Data Repository Item

APPENDIX DR1.

Samples for OSL dating were collected at 10-20 cm intervals from freshly cleaned sections at the sites, either as 10x10x10 cm blocks or in metal tubes hammered into the section face. Samples were wrapped in light-tight black plastic bags immediately after being removed from the sections and were processed in the laboratory under subdued red light. Sunlight-exposed outer surfaces of blocks and the ends of tube samples were excluded from equivalent dose (D_e) determinations but retained for radioisotope measurements (to determine dose rate). Carbonates and organic matter were removed from the D_e (unexposed) fractions using 0.1 M HCl and 15% H_2O_2. Quartz was isolated by immersion in 35% H_2SiF_6 for up to 4 weeks with a subsequent 0.1M HCL wash to remove fluorite precipitates. The coarse silt fraction (40-63 μm) was obtained by wet sieving. D_e values were measured using the SAR procedure (Murray and Wintle, 2000) or using a standardized growth curve (see below) performed on a Risø TL-DA-15 TL/OSL reader (Figure DR1). A blue LED (λ = 470 ± 20 nm) stimulation source was used on samples and the OSL signal was measured using a 9235QA photomultiplier tube filtered by 6mm of Hoya U340 glass (Bøtter-Jensen et al., 2000). The signal was integrated from the first 0.6 s of stimulation minus a background estimated from the last 6 s of stimulation. All growth curves were fitted using a saturating exponential plus linear function. Aliquots yielding recycling ratios (Murray and Wintle, 2000) or IR ratios (Duller, 2003) differing from unity by greater than 10% were rejected. The uncertainty on individual D_e values was estimated using Monte Carlo simulation and a weighted mean D_e (with one standard error uncertainty) was calculated for each sample (up to 14 aliquots).

In order to increase the efficiency of obtaining dates, the D_es of certain samples from Xifeng and the main section at Beiguoyuan were obtained through constructed standardized growth curves (SGC). Roberts and Duller (2004) suggest that when using the SAR technique, which normalizes all data to the luminescence intensity observed using a fixed "test dose", quartz may exhibit a uniform response to laboratory dose and thus growth curves for samples from the same site or region will be identical within errors. Roberts and Duller (2004) utilized this to construct SGCs for different sediments. An SGC is constructed through calculation of mean sensitivity-corrected luminescence intensity for each dose point in the growth curve. Equivalent doses can therefore be calculated for aliquots where only the sensitivity-corrected natural luminescence intensity has been measured. This approach can facilitate high-resolution dating of Chinese loess by dramatically increasing sample throughput (Stevens et al., in press). The validity of this approach was tested using samples from Beiguoyuan. After construction of an SGC from 121 aliquots from the main section at Beiguoyuan, Monte Carlo simulation was used to calculate the D_e for nine different samples from this section. Figure DR2 shows D_es with errors calculated using an SGC, plotted against standard SAR D_e values. D_es calculated using the SGC are identical within errors to those obtained through the standard SAR technique, confirming the applicability of an SGC approach in this case. A further SGC was then constructed using dose response data of 208 aliquots from Xifeng (regeneration doses of 5, 10, 20, 50 and 100 Gy using a 20 Gy test dose). Equivalent doses were calculated for samples from Beiguoyuan and Xifeng sections using the SGC measured for that site (Table DR1).

Dose rates were calculated using uranium, thorium and potassium contents measured using Inductively Coupled Plasma Mass Spectrometry (ICP-MS) and

Atomic Emission Spectrometry (-AES). ICP samples were prepared by lithium metaborate or sodium peroxide fusion. Dose rates were calculated assuming a water content of 8±4% based on current moisture contents determined in the laboratory, and an alpha efficiency of 0.04±0.02 (Rees-Jones, 1995). Alpha and beta attenuation was calculated using Bell (1980) and Mejdahl (1979) and dose rate conversion factors were taken from Adamiec and Aitken (1998). Uncertainties are based on the propagation, in quadrature, of individual errors for all measured quantities, which if unknown are taken as 10%. In addition to uncertainties calculated from counting statistics, errors due to 1) beta source calibration (3%, Armitage and Bailey, 2005), 2) radioisotope concentration (3%), 3) dose rate conversion factors (3%) and 4) attenuation factors (3%) have been included (Murray and Olley, 2002). The cosmic dose was calculated using present day burial depth (Prescott and Hutton, 1994). D_e, dosimetry and age data are presented in Table DR1.

