The last interglacial as represented in the glaciochemical record from Mount Moulton Blue Ice Area, West Antarctica

Elena V. Korotkikh, Paul A. Mayewski, Michael J. Handley, Sharon B. Sneed, Douglas S. Introne, Andrei V. Kurbatov, Nelia W. Dunbar, William C. McIntosh

*Climate Change Institute, University of Maine, Orono, ME 04469-5790, USA
**Department of Earth Sciences, University of Maine, Orono, ME 04469-5790, USA
**Earth and Environmental Science Department, New Mexico Bureau of Geology, New Mexico Institute of Mining and Technology, Socorro, NM 87801-4796, USA

**Article Info**
Received 3 June 2010
Received in revised form 25 April 2011
Accepted 27 April 2011
Available online 24 May 2011

**Keywords:**
- Last interglacial
- Glaciology
- Paleoclimate

**Abstract**
Understanding climate during the last interglacial is critical for understanding how modern climate change differs from purely naturally forced climate change. Here we present the first high-resolution ice core record of the last interglacial and transition to the subsequent glacial period from Antarctica and the first glaciochemical record for this period from West Antarctica. Samples were collected from a horizontal ice trench in the Mt. Moulton Blue Ice Area (BIA) in West Antarctica and analyzed for their soluble major anions (Cl\(^-\), NO\(_3\)\(^-\), SO\(_4\)\(^{2-}\)), major and trace elements (Na, Mg, Ca, Sr, Cr, Cs, Ba, La, Ce, Pr, Pb, Bi, U, As, Al, S, Ti, V, Cr, Mn, Fe, Co, Cu, Zn) and water hydrogen isotopes (\(^{18}D\)). The last interglacial is characterized by warmer temperatures (\(^{18}D\)), weakened atmospheric circulation (dust elements, seasalts aerosols), decreased sea ice extent (Na, nssSO\(_4\)\(^{2-}\)) and decreased oceanic productivity (nssSO\(_4\)\(^{2-}\)). A combined examination of Mt. Moulton seasalts, dust, nssSO\(_4\)\(^{2-}\) and \(^{18}D\) records indicates that the last interglacial was extremely stable compared to glacial age climate events and it ended through a long period of gradual cooling unlike that projected for future Holocene climate.

© 2011 Elsevier Ltd. All rights reserved.

1. Introduction
The last interglacial (also known as the Eemian in Europe or marine isotope stage 5e) is the most recent analog for the present (Holocene) interglacial and therefore the most recent analog for a purely naturally forced interglacial. It is characterized by a diminution of ice sheets and establishment of biotic assemblages similar to those of the Holocene (Van Kolfschoten et al., 2003). It appears that global temperatures during the last interglacial were on average ~1.5 °C higher than today (Turney and Jones, 2010). Temperature reconstructions for East Antarctica suggest that the peak temperature during the last interglacial was higher than late Holocene values by about 3–4.5 °C (Petit et al., 1999; Watanabe et al., 2003; Kawamura et al., 2007; Jouzel et al., 2007). Global sea level was at least 3 m, and very likely more than 6.6 m, higher than at present as a result of disintegration of the West Antarctic and Greenland ice sheets (Cuffey and Marshall, 2000; Kopp et al., 2009).

CO\(_2\) concentrations in the atmosphere were briefly higher than those during the pre-industrial Holocene (Petit, 1999).

Published records suggest differences in timing, duration and stability for the last interglacial (Winograd et al., 1997; Adams et al., 1999; Kulda et al., 2002). Only five ice core records fully cover the last interglacial and these come from East Antarctica (Petit et al., 1999; Steig et al., 2000; Groote et al., 2001; EPICA Community Members, 2006; Jouzel et al., 2007; Kawamura et al., 2007). However the climate during the last interglacial in West Antarctica is of special interest, since the West Antarctic Ice Sheet (WAIS) most likely contributed to sea level rise above that of the present during the peak of the last interglacial (Overpeck et al., 2006). The WAIS is the largest potential source of the up to 1.4 m potential sea level rise projected as a consequence of warming by 2100 (ACCE (Antarctic Climate Change and the Environment), 2009) making understanding of the last interglacial climate in this region of particular significance. In this work we present the first glaciochemical record of the last interglacial and transition to the subsequent glacial period from West Antarctica. Rather than using a standard vertical ice core we used samples collected from a horizontal ice trench in the Mt. Moulton BIA. The record is high resolution and contains a suite of 27 measurements, including major anions, major and trace elements.
2. Methodology

