Supplement of

Effective Beryllium-10 production rate for the mid-elevation mountainous regions of Central Europe deduced from a multi-method study of moraines and lake sediments in the Black Forest, Germany

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Detailed sample documentation

FS-01a

Table S1. Location and dimensions of the FS-01a boulder, characteristics of the sampling surface, sample thickness, and topographic shielding factors derived from field data and with the ArcGIS toolbox of Li (2018).

Coordinates (WGS 1984 coordinate system)		47.872193 °N 8.033919 °E
Elevation (m above sea-level)		1128
Context		Boulder on the distal side of the ice-marginal moraine at position FS-01 of the former Feldsee cirque glacier
Lithology		Gneiss
Dimensions: length, width, and height (m)		3.20 × 2.20 × 1.60
Strike/dip of the sampled surface (°)		210/10
Height above ground of the sampled surface (m)		1.50
Sample thickness (cm)		1.5
Topographic shielding factor	**Field-data-based (Balco, 2018)**	0.941791
	Digital-elevation-model-based (Li, 2018)	0.958616

Figure S2. Photo of the FS-01a boulder.

FS-02a

Table S3. Location and dimensions of the FS-02a boulder, characteristics of the sampling surface, sample thickness, and topographic shielding factors derived from field data and with the ArcGIS toolbox of Li (2018).

Coordinates (WGS 1984 coordinate system)		47.872164 °N 8.035611 °E
Elevation (m above sea-level)		1113
Context		Boulder on the crest of the ice-marginal moraine at position FS-02 of the former Feldsee cirque glacier
Lithology		Gneiss
Dimensions: length, width, and height (m)		2.80 × 2.60 × 1.10
Strike/dip of the sampled surface (°)		160/30
Height above ground of the sampled surface (m)		1.05
Sample thickness (cm)		2.4
Topographic shielding factor	**Field-data-based (Balco, 2018)**	0.932007
	Digital-elevation-model-based (Li, 2018)	0.947912

Figure S4. Photo of the FS-02a boulder.

FS-02b

Table S5. Location and dimensions of the FS-02b boulder, characteristics of the sampling surface, sample thickness, and topographic shielding factors derived from field data and with the ArcGIS toolbox of Li (2018).

Coordinates (WGS 1984 coordinate system)		47.871428 °N 8.037746 °E
Elevation (m above sea-level)		1103
Context		Boulder on the crest of the ice-marginal moraine at position FS-02 of the former Feldsee cirque glacier
Lithology		Gneiss
Dimensions: length, width, and height (m)		2.20 × 1.70 × 0.90
Strike/dip of the sampled surface (°)		190/10
Height above ground of the sampled surface (m)		0.85
Sample thickness (cm)		2.6
Topographic shielding factor	**Field-data-based (Balco, 2018)**	0.982220
	Digital-elevation-model-based (Li, 2018)	0.987496

Figure S6. Photo of the FS-02b boulder and the sampling surface.

FS-02c

Table S7. Location and dimensions of the FS-02c boulder, characteristics of the sampling surface, sample thickness, and topographic shielding factors derived from field data and with the ArcGIS toolbox of Li (2018).

Coordinates (WGS 1984 coordinate system)		47.869931 °N 8.036674 °E
Elevation (m above sea-level)		1108
Context		Boulder on the crest of the ice-marginal moraine at position FS-02 of the former Feldsee cirque glacier
Lithology		Gneiss
Dimensions: length, width, and height (m)		3.10 × 2.90 × 1.40
Strike/dip of the sampled surface (°)		100/5
Height above ground of the sampled surface (m)		1.40
Sample thickness (cm)		2.0
Topographic shielding factor	**Field-data-based (Balco, 2018)**	0.984843
	Digital-elevation-model-based (Li, 2018)	0.987583

Figure S8. Photo of the FS-02c boulder.

FS-02d

Table S9. Location and dimensions of the FS-02d boulder, characteristics of the sampling surface, sample thickness, and topographic shielding factors derived from field data and with the ArcGIS toolbox of Li (2018).

