

Proceedings of the LGP Terrestrial Darwin Workshop

9-10 September, 2008

Tim Hobson Room (Antarctic Visitors Centre)

In Attendance:

Peter Almond (Lincoln U), Mark Gall (NIWA), Shulamit Gordon (AntarcticaNZ), Allan Green (U Waikato), Malcolm McLeod (Landcare), Fiona Shanhun (Lincoln U), Carol Smith (Lincoln U), Brian Sorrell (NIWA), Bryan Storey (Gateway Antarctica, U Canterbury), Briar Wait (Gateway Antarctica, U Canterbury), Jenny Webster-Brown (*Convener*, U Auckland).

Apologies: Megan Balks (U Waikato), Nancy Bertler (GNS/Victoria U), Roberta Farrell (U Waikato), Ian Hogg (U Waikato).

The following notes were taken to allow the information presented and discussed at this workshop to be distributed more widely. Please note that the content should not be quoted or otherwise used without the permission of the presenter concerned. Some of the results aired were early or interim results and may change with time.

DAY 1: Tuesday 9 Sept

Time

10.00am Brief introduction and welcome (Jenny Webster-Brown)

A general welcome to the 2 day workshop, re-iteration of the purpose of the workshop; To exchange information gained in the past Darwin LGP season (2007/08), discuss plans for the next and final season, recognize synergies and maximize collaborative opportunities. It was emphasized that the time allowed for discussion following each presentation, and at the end of the day, was deliberately generous to encourage more informal communication.

10.15am Bryan Storey (KO56)

The principal question to be answered by this research is: How high (thick) was the ice at the last glacial maximum (LGM, 20,000 yrs BP), how rapidly did it retreat and what age are the landscape surfaces being investigated for their biodiversity? Specifically we don't know what height the ice reached during the LGM in the Darwin region.

Previous research in the Darwin Hatherton area by Bockheim et al (1989) suggested that ice in the Diamond Hill region, at the confluence of the Darwin Glacier and the Ross Ice Shelf, was about 1000 to 1200 metres higher than today at the LGM. Their results are based on carbon dating of algae on the surface or beneath boulders on the moraine. More recently, using a modeling approach, Anderson et al (2004) modified their result to suggest that the ice was about 800 metres thicker than today at the LGM. Initial results from the 2006/07 event's surface rock exposure dating (cosmogenic ^{10}Be & ^{26}Al), suggests that the land surface at Diamond Hill (400m asl) are much older than previously thought and have been exposed for 610-620,000yrs. Near the terminus of the Foggy Dog glacier (700m asl), exposure dates of 80-90,000 yrs BP have been measured.

However, ice may have been as much as 800m higher than the *current* ice level at L Wellman. The oldest moraines mapped by Jim Bockheim are at this level, and are highly weathered (as later described by Malcom McLeod). The dating results from 2007/08 sampling in the L Wellman area are not yet available, but expected any day.

In 2008/09 the event is moving into the upper Hatherton glacier area, another area where moraines have previously been mapped by Jim Bockheim. This research is being undertaken in conjunction with the study of glacial ice dynamics on the Hatherton, led by Wendy Lawson.

Discussion:

- There is some concern about how reliable the cosmogenic dating is in this terrain, though there is no reason at the moment to suspect it is not giving realistic dates.
- How was the "big wet" event, recorded in the Dry Valleys region by the higher shorelines of L Vanda and the former L Washburn (110,000 yrs BP in the Taylor Valley) represented in this area? Note that exposed rock surfaces in the Dry Valleys are as much as 12-13 myo.
- Surface exposure dating has implications for biodiversity and whether areas were refugia for organisms during the LGM. Biologists have argued for a more continuous record of habitation of certain areas than indicated by glaciologists in the past.
- As noted in Bockheim (1989) ^{14}C ages of dried algae provide a minimum age for the exposed surface. The possible influence of wind blown algae has not been assessed.

11.00am Malcolm McLeod (K123)

This research is determining the age range of soils in the L Wellman area, to test the hypothesis that the structure and diversity of microbiological communities (primarily bacteria) are related to soil development. Jim Bockheim has identified a sequence of glacial drifts; the Hatherton at 5-10,000 yrs BP (using ^{14}C dating of dried algae), the Britannia at 12-24,000 yrs BP (^{14}C dating of algae), the Danum (200,000 yrs BP) and the Isca (900,000 yrs BP). The latter drifts have been dated by correlation with similar Dry Valley moraine sequences.