Mt. Moulton BIA is located in the Flood Range of Marie Byrd Land in West Antarctica (76° 4’S, 134° 42’W) at an elevation of 2820 m above sea level (Figs. 1 and 2). The BIA formed on the southern shoulder of Mt. Moulton as a result of a nunatak (Prahl Crags) obstructing ice flow from the summit (Dunbar et al., 2008). The ~600 m of exposed ice contains more than 40 volcanic tephra layers distributed over the last ~500 ka. The geochemical composition of the tephra layers suggests that most of them were derived from Mt. Berlin, located 20 km from Mt. Moulton (Wilch et al., 1999; Dunbar et al., 2008).

Forty-two meters of the Mt. Moulton ice trench were melted using the University of Maine continuous melting system (Osterberg et al., 2006) at a sample resolution of ~0.8–1 cm. There are three gaps in the melted section totaling 1.62 m. Each block of ice (~50 cm length) extracted from the horizontal trench was cut into 3.5 × 3.5 cm sections. The ends of each ice block were scraped using a clean ceramic knife before melting to prevent contamination. Samples were collected from the inner and outer parts of the samples. To avoid contamination only the inner portion of each sample was used for major anion and trace element analysis. The meltwater from the potentially contaminated outer part was collected for stable isotope analysis.

All 3795 samples were analyzed for their soluble major anion content (Cl\(^-\), NO\(_3^-\), SO\(_4^{2-}\)) by ion chromatography (IC) and for major and trace elements (Na, Mg, Ca, Sr, Cd, Cs, Ba, La, Ce, Pr, Pb, Bi, U, As, Al, Ti, V, Cr, Mn, Fe, Co, Cu, Zn) by inductively coupled plasma sector field mass spectrometry (ICP-MS). Major anions were analyzed on a Dionex DX-500 ion chromatograph coupled to a Gilson autosampler, and concentrations are reported in ug/L (ppb). Major and trace elements analyses were performed with the UMaine Thermo Electron Element2 ICP-MS coupled to a Cetac Model ASX-260 autosampler. Concentrations are reported in ug/L (ppb), ng/L (ppt) and pg/L (ppq). The ICP-MS samples were acidified to 1% with double-distilled HNO\(_3\) under a class-100 High Efficiency Particle Air (HEPA) clean bench and allowed to react with the acid for approximately 1 week before being frozen. Approximately every fifth sample (713 total) was analyzed for δD by isotope ratio mass spectrometry (IRMS) using a Micromass Isoprime mass spectrometer. Data are reported in delta (δ) notation relative to standard mean ocean water (SMOW).

The sampled section contains several englacial tephra layers, three of them have been dated by \(^{40}\)Ar/\(^{39}\)Ar radiometric dates: BIT-158 (104.9 ± 0.6 ka), BIT-160 (118.1 ± 1.3 ka) and BIT-162...
The positions of these tephra layers allow us to be certain that the sampled section covers the last interglacial period (Fig. 3).

3. Results and discussion

3.1. Mt. Moulton glaciochemical records

Fig. 3 shows Mt. Moulton glaciochemical records delivered from different sources. Seasalt aerosols are one of the major impurities in Antarctic ice cores. They are represented mainly by Na and Cl. The primary sources for seasalt aerosols in Antarctica are open water and new sea ice surfaces (Legrand and Mayewski, 1997).

