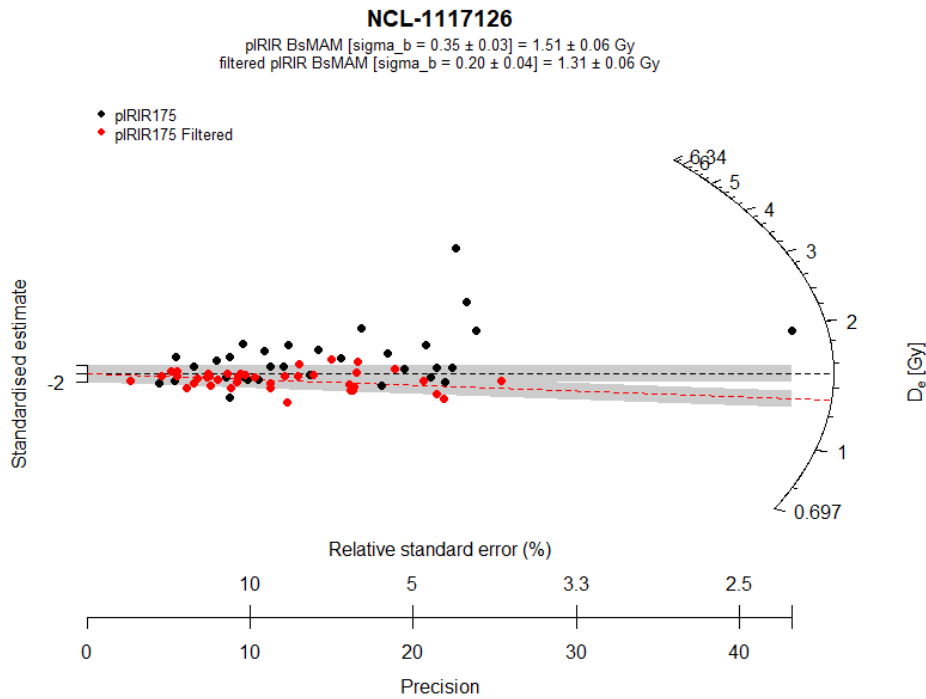


Figure S5. Radial plot of equivalent dose obtained from single-grain feldspar pIRIR measurement of NCL-1117126. The black dotted line indicates the BsMAM result of the total dataset, and the red dotted line indicates the BsMAM result of the filtered dataset. The σ_b values applied for each BsMAM are indicated in the figure.

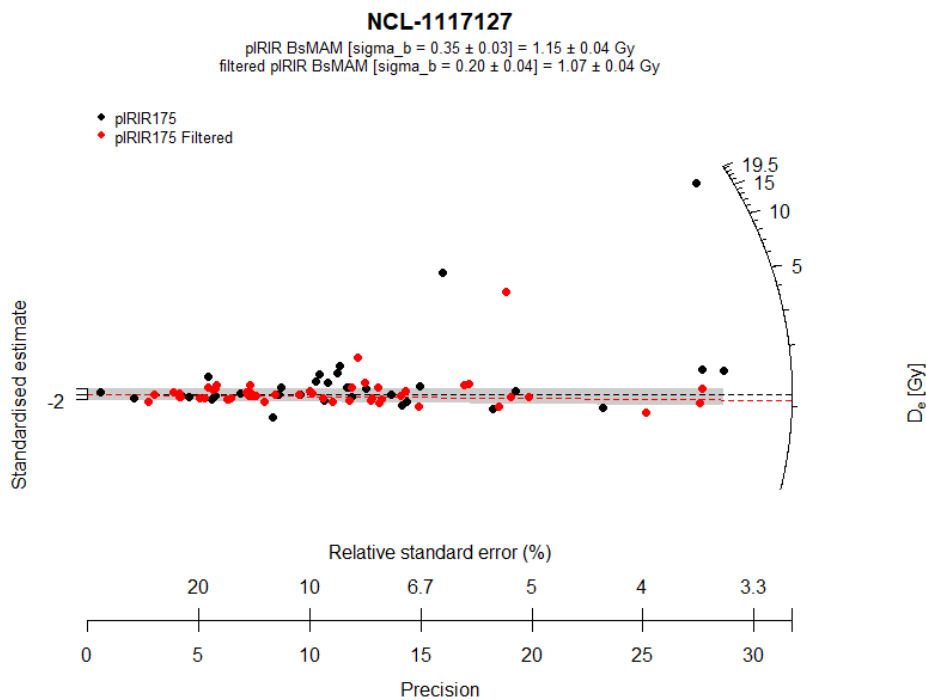


Figure S6. Radial plot of equivalent dose obtained from single-grain feldspar pIRIR measurement of NCL-1117127. The black dotted line indicates the BsMAM result of the total dataset, and the red dotted line indicates the BsMAM result of the filtered dataset. The σ_b values applied for each BsMAM are indicated in the figure.

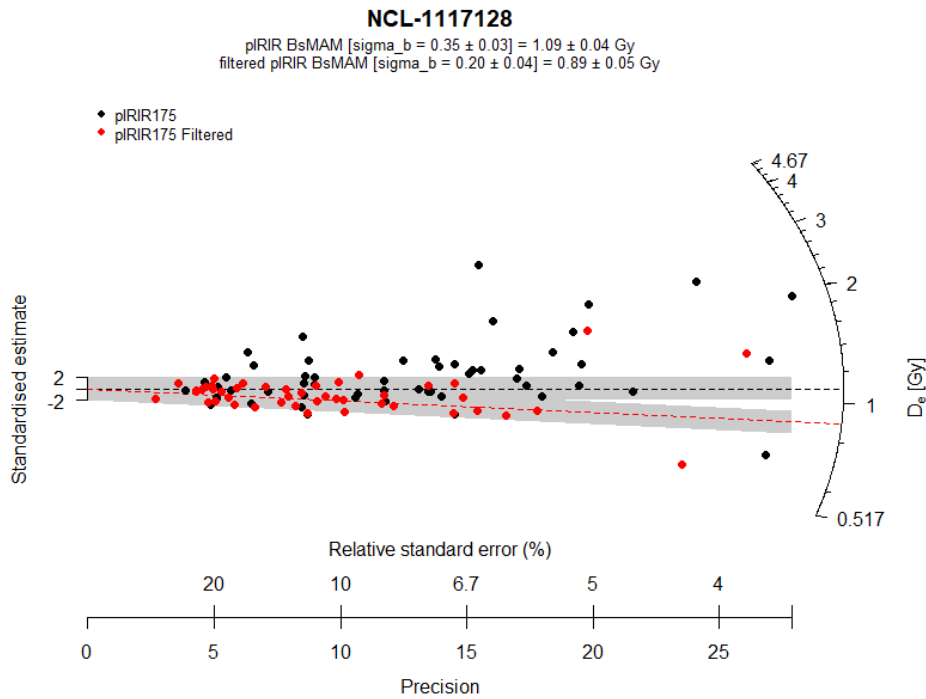


Figure S7. Radial plot of equivalent dose obtained from single-grain feldspar pIRIR measurement of NCL-1117128. The black dotted line indicates the BsMAM result of the total dataset, and the red dotted line indicates the BsMAM result of the filtered dataset. The σ_b values applied for each BsMAM are indicated in the figure.

