What on Earth

A Canadian Newsletter for the Earth Sciences

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Gold, Paymaster mine, Timmins, Ontario.
photo; Brian Boyle, specimen donated by W.C. Ringsleben
size: 6 x 4.5 x 1.5 cm.© Royal Ontario Museum

University of Waterloo

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Ontario Gold Specimens from the collection of the Royal Ontario Museum.

Wire Gold from Pamour Mine, South Porcupine, Ontario. photo: Brian Boyle.
12 x 9 x 4 cm. (The wire is 3 cm. long)

Schumacher mine, (formerly McIntyre Mine) Timmins, Ontario. photo: Brian Boyle.
6 x 3 x 2 cm.

Dome mine, South Porcupine, Ontario. photo: Brian Boyle.
15 x 7 x 4 cm. 36 troy ounces of gold.

Sachigo River mine, Foster Lake, Kenora District, Ontario. photo: Brian Boyle.
6 x 3 x 2 cm.

Editorial

WAT ON EARTH is dead. Long live What On Earth! Thanks to a "PromoScience" grant from the Natural Engineering and Research Council we are branching out in a new direction. Hopefully it is already obvious that there is a new "look and feel" to this issue. In order to prevent confusion with the old issues we have re-numbered the issue, created a new ISSN number and moved from "Spring and Fall" to "Summer and Winter". At this time we still propose bringing out two issues per year, but this might be increased if there is sufficient demand. Peter and I will still continue to produce the new version at Waterloo, although again I would ask for regional correspondents to feed material to us. Librarians please note that this is a name change and the content remains essentially the same; items dedicated toward education in the Earth sciences.

As I mentioned in the last editorial the Canadian Geoscience Education Network (CGEN) is trying to move ahead to bring geoscience topics into a more prominent position. This is being accomplished by building on four initiatives. Improving the frequency of EdGEO activities (teacher workshops aimed at the dissemination of Earth science information); EarthNet (a web-based Geoscience information site); Geoscape Canada (locally-aimed geoscience programmes based on posters and teaching activities) and this Earth science Newsletter (now approaching its 16th year). The CGEN initiative is particularly timely since just one year from now Canada will be hosting the Fourth International Geoscience Education conference (GEOSCIED IV) in Calgary.

Many of you are teachers or students interested in Earth science, and this conference is a "must". It will be held August 10 to 14, 2003 at the University of Calgary. The website is: www.geoscied.org and if you have ever wished to look for dinosaur remains, visit the Burgess Shale, walk on a modern glacier, learn about new and innovative teaching methods and their evaluations, this is the conference for you. In the next issue we will dedicate more space to providing you with major themes, field excursions and workshops, but if you need advance warning, this is it. Mark August 10 to 14th, 2003 in your calendars (and a week either side if you are interested in field trips in various parts of Alberta and BC).

Now back to this issue. Although it will be a little time before it is active, we have also created a new web site to replace the rather cumbersome WAT ON EARTH web address (Past issues of WAT ON EARTH can be easily located by using www.google.ca and typing in WAT ON EARTH). Our NEW website is just www.whatonearth.org which we trust will be easier to remember.

This issue has a number of items which we hope will be of interest. It starts off with several articles on gold, with a spectacular cover photo, courtesy of the Royal Ontario Museum, of gold from the Paymaster Mine, Timmins, Ontario. Four other images of Ontario gold specimens are inside the front cover. The gold theme is followed by articles from Kelly Snyder on general aspects of gold and its importance, and by Hiroyuki Il on Japanese Gold Deposits. Laura Luckasavitch has provided us with some Gold Rush Poetry, and there is a brief mention of the role of the RCMP as they looked after the Klondike miners at the turn of the 1900's. Laura has provided a second article on "What are the Olympic Medals made of?" that might be a way of applying the "geo-gold" to math areas. There are three Quaternary themes in this issue with David Eden commenting on iceberg marks near Toronto; Kristina Anderson on "The Irish Elk - victim or success?" and "Maryhill Glacial Landforms", by Peter Van Dreil, Paul Karrow and Peter Russell. Maurice Dusseault comments on "Canadian Petroleum and United States Needs", and Ted Appleyard remarks, "What a Nice Gneiss", on that monolithic slab that was installed in the CEIT centre (see WAT ON EARTH, Fall, 2001). Finally, I have tried to introduce a basic exploration of igneous rocks in the centre of the issue with a pull-out centre fold in colour that teachers might find of use. In addition I have commented on some of the terminology used in common igneous landforms and on the shapes of volcanoes. Lastly there is a note on a visit to Jan Mayen and some of the fabulous geology and geomorphology that can be seen (if you are very lucky) on this normally fog-shrouded, rarely visited, North Atlantic island. We hope that you enjoy the content. Peter and I are always willing to take articles and to receive feedback on any items.

Alan Morgan

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INSIDE THIS ISSUE

GOLD

Kelly Snyder

Gold is a metal prized for its beauty, usefulness and scarcity. Gold is one of the most lustrous (shiny) metals. Its chemical symbol, Au, comes from ***aurum***, the Latin word for shining dawn. Gold is a soft metal. It is the most malleable of all metals. Malleability is a metal's ability to be beaten or pressed into various shapes without breaking. Gold can be beaten into extremely thin transparent sheets. Gold is one of the densest metals. Gold weighs about 19 times as much as an equal volume of water at 20°C (68°F). One cubic foot (0.028 m^3) of gold weighs over half a ton.

Gold does not rust like iron because it is unaffected by water or oxygen in air. Gold does not tarnish like silver because it is unaffected by sulfur compounds. However, gold dissolves in aqua regia, a mixture of hydrochloric acid and nitric acid. Gold is rarely used in pure form. It is usually combined with one or more other metals to form an alloy. Copper is the metal most commonly alloyed with gold.

Manufacturers express the proportions of gold in an alloy by: (1) karats or (2) fineness. The karat system, which is usually used for jewelry and ornaments, divides the alloy into 24 parts. One karat (sometimes spelled carat) is equal to one 24th part. Therefore, 24-karat gold is pure gold. Jewelry made of 14-karat gold consists of 14 parts gold and 10 parts of some other metal or metals. The fineness scale, used mostly for industrial products, expresses the proportion of gold parts per thousand. Five hundred fine gold means the alloy consists of 500 parts gold and 500 parts other metal.

Since people have put such a high value on gold, its presence has attracted much attention throughout the ages. One of the main reasons for Spanish and Portuguese explorers taking an interest in South America was to plunder the region for gold.

The 19th century saw several gold rushes in the United States, Canada, Russia, South America and Australia. The 1848-49 gold rush in California produced more new gold than had been found in the previous three centuries and made the United States the largest gold producer in the world. But as these gold fields were worked out others took their place in Alaska, Australia and South Africa. Of the probable world gold reserves, about half are to be found in Witwatersrand area of South Africa.

Canada's history is closely tied to the discovery of gold within its borders. With the discovery of gold in California, every place west of the Rocky Mountains was considered a likely spot for another great strike. The first gold discovered in British Columbia was found on the Queen Charlotte Islands in 1850. By April 1858, the Fraser River Gold Rush was on in force. The Fraser River Gold Rush gave a tremendous boost to Vancouver, a sleepy hamlet of two to three hundred people. The gold rush precipitated development, changing the face of British Columbia and the Canadian West beyond recognition.

As early as 1873, men moved into the Klondlike, working creek beds of the mighty Yukon River and its numerous tributaries. In 1895, there were no people living where the Yukon and Klondike rivers flow together. By 1897, Dawson City was well established. It became the center of supplies for the gold field to which men were flocking in ever-increasing numbers, from all over the world. Dawson City in its heyday had grown almost overnight from a few log cabins to a bustling boisterous town filled with shops, restaurants, saloons, banks and, above all, people. It boasted sewers and sidewalks and plate-glass windows as well as its own telephone and electricity systems. The Yukon was a success for Canadian miners and mining. In the year 1900, about $22,000,000 worth of gold was produced in the Yukon; that was the peak year. Between 1885 and 1927, the total yield of the Yukon gold exceeded $175,000,000. Even today, the Yukon is still producing gold. We may think that the discovery of gold in the Yukon is the most memorable event in the history of Canadian gold mining, but the discoveries at and near Kirkland Lake, Ontario, remain the most profitable. In July 1911, a solitary prospector by the name of William H. Wright discovered gold while prospecting in the Timiskaming District of northern Ontario. Six months later Harry Oakes was prospecting on the south-west of Wright's location and made a grub stake, that would later become the Lake Shore mine, which has the deepest mining shaft on the continent.

The finds of Wright and Oakes brought on a new burst of mining activity in the Canadian Shield. Gradually the communities of Kirkland Lake, Porcupine and Timmins grew in strength and size. Gold mining was not "a flash in the pan" here, but the area remained a gold-mining center into the 1950s, but by 1970, most of the mines in the area had closed and iron mining became the leading economic activity.

Throughout history, people have used gold mostly as money and for jewelry. Today, gold also has many other uses. All countries accept gold in payment for international debts, though such payments are not common. The world's governments hold about 42,000 short tons (38,000 metric tons or 38 million kilograms) of gold in their official stocks. Almost all of the gold is in brick-like bars, which are called ingots. The United States government stores its gold mainly in the Federal Reserve Bank in New York City and at a depository in Fort Knox, Kentucky. Gold bars are a form of bullion – that is metal held for its value as a metal rather than as money.

Gold is almost entirely non-reactive. Although this means the gold will not form compounds, it also means that, where non-reactive materials are needed, gold has an important part to play. Because it is rare, it is also expensive to use. This is why gold is used only where such materials are important.

Gold is a good conductor of electricity and does not oxidize, so it is important for use in electrical circuits, such as microelectronics, and for connectors and switches. Most of the gold used is electroplated on to some less expensive base material. Since it does not corrode, gold is used in places where there is a corrosive atmosphere such as certain chemical processes. For the same reason, gold can be used safely in amalgams to make dental fillings. Thin gold films on spacecraft reflect infrared rays from the sun, which can harm both people and equipment. A transparent gold film in windows of large office buildings also reflects infrared rays, helping to keep the buildings cool in summer. Artists used gold leaf, thin sheets of gold for decoration and lettering.

Uses for Gold:

Aircraft - gold coated windows
Artistic Work
Automobile air bag deployment system, gold plated system sensors in the engine and exaust system
Catalysts - used in chemical reactions for industrial applications
Coins
Computers
Decorations
Dentistry
Electrical and Electronic Devices
Eye surgery - eyelid load implants allow the eye to blink property.
Fire Fighting - Firefighters wear gold coated protective shields to protect the eyes.
Food freshness sensors - measure levels of carbon dioxide
Jet Engines
Jewelry
Lasers for medical use, sealing wounds, rejuvinating skin tissue.
Medical Field – Treatment of Arthritis
Money – Gold Standard
Photographic Films
Radios
Reflectors to confuse incoming heatseeking missiles
Surgery - tools for clearing clogged coronary arteries, prostate cancer treatment.
Space Industry – Heat Shields and Helmet Visors
Telephones - in the diaphragm of the mouthpiece
Televisions – T.V. Screens
Thermometers - gold helps the thermometer to record the body's temperature in 2 seconds.
Windows - coating to reflect infrared

Facts about Gold:

- A cubic room 18m per side could contain all the gold ever mined.
- The heaviest gold nugget - 90kg - was found in Australia.
- Depending on the ore, sometimes only 25 grams of gold is extracted from 13 metric tons of rock.
- South Africa is the largest producer of gold in the world.

School Activities

Science

- Make a list of the unique properties of gold and/or the various uses of gold.
- Write an essay on why alchemists failed to produce gold from another substance.
- Make a kit and conduct tests to compare different metals.
- Separate a mixture of sand and water using a coffee filter. Then, separate a mixture of sand and sugar by adding water to dissolve the sugar and pour the mixture through a filter to leave only the sand behind. Next, separate iron powder and sulphur using a magnet. Finally, separate salt from salt-water by allowing the water to evaporate.
- Metals may precipitate to form an ore. Inside the earth, metals seep into cracks forming veins of ore. To observe this phenomenon, place an iron nail in a bowl of water. Let the nail rust. Then, place a dry sponge in the bowl. A few days later the rust will be absorbed by the sponge "rock."
- Pan for gold in the classroom. Mix one quarter cup of "gold" - copper pellets or iron filings - with 10L of coarse sand and add water to make a slurry. Then, have students use shallow pans to swirl the slurry over another large pot. Continue to add water until only the pellets or filing are left.
- Build a small sluice box with wood, carpeting and chicken wire. Place the box at a 5-15 degree angle. Run a slow stream of water down the sluice and place some fine mixed materials on top of the sluice box. The heaviest material will be caught in the chicken-wire riffles.
- To demonstrate land reclaimation after mining, have students pour water - (demonstrating erosion) - over three mounds of soil, sand and gravel and then have students plant grass seeds on the three mounds. What happens? Try to explain the benefits of reclaiming old mine sites.

Social Studies

- Consider the possibilities for gold mining on the moon or profitably extracting gold from sea water.
- Read myths surrounding gold - Jason and the Argonauts, Tommy-knocker, King Solomon's Mines, Blackbeard's treasure, Rumpelstiltskin, King Midas and the Lost Dutchman's mine.
- Check the newspaper for current gold prices and prepare graphs to illustrate how gold prices fluctuate.
- Write an essay on the use of gold as a monetary standard.
- Prepare and present a report on gold rushes throughout the world.
- Create a scrap book containing pictures of modern mining operations.
- Research mining superstitions.
- Research and prepare a report on the dangers involved in mining.

More Suggestions...

- Visit a mining operation in your community and discuss the mine's economic and environmental impact on your community.
- Contact a local geologist to identify nearby spots where students might pan for gold (or another "heavy" mineral).
- Investigate mining-related careers - metallurgist, geologist, mining engineer, chemical engineer, surveyor, driller, blaster, cartographer and environmental scientist.

