Supplementary Information for:

Glaciovolcanic evidence for a polythermal Neogene East Antarctic Ice Sheet

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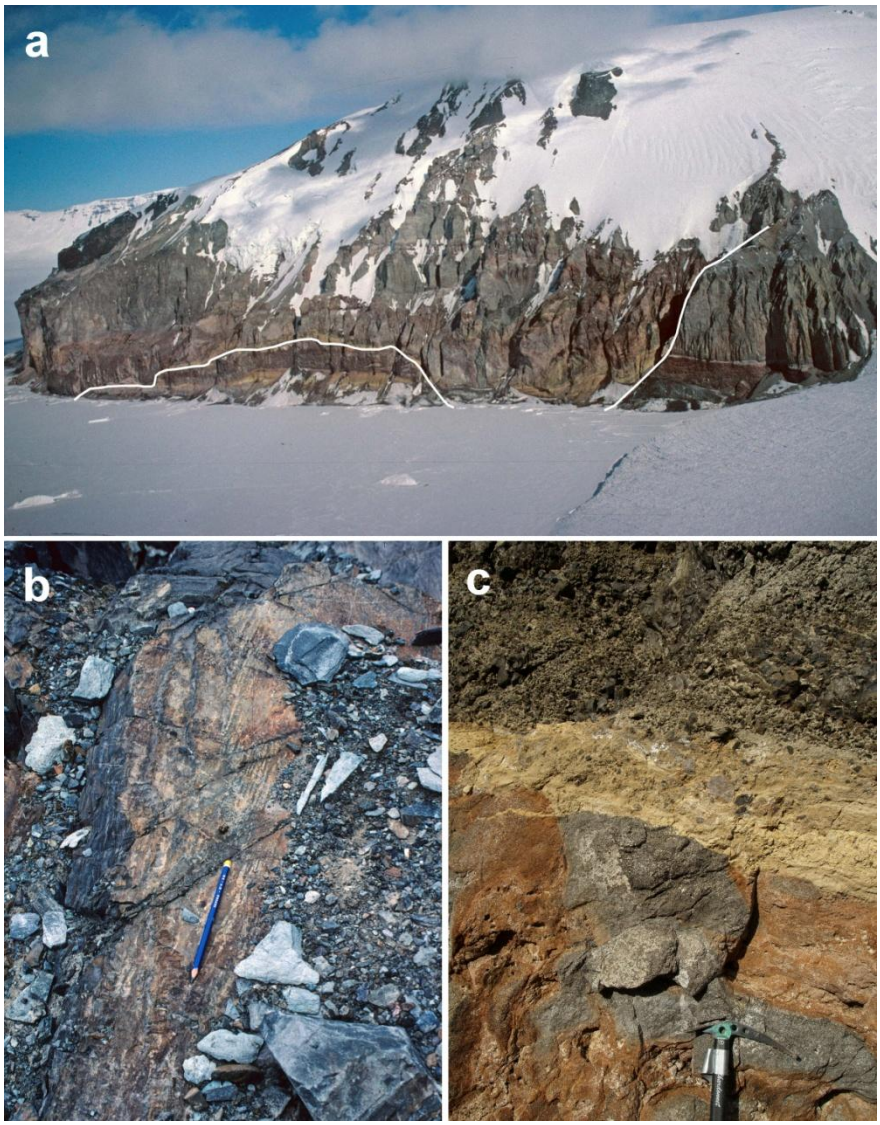

Figure DR1. Glaciovolcanic sequences and related features indicative of the basal thermal regime of the EAIS in Victoria Land. 1. Wet-based ice features: (a) prominent erosional unconformity in felsic sheet-like sequences at northern Mandible Cirque, Daniell Peninsula; sequence is ~600 m thick; (b) striated metamorphic basement surface underlying volcaniclastic rocks, west of Hallett Peninsula; striations parallel to pencil; (c) cross section through sharp erosional surface truncating mafic lava pillow (grey) overlain by yellow fluvial sandstones and grey hyaloclastite breccia at Minna Hook.