REFERENCES CITED

Adamiec, G., Aitken, M.J., 1998, Dose rate conversion factors: update: Ancient TL, v. 16, p. 37-50.

Armitage, S.J., Bailey, R.M., 2005, The measured dependence of laboratory beta dose rates on sample grain size: Radiation Measurements, v. 39, p. 123-127.

Bell, W.T., 1980, Alpha dose attenuation in quartz grains for thermoluminescence dating: Ancient TL, v. 12, p. 4-8.

Bøtter-Jensen, L., Bulur, E., Duller, G.A.T., Murray, A.S., 2000, Advances in luminescence instrumentation: Radiation Measurements, v. 32, p. 523-528.

Duller, G.A.T., 2003, Distinguishing quartz and feldspar in single grain luminescence measurements: Radiation Measurements, v. 37, p. 161-165.

Mejdahl, V., 1979, Thermoluminescence dating: beta-dose attenuation in quartz grains: Archaeometry, v. 21, p. 61-72.

Murray, A.S., Wintle, A.G., 2000, Luminescence dating of quartz using an improved single-aliquot regenerative-dose procedure: Radiation Measurements, v. 32, p. 57-73.

Murray, A.S., Olley, J.M., 2002, Precision and accuracy in the optically stimulated luminescence dating of sedimentary quartz: A status review: Geochronometria, v. 21, p. 1-16.

Prescott, J.R., Hutton, J.T., 1994, Cosmic ray contributions to dose rates for luminescence and ESR dating: large depths and long term variations: Radiation Measurements, v. 23, p. 497-500.

Rees- Jones, J., 1995, Optical dating of young sediments using fine-grain quartz: Ancient TL, v. 13, p. 9-13.

Roberts, H.M., Duller, G.A.T., 2004, Standardised growth curves for optical dating of sediment using multiple-grain aliquots: Radiation Measurements, v. 38, p. 241-252.

Stevens, T., Armitage, S.J., Lu, H., Thomas, D.S.G., in press, Examining the potential of high sampling resolution OSL dating of Chinese loess: Quaternary Geochronology.

FIGURES

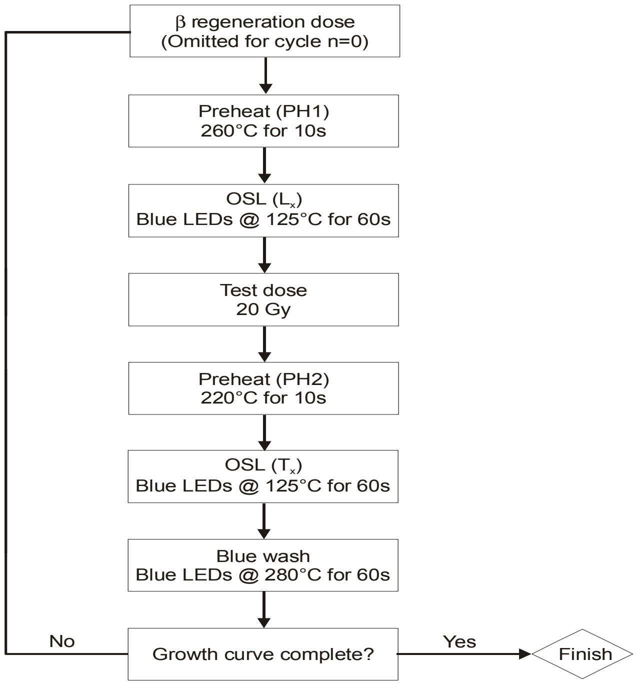

Figure DR1. Modified SAR protocol used in study.