The most important natural sources for $\text{SO}_4^{2-}$ in the atmosphere are: seasalt aerosols, volcanic and marine biogenic emissions and background mixed sources transported through the stratosphere (Mayewski et al., 1990; Legrand and Mayewski, 1997; Dixon et al., 2004). Seasalt and non-sea-salt components of $\text{SO}_4^{2-}$ were calculated using the technique described by O’Brien et al. (1995). The results show that the average seasalt contribution to the Mt. Moulton $\text{SO}_4^{2-}$ record is very small (5.9%) and almost all nss$\text{SO}_4^{2-}$ ($94.1\%$) has a non-seasalt origin. Volcanic input during background periods is small, no more than $10-13\%$ of the deposition of nss$\text{SO}_4^{2-}$ over Antarctica (Boutron and Patterson, 1986; Gabrielli et al., 2005; Wolff et al., 2006). Previous studies show that marine biogenic sources dominate the sulfur budget in the Antarctic region. Most of the nss$\text{SO}_4^{2-}$ comes from oxidation of dimethylsulphide (DMS) produced by marine phytoplankton and emitted from the ocean surface (Legrand et al., 1991; Legrand and Mayewski, 1997; Minikin et al., 1998).
NO$_3^-$ is contributed by a variety of sources such as tropospheric lightning, NO$_x$ produced from N$_2$O oxidation in the lower stratosphere, and surface sources such as biomass burning and NO exhalations from soils (Legrand and Kirchner, 1990).

We conducted empirical orthogonal function (EOF) analysis on all of the ice core time series in order to investigate inter-species relationships and reveal different sources for Mt. Moulton aerosols (Table 1). EOF1 represents 43.4% of the total variance and is heavily loaded with the elements Sr, Ba, La, Ce, Pr, Al, Ca, Ti, V, Mn, Fe, Co (percentages ranged between 63 and 85%). According to the elemental composition, EOF1 most likely represents the composition of the primary mineral dust sources impacting Mt. Moulton (Fig. 4). Enrichment factors (EF) were also calculated for all transition of the primary mineral dust sources impacting Mt. Moulton Fe, Co (percentages ranged between 63 and 85%). According to the heavily loaded with the elements Sr, Ba, La, Ce, Pr, Al, Ca, Ti, V, Mn, transition of the reference element in the ice sample and R2 the concentration of the reference element in the upper crust. Upper continental crust (UCC) values are from Wedepohl (1995). Al was selected as a crustal reference element, because it is the second most abundant element in the earth's crust and the only known source of Al in Antarctica is crustal dust. It has been widely used for calculation of EF in earlier studies (Tuncel et al., 1989; Gabrielli et al., 2005). Elements with EFs lower than 5 usually are considered non-enriched, delivered entirely from crustal dust. The differences in the composition of rock and soil dust reaching Antarctica can be attributed to variations of EFs of elements between 0 and 5 (Tuncel et al., 1989; Siggaard-Andersen et al., 2007). The mean EF values of the non-