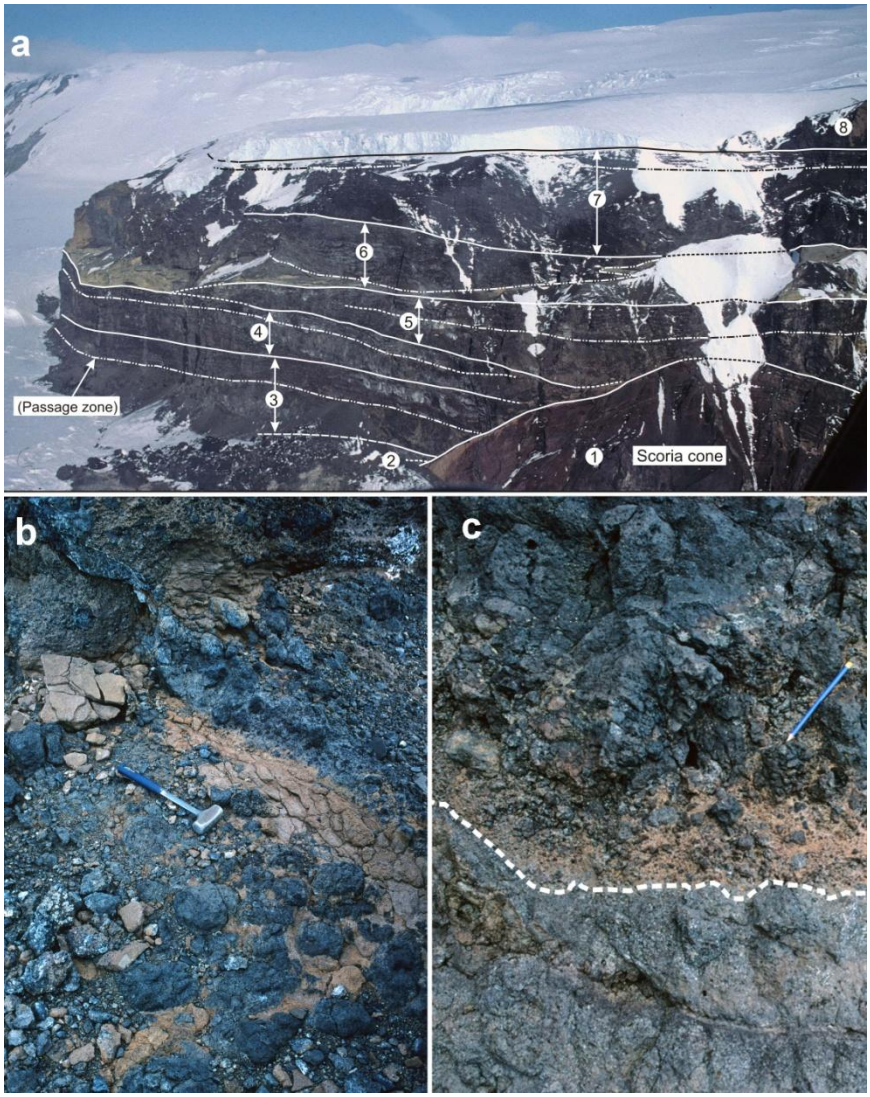

Figure DR2. Glaciovolcanic sequences and related features indicative of the basal thermal regime of the EAIS in Victoria Land. Cold-based ice features: (a) ~600 m section of multiple lava-fed deltas (numbered 2-8) lacking erosion and interbedded glacial sediments overlying an erosionally unmodified basal scoria cone; Cape Phillips, Daniell Peninsula; (b)-(c) plan and cross sectional views of a rough-textured surface between two lava-fed deltas, showing a general lack of glacial erosion and (in b) presence of essentially unmodified lava clinkers; northern Daniell Peninsula.

Table DR1. Inferred basal thermal regimes and age of ice associated with glaciovolcanic sequences in Victoria Land

