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Age ranges of the Tibetan ice cores with emphasis on the Chongce ice cores, western Kunlun Mountains

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Abstract. An accurate chronology is the essential first step for a sound understanding of ice core records. However, dating ice cores drilled from the high-elevation glaciers is challenging and often problematic, leading to great uncertainties. The Guliya ice core, drilled to the bedrock (308.6 m in length) along the western Kunlun Mountains on the northwestern Tibetan Plateau (TP) and widely used as a benchmark for palaeoclimate research, is believed to reach $>$ 500 ka (thousand years) at its bottom. Meanwhile other Tibetan ice cores (i.e. Dasuopu and East Rongbuk in the Himalayas, Puruogangri in the central TP and Dunde in the north-eastern TP) are mostly of Holocene origin. In this study, we drilled four ice cores into bedrock (216.6, 208.6, 135.8 and 133.8 m in length, respectively) from the Chongce ice cap $\sim$ 30 km to the Guliya ice core drilling site. We took measurements of ^{14}C, ^{210}Pb, tritium and β activity for the ice cores, and used these values in a two-parameter flow model to establish the ice core depth–age relationship. We suggested that the Chongce ice cores might be of Holocene origin, consistent with the other Tibetan ice cores except Guliya. The remarkable discrepancy between the Guliya and all the other Tibetan ice core chronology implies that more effort is necessary to explore multiple dating techniques to confirm the age ranges of the TP glaciers, including those from Chongce and Guliya.

1 Introduction

Ice cores from the Tibetan Plateau (TP) provide a wealth of information for past climatic and environmental conditions that extend beyond the instrumental period (e.g. Thompson et al., 1989, 1997, 2000). An accurate chronology is the essential first step for a sound understanding of such ice core records. However, ice core dating is always a challenging task because seasonal signals suitable for annual layer counting are usually only observable in the top sections of ice cores. For deeper (older) sections, annual cycles cannot be identified due to rapid thinning of ice layers. If sufficient organic matter (e.g. plant or insect fragments) is found inside the ice cores, the conventional radiocarbon (^{14}C) dating can be used (Thompson et al., 2002). Unfortunately, the presence of such material is far from guaranteed, which limits its application for ice core dating. Recently, a novel method was developed to extract water-insoluble organic carbon (WIOC) particles at microgram level from carbonaceous aerosol embedded in the glacier ice for accelerator mass spectrometry (AMS) ^{14}C dating (Jenk et al., 2007; Uglietti et al., 2016). Carbonaceous aerosol is constantly transported to the glaciers, where it is deposited and finally incorporated into the glacier ice. Consequently, carbonaceous aerosol in ice cores can provide reliable dating at any given depth when the samples contain sufficient carbon mass ($>$ 10 µg). Here we applied this recently established technique to date the Tibetan ice cores.

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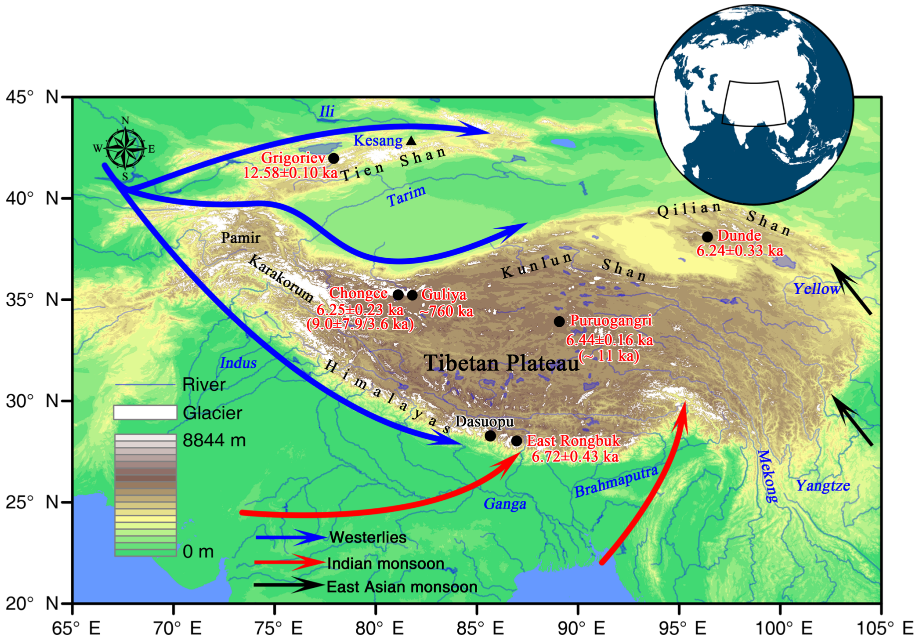