Coordinates (WGS 1984 coordinate system)		47.870075 °N 8.037022 °E
Elevation (m above sea-level)		1107
Context		Boulder on the crest of the ice-marginal moraine at position FS-02 of the former Feldsee cirque glacier
Lithology		Gneiss
Dimensions: length, width, and height (m)		2.50 × 2.30 × 1.80
Strike/dip of the sampled surface (°)		20/15
Height above ground of the sampled surface (m)		1.65
Sample thickness (cm)		1.9
Topographic shielding factor	**Field-data-based (Balco, 2018)**	0.986562
	Digital-elevation-model-based (Li, 2018)	0.988521

FS-03a

Table S10. Location and dimensions of the FS-03a boulder, characteristics of the sampling surface, sample thickness, and topographic shielding factors derived from field data and with the ArcGIS toolbox of Li (2018).

Coordinates (WGS 1984 coordinate system)		47.869613 °N 8.037770 °E
Elevation (m above sea-level)		1108
Context		Boulder on the distal side of the ice-marginal moraine at position FS-03 of the former Feldsee cirque glacier
Lithology		Gneiss
Dimensions: length, width, and height (m)		3.20 × 2.00 × 2.20
Strike/dip of the sampled surface (°)		0/0
Height above ground of the sampled surface (m)		1.40
Sample thickness (cm)		2.1
Topographic shielding factor	**Field-data-based (Balco, 2018)**	Not determined, as the boulder was located in a dense mixed forest
	Digital-elevation-model-based (Li, 2018)	0.989194

Figure S11. Photo of the FS-03a boulder and the sampling surface.

FS-03b

Table S12. Location and dimensions of the FS-03b boulder, characteristics of the sampling surface, sample thickness, and topographic shielding factors derived from field data and with the ArcGIS toolbox of Li (2018).

Coordinates (WGS 1984 coordinate system)		47.869690 °N 8.037641 °E
Elevation (m above sea-level)		1112
Context		Boulder on the distal side of the ice-marginal moraine at position FS-03 of the former Feldsee cirque glacier
Lithology		Gneiss
Dimensions: length, width, and height (m)		2.20 × 2.20 × 2.50
Strike/dip of the sampled surface (°)		100/35
Height above ground of the sampled surface (m)		1.90
Sample thickness (cm)		2.1
Topographic shielding factor	**Field-data-based (Balco, 2018)**	Not determined, as the boulder was located in a dense mixed forest
	Digital-elevation-model-based (Li, 2018)	0.954505

FS-03c

Table S13. Location and dimensions of the FS-03c boulder, characteristics of the sampling surface, sample thickness, and topographic shielding factors derived from field data and with the ArcGIS toolbox of Li (2018).

Coordinates (WGS 1984 coordinate system)		8.037687 °E 47.869732 °N
Elevation (m above sea-level)		1110
Context		Boulder on the distal side of the ice-marginal moraine at position FS-03 of the former Feldsee cirque glacier
Lithology		Gneiss
Dimensions: length, width, and height (m)		4.50 × 2.70 × 3.90
Strike/dip of the sampled surface (°)		80/20
Height above ground of the sampled surface (m)		1.60
Sample thickness (cm)		1.9
Topographic shielding factor	**Field-data-based (Balco, 2018)**	Not determined, as the boulder was located in a dense mixed forest
	Digital-elevation-model-based (Li, 2018)	0.985596

Figure S14. Photo of the FS-03c boulder and the sampling surface.

FS-03d

Table S15. Location and dimensions of the FS-03d boulder, characteristics of the sampling surface, sample thickness, and topographic shielding factors derived from field data and with the ArcGIS toolbox of Li (2018).

Coordinates (WGS 1984 coordinate system)		8.038474 °E 47.871280 °N
Elevation (m above sea-level)		1099
Context		Boulder at the end of the distal side of the ice-marginal moraine at position FS-03 of the former Feldsee cirque glacier
Lithology		Gneiss
Dimensions: length, width, and height (m)		2.70 × 2.20 × 0.90
Strike/dip of the sampled surface (°)		0/0
Height above ground of the sampled surface (m)		0.85
Sample thickness (cm)		2.0
Topographic shielding factor	**Field-data-based (Balco, 2018)**	0.985519
	Digital-elevation-model-based (Li, 2018)	0.989967

Figure S16. Photo of the FS-03d boulder and the sampling surface.

