GSA Data Repository Item 2019190

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# Data Repository

**DR1**

**TABLE S1.** STABLE ISOTOPE ANALYSES OF GROUND ICE AND SNOW

**DR2**

**Figure S1.** Selected soil pit stratigraphic columns characteristic of ice marginal environments in McMurdo Sound for massive diamict (A: DME-13-40 and B: ACE-15-21) and stratified sediments, which include bedded deltaic ice-contact sediments (C: ACE-14-29, D: ACE-14-05, E: ACE-14-06) and kame terrace deposits (F: ACE-14-25). Colors scheme corresponds to sediment color.

**Figure S2.** Detailed glacial geologic maps of key field areas and fossil algae calibrated radiocarbon ages (cal. kyr BP) (Table S2) in McMurdo Sound: A) north Mount Discovery, B) north Brown Peninsula, C) northwest Black Island, and D) north Mount Morning. Geologic mapping symbology, color scheme, and nomenclature follows the format of Plate 1. Contour intervals are 100 m in panels A and D and 20 m in panels B and C. Base image is a digital elevation model (2 m/pixel) created by the Polar Geospatial Center using DigitalGlobe Inc. imagery.

## DR1

**TABLE S1: STABLE ISOTOPE ANALYSES OF GROUND ICE AND SNOW**

| Sample | Location | Depth below surface (cm) | Depth below ice surface (cm) | Elevation (masl) | Description | $\delta^{18}O$ (V-SMOW) (‰) | | | | | | δD (V-SMOW) (‰) | | | | | | | | †Deuterium excess (‰) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | *1* | *2* | *3* | **Mean** | 1σ | n | *1* | *2* | *3* | *4* | *5* | **Mean** | 1σ | n | |
| *Massive ice below diamict* | | | | | | | | | | | | | | | | | | | | |
| ACI-15-04C-1 | Black Island | 50-55 | 0-5 | 483 | Mostly clean ice, rich in mirabillite | -28.73 | -28.69 | -- | **-28.71** | 0.03 | 2 | -235.58 | -235.90 | -235.32 | -- | -- | **-235.60** | 0.29 | 3 | **-5.90** |
| ACI-15-04C-2 | Black Island | 55-60 | 5-10 | 483 | Mostly clean ice rich in mirabillite | -26.18 | -26.15 | -- | **-26.17** | 0.02 | 2 | -220.95 | -221.16 | -- | -- | -- | **-221.06** | 0.15 | 2 | **-11.73** |
| ACI-15-05B | Black Island | 42-45 | 2-5 | 496 | Massive ice with some veins of fine grained sediment and isolated gravel grains | -26.25 | -26.28 | -26.35 | **-26.30** | 0.05 | 3 | -221.54 | -221.33 | -- | -- | -- | **-221.20** | 0.42 | 2 | **-10.83** |
| ACE-13-04 | Mount Discovery | 40 | 5 | 515 | Clean ice | -21.13 | -21.17 | -- | **-21.15** | 0.03 | 2 | -188.39 | -188.98 | -- | -- | -- | **-188.69** | 0.42 | 2 | **-19.49** |
| DME-13-40A | Mount Discovery | 35-40 | 5-10 | 516 | Clean ice | -14.82 | -14.90 | -- | **-14.86** | 0.06 | 2 | -123.59 | -122.20 | -123.01 | -122.51 | -- | **-122.83** | 0.61 | 4 | **-3.97** |
| DME-13-40B | Mount Discovery | 40-45 | 10-15 | 516 | Ice below | -15.20 | -15.51 | -- | **-15.35** | 0.22 | 2 | -126.30 | -125.63 | -125.46 | -- | -- | **-125.80** | 0.44 | 3 | **-2.98** |
| DME-13-40C | Mount Discovery | 45-50 | 15-20 | 516 | Clean ice | -15.31 | -15.22 | -- | **-15.26** | 0.06 | 2 | -124.69 | -125.11 | -- | -- | -- | **-124.90** | 0.29 | 2 | **-2.80** |
| DME-13-40D | Mount Discovery | 50 - 80 | 20-50 | 516 | Bulk sample of massive ice | -15.26 | -15.43 | -- | **-15.35** | 0.12 | 2 | -122.94 | -122.54 | -123.36 | -- | -- | **-122.95** | 0.41 | 3 | **-0.18** |
| DME-13-40E | Mount Discovery | 80-90 | 50-60 | 516 | Very dirty ice in a debris layer | -18.94 | -18.94 | -- | **-18.94** | 0.00 | 2 | -154.63 | -154.32 | -- | -- | -- | **-154.48** | 0.22 | 2 | **-2.95** |