Figure 1. Map showing the locations of ice core drilling sites. The numbers for each site except Guliya are the oldest-measured ^{14}C ages, while the number inside the bracket below the Chongce site is the estimated ice age at the ice–bedrock interface. The schematic positions of the westerlies and the monsoon circulations are from Yao et al. (2013). Data on glaciers are from the Global Land Ice Measurements from Space (GLIMS, available at http://www.glims.org, last access: 13 July 2018). The topographic data were extracted using ETOPO1 elevations global data, available from National Oceanic and Atmospheric Administration at http://www.ngdc.noaa.gov/mgg/global/global.html (last access: 13 July 2018).

2 Chronology of previous ice cores

There are quite a few ice cores that have been drilled to the bedrock in the TP (Fig. 1). Below we briefly review the available information on the bottom ages of these ice cores. Please refer to the original literature for more details.

2.1 The Dunde ice cores

In 1987, three ice cores to bedrock (139.8, 136.6 and 138.4 m in length) were recovered at an altitude of 5325 m a.s.l. from the Dunde ice cap (38°06′ N, 96°24′ E) in the Qilian Shan on the northern TP (Fig. 1). Surface and basal borehole temperatures were −7.3 and −4.7 °C, respectively. The 2 ‰ shift in δ^{18}O, concurrent with a sudden increase in dust concentration 14 m above the bedrock was interpreted as evidence of glacial-stage ice (Thompson et al., 1989). The core was extrapolated to 40 ka BP at a depth of 5 m above the bedrock by applying a two-dimensional flow model and was suggested to be potentially more than 100 ka BP at the ice–bedrock interface (Thompson et al., 1989). Later, Thompson et al. (2005) provided a single ^{14}C date of 6.24 ± 0.33 ka BP for a sample collected close to the ice–bedrock interface (exact distance above the interface unavailable) and suggested that this core may be of Holocene origin.

2.2 The Guliya ice core

In 1992, a 308.6 m ice core to bedrock was recovered at an elevation of 6200 m a.s.l. from the Guliya ice cap (35°17′ N, 81°29′ E) in the western Kunlun Mountains on the northwestern TP (Fig. 1). The Guliya ice cap is surrounded by vertical ice walls 30 to 40 m high and has internal temperatures of −15.6 °C at 10 m, −5.9 °C at 200 m and −2.1 °C at its base. The top 266 m of the Guliya core was dated to a period spanning 110 ka BP, and the ice below 290 m was suggested to be $>$ 500 ka BP, or to $\sim$ 760 ka BP at the ice–bedrock interface based on ^{36}Cl dead ice at the bottom section (Thompson et al., 1997).

2.3 The Dasuopu ice cores

In 1997, three ice cores were drilled from the Dasuopu glacier (28°23′ N, 85°43′ E) in the Himalayas. The first core (159.9 m in length) was drilled at an altitude of 7000 m a.s.l., and two more cores (149.2 and 167.7 m in length, respectively) were drilled 100 m apart on the col at an altitude of 7200 m a.s.l. (Thompson et al., 2000). Borehole temperatures were −16 °C at 10 m and −13 °C at the ice–bedrock interface (Yao et al., 2002). The δ^{18}O record of the Dasuopu ice core lacks the 5 to 6 ‰ depletion that characterizes glacial stage ice from the tropics to the polar regions (Yao et al., 2002). Furthermore, Dasuopu's basal ice does not contain (parts per million by volume) methane levels as low as 0.4 ppmv that characterize glacial ice in polar ice cores (Raynaud et al., 2000). Thus, it was suggested that the Dasuopu ice field accumulated entirely during the Holocene (Thompson et al., 2005).

