Rock mass loss on a nunatak in Western Dronning Maud Land, Antarctica

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Abstract

This paper presents the first rock mass loss data for uncut clasts from continental Antarctica. A rock mass loss experiment using doleritic rock samples was conducted over a seven-year period, between 2008 and 2014 at the Vesleskarvet nunataks, Western Dronning Maud Land. The data show that approximately 10% of clasts have experienced relatively large rates of mass loss. The data suggest that rock mass loss occurs in a series of events which are impossible to predict in terms of frequency and/or magnitude. However, extrapolating from the data obtained during the seven-year period indicates that rates of mass loss are slow and of the order of 1% per 100 years. Direct erosion by wind (including abrasion) as well as mechanical and chemical weathering are suggested to be responsible for rock mass loss. Rock properties, weathering environment and a lack of available moisture may be contributing factors to the slow rate of rock decay. This paper suggests that in this area of Antarctica, the slow rate of rock mass loss increases the longevity of existing periglacial landforms such as patterned ground and blockfields, but inhibits development of new patterned ground through the slow production of fines.

Keywords: Antarctica; rock mass loss; weathering; Vesleskarvet; Western Dronning Maud Land

Introduction

Ice-free areas in continental Antarctica are characterized by low air temperatures, strong winds and a paucity of water in the liquid phase (Matsuoka, 1995). These conditions are conventionally thought to be responsible for slow rock decay. Some studies (i.e. Hall and André, 2001; Bockheim, 2002; Matsuoka et al., 2006; Hall et al., 2008a; Hall et al., 2008b, McKay et al., 2009; Guglielmin et al., 2011) have addressed aspects of weathering in continental Antarctica but no known studies specifically investigate the rate of rock mass loss. The only known studies on the rate of rock mass loss in the southern polar regions are by Hall (1990) who reports annual mean mass loss rates of 0.02% for freshly cut clasts of different lithologies from Signy Island, Maritime Antarctica and Sumner (2004) that documents annual mean mass loss rates of 0.02 and 0.1% for naturally shaped grey and black lava clasts on sub-Antarctic Marion Island. Given this, the aim of this paper is to determine the contemporary rate of rock mass loss at the Vesleskarvet nunataks, Western Dronning Maud Land, Antarctica. Determination of contemporary rock mass loss at inland nunataks is significant in terms of the production of fines for current pedogenic and periglacial processes as well as existing landform longevity. Even under the extremely harsh climate (*i.e.* lack of available moisture) and geographic isolation of the study site, the production of fines does occur and may be significant for the facilitation of habitats for biota, which typically colonize the fringes (troughs) of sorted patterned ground in ice-free areas (Lee et al., 2013).

Study Site

Ice-free areas of Antarctica comprise less than 1% of the subaeriel extent of the continent (Bockheim and Hall, 2002). Much of the geomorphological research in Antarctica occurs in ice-free areas along the Antarctic Peninsula (e.g. Cofaigh et al., 2014) and in the Dry Valleys (e.g. Speirs et al., 2008) and, due to their isolation, very few studies have been conducted in the inland regions in Antarctica, including Dronning Maud Land (e.g. Matsuoka et al., 2006; Hedding et al., 2010 and Hansen et al., 2013). The conditions on inland nunataks may be more extreme than those found on the peninsula (Walton, 1984) since they are separated from the stabilizing climatic influence of the ocean.

This study was conducted on the Southern Buttress next to the SANAE IV research station at the Vesleskarvet nunataks (71° 40′ S 2° 51′ W) in Western Dronning Maud Land (Figure 1). This rocky outcrop forms part of the Ahlmannryggen-Borgmassivet Mountains (SASCAR, 1981) and is 160km inland of the Princess Martha coast of Dronning Maud Land . The main nunatak peaks at roughly 850 m a.s.l. and has an exposed surface area of some 22.5 ha. The nunatak is divided into two lobes named the “Northern and Southern Buttresses”, of which the northern is the larger. The average ambient air temperature measured at Vesleskarvet is –8.3 °C and –21.8 °C for the Austral summer and winter months respectively (Hansen et al., 2013). The dominant wind direction is from the east and annual average wind speeds approximate 11 ms^{-1} but gusts of up to 61.9 ms^{-1} have been recorded. Hansen (2013) reports that the relative humidity at Vesleskarvet is 63 % throughout the year but Western

Dronning Maud Land is very arid and receives between 55 and 81 mm of precipitation annually, falling exclusively as snow (Reijmer and van den Broeke, 2001).