| DME-13-40F | Mount Discovery | >90 | >60 | 516 | Very dirty ice | -20.37 | -20.21 | -- | **-20.29** | 0.11 | 2 | -160.71 | -160.83 | -161.36 | -160.82 | -- | **-160.93** | 0.29 | 4 | **1.38** |
| DME-13-41 | Mount Discovery | 35-45 | 5-15 | 512 | Clean ice below | -29.04 | -28.84 | -- | **-28.94** | 0.14 | 2 | -239.46 | -237.69 | -239.25 | -237.52 | -237.20 | **-238.23** | 1.05 | 5 | **-6.73** |
| *Ice cement below stratified sediment* | | | | | | | | | | | | | | | | | | | | |
| ACE-14-26A | Brown Peninsula | 20 | 0 | 216 | Dirty ice with silt veins, below algae in stratified layers | -16.39 | -16.43 | -- | **-16.41** | 0.03 | 2 | -167.84 | -168.03 | -167.42 | -- | -- | **-167.77** | 0.31 | 3 | **-36.47** |
| ACE-14-26B | Brown Peninsula | 20 | 0 | 216 | Dirty ice , base of pit 2 of 2 | -32.75 | -32.70 | -32.77 | **-32.74** | 0.04 | 3 | -272.99 | -273.92 | -274.05 | -- | -- | **-273.65** | 0.58 | 3 | **-11.72** |
| ACE-14-26C | Brown Peninsula | 20 | 0 | 216 | Dirty ice veins, base of pit | -24.14 | -24.20 | -- | **-24.17** | 0.04 | 2 | -227.38 | -228.40 | -227.85 | -- | -- | **-227.88** | 0.51 | 3 | **-34.53** |
| ACE-14-26D | Brown Peninsula | 20 | 0 | 216 | Clean ice from base of pit | -30.82 | -30.94 | -- | **-30.88** | 0.09 | 2 | -261.60 | -261.74 | -- | -- | -- | **-261.67** | 0.10 | 2 | **-14.62** |
| ACI-14-27A | Brown Peninsula | 20 | 0 | 237 | Clean ice within deformed debris bands | -19.43 | -- | -- | **-19.43** | N/A | 1 | -193.75 | -194.62 | -195.12 | -- | -- | **-194.50** | 0.69 | 3 | **-39.04** |
| ACI-14-27B | Brown Peninsula | 25 | 5 | 237 | Dirty ice within deformed debris bands | -23.66 | -23.75 | -- | **-23.70** | 0.06 | 2 | -218.14 | -218.45 | -217.65 | -217.50 | -- | **-217.94** | 0.44 | 4 | **-28.33** |
| ACI-14-27C | Brown Peninsula | 25 | 5 | 237 | Ice with deformed debris bands | -18.67 | -18.64 | -18.66 | **-18.66** | 0.02 | 3 | -191.00 | -191.39 | -- | -- | -- | **-191.19** | 0.28 | 2 | **-41.92** |
| ACI-14-28A | Brown Peninsula | 30 | 0 | 237 | Surface ice cement | -17.27 | -16.38 | -- | **-16.82** | 0.63 | 2 | -127.20 | -125.97 | -125.68 | -- | -- | **-126.28** | 0.81 | 3 | **8.31** |
| ACI-14-28B-1 | Brown Peninsula | 35-40 | 5-10 | 237 | Ice cement below 30 cm of till | -28.47 | -28.26 | -- | **-28.36** | 0.15 | 2 | -237.96 | -237.15 | -238.58 | -237.18 | -- | **-237.71** | 0.69 | 4 | **-10.80** |
| ACI-14-28B-2 | Brown Peninsula | 35-40 | 5-10 | 237 | Ice cement below 30 cm of till | -32.60 | -32.29 | -- | **-32.45** | 0.22 | 2 | -257.65 | -256.99 | -257.56 | -- | -- | **-257.40** | 0.36 | 3 | **2.18** |
| *Modern Snow* | | | | | | | | | | | | | | | | | | | | |
| Mount Discovery Modern snow | Mount Discovery | Surface | -- | 522 | Snow swept off snowbank 0.5 hr after snowfall | -17.69 | -17.64 | -- | **-17.67** | 0.03 | 2 | -129.71 | -130.31 | -129.56 | -- | -- | **-129.86** | 0.40 | 3 | **11.47** |
| Brown Peninsula modern snow #2 | Brown Peninsula | Surface | -- | 237 | Snowfall collected 11/29/14 collected two days after storm | -25.12 | -24.81 | -- | **-24.96** | 0.22 | 2 | -201.25 | -202.48 | -204.60 | -203.85 | -- | **-203.04** | 1.48 | 4 | **-3.33** |
| Brown Peninsula modern snow #1 | Brown Peninsula | Surface | -- | 335 | Snowfall from 11/26/2014 storm | -27.41 | -27.39 | -27.44 | **-27.41** | 0.03 | 3 | -221.03 | -223.48 | -222.42 | -221.75 | -- | **-222.17** | 1.04 | 4 | **-2.86** |