2.4 The Puruogangri ice cores

In 2000, three ice cores (118.4, 214.7 and 152 m in length) were recovered at an altitude of 6070 m a.s.l. from the Puruogangri ice cap (33°55′ N, 89°05′ E) on the central TP (Fig. 1). Borehole temperatures were −9.7 °C at 10 m and −5 °C at the ice–bedrock interface. The measured oldest ^{14}C date is 6.44 ± 0.16 ka BP at 210.5 m depth of the 214.7 m ice core. The dating was extrapolated another 0.5 m further down to 7 ka BP (Thompson et al., 2006). The Puruogangri ice cores were suggested to be of Holocene origin (Thompson et al., 2005).

2.5 The East Rongbuk ice cores

In 2001, one ice core to bedrock (117.1 m in length) was drilled on the col of East Rongbuk Glacier (28°1′ N, 86°58′ E, 6518 m a.s.l.) on the northern slope of Qomolangma (Mount Everest) in the Himalayas. In 2002, two more ice cores (108.8 and 95.8 m in length, respectively) were drilled to bedrock near the previously drilling site. In a previous study, we matched the $CH_4/\delta^{18}O_{atm}$ phase record of both the East Rongbuk 117.1 and 108.8 m cores to the GRIP CH_4 and the GISP2 $\delta^{18}O_{atm}$ of the Greenland summit ice cores, and the results suggest a Holocene origin of the East Rongbuk ice cores (Hou et al., 2004).

2.6 The Grigoriev ice core

In 2007, an ice core to bedrock (86.87 m long) was recovered at an altitude of 4563 m a.s.l. at the top of the Grigoriev ice cap (41°59′ N, 77°55′E) in the western Tien Shan (Fig. 1). Borehole temperatures were −2.7 °C at 10 m and −3.9 °C at the ice–bedrock interface. Takeuchi et al. (2014) suggested that the bottom age of the Grigoriev ice core coincides with the Younger Dryas cold period (YD, 11.7–12.9 ka BP). However, the oldest ^{14}C age (12.58 ± 0.10 ka) is obtained from a soil sample collected underneath the glacier, which should be considered an upper constraint for the age of ice at the ice–bedrock interface.

3 The Chongce ice cores

In 2012, we drilled two ice cores to bedrock with lengths of 133.8 m (Core 1) and 135.8 m (Core 2) and a shallow core (Core 3) of 58.8 m at an altitude of 6010 m a.s.l. from the Chongce ice cap on the north-western TP (35°14′ N, 81°7′ E; Fig. 1). The direct distance between the Chongce and the Guliya ice core drilling sites is ∼ 30 km (Fig. S1 in the Supplement). In 2013, two more ice cores were recovered to bedrock with lengths of 216.6 m (Core 4) and 208.6 m (Core 5) at an altitude of 6100 m a.s.l. on the Chongce ice cap (35°15′ N, 81°5′ E). The detailed positions of the five Chongce ice cores are shown in Fig. S2. Borehole temperatures are −12.8, −12.6 and −12.6 °C at 10 m depth for Core 1, Core 2 and Core 3, −8.8 and −8.8 °C at 130 m depth for Core 1 and Core 2, respectively (Fig. S3), suggesting that the Chongce ice cap is frozen to the bedrock. The density profiles of the Chongce Core 2, Core 3 and Core 4 are shown in Fig. S4. All the ice cores were transported in a frozen state to the cold room in the Nanjing University for further processing. The basal sediment collected from the bottom of Core 4 was measured for the first luminescence dating, resulting in an age of 42 ± 4 ka BP, which was regarded as an upper constraint for the age of the bottom ice at the drilling site (Zhang et al., 2018).