Websites

Ontario's first gold mine in Eldorado:
www.ilap.com/breberg/geo/richgeo.htm
Information on the Deloro Puton:
www.canadianrockhound.com/fall97/cr9701402_madoc.html
Prospectors and Developers Association of Canada's Mining Matters:
www.pdac.ca/miningmater/index.html
California Gold Rush Vocubulary Exercise:
www.vocabulary.com/goldrush12.html
Science, Music, Drams, Math, Reading, Social Studies Activities about Gold:
ww.mii.org/goldhist.htm
Historical Alchemy and Gold:
www.crystallinks.com/alchemy.html

What a Nice Gneiss!

When the monolith recently placed in the atrium-to-be of the new Centre for Environmental and Information Technology (CEIT) finally can be viewed in its full glory, there will, no doubt, be many passers-by who will puzzle about its name. Is it pronounced "neece", or "G-neece", or "G-niss", or what? Metamorphic rock terminology is nowhere near as complicated as that of igneous rocks but nevertheless does possess a number of important terms derived from classical language roots or 19thC European sources that are not immediately intelligible. The term gneiss is one of the latter — and by the way, it is pronounced "nice" as the pun in the title indicates.

The majority of metamorphic rock names comprise a textural descriptor, in this case "gneiss", and a compositional descriptor, often something like "granitic" or possibly "migmatitic". There is a problem though, and that is that not everyone uses the term "gneiss" in the same way. (Dumb metamorphic petrologists!) It was apparently first used in 1561 by Agricola to describe the country rocks around the mineral-rich Erzgebirge district in Germany and Czechoslovakia. The problem resides in whether compositional layering of light-coloured (felsic) minerals and dark-coloured (mafic) minerals into alternating bands is an essential property. Those who would deny that mineral segregation layering is essential to a gneiss would apply the term to any foliated, medium to high grade metamorphic rock that is not a schist, i.e. a low to medium grade rock particularly enriched in well-foliated micaceous minerals.

My predilection is that historical usage favours the term "gneiss" for a foliated rock, of high metamorphic grade, consisting of alternating mineralogically distinct (usually felsic and mafic) layers. The recrystallization process which results in the minerals segregating into these layers is invariably the result of strong deformation (strain) resulting from viscous flow of the rock under conditions of very high temperature and pressure. If it is possible to discern the nature of the pre-metamorphic parent rock it is permissible to distinguish "orthogneiss" — derived from an igneous parent, from "paragneiss" — derived from a sedimentary parent. Because the monolith is still cocooned in a protective wrapping as the building rises around it, I can't study it closely enough right now to say to which of these two classes it belongs.

The compositional modifier is easier to explain. "Granitic", used sensu lato, means an assemblage predominantly of quartz and feldspar with much smaller amounts of mafic minerals, especially biotite mica, amphibole, maybe pyroxene, and frequently very minor amounts of minerals like garnet, sphene, etc. The term "migmatitic", on the other hand, is derived from the Greek word for "mixture" and is used for rocks in which a metamorphic-looking component is combined intimately with an igneous-looking component. These rocks are most commonly the result of partial melting of the original rock under conditions of very high metamorphic temperatures. The igneous-looking phase is usually "granitic", so our granitic gneiss may also be migmatitic.

During regional metamorphism such as occurs typically in mountain belts during the mountain-building episode (orogeny) there is always intensive deformation. Under the high temperatures and pressures such as exist within the core of such belts, the rocks deform, not as rigid, brittle objects that we associate them to be under surface P–T conditions, but rather by flowing in a viscous fashion. The layering and foliation that exists in the gneisses will commonly be deformed subsequently. Thus we may observe folds, sometimes of quite complex form; nice examples are present in the CEIT building monolith.

Now, what about this particular monolith? What do we know about its geological history?

Its home for the past billion years (more-or-less!) has been with rocks that now are exposed in an outcrop north of the French River in Bigwood Township, south of Sudbury. This is an area that occurs within the Grenville Tectonic Province of the Canadian Precambrian Shield. The Grenville Province comprises the roots of a collisional orogenic (mountain) belt that is exposed along the southeastern margin of the Canadian Shield from the east coast of Georgian Bay as far as the Labrador coast. In reality, the Grenville rocks go much farther than that and have been identified in southern Norway and southwestern Sweden before they dive under younger rocks again. In the other direction, they are known to extend in the subsurface at least as far as the Sierra Madre mountains in Mexico. Some folk even contend that the same fold-belt can be found in Antarctica and possibly even on the southeastern margin of Africa. The ponderous pavane of plate tectonics certainly frees up the imagination!

The Grenville mountains were formed around a billion years ago when some other wandering continent collided with the eastern flank of the Laurentian Craton, i.e. proto-North America. The latest idea is that this bulldozing bully may have been the western flank of what later became South America! As a consequence of this head-butting, the Grenville mountains were thrust up in a series of stages into a mountain range that would have resembled, perhaps even rivaled, the contemporary Alpine/Himalayan chain. This happened between 1.300 Ga (Giga-years — i.e. 1.3 billion years ago) and 0.950 Ga (i.e. 950 million years ago).

The French River gneisses appear originally to have been part of the margin of the Laurentian craton (read continental core) and had been emplaced during an even earlier magmatic/metamorphic event sometime between 1.900 and 1.450 Ga (billion years ago). We would have to date our monolith radiometrically to determine when within this rather large range our rock was born. However, its rest was not peaceful for once the Grenville collision occurred it was heated and deformed under the combined pressure of the colliding continent and the weight of perhaps as much as 25 km of superincumbent rocks. It was during this protracted orogenic stage that our gneiss became, gneissic, migmatitic and folded, all more-or-less at the same time.

To human eyes young mountain ranges appear as prominent upward thrusting elements of topography, but like an iceberg their greatest mass is really below the surface and extends downward as a great root into the upper mantle and, to use another analogy, when the superstructure of the range is reduced by weathering, erosion and transport of sediment away from the range, the whole belt, root and all, rise buoyantly, like a ship being emptied of its cargo. Thus, over perhaps hundreds of millions of year, the Grenville rocks rose inexorably upward in response to surface unloading and the French River gneisses came closer and closer to the surface, cooling all the while. It would appear that they were not far from their present crustal level as the Precambrian Eon turned into the Phanerozoic and the pages on the calendars flipped over to the Cambrian period. The final event, perhaps, was the passage overhead of the great Pleistocene ice-sheets which scraped away the final few centimetres off the surface and the gneisses finally saw the light of day.

So, should you ever pass through the atrium of Earth Science's soon-to-be new home, pause and cast your eyes at the oldest member of the department, standing there proudly. Tip your hat to it and say, "What a nice gneiss — and have a good day!".

Iceberg Alert for Toronto By David Eden

To dispel any alarm, I should clarify that the Iceberg Alert applied about 50,000 years ago and is not a current concern. Unfortunately, written records of the pre-historic Iceberg Alert have not survived more recent glaciations in the Toronto area. However, there is a record of one of the larger icebergs preserved in the muddy and sandy sediments of the Scarborough Bluffs. This geologic structure was the main subject of my M.Sc. thesis at the University of Toronto: "Ice Scouring as a Geologic Agent: Pleistocene Examples from Scarborough Bluffs and a Numerical Model". Along with my M.Sc. supervisor, Dr. Nick Eyles, I interpret this structure to be an ice scour caused by a floating iceberg in an ancestral ice-dammed Lake Ontario.

Ice scours are the track left behind on the sea floor or lake floor when an iceberg, or a mass of seasonal pack ice, "bottoms out" in shallower water. Ice scours criss-cross the sea floor in modern polar oceans, in areas such as the Beaufort Sea and the continental shelves off Greenland, Norway and Antarctica. Closer to home, modern ice scours from seasonal pack ice occur on the floor of Lake Erie. Ancient examples are preserved in the Glacial Lake Agassiz sediments in Manitoba (featured in WAT ON EARTH Vol.10 (2) p.4, 1997) and show up clearly on aerial photographs. Chris Woodworth-Lynas, then with C-CORE in Newfoundland, studied the Lake Agassiz scours in cross-section with the help of a backhoe.

Through shoreline erosion and slope failure, nature has graciously exposed a cross-sectional view of an ice scour at Cudia Park on the Scarborough Bluffs. This is fortunate, because the rappelling equipment I needed to access the scour was not rated for heavy construction machinery. Photographs and a sketch of the ice scour structure are shown in Figures 1 and 2. The structure is cut in clayey silt and is infilled with storm-deposited sands. The scour trough is about 4 m deep and 10 m wide, and has sub-scour sediment deformation up to 5 m below the bottom of the scour trough. A ground penetrating radar (GPR) survey confirmed that the scour extends further inland. Using a numerical model of the ice scour forces, we estimated that the downward scouring force of the ice mass was about 5 MN, which is consistent with an ice keel draft of about 20 m. This water depth estimate is consistent with independent sedimentological estimates based on the amplitude of nearby sand beds. We have published papers on the study in Sedimentology and the Canadian Geotechnical Journal.

I conducted the M.Sc. studies part-time while working for Golder Associates in Mississauga, who provided partial support for the programme. In addition to thanking Dr. Nick Eyles for excellent supervision and helpful insight, I'd like to thank Mike Doughty and Kyle Hodder of the University of Toronto for assistance in the research.

David Eden is a Waterloo grad (B.A.Sc., Geological Engineering, 1996) who recently made a career switch to risk management at Ontario Power Generation. He is a part-time MBA student at the Rotman School of Business, University of Toronto.

Figure 1: Photographs of Cudia Park Ice scour. A: summer view, B: winter view. arrows in B indicate "berms" of ploughed sediment at the sides of the scour and deformation below the scour.

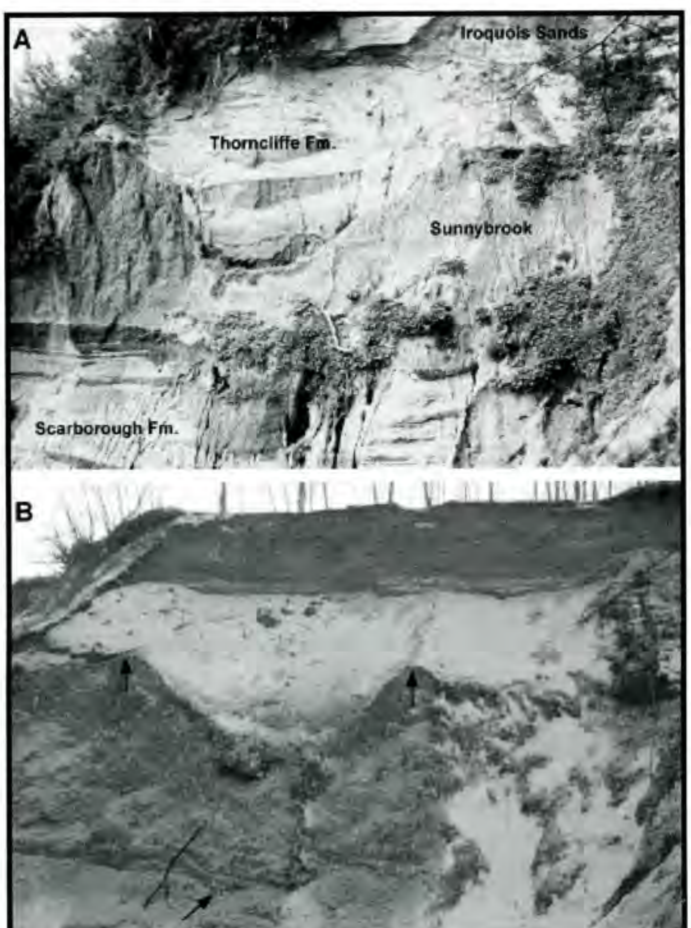
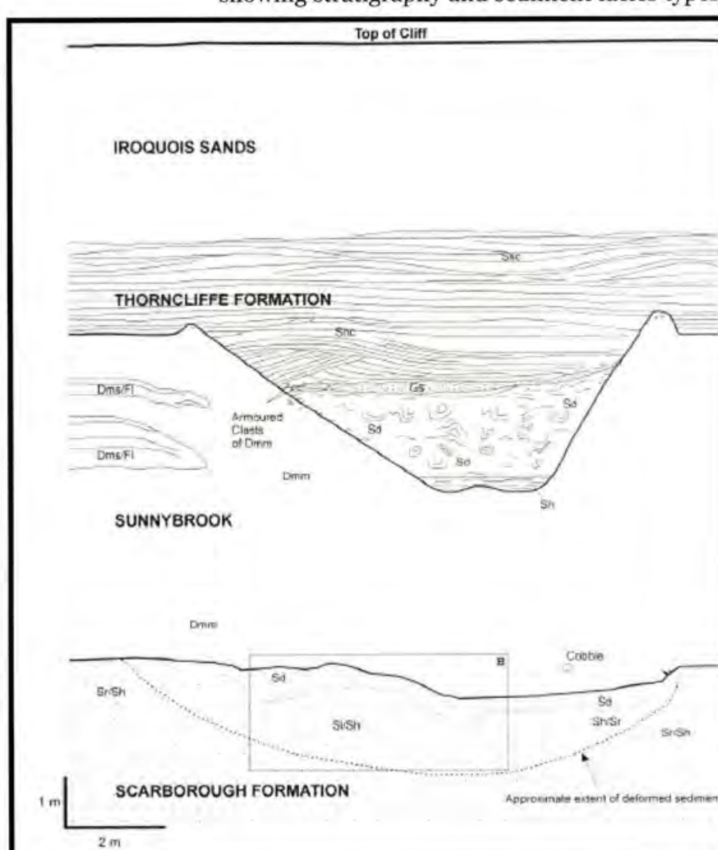


Figure 2; Sketch of ice scour shown in Figure 1, showing stratigraphy and sediment facies types.



