POLAR WEEKEND

MCMURDO DRY VALLEYS ANTARCTICA

TOPIC: The McMurdo Dry Valleys, An Ecosystem of microbial life

PROJECT PERSONNEL: Dr. Andrew G. Fountain, Geologist, Portland State University, Portland Oregon

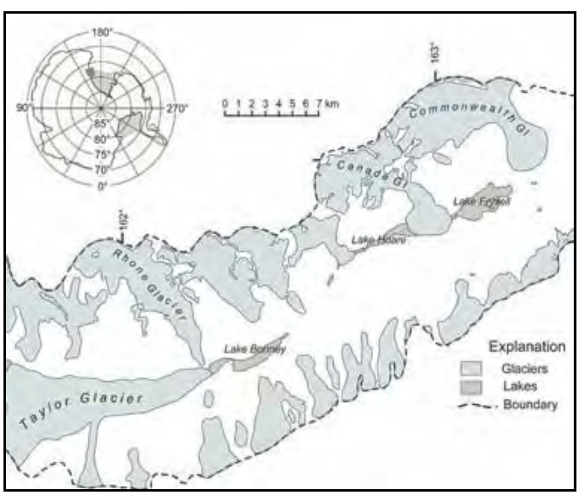
PHOTO: Dr. Fountain in the Dry Valleys of Antarctica on a 'warm' Antarctic summer day.

WHERE ON THE MAP ARE WE? The Dry Valleys are located among mountains by McMurdo Sound and the Ross Ice Shelf at 77 ºSouth on the part of Antarctica closest to New Zealand

HOW WERE THE DRY VALLEYS FORMED: About 65 million years ago as the Transantarctic Mountains were being pushed up, ice was flowing eastward from the boundary of the plateau and cut deep valleys into the rocks. The ice formed the valleys making pathways through the mountain range for ice flowing from the plateau. Many years later several of these valleys, were pushed up higher than others and were no longer pathways for glacier ice; these are what we call the "Dry Valleys". The largest area on the continent without ice ~ 4000 sq km, it is an amazing place to see what lies beneath the ice that covers the rest of the continent.

GENERAL BACKGROUND INFORMATION ON THE SUBJECT:

The McMurdo Dry Valleys are the southern-most terrestrial (land based) ecosystem composed of soil, streams, and lakes. Completely devoid of terrestrial vegetation, the region is considered one of the most extreme deserts on the planet - the valleys receive the equivalent of only 6 mm of water, on average, each year in the form of snow. Because of the cold dry climate this ecosystem lacks higher plants or animals, only microbial life like plankton and mosses live here. This environment is very sensitive to changes in the polar climate because most of the water is stored as ice in the glaciers. A slight warming or cooling greatly changes stream flow and lake levels. (photo below by Hassan Basagic)



LEFT: Map of the Dry Valley area from the LTER program.

ABOVE: A ventifact worked over by wind.

TERMS YOU SHOULD KNOW (VOCABULARY):

microbial – micro-organism sized (seen by a microscope)
permafrost – perennially frozen ground
ventifact – a wind-sculpted rock (photo) that has been shaped by a process like our modern sand blasting technique.
ablation – ice mass loss in all its forms (melting, evaporation, sublimation - direct change from solid to gas)
nematodes - microscopic worms that live in the soil and feed on bacteria, fungi etc. They represent the top of the food chain in the Dry Valleys!

WHY ARE WE STUDYING THIS IN THE POLAR REGIONS?

Many reasons! (1) This ecosystem has few biological parts (no trees, no rabbits, etc) compared to those in warmer regions. This means the role of each piece becomes more obvious and easier to study. Check back to the vocabulary where we note that small microscopic worms are at the TOP of the food chain in the Dry Valleys. (2) The fewer pieces in the system can also allow us to isolate how nutrients like carbon and nitrogen are cycled through the system. Since there are no large plants and animals to transfer carbon into the area, you can treat the area like a laboratory and isolate the carbon and nutrients to watch how they move through the system. (3) Permafrost in this region is the oldest on the Earth - it is some 10 million years old, over 3 times older than in Arctic permafrost (~3 million), and may give clues to past climates through examining the microorganisms in the frozen layer of ground ice.

HOW DOES THIS AFFECT US HERE IN THE UNITED STATES?

Our studies help us to understand basic biological processes in soils and lakes, and how small changes in temperature can affect carbon and nutrient cycles. It helps us to understand how rocks weather. Finally, it helps us understand earlier climates and the influence of human-induced climate changes.

ACTIVITIES YOU CAN TRY:

Dr. Fountain with students at the Polar Fair

Glacier Goo model

1. **Make a glacier to see how the ice moves in the Dry Valley region:**
Using glacier goo observe how a glacier moves flowing under gravity from areas that are higher to lower. Follow the directions in the activity sheet labeled “Glacier Movement”. Using clay create a topography that looks like the Dry Valley image on this handout.