The rock exposures at Vesleskarvet comprise homogenous mafic igneous rocks of the Borgmassivet Intrusions, the dominant rock type in the northern Ahlmannryggen (Classen and Sharp, 1993). Steele et al. (1994) indicate that these nunataks have been severely ice and frost-shattered to a depth of approximately one meter, forming a substratum of large angular boulders. Both buttresses display autochthonous blockfields (Hansen et al., 2013) and rock faces exhibit case hardening. Lee et al. (2013) note that although liquid water availability is primarily driven by microclimatic rather than by macroclimatic temperature, liquid water is scarce, occurring only during the short austral summer when microclimatic temperatures are high enough to cause brief periods of snow and ice melt. Nevertheless, the visually limited liquid in summer facilitates biological activity (Lee et al., 2013) and chemical weathering as illustrated by the presence of weathering rinds up to 0.01m in thickness. Weathering rinds are reddish-brown in colour and are evident on almost all rock surfaces on the Vesleskarvet nunataks (Figure 2B). Lithosols are found extensively in depressed flat areas throughout the nunatak and in small isolated patches in sheltered areas between rocks.

Methodology

To initiate the rock mass loss experiment, 74 small uncut dolerite clasts ranging in size from 93-to 318 grams were selected, dried in an oven and weighed to obtain their dry mass. In the austral summer of 2007-2008, these clasts were separated into 8 groups and placed at random locations on the Southern Buttress of Vesleskarvet. Clasts were then weighed yearly to determine mass loss over a seven-year period. Several clasts were lost during the study, presumably due to strong winds dislodging them from their sites and at the end of the experiment 39 clasts remained. The possible displacement of clasts within each study site were not recorded. A control set, comprising 18 clasts, was also incorporated into the study. The control set of clasts was dried and weighed at the onset of the experiment and only dried and weighed every second year to determine any experimental error. The clasts were placed in a storeroom in the SANAE IV research station which represents a relatively stable environment where temperatures range from 18 °C to 22 °C and relative humidity averages 65 %. Similar to the rock mass loss experiments conducted by Hall (1990) and Sumner (2004), the dry weight, porosity, microposity, water absorption and saturation coefficient of the dolerite clasts was determined at the end of the study (Table 1).

Results and Discussion

Over the seven-year study, annual mean rock mass loss was observed to be 0.01 %. However, annual mean mass loss from individual clasts varies quite considerably (Table 2). The maximum rate of annual mean mass loss recorded was 0.214 % (Table 2). During the study approximately 10 % of the clasts weighed suffered mass loss that is an order of magnitude greater than the remaining 90 % of clasts. It is suggested that these clasts have undergone weathering and/or direct erosion by wind (including abrasion). Therefore, the current data set indicates that the rate of rock mass loss occurs in a series of events which are impossible to predict in terms of frequency and/or magnitude. All clasts used in the experiment exhibited weathering rinds of varying thickness (Figure 2) but no clasts exhibited visual signs of flaking or fracturing during the weighing process. It is suggested that, similar to the observation of Sumner (2004), mass loss appears to occur on a granular scale. No trend or stabilization of annual mass loss was noted. Mass loss for the control sample of clasts indicates an annual mean mass loss of 0.003 % (Table 3).