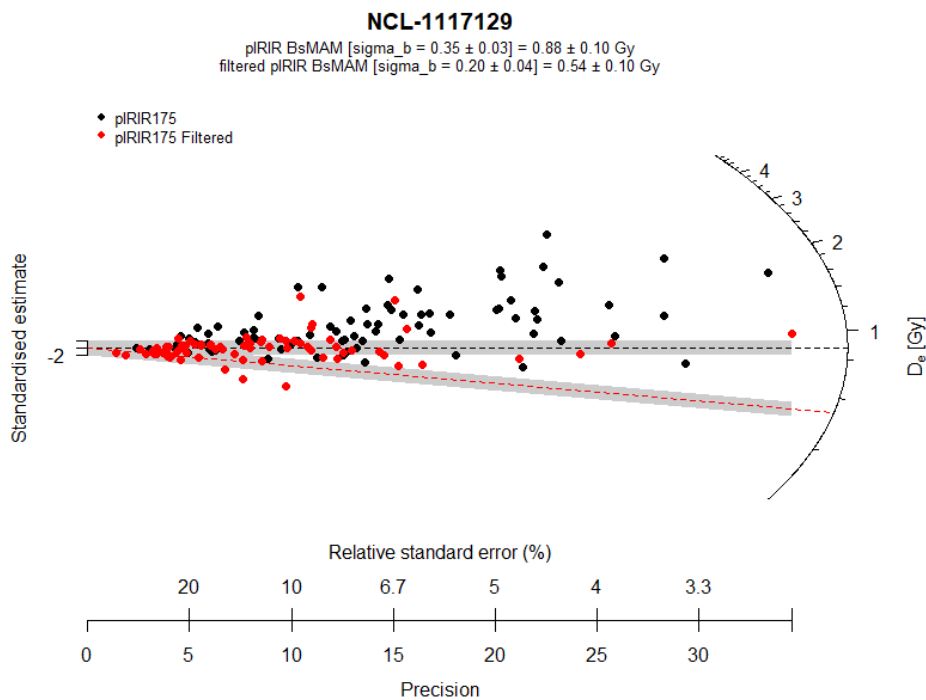


Figure S8. Radial plot of equivalent dose obtained from single-grain feldspar pIRIR measurement of NCL-1117129. The black dotted line indicates the BsMAM result of the total dataset, and the red dotted line indicates the BsMAM result of the filtered dataset. The σ_b values applied for each BsMAM are indicated in the figure.

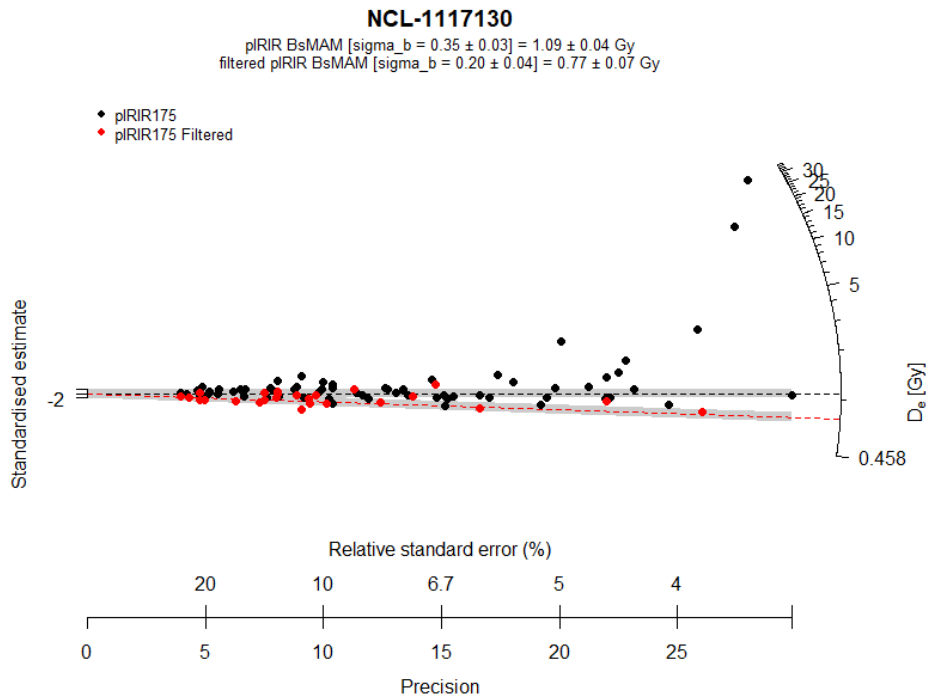


Figure S9. Radial plot of equivalent dose obtained from single-grain feldspar pIRIR measurement of NCL-1117130. The black dotted line indicates the BsMAM result of the total dataset, and the red dotted line indicates the BsMAM result of the filtered dataset. The σ_b values applied for each BsMAM are indicated in the figure.

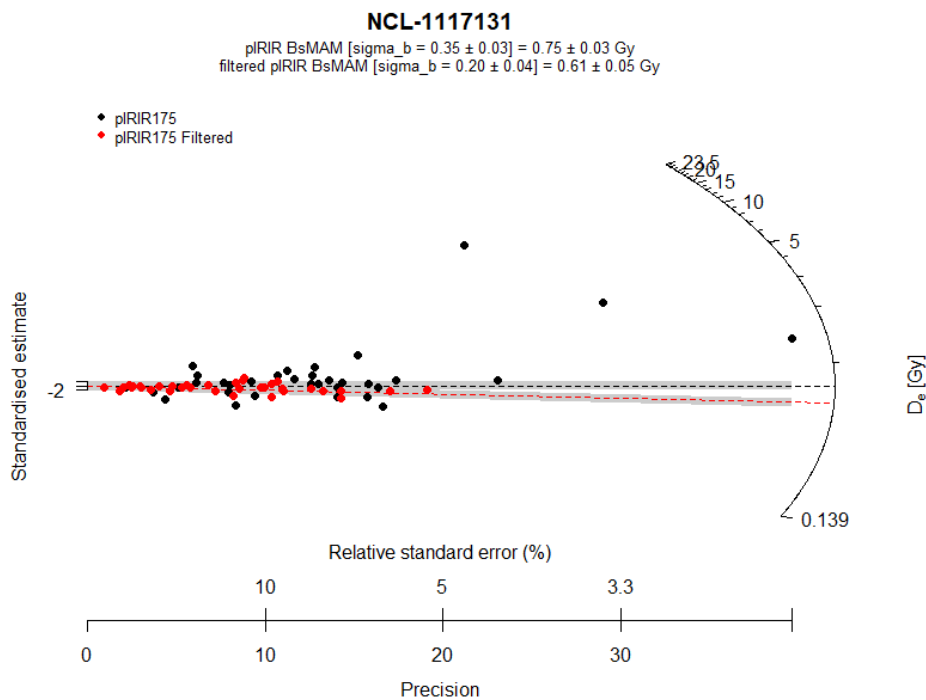


Figure S10. Radial plot of equivalent dose obtained from single-grain feldspar pIRIR measurement of NCL-1117131. The black dotted line indicates the BsMAM result of the total dataset, and the red dotted line indicates the BsMAM result of the filtered dataset. The σ_b values applied for each BsMAM are indicated in the figure.