4 Measurements

4.1 ^{14}C

We took ^{14}C measurements on WIOC extracted from 22 samples collected discretely along the 216.6 m Chongce Core 4 and nine samples along the 135.8 m Chongce Core 2, as well as five samples collected from the East Rongbuk 95.8 m ice core. The ^{14}C sample decontamination was taken at the Paul Scherrer Institute by removing the ∼ 3 mm outer layer with a bandsaw in a −20 °C cold room and rinsing it with ultra-pure water in a class 100 laminar flow box. The WIOC fraction of carbonaceous particles in the sample was filtered onto freshly preheated quartz-fibre filters (Pallflex Tissuquartz, 2500QAO-UP), then combusted stepwise (10 min at 340 °C; 12 min at 650 °C) using a thermal–optical carbon analyser (Model4L, Sunset Laboratory Inc., USA) to separate organic carbon (OC) from elemental carbon (EC), and the resulting CO_2 was measured by the Mini Carbon Dating System (MICADAS) with a gas ion source for ^{14}C analysis at the University of Bern LARA laboratory. Details on sample preparation procedures and analytical methods can be found in previous studies (Jenk et al., 2007, 2009; Sigl et al., 2009; Uglietti et al., 2016). The overall procedural blanks were estimated using artificial ice blocks of frozen ultra-pure water, which were treated the same way as real ice samples. The average overall procedural blank is 1.34 ± 0.62 µg carbon with a $F^{14}C$ of 0.69 ± 0.13 (Uglietti et al., 2016). Conventional ^{14}C ages were calibrated using OxCal v4.2.4 software with the IntCal13 calibration curve (Bronk Ramsey and Lee, 2013; Reimer et al., 2013).

4.2 ^{210}Pb

The accessible time range using radioactive isotope ^{210}Pb dating is ∼ 150 years due to the 22.3-year half-life of ^{210}Pb, a product of the natural ^{238}U decay series. Here ^{210}Pb dating

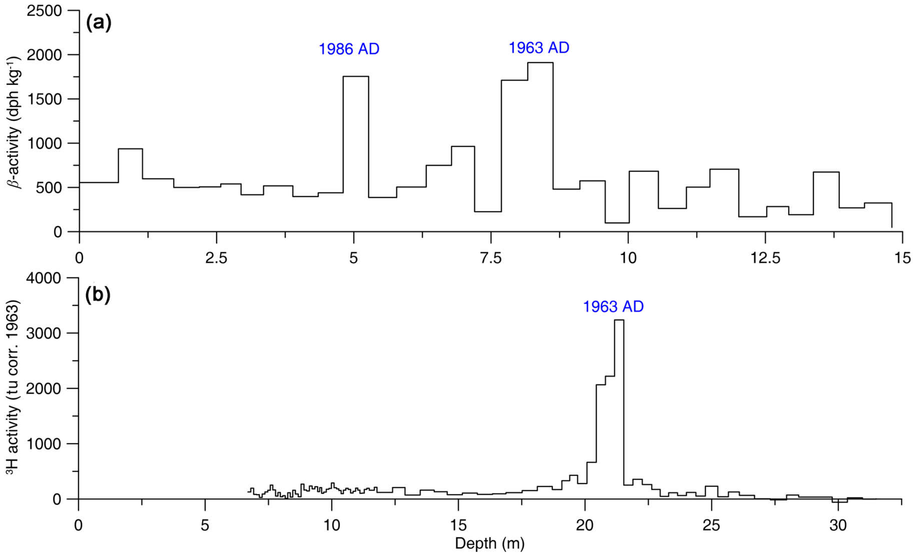

Figure 2. The β activity profile of the Chongce 58.8 m Core 3 **(a)** and the tritium (corrected for the decay) profile of the Chongce 216.6 m Core 4 **(b)**. TU (tritium units) is one tritium atom/1018 hydrogen atoms.