Extrapolation of rock mass loss (see Hall, 1990; Sumner, 2004) suggests that clasts may breakdown completely in 10 000 years at this location on continental Antarctica. Thus, the longevity of small clasts at Vesleskarvet are an order of magnitude greater than grey lava (basalt) clasts on sub-Antarctic Marion Island (Sumner, 2004) and ‘naturally shaped’ clasts on Signy Island, Maritime Antarctica (Walton and Hall, 1989). Annual mean mass loss at Vesleskarvet is also twice as slow as freshly cut blocks of various Signy Island lithologies (Hall, 1990). However, the freshly cut blocks used by (Hall, 1990) would not have been chemically weathered and, therefore, would most likely have been more reactive to chemical weathering. Although none of the clasts showed visual signs of mechanical weathering, evidence of mechanical weathering (Figure 2a) and chemical weathering (Figure 2b) were noted on exposed rock surfaces. Thus, the data presented point toward a suite of mechanisms which are responsible for rock mass loss. Erosion by the wind (including abrasion), mechanical weathering and chemical weathering should be considered. Most of the rock surfaces at Vesleskarvet exhibit weathering rinds and, therefore, chemical weathering may be particularly important in weakening the outer areas of clasts making them susceptible to erosion. Since no obvious visual signs of rock mass loss were evident, granular disintegration may also play a role. Lichen growth on rocks at Vesleskarvet also provide indications that biological activity may be responsible for rock mass loss (see Hall et al. 2008a). The slow rate of rock mass loss at Vesleskarvet may be attributable to the inherent rock properties, the long austral winters where sunlight is absent and when temperatures remain relatively constant at -15 °C, and/or the paucity of available moisture. This suggests that longer-term studies should be set up to determine the role, frequency and magnitude that various processes may play in the breakdown of rocks in this region of Antarctica. Studies on chemical weathering should also be conducted since rock temperatures can reach up to 30 °C during the austral summer (unpublished data) which can facilitate rock mass loss.

The availability of fine material is inherently necessary for the development of patterned ground and the fringes of polygons represent zones where finer aeolian and frost sorted material can accumulate as patterned ground develops (see Kessler et al., 2001). Lee et al. (2013) suggest that the most important environmental variable, maximum soil moisture content, can account for as much as 80% of the variance in the abundance of mites in polygons on the Jutulsessen nunatak, Western Dronning Maud

Land. Barrett et al. (2004) reported that polygon centres contain the highest abundance of species and biodiversity at sites in the McMurdo Dry Valleys, Antarctica. Therefore, the current production of fines from rock mass loss in this area can create habitats for invertebrates and may be significant since fine material should retain moisture and facilitate chemical weathering in an extremely dry environment. However, fines in existing patterned ground may also represent remnants of rock breakdown under different environmental conditions.

Conclusion and Further Research

This note presents the first rock mass loss study for continental Antarctica. Extrapolation of rock mass loss suggests that clasts may breakdown completely in 10 000 yr. However, the data indicates that the rate of decay occurs in a series of events which are impossible to predict in terms of frequency and/or magnitude. Long-term rock mass studies should be set up to specifically investigate this aspect. The documented rate of rock mass loss is particularly slow, will limit the production of fines and inhibit periglacial and pedogenic processes. The slow rate of rock mass loss increases the longevity of existing periglacial landforms such as patterned ground and blockfields. Areas, which comprise fines may represent preferential locations for colonization by invertebrates but the linkages between the prevalence of fines and soil moisture should be investigated as well as the environmental controls for the abundance of species and biodiversity in continental Antarctica.

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References

Barrett, J.E., Virginia, R.A., Wall, D.H., Parsons, A.N., Powers, L.E., and Burkins, M.B., 2004: Variation in biogeochemistry and soil biodiversity across spatial scales in a polar desert ecosystem. *Ecology*, 85: 3105-3118.

Bockheim, J.G., 2002: Landform and soil development in the McMurdo Dry Valleys, Antarctica: a regional synthesis. *Arctic, Antarctic and Alpine Research*, 34: 308-317.

Bockheim, J.G., and Hall, K., 2002: Permafrost, active-layer dynamics and periglacial environments of continental Antarctica. *South African Journal of Science*, 98: 82-90.

Claasen, P., and Sharp, P.A. (eds.), 1993: *Draft Comprehensive Environmental Evaluation (CEE) of the proposed new SANAE IV facility at Vesleskarvet, Queen Maud Land, Antarctica*. Pretoria: Department of Environment Affairs.

Cofaigh, C.Ó., Davies, B.J., Livingstone, S.J., Smith, J.A., Johnson, J.S., Hocking, E.P., Hodgson, D.A., Anderson, J.B., Bentley, M.J., Canals, M., Domack, E., Dowdeswell, J.A., Evans, J., Glasser, N.F., Hillenbrand, C.-D., Larter, R.D., Roberts, S.J., and Simms, A., 2014: Reconstruction of ice-sheet changes in the Antarctic Peninsula since the Last Glacial Maximum. *Quaternary Science Reviews*, 100: 87-110.