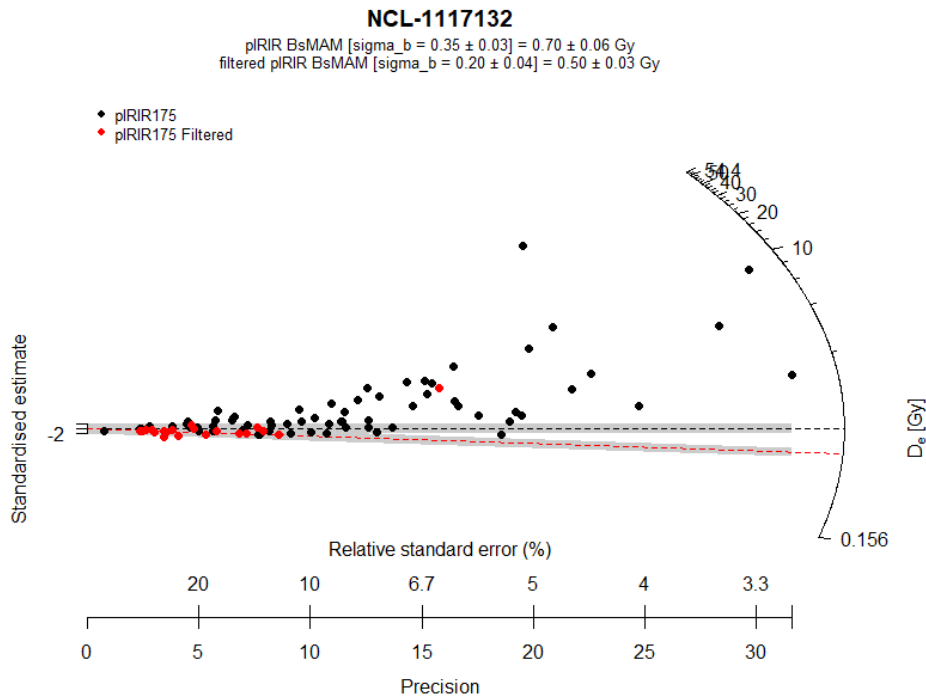


Figure S11. Radial plot of equivalent dose obtained from single-grain feldspar pIRIR measurement of NCL-1117132. The black dotted line indicates the BsMAM result of the total dataset, and the red dotted line indicates the BsMAM result of the filtered dataset. The σ_b values applied for each BsMAM are indicated in the figure.

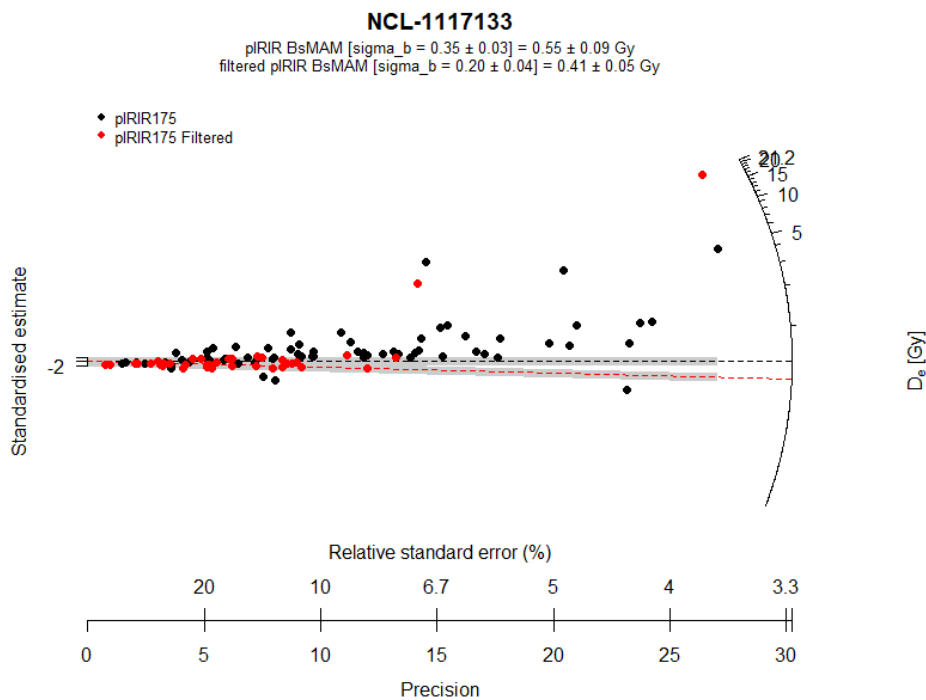


Figure S12. Radial plot of equivalent dose obtained from single-grain feldspar pIRIR measurement of NCL-1117133. The black dotted line indicates the BsMAM result of the total dataset, and the red dotted line indicates the BsMAM result of the filtered dataset. The σ_b values applied for each BsMAM are indicated in the figure.

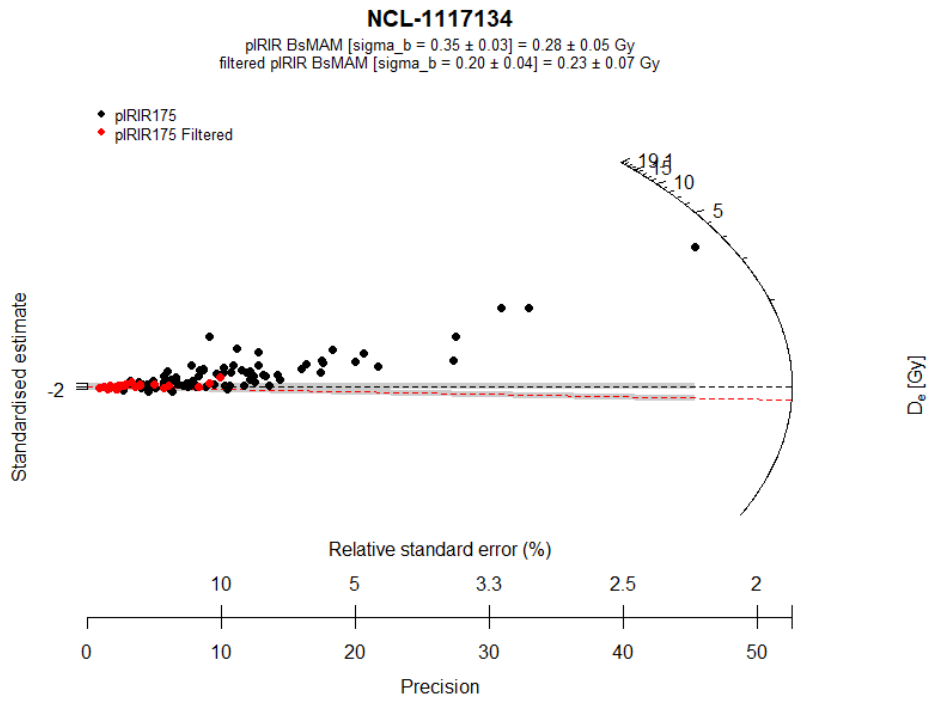


Figure S13. Radial plot of equivalent dose obtained from single-grain feldspar pIRIR measurement of NCL-1117134. The black dotted line indicates the BsMAM result of the total dataset, and the red dotted line indicates the BsMAM result of the filtered dataset. The σ_b values applied for each BsMAM are indicated in the figure.