Gold Rush Poetry

by Laura Luckasavitch
Subject: English – poems, History – Canadian and American
Grades: 7 - 10

The gold rush affected many people in many ways. Here are a few poems that tell stories about what the gold rush was like. Read these to your class, discuss the significance of the poems, and then get them to write a poem about the gold rush after doing a bit of research about the way of life back then.

The Happy Miner

I am a happy miner,
I love to sing and dance;
I wonder what my love would say
If she could see my pants.
With canvas patches on the knee,
And one upon the stern;
I'll wear them while I'm digging here,
And home when I return.

Chorus:
So I get in a jovial way
I spend my money free;
And I have got a-plenty,
So come drink lager beer with me!

They wish to know if I can cook,
And what I have to eat;
And tell me, should I take a cold,
Be sure to soak my feet.
But when they talk of cooking,
I'm mighty hard to beat;
I've made ten thousand loaves of bread
The Devil couldn't eat.

From ***The Forty-Niner*s** by Archer Butler Hulbert

Alas!

I've been to California, and I haven't got a dime,
I've lost my health, my strength, my hope, and I have lost my time.
I've only got a spade and pick and if I felt quite brave,
I'd use the two of them 'ere things to scoop me out a grave.

From ***Troupers of the Gold Coast*** by Constance Rourke

The Klondike Miner

A Klondike City mining man lay dying on the ice,
There was lack of women's nursing, for he didn't have the price,
But a comrade knelt beside him as the sun sank to repose,
To hear what he might have to say and watch him while he froze.

The dying man, he raised his head above the banks of snow,
And he said, "I've never seen it thaw when 'twas forty-five below;
Take a message and a token to some distant friends thereat,
For I was born at Gibbons, at Gibbons on the Platte.

"Tell my brother and companions if ever you get back East,
That this blooming Klondike country is no place for man or beast,
For the mountains are too rugged and the weather is too cold,
And the wheat fields of Nebraska yield a better grade of gold.

"Here an honest day of labour won't buy a pound of grease,
And the price of leather biscuits is sixty cents apiece;
Tell my father not to sorrow with a sorrow deep and dense,
For I would not thus have perished if I had a lick of sense,
But to keep the sorrel horses and the high-grade cattle fat
Upon the farm at Gibbons, at Gibbons on the Platte.

"I thought to make a fortune here," the dying man did say,
And then he hove a sigh or two and froze up right away;
And it took of golden shekels two hundred, yes, more than that,
To ship him back to Gibbons, to Gibbons on the Platte.

From ***Flying Cloud*** by M.C. Dean

Royal Canadian Mounted Police

The RCMP has had a varied history beginning in 1873. They are a very important part of Canada's past and have helped shape our police force that we have today. It all began on May 23, 1873 when Dominion Parliament thought a police force was necessary for the North-West Territories. Their objectives were:

1. To stop liquor traffic among Indians.
2. Gain respect and confidence.
3. Break old practices by tact and patience.
4. Collect customs dues.
5. Perform all duties of a police force

Although they were formed in 1873 there wasn't a need for a police force until 1895.

The Klondike Gold Rush had begun to interest many from around the world and the NWMP were ready for it. Charles Constantine and his men began to build the first Mounted Police post in the Yukon, which was called Fort Constantine. At the beginning there were only 19 officers and men of the NWMP. They arrived just in time for the Gold Rush and helped to control the crimes and keep justice alive. However, soon after they arrived they found that they couldn't handle the rush, so they created 31 detachments that spread out over the Yukon. One of the most important detachments was situated at the summits of both White and Chilkoot passes. They collected customs duty for supplies brought into the Yukon by gold seekers.

Between 1898 and 1900 the Canadian government sent a two-hundred man force to assist the NWMP to guard prisoners, banks and gold shipments. The NWMP became the symbol of personal security and justice in the Yukon. Samuel Benfield Steele who was the superintendent of the NWMP said: "The whole demeanor of the people changed the moment they crossed the summit. The pistol was packed in the valise and not used. The desperado, if there, had changed his ways, no one feared him." They were a well respected organization who made the Klondike Gold Rush a safe and just place for people to mine for gold. The NWMP's efforts were recognized by King Edward VII who renamed them the Royal North-West Mounted Police in 1904. It wasn't until 1920 that they changed their name to the Royal Canadian Mounted Police gaining the respect and recognition they deserve from Canadians.

Resources:
1. Historical Highlights. www.rcmp-grc.ca/html/history.htm 2002
2. Klondike Gold Rush. www.rcmpmuseum.com 1998-2001

3. The Establishment of the NWMP. www.rcmpmuseum.com 1998-2001

What Are The Olympic Medals Made Of?

by Laura Luckasavitch

Subject: Math - fractions, percent, simple algebra, cross multiplying, problem solving
Grades - Ontario Curriculum:
Grade 8 - Number Sense and Numeration
Grade 9 - Number Sense and Algebra

For the Olympics, gold medals are awarded to the first place, silver to the second, and bronze to the third. But are these medals actually made out of the mineral that they are named after? The gold and silver medals are both made of silver. The gold medals are then coated with gold. Each Olympic gold medal is made up of 210g of silver and is coated with 6g of 24 carat gold. The bronze medals are made of copper, zinc, tin, and a very small amount of silver. In the Sydney 2000 Olympics and the Paraolympic Games, each bronze medal contained 1% silver and the remaining 99% was made from coinage bronze. Bronze coinage is made up of 97% copper, 2.5% zinc, and 0.5% tin. This bronze came from Australian currency, which is no longer in circulation.
Information here was taken from the web site:
http://www.minerals.org.au/olympics/themedals.html

Student Questions and Answers

1. What % of the gold medals are actually gold? Silver?
Gold: 6 / 216 = 2.8%
Silver: 210 / 216 = 97.2%

2. How much gold is actually needed to make 50 gold medals? How much silver is needed?
Gold: 6g x 50 = 300g
Silver: 210g x 50 = 10500g or 10.5kg

3. How much gold is actually needed to make 90 gold medals? How much silver is needed?
Gold: 6g x 90 = 540g
Silver: 210g x 90 = 18900g or 18.9kg

4. Pure gold is 24 carats (k). 10k gold means that the gold is 10 / 24 parts pure and that 14 parts are other metals, usually composed of copper and zinc. These metals give the gold object it's hardness. What percent of 10k gold is pure gold? 14k? 18k? 24k?

10k: 10k / 24k x 100% =
41.7% pure gold
14k: 14k / 24k x 100% =
58.3 % pure gold
18k: 18k / 24k x 100% =
75% pure gold
24k: 24k / 24k x 100% =
100% pure gold

5. If 10k gold was used instead of the 24k gold, how much real gold would be in 1 gold medal? Give your answer in percentage and grams.

10k / 24k = 41.7 % real gold
0.417 x 6g = 2.5g real gold per medal
2.5g / 216g = 1.2% real gold per medal

6. If 18k gold was used instead of the 24k gold, how much real gold would be in 1 gold medal? Give your answer in percentage and grams.

18k /24k = 75% real gold
0.75 x 6g = 4.5g real gold per medal
4.5g / 216g = 2.1% real gold per medal

More Challenging Questions
7. If the bronze medal has the same mass as the gold medal, how much silver, copper, zinc, and tin will be needed for 1 bronze medal?

Silver: 1% / 100% = xg / 216g
x = 2.2g
Copper + Zinc + Tin = 216g - 2.2g = 213.8g
Copper: 97% / 100% = xg / 213.8g
x = 207.4g
Zinc: 2.5% / 100% = xg / 213.8g
x = 5.3g
Tin: 0.5% / 100% = xg / 213.8
x = 1.1g

8. How much silver, copper, zinc, and tin would be needed for 50 bronze medals?

Silver: 2.2g x 50 = 110g
Copper: 207.4g x 50 = 10370g or 10.37kg
Zinc: 5.3g x 50 = 265g
Tin: 1.1g x 50 = 55g

9. If no silver was used in the bronze medals and only the coinage bronze was used, how much copper, zinc, and tin would be needed for 1 bronze medal?

Copper: 97% / 100% = xg / 216g
x = 209.5g
Zinc: 2.55 / 100% = xg / 216g
x = 5.4g
Tin: 0.5% / 100% = xg / 216g
x = 1.1g

A basic introduction to rocks - Part 1: The Igneous Rocks

Introduction

The new grant from NSERC's "Promo Science" initiative has allowed us to strike out in a new direction. Because it enables us to use colour it finally allows us the last stage in what we have been trying to do in black and white over the last 15 years. It allows us to explain things in still more detail, and in a way that was impossible before. To make the most of this we intend to embark on a series of small vignettes that hopefully will assist teachers and students in understanding some of the fundamentals in geology and the other "Earth sciences". Perhaps the most traumatic experience for many is in understanding rocks.

Our world is made of rocks. We use them on a daily basis, usually by walking or driving on them (or on some crushed and reconstituted version thereof). Our homes and office buildings are often made of rock materials;- bricks as refired clays, walls as reworked gypsum, dining utensils such as plates, cups and saucers (pottery, ceramic and china), counter tops and floors as slabs of rocks of various origins. Rocks are aggregates of different mineral grains and can be divided into three major families or rock groupings.

First are the Igneous (or "fire-formed") Rocks, usually created by outpourings from various volcanoes or by cooling deep under the crust. Ultimately, even deeply buried rocks are exposed to surface weathering and break down into their constituent minerals. These mineral grains are removed as sediment and are transported by gravity, wind, ice and water to a place of deposition where they accumulate, normally as marine sediments. The sediments, whether marine or terrestrial, become compressed and are often invaded by cementing agencies carried by percolating water. They are then lithified — turned from loose grains back to solid rock — for example limestones and sandstones, forming the second great rock group of the **Sedimentary Rocks.**

Sedimentary rocks suffer one of two fates. They can be weathered, broken down again into constituent grains and recycled as sediments, or they can be still more deeply buried, heated and involved in different types of tectonic movement. The associated heat and pressure together with circulating fluids modify and change these former sedimentary rocks into a third group known as the **Metamorphic Rocks.** Incidentally igneous rocks and earlier metamorphic rocks can also be modified or re-modified in the same fashion if they are involved in similar Earth movements. Schists, gneisses and marbles are examples of metamorphic rocks. These aspects of formation, weathering, erosion, deposition, lithification, and modification were covered in a description of "The Rock Cycle" in an earlier issue of WAT ON EARTH (Volume 13, No. 1. November 1999).

In this issue I would like to first describe the Igneous Rocks, with later issues of "What on Earth" covering the other rock families. All aspects of these topics are covered in as much detail (sometimes more) in our companion website; www.whatonearth.org.

The Igneous Rocks

Igneous rocks are typified by the "interlocking" nature of the crystal grains in the rock types where these are easily visible. It is important to understand the classification of these rocks since they are very common in most of the Canadian Shield and pieces have often been transported into areas further south, west and east, by the glaciers of the recent past. Igneous rock classifications vary from being relatively simple (rocks can be divided into dark and light and coarse to fine) to extremely sophisticated, with categories depending on the chemical and optical classification of the constituent minerals. We will only deal with the simple classification of igneous rocks, although it is important to understand that this does rely on the fundamental chemical makeup of the rock, which in turn is a product of the way in which these rocks originated. For example, the presence and percentage of silica in the rock is extremely important as well as the makeup of feldspar minerals and the presence of accessory minerals. In its simplest form (centrefold) the classification is based on colour (horizontal) and grain size or texture (vertical).

Colour

The left hand side of the chart is dominated by silica-rich and hence, light coloured rock types. Moving to the right, the rocks become progressively darker as the percentage of iron- and magnesium-rich minerals increases. Remember that there truly is a gradation from light to dark, and while it might be moderately easy to recognise the end members, the rocks in between are far more difficult to differentiate. These "in between" rocks fall into an "intermediate" category between the light coloured, silica-rich left side (termed acid or [acidic]) and the much darker right side (basic) rocks.

Texture

Igneous rocks commonly exposed at the surface originate in magmatic masses deep beneath the earth, usually at depths of anywhere from 10 to 50+ km and occasionally, and far more unusually, at much greater depths (~150+ km). Rocks that cool below the crust are termed **intrusive.** When these magma masses cool over long periods of time inside the crust the crystals within the rocks can be quite coarse, although large crystals are also a function of abundant elements that allow the crystals to grow. We call these rocks "plutonic" and the coarse-grained texture is described as "phaneritic". Crystals can range from millimetres to larger than one metre in size. These giant crystals form pegmatites (see WAT ON EARTH Fall Issue 2001, volume 15, number 1.)

Generally as the magma moves towards the surface the grain size decreases to one millimetre or less. This is a medium-grain size. Rocks in this higher crustal position often have two distinctly different crystal sizes with quite coarse crystals sitting in a far finer medium-grained matrix. These rocks are termed "hypabyssal" and the two-grain size texture is termed "porphyritic". In a porphyry the larger crystals set into the medium-grained matrix are known as "phenocrysts". We presume that these crystal "two-sized" rocks were created when magma moved more rapidly into near-surface conditions allowing the initial large crystals that had already formed to be enveloped in a finer crystal mass.

Eventually the magma reaches the surface where it is extruded as lavas of various types. Rocks that are poured out on the surface are **extrusive.** A lava is magma that has lost most of its volatiles which "boil off" as gases and liquids, including water. This rapid quenching in the much cooler surface environment means that crystals have little time to form. As such they have a fine-grained texture. This textural category is termed "apahanitic" and the rocks are said to be volcanic in nature. The crystals within the aphanitic texture usually cannot be discerned with the eye and even are difficult to see with a hand lens. In some cases the lava cools so rapidly that volcanic glasses are formed, as in the case of obsidian.

The chemical makeup is important in not only determining the colour of the rock and its constituent minerals, but also the shape of the volcano and the nature of the volcanic eruption. I will discuss this in a later article.