was taken on the Chongce 216.6 m Core 4 with a total of 52 samples collected from the depth of 0–76.6 m. Each sample (∼ 100–200 g) was cut parallel to the drilling axis in a room with a temperature of −20 °C. The samples were processed according to the standard method established by Gäggeler et al. (1983). The samples were melted for 24 h after 0.05 % (V : V) analytical reagent HCl (30 %) was added. Afterwards, 100 µL ^{209}Po tracer was added to the solution to determine the yield of the separation. Spontaneous deposition of Po on an Ag disk (15 mm diameter), which was fixed on a wire and immersed in the liquid, was achieved during ∼ 7 h at 95 °C in 500 mL Erlenmeyer flasks using a magnetic stirrer. After drying, the disks were measured by α counting at the Paul Scherrer Institute. The samples were positioned in vacuum chambers at a distance of 1 mm from silicon surface barrier detectors (ORTEC, ruggedized, 300 and 450 mm^2) having an α energy resolution of ∼ 23 keV full width at half maximum at 5.3 MeV. The yield of ^{209}Po tracer was measured via its 4.9 MeV α line. Typical chemical yields were ∼ 75 %.

4.3 Tritium

Tritium measurements were taken on the Chongce 216.6 m Core 4, with 51 samples collected successively from the depth range of 6.7–11.8 m (corresponding to a sampling resolution of ∼ 0.1 m per sample) and 42 samples from the depth range of 11.8–32.0 m (corresponding to a sampling resolution of ∼ 0.5 m per sample). Each sample is ∼ 10 g. Samples were analysed at the Paul Scherrer Institute using liquid scintillation counting (TriCarb 2770 SLL/BGO, Packard SA). The detection limit for 3H measurements is < 10 TU.

4.4 β activity

Twenty-two samples were collected successively from the top to a depth of 10.3 m of the Chongce 58.8 m Core 3. Each sample is ∼ 1 kg. The β activity was measured using an alpha–beta multi-detector (Mini 20, Eurisys Mesures) at the National Key Laboratory of Cryospheric Sciences, China. More details can be found in An et al. (2016).

5 Results

The β activity profile of the Chongce 58.8 m Core 3 is shown in Fig. 2a. A β activity peak at depths of 8.2–8.4 m was referenced as 1963, while a second β activity peak at depths of 4.8–5.1 m was set to 1986, corresponding to the 1986 Chernobyl nuclear accident. Both β activity peaks were also observed in the Muztagh Ata ice core from the Eastern Pamir (Tian et al., 2007). The calculated mean annual accumulation rate is 140 mm w.e. (water equivalent) year^{-1} for the period of 1963–2012.

The tritium profile of the Chongce 216.6 m Core 4 is shown in Fig. 2b. The tritium activity was corrected for decay to the time of deposition, because our purpose is to identify the apparent tritium peak (3237 ± 89 TU) at the depth of 21.4 m. The depth of the sample with the highest activity was related to the year 1963, when the atmospheric test ban treaty was signed and tritium levels in precipitation began to decline gradually because of radioactive decay and the cessation of atmospheric testing (e.g. Kendall and Doctor, 2003). The calculated mean annual accumulation rate is 297 mm w.e. year^{-1} for the period of 1963–2013.

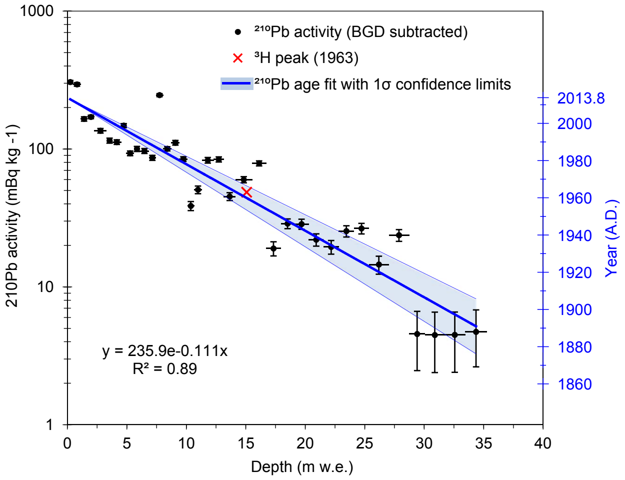

Figure 3. ^{210}Pb activity profile of the Chongce 216.6 m Core 4 and the derived age–depth relationship. The ^{3}H fallout horizon indicating the year 1963 is located within the uncertainty of the ^{210}Pb results. Please note that the 1σ confidence band is related to the right-hand y axis only.