Section S4. Age model results obtained from IRSL₅₀ signals

Table S4. Results of age models applied to D_e obtained from IRSL₅₀ signals. Note that the ages are rounded to decades. The σ_b applied to the BsMAM are equivalent to their pIRIR₁₇₅ counterparts.

Sample	Depth (cm)	Dose rate (Gy/ka)	CAM (Gy)	OD (%)	CAM (a)	BsMAM (Gy) $\sigma_b = 0.35 \pm 0.03$	BsMAM (a) $\sigma_b = 0.35 \pm 0.03$	CAM Filtered (Gy)	OD Filtered (%)	CAM Filtered (a)	BsMAM Filtered (Gy) $\sigma_b = 0.20 \pm 0.04$	BsMAM Filtered (a) $\sigma_b = 0.20 \pm 0.04$
NCL-1117134	22	2.10 ± 0.10	0.20 ± 0.08	72 ± 6	90 ± 40 (1920 ± 40 CE)	0.14 ± 0.01	70 ± 10 (1950 ± 10 CE)	0.20 ± 0.14	51 ± 12	90 ± 70 (1920 ± 70 CE)	0.12 ± 0.04	60 ± 20 (1960 ± 20 CE)
NCL-1117133	31	1.99 ± 0.10	0.41 ± 0.06	73 ± 5	210 ± 30 (1810 ± 30 CE)	0.38 ± 0.01	190 ± 10 (1830 ± 10 CE)	0.39 ± 0.14	71 ± 10	200 ± 70 (1820 ± 70 CE)	0.32 ± 0.04	160 ± 20 (1860 ± 20 CE)
NCL-1117132	41	2.03 ± 0.10	0.47 ± 0.07	63 ± 5	230 ± 30 (1790 ± 30 CE)	0.42 ± 0.02	210 ± 20 (1810 ± 20 CE)	0.42 ± 0.11	47 ± 8	210 ± 60 (1810 ± 60 CE)	0.38 ± 0.02	190 ± 20 (1830 ± 20 CE)
NCL-1117131	50	2.07 ± 0.10	0.54 ± 0.05	48 ± 3	260 ± 30 (1760 ± 30 CE)	0.52 ± 0.02	250 ± 20 (1770 ± 20 CE)	0.49 ± 0.05	22 ± 4	240 ± 30 (1780 ± 30 CE)	0.46 ± 0.03	220 ± 20 (1800 ± 20 CE)
NCL-1117130	60	2.09 ± 0.10	0.65 ± 0.05	50 ± 4	310 ± 30 (1700 ± 30 CE)	0.62 ± 0.03	300 ± 20 (1720 ± 20 CE)	0.76 ± 0.07	28 ± 5	360 ± 40 (1660 ± 40 CE)	0.63 ± 0.09	300 ± 50 (1710 ± 50 CE)
NCL-1117129	70	2.11 ± 0.10	0.71 ± 0.03	38 ± 2	340 ± 20 (1680 ± 20 CE)	0.68 ± 0.02	320 ± 20 (1700 ± 20 CE)	0.72 ± 0.04	31 ± 3	340 ± 30 (1680 ± 30 CE)	0.64 ± 0.05	300 ± 30 (1710 ± 30 CE)
NCL-1117128	81	2.11 ± 0.10	0.76 ± 0.03	35 ± 2	360 ± 20 (1660 ± 20 CE)	0.74 ± 0.03	350 ± 20 (1670 ± 20 CE)	0.83 ± 0.04	24 ± 3	400 ± 30 (1620 ± 30 CE)	0.78 ± 0.04	370 ± 30 (1650 ± 30 CE)
NCL-1117127	96	2.12 ± 0.10	1.01 ± 0.05	56 ± 4	480 ± 30 (1540 ± 30 CE)	0.91 ± 0.03	430 ± 20 (1590 ± 20 CE)	1.08 ± 0.07	43 ± 5	510 ± 40 (1510 ± 40 CE)	0.96 ± 0.04	460 ± 30 (1560 ± 30 CE)
NCL-1117126	101	2.00 ± 0.10	1.10 ± 0.04	46 ± 3	550 ± 40 (1470 ± 40 CE)	1.05 ± 0.04	530 ± 30 (1490 ± 30 CE)	1.15 ± 0.04	17 ± 3	570 ± 40 (1440 ± 40 CE)	1.12 ± 0.07	560 ± 40 (1460 ± 40 CE)
NCL-1117125	112	1.97 ± 0.10	1.60 ± 0.06	60 ± 5	810 ± 50 (1200 ± 50 CE)	1.33 ± 0.07	680 ± 50 (1340 ± 50 CE)	1.67 ± 0.10	55 ± 7	850 ± 70 (1170 ± 70 CE)	1.31 ± 0.12	670 ± 70 (1350 ± 70 CE)
NCL-1117124	123	2.02 ± 0.10	4.86 ± 0.06	75 ± 4	2410 ± 120 (390 ± 120 BCE)	2.74 ± 0.26	1360 ± 150 (660 ± 150 CE)	5.52 ± 0.11	71 ± 8	2740 ± 150 (720 ± 150 BCE)	2.77 ± 0.33	1380 ± 180 (640 ± 180 CE)
NCL-1117123	142	2.09 ± 0.10	12.21 ± 0.04	52 ± 3	5840 ± 290 (3830 ± 290 BCE)	7.96 ± 1.04	3810 ± 530 (1790 ± 530 BCE)	12.46 ± 0.08	50 ± 6	5960 ± 290 (3940 ± 290 BCE)	6.29 ± 0.94	3010 ± 470 (990 ± 470 BCE)
NCL-1117122	165	2.15 ± 0.10	15.37 ± 0.03	33 ± 2	7140 ± 340 (5120 ± 340 BCE)	15.05 ± 0.74	6990 ± 490 (4970 ± 490 BCE)	16.82 ± 0.05	29 ± 3	7810 ± 370 (5790 ± 370 BCE)	14.57 ± 3.11	6760 ± 1480 (4750 ± 1480 BCE)