If we return to our igneous rock classification we can see in the "acidic" category that **granite** (light coloured, coarse-grained intrusive), give rise to **microgranite** (medium-grained intrusive) and eventually to the light-coloured extrusive lava type known as **rhyolite**. Typical colours represented in these categories are predominantly white, light-grey to buff and pink. Very rapidly cooled rhyolitic lavas often have glass crusts that appear black in colour. In fact when these are looked at in thin flakes, the rock colour is quite light grey. These glasses are known as **obsidian,** and although typically black when massive, they can also be greenish, purple, brown, yellow and even red in colour. The volcanoes that produce rhyolitic lavas are very gaseous. Extremely violent eruptions can produce a highly frothed lava, typically silver or buff-brown in colour, that is known as **pumice**. Such explosive eruptions will allow thick deposits of ash to accumulate around, and downwind from, the volcano. These ash deposits will lithify to form a consolidated rock known as tuff.

The "intermediate rocks" can be subdivided into "lighter" and "darker" categories. At the lighter end the phaneritic rock **syenite**, gives way to medium-grained **microsyenite** and then to the lava **trachyte**. In the darker section, phaneritic **diorite** gives way to the hypabyssal rock type, **microdiorite**, and then to the aphanitic lava, **andesite.**

In the basic category the dark-coloured phaneritic rock type, **gabbro**, is replaced higher in the crust by medium-grained **diabase** (also known as **dolerite** in Europe) and then by the aphanitic lava type, **basalt.** Fast moving lava flows cool very rapidly and **tachylyte** (thin glassy films) are created on the surface. This is particularly true if the lavas are produced under water, or under ice. Although eruptions by basic volcanoes are not that explosive, initially there are a lot of lava fountains. Lava clots and ash get ejected near the vent, and the gas content creates voids in the lava ejecta forming **scoria,** the basic equivalent of pumice.

In the classification the final category involves the ultra-basic rocks. These are rich in iron and magnesium, generally formed deep within the crust or even at the top of the underlying mantle. They are exposed at the Earth's surface by tectonic movements that have brought mantle rocks to the surface in plate tectonic collisions of various sorts. The rocks are dark coloured, and frequently greenish, because of the presence of the mineral olivine. Typical examples are **dunite** (named from Mt. Dun in New Zealand and made exclusively from the glassy green mineral, olivine), and **peridotite**, that contains olivine, and other dark minerals. In Canada peridotite and a companion rock sepentinite, are found in Gros Morne Park in Newfoundland, as well as the in the area south of Quebec City. They are also present elsewhere in northern Quebec, northern Ontario, in parts of Nunavut and in British Columbia.

In later features we will deal with the other two families of rocks as well as products that are associated with volcanoes and the near-crust environment.

Alan V. Morgan

How many different types of rocks are used around you? A good student exercise would be to identify natural and "artificial" (human-modified) rocks.

Igneous rocks; features and landforms.

It is important to remember that volcanoes are not scattered randomly over the surface of the Earth. They are usually, but not always, located near the margins of the huge lithospheric plates that makeup the Earth's surface. The shapes of volcanic landforms are a reflection of the composition of the lavas that are extruded by the volcano.

Lava composition also affects the type of activity exhibited by the volcano. Before we return to the types of volcanoes we should revisit the nature of the magma and how lavas reach the surface. Figure 1a illustrates a hypothetical crustal section extending about 10 to 15 km under a volcano. Magma originates under heat and pressure deep beneath the Earth's surface in magma chambers or batholiths (bottom of Fig. 1a). The rock types seen when the magma cools in a batholith might be granite (if the rock type is acidic), perhaps syenite or diorite (if intermediate) or gabbro (if basic) – (see the igneous rock classification elsewhere in this issue).

Magma rising from the batholith makes its way toward the surface. When solidified the rock type (at 1) would be very coarse grained or phaneritic (because of slow cooling and abundant elements). Fragments as well as much larger pieces of the roof of the batholith can be seen subsiding into the magma chamber. Frequently these completely melt or are substantially altered. In some cases smaller fragments can be carried rapidly to the surface in an almost unchanged form where they can tell us about the nature of the rocks at depth. These "strange rocks" are known as xenoliths.

The magma rising to the surface cools more rapidly as it ascends to regions of lower temperatures and pressures. Fluid offshoots from the main feeder work their way into the country rock forming dykes and sills. Sills are long, flat intrusions that run parallel to the "grain" of the country rock. Dykes cut across the grain of the country rock. A transgressive sill, is where a flat intrusion moves up from one level to a different level in the country rock. The area at 2 illustrates a smaller chamber or reservoir where magma might gather below the near-vertical conduit to the surface. Crystals forming here are smaller and may contain isolated larger crystals that have been transported from below. This two-sized igneous rock texture is "hypabyssal". A small offshoot where the magma has forced the bedrock upward into a domed structure is illustrated as a laccolith. The grain-size is medium in rocks that solidify at this level.

Magma continues upward, penetrating cracks and expanding joints in the country rock to a point where it eventually escapes at the surface. This is the position of the volcano. At the surface under relatively low temperature and pressure conditions, the magma degasses and chills rapidly, producing lava with very small (fine-grained or aphanitic) crystals (at 3). The shape of the volcano is reflected by the chemical composition of the lava and this is seen in Figure 1b.

Three volcanoes are illustrated. At the top is Skalbreid, north of Thingvellir in south-central Iceland. This is a typical example of a "Shield" volcano. (So-called, because it resembles an old Viking shield resting on its base). Here the basalt lavas are very fluid and run rapidly across the landscape. These are volcanoes with "Montezuma's revenge", and can be easily compared to humans with "the runs"! Because the lava flows readily, the volcanoes have low slope angles and are not usually explosive. However, they do have spectacular lava fountains and produce prodigious quantities of lava. These are well represented by volcanoes in oceanic areas of the planet, such as Hawai'i and Iceland, but they also exist in continental areas elsewhere.

The middle image is of Ngauruhoe, a large (2291m-high) volcano in Tongariro National Park, North Island, New Zealand. Intermediate volcanoes are commonly seen in areas of plate margin subduction, where oceanic crust descends beneath the continents. The volcanoes of the west side of North America, Central and South America and the Caribbean are often of this type. These volcanoes are steep-sided and, because of their explosive nature, can be very catastrophic. They are represented by some of the Caribbean volcanoes (and many others elsewhere). I often describe these as "constipated volcanoes" and their gaseous and explosive nature can be easily related to human alimentary systems! The lava type is commonly rhyo-dacite (a more-intermediate composition than rhyolite), trachyte or andesite (named from volcanic rocks along the Andes). Ngauruhoe frequently extrudes andesite, and is one of the most active volcanoes in the world.

At the bottom is Beerenberg volcano, on Nord Jan, Jan Mayen Island, North Atlantic. Beerenberg is a classical stratovolcano — a huge volcanic pile that is made up of alternating layers of lava and ash. The volcano is 2277m high, and extends another three kilometres below sea level. This cone also shows that volcanoes can vary in composition through time. Most of the modern eruptions have been basaltic, but Beerenberg also has had a long history of trachytic eruptions. (Also see the Jan Mayen article in this issue).

In summary, igneous rocks when formed at depth have coarse textures (large crystals) but when they are extruded as lavas, the crystal sizes are quite small. Volcanoes, whose position are usually determined by the boundaries of plates, or stresses within plates especially in the vicinity of "hot spots", vary in shape and activity by the chemical composition of the lavas that are extruded.

Alan V. Morgan

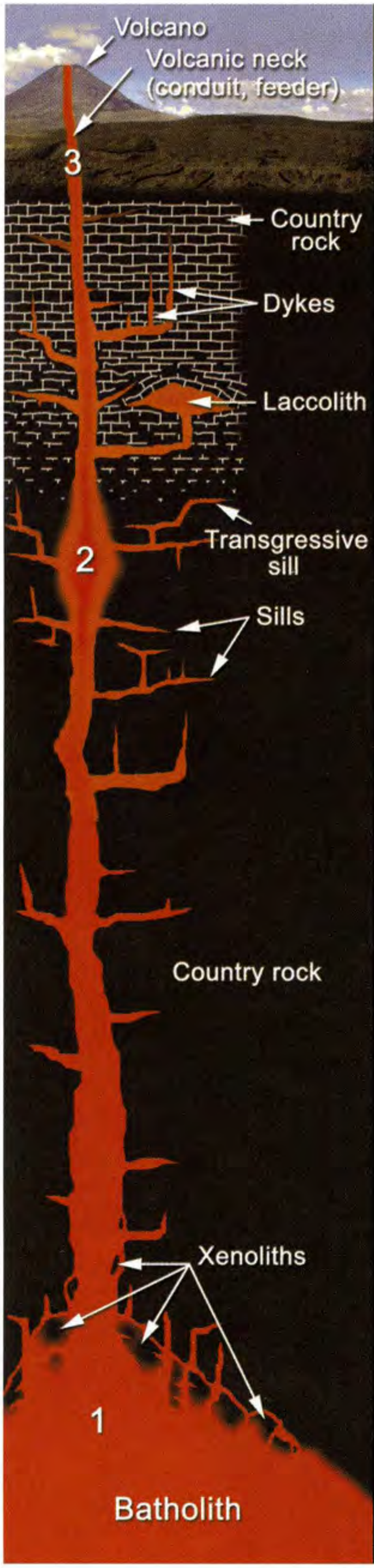
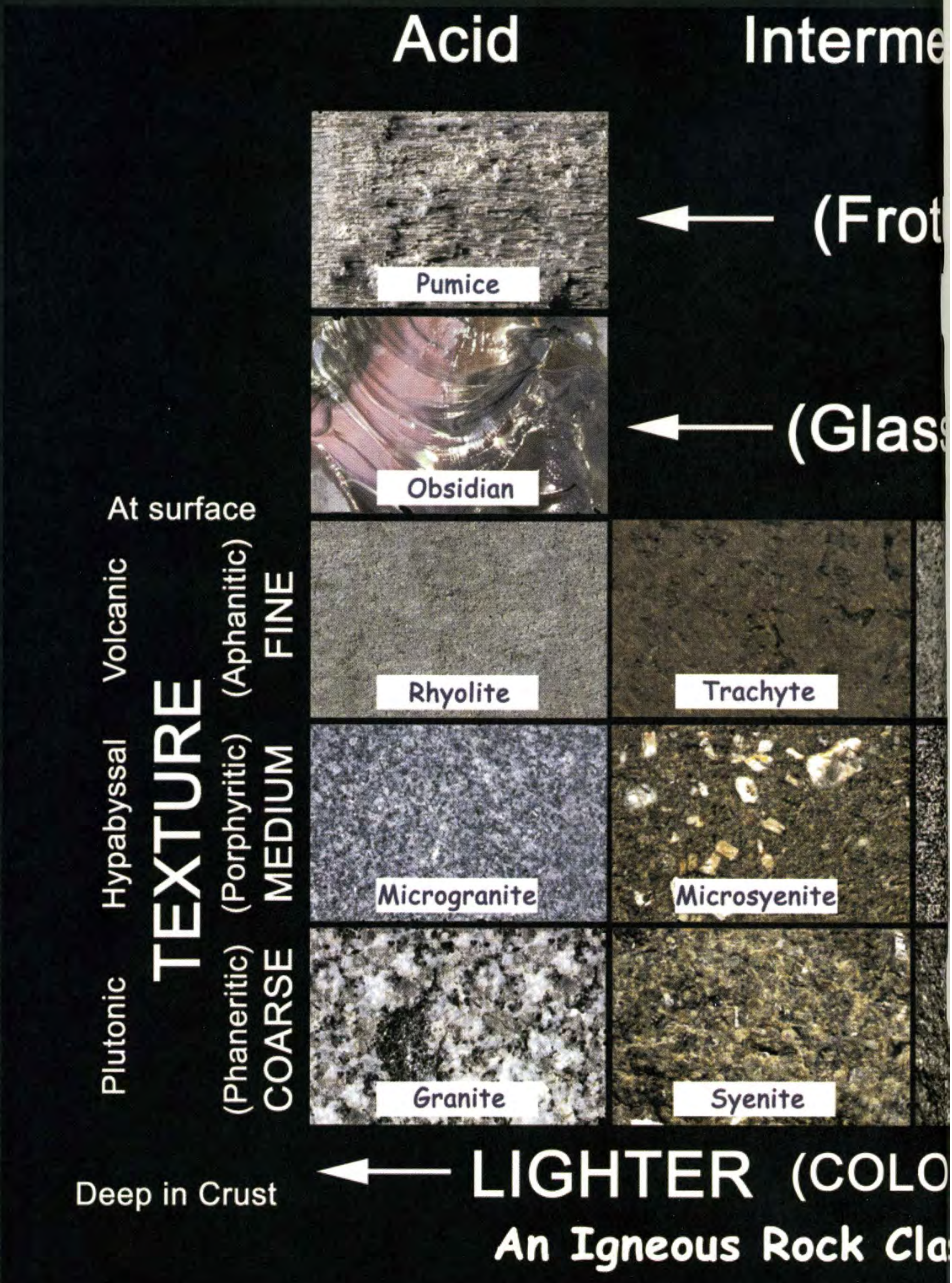