FS-03e

Table S17. Location and dimensions of the FS-03e boulder, characteristics of the sampling surface, sample thickness, and topographic shielding factors derived from field data and with the ArcGIS toolbox of Li (2018).

Coordinates (WGS 1984 coordinate system)		8.038263 °E 47.870467 °N
Elevation (m above sea-level)		1106
Context		Boulder on the distal side of the ice-marginal moraine at position FS-03 of the former Feldsee cirque glacier
Lithology		Gneiss
Dimensions: length, width, and height (m)		2.30 × 2.00 × 2.00
Strike/dip of the sampled surface (°)		320/35
Height above ground of the sampled surface (m)		1.15
Sample thickness (cm)		2.4
Topographic shielding factor	**Field-data-based (Balco, 2018)**	0.958662
	Digital-elevation-model-based (Li, 2018)	0.960224

Figure S18. Photo of the FS-03e boulder and the sampling surface.

FS-03f

Table S19. Location and dimensions of the FS-03f boulder, characteristics of the sampling surface, sample thickness, and topographic shielding factors derived from field data and with the ArcGIS toolbox of Li (2018).

Coordinates (WGS 1984 coordinate system)		8.038298 °E 47.870475 °N
Elevation (m above sea-level)		1106
Context		Boulder on the distal side of the ice-marginal moraine at position FS-03 of the former Feldsee cirque glacier
Lithology		Gneiss
Dimensions: length, width, and height (m)		3.20 × 2.30 × 2.20
Strike/dip of the sampled surface (°)		160/20
Height above ground of the sampled surface (m)		1.60
Sample thickness (cm)		2.8
Topographic shielding factor	**Field-data-based (Balco, 2018)**	0.982962
	Digital-elevation-model-based (Li, 2018)	0.985626

Figure S20. Photo of the FS-03f boulder and the sampling surface.

Photos of radiocarbon dated macrofossils

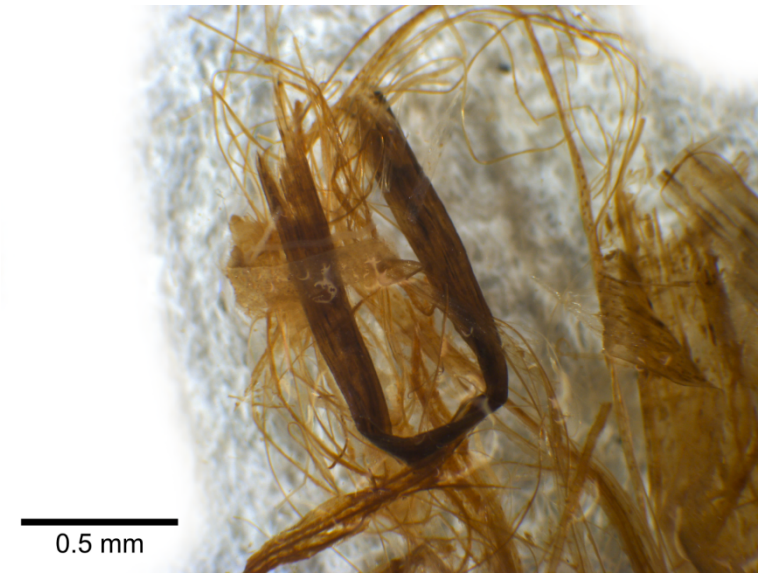

Figure S21. Photo of the FSM536 sample.

Figure S22. Photo of the FSM538 sample.