Section S5. Radial plots of single-aliquot quartz OSL measurements

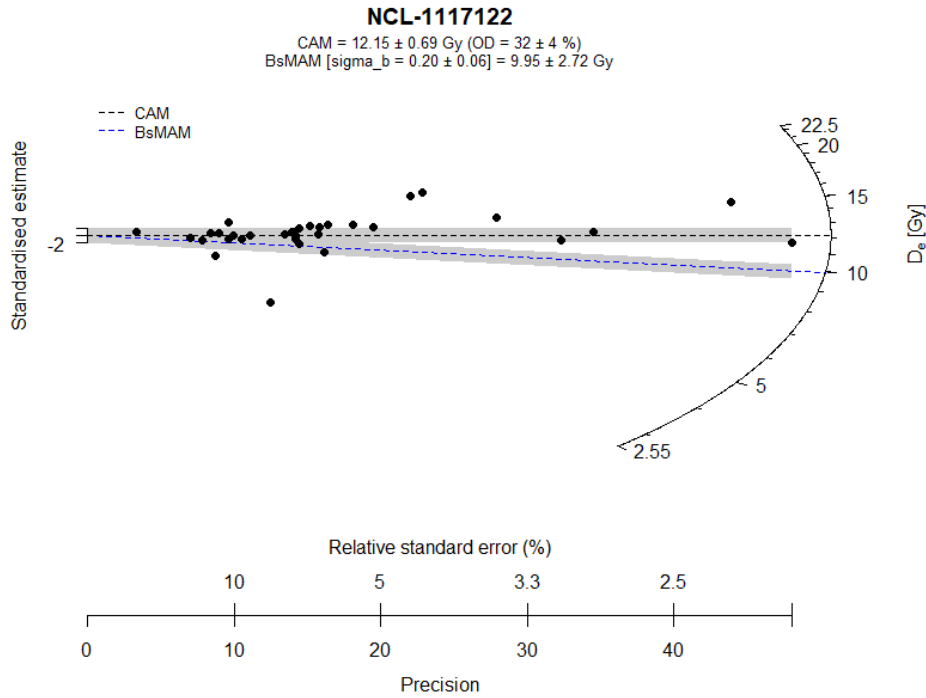


Figure S14. Radial plot of equivalent dose obtained from single-aliquot quartz OSL measurement of NCL-1117122. The black dotted line indicates the CAM result, and the blue dotted line indicates the BsMAM result.

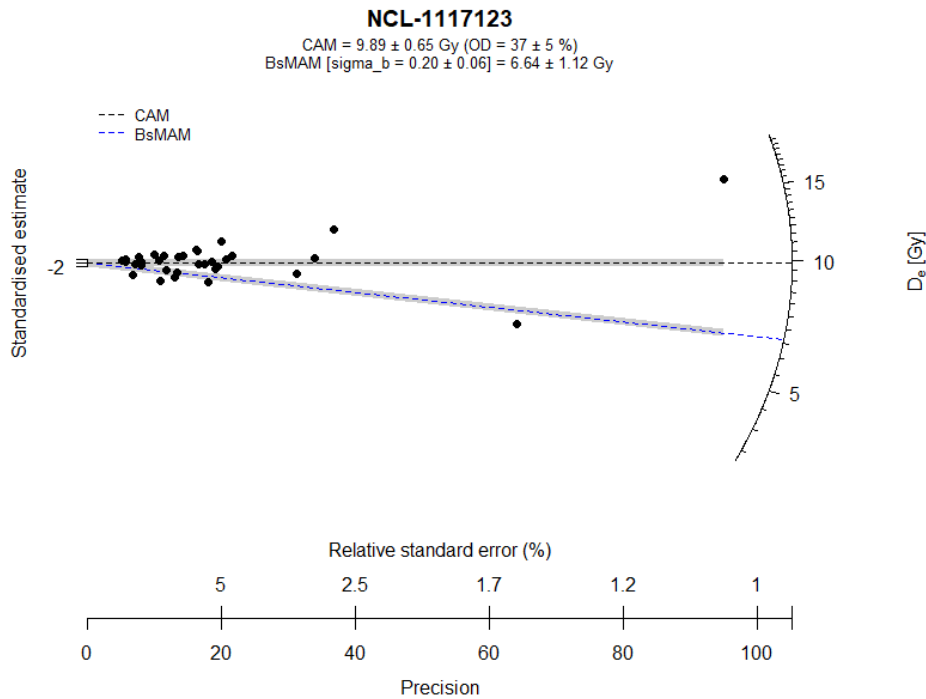


Figure S15. Radial plot of equivalent dose obtained from single-aliquot quartz OSL measurement of NCL-1117123. The black dotted line indicates the CAM result, and the blue dotted line indicates the BsMAM result.

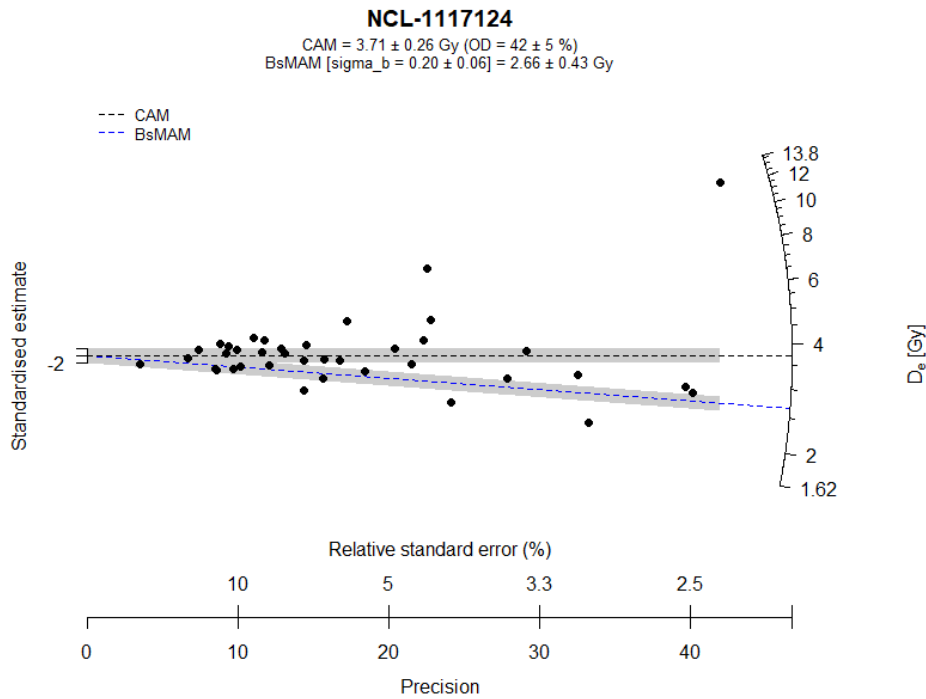


Figure S16. Radial plot of equivalent dose obtained from single-aliquot quartz OSL measurement of NCL-1117124. The black dotted line indicates the CAM result, and the blue dotted line indicates the BsMAM result.

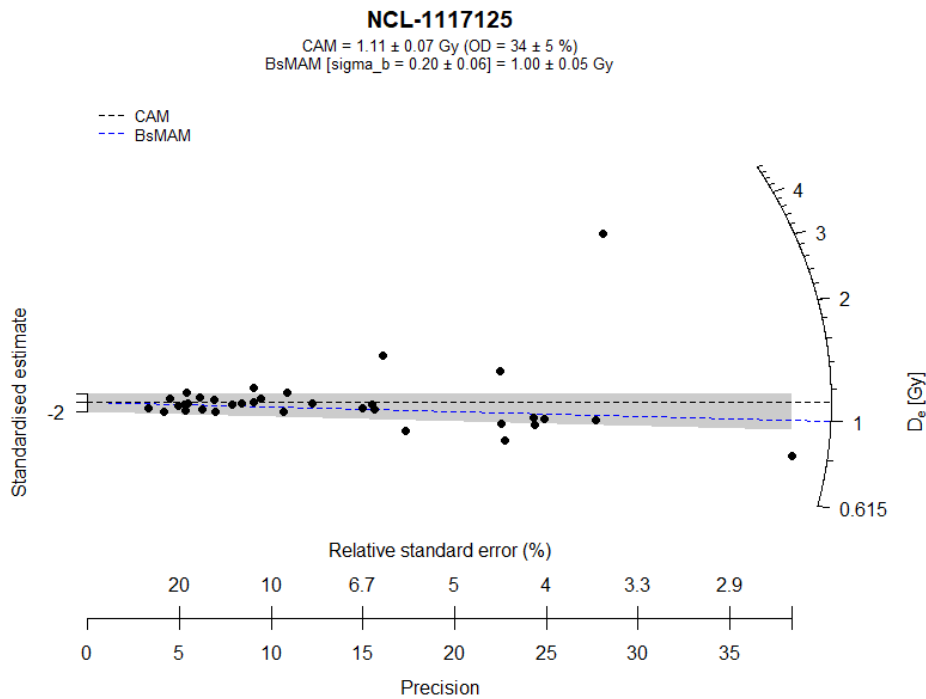


Figure S17. Radial plot of equivalent dose obtained from single-aliquot quartz OSL measurement of NCL-1117125. The black dotted line indicates the CAM result, and the blue dotted line indicates the BsMAM result.