†Deuterium excess (‰) = δ18O - 8*δD

Fig S1

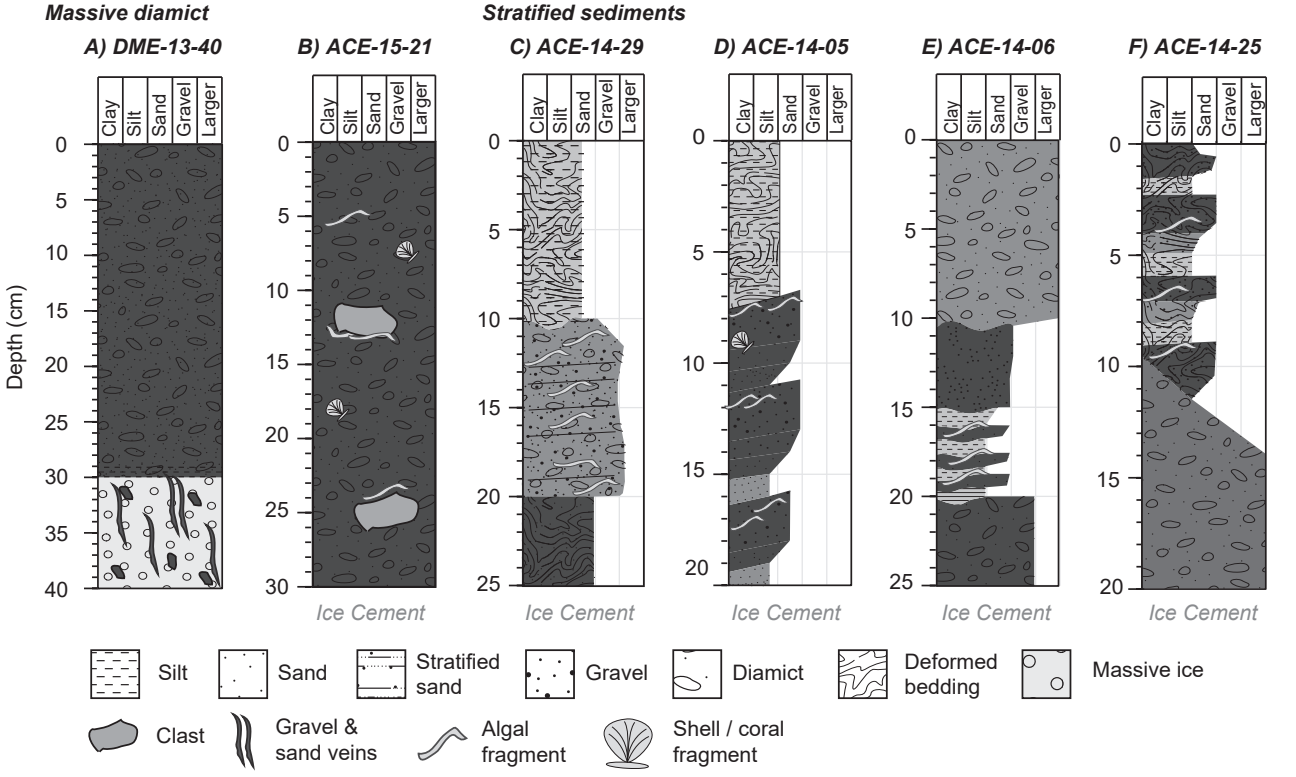
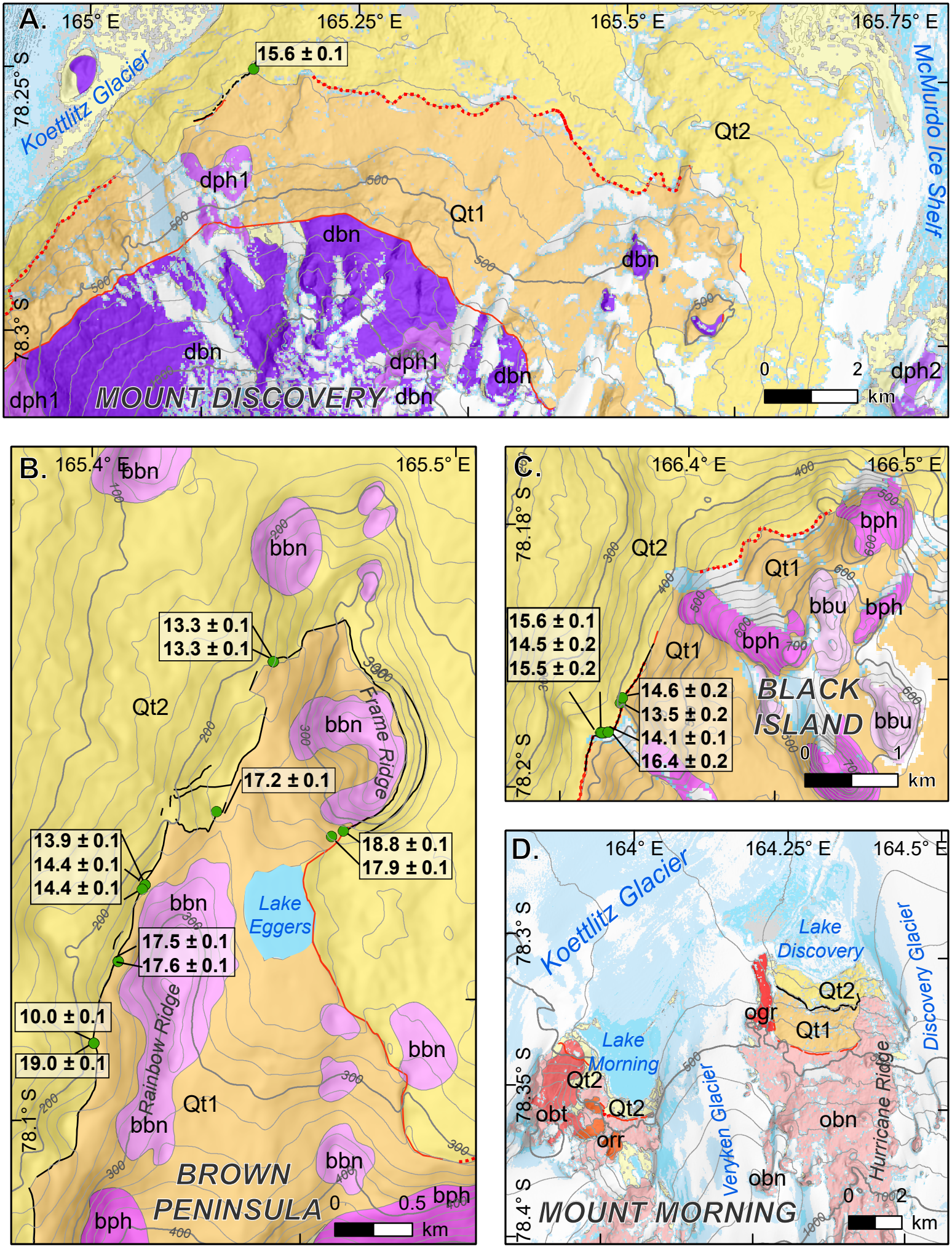