Table 1  

<table>
<thead>
<tr>
<th>Element</th>
<th>EOF 1</th>
<th>EOF 2</th>
<th>EOF 3</th>
<th>EOF 4</th>
<th>EOF 5</th>
<th>EOF 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sr88(LR)</td>
<td>70.7</td>
<td>10.1</td>
<td>0.7</td>
<td>3.3</td>
<td>3.2</td>
<td>2.0</td>
</tr>
<tr>
<td>Cd111(LR)</td>
<td>0.8</td>
<td>4.2</td>
<td>-1.1</td>
<td>3.2</td>
<td>0.2</td>
<td>0.0</td>
</tr>
<tr>
<td>Cs133(LR)</td>
<td>12.1</td>
<td>24.2</td>
<td>10.0</td>
<td>-0.3</td>
<td>-3.9</td>
<td>-6.1</td>
</tr>
<tr>
<td>Ba138(LR)</td>
<td>82.5</td>
<td>5.7</td>
<td>0.1</td>
<td>-0.2</td>
<td>1.2</td>
<td>1.2</td>
</tr>
<tr>
<td>La139(LR)</td>
<td>7.9</td>
<td>3.2</td>
<td>0.5</td>
<td>11.9</td>
<td>0.0</td>
<td>0.2</td>
</tr>
<tr>
<td>Ce140(LR)</td>
<td>80.0</td>
<td>3.1</td>
<td>0.4</td>
<td>12.0</td>
<td>0.0</td>
<td>0.2</td>
</tr>
<tr>
<td>Pr141(LR)</td>
<td>80.2</td>
<td>3.5</td>
<td>0.4</td>
<td>11.6</td>
<td>-1.1</td>
<td>0.3</td>
</tr>
<tr>
<td>Pb208(LR)</td>
<td>9.8</td>
<td>42.1</td>
<td>-20.0</td>
<td>0.3</td>
<td>0.5</td>
<td>0.1</td>
</tr>
<tr>
<td>Bi209(LR)</td>
<td>1.0</td>
<td>6.8</td>
<td>-1.6</td>
<td>2.5</td>
<td>0.4</td>
<td>0.6</td>
</tr>
<tr>
<td>U238(LR)</td>
<td>52.3</td>
<td>10.4</td>
<td>0.0</td>
<td>20.5</td>
<td>-0.4</td>
<td>0.5</td>
</tr>
<tr>
<td>As75(LR)</td>
<td>18.2</td>
<td>5.7</td>
<td>-0.2</td>
<td>6.0</td>
<td>0.3</td>
<td>0.5</td>
</tr>
<tr>
<td>Al27(MR)</td>
<td>70.5</td>
<td>-3.6</td>
<td>-0.2</td>
<td>-0.1</td>
<td>-0.7</td>
<td>-0.1</td>
</tr>
<tr>
<td>Si28(MR)</td>
<td>41.9</td>
<td>0.2</td>
<td>13.4</td>
<td>-1.2</td>
<td>27.9</td>
<td>-2.6</td>
</tr>
<tr>
<td>Ca44(MR)</td>
<td>80.4</td>
<td>-4.2</td>
<td>-0.3</td>
<td>-1.0</td>
<td>0.0</td>
<td>0.1</td>
</tr>
<tr>
<td>Ti47(MR)</td>
<td>80.9</td>
<td>-12.2</td>
<td>0.0</td>
<td>-2.0</td>
<td>0.0</td>
<td>-0.4</td>
</tr>
<tr>
<td>V51(MR)</td>
<td>69.1</td>
<td>-12.5</td>
<td>-1.5</td>
<td>-4.9</td>
<td>-3.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Cr52(MR)</td>
<td>5.0</td>
<td>2.8</td>
<td>-12.1</td>
<td>-3.7</td>
<td>-15.9</td>
<td>2.7</td>
</tr>
<tr>
<td>Mn55(MR)</td>
<td>85.0</td>
<td>1.6</td>
<td>-0.2</td>
<td>5.4</td>
<td>-1.4</td>
<td>1.0</td>
</tr>
<tr>
<td>Fe56(MR)</td>
<td>87.8</td>
<td>-1.6</td>
<td>-1.5</td>
<td>0.0</td>
<td>-3.8</td>
<td>0.4</td>
</tr>
<tr>
<td>Co59(MR)</td>
<td>63.0</td>
<td>-3.5</td>
<td>-7.2</td>
<td>-9.0</td>
<td>-2.8</td>
<td>0.4</td>
</tr>
<tr>
<td>Na23(MR)</td>
<td>8.6</td>
<td>28.6</td>
<td>30.9</td>
<td>-10.5</td>
<td>-8.1</td>
<td>4.9</td>
</tr>
<tr>
<td>Mg24(MR)</td>
<td>43.0</td>
<td>-7.8</td>
<td>-1.4</td>
<td>-6.0</td>
<td>-1.9</td>
<td>0.4</td>
</tr>
<tr>
<td>Cu63(MR)</td>
<td>3.4</td>
<td>26.1</td>
<td>-28.3</td>
<td>-15.4</td>
<td>8.6</td>
<td>-0.6</td>
</tr>
<tr>
<td>Zn66(MR)</td>
<td>4.1</td>
<td>30.7</td>
<td>-30.5</td>
<td>-12.9</td>
<td>5.1</td>
<td>-0.3</td>
</tr>
<tr>
<td>Cl$^-$</td>
<td>2.1</td>
<td>24.6</td>
<td>38.0</td>
<td>-17.4</td>
<td>-9.8</td>
<td>0.9</td>
</tr>
<tr>
<td>NO$_3^-$</td>
<td>2.1</td>
<td>2.1</td>
<td>4.7</td>
<td>-2.6</td>
<td>3.2</td>
<td>80.3</td>
</tr>
<tr>
<td>SO$_4^{2-}$</td>
<td>37.0</td>
<td>0.2</td>
<td>19.0</td>
<td>-2.3</td>
<td>30.4</td>
<td>0.4</td>
</tr>
</tbody>
</table>