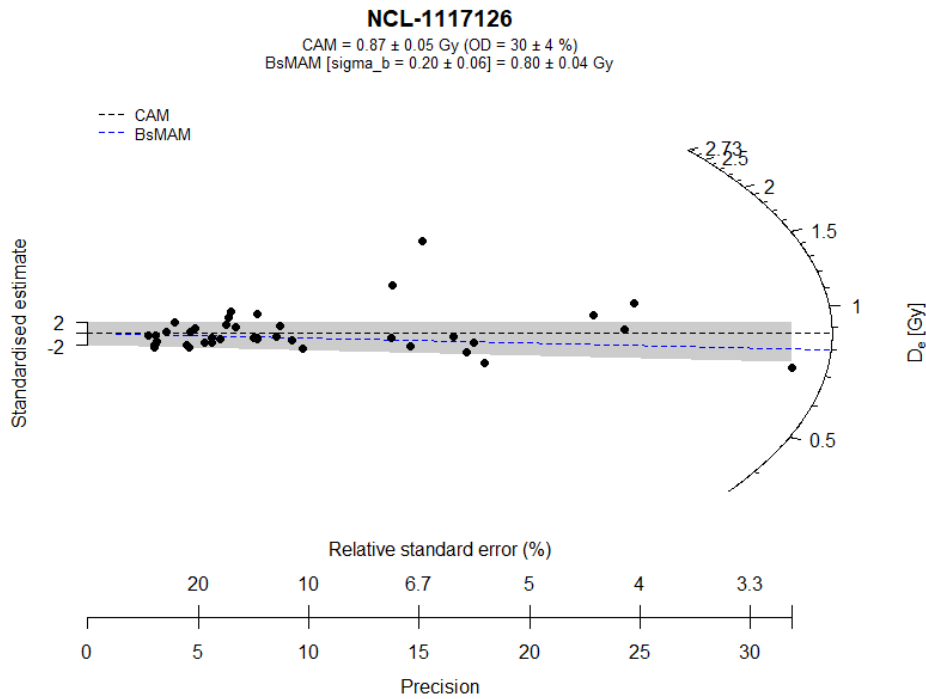


Figure S18. Radial plot of equivalent dose obtained from single-aliquot quartz OSL measurement of NCL-1117126. The black dotted line indicates the CAM result, and the blue dotted line indicates the BsMAM result.

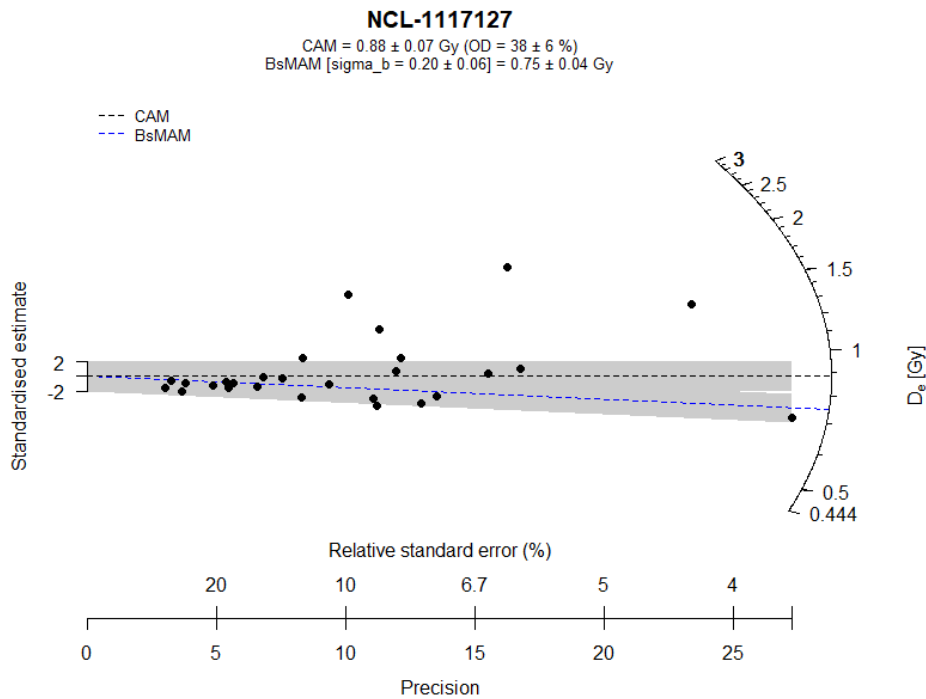


Figure S19. Radial plot of equivalent dose obtained from single-aliquot quartz OSL measurement of NCL-1117127. The black dotted line indicates the CAM result, and the blue dotted line indicates the BsMAM result.

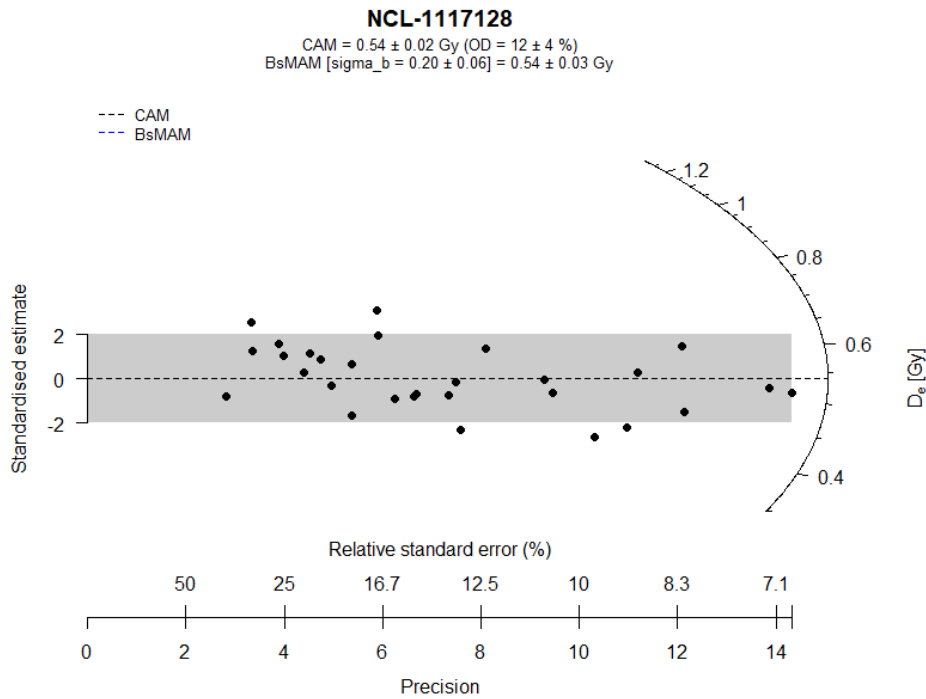


Figure S20. Radial plot of equivalent dose obtained from single-aliquot quartz OSL measurement of NCL-1117127. The black dotted line indicates the CAM result, and the blue dotted line indicates the BsMAM result.