Figure 1a: – left side. Crustal section of approximately 15 km.
Figure 1b: – right side. Three volcanoes (Top) Skalbreid, Iceland, a volcano with basaltic lava; (Centre) Ngauruhoe, New Zealand, a volcano of andesitic composition and (Bottom) Beerenberg on Jan Mayen, a composite volcano with trachyte and basalt, alternating with ash.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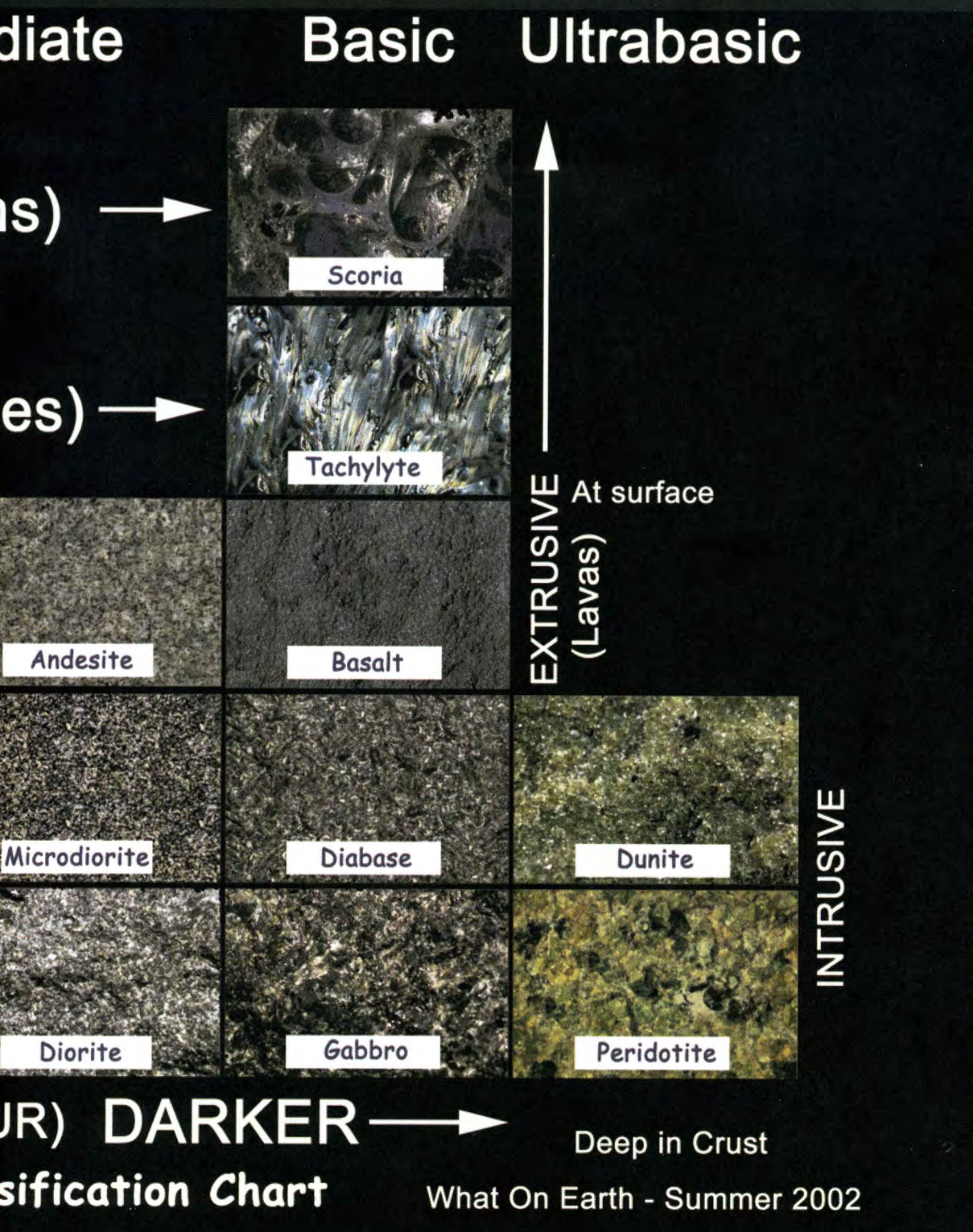
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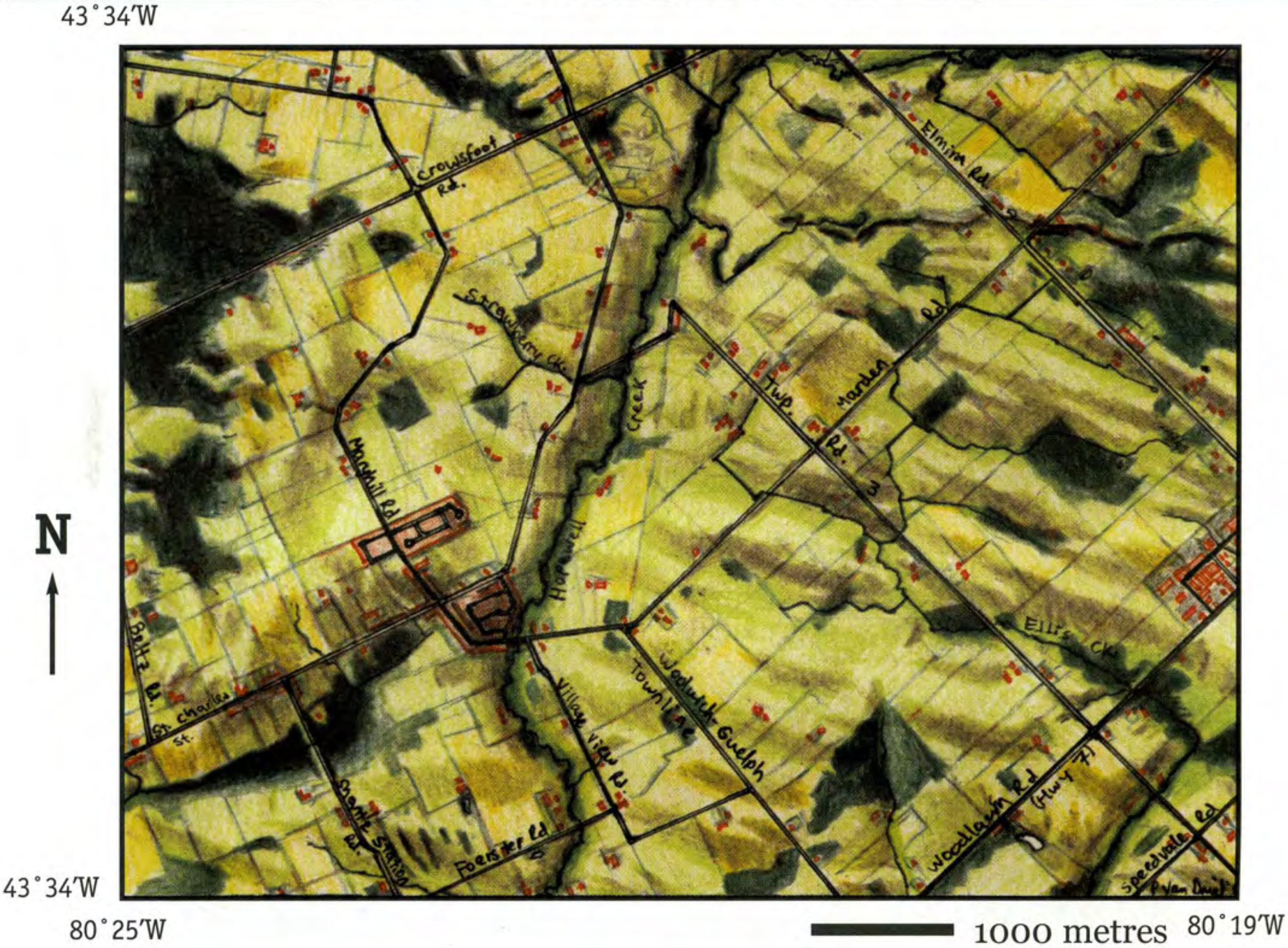
What On Earth - Summer 2002

Maryhill near Kitchener, Ontario - Glacial Landforms

Peter Van Dreil, Paul F. Karrow and Peter Russell



Maryhill Church perched on top of a drumlin.

This map of Maryhill was hand drawn by Peter Van Dreil, graduate student in the Earth sciences department. Peter produced other maps, which appeared in Wat on Earth, Volume 14, number 1. By the use of maps, air photos and his own exploration of the area Peter enhances the features of the topography. The topography of the Maryhill area near Kitchener has been modified by glacial and post-glacial activity.

Pleistocene deposits up 30 metres thick blanket the bedrock surface. The till plain in this area is sandy Port Stanley Till. Ice motion across the area is shown by fluting of the till surface and formation of drumlins. These features show that the Wentworth Till was deposited from a glacier spreading out towards the northwest, from the Lake Ontario Basin. Drumlins are commonly between 1 and 1.6 km long, 0.5 km wide and 15 metres high.

The speed of ice melting and advance remained the same for a period allowing the formation of an end moraine. The end moraine in Maryhill (part of the Breslau moraine) rises about 23 metres above the surrounding sandy till plain.

In the northeast part of the area is a thin sharp-crested sand and gravel ridge, which formed in the same direction as the ice-movement. The ridge is an esker. Eskers formed as meltwater streams flowed under the stagnating ice. A stream eroded the ice under the glacier and deposited sand in the space. As with any stream, some areas were subject to erosion and others to deposition. Eskers are generally intermittent, with the separated sand ridges joined by trough-like depressions. This esker is part of the Guelph Esker, which can be followed from the City of Guelph to West Montrose on the Grand River. In many places eskers have been worked for sand and gravel, destroying these physical features.

Hopewell Creek flows in a valley filled with outwash sand and gravel. The valley filled with sorted and stratified gravel and sand as sediment laden melt water flowed across the area.

Pleistocene Geology map modified from Ontario Department of Mines Map 2133 GUELPH AREA Pleistocene Geology by Paul F. Karrow, 1968.

Port Stanley Till plain from Maryhill Church.

The Irish Elk - Victim or Success?

Kristina Anderson

The Irish Elk

Time Range:	450,000-9,500 Before Present
Antlers:	up to 3.7 meters across and 35 Kg
Antler Growth Time:	~120 days
Weight:	Males ~726 Kg
	Females ~ 454 Kg
Closest Living Relative:	Fallow Deer
Lifestyle:	The Irish Elk was a highly specialized speed and endurance runner. The Irish Elk had long legs and had large rib cage
that	held a large heart and lungs.
Cave Sketches:	Paintings left by our paleolithic ancestors on cave walls suggest the Irish Elk was light-coloured with sharp body markings and had a long, muscular neck without a mane.

The Irish elk has been the focus of debate since its discovery. Even the name Irish elk is a point of debate. Unfortunately, the Irish elk was neither exclusively Irish nor an elk. The Irish elk was the largest deer that ever lived. The name was first given because the European moose – an "elk" to the English – was the only familiar animal with antlers that even approached those of the giant deer in size. Furthermore, Ireland's exclusive claim to the giant deer vanished in 1746 when a skull and antlers were discovered in Yorkshire England. The first continental discovery followed in 1781. We now know the giant deer ranged as far east as Siberia and China and as far south as northern Africa.

In 1697, Thomas Molyneux wrote the first scientific description of *Megaloceros giganteus*. Molyneux argued the Giant Irish Deer was not extinct but rather the North American moose. Molyneux's limited knowledge of the North American moose allowed him to satisfy his religious conviction that God wouldn't allow any of his creatures to go extinct. Molyneux's stated:

"That no real species of living creatures is so utterly extinct, as to be lost entirely out of the world, since it was first created, is the opinion of many naturalists; and 'tis grounded on so good a principle of Providence taking care in general of all its animal production that it deserves our assent." (Sic)

Molyneux's convictions were shared by most scientists of his time. For the next century, scientists argued as to which modern species the giant deer belonged? Opinion was equally divided between the North American moose and the reindeer. New fossil species were continuously being unearthed and eighteenth-century geologists were having increasing difficulty in arguing unknown creatures were all still living in some remote region of the globe. Had God experimented continually in both creation and destruction? If so, the world was surely older than the six thousand years the literalists allowed. Extinction was the first great battleground of modern paleontology and the extinction of the Irish elk was hotly debated. Georges Cuvier, a French paleontologist, was using the giant deer to defend extinction as a natural phenomenon. By 1812, Cuvier resolved that the giant deer was unlike any modern animal and thus extinction did occur. But for those scientists who accepted extinction, the debate focused on when the extinction had occurred: specially, had the giant deer survived the Noachian flood? If the giant deer had survived the flood, the next logical conclusion was people must be responsible for the extinction of the giant deer. In 1830, Hibbert implicated the Romans and the extravagant slaughter at public games. However, the Romans never conquered Ireland where the most numerous fossils of the giant deer are found. In 1851, Montel blamed the Celtic tribes, but the deer went extinct two thousand years before the Celts came to Ireland.

In 1859, Charles Darwin published the Origin of Species. Darwin's theory of natural selection required evolutionary adaptations be beneficial to the species involved. As a result, anti-darwinians searched the fossil record for adaptations that would not have benefited the species involved. The theory of orthogenesis was born. Orthogenesis proposed that evolution proceeded in straight lines and certain evolutionary trends, once started, could not be stopped even if the trends led to extinction. For example, saber-toothed "tigers" could not stop growing their teeth and mammoths could not stop growing their tusks. But by far the most famous example of orthogenesis was the Irish elk itself. The giant deer was supposed to have been bowed under by the weight of its own antlers. This excess weight caused the giant deer to become tangled in trees and mired in ponds. Thus, orthogenesis claimed the Irish elk's own antlers led to its extinction.

Darwinians, led by Julian Huxley, launched a counterattack on orthogenesis in the 1930s. Huxley noted that among modern deer species antler size increases at a higher rate compared to body size. Huxley coined the term allometry to describe this relationship. Allometry provided a comfortable explanation for the giant deer's antlers. Since Irish elk were the largest deer, the size of the Irish elk's antlers was due to an allometric relationship present in all deer. Now, increased body size could be seen as the favoured evolutionary trait. The large antlers might only have been an automatic consequence of an increased body size.

In 1973, Stephen Jay Gould questioned the traditional explanation. Gould felt the allometry theory held a "curious remnant of the older, orthogentic view". Could the large antlers have had a primary function? Perhaps, the antlers were used to combat predators and rival males or to attract females. Today, scientific studies would suggest antlers serve as a visual dominance-rank symbol designed to prevent bodily injury rather than weapons in deadly combat. The antlers of the Irish elk were arranged to display the palm of the antler fully when the animal looked straight ahead. This suggests the Irish elk's antlers were indeed used for display rather than combat.

