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ABSTRACT

Evidence for an 8.2 ka event–related advance for an Alpine glacier was missing for a long time. In the light of dendrochronological analyses for tree remains found in front of the Mont Miné Glacier, Swiss Alps, we present evidence for such an advance related to the 8.2 ka event. Calendar dates established for dozens of tree remains place this glacier advance ~8175 yr before A.D. 2000. Therefore, this 8.2 ka advance response of the Mont Miné Glacier terminated a nearly millennial-long retreat period with a glacier always shorter than today.

INTRODUCTION

The 8.2 ka event has been identified as a major Holocene climatic cooling episode in the North Atlantic realm (Alley and Agustsdottir, 2005). This event was recognized as the most extreme climatic anomaly in the Greenland ice core $\delta^{18}O$ records during the Holocene. It is commonly postulated to be the consequence of weakened ocean overturning circulation triggered by a catastrophic drainage of Lake Agassiz in North America (Kleiven et al., 2008). The duration of the entire 8.2 ka event in Greenland was ~160 yr (between 8297 and 8136 yr before A.D. 2000 [b2k]) (Thomas et al., 2007).

In central Europe, this event has been recorded in several proxy data sets that cover the early Holocene. Isotope records from lake sediments (von Grafenstein et al., 1998, 1999) and speleothems (Boch et al., 2009) show a climatic event that lasted between 100 and 130 yr and led to a reconstructed temperature depression of ~1.5–3 °C. Other, mainly vegetation-based, records indicate that the 8.2 ka event was the onset of a longer lasting (until ca. 7.6 ka) cold and wet period in central Europe (e.g., Kofler et al., 2005). However, clear evidence for this event in terms of a major climate archive, mountain glaciers, has been missing so far for the European Alps. Only Kerschner et al. (2006) proposed an 8.2 ka glacier advance based on exposure age dating results on moraines of a small glacier system in the northern Alps; however, these dating results are still being discussed (Ivy-Ochs et al., 2009). On the basis of dendrochronological analyses we present for the first time a calendar date for the advance of an Alpine glacier (the Mont Miné Glacier, Swiss Alps) in response to the 8.2 ka event that terminated a nearly millennial-long retreat period with a Mont Miné Glacier that was always less extended than it is today.

SITE

The north-exposed Mont Miné Glacier (Fig. 1; 46°0′N, 7°33′E; current length 7.95 km; area [in 1973] 10.974 km², highest point 3720 m; current glacier terminus elevation 2000 m above sea level [a.s.l.]) is located in the Val d'Hérens, Valais Alps, Switzerland. Until A.D. 1956, this glacier had a combined glacier tongue with the neighboring Ferpècle Glacier. Length-change measurements for the Mont Miné/Ferpécle Glacier started in 1891. This length-change record indicates an overall retreat of the Mont Miné Glacier of ~830 m from 1891 until the early 1970s (Glaciological Reports, 1881–2009). Between 1971 and 1989 the glacier advanced by 83 m, followed by a strong retreat (1990–2010, 539 m). The total retreat from the mid-nineteenth century maximum glacier position is ~2.1 km (Röthlisberger, 1976; Glaciological Reports, 1881–2009). The length-change record of the Mont Miné Glacier is in agreement with the general behavior of Alpine glaciers since the middle of the nineteenth century (Zemp et al., 2006). It is expected that the accelerated retreat of these last years (20–30 m/yr) will continue, because the snout of the Mont Miné Glacier has almost no direct connection with the upper part of the glacier, owing to a big rock cliff. The glacier terminus is therefore dynamically decoupled from the active glacier and currently largely fed by ice avalanches (Fig. 1).

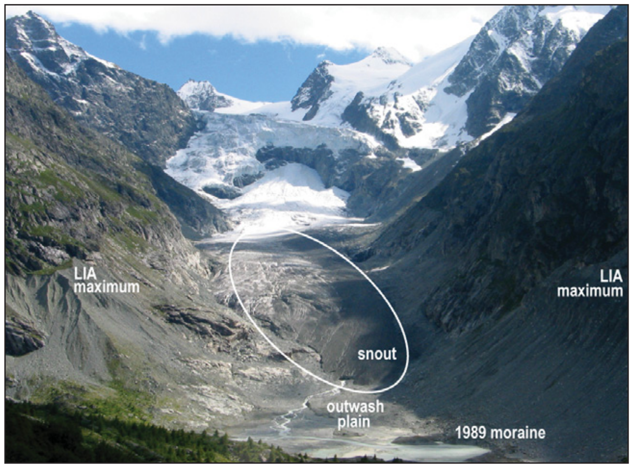

Figure 1. Overview of snout and forefield of Mont Miné Glacier, Swiss Alps. Note that snout is only connected to upper part of glacier by small ice band and it is mainly fed by ice avalanches. Tree remains were observed melting out at glacier terminus or were found on outwash plain below. We assume that growth locations of 8.2 ka trees were in area that is today widely covered by ice (e.g., between ca. A.D. 2005 terminus position of glacier and rock cliff behind). Ellipse roughly indicates inferred tree growth locations (2007 photo). LIA—Little Ice Age.

The tree line in this area is located at ~2300 m a.s.l. Most sections of the Mont Miné Glacier forefield are already covered with young trees, mainly *Larix decidua*.

MATERIALS AND METHODS

In the summers of 2006, 2007, 2009, and 2011, we collected more than 35 wood samples from tree remains found on the outwash plain in front of the terminus of the Mont Miné Glacier. Usually the tree remains were on the surface in or near the braided glacial stream. Some trunks were discovered partly embedded in the gravel of the outwash plain. In a few cases, tree remains were observed melting out at the front of the glacier tongue. The tree remains found were usually parts of stems with lengths to 9.4 m and diameters to 0.9 m. Nine trunks with remains of roots were investigated. A few of the stem fragments also showed partly intact beginnings of branches. No sample was found in an in situ position, e.g., rooted. The growth positions of these trees have to be sought in an area that is still under ice today or became free of ice after 2004 (Fig. 1). Usually the outer parts of the tree remains were eroded and sometimes compressed owing to transport under the glacier or in the glacier river and overloading ice masses, respectively. In some cases, however, remains of sapwood and even terminal rings were preserved. Some trunks (e.g., samples MM-906, MM-1104, and MM-1106) were found probably near their former growth locations, based on their good conservation, i.e., with bark and root remains. These trunks are still partly embedded in the gravel at the outwash plain but were exposed by the glacial stream. The place

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where these trunks were discovered corresponds to the position of the glacier terminus in 2005.

Sections were taken from the tree remains found between 2006 and 2011 for dendrochronological analyses (for details see the GSA Data Repository[1]).

Calendar dating of the Mont Miné samples is mainly based on cross-dating with the Eastern Alpine Conifer Chronology (EACC; Nicolussi et al., 2009). Radiocarbon dates were already published for several tree remains found in 1997 and 1998 on the forefield of the Mont Miné Glacier (Hormes et al. 2001). Three of these remains that showed sufficient numbers of tree rings were also dendrochronologically analyzed for this study. In addition, three ^{14}C dates were established for tree remains sampled in 2007 and 2009. (Table DR1 in the Data Repository lists all samples for which radiocarbon dates, as well as tree-ring analyses, were carried out.) Calibration of the radiocarbon dates (Table DR2), as well as wiggle matching of dendrochronologically cross-dated samples, was done with OxCal 3.1 (Bronk Ramsey 1995) and the IntCal09 calibration data set (Reimer et al., 2009).

RESULTS

All samples investigated belong to the tree species *Larix decidua* and *Pinus cembra* (Table DR1), typical tree-line species growing on glacier forefields in the Alps (e.g., Nicolussi and Patzelt, 2000; Joerin et al., 2008). The tree-ring series obtained are as long as 743 yr; including estimated tree-ring numbers for missing inner parts of some samples, minimum lifespans for some trees reach ~860 yr, extraordinarily high for Alpine tree species.

Cross-dating was successful for most of the Mont Miné tree-ring series (for details, the Data Repository; e.g., Table DR1). The averaging of 35 cross-dated series resulted in a 787-yr-long Mont Miné site chronology (MMC). Dendrochronological dating is based on a successful correlation with the calendar-dated EACC (Nicolussi et al., 2009). Accordingly, the MMC covers the time span 8955–8168 calendar yr b2k (6956–6169 B.C.).

The radiocarbon dates obtained from samples whose tree-ring series are included in the MMC (Table DR2) confirm the dendrochronological dating results. Wiggle matching was carried out with four ^{14}C, as well as dendrochronologically, dated samples. The wiggle matching results (1σ range 30 yr; 2σ range 50 yr) completely overlap the calendar dates of the wood sections used for radiocarbon dating, and therefore verify the tree-ring dating results (Table DR2).

Only one calendar-dated sample obtained from a small *Larix decidua* trunk found in 2009 a few meters in front of the glacier snout does not date to 9–8 ka, but shows a younger age; cross-dating with the EACC tree-ring series of this Mont Miné tree remain ranges from 7497 to 7244 yr b2k (5498–5245 B.C.).

Most of the logs investigated show no terminal rings (waney edge) or remains of sapwood. For some Mont Miné logs, however, terminal rings could be identified indicating dates of death between ca. 8183 and 8168 yr b2k (6183–6169 B.C.; Fig. 2). For some other samples where there was no terminal ring, but sapwood was preserved, the date of death could be estimated as ca. 8180–8170 yr b2k. None of the logs with the highest individual lifespans had a preserved inner part, probably because of decay processes during their lifetime. Thanks to estimates of the number of missing pith rings, germination dates can be roughly assumed for ca. 9080–8980 yr b2k (ca. 7080–6980 B.C.; Fig. 2) for these samples. The length of the MMC, the sapwood, and the pith estimates show a time span of ~900 yr (ca. 9080–8168 yr b2k) when tree growth was possible in an area that was free of ice since ca. 2005, or is today still covered by the Mont Miné Glacier.

[1]GSA Data Repository item 2012231, details of materials and methods, is available online at www.geosociety.org/pubs/ft2012.htm, or on request from editing@geosociety.org or Documents Secretary, GSA, P.O. Box 9140, Boulder, CO 80301, USA.

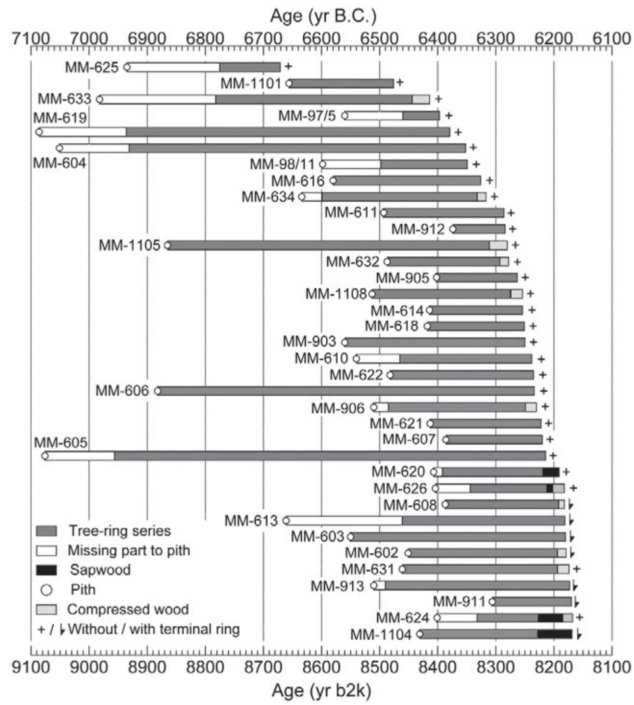

Figure 2. Temporal distribution of tree remains from Mont Miné Glacier, Swiss Alps, found in front of current snout position. Each bar represents a dendrochronologically dated sample. Length of gray bars indicates length of tree-ring series established for each sample. Numbers of tree rings are estimated for possibly missing inner part of sample; compressed outer rings as well as identified sapwood are also indicated. Note that many tree remains did not preserve their last tree rings before death owing to abrasion of outer wood sections due to transport and embedding below glacier. Determined death dates of these trees range from 8183 to 8168 yr before A.D. 2000 (b2k) (6183 to 6169 B.C.). B.C.E.—before Common Era.

DISCUSSION

The tree remains found in front of the terminus of the Mont Miné Glacier indicate a smaller glacier extent than today for most of the period 9–8 k.y. ago. More than 30 tree fragments could be calendar dated from that time period and terminal rings indicate the end of this growth period at 8183–8168 yr b2k. None of the logs were found in an in situ position, but the good preservation of some trunks suggests that the glacier reached a length equal its current size (A.D. 2005–2010) ca. 8170 yr b2k. We assume that the trees grew in the area between the glacier terminus position in 2005 and the rock face behind. An open forest consisting of *Pinus cembra* and *Larix decidua* trees can be assumed for nearly an entire millennium before ca. 8170 yr b2k for that valley area. This forest period ended owing to the advance of the Mont Miné Glacier, which is temporally synchronous with the 8.2 ka event characterized by cooling in the North Atlantic realm. This is the first time that an 8.2 ka event–related glacier advance has been calendar dated.

There is widespread evidence for a broad impact of the 8.2 ka climatic event on the Northern Hemisphere's environment (Alley and Agustsdottir, 2005). A possible effect on glaciers in the European Alps has been discussed for years, but clear evidence was lacking. Kerschner et al. (2006) suggested an 8.2 ka event–related advance of small glaciers in the Kromer Valley, northern Alps, based on exposure age dating of boulders that partly components of moraines. These moraines, however, are ~1 km outside the Little Ice Age (LIA; main phase ca. A.D. 1570–1860) moraines of this glacier system and the average age for moraine stabilization of 8.41 ka predates the 8.2 ka event. That sheds doubt on the interpretation, and a reconsideration of this location is underway (Ivy-Ochs et al.,

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2009). At other Alpine glaciers the possible impact of this climatic event remained unclear mainly because of imprecise dating (e.g., Nicolussi and Patzelt, 2001). Luetscher et al. (2011) suggested a biphasic advance of the Upper Grindelwald Glacier, Swiss Alps, ca. 8.2 ka based on analyses of speleothems. The collection of ^{14}C dates by Joerin et al. (2006) indicating smaller extents of the Alpine glaciers than ca. A.D. 2000 shows almost complete data coverage for the period 9–8 k.y. ago. There is a gap in the data at about 8 ka, however, suggesting a general advance period of Alpine glaciers. Joerin et al.'s (2006) results are consistent with the log collection from the Monte Miné Glacier. Both data sets indicate a nearly millennial-long glacier retreat period ca. 8.6 ka terminated by a glacier advance probably related to the 8.2 ka event.

Evidence for similar glacier advances is available from other mountain and glaciated areas of the Northern Hemisphere. In southern Norway, increased glacier activity between 8.5 and 8.0 ka, the so-called Finse event, was recorded in lakes fed by glacier sediments (Nesje, 2009). Likewise, lake investigations suggest a glacier advance period ca. 8.2 ka on Baffin Island, Arctic Canada, interrupting a long-lasting retreat period (Miller et al., 2005). Mainly detrital wood samples found in some recently deglaciated glacier forefields of western Canada with ages ranging from 8630 to 8020 cal yr B.P. were interpreted as evidence for an 8.2 ka event–related minor advance period (Menounos et al., 2004). Radiocarbon-dated caribou dung and plant material prove the increase of an ice patch between 8.3 and 8.0 ka in southwest Yukon (Farnell et al., 2004).

Confirmation of an impact of the 8.2 ka cooling event on the environment of the greater Alpine area comes from vegetation, lake, and cave proxies. Several vegetation studies at high-altitude sites in the Alps show a decrease of the tree line ca. 8.2 ka, suggesting cooler summer temperatures and a reduced length of the vegetation period (e.g., Wick and Tinner, 1997; Kofler et al., 2005; Nicolussi et al., 2005). Most of these records suggest that the 8.2 ka period was not only a relatively short event, but the initial "shock" at the beginning of a centuries-long phase with relatively cool summer conditions in the Alps. Beside the vegetation-based and therefore summer-related proxy records, the largely missing evidence for strongly retreated terminus positions of Alpine glaciers ca. 8 ka (Joerin et al., 2006) supports the idea of an interruption of the thermal optimum in the Alps following the 8.2 ka event and lasting some centuries. The Alpine thermal optimum spans the early and middle Holocene and was characterized by glaciers usually shorter than today's (Joerin et al., 2006, 2008; Goehring et al., 2011).

Contrary to the glacier- and vegetation-based records, the precipitation $\delta^{18}O$ record of Lake Ammersee shows that the period ca. 8.2 ka was an episode of continuously reduced values over just ~130 yr (von Grafenstein et al., 1998, 1999). The speleothem $\delta^{18}O$ record from the Katerloch Cave demonstrates a negative $\delta^{18}O$ excursion of similar duration but at a slightly younger age (Fig. 3); however, that might be related to dating uncertainties of 100–150 yr for this record (Boch et al., 2009). In contrast to the Greenland $\delta^{18}O$ ice-core records, both central European records indicate similar $\delta^{18}O$ values as those of the 8.2 ka event also during other phases at 9–8 ka, but the duration of these phases was always short.

Assuming that the advance of the Mont Miné Glacier was directly triggered by the 8.2 ka event, the temporal position of the advance within the 8.2 ka period is relevant as regards the reaction time of the glacier to the forcing and the possible continuation of the advance after 8168 yr b2k. Comparison with the mid-European $\delta^{18}O$ records from Lake Ammersee and the Katerloch Cave, as well as the North Greenland Ice Core Project (NGRIP) $\delta^{18}O$ data, shows differences in the precise timing of the event (Fig. 3). According to the NGRIP and the Ammersee record (both on the Greenland Ice Core Chronology 2005 time scale), the Mont Miné Glacier advanced at the end of (NGRIP) or slightly after (Ammersee) the 8.2 ka event, to an extent approximate to that of today. Based on that comparison, the glacier needed more than 100 yr to reach such an extent, and the end of the advance can be placed shortly after ca. 8150 yr

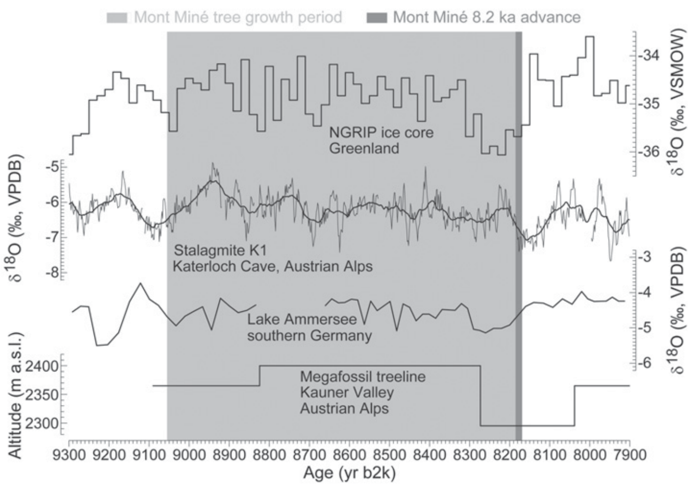

Figure 3. Comparison of Mont Miné tree growth period and 8.2 ka–related advance of this glacier with 8.2 ka event-sensitive proxy records. These records are given on published time scales. Mont Miné Glacier advance ca. 8175 yr before A.D. 2000 (b2k) plots in 8.2 ka period of all records. Owing to dating uncertainties of $\delta^{18}O$ records, relative position of glacier advance (at beginning, middle, or end of event) remains unclear. NGRIP—North Greenland Ice Core Project; VSMOW—Vienna standard mean ocean water; VPDB—Vienna Peedee belemnite; a.s.l.—above sea level.

b2k. In contrast, the timing of the glacier advance is near the minimum of the Katerloch Cave $\delta^{18}O$ record. From this record, a continuation of the glacier advance could be derived for at least several decades. The NGRIP time scale seems more reliable than the Katerloch dating accuracy, however, owing to the compilation of well-dated records by Cheng et al. (2009). The tree-line record from the Kauner Valley, eastern Alps, that is based on subfossil tree remains (Nicolussi et al., 2005) indicates a marked drop of the Alpine tree-line position roughly synchronous with the onset of the 8.2 ka event in the NGRIP and the Ammersee $\delta^{18}O$ records. It suggests, however, a much longer duration of the 8.2 ka event–related cooling than the other records (Fig. 3). The relatively late rise of the tree line in the Kauner Valley after the end of the 8.2 ka event can be explained by a generally delayed reaction of alpine tree lines to warming. Therefore, this rise cannot be used to estimate the end of the 8.2 ka related Mont Miné Glacier advance.

The 8.2 ka advance of the Mont Miné Glacier proves that there was a reaction of this body of ice lasting from a few decades to as much as ~130 yr as a result of the 8.2 ka cooling event, depending on the dating of the proxy records (Fig. 3). The relatively short time span the glacier needed to reach a length similar to that of today also suggests that no complete reformation of the Mont Miné Glacier was necessary to produce that advance. It is unlikely, however, that Alpine glaciers advanced as far as, or even farther, than during the LIA at ca. 8.2 ka; therefore corresponding records are missing.

CONCLUSIONS

In the light of the analysis of tree remains found at the actual glacier snout of the Mont Miné Glacier, we present the first calendar-dated evidence for an advance within the 8.2 ka cooling event. Several tree fragments date this advance from 8183 to 8168 yr b2k. The Mont Miné Glacier reached the current ice extent at that time.

This glacier advance documents the end of a long-lasting retreat period that goes back at least to 9.1 ka, and during that time, the Mont Miné Glacier was continuously shorter than in A.D. 2005–2010.

The relative temporal position of the Mont Miné Glacier advance ca. 8175 yr b2k, within the 8.2 ka cooling event (at the beginning, middle, or end), remains unclear owing to less-accurate dating of several highly resolved climate proxy records; e.g., $\delta^{18}O$ records from Greenland ice cores, as well as from central European lake sediments and speleothems.

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Supplementary Online Material for the Paper "The 8.2 ka event – calendar-dated glacier response in the Alps"

Details of Material and Methods

Wood species identification was done for all samples. Total ring widths were measured to a precision of 1 µm by using a LINTAB device and the TSAP software package for at least two radii per sample. A mean tree-ring width series for each sample analyzed was established by crossdating and averaging the measurements of the single radii. The length of the mean series of a sample indicates only the minimum lifetime of the specific tree. For sections with a missing inner part of the stem the tree-ring number between the pith and the first tree-ring measured was estimated.

The mean series of each sample was used for comparison with the other local tree-ring series and reference chronologies. For dendrochronological cross-dating statistical parameters were calculated and visual controls were applied. The cross-dated tree-ring series from the Mont Miné Glacier were averaged to a site chronology (Mont Miné chronology, MMC). Calendar dating of the MMC is based on the Eastern Alpine Conifer Chronology (Nicolussi et al., 2009): overlap: 788 years, *gleichläufigkeit* (sign test): 70%, t-value: 12.9.

Table DR1. Mont Miné Glacier: dendrochronologically and radiocarbon-dated samples from the ninth and eighth millennium BP. The table indicates tree species, number of measured tree-rings per sample, dating results (^{14}C-dates for only radiocarbon-dated samples or calendar dates of the first and last ring of the dendrochronologically dated tree-ring series), pith offset information (estimated number of rings) for wood samples with missing central part, number of compressed and therefore unmeasured outer rings, estimated minimum lifespan for each sample and information on the terminal ring of each sample (waney edge: yes/ no). The calibrated results of the ^{14}C dates are given in Table DR2.

Sample code	Tree species	Tree-ring series (n)	^{14}C date (yr BP) / calendar date (yr b2k)	Pith offset (tree rings, n)	Outer, compressed tree rings, not measured (n)	Minimum lifespan, estimated (yr)	Waney edge
MM97-1	*Larix decidua*	83	7885±32	c. 8	-	91	n
MM97-5	*Pinus cembra*	64	8459 - 8396	c. 100	-	164	n
MM98-11	*Larix decidua*	150	8497 - 8348	c. 100	-	250	n
MM-602	*Pinus cembra*	258	8450 - 8193	0	c. 10	268	y
MM-603	*Pinus cembra*	372	8550 - 8179	0	-	372	y
MM-604	*Pinus cembra*	580	8930 - 8351	c. 120	-	700	n
MM-605	*Pinus cembra*	743	8955 - 8213	c. 120	-	863	n
MM-606	*Pinus cembra*	649	8881 - 8233	0	-	649	n
MM-607	*Pinus cembra*	167	8385 - 8219	0	-	167	n
MM-608	*Pinus cembra*	196	8386 - 8191	0	c. 8	204	y

MM-610	*Pinus cembra*	228	8464 - 8237	c. 75	-	303	n
MM-611	*Pinus cembra*	208	8493 - 8286	0	-	208	n
MM-613	*Pinus cembra*	281	8460 - 8180	c. 200	-	481	y
MM-614	*Pinus cembra*	161	8413 - 8253	0	-	161	n
MM-616	*Pinus cembra*	255	8579 - 8325	0	-	255	n
MM-618	*Larix decidua*	168	8417 - 8250	0	-	168	n
MM-619	*Pinus cembra*	558	8935 - 8378	c. 150	-	708	n
MM-620	*Larix decidua*	202	8391 - 8190	c. 15	-	217	n
MM-621	*Pinus cembra*	192	8412 - 8221	0	-	192	n
MM-622	*Pinus cembra*	251	8481 - 8234	0	-	251	n
MM-624	*Larix decidua*	150	8331 - 8182	c. 70	-	220	n
MM-625	*Pinus cembra*	105	8774 - 8670	c. 160	-	265	n
MM-626	*Larix decidua*	153	8353 - 8201	c. 60	c. 20	233	n
MM-631	*Pinus cembra*	268	8460 - 8193	0	c. 20	288	n
MM-632	*Larix decidua*	195	8486 - 8292	0	c. 15	210	n
MM-633	*Larix decidua*	369	8781 - 8413	c. 200	-	569	n
MM-634	*Pinus cembra*	268	8598 - 8331	c. 35	c. 15	318	n
MM-904	*Pinus cembra*	86	7525±20	0	-	86	n
MM-905	*Larix decidua*	141	8400 - 8262	0	-	141	n
MM-906	*Pinus cembra*	139	8390 - 8252	c. 120	c. 15	274	n
MM907	*Pinus cembra*	254	7497 - 7244	0	-	254	n
MM-911	*Pinus cembra*	137	8305 - 8169	0	-	137	y
MM-912	*Larix decidua*	91	8373 - 8283	0	-	91	n
MM-913	*Pinus cembra*	318	8489 - 8172	c. 20	-	338	y
MM-1101	*Pinus cembra*	181	8655 - 8475	0	-	181	n
MM-1104	*Larix decidua*	264	8431 - 8168	0	-	264	y
MM-1105	*Larix decidua*	553	8862 - 8310	c. 2	-	553	n
MM-1108	*Larix decidua*	239	8512 - 8274	0	c. 20	259	n

Table DR2. Mont Miné Glacier: radiocarbon-dated as well as dendrochronologically analyzed wood samples from the ninth millennium BP. The removal positions of the ^{14}C samples used for radiocarbon dating by Hormes et al. (2001) were not recorded. We assume a central removal position with regard to the tree-ring series for the two ^{14}C samples/dates (MM 97/5 and MM 98/11) that we utilized for wiggle matching.

Sample code	Source	^{14}C sample (tree-ring series no.)	Laboratory number	^{14}C age (yr BP)	cal. ^{14}C age (1 σ range, yr BC)	cal. ^{14}C age (2 σ range, yr BC)	wiggle matching age (1 σ range, yr BC)	wiggle matching age (2 σ range, yr BC)	Calendar-date of the ^{14}C-sample (yr BC)
MM 97/1	Hormes et al. (2001)	not rec.	B-7307	7885±32	6770-6650	7010-6640	-	-	-
MM 97/5	Hormes et al. (2001)	not rec.	B-7310	7523±32	6435-6385	6460-6260	6455- 6425	6460- 6410	c. 6428
MM 98/11	Hormes et al. (2001)	not rec.	B-7305	7626±33	6485-6435	6570-6420	6450-6420	6455-6405	c. 6423
MM-611	this study	8-9	ETH 37235	7670±40	6570-6460	6600-6440	6510- 6485	6515- 6470	6487-6486
MM-904	this study	8-21	GrN 32664	7525±20	6430-6395	6440-6375	-	-	
MM-911	this study	116-124	GrN 32445	7230±25	6210-6030	6210-6020	6205-6180	6210- 6165	6191-6183