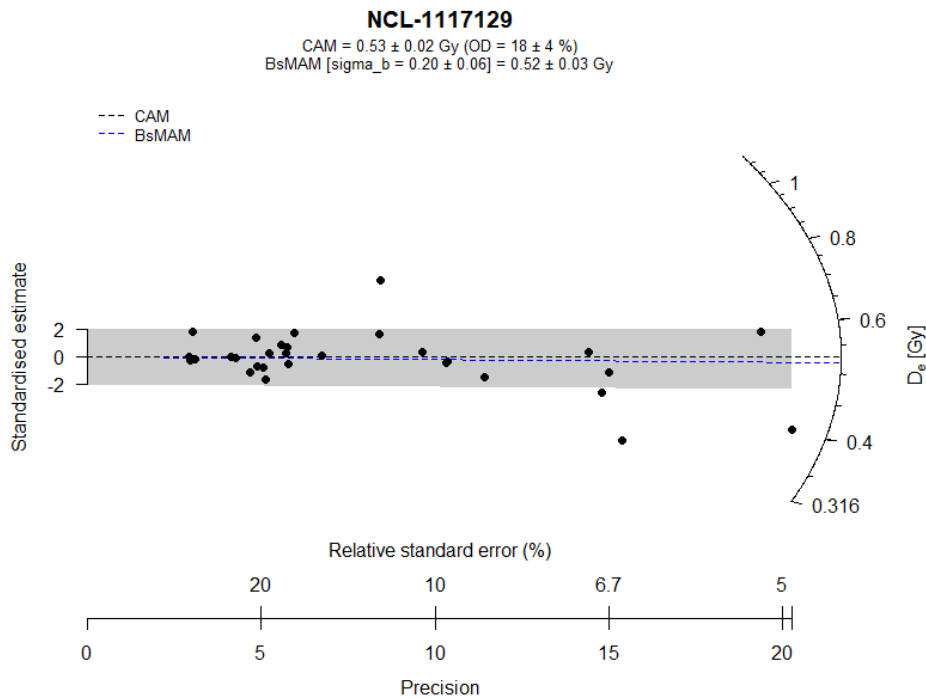


Figure S21. Radial plot of equivalent dose obtained from single-aliquot quartz OSL measurement of NCL-1117129. The black dotted line indicates the CAM result, and the blue dotted line indicates the BsMAM result.

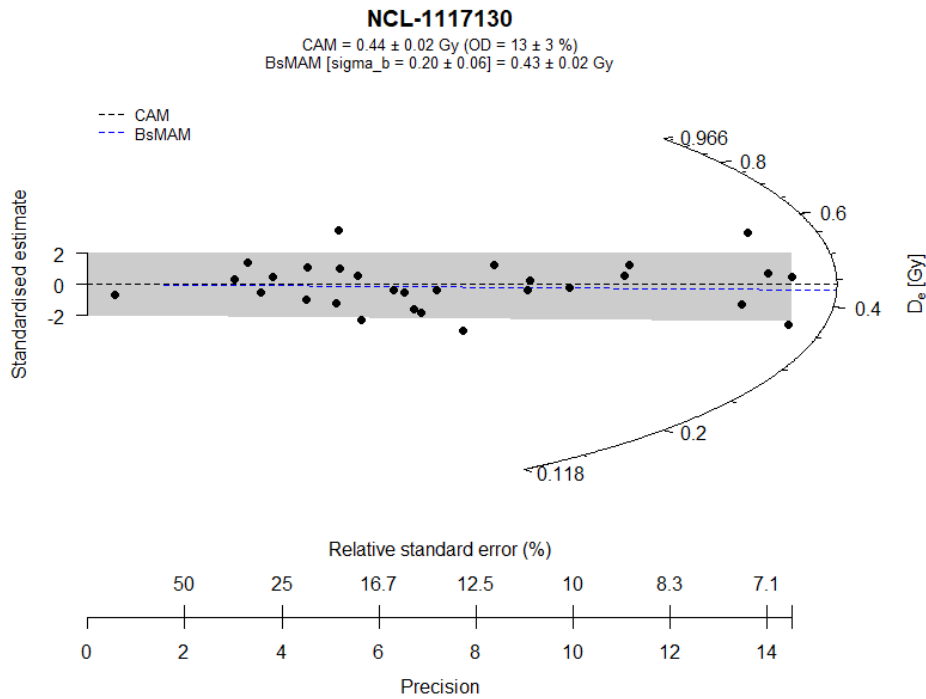


Figure S22. Radial plot of equivalent dose obtained from single-aliquot quartz OSL measurement of NCL-1117130. The black dotted line indicates the CAM result, and the blue dotted line indicates the BsMAM result.

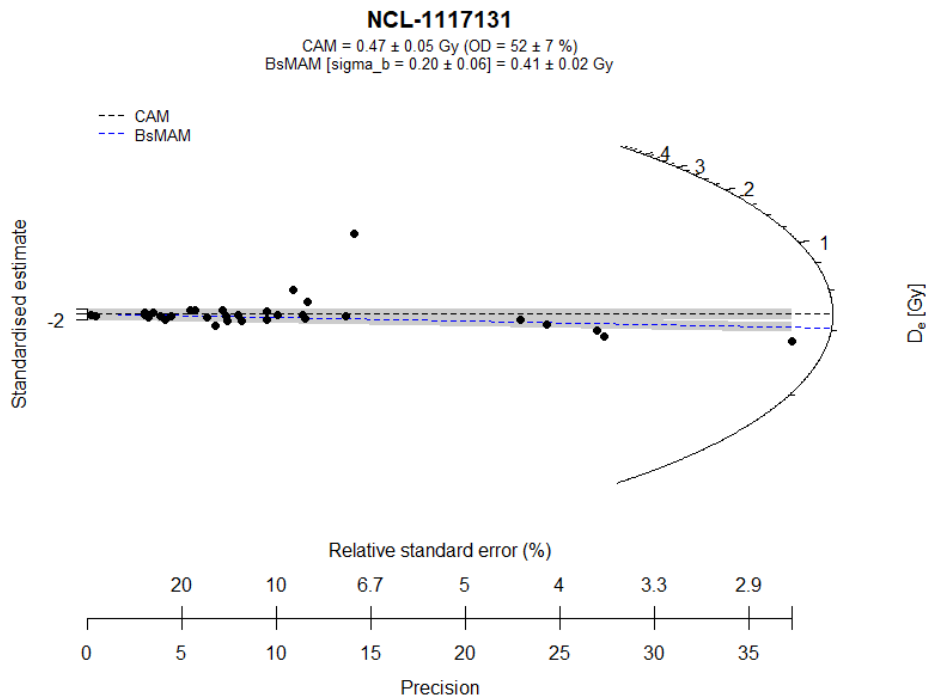


Figure S23. Radial plot of equivalent dose obtained from single-aliquot quartz OSL measurement of NCL-1117131. The black dotted line indicates the CAM result, and the blue dotted line indicates the BsMAM result.