Cooke, R.U., 1979: Laboratory simulation of salt weathering processes in arid environments. *Earth Surface Processes*, 4: 347-359.

Guglielmin, M., Favero-Longo, S.E., Cannone, N., Piervittori, R., and Strini, A., 2011: Role of lichens in granite weathering in cold and arid environments of continental Antarctica. *The Geological Society of London Special Publications*, 354: 195-204.

Hall, K., 1990: Mechanical weathering rates on Signy Island, maritime Antarctic. *Permafrost and Periglacial Processes*, 1: 61-67.

Hall, K., André, M.-F., 2001. New insights into rock weathering from high-frequency rock temperature data: an Antarctic study of weathering by thermal stress. *Geomorphology* 41: 23–35.

Hall, K., Guglielmin, M., and Strini, A., 2008a: Weathering of granite in Antarctica: I. Light penetration into rock and implications for rock weathering and endolithic communities. *Earth Surface Processes and Landforms*, 33: 295-307.

Hall, K., Guglielmin, M., and Strini, A., 2008b: Weathering of granite in Antarctica: II. Thermal stress at the grain scale. *Earth Surface Processes and Landforms*, 33: 475-493.

Hall, K., Walton, D.W.H., Wynn-Williams, D.D., Callaghan, T., Drewry, D.J., and Block, W.C., 1992: Rock weathering, soil development and colonization under a changing climate. *Philosophical Transactions: Biological Sciences*, 338(1285): 269-277.

Hansen, C.D., 2013: *The characterisation of an openwork block deposit, Western Dronning Maud Land, Antarctica*. M.Sc dissertation, Department of Geography, Rhodes University, Grahamstown, 198 pp.

Hansen, C.D., Meiklejohn, K.I., Nel, W., Loubser, M.J., and van der Merwe, B.J., 2013: Aspect-controlled weathering on a blockfield in Dronning Maud Land, Antarctica. *Geografiska Annaler: Series A, Physical Geography*, 95: 305-313.

Hedding, D.W., Meiklejohn, K.I., Le Roux, J.J., Loubser, M.J., and Davis, J.K., 2010: Some observations on the formation of an active pronival rampart at Grunehogna Peaks, Western Dronning Maud Land, Antarctica. *Permafrost and Periglacial Processes*, 21: 355-361.

Kessler, M.A., Murray, A.B., Werner, B.T., and Hallet, B., 2001: A model for sorted circles as self-organized patterns. *Journal of Geophysical Research*, 106: 13287-13306.

Lee, J.E., Le Roux, P.C., Meiklejohn, K.I., and Chown, S.L., 2013: Species distribution modeling in low-interaction environments: insights from a terrestrial Antarctic ecosystem. *Austral Ecology*, 38: 279-288.

Matsuoka, N., 1995: Rock weathering processes and landform development in the Sør Rondane Mountains, Antarctica. *Geomorphology*, 12: 323-339.

Matsuoka, N., Thomachot, C.E., Oguchi, C.T., Hatta, T., Abe, M., and Matsuzaki, H., 2006: Quaternary bedrock erosion and landscape evolution in the Sør Rondane Mountains, East Antarctica: Reevaluating rates and processes. *Geomorphology*, 81: 408-420.

McKay, C.P., Molaro, J.L., and Marinova, M.M., 2009: High-frequency rock temperature data from hyper-arid desert environments in the Atacama and the Antarctic Dry Valleys and implications for rock weathering. *Geomorphology*, 110: 182-187.

Reijmer, C.H., and van den Broeke, M.R., 2001: Moisture precipitation in Western Dronning Maud Land, Antarctica. *Antarctic Science*, 13: 210-220.

Ryan, P.G., Watkins, B.P., Lewis Smith, R.I., Dastych, H., Eicker, A., Foissner, W., Heatwole, H., Miller, W.R., and Thompson, G., 1989: Biological survey of Robertskollen, western Dronning Maud Land: area description and preliminary species list. *South African Journal of Antarctic Research*, 19: 10-20.