The Irish elk had become a specialised feeder. Rapidly changing climate at the end of the last "ice age" and new plant succession resulted in the demise of seasonal grasses upon which the Irish elk depended. Darwinian evolution decrees no animal shall evolve harmful structure, but this offers no guarantee when times change. The Irish elk fell victim to its own previous success.

Websites:

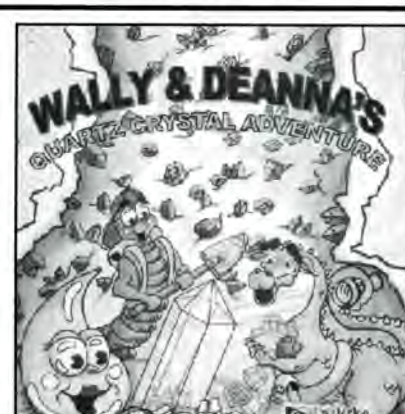
www.ucmp.berkeley.edu/mammal/artio/irishelk.html

http://news.bbc.co.uk/hi/english/sci/tech/newsid_791000/91385.stm

www.ippcc.ie/infoirishelk.html

A full-size cast of an Irish elk skull in the collection of the Earth Sciences Museum at the University of Waterloo.

Wally and Deanna's Quartz Crystal Adventure



Wally and Deanna's Quartz Crystal Adventure is the next chapter in the life of Wally Worm and Deanna Waterdroplet. Following the same colourful and adventurous theme as Wally & Deanna's "Groundwater Adventure", and the "Wetlands Adventure", this educational chapter leads us through a wonderfully illustrated journey of the "quartz" World. Starting from the initial formation of quartz to learning how we use quartz for many common household items, you will quickly understand why people say we live in the "Silicon Age"

Authors: Leanne Gelsthorpe and Peter Russell (co-editor of What on Earth).
Illustrator: Roger Fernandes.
Order your copy of Wally and Deanna's Quartz Crystal Adventure from Waterloo Hydrogeologic Inc., 460 Phillip Street, Suite 101, Waterloo, ON N2L 5J2 Tel: (519) 746-1798 Email: info@flowpath.com Web site: www.flowpath.com

An outline of Japanese gold and silver production.

Hiroyuki Ii, Faculty of Systems Engineering, Wakayama University, Japan.
Visiting professor at the University of Waterloo in 2001-2002

In A.D.674 the first silver was produced from Tsushima Island between Kyushu Island and Korea Peninsula which is on the route connecting Korea and Japan (Fig. 1). The discovery depended on new smelter technology from China and Korea to extract silver from galena. Later a Japanese emperor interested in spreading Buddhism directed efforts to find gold, copper and mercury. Mining specialists from China and Korea worked on the project to find these minerals.

Figure 1: Map illustrating the position of Japanese gold deposits, mining areas and places mentioned in the text.

The first gold from Japanese placers was discovered in A.D.749 at the east of Tohoku area (Fig. 1). The discovery of this placer deposit helped to finance the construction of the famous huge statue of Buddha in Todaiji temple. The Buddha, made of gold-plated copper, was built in A.D.752 just after the discovery of the placer gold. It is a site that is frequented today by many foreign travelers.

Production of placer gold from this district continued until about 1300 and the total gold recovered reached an estimated 30 tonnes. In the Tyusonji religious complex the Konjikido wooden temple covered with gold was built in 1126 at the centre of a placer gold production area. The "Gold Island" story in the travels of Marco Polo is derived from Konjikido whose name means "golden-colored temple" in Japanese.

Granite is distributed in this area and some quartz veins can be found in the Paleozoic and Mesozoic sedimentary rocks surrounding and within the granite. This type of quartz vein which includes mesothermal gold is formed at 1 km to 4 km depth and 200° to 300° C. The first placer gold discoveries in Japan were derived from mesothermal gold deposits. This is a similar setting to Precambrian gold deposits found in Timmins and Val D'Or districts in eastern Canada where coarse gold grains are found in quartz veins associated with pyrite and arsenopyrite.

Most Japanese gold and silver ores are today extracted from epithermal deposits originally formed less than 1 km in depth and at temperatures of between 100 and 200°C.
However, in the past, these deposits were not utilised. It was difficult to smelt metal from these ores because the gold grains are very fine and the ore contains a lot of sulphide minerals. In addition placer gold is not usually derived from such epithermal deposits because of the fine grain size.

The development of mined epithermal deposits started in 1550. Before the Tokugawa period (1603 ~1867), total gold production reached 230 tonnes. The Sado mine which closed in 1989 had a total output of 15.3 million tonnes of crude ore, containing 80 tonnes of gold and 2,330 tonnes of silver. It was the second largest gold mine in Japan. The mine was discovered in 1596 and supported the Tokugawa shogunate. The gold was used to supply currency for over 250 years. During the Tokugawa period alone, gold production in Japan was about 100 tonnes.

Large scale production of copper, lead, zinc, silver and gold extracted from Kuroko deposits or epithermal ores was made possible by European and American technological innovations. These involved water pumps, elevators, dynamite and new smelting methods and commenced in the Meiji period (1868~).

A Kuroko deposit is a kind of sediment formed on the sea floor accompanied with acidic volcanic activity. The deposit is composed of black ore (a fine-grained aggregate of barite, sphalerite and galena), yellow ore (an aggregate of chalcopyrite and pyrite) and a gypsum. Unfortunately today all Kuroko mines are closed. Until recently Kuroko deposits had only been discovered in Japan. The total production of copper, zinc, lead and silver from these deposits was very high. One of the biggest Kuroko mines, Kosaka mine, produced 12 million tonnes of crude ore with the following metal content (Cu -1.8%, Pb - 1.8%, Zn - 4.9%, Au - 0.8g/t, Ag - 93g/t).

Gold production from the Meiji period until today has reached 1,200 tonnes, with most of the gold coming from epithermal deposits. As mentioned above, the gold grains in many epithermal deposits are very minute, requiring a cyanide process for extraction, as well as the complex methods used to extract gold from a silica ore. Recently the Japanese government has tried to find more epithermal gold deposits. As a result, the Hishikari mine was discovered in 1981. This has an estimated total gold of 250 tonnes with an average grade 80 g/t. Although the Hishikari mine possesses a high-grade ore, the very fine grain-size of the gold (an average of 0.01mm) would have prevented processing in the past. After this discovery, similar gold veins were noticed in other districts of Japan.

Epithermal gold and silver deposits

Epithermal gold and silver deposits are formed by volcanic activity accompanying plate subduction. In Japan there are a many volcanic and hydrothermally active areas caused by plate subduction. Most epithermal gold deposits were formed by hot springs precipitating gold and ores are being formed in this way in Japan today.

Epithermal ores fall into several groups. One of these is the Adularia-sericite type gold deposits, also known as Silver black. Many epithermal gold and silver ores are found in veins composed of quartz, clay minerals, adularia and calcite. They have a rhythmically layered structure and are found in most Japanese gold mines. Sometimes the layered ore includes "silver black", a black coloured band of mineral aggregates composed of electrum (gold and silver alloy), sulphides of silver, chalcopyrite, galena, sphalerite, tetrahedrite and pyrite and clay minerals. Gold and silver concentrations in silver black are quite high. Gold and silver values in the ore are strongly dependent on the quality and quantity of the silver black. Generally the silver content is over ten times higher than gold. Mineral composition in the silver black is very changeable. Figure 2 shows typical silver black from the No.2 veins of Seikoshi mine in central Japan and Figure 3 shows high-grade ore (Au content 1000 g/t) from Keisen No.3 vein 55 ml in Hishikari mine. Gangue mineral crystals found in cavities or "vugs" are often found and the Kushikino mine in Kyushu is famous for beautiful twinned calcite crystals (Fig. 4).

Figure 2: *Electrum grains (lightest color) within acanthite (light color) layer in silver black band composed of chlorite, pyrite, chalcopyrite, sphalerite and galena are 1 mm in diameter.*

Another epithermal gold deposit is the so-called "Nansatsu-type" gold deposit. This is a massive rock, heavily silicified by acid hydrothermal solutions. Most of the elements in the original rock have been leached with the exception of silica. The original rocks were andesite lavas, tuffs, breccias and tuffaceous shales. Some silicified rocks contain 98 % or more of SiO2 which is mined for pure silica used to make glass and ceramics.

Some silicate rocks in the south of the Satsuma peninsula in southern Japan contain gold. This is called Nansatsu-type gold ore in Japan and contains native gold, pyrite, enargite, covellite and native sulphur with porous quartz. Figure 5 shows typical gold ore from the Akeshi Mine. The term Nansatsu means "south of Satsuma" in Japanese.

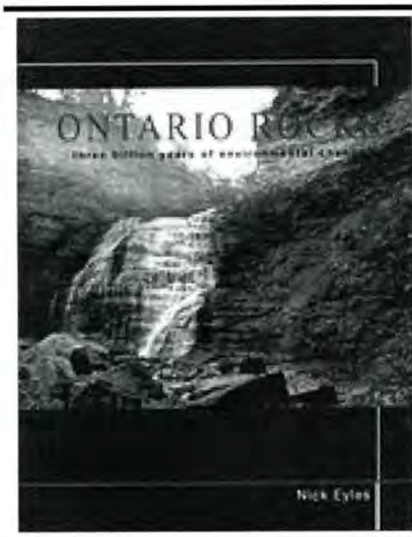
Gold is sometimes concentrated at the top of epithermal veins of copper, lead and zinc. Old Japanese mines started with gold production and mined copper, zinc or lead later. There were a lot of copper mines in Tohoku area, north of Honsyu Island and some copper mines contain gold at the surface. This gold ore is composed of chlorite, hematite and quartz. This is named "Narumi gold ore" for its color since "Narumi" means the mixing of red and green colors and is derived from Japanese traditional dyeing. Although visible gold in Narumi gold ore is very rare, Narumi gold ore in the San-ei mine in Yamagata prefecture recorded ca. 100 g/t of gold and visible (but minute) gold grains were noted by the author in the waste rock (Fig. 6).

Figure 3: *The paired thin brown dark bands in a quartz and adularia mixed layer are very small grain-sized aggregates of electrum from Keisen No.3 vein 55 ml in Hishikari mine.*

Figure 4: *Twinned calcite crystals from the Kushikino mine in Kyushu.*

Figure 5: *Gold ore from the Akeshi Mine. In the upper half of the sample, large vugs are filled with sulphur and the silicified rock is indicated by the light colour. In the lower half of sample, there is no sulphur and the rock is very porous. Covellite (a copper sulphide) or pyrite (iron sulphide) is concentrated at the boundary between two zones.*

Figure 6: *Microscopic view of Narumi gold ore with native gold and chlorite in quartz from San-ei mine. Lateral width is 0.4 mm.*



Ontario Rocks - Three Billion Years of Environmental Change

Written by Nick Eyles

8.5 x 11, 380 pages
Full-colour throughout
Charts, maps, photos, index, glossary
ISBN: 1-55041-619-7 pb $49.95 CDN / $45.00 US

In its long and rocky past, the place we call Ontario has travelled across the equator, been peppered by meteorites, seen the rise and fall of towering mountains and has been home to some of the strangest creatures known. In fact, what seems today like a changeless landscape was once covered by vast inland seas and huge continent-wide ice sheets measuring 2-kilometres thick, leaving in their wake the Great Lakes and countless glacial landforms.

Ontario Rocks tells the fascinating 3-billion-year story of Ontario's geological evolution. Packed with original full-colour photographs, maps, charts and figures, this highly informative book explores the making of the Great Lakes, the Canadian Shield, the Niagara escarpment, tills, moraines, rivers, gorges and much more. Ontario Rocks also touches on the commercial use of rocks, the relation between geology, pollution and groundwater, with special attention paid to the Walkerton crisis.

Ontario Rocks is an essential reference for students and the perfect travel companion for outdoor enthusiasts, hikers, campers, cottagers, weekend explorers and the budding rockhound in all of us.

Canadian Petroleum and United States Needs

Maurice B Dusseault

Summary
The United States reached its peak oil production in 1970. World production of conventional oil[1] will likely peak around 2004-2005, and competition for oil resources will become more intense. Does the United States have reasonable alternatives to increased imports from the Middle East, South America and Africa?

An alternative exists in the Canadian heavy oil[2] deposits. There is enough oil in these reservoirs to provide over 100 years of full energy security with no foreign imports to the United States and Canada. The technology to do this economically has been developed in the last 20 years.

Oil Consumption
World conventional oil production will soon peak: all major land basins have been explored, new large discoveries are increasingly unlikely, and per-barrel finding costs are rising, driving discovery rates down[3]. Offshore oil does not represent salvation: deep offshore projects will contribute 8-15% to conventional oil reserves, these projects are expensive, and only large finds can be developed profitably. In developing countries, demand will continue to rise for the foreseeable future.

New technologies and higher oil prices will affect the rate of decline, but it is unlikely that the coming decline in conventional oil production will be reversed. Aggressive conservation could reduce demand, as happened temporarily in 1977-1980, but continued global economic development will increase it; therefore, energy sources other than conventional oil will be required. Natural gas will help fill the gap, but that too will peak and decline, likely within 15-20 years.

Why is US consumption important? American daily consumption is about 17 million barrels, or 22% of world supplies; Canada consumes less than 10% of the US rate. The US imports one-third of its natural gas, all from Canada, and more than 50% of its oil, with Canada the largest foreign supplier to the US. Saudi Arabia and Venezuela (#2 and #3) supply about 15% and 14% of US oil imports, and Canada supplies about 16-17%. Incidentally, Canada imports oil on the East Coast of Canada, but overall, Canada produces about 2.2 million barrels per day, and our net exports are about 700,000 b/d, although our gross exports to the US are about 1.6 million b/d. Thus, most US imported oil comes from politically unstable countries via long and potentially vulnerable sea transportation routes. This is of concern to the US.