Morphological characteristics have been used to identify the drifts, including degree of staining, coherence, pseudomorphs, salts, ice-cemented permafrost, and the degree of chemical weathering. Soils pits were dug on the 4 drifts and sampled at 3 depths. Microbial and soil chemistry results are not yet available. However, good correlations between drift age and weathering intensity (e.g. staining 0-30cm deep), permafrost (45-61cm deep) and

pseudomorphs (0-25cm deep) has been identified. Moisture penetrates the soil to depths of 30-40cm.

This event will not be going to Darwin in 2008/09 season.

Discussion:

- There were 2 stages of soil salt formation noted. Brown salts coating the lower surfaces of rocks appear to be carbonates, but this was not confirmed in absence of HCl reagent.

11.45am Ian Hogg (KO24) (presentation given by Allan Green)

Terrestrial invertebrate distribution in the Darwin has been investigated in 2005, 2007 and 2008, and found to be very sparse on all occasions. This appears to be a hostile habitat, worse even than the Dry Valleys. Only one species of mite and no *Collembola sp* (springtails) were observed. A small number of nematodes, rotifers and tardigrades were observed in same areas as mites; i.e., at Diamond Hill, Junction Spur and in the Smith Valley. No invertebrates at all were seen at L Wilson, L Wellman, Foggy Dog glacier and Dusky Ridge.

Collembola sp have been observed further south at the Beardmore and Scott Glaciers (84°S) so their absence here was unexpected. They are common (3-4 species) around Ross Is, Granite Harbour and in the Miers Valley, but these populations are believed to have always been isolated from each other. Their survival technique is to supercool and avoid above ground exposure (or they would freeze-dry), so they are not mobile populations. For example, in the Taylor Valley, their current distribution relates to the shoreline of the former Lake Washburn. The Beardmore population has probably been there since ice retreated from this area.

Discussion:

- As with lichens (Allan's following presentation) invertebrates were mainly observed at higher altitude (e.g., on Diamond Hill). This may be due to greater moisture (low cloud) or greater substrate age and stability.
- This area is a biological "block" ... unlike the Victoria and Wright Valleys which acted as refugia in last LGM. Why?

12.30pm LUNCH

1.30pm Allan Green (KO24)

Endolithic microbial communities are algae and bacteria living beneath the surface of rocks, and are the most abundant vegetation in the Dry Valleys. Their photosynthetic activity can drive the pH of weathering fluids up to >9, facilitating the dissolution of silica from the rocks. They are mainly cyanobacteria, particularly *Nostoc sp*.

Their photosynthetic activity is measured using fluorescence, and remote PAM will be used to

measure this in the Diamond Hill area this coming season. Activity is not just initiated by snow melt on rock surfaces, but also by “dew”, which is the ice rind formed on rock in response to surface temperatures changing over 50°C during the course of a day (e.g., from >20°C around midday to <-25°C at midnight).

A lichen survey has also been undertaken over the last two seasons: 12 lichen *sp* + 1 moss were identified in the Brown Hills, but only 2 lichen *sp* and no moss at L Wellman. Again, the lack of lichen may be due to lack of moisture in this area. The Beardmore boasts a “jungle” of 26 lichen *sp* + 1 moss *sp*. Five of these species are new to Antarctica, and 33% are new to the Ross Sea area. Are these the remnants of original vegetation, acting as refugia during the LGM?

Discussion:

- The lichen growth rate does show a latitudinal effect (0.877 mm/yr at 62°S and 0.01 mm/yr in the Taylor Valley (77°S). This appears to be a precipitation (moisture) control.
- The presence of “spongy” soils on Diamond Hill was noted. Maybe biological but may also be salt formation, an ice freeze/thaw texture in the soil?

2.15pm Jenny Webster-Brown (KO81)

The purpose of this collaborative NIWA/Cawthron/U Auckland research programme is the characterization of the meltwater geochemistry and aquatic ecosystem processes, in terrestrial and glacial pond and lake systems. One of the objectives is to determine whether these change with latitude, elevation and proximity to the coast. Geochemical results for the Darwin (so far) can be summarized as follows;