SASCAR (South African Scientific Committee for Antarctic Research), 1981. *Reconnaissance Geological Map of the Ahlmannryggen Area, Western Dronning Maud Land, Antarctica, SR29-30/15 (part) and SR29-30/16*, 1: 250 000 Sheet 1. Pretoria: South African Scientific Committee for Antarctic Research.

Speirs, J.C., McGowan, H.A., and Neil, D.T., 2008: Meteorological controls on sand transport and dune morphology in a polar desert: Victoria Valley, Antarctica. *Earth Surface Processes and Landforms*: 33, 1875-1891.

Sumner, P.D., 2004: Rock Weathering Rates on Subantarctic Marion Island. *Arctic, Antarctic and Alpine Research*, 36: 123-127.

Steele, W.K., Balfour, D.A., Harris, Dastych, H., Heyns, J., and Eicker, A., 1994: Preliminary biological survey of Vesleskarvet, northern Ahlmannyggen, western Queen Maud Land: site of South Africa’s new Antarctic base. *South African Journal of Antarctic Research*, 24: 57-65.

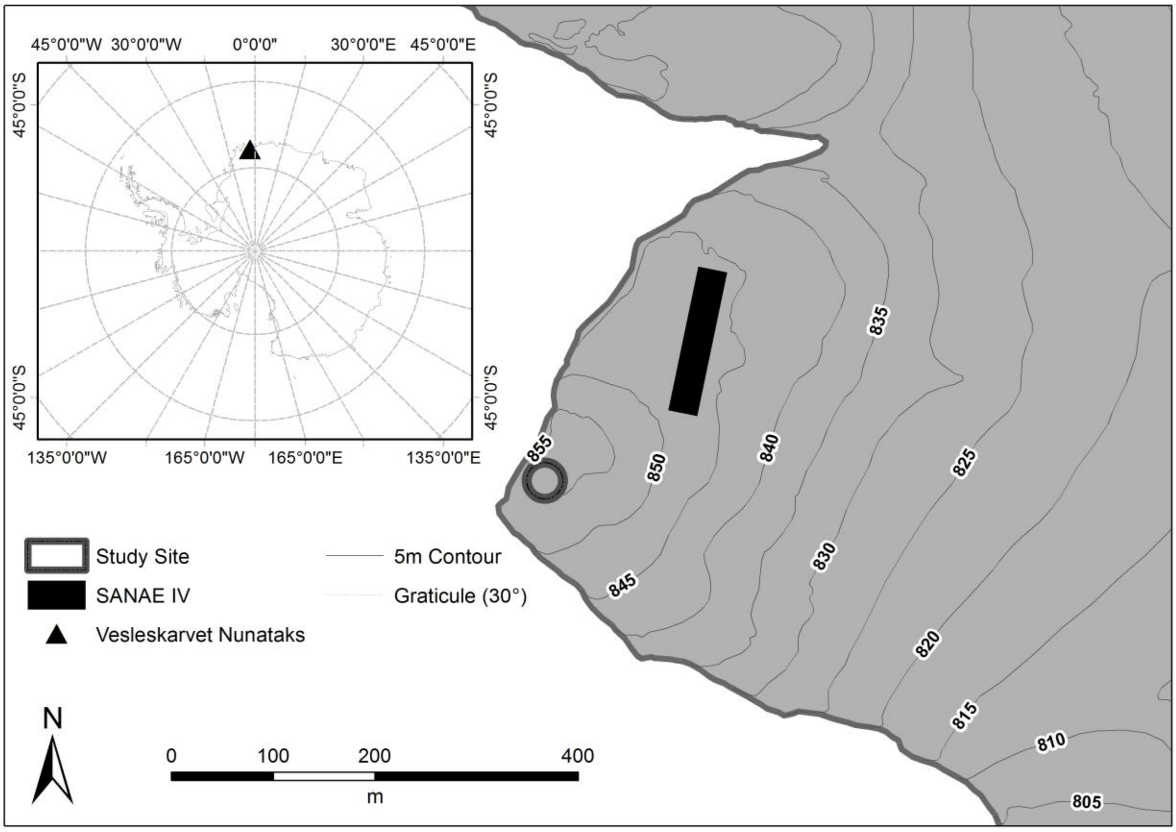
Walton, D.W.H., 1984: The terrestrial environment. *In* Laws, R.M., (ed.) *Antarctic Ecology*. London: Academic Press, 1-60.