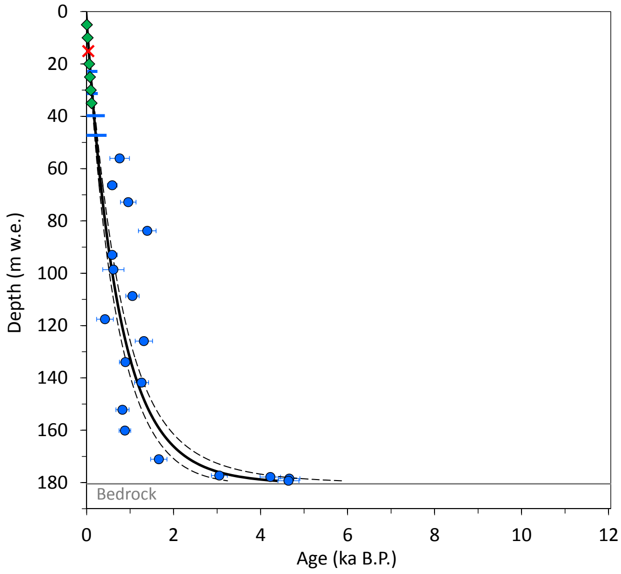

Figure 4. The depth–age relationship of the Chongce 216.6 m Core 4. The dashed lines represent the 1σ confidence interval of the 2p model fit (solid line). The red cross stands for the tritium horizon, green diamonds for the ^{210}Pb ages calculated at intervals of 5 m w.e. (Fig. 3), and the blue dots for the calibrated ^{14}C ages with 1σ error bar.

The ^{210}Pb activity profile of the Chongce 216.6 m Core 4 is in Fig. 3 shows an exponential decrease as a function of depth in line with the radioactive decay law. The ^{210}Pb activity concentrations are in the range 7.5–317 mBq kg^{-1} but remain relatively stable for the lower 16 samples with an average of 11.2 ± 2.1 mBq kg^{-1} (not shown). This average was taken as background ^{210}Pb (BGD) from the mineral dust contained in the ice core and was subtracted from the measured ^{210}Pb activity concentrations. From the linear regression of the logarithmic ^{210}Pb activities (BGD subtracted) against depth (Fig. 3), the value of the axis intercept (236 ± 33 mBq kg^{-1}) corresponds to the ^{210}Pb activity at the surface of the Chongce ice cap. Following the widely applied approach described by Gäggeler et al. (1983), the ice age was derived using the constant initial concentration (CIC) model of Eq. (1). We calculated 1891 ± 15 at the depth of 44.09 m (i.e. 34.36 m w.e.), resulting in a mean annual net accumulation rate of 280 ± 47 mm w.e. year^{-1} for the period of 1891–2013. This value is in very good agreement with the value of 297 mm w.e. year^{-1} for the period of 1963–2013 derived from the tritium profile of the same ice core (i.e. the Chongce 216.6 m Core 4, Fig. 2b).

$$t_s = \lambda^{-1} \ln \left(\frac{C_0}{C_S} \right), \qquad (1)$$

where t_s stands for the age of ice at a certain depth with ^{210}Pb activities (subtracted) C_S, λ for the decay constant of ^{210}Pb (0.03114 year^{-1}) and C_0 for the ^{210}Pb surface activity.

The ^{14}C age profiles of the Chongce 216.6 m Core 4 and the 135.8 m Core 2 are shown in Figs. 4 and 5, and the results are given in Tables S1 and S2 in the Supplement, respectively. We initially collected the ^{14}C samples, taking into consideration the chronology of the Guliya ice core, but finally realized that most of the samples, especially those collected from the upper sections, are too young to be dated with an acceptable uncertainty. For instance, we obtained 1891 ± 15 at the depth of 44.09 m from the ^{210}Pb measurements (Fig. 3), and the ^{14}C ages are 0.013–0.269 ka cal BP at the depth of 40.11–40.97 m, and modern to 0.430 ka cal BP at 50.06–50.82 m. Even though all obtained calibrated age ranges of the uppermost four samples include the expected ages based on the ^{210}Pb dating results, they have large uncertainties due to the young age and the relatively flat shape of the calibration curve in the past 500 years. Furthermore, anthropogenic contribution for samples younger than 200 years is likely introduce an old bias in ^{14}C ages due to fossil fuel (^{14}C dead) contribution (Jenk et al., 2006). Only 2 % fossil contribution would shift the mean of the calibrated age ranges for these samples by up to 200 years towards younger ages, resulting in a smaller age range close to the ages estimated by ^{210}Pb dating. The ^{14}C age profile in the depth range of 80–180 m shows large scatter and no clear increase in age (Fig. 4). This is likely caused by the relatively young age of samples in combination with relatively large analytical uncertainties due to the presence of high mineral dust load in the Chongce ice core.