Soil salts are predominantly gypsum (CaSO_4), calcite (CaCO_3), nitratine (NaNO_3), halite (NaCl) and thenardite or mirabilite (Na_2SO_4), but include minor Mg sulphate and Ca chloride salts in evaporated pond beds. A period of cooling since 1993 has resulted in many dried ponds in the Diamond Hill area. However, there has been little change in the depth and geochemistry of L Wilson since last sampled in 1993, despite the intervening cooler period. Meltwaters range from very dilute (conductivity <10 $\mu\text{S}/\text{cm}$ in the supraglacial pond (SGP) waters) to very saline (>100 mS/cm in evaporated terrestrial ponds), and all are enriched in NO_3 . Tritium dating suggests that SGP waters are derived from glacial ice of >100 y.o., but terrestrial pond waters are derived from more recent snow melt (<20 y.o.). Trace element (Fe, Mn, Cu, Zn, Pb, As, U & Mo) concentrations were measured in 5 terrestrial ponds, 3 large supraglacial surface water systems (ponds, lakes and cryoconites collectively termed “SGP” features) and as a function of depth in Lake Wilson.

Aquatic macroinvertebrates showed greatest diversity at higher elevation. On the higher slopes of Diamond Hill; rotifers, a nematode, tardigrades and a platyhelminth were observed in Lunch Pond. However, in the SGP systems only a single rotifer (*Philodina sp.*) was seen.

In 2008/09, ponds and lake waters at L Wellman, L Hendy (Grant Valley), L Judith and Dusky Ridge, and again at Diamond Hill, will be sampled to get more representative data for the Darwin area

Discussion:

- What is the mode of formation of carbonate salt deposits on the tops and sides of rocks (as noted in the L Wilson shoreline area)? Where would the Ca come from?

3.00pm Fiona Shanhun (KO72)

This event has no results to date as their first field season will be 2008/09. The plan is to use radiogenic dating (U/Th & ^{14}C) and C and O isotopic compositions of soil carbonate minerals to derive a paleotemperature record. The paleothermometer is based on the temperature dependent fractionation of C isotopes. This fieldwork will take place in the Darwin and Taylor Valleys.

The $\delta^{13}\text{C}$ signature of atmospheric and soil CO_2 is very different (-6.5 ‰ for air, cf -11‰ to -27‰ for soil, depending on photosynthetic pathway). Surface carbonate deposits will be preferred in order to minimise effects of soil respiration and diffusion of CO_2 with depth. Surfaces need to be post- LGM age as variation in atmospheric $\delta^{13}\text{C}$ is known and controlled for. Laser ablation ICP-MS (U Melbourne) will be used to analyze fine layers of the carbonate minerals, simultaneously determining U, Th, C and O isotopes. Soil respiration rates, $\delta^{13}\text{C}$ and CO_2 concentration depth-profiles will be measured, as well as soil chemistry parameters such as sodicity, pH, EC, and diurnal variability in soil moisture and temperature to establish the conditions of carbonate precipitation.

It is uncertain whether the carbonate fractionation will reflect a meaningful temperature, and which temperature (e.g., mean summer, max summer, mean winter etc.). If the paleotemperature proxy is unsuccessful, data gained will contribute to understanding the influence of soil development (particularly salt formation) on terrestrial ecosystems.

Discussion:

- There are many assumptions being made at this early stage of this work. This year will be mainly a shake down to see which are reasonable. An ambitious work schedule is planned.

3.45 Tea break

4.00 General Discussion

- Helicopters NZ wish to change the location of the 2008/09 LGP base camp, as they feel that Lake Judith is likely to be too windy for routine operations. They prefer L Wellman or Grant Valley.
- A base camp at L Wellman is not useful to KO56 and KO72, and only marginally useful to KO81. KO24 is not involved in this base camp.
- The option of a base camp in the Grant Valley (L Hendy) with Helicopters NZ, and an

auxiliary camp at Lake Judith, seems a useful compromise. KO81 to occupy both camps for a time. Helo access to the Upper Hatherton (KO56), Dusky Ridge, and L Wellman are anticipated, and 4 skidoos will be based at the Lake Judith camp.

- Diamond Hill camp plans remain unchanged. The position of this smaller LGP camp is still not easy to finalize, but the general area is agreed upon. Shul to check out potential camp sites in the vicinity of Lunch Pond on the November reconnaissance trip. KO24 camps will be in this area also and there may be a chance for a single camp site.
- The KO81 and K123 research programmes will be rebidding for FRST funding for 2010/11, which introduces uncertainty into the future plans for these events. However, the Landcare team (K123) is not going south for 2 seasons, and is not anticipating going to the Beardmore (discussion continued on Wednesday)

DAY 2: Wednesday 10 Sept

Time

10.00am **Summary of results from Tuesday**

10.15am **Shulamit Gordon (AWS data review)**

An initial analysis of the available AWS data for the LGP sites; Cape Hallet, Granite Harbour, Terra Nova Bay (TNB) and Brown Hills (Darwin) has been undertaken. The longest record is for Cape Hallet (6 yrs), and the shortest for Brown Hills (4 yrs). Good records for mean monthly temp, humidity, wind speed are available. Humidity was consistently lower for the Darwin and TNB, with an average over the recorded data of ~45% humidity, than for Hallet and Granite Harbour (~65% and ~60% humidity respectively), supporting other evidence for low humidity in the Darwin region. TNB and the Darwin also had the highest wind speeds, though temperatures have been up to 5°C lower in the Darwin.