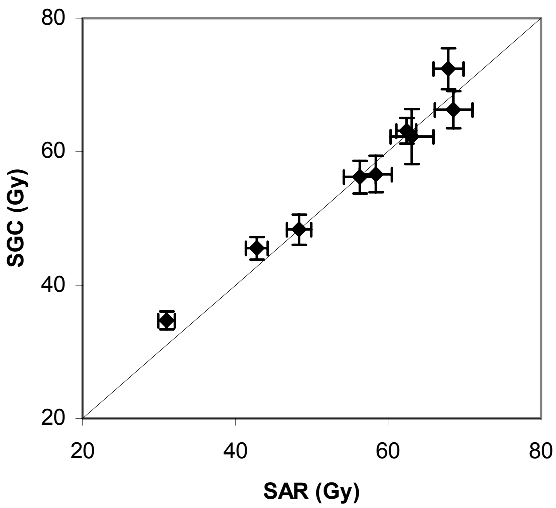

Figure DR2. Equivalent doses (Gy) for Beiguoyuan samples determined using a standardized growth curve (SGC) and the standard single aliquot regeneration (SAR) protocol. The dark line is the 1:1 line.

TABLES

TABLE DR1. OPTICAL DATING RESULTS SHWOING SAMPLE CODE, SAMPLING DEPTH, U-, Th- AND K-CONCENTRATIONS, COSMIC DOSE, TOTAL DOSE RATE, EQUIVALENT DOSE (D_e), NUMBER OF SAMPLES (n), AND THE AGE.*