Table 1  

Percent variance of each elemental time series explained by Empirical Orthogonal Function (EOF) analysis.

3.2. Climate during the last interglacial

At the end of the penultimate glacial period at about 136–135 ka B.P. (243–244 m) Mt. Moulton sea salt and nssSO$_4^{2-}$ concentrations were high, due to greater cyclonic activity (Mayewski et al., 1997; Kreutz et al., 2000), increased sea ice extent (Wolff et al., 2003) and/or increased oceanic productivity associated with sea ice (Gibson et al., 1990; Legrand et al., 1991; Welch et al., 1993) (Fig. 3). The maximum NO$_3^-$ concentration (~15ug/L) is at a distance of 242.5 m possibly indicating increased persistence and/or extent of polar stratospheric clouds (Mayewski and Legrand, 1990) related to the cooler conditions in the upper atmosphere over the ice sheet during the glacial. The highest dust concentrations (~2–6 times higher than during most of the record), as represented by EOF1, are from 243.5 m (135.6 ka B.P.) to ~239.5 m likely caused by intensified atmospheric circulation and/or drier conditions in the source areas supplying dust to West Antarctica (Dixon et al., in press). The beginning of the last interglacial was marked by a major decrease in sea salts and nssSO$_4^{2-}$ concentrations around 242 m likely indicating weakening of atmospheric circulation and a decrease of the sea ice extent. However dust concentrations remain high for a longer period of time, until 238 m. Decrease in dust aerosols around 238 m is associated with the last interglacial 3D maximum (increase in temperature). This drop in dust concentrations might be caused by changes in the dust source areas and/or reduction in the size of the southern circumpolar vortex and therefore the scope of southern hemisphere dust areas impacted by the vortex. The East Antarctic records also show higher dust concentrations during the end of penultimate glacial period than during the last interglacial (Petit et al., 1999; Lambert et al., 2008). However, in contrast with the Mt. Moulton record, dust concentrations in East Antarctica decrease long before the temperature reaches its maximum. This difference in dust loading may be caused by differing atmospheric circulation patterns and/or different dust sources impacting East and West Antarctica.

During the last interglacial the mean levels of Na and CI concentrations were low (12 and 25 ug/L respectively), and fairly stable with one increase in both concentrations of 25–30 ug/L between 237 and 240 m associated with the last interglacial temperature maximum (a maximum 3D value of ~195 to ~185°C). In general high concentrations of sea salts in ice cores have been attributed to greater cyclonic activity at the open water source, more efficient zonal and meridional transport (Mayewski et al., 1997; Petit et al., 1999; Kreutz et al., 2000) or/and greater winter sea ice production and extent (Wolff et al., 2003). However most likely during the warmest phase of the last interglacial sea ice extent was much lower and open water was closer to the Antarctic mainland. Coincident with this is the lowest level of nssSO$_4^{2-}$ also indicative of a minimum sea ice extent during this time. The West Antarctic Ice Sheet (WAIS) was much smaller during the peak of the last interglacial and as previously suggested contributed to a sea level rise above that of the present (Overpeck et al., 2006). Therefore, the increase in sea salt concentration is explained by the proximity of an open water source to the Mt. Moulton site associated with reduction in sea ice extent and shrinkage of the WAIS (Overpeck et al., 2006).