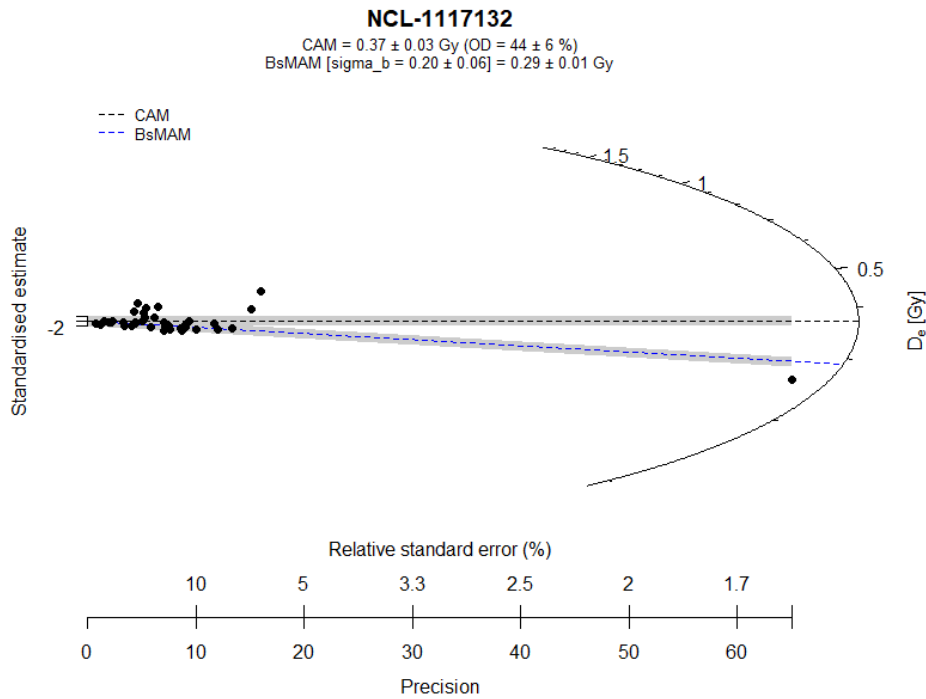


Figure S24. Radial plot of equivalent dose obtained from single-aliquot quartz OSL measurement of NCL-1117132. The black dotted line indicates the CAM result, and the blue dotted line indicates the BsMAM result.

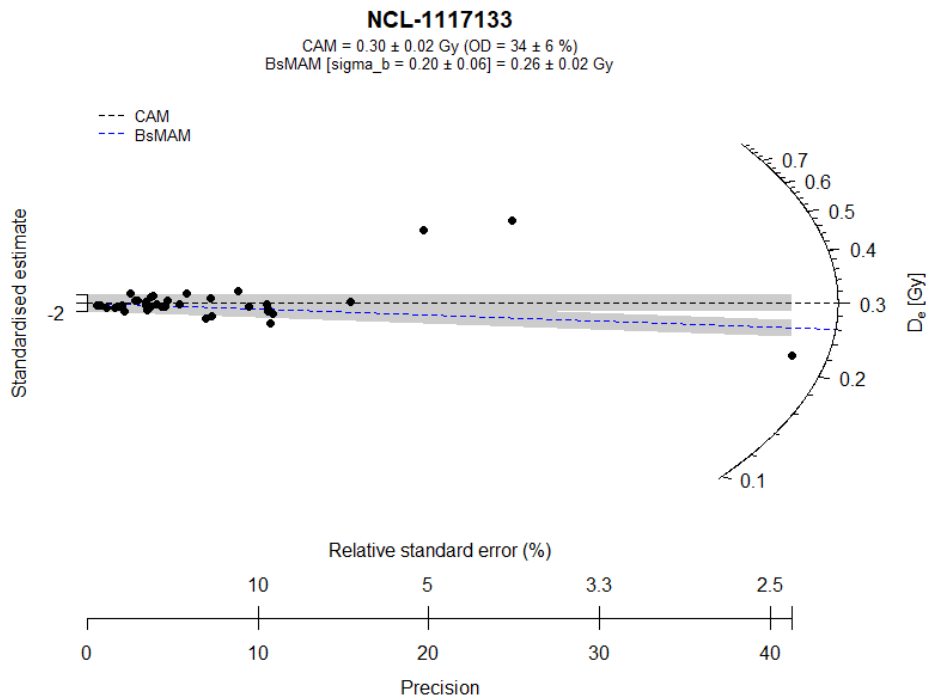


Figure S25. Radial plot of equivalent dose obtained from single-aliquot quartz OSL measurement of NCL-1117133. The black dotted line indicates the CAM result, and the blue dotted line indicates the BsMAM result.

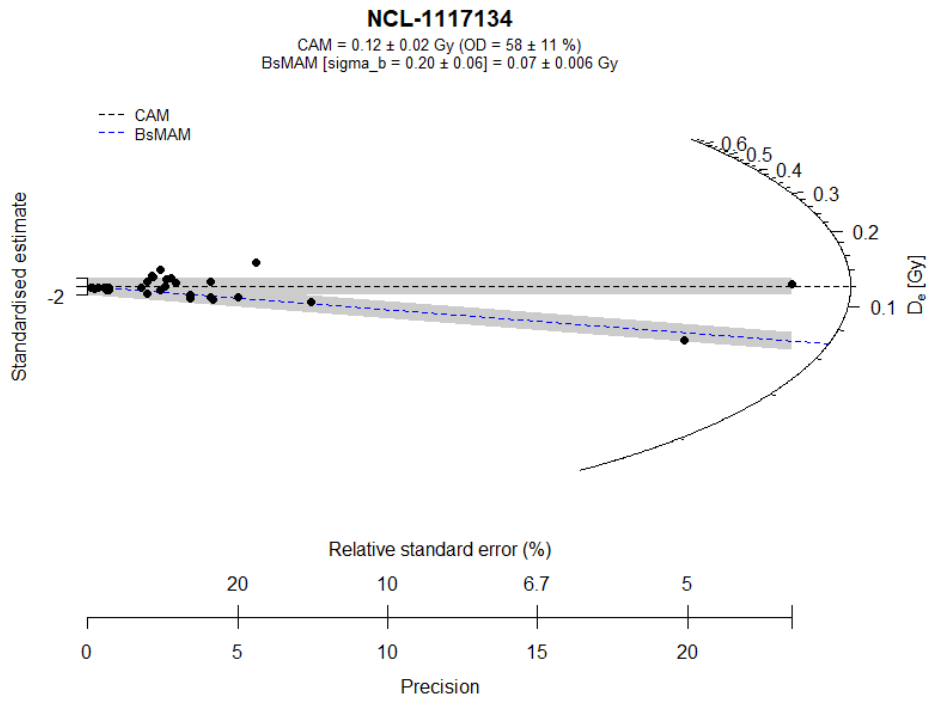


Figure S26. Radial plot of equivalent dose obtained from single-aliquot quartz OSL measurement of NCL-1117134. The black dotted line indicates the CAM result, and the blue dotted line indicates the BsMAM result.