Sample CH04/	Depth (cm)	U (ppm)	Th (ppm)	K (%)	Cosmic (Gy/ka)	Dose rate (Gy/ka)	D_e (Gy)	n	Age (ka)
Beiguoyuan Main site									
1/1	30-40	2.32±0.07	10.29±0.31	1.68±0.05	0.24±0.01	3.21±0.12	25.4±1.0	13	7.9±0.4
1/2	40-50	2.31±0.07	10.16±0.31	1.70±0.05	0.23±0.01	3.22±0.12	24.3±1.0	12	7.6±0.4
1/3	50-60	2.30±0.07	10.05±0.30	1.68±0.05	0.23±0.01	3.18±0.12	31.0±1.1	14	9.8±0.5
1/4	60-70	2.34±0.08	10.61±0.32	1.70±0.05	0.23±0.01	3.25±0.12	26.5±1.5	14	8.1±0.5
1/5	70-80	2.27±0.07	10.41±0.32	1.70±0.05	0.22±0.01	3.22±0.12	31.7±1.2	14	9.9±0.5
1/6	80-90	2.26±0.10	10.37±0.36	1.65±0.05	0.22±0.01	3.16±0.12	46.1±1.7SGC	12	14.6±0.8
1/7	90-100	2.33±0.07	10.34±0.32	1.71±0.05	0.22±0.01	3.23±0.12	42.8±1.4	14	13.3±0.7
1/8	100-110	2.33±0.07	10.12±0.31	1.73±0.05	0.21±0.01	3.23±0.12	51.7±3.0SGC	11	16.0±1.1
1/9	110-120	2.35±0.07	9.84±0.30	1.69±0.05	0.21±0.01	3.17±0.12	58.7±1.6	14	18.5±0.9
1/11	130-140	2.08±0.07	9.38±0.28	1.75±0.05	0.21±0.01	3.11±0.12	58.4±2.1	13	18.8±1.0
1/12	140-150	2.20±0.07	9.60±0.29	1.76±0.05	0.20±0.01	3.17±0.12	54.4±1.8SGC	23	17.2±0.9
1/13	150-160	2.09±0.06	9.30±0.28	1.75±0.05	0.20±0.01	3.10±0.12	56.3±2.1	13	18.1±1.0
1/14	160-170	2.18±0.08	9.83±0.30	1.77±0.05	0.20±0.01	3.18±0.12	56.5±1.8SGC	10	17.7±0.9
1/15	170-180	2.13±0.07	9.45±0.29	1.70±0.05	0.20±0.01	3.08±0.12	61.1±2.0	14	19.9±1.0
1/16	180-190	2.19±0.07	9.68±0.30	1.73±0.05	0.19±0.01	3.13±0.12	58.4±1.9SGC	24	18.7±0.9
1/17	190-200	2.26±0.07	9.47±0.29	1.76±0.05	0.19±0.01	3.16±0.12	63.1±2.8	13	20.0±1.2
1/18	200-210	2.28±0.07	9.90±0.30	1.77±0.05	0.19±0.01	3.20±0.12	59.7±2.1SGC	12	18.6±1.0
1/19	210-220	2.24±0.07	9.79±0.30	1.75±0.05	0.19±0.01	3.17±0.12	62.4±1.3	13	19.7±0.9
1/20	220-230	2.26±0.07	9.84±0.30	1.78±0.05	0.18±0.01	3.20±0.12	63.4±4.3SGC	11	19.8±1.5
1/21	230-240	2.29±0.07	9.83±0.30	1.81±0.05	0.18±0.01	3.23±0.12	63.7±5.4	11	19.7±1.8
1/22	240-250	2.30±0.07	9.96±0.30	1.83±0.06	0.18±0.01	3.26±0.12	67.9±2.0	14	20.8±1.0
1/23	250-260	2.34±0.07	10.04±0.30	1.85±0.06	0.18±0.01	3.30±0.13	68.1±4.4SGC	12	20.7±1.5
1/24	260-270	2.38±0.07	10.25±0.31	1.82±0.05	0.17±0.01	3.29±0.13	66.6±2.9SGC	12	20.2±1.2
1/25	270-280	2.44±0.08	10.25±0.31	1.87±0.06	0.17±0.01	3.37±0.13	68.8±2.5	14	20.3±1.1
1/26	280-290	2.40±0.07	10.07±0.30	1.83±0.06	0.17±0.01	3.28±0.13	66.9±3.4SGC	12	20.4±1.3
1/27	290-300	2.45±0.07	10.02±0.31	1.80±0.05	0.17±0.01	3.27±0.12	66.3±4.3	13	20.3±1.5
1/28	300-310	2.28±0.07	9.57±0.29	1.82±0.05	0.16±0.01	3.20±0.12	64.5±3.0SGC	12	20.1±1.2