The Mt. Moulton record reveals several dust peaks during the last interglacial (Fig. 4). These dust increases happened rapidly and lasted for a short period of time. The 3D temperature proxy, however, does not reveal changes concurrent with these dust events. These dust
peaks are, therefore, most likely related to changes in atmospheric circulation and/or differences in emission strength in source areas. While the onset of the last interglacial at Moulton is clearly recorded as a rapid shift from glacial to interglacial conditions, the end of the last interglacial is significantly less distinct. The termination of the last interglacial may be marked by a large increase in all of the dust elements at \( \sim 224.5 \) m although the levels are still within the range of deglacial levels. However, all of the dust elements reveal only a short increase in concentration starting at \( \sim 224.5 \) m. By contrast, concentrations of Al and Co remain high for a much longer period of time until \( \sim 215 \) m (Fig. 4). Differences in dust elements over time may be caused by differing atmospheric circulation patterns and/or dust sources impacting Mt. Moulton.
Between 222 and 223 m, following the dust rise noted above, there is a decrease in δD (~10‰), interpreted as a temperature decrease. This δD decrease indicates a shift to colder conditions and could also be used as an indicator of the end of the last interglacial. The end of the last interglacial may also be recorded by an increase in Na and Cl− concentrations back to deglacial range values near 219 m potentially due to an increase of winter sea ice extent and/or increased storm intensity.

The nssSO4^2− concentration starts to rise around 118 ka B.P. (215.6 m), likely due to an increase in sea ice extent and biogenic emission, and may also mark the end of the last interglacial. The beginning of the nssSO4^2− rise is coincident with the position of the BIT-160 tephra layer. Thus this tephra layer provides a solid radiometric date on the possible end of the last interglacial. After 215.6 m nssSO4^2− concentrations continued to rise reaching deglacial range values at ~210 m. This timing corresponds with a Na and Cl− rise and another δD drop marking yet another possible end date for the last interglacial. In this case, the last interglacial would be almost twice the duration with a transition in the middle to relatively colder climate conditions with increased cyclonic activity and greater sea ice extent.

3.3. The hydrogen isotope record and correlation with other Antarctic ice cores

The oxygen and hydrogen isotopic composition of polar ice is classically assumed to provide records of local surface temperature (Lorius et al., 1985; Petit et al., 1999). Fig. 5 shows the isotope time series for the period 102–140 ka B.P. from published East Antarctic ice core records: Vostok (Petit et al., 1999), EPICA Dome C (Jouzel et al., 2007), Dome Fuji (Kawamura et al., 2007), EPICA Dronning Maud Land (EDML) (Members, 2006) and Taylor Dome (Steig et al., 2000; Grootes et al., 2001). This time period covers the last interglacial to the onset and termination of the last glacial.

Between 210 and 212 m, BIT-162 places the solid date to the beginning of the Termination II in the Mt. Moulton record. This is in agreement with the beginning of deglaciation as seen in the EPICA Dome C, EDML and Vostok records. The Dome Fuji and Taylor Dome records show slightly younger date for beginning of Termination II at ~137 ka B.P.

All records show rapid shifts from the glacial to interglacial climates followed by gradual return to glacial conditions. Mt. Moulton δD has a more rapid shift from the glacial to interglacial climate between 135.6–133 ka B.P. However this rapid deglaciation is most likely due to the lack of changes in the accumulation rates between glacial and interglacial conditions in the Mt. Moulton age model. If we assume that deglaciation in the Mt. Moulton record is similar in duration with East Antarctic records, the deglaciation could be ~1.7 times longer. In this case the warmest part of the last interglacial in the Mt. Moulton record, characterized by maximum δD values (~187‰), will be at ~128–129 ka B.P. instead of 132 ka B.P.