We made use of the ^{14}C ages (excluding the top four samples for the reasons discussed above), the ^{210}Pb results (Fig. 3) and the tritium horizon (Fig. 2) to establish the depth–age relationship for the Chongce 216.6 m Core 4

(Fig. 4), by applying a two-parameter flow model (2p model) (Bolzan, 1985 and in the Supplement). To avoid overfitting of the data and giving to much weight to individual data points, we prefer not to make assumptions about changes in accumulation, such as by applying a Monte Carlo approach (Uglietti et al., 2016; Gabrielli et al., 2016). However, we understand that the 2p model is limited, though widely used for establishing the ice core chronology including the Dunde (Thompson et al., 1989) and the Puruogangri (Thompson et al., 2006) ice cores, and cannot account for the complex flow regimes close to the glacier bedrock. Therefore, we simply used the flow model to fit the dating points to obtain a continuous age–depth scale. In order to make full use of the information available, we estimated the age at the ice–bedrock by extrapolating the 2p model to the bedrock. The results of the bottom ages were provided in the Supplement.

6 Discussion

We have noticed the apparent incoherence between the depth–age relationship of Core 2 and Core 4, which may be caused by their surface topography, resulting in different accumulation rates at their respective drilling sites. The mean annual accumulation rate of Core 3 (several metres away from Core 2 drilling site) is calculated to be 140 mm w.e. year^{-1} for the period of 1963–2012, while the mean annual accumulation rate of Core 4 is 297 mm w.e. year^{-1} for the period of 1963–2013. It is possible that the Core 4 drilling site may receive extra snow, such as from snow drifting, whereas part of the snow deposition at the Core 3 drilling site may be blown away due to wind scouring (Fisher et al., 1983). The impact of wind scouring on the ice core drilled from the Dasuopu summit was also suggested (Thompson et al., 2018). Nevertheless, a full understanding of this difference will require long-term in situ observations that are unavailable at this moment.

It was previously suggested that the Himalayan ice cores (Dasuopu and East Rongbuk) were of Holocene origin (Thompson et al., 2005; Hou et al., 2004). The oldest-calibrated ^{14}C age for a sample collected down to the ice–bedrock interface of the East Rongbuk 95.8 m ice core, is 6.72 ± 0.43 ka BP, confirming its Holocene origin. The ice cores from Puruogangri in the central TP and, to a lesser degree, Dunde in the north-eastern TP are of Holocene origin too (Thompson et al., 2005). For the Chongce ice cores, the measured oldest calibrated ^{14}C ages are similar to what are measured for the East Rongbuk, Puruogangri and Dunde ice cores (Fig. 1). Our estimated ages at the ice–bedrock interface ($8.3\pm^{6.2}_{3.6}$ ka BP for the Chongce 216.6 m Core 4 and $9.0\pm^{7.9}_{3.6}$ ka BP for the Chongce 135.8 m Core 2 respectively, see details in Supplement) are either of Holocene origin or, less likely, originate in the late deglaciation period, similarly to the result of the Grigoriev ice core in the western Tien Shan (Takeuchi et al., 2014). In both cases, the results confirm the upper constraint of 42 ± 4 ka BP derived from the luminescence age of the basal sediment sample collected from the bottom of the Chongce 216.6 m Core 4 (Zhang et al., 2018).