1/29	310-320	2.31±0.07	9.65±0.29	1.78±0.05	0.16±0.01	3.18±0.12	71.9±2.4SGC	19	22.6±1.2
1/30	320-330	2.39±0.08	10.13±0.31	1.79±0.05	0.16±0.01	3.25±0.12	64.8±1.7SGC	27	20.0±0.9
Beiguoyuan Holocene site									
1/244	85	2.31±0.07	10.89±0.34	1.86±0.06	0.22±0.01	3.40±0.13	3.7±0.2	14	1.1±0.1
1/245	95	2.43±0.07	11.41±0.35	1.88±0.06	0.22±0.01	3.49±0.13	0.7±0.1	14	0.2±0.0
1/246	105	2.39±0.07	11.17±0.34	1.93±0.06	0.21±0.01	3.50±0.13	0.9±0.2	14	0.3±0.1
1/247	115	2.52±0.08	11.63±0.36	1.95±0.06	0.21±0.01	3.59±0.14	0.9±0.0	14	0.3±0.0
1/248	125	2.31±0.07	11.34±0.35	2.03±0.06	0.21±0.01	3.59±0.14	7.5±0.5	12	2.1±0.2
1/249	135	2.25±0.07	10.72±0.32	1.94±0.06	0.21±0.01	3.44±0.13	12.5±0.3	13	3.6±0.2
1/250	145	2.43±0.08	11.45±0.36	1.96±0.06	0.20±0.01	3.56±0.14	13.4±0.3	14	3.8±0.2
1/251	155	2.29±0.07	10.83±0.33	1.93±0.06	0.20±0.01	3.44±0.13	15.3±0.3	14	4.4±0.2
1/252	165	2.18±0.07	10.45±0.33	1.88±0.06	0.20±0.01	3.34±0.13	15.3±0.6	13	4.6±0.3
1/253	175	2.23±0.08	10.48±0.33	1.90±0.06	0.19±0.01	3.37±0.13	16.5±0.3	14	4.9±0.2
1/254	185	2.24±0.07	10.45±0.32	1.85±0.06	0.19±0.01	3.32±0.13	20.2±0.6	14	6.1±0.3
1/255	195	2.16±0.07	10.21±0.31	1.90±0.06	0.19±0.01	3.32±0.13	23.9±0.5	14	7.2±0.3
1/256	205	2.58±0.16	10.59±0.32	1.88±0.06	0.19±0.01	3.45±0.13	27.4±0.9	14	8.0±0.4
1/257	215	2.40±0.08	10.51±0.32	1.88±0.06	0.18±0.01	3.39±0.13	24.3±1.0	14	7.2±0.4
1/258	225	2.42±0.08	10.18±0.31	1.85±0.06	0.18±0.01	3.34±0.13	32.9±0.9	14	9.9±0.5
1/259	235	2.38±0.07	9.76±0.30	1.85±0.06	0.18±0.01	3.29±0.12	47.4±2.4	10	14.4±0.9
1/260	245	2.36±0.07	9.74±0.30	1.81±0.05	0.18±0.01	3.24±0.12	44.4±1.2	10	13.7±0.6
1/261	255	2.44±0.07	10.24±0.33	1.83±0.06	0.18±0.01	3.32±0.13	40.2±0.8	13	12.1±0.5
1/262	265	2.38±0.07	9.85±0.30	1.81±0.05	0.17±0.01	3.25±0.12	47.1±1.1	14	14.5±0.6
1/263	275	2.38±0.07	10.07±0.31	1.83±0.06	0.17±0.01	3.28±0.12	50.1±1.9	12	15.3±0.8
1/264	285	2.70±0.08	9.87±0.30	1.79±0.05	0.17±0.01	3.26±0.12	47.2±1.2	13	14.5±0.7
Xifeng Site									
2/1	30	2.59±0.08	11.32±0.34	2.05±0.06	0.23±0.01	3.70±0.14	1.6±0.2	12	0.4±0.1
2/2	40	2.64±0.08	11.80±0.36	2.02±0.06	0.22±0.01	3.71±0.14	1.1±0.2	12	0.3±0.1
2/3	50	2.72±0.08	12.07±0.37	2.05±0.06	0.22±0.01	3.79±0.14	1.1±0.0	12	0.3±0.0
2/4	60	2.94±0.09	13.32±0.42	2.13±0.06	0.22±0.01	4.01±0.15	4.2±0.1	12	1.1±0.1
2/5	70	2.81±0.09	13.18±0.40	2.18±0.07	0.22±0.01	4.01±0.15	7.5±0.2	12	1.9±0.1
2/6	80	2.76±0.09	12.56±0.38	2.16±0.07	0.21±0.01	3.93±0.15	10.0±0.3	10	2.5±0.1
2/7	90	2.60±0.08	13.04±0.41	2.39±0.07	0.21±0.01	4.13±0.16	6.8±0.2SGC	12	1.6±0.1