Locality	Age (Ma)*	Interpreted thermal regime	Comments
Cape Washington [74° 38.59'S, 165° 25.32'E]	2.88±0.008 – 1.73±0.04	**Cold-based**	Multiple lava-fed deltas (2 dated)
Cape Adare, Adare Peninsula (eruptions) [71° 17.85'S, 170° 12.93'E]	c. 3.8	**Cold-based**	Sequence examined at top only, by helicopter elsewhere; age by K-Ar only
Cape Adare, Adare Peninsula (unconformity within sequence) [71° 17.85'S, 170° 12.93'E]	>3.8	**Wet-based**	Prominent erosional glacial unconformity within volcanic sequence; age uncertain (by K-Ar only); probably caused by expanded much thicker ice sheet
←		**Substantial time gap**	→
West of Cape Daniell, Daniell Peninsula [72° 40.33'S, 169° 43.07'E]	6.34±0.05 – 5.6±0.5	**Cold-based**	Multiple lava-fed deltas; top & base deltas dated; youngest dated by K-Ar
North Cotter Cliffs, E Hallett Peninsula [72° 20.98'S, 170° 16.38'E]	6.60±0.80	**Cold-based**	Multiple lava-fed deltas; only one delta dated; by K-Ar
North of Salmon Cliff, W Hallett Peninsula [72° 21.55'S, 170° 07.36'E]	7.05±0.04	**Cold-based**	Multiple lava-fed deltas; only one delta dated
Roberts Cliff, W Hallett Peninsula [72° 24.04'S, 170° 03.28'E]	7.26±0.05	**Cold-based**	Multiple lava-fed deltas; only one delta dated
Redcastle Ridge, W Hallett Peninsula [72° 25.83'S, 169° 56.39'E]	7.41±0.04	**Cold-based**	Multiple lava-fed deltas; only one delta dated
Northern Coulman Island (unconformity within sequence) [73° 20.45'S, 169° 46.88'E]	c. 7.4	**Wet-based**	Age by K-Ar; probably caused by expanded much thicker ice sheet
Coulman Island (eruptions) [73°30'S, 169°45'E]	7.2±1.0 – 7.6±0.8	**Cold-based**	Multiple lava-fed deltas; ages by K-Ar
West Edisto Inlet (Herschel Tuffaceous Moraine), W of Hallett Peninsula [72° 21.64'S, 169° 54.97'E]	c. 7.4	**Wet-based**	Lacustrine sequence infilled by ash turbidites situated on the flank of a valley-filling glacier; age similar to or older than nearby Hallett Peninsula sequences
Tucker Glacier [72° 34.84'S, 169° 18.04'E]	7.61±0.05	**Wet-based**	Thermal regime possibly reflects that of expanded adjacent outlet glacier
←		**Substantial time gap**	→
Minna Hook (7) [78.653°S, 167.207°E]	9.40±0.30	**Wet-based**	
Minna Hook (6) [78.664°S, 167.214°E]	9.53±0.07	**Wet-based**	Felsic dome with hyaloclastite breccia base and basal diamict (till) on glacially eroded surface
Mandible Cirque, Daniell Peninsula [73° 06.49'SS, 169° 24.97'E]	9.68±0.05	**Wet-based**	Felsic dome in sequence with hyaloclastite breccia dome bases, diamict (till) and glacially eroded surface
Cape Jones, Daniell Peninsula [73° 16.88'S, 169° 11.97'E]	9.87±0.09	**Cold-based**	Minor erosion but no diamict or fluvial sediments; volcano slopes pristine above c. 400-600 m a.s.l.
Cape Phillips, Daniell Peninsula [73° 04.52'S, 169° 36.60'E]	9.95±0.07	**Cold-based**	Minor erosion but no diamict or fluvial sediments
Minna Hook (unconformity	c. 10.38 – 9.40	**Wet-based**	Age bracketed by dated units;

within sequence) [78.65°S, 167.20°E]			probably caused by expanded much thicker ice sheet
Minna Hook (5)** [78.641°S, 167.205°E]	c. 11.47 – 10.39	**Wet-based**	Age bracketed by dated units
Minna Hook (4)** [78.586°S, 167.124°E]	10.50±0.30	**Wet-based**	
Minna Hook (3)** [78.590°S, 167.164°E]	c. 11.2 – 10.5	**Wet-based**	Age bracketed by dated units
Minna Hook (unconformity within sequence) [78.59°S, 167.14E]°	c. 11.2 – 10.6	**Wet-based**	Age bracketed by dated units
Minna Hook (2)** [78.617°S, 167.192 °E]	c. 11.40 – 11.20	**Wet-based**	Age bracketed by dated units
Minna Hook (1) [78.591°S, 167.165 °E]	c. 11.40 – 11.21	**Wet-based**	Age bracketed by dated units

* All ages by ^{40}Ar-^{39}Ar except where otherwise indicated in comments; from Fargo (2009), Gemelli (2009) and Smellie et al. (2011); see Table 2 for analytical details of ages.

** Despite similar or overlapping ages, the dated informally-numbered units at Minna Hook included in this table relate to different lava-fed deltas.