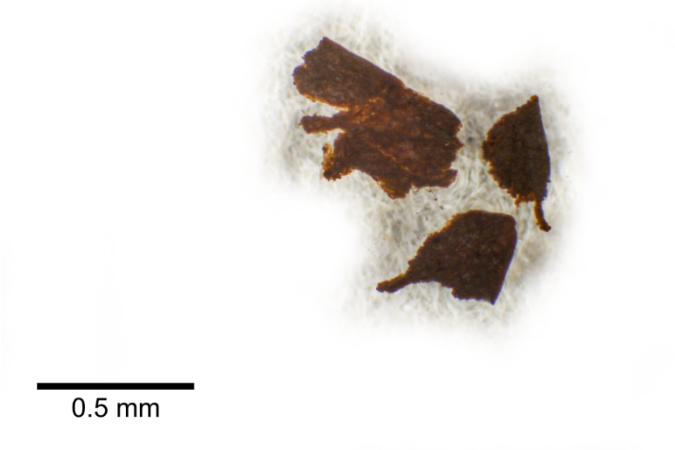

Figure S23. Photo of the FSM550 sample.

Figure S24. Photo of the FSM553 sample.

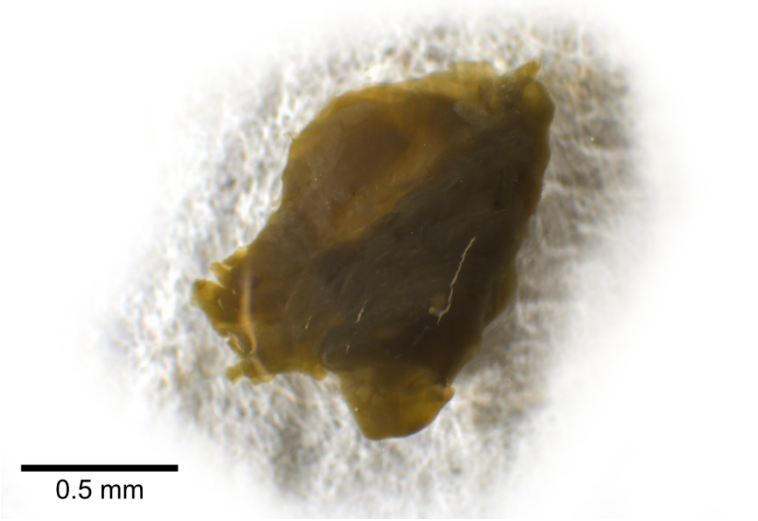

Figure S25. Photo of the FSM558 sample.

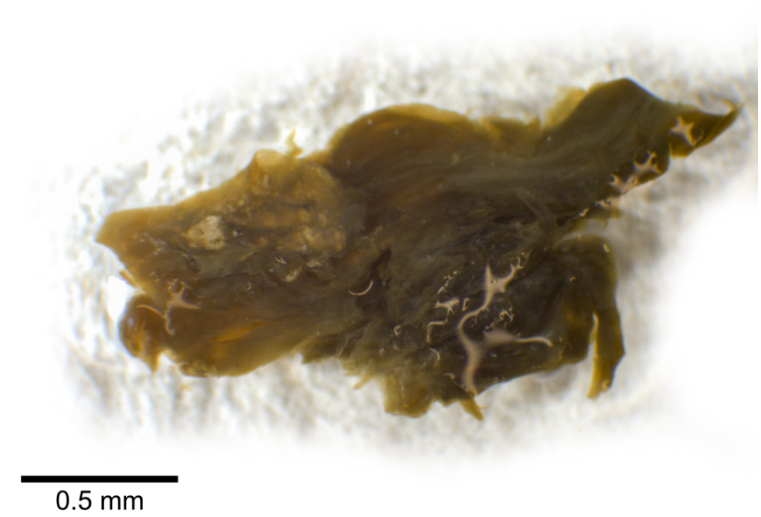

Figure S26. Photo of the FSM560 sample.