2/8	100	2.60±0.08	12.24±0.37	2.08±0.06	0.21±0.01	3.78±0.12	17.3±0.5	14	4.6±0.2
2/9	110	2.52±0.08	11.57±0.35	2.06±0.06	0.20±0.01	3.68±0.14	18.1±0.5	14	4.9±0.2
2/10	120	2.69±0.08	12.32±0.37	2.03±0.06	0.20±0.01	3.75±0.14	17.9±0.4	13	4.8±0.2
2/11	130	2.48±0.08	10.71±0.33	1.91±0.06	0.20±0.01	3.46±0.13	20.5±0.5	14	5.9±0.3
2/12	140	2.72±0.18	10.10±1.05	1.73±0.05	0.20±0.01	3.31±0.14	32.3±2.3	14	9.7±0.8
2/13	150	2.58±0.17	10.80±1.13	1.84±0.06	0.19±0.01	3.43±0.14	31.0±2.5	14	9.0±0.8
2/14	160	3.10±0.20	10.80±1.13	1.72±0.05	0.19±0.01	3.45±0.15	37.1±0.8	12	10.7±0.5
2/15	170	3.00±0.20	11.70±1.22	1.74±0.05	0.19±0.01	3.51±0.15	28.6±1.7	12	8.1±0.6
2/16	180	2.75±0.18	10.60±1.11	1.79±0.05	0.19±0.01	3.40±0.14	40.9±2.5	10	12.0±0.9
2/17	190	4.16±0.27	10.90±1.14	1.76±0.05	0.18±0.01	3.78±0.17	59.6±1.2SGC	36	15.8±0.8
2/18	200	2.46±0.16	10.30±1.08	1.75±0.05	0.18±0.01	3.26±0.14	27.4±1.6SGC	12	8.4±0.6
2/19	210	2.51±0.16	10.00±1.04	1.77±0.05	0.18±0.01	3.27±0.14	37.2±1.6SGC	12	11.4±0.7
2/20	220	3.75±0.24	12.00±1.25	1.86±0.06	0.18±0.01	3.84±0.17	37.0±1.6	14	9.6±0.6
2/21	230	2.93±0.19	8.40±0.88	1.63±0.05	0.17±0.01	3.12±0.13	58.5±2.1SGC	12	18.8±1.0
2/22	240	2.24±0.15	8.90±0.93	1.69±0.05	0.17±0.01	3.03±0.12	66.4±3.4	12	21.9±1.4
2/23	250	2.21±0.14	9.60±1.00	1.77±0.05	0.17±0.01	3.15±0.13	48.3±2.4SGC	12	15.4±1.0
2/24	260	2.50±0.16	10.50±1.10	1.71±0.05	0.17±0.01	3.24±0.14	63.6±2.1	12	19.7±1.1
2/25	270	2.41±0.16	9.10±0.95	1.77±0.05	0.16±0.01	3.16±0.13	66.0±4.7SGC	11	20.9±1.7
2/26	280	3.46±0.23	10.60±1.11	1.81±0.05	0.16±0.01	3.59±0.15	74.2±2.8	12	20.7±1.2
2/27	290	2.78±0.18	12.00±1.25	1.83±0.06	0.16±0.01	3.53±0.15	66.7±1.8SGC	12	18.9±1.0
2/28	300	2.85±0.19	11.20±1.17	1.69±0.05	0.16±0.01	3.36±0.15	73.9±2.6	14	22.0±1.2
2/29	310	2.75±0.18	9.70±1.01	1.85±0.06	0.16±0.01	3.36±0.14	76.7±2.0SGC	12	22.8±1.1
2/30	320	2.48±0.16	10.20±1.06	1.78±0.05	0.15±0.01	3.26±0.14	67.8±1.9SGC	24	20.8±1.1
2/31	330	3.02±0.20	10.40±1.09	1.83±0.06	0.15±0.01	3.46±0.15	82.8±2.6SGC	9	23.9±1.3
2/32	340	2.45±0.16	10.40±1.09	1.82±0.05	0.15±0.01	3.30±0.14	86.3±2.2	14	26.2±1.3
2/33	350	3.47±0.23	9.90±1.03	1.86±0.06	0.15±0.01	3.57±0.15	88.0±2.6SGC	12	24.7±1.3
2/34	360	2.50±0.16	10.30±1.08	1.93±0.06	0.15±0.01	3.40±0.14	89.1±2.5	13	26.2±1.3