After completing the activity compare your glacier to the image above. Do you see similarities between the image and your glacier? What looks the same? How would you describe the movement of your glacier? Do you think this is how a real glacier moves?

2. **Permafrost** – Permafrost underlies many areas of Antarctica. Permafrost has two layers, a top layer that thaws seasonally which is called the ‘active’ layer, and a deep bottom layer that remains frozen all year. Humans have had a significant impact on the ecosystems of Antarctica and permafrost is a very sensitive to human disturbance through construction and removal of the active layer. These impacts include contamination of soils and vegetation, disturbance of wildlife, and the importation of alien organisms. Where active layer removal occurred, warming of the exposed ice-cemented permafrost took place causing melt-out and surface subsidence. Scientists have determined that up to 30 years after disturbance no significant re-establishment of icy permafrost has occurred.

For this activity we will be creating a sandy permafrost environment much like the one pictured below.

(photo Hassan Basagic from activity poster)

• Using 2 plastic storage boxes and mix sand with water to form a moist sand-water mixture. Layer this wet sand in the bottom of both boxes (about 3 to 4 inches thick). Cover just one of the boxes with a layer of ‘dry’ dirt and sand (box A), and then freeze both boxes overnight.

• Remove both and have the students measure the thickness of the mixture in box A and box B. In box A how much is in the active layer (dry sand) and how much is the deep permafrost? (In Antarctica active-layer thickness and depth to ice-cemented permafrost are related to the regional climate, how close the glaciers are, and the albedo of surface rocks. Permafrost thickness can measure from non-existent or zero to ~1000 m!)

• Next, let’s check temperature. Create a chart of time and temperature for each box - A and B. Have students place a thermometer down into the frozen permafrost layer of each mixture and record the temperatures and the depth. (At a depth of 50 m permafrost temperature measurements range between –14 and –24°C.) temperature of the two boxes regularly every 10 minutes.

Make a prediction.
Will the temperature be the same in the two boxes after the first 10 minutes?

How about after the second 10 minutes?

Will it always be the same?

How long do you predict it will be before the ice in the permafrost is completely melted?

Wrap up: Based on your experiment, how important is the active layer to the protection of the permanent permafrost?

If it were to be removed by humans what might happen to this very special environment?

TO LEARN MORE ABOUT THIS TOPIC: Go to: www.mcmlter.org

Polar Fair Glacier Recipe & Activity:

Glacier Goo Recipe:
Mix#1:
One 20 oz cup
1 stirring stick
3/4 cup warm water
1 cup Elmers white glue

Mix#2:
one 8 oz cup
1/2 cup warm water
one stirring stick (for the 8 oz cup)
2 tsp. Borax powder
1 qt plastic zip lock bag
****
Mix # 1:
In the large cup, add 3/4 cup warm water and 1 cup glue. Stir until well mixed.
Mix # 2:
In the smaller cup, measure 1/2 cup warm water. Add 2 tsp. of Borax powder.
Stir until the powder is dissolved. Pour Mix 2 (the powder mix) into the glue mix. Stir until a glob forms and most of the water is mixed in. This happens quickly! Knead and work the mix for 2 – 3 minutes. Most, if not all, of the water will be incorporated into the mixture.
Place the glacier goo in the zip lock bag. The mixture will store for a few months.

Glacier Movement
Glaciers move! They are often referred to as rivers of moving ice. Glaciers form in areas where it remains cold enough for snow not to melt seasonally and thus accumulate over time. Slowly compressing under its own weight the fallen snow becomes a huge mass of ice. Glaciers retreat or advance depending upon whether there is snow accumulation or melting (ablation). As a glacier grows, its weight and the pull of gravity cause it to move slowly over land. The rate of movement can be slow or glaciers may move several hundreds of feet in a season resulting in a glacial surge. In this activity students will observe how glaciers move.

What you will need for the glaciers:
- Glacier Goo pre-made for the groups
- Cookie sheet or shallow aluminum pan
- Box of clay
- Wax paper
- Drawing paper (one sheet for each student in the group)
- ruler
- Brown marker
- Watch or timekeeping device

Activity
1. Use clay to make a landform for the glacier base. Students can create either an Alpine Glacier which would resemble the Transantarctic Mountains or a Continental Glacier.
3. Measure the distances across their landform, then draw a map of equal size that shows the shape, including any slopes and edges.

3. Before starting: Assign a time interval to record observations. At that specific time, the

assigned group member will draw the shape and location of the glacier snout (or terminus) or the circular edge of the glacier.