Massive diamict
Stratified sediments
A) DME-13-40
B) ACE-15-21
C) ACE-14-29
D) ACE-14-05
E) ACE-14-06
F) ACE-14-25
Clay
Silt
Sand
Gravel
Larger
Depth (cm)
Ice Cement
Silt
Sand
Stratified sand
Gravel
Diamict
Deformed bedding
Massive ice
Clast
Gravel & sand veins
Algal fragment
Shell / coral fragment

Fig S2


A.
165° E
165.25° E
165.5° E
165.75° E
78.25° S
78.3° S
Koettlitz Glacier
McMurdo Ice Shelf
15.6 ± 0.1
Qt2
Qt1
dph1
dbn
dph2
MOUNT DISCOVERY
0
2
km
B.
165.4° E
165.5° E
78.1° S
bbn
Qt2
Qt1
bph
13.3 ± 0.1
13.3 ± 0.1
17.2 ± 0.1
13.9 ± 0.1
14.4 ± 0.1
14.4 ± 0.1
17.5 ± 0.1
17.6 ± 0.1
10.0 ± 0.1
19.0 ± 0.1
18.8 ± 0.1
17.9 ± 0.1
Frame Ridge
Rainbow Ridge
Lake Eggers
BROWN PENINSULA
0
0.5
km
C.
166.4° E
166.5° E
78.18° S
78.2° S
Qt2
Qt1
bph
bbu
15.6 ± 0.1
14.5 ± 0.2
15.5 ± 0.2
14.6 ± 0.2
13.5 ± 0.2
14.1 ± 0.1
16.4 ± 0.2
BLACK ISLAND
0
1
km
D.
164° E
164.25° E
164.5° E
78.3° S
78.35° S
78.4° S
Koettlitz Glacier
Lake Discovery
Discovery Glacier
Lake Morning
Qt2
Qt1
ogr
obt
orr
obn
Veryken Glacier
Hurricane Ridge
MOUNT MORNING
0
2
km