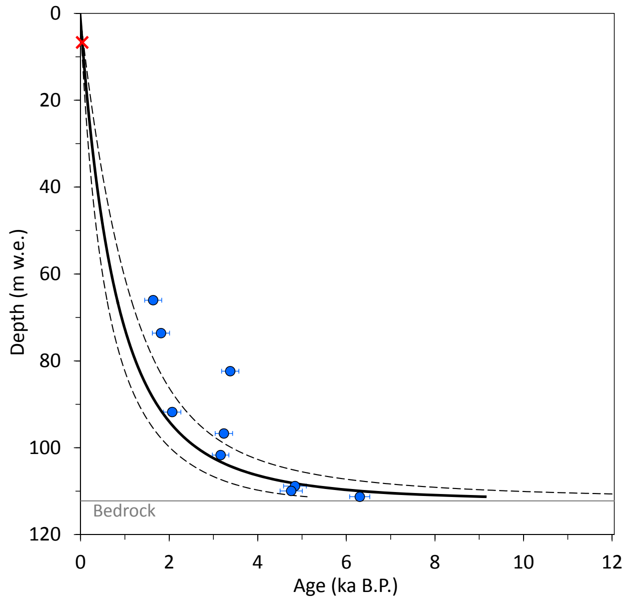

Figure 5. The depth–age relationship of the Chongce 135.8 m Core 2. The dashed lines represent the 1σ confidence interval of the 2p model fit (solid line). The red cross stands for the β activity horizon (Fig. 2) and the blue dots for the calibrated ^{14}C ages with 1σ error bars.

It is apparent that the age range of the Guliya ice core is at least an order of magnitude older than that of the other Tibetan and the Tien Shan ice cores. Thompson et al. (2005) previously considered this as evidence that the growth (glaciation) and decay (deglaciation) of large ice fields in the lower latitudes are often asynchronous. However, our new understanding of the chronology of the Chongce ice cores suggests a similar age range of the ice cores in the western Kunlun Mountains in comparison to the other Tibetan cores. Though the validity of the Guliya chronology has been assumed since its publication (Thompson et al., 2005; Thompson, 2017), Cheng et al. (2012) argued that the Guliya ice core chronology should be shortened by a factor of 2 in order to reconcile the difference in the δ^{18}O variations between the Guliya ice core and the Kesang stalagmite records (Fig. 1 and Supplement). Although, at this moment, we cannot give the final word on the age ranges of the Tibetan ice cores, it is necessary to explore more independent evidence to decipher the age dilemma of the ice cores from the western Kunlun Mountains on the north-western TP.

We notice that, in 2015, a new Guliya ice core (309.73 m in length) was drilled close to the location of the 1992 Guliya core drilling site. Thompson et al. (2018) suggested that future analyses will include ^{14}C, ^{36}Cl, ^{10}Be, δ^{18}O of air in bubbles and argon isotopic ratios ($^{40}Ar/^{38}Ar$) on deep sections of the new Guliya ice core to more precisely determine the age of the Guliya ice cap. We look forward to their new results.

7 Conclusions

We provided calibrated ^{14}C ages and age estimation at the ice–bedrock interface of the Chongce ice cores drilled from the western Kunlun Mountains on the north-western Tibetan Plateau, where exceptional length of the ice core record was previously suggested. Our results suggest that the age ranges of the Chongce ice cores is similar to the other Tibetan ice cores except the Guliya ice core, confirming the recent conclusion derived from the luminescence age of the Chongce ice core. The current work may have many implications, such as whether or not asynchronous glaciation on the Tibetan Plateau exists. Undoubtedly, more effort is necessary to explore multiple dating techniques to confirm the ages of the Tibetan glaciers, including those from Chongce and Guliya.

Data availability. The ^{14}C data on the Chongce ice cores are provided in the Supplement.

Supplement. The supplement related to this article is available online at: https://doi.org/10.5194/tc-12-2341-2018-supplement.

Author contributions. SH conceived this study, drilled the Chongce ice cores and wrote the paper. CW, TMJ and MS measured the ^{14}C, ^{210}Pb, β activity and tritium. All authors contributed to a discussion of the results.

Competing interests. The authors declare that they have no conflict of interest.

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