Walton, D. W. H., and Hall, K. J., 1989: Rock weathering and soil formation in the maritime Antarctic: an integrated study on Signy Island. Paper presented at the Second International Conference on Geomorphology, Frankfurt.

Figure Captions

Figure 1: Location map of Vesleskarvet, Western Dronning Maud Land, Antarctica.

Figure 2: Evidence of fractures indicating (a) mechanical weathering and (b) discolouration of the rock surface (weathering rinds) indicative of chemical weathering at Vesleskarvet, Western Dronning Maud Land.



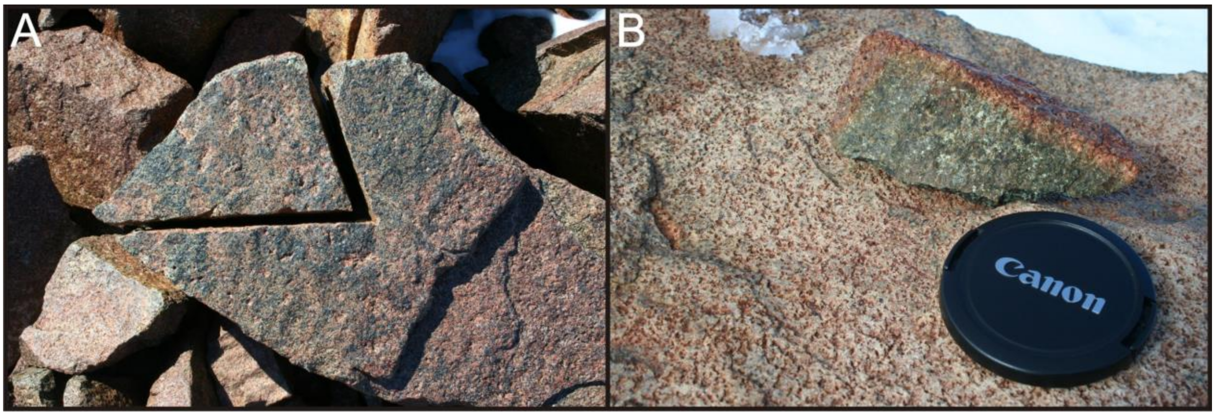


Table 1. Rock physical properties (Cooke, 1979) of a sample set of dolerite clasts from Vesleskarvet, Western Dronning Maud Land (Adapted from Hansen, 2013).

Rock type - Dolerite		**Porosity (%)**	**Micro-porosity (%)**	**Water absorption**	**Saturation coefficient**
	Mean	0.60	82.06	0.57	0.94
	Median	0.53	84.62	0.51	0.94
(n=20)	Std. dev.	0.22	8.63	0.24	0.04

Table 2. Mass loss from dolerite clasts between the austral summers of 2007/2008 and 2013/2014.