Canadian Oil and Canadian Technology
Could Canadian oil possibly meet all of US needs? Because of the vastness of Canadian heavy oil deposits and the stability of the country, the answer is yes. Alberta and Saskatchewan heavy oil and bitumen resources are massive: the total resource is estimated to be around ~2.5×10^{12} (trillion) bbl. It seems that about 25% of this can be extracted, and many believe that 40% will be attainable with emerging and future technologies. These simple facts lead to a dramatic conclusion: Canadian heavy oil resources can provide about 100 years of secure oil supply at 100% of current consumption rates. Also, Canada is a stable, democratic, and developed society, and land access means pipelines, rather than more vulnerable supertankers.

At an oil price of US$25/bbl, about 20-25% of Canadian heavy oil can probably be extracted profitably using existing technologies. These technologies include:

- Cold heavy oil production with oil sand, now producing 460,000 barrels per day in Canada
- Steam-assisted gravity drainage, with many large projects recently initiated
- Pressure pulsing, an emerging aid to production that is already commercialized
- Mining, which has already produced more than two billion barrels of oil and which can be used to access the shallowest 6% of the total resource (perhaps another 50-75 billion barrels from mining alone)
- Vapor-assisted petroleum extraction and *in situ* combustion using horizontal wells, both still at the conceptual stage

These advances have removed technological barriers to increased production, but sustained rapid expansion of heavy oil production will need price stability and environmental vigilance. Heavy oil is rich in carbon: coking and hydrogenation[4] are needed to convert it into a product that can be refined into gasoline and diesel fuel. This requires numerous large heavy oil upgraders, and these expensive facilities must also remove sulphur and heavy metals (Ni, V, Ti) safely during processing. Upgraders generate solid wastes such as coke, and some production technologies (e.g. mining, producing oil with sand) generate mineral tailings and wastes that must be disposed of properly.

Thermal production technologies require that up to 40-50% of operating expenses be spent on heat. The current heat source is natural gas, which is valuable as a resource in its own right as well being a hydrogen source for upgrading. Many interesting energy trade-offs are possible in this area.

Most of these issues appear to have been solved with existing environmental and refining technology, and heavy oil production can be increased rapidly if needed.

American Energy Policy
North America is not running out of oil; it is only running out of cheap conventional oil. Possible solutions include conservation, alternative energy sources, increasing imports, or production from non-conventional oil resources. The vast Canadian heavy oil deposits represent an economically attractive option; these deposits are already being exploited, and because of recent technological advances, more rapid development is feasible. This option could provide a secure, land-based energy source for the US and Canada for the foreseeable future.

Development of the Canadian heavy oil deposits should be the cornerstone of any American policy that seeks to guarantee a stable, secure, and economic long-term petroleum supply for the United States. Canadian politicians and technical experts should acknowledge this, and study its implications carefully. It will be one of the most economically interesting and important issues to arise in this generation.

Footnotes:

1. Conventional oil is defined here as oil having a gravity of > 20°API or a reservoir viscosity of < 100 cP.

API = American Petroleum Institute. **°API is a measure of density:** a value of 10° (API is equivalent to the density of water, and is a very heavy oil. A light oil would have a value of 35°API to 42°API, and this would be a very light hydrocarbon with low viscosity, and a specific gravity of perhaps 0.71 - 0.75

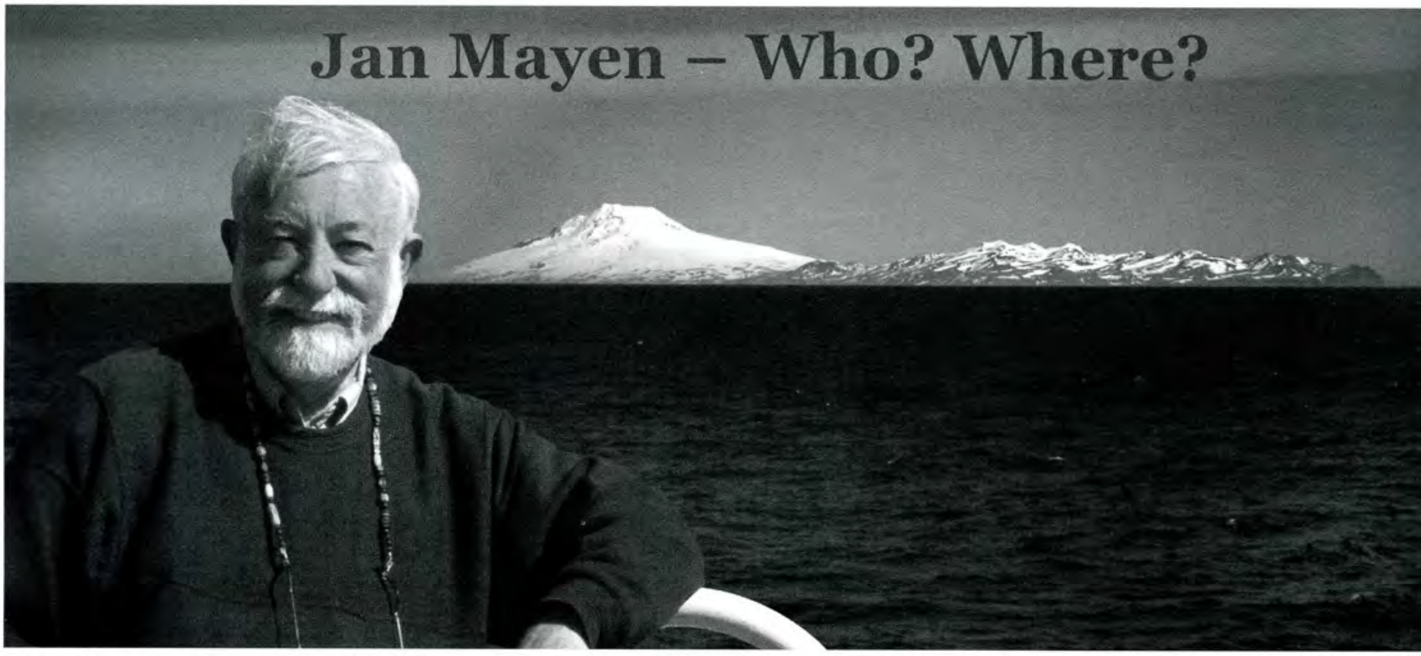
2. Heavy oil is defined here as all oil < 20°API gravity, or all oil with a viscosity >100 cP. One may assume that in heavy oil, natural flow rates cannot sustain economic exploitation, and improved oil recovery methods must be used.

The units cP are centipoises, an expression of viscosity (or "thickness). The viscosity of water at room temperature is 1 cP (centipoises). Glycerine in a bottle has a viscosity of 500 cP. Liquid honey has a viscosity of 15,000 to 50,000 cP. Roof tar has a viscosity of 50,000,000 cP. Heavy oil has a viscosity from 100 cP to 10,000 cP. The oil being mined in the oil sands by Syncrude has a viscosity of 500,000 to 1,000,000 cP.

3. Deffyes, K. 2001. Hubbert's Peak, Princeton University Press, NJ. (A "must-read" if you are interested.)

4. Hydrogenation means H must be added; the cheapest source is CH_4, also the principal component of natural gas.

Jan Mayen – Who? Where?



There is a popular misconception by most of the general public that when the academic term ends university professors retire to the pool or cottage and sit around waiting for the next term to begin! I'm afraid that just isn't so. While Peter was labouring in the preparation of this issue of "What on Earth" I was off on a Russian icebreaker sailing around Iceland, and north to Jan Mayen and Spitsbergen. On this voyage I was trying to introduce 100 or so naturalists to the geology of the regions that we were visiting. I looked forward to this challenge. We were visiting prime areas of the world for classical interpretations of plate tectonics and particularly (at least in the case of Iceland and Jan Mayen), volcanic activity.

O.K. so I can hear most of you muttering, why Jan Mayen? Well, that story goes back 42 years when I was just 17 on

Figure 1: *The author and the island of Jan Mayen from the bridge of the Professor Molchanov, ~ 10:00 am., June 04, 2002. Beerenberg volcano (centre) forms the bulk of Nord Jan, and the lower topography extending from the centre to the right is Sør Jan, a region comprised of relatively young scoria cones and trachytic domes.*

Figure 2: *(left) Tectonic setting and (right). Jan Mayen;arrows show location of places mentioned in the text.*

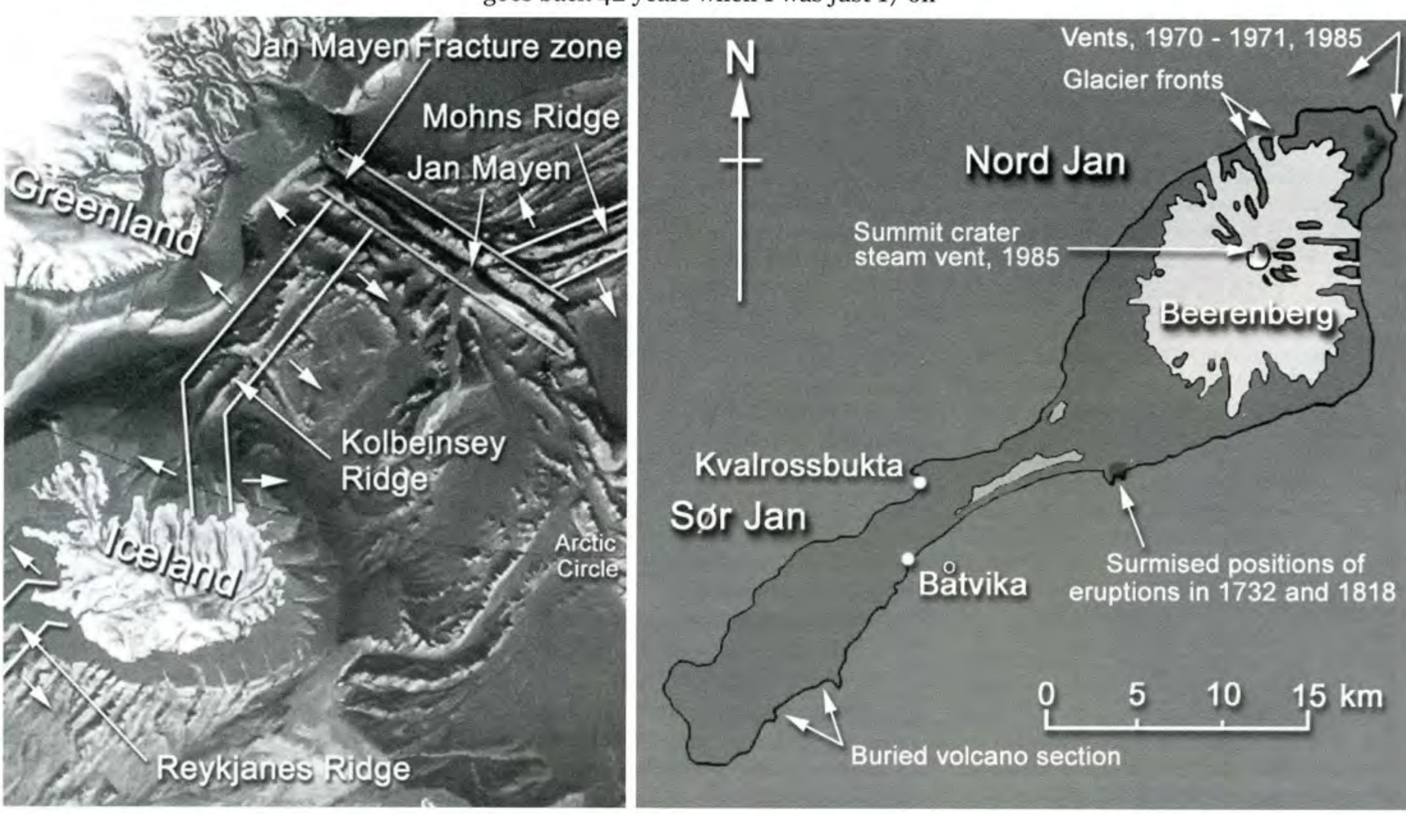


Figure 3: *A 17th century whaling ship northwest of Jan Mayen. The volcanic spire of Beerenberg (Beeren Bergh) is prominent and exaggerated. Compare Figure 8 which is taken closer inshore but from approximately the same position. The rounded cones of Sør Jan can be seen in the distance.*

Figure 4: *This is a fanciful rendition is of the Dutch whaling centre, likely at Kvalrossbukta. Again the cone of Beerenberg is dominant, and the hills of Sør Jan can be seen on the right.*

an expedition in central Iceland. Our leader had been on Jan Mayen in 1959, and had commented that if we ever had the opportunity to visit the island we should. Almost half a century later the opportunity arose, and so on a crystal clear morning I first sighted Beerenberg, the northern volcano of Jan Mayen over 100 km away from the bridge of our vessel, the Professor Molchanov.
Considering that the island is fog- and cloud-shrouded for about 360 days of the year our visit on June 4th and 5th must have been truly exceptional (Fig. 1).

Jan Mayen is situated in the middle of the North Atlantic, some 500 km from Greenland 600 km from Iceland, and about 1000 km from both Norway and Spitsbergen — in other words, it's an almost unknown tourist destination! The island is located at approximately 71° N and 8° W, and it is about 54 km long by 15 km wide. It is roughly hourglass shaped with the northern portion called Nord Jan and the southern, Sør Jan. The highest point is Beerenberg volcano on Nord Jan at 2,277 m (7468'). Tectonically the island sits on the margin of a large transform fault, the Jan Mayen Fracture Zone, just at the commencement of the northward-trending Mohns Ridge. The offset Ridge to the south, about 160 km west, is the Kolbeinsey Ridge that runs from north Iceland to the Jan Mayen transform fault. The main tectonic elements are illustrated in Figure 2.
The island was reputedly first sighted by Henry Hudson (of Hudson Bay fame) in 1607. However, this claim and perhaps those of the Icelanders hundreds of years earlier are pre-empted by the first officially recognised sighting in 1614 by a Dutch captain, Jan May, and hence the name. Unfortunately the Dutch came to hunt whales, and did so with great gusto for about three decades, until the whales (particularly the "Right" whale) became exterminated (Figs. 3 and 4). Following the demise of the whale populations the island was only intermittently visited for about 250 years. Captain Jacob J. Laad reported an eruption on Beerenberg in 1732, and W. Scoresby reported a second in the same area in 1818. Since then five eruptions have been noted.