4. Have students apply their Glacier goo to the top of the glacier. Using a timer or watch with a second hand, call out time in one minute intervals until the "glacier goo" reaches the bottom of the landform **or** the edge of the wax paper. **(Example: draw what is observed after one minute, and label time, after 2 minutes, and label time etc.)**

5. After stopping, have the students arrange their maps in time order, i.e., one minute, two minutes, three minutes, etc. to compare the changes in the glacier and the time. Ask students to make a statement about how the "glacier goo" moved. **(Students with alpine glaciers should state that the glacier flowed downward, while students with continental glaciers should state that the glacier flowed outward in all directions.)**

Modified from Louisiana Public Broadcasting
http://www.lpb.org/education/classroom/itv/envirotacklebox/

McMurdo Dry Valleys of Antarctica
An ecosystem of microbial life

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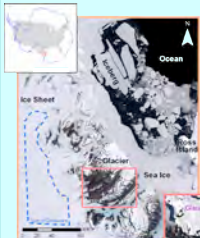
Research funded by the National Science Foundation

Member of the Long-Term Ecological Research Network

The **McMurdo Dry Valleys** form the largest relatively ice-free area on the Antarctic continent, approximately 4,800 sq km – about the size of Delaware.



Life approaches its environmental limits here in one of the driest and coldest ecosystems on earth.

The low biodiversity and slow growth rates of its organisms make this ecosystem highly susceptible to local and global human disturbance.

This environment could be like a tropical Mars.

Dry Valley Ecosystems

Liquid water is the primary limit to life.

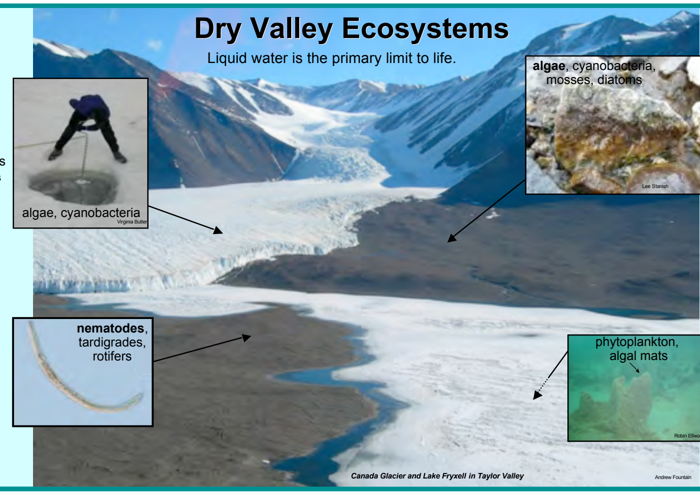
Glaciers

Glaciers cover about one third of the McMurdo Dry Valleys.

- They are refugia for life
- They are frozen reservoirs that supply water to streams and perennial ice-covered lakes

Soils

Globally, there are no other soil systems where nematodes represent the top of the food chain and where food webs have such simple structure.



Streams

Flow for 10 weeks a year

Microbial mat and moss communities are often found within and along the margins of streams

Lakes

Capped with perennial ice covers 4 m thick.

The lakes support phyto-plankton throughout the year.

We study the physical processes that affect the ecosystem.

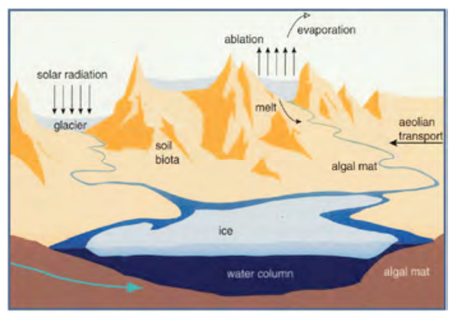
Geologic legacy

Because nutrients are cycled slowly in the polar climate, ancient resources affect the contemporary ecosystem.

A volcanic dike above Taylor Valley.

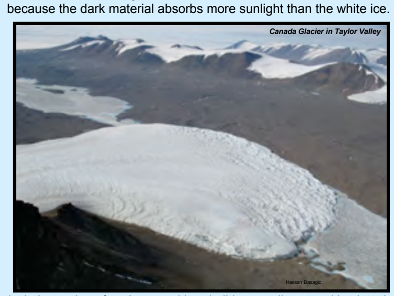
Antarctica is a desert and the McMurdo Dry Valleys are a desert within a desert.

We only get maybe 5 cm of snow (water equivalent) a year, most of which evaporates before wetting the soil.



Blowing sand

Sediment blown onto glaciers and lake ice causes the ice to melt faster because the dark material absorbs more sunlight than the white ice.



This glacier's rough surface is caused by windblown sediment melting into the ice.

Working like sandpaper, windblown sediment also sculpts rocks into strange shapes called **ventifacts**.

Melting glaciers

Dry Valley glaciers melt intermittently during summer because the air temperature is only occasionally above freezing.

Streams convey glacier melt to the lakes. These glaciers have large cliffs that often melt faster than the rest of the glacier.

Melting permafrost

Melting of ice beneath the surface can create ponds in an otherwise dry landscape.