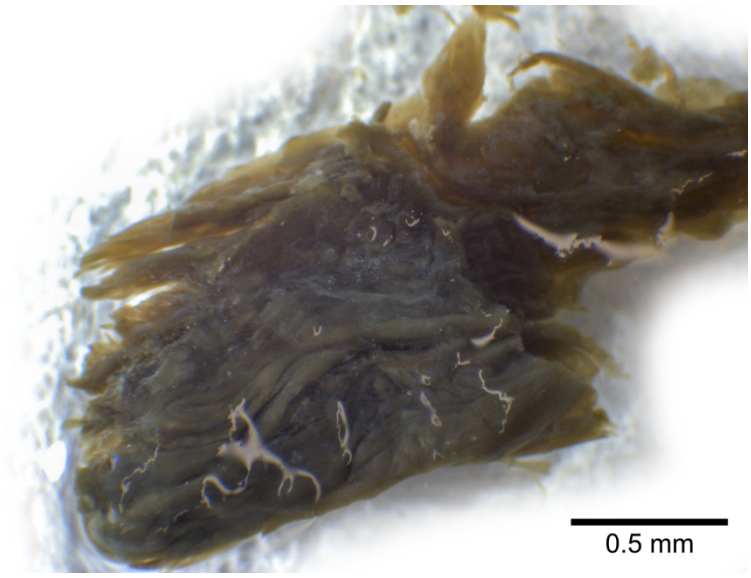

Figure S27. Photo of the FSM563 sample.

Input code for the *P_Sequence*

```
Plot()
{
 P_Sequence("Feldseemoor",1,2,U(-2,2))
 {
  Boundary("Lower boundary of lake sediments")
  {z=568;};
  R_Date("FSM-563", 12880, 60)
  {z=561;};
  R_Date("FSM-559", 12770, 60)
  {z=556;};
  R_Date("FSM-558", 12930, 70)
  {z=554;};
  R_Date("FSM-550", 11540, 120)
  {z=543;};
  R_Combine("FSM-450a / FSM-450b")
  {
   R_Date("FSM-450a", 8620, 60);
   R_Date("FSM-450b", 8650, 50);
   z=428;
  };
  Boundary("Upper boundary of lake sediments")
  {z=400;};
 };
};
```

Input-sheet for the online calculators formerly known as the CRONUS-Earth online calculators

Name for calibration data set: Feldsee Cirque

FS-2a 47.87216 8.03561 1113 std 2.4 2.65 0.947912 0 2020;

FS-2a Be-10 quartz 135802 5343 STD11;

FS-2a true_t FSM 15630 450;

FS-2b 47.87143 8.03775 1103 std 2.6 2.65 0.987496 0 2020;

FS-2b Be-10 quartz 140611 5307 STD11;

FS-2b true_t FSM 15630 450;

FS-2c 47.86993 8.03667 1108 std 2.0 2.65 0.987583 0 2020;

FS-2c Be-10 quartz 142114 4623 STD11;

FS-2c true_t FSM 15630 450;

FS-3a 47.86961 8.03777 1108 std 2.1 2.65 0.989194 0 2020;

FS-3a Be-10 quartz 160738 13164 STD11;

FS-3a true_t FSM 15630 450;

FS-3c 47.86973 8.03769 1110 std 1.9 2.65 0.985596 0 2020;

FS-3c Be-10 quartz 141544 4610 STD11;

FS-3c true_t FSM 15630 450;

FS-3d 47.87128 8.03847 1099 std 2.0 2.65 0.989967 0 2020;

FS-3d Be-10 quartz 133327 4670 STD11;

FS-3d true_t FSM 15630 450;

FS-3e 47.87047 8.03847 1106 std 2.4 2.65 0.960224 0 2020;

FS-3e Be-10 quartz 144143 5434 STD11;

FS-3e true_t FSM 15630 450;

FS-3f 47.87047 8.03830 1106 std 2.8 2.65 0.985626 0 2020;

FS-3f Be-10 quartz 147407 5026 STD11;

FS-3f true_t FSM 15630 450;

References

Balco, G.: Topographic shielding calculator, http://stoneage.ice-d.org/math/skyline/skyline_in.html, last access: 17 October 2023, 2018.

Li, Y.-K.: Determining topographic shielding from digital elevation models for cosmogenic nuclide analysis: a GIS model for discrete sample sites, J. Mt. Sci., 15, 939–947, https://doi.org/10.1007/s11629-018-4895-4, 2018.