Many hours after our initial sighting Jan Mayen gradually loomed closer, until the high cliffs along the southeast coast finally hid the northward view along the west side of Nord Jan. The cliffs of Sør Jan, usually fog shrouded, revealed a fantastic sight of complete cinder cones, buried under younger lava flows, and then transected by the sea to produce incredible cross-sections of the internal features of the small vents (Fig. 5). This one view alone was worth the trip, but there were more spectacular sights to come!

Arriving at the Norwegian weather station at Båtvika we came ashore on zodiacs, to land on a wonderful black sand beach. Here the wind had winnowed the basaltic sand and concentrated small drifts of olivine (Fig. 6). The Norwegian weather station (also acting as a LORAN C navigational station) is located beneath some steep cliffs with wonderful talus (scree) slopes and on top of some young looking (almost certainly post-glacial) lava flows (Fig. 7). A closer examination revealed that the flows had large olivine crystals (the source of the rounded olivine grains in the beach sands) as well as calcium-rich plagioclase feldspars and pyroxene crystals. These three (olivine, anorthite feldspar and pyroxene) are the first formed minerals as basaltic magmas cool.

Because the weather was so outstanding, after a short shore visit we re-embarked and the Professor Molchanov sailed northward around Nord Jan. Beerenberg was beautifully exposed in the late evening light as we went around the north side of the volcano. Huge glaciers cascaded down the flanks, and on the northeast corner we could see the location of the penultimate eruption (Fig. 8). This was a flank eruption from a 6 km-long fissure that started at an elevation of 1000m and went down to near sea level. The eruption commenced likely at 04:00 on September 18th 1970 and continued to January of 1971. Precise observations on the event were severely limited because of the poor weather conditions that prevailed in the area. There were four active craters (Figs. 2, 8) and the lava flows, like those on Heimaey in Iceland, (Wat On Earth, Fall issue, 1998; Morgan 2000) added new land on the northeast side of the island.

The most recent eruption on Beerenberg was another basaltic outpouring that commenced on January 6th 1985, but seemingly ceased on January 10th. The approximately 7 million m^3 of lava that was extruded from a ~1 km fissure is about the same as the output in the first four days of the eruption from the volcano Eldfell on Heimaey, Iceland January 1973. The position of the crater that had developed by January 8th at some 200m elevation is shown in Figure 8.

The lava field that flowed from this main crater extended about 1 km to the NNE. There are reports that small (mag. ~5.0) earthquakes accompanied the eruption. A vigorous summit steam-venting episode commenced on 3rd and 4th of April, 1985, and lasted several weeks.

We continued to sail down the west coast toward Kvalrossbukta, passing several spectacular glacier tongues that cascaded from the summit of Beerenberg to sea level (Fig 9). The following day we returned to cruise along the ice margin in the zodiacs (Fig. 10). There were many interesting glacial features noted. The black basaltic ash from the eruptions on Jan Mayen has been incorporated into the glaciers and can be easily seen in the shear-planes developed within the ice and exposed at the glacier terminus. Pronounced lateral moraines can be seen in many areas. Terminal moraines are absent as the glacier front reaches the sea. Bedrock could be seen beneath the ice front and a black sand beach fringed the glacier terminus (Fig. 10).

The Professor Molchanov reached our overnight mooring at Kvalrossbukta, sheltering in a small bay on the central west side of Jan Mayen. The anchorage lies protected by a breached and almost entirely eroded crater. The high northern cliffs are stratified tuffs with hyaloclastites likely created by basaltic subglacial eruptions. Kvalrossbukta is the likely position of the main whaling that was conducted on from Jan Mayen from its discovery to about 1650 (Figures 3 and 4). A careful study of the woodcut (Fig. 3; - date uncertain but *ca.* 1620) shows three small boats in the process of harpooning a whale, probably about in the position of Fig. 8, at the extreme northern end of Nord Jan.

The second painting by Mann in 1636 shows a flensing and blubber-boiling scene and probably at Kvalrossbukta. The disturbing aspect of both of these images is the "double blow" seen depicted from the harpooned whale in Figure 3 and several whales in the sea in Figure 4. This V-shaped blowhole venting is characteristic of the Right Whale (*Eubalaena glacialis*). It was "right" because it was the best whale to catch, with a high oil content and abundant baleen.

The Right Whale, a 50+ tonne leviathan, is one of the more unfortunate whale species hunted by man and the North Atlantic Right Whale is now practically extirpated, with less that 1,000 to perhaps as few as 350 individuals still living.

Following our shore visit and glacier-front cruises on June 5th., we sailed south from Jan Mayen to the Tjörnes region of north Iceland and from there down the east and south coasts of Iceland. Perhaps more on the Icelandic circumnavigation in another issue of What on Earth.

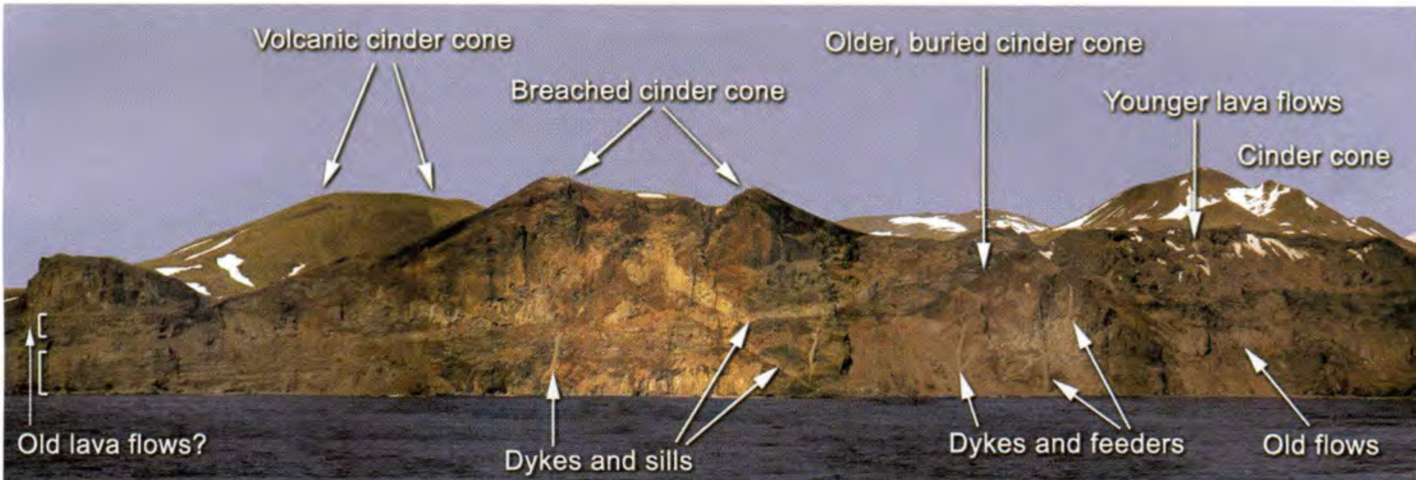
Alan V. Morgan.

References and copyright

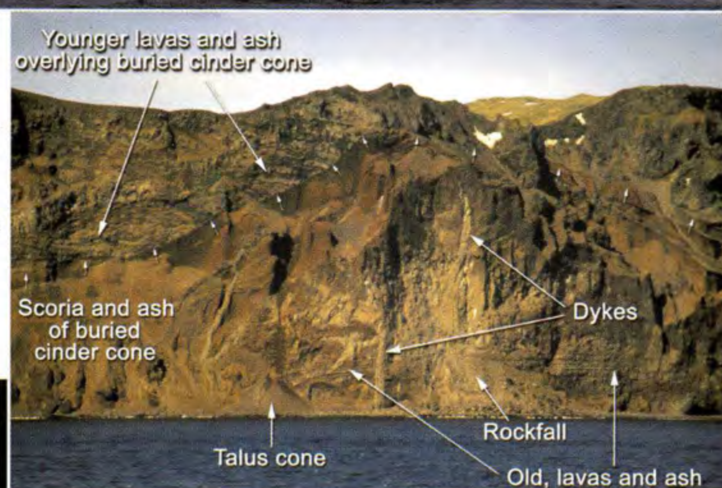
Morgan, A.V. 2000. The Heimaey Eruption, Iceland: - A 25 Year Retrospective. Geoscience Canada 27 (1): 11-18.

Most of the background geological information is derived from the Global Volcanism Program; Volcanic Activity Reports – Jan Mayen. It can be accessed at:
http://www.volcano.si.edu/gvp/volcano/region17/atlantic/janmayen/var.htm

__Figure 5:__ This "text book" section between Sørkapp and Kapp Wien reveals millenia of lava flows and erosion exposed in the sea cliffs of Sør Jan. In summary, a number of older flows (far left and low centre right) are covered with a buried cinder cone (centre). Erosion has provided a cross-section through this small cone clearly showing the dykes and feeders that fed the centre of the small volcano. Later eruptions have produced a line of younger cinder cones, most of which are inland, but the eruption that covered the buried cinder cone, came from a younger and much larger volcano that has also been exposed by the sea (centre and slightly left). Again, feeder dykes and sills can be seen in the middle of this younger volcanic pile.



The section (opposite) is an enlargement of the centre of Figure 5. Here the detail of the buried cinder cone can be seen (the edge is outlined in small arrows). The sharp contact of the scoria and cinders of the cone and the overlying, younger, lavas and ash are visible. In addition the dykes and sills that make up the stockwork of the buried volcano are clearly exposed. Erosion at the base of the sea cliff has caused a rockfall onto the beach and several small talus cones (one marked) indicate where loose debris is falling from the section.



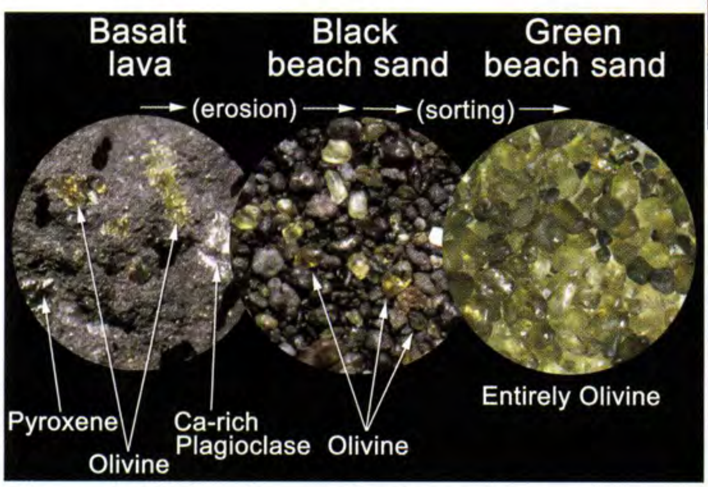


__Figure 6:__ The basalts near the Norwegian station at Båtvika (right) contain large crystals of olivine (golden-green), plagioclase feldspar (whitish grey) and pyroxene (Augite). Violent winter storms break up the lavas and the constituent minerals are converted to rounded grains of sand (centre). These form the black sand beaches. Further water and wind activity has reworked the surface layer of the sands to form a predominantly green beach sand of concentrated olivine grains (right).

__Figure 7:__ Beerenberg volcano from the weather station at Båtvika. From the station to the summit is approximately 25 km.

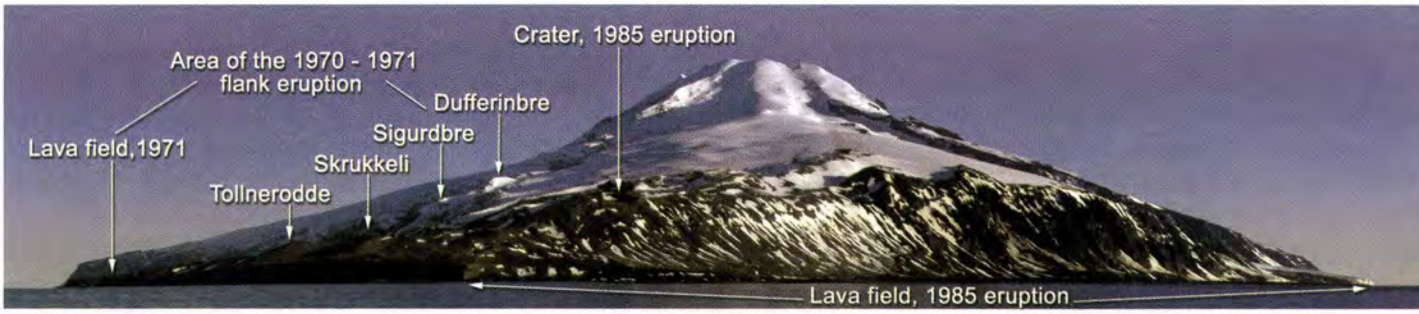


Figure 8: *Beerenberg is the most northerly active volcano in the world. The oldest rocks appear to date from ~700,000 yr. This view is from the offshore near the extreme northeast corner of the island (see Fig. 2). The four craters of the 1970 – 1971 eruption are indicated, and the position of the 1985 vent is also shown. The most distant high headland on the left, some 16 km away, is the easternmost point of central Nord Jan. The glacier entering the sea (extreme right) is about 9 km away on the northwest coast and the summit of Beerenberg is approximately 14 km distant. Photo taken at ~ 9:30 pm., June 04, 2002.*