Table DR2. Summary details of ^{40}Ar-^{39}Ar ages for volcanic sequences in Victoria Land used in this study

Sample	Locality	Technique	Material	^{39}Ar% concordant segment (plateau)	n[a]	Error-weighted mean age (Ma)[b]	±2σ (internal error)	MSWD[c]	Total gas age (Ma)	±2σ (internal error)	Ref
11-01-06 JS5	Cape Washington (2) [74° 38.59'S, 165° 25.32'E]	Lazer step heating	Groundmass	61.6	4	**1.729**	**0.037**	1.19	1.852	0.080	Gemelli 2009
11-01-06 JS3	Cape Washington (1) [74° 38.59'S, 165° 25.32'E]	Lazer step heating	Groundmass	60.8	3	**2.885**	**0.080**	1.63	2.958	0.037	Gemelli 2009
2-01-06 JS7	Bluff 7 km WNW of Cape Daniell, Daniell Peninsula [72° 40.33'S, 169° 43.07'E]	Lazer step heating	Groundmass	53.9	4	**6.338**	**0.050**	1.8	6.445	0.045	Smellie et al 2011
1-01-06 JS5	First bluff N of Salmon Cliff, Hallett Peninsula [72° 21.55'S, 170° 07.36'E]	Lazer step heating	Groundmass	74.9	5	**7.049**	**0.040**	0.22	7.070	0.043	Smellie et al 2011
29-12-05 JS10	Roberts Cliff, Hallett Peninsula [72° 24.04'S, 170° 03.28'E]	Lazer step heating	Groundmass	72.3	5	**7.257**	**0.050**	1.5	7.322	0.053	Smellie et al 2011
4-01-06 JS1	Redcastle Ridge, Hallett Peninsula [72° 25.83'S, 169° 56.39'E]	Lazer step heating	Groundmass	61.0	4	**7.407**	**0.043**	0.36	7.441	0.047	Smellie et al 2011
4-01-06 JS11	S flank of Tucker	Lazer step heating	Groundmass	57.3	4	**7.605**	**0.049**	0.20	7.322	0.062	Smellie et al

	Glacier, 4.5 km NW of Crater Cirque [72° 34.84'S, 169° 18.04'E]										2011
19-12-05 JS2	Mandible Cirque, Daniell Peninsula [73° 06.49'SS, 169° 24.97'E]	Total fusion	Alkali feldspar	-	8	**9.683**	**0.051**	0.50	9.669	0.051	Smellie et al 2011
21-12-05 JS8	Cape Jones, Daniell Peninsula [73° 16.88'S, 169° 11.97'E]	Lazer step heating	Groundmass	54.4	4	**9.866**	**0.088**	1.6	10.144	0.092	Smellie et al 2011
4-01-06 JS6	Cape Phillips, Daniell Peninsula [73° 04.52'S, 169° 36.60'E]	Lazer step heating	Groundmass	-	-	No plateau	-	-	**9.950**	**0.066**	Smellie et al 2011
MB06-587	Minna Hook (7) [78.653°S, 167.207°E]	Lazer step heating	Groundmass	90.76	8	**9.4**	**0.3**	0.64	9.0	0.4	Fargo 2009
MB06-504	Minna Hook (6) [78.664°S, 167.214°E]	Lazer step heating	Groundmass	100	10	**9.53**	**0.07**	1.68	9.51	0.07	Fargo 2009
MB06-765	Minna Hook (4) [78.586°S, 167.124°E]	Lazer step heating	Groundmass	100	10	**10.5**	**0.3**	1.23	11.0	0.7	Fargo 2009
MB06-509	Minna Hook (bracketing age) [78.659°S, 167.212°E]	Lazer step heating	Kaersutite	100	9	**10.39**	**0.09**	0.85	10.36	0.09	Fargo 2009
MB06-761	Minna Hook (bracketing age) [78.587°S, 166.843°E]	Lazer step heating	Groundmass	78.88	6	**11.2**	**0.1**	5.17	11.5	0.2	Fargo 2009
MB06-763	Minna Hook (bracketing age) [78.585°S, 167.127°E]	Lazer step heating	Groundmass	63.72	5	**11.42**	**0.08**	1.86	11.8	0.4	Fargo 2009
MB06-546	Minna Hook (bracketing age) [78.641°S, 167.205°E]	Lazer step heating	Groundmass	81.8	6	**11.47**	**0.08**	4.14	11.6	0.09	Fargo 2009

[a] – number of steps or analyses used in the error-weighted mean calculation.

[b] – preferred ages indicated in bold typeface.

[c] – mean squares of weighted deviates.

Notes:

1. Ages of units not dated directly (Minna Hook only) were bracketed by dating units higher and lower in the succession.

2. All ages are relative to Fish Canyon sanidine at 28.02 Ma (Renne et al., 1998) and decay constants are after Steiger and Jaeger (1977).

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