Discussion:

- A great deal more information can be gleaned from the available AWS data, but needs someone to work with it. It may make a good thesis study for a mathematically inclined MSc student.
- Using the ARGOS system (satellite) for AWS would be useful. Continuous download of data via satellite would then be available, and the AWS would only need to be visited every 2nd year for maintenance.
- A comparison with GA's AWS data from the Darwin Glacier would be useful to determine local variability within the Darwin region. It is likely that the Brown Hills AWS will remain in position in Darwin, whereas those on the glacier (GA's AWSs) will be removed at the end of the coming season.

- The potential for data incorporation into the NIWA NEON hydrometric network was raised as a way of getting the data analyzed and interpreted as part of this network.

11.00 Craig Marshall KO66 (*absent but presentation viewed*)

The presentation covered the nematode research undertaken at more northern latitudes, as this event has not yet worked in the Darwin. The relationship between nematode occurrence and soil salinity, moisture and carbon content has been studied. Now planning a visit the Darwin in 2008/09, looking for nematodes and springtails, but plans were not covered in the presentation.

11.45 Brian Sorrell (KO81)

For the terrestrial and SGP meltwater systems in the vicinity of L Wilson and Diamond Hill (described yesterday), analyses for inorganic nutrients, Chlor-*a*, and DOC have been completed, and phytoplankton species identified. Analyses still to be completed include particulate and total nutrients, viruses, enzymes and mat composition.

All meltwaters, even SGP ponds, had very high NO₃ concentrations (SGP waters up to 20 mg/L), while Chlor-*a* concentrations were consistently low throughout the L Wilson area (<0.1 µg/L), but higher at Foggy Dog pond (0.2µg/L). SGP cryoconites were characterized by high N (NO₃ + NH₄) of up to 100µg/L, but low PO₄ concentrations. There was a low biodiversity of cyanobacterial throughout the L Wilson region area, although different bacteria were present in different ponds.

The objectives for the 2008/09 include;

- sampling elsewhere in the Hatherton/Darwin region to improve the baseline data for this area
- undertaking process studies including phyto-PAM, ¹⁴C and O₂ flux studies
- undertaking experiments to determine the effects of nutrient additions.

Discussion:

- May not use PAM to determine cyanobacterial mat productivity as light/dark oxygen uptake is likely to provide a better indication of overall activity.
- Cryoconites are considered major productive environments for this area.

12.30 LUNCH

1.30 General Discussion.

This discussion focused on future planning for the LGP sites, specifically on the choice of an extreme southern site.

- The most likely options are the Beardmore Glacier, or further south at the Scott or Leverett Glaciers. For the latter, access may be possible via the new South Pole route. A decision needs to be made on where to place effort for the next LGP site by June 2009. USAP are not planning a big camp at the Beardmore for next 2 years.
- Allan Green noted that KO24 were keen to spend time at Mt Kyffen (Beardmore), an area of rich biodiversity that they had last been to in 2003. They had seen running water in the area on this visit. Ian Hogg has had a request in to go to the Beardmore since 2006.
- KO81 not so keen to divert their effort further south at the moment, as other areas warrant more attention to follow through on earlier findings in LGP studies.
- KO56 is interested in all of the large glacial systems along this coast, both the glaciers themselves (for rate of ice movement) and the ice-free (moraine) areas. They could go to Scott, Koettlitz or Lincoln Glaciers, with the same interest as for the Darwin, but it does depend somewhat on the results from this season's sampling at L Wellman.
- KO72 keen to go to Scott Glacier area (Beardmore not so useful) if they can extend their work further south. Need to get this season's results first!
- There is a high profile Trans Antarctic event planned, which may provide opportunities for traverse work between Ross Is and the Peninsula. The initiative is mainly from the UK and NZ, and NZ collaboration in this will be a key factor.

4.00 Finish