Sample	**2007/2008 Dry Mass (g)**	**2013/2014 Dry Mass (g)**	**Percentage Mass Loss Over 7 Years**	**Total Mass Loss (g)**	**Annual Mean Mass Loss (%)**	**100-Year Mass Loss (%)**
1	304.352	304.260	0.030	0.092	0.004	0.432
2	259.695	259.692	0.001	0.003	0.000	0.017
3	212.277	212.249	0.013	0.028	0.002	0.188
4	240.324	240.247	0.032	0.077	0.005	0.458
5	277.123	277.098	0.009	0.025	0.001	0.129
6	238.102	234.529	1.501	3.573	0.214	21.437
7	286.879	286.848	0.011	0.031	0.002	0.154
8	283.177	282.876	0.106	0.301	0.015	1.518
9	254.538	254.535	0.001	0.003	0.000	0.017
10	297.428	297.361	0.023	0.067	0.003	0.322
11	263.045	262.984	0.023	0.061	0.003	0.331
12	296.542	296.537	0.002	0.005	0.000	0.024
13	250.508	250.465	0.017	0.043	0.002	0.245
14	287.586	287.481	0.037	0.105	0.005	0.522
15	201.286	201.249	0.018	0.037	0.003	0.263
16	224.640	223.878	0.339	0.762	0.048	4.846
17	272.010	271.971	0.014	0.039	0.002	0.205
18	237.744	237.684	0.025	0.060	0.004	0.361
19	249.252	249.183	0.028	0.069	0.004	0.395
20	195.195	195.150	0.023	0.045	0.003	0.329
21	307.294	307.283	0.004	0.011	0.001	0.051
22	170.523	170.512	0.006	0.011	0.001	0.092
23	282.412	282.401	0.004	0.011	0.001	0.056
24	268.069	268.061	0.003	0.008	0.000	0.043
25	238.087	238.008	0.033	0.079	0.005	0.474
26	285.551	285.530	0.007	0.021	0.001	0.105
27	259.004	258.949	0.021	0.055	0.003	0.303
28	205.015	204.961	0.026	0.054	0.004	0.376
29	318.843	318.714	0.040	0.129	0.006	0.578
30	263.822	263.792	0.011	0.030	0.002	0.162
31	198.003	197.787	0.109	0.216	0.016	1.558
32	261.485	261.365	0.046	0.120	0.007	0.656
33	205.753	205.712	0.020	0.041	0.003	0.285
34	163.920	163.910	0.006	0.010	0.001	0.087
35	127.930	127.927	0.002	0.003	0.000	0.034
36	191.664	191.640	0.013	0.024	0.002	0.179
37	243.944	243.912	0.013	0.032	0.002	0.187
38	260.586	260.572	0.005	0.014	0.001	0.077
39	93.660	93.642	0.019	0.018	0.003	0.275
Average	**243.007**		**0.068**	**0.162**	**0.010**	**0.968**
Std. dev.	**49.520**		**0.242**	**0.575**	**0.035**	**3.457**
Max	**318.843**		**1.501**	**3.573**	**0.214**	**21.437**
Min	**93.660**		**0.001**	**0.003**	**0.000**	**0.017**
Range	**225.183**		**1.499**	**3.570**	**0.214**	**21.421**

Table 3. Mass loss from the control sample of dolerite clasts between the austral summers of 2007/2008 and 2013/2014.

Sample	**2007/2008 Dry Mass (g)**	**2013/2014 Dry Mass (g)**	**Percentage Mass Loss Over 7 Years**	**Total Mass Loss (g)**	**Annual Mean Mass Loss (%)**	**100-Year Mass Loss (%)**
1	271.543	271.495	0.018	0.048	0.003	0.25
2	251.819	251.781	0.015	0.038	0.002	0.22
3	274.234	274.219	0.005	0.015	0.001	0.08
4	268.191	268.158	0.012	0.033	0.002	0.18
5	263.953	263.911	0.016	0.042	0.002	0.23
6	294.081	294.079	0.001	0.002	0.000	0.01
7	223.608	223.603	0.002	0.005	0.000	0.03
8	296.361	296.297	0.022	0.064	0.003	0.31
9	258.071	258.008	0.024	0.063	0.003	0.35
10	205.766	205.73	0.017	0.036	0.002	0.25
11	255.912	255.862	0.020	0.050	0.003	0.28
12	252.667	252.606	0.024	0.061	0.003	0.34
13	230.829	230.724	0.045	0.105	0.006	0.65
14	209.036	208.998	0.018	0.038	0.003	0.26
15	292.765	292.649	0.040	0.116	0.006	0.57
16	309.322	309.289	0.011	0.033	0.002	0.15
17	202.468	202.384	0.041	0.084	0.006	0.59
18	319.210	319.185	0.008	0.025	0.001	0.11
Average	**259.99**		**0.019**	**0.048**	**0.003**	**0.270**
Std. dev.	**35.21**		**0.013**	**0.031**	**0.002**	**0.182**
Max	**319.21**		**0.045**	**0.116**	**0.006**	**0.650**
Min	**202.47**		**0.001**	**0.002**	**0.000**	**0.010**
Range	**116.74**		**0.045**	**0.114**	**0.006**	**0.640**