2/35	370	2.54±0.17	8.90±0.93	1.73±0.05	0.14±0.01	3.12±0.13	89.2±2.2SGC	24	28.6±1.4
2/36	380	2.37±0.15	10.40±1.09	1.87±0.06	0.14±0.01	3.32±0.14	92.4±2.8	13	27.8±1.4
2/37	390	3.25±0.21	11.30±1.18	1.68±0.05	0.14±0.01	3.45±0.15	97.0±2.8SGC	12	28.1±1.5
2/38	400	2.41±0.16	10.80±1.13	1.86±0.06	0.14±0.01	3.35±0.14	92.0±3.5	14	27.5±1.6
2/39	410	2.53±0.16	10.90±1.14	1.82±0.05	0.14±0.01	3.35±0.14	95.9±2.5SGC	11	28.6±1.4
2/40	430	2.47±0.16	9.90±1.03	1.83±0.06	0.13±0.01	3.26±0.14	94.8±4.1	10	29.1±1.8
Shiguanzhi Site									
4/3	5-15	2.58±0.08	13.08±0.40	2.13±0.06	0.22±0.01	3.90±0.15	0.6±0.1	6	0.1±0.0
4/4	15-25	2.56±0.08	12.64±0.38	2.08±0.06	0.21±0.01	3.81±0.15	1.0±0.2	8	0.3±0.0
4/5	25-35	2.63±0.08	13.00±0.41	2.12±0.06	0.21±0.01	3.88±0.15	1.6±0.0	14	0.4±0.0
4/6	35-45	2.67±0.08	13.38±0.40	2.10±0.06	0.21±0.01	3.91±0.15	1.7±0.0	14	0.4±0.0
4/7	45-55	2.65±0.08	13.15±0.40	2.13±0.06	0.20±0.01	3.90±0.15	2.6±0.3	13	0.7±0.1
4/8	55-65	2.85±0.09	14.57±0.44	2.18±0.07	0.20±0.01	4.12±0.16	9.6±0.2	14	2.3±0.1
4/9	65-75	2.76±0.08	14.61±0.46	2.32±0.07	0.20±0.01	4.22±0.16	23.9±0.5	10	5.7±0.2
4/10	75-85	2.70±0.08	14.25±0.46	2.32±0.07	0.20±0.01	4.18±0.16	36.7±0.6	14	8.8±0.4
4/11	85-95	2.75±0.08	14.14±0.43	2.30±0.07	0.19±0.01	4.16±0.16	32.4±0.7	14	7.8±0.3
4/12	95-105	2.67±0.08	13.44±0.44	2.27±0.07	0.19±0.01	4.05±0.16	58.1±0.8	13	14.3±0.6
4/13	105-115	2.65±0.08	13.14±0.40	2.27±0.07	0.19±0.01	4.02±0.15	28.2±1.2	14	7.0±0.4
4/14	115-125	2.71±0.09	13.73±0.44	2.32±0.07	0.18±0.01	4.12±0.16	40.2±0.8	13	9.8±0.4
4/15	125-135	2.53±0.08	11.19±0.34	1.91±0.06	0.18±0.01	3.50±0.13	74.2±1.1	4	21.2±0.9
4/16	135-145	2.55±0.08	11.53±0.35	1.93±0.06	0.18±0.01	3.55±0.15	29.4±1.1	14	8.3±0.4
4/17	145-155	2.48±0.08	11.40±0.35	1.93±0.06	0.18±0.01	3.51±0.13	25.5±1.4	6	7.3±0.3
4/18	155-165	2.38±0.08	11.27±0.35	1.93±0.06	0.18±0.01	3.47±0.13	79.8±3.0	5	23.0±1.2
4/19	175-185	2.22±0.07	11.24±0.34	1.95±0.06	0.17±0.01	3.40±0.13	99.2±1.7	13	28.8±1.2
4/20	195-205	2.20±0.07	11.48±0.35	2.03±0.06	0.17±0.01	3.53±0.14	104.6±2.7	2	29.6±1.4

* Ages and radioisotope concentrations are quoted to one standard deviation (or 10% if dispersion data is unknown), cosmic dose with 5% error and D_e to one standard error. SGC denotes a sample where the D_e has been calculated using a standard growth curve.