The major difference between West and East Antarctic isotope records occurs during the period ~112–122 ka B.P. as seen in the Mt. Moulton record. This corresponds to the interval between 108.5 and 120 ka B.P. in the EPICA Dome C, EDML and Vostok time series; ~112–122 ka B.P. in Dome Fuji; and ~110–120 ka B.P. in the Taylor Dome records. While the East Antarctic records show a continual decline in the isotope time series, the Mt. Moulton δD record remains relatively stable for a long period, around 7 ka, using the linear interpolation, followed by a decrease of ~1‰ between 208 and 210 m. The minimum temperature at distance of ~208 m in the Mt. Moulton record coincides with the temperature drop ~111 ka B.P. in Taylor Dome and most likely corresponds to a cold interval at ~108.5 ka B.P. in the EPICA Dome C, EDML and Vostok records; and at ~112 ka B.P. in Dome Fuji record. The difference in timing is most likely caused by dating uncertainties of the existing timescales. During this time, between ~112–122 ka B.P. (~210–220 m), the Mt. Moulton (Fig. 3) record in the Na concentration indicating stronger atmospheric circulation and/or increased sea ice extent (Kreutz et al., 2000; Wolff et al., 2006).
increased cyclonic activity (and therefore isotope values) may increase at sites, such as Mt. Moulton, that are heavily influenced by marine air masses (Kreutz et al., 1997). Therefore while East Antarctica underwent steady cooling, the Moulton West Antarctic climate remained relatively warm, most likely due to the stronger and more consistent oceanic influence and increased cyclonic activity in this region.

4. Conclusion

For the first time a high-resolution glaciochemical record of the last interglacial from West Antarctica has been developed. The Mt. Moulton record is the only ice core record of the last interglacial from Antarctica that has any absolute dated sections based on the 40Ar/39Ar radiometric dates from the englacial tephra layers (Dunbar et al., 2008). Position of BIT-162 (135.6 ± 0.9 ka B.P.) is located right at the beginning of the transition from the penultimate glacial period to the last interglacial and BIT-160 (118.1 ± 1.3 ka B.P.) is situated near the end of the last interglacial. Thus these tephra layers allow the opportunity to place solid radiometric dates on the climate records covering the last interglacial, however future work is required to estimate the correct ice age between these tephra layers.

In summary the Mt. Moulton record demonstrates that different environmental proxies do not necessarily respond simultaneously to changes in climate, making it essential to combine several to define the characteristics and duration of the last interglacial. Mt. Moulton records show that the beginning of the last interglacial occurs at a distance of ~242 m in the ice trench. It is marked by a major
decrease in sea salts and nssSO₄²⁻ concentrations likely indicating weakening of atmospheric circulation and a decrease of sea ice extent. At the same time δD values increased, indicating warming.

Temperature reaches its maximum value at ~238 m, which is characterized by maximum δD values (~187‰). At this time an increase in sea salt concentrations and the lowest level of nssSO₄²⁻ are indicative of a minimum sea ice extent and a potential reduction in size of the WAIS, and therefore proximity of open water to the Mt. Moulton site.

A combined examination of Mt. Moulton sea salts, dust, nssSO₄²⁻ and δD records indicate that the end of the last interglacial in West Antarctica was gradual and occurred sometime between 210 and 224.5 m. Mt. Moulton records show that the end of the last interglacial does not hint at any of the dramatic changes related to warming in climate that are projected for Antarctica in the future.

Acknowledgments

This research was supported by grants from the National Science Foundation Office of Polar Programs (0636506, 0837883, 0838843), the National Oceanic and Atmospheric Administration and W.M. Keck Foundation.

References


Legrand, M., Mayewski, P., 1990. A combined examination of Mt. Moulton sea salts, dust, nssSO₄²⁻ and δD records indicate that the end of the last interglacial in West Antarctica was gradual and occurred sometime between 210 and 224.5 m. Mt. Moulton records show that the end of the last interglacial does not hint at any of the dramatic changes related to warming in climate that are projected for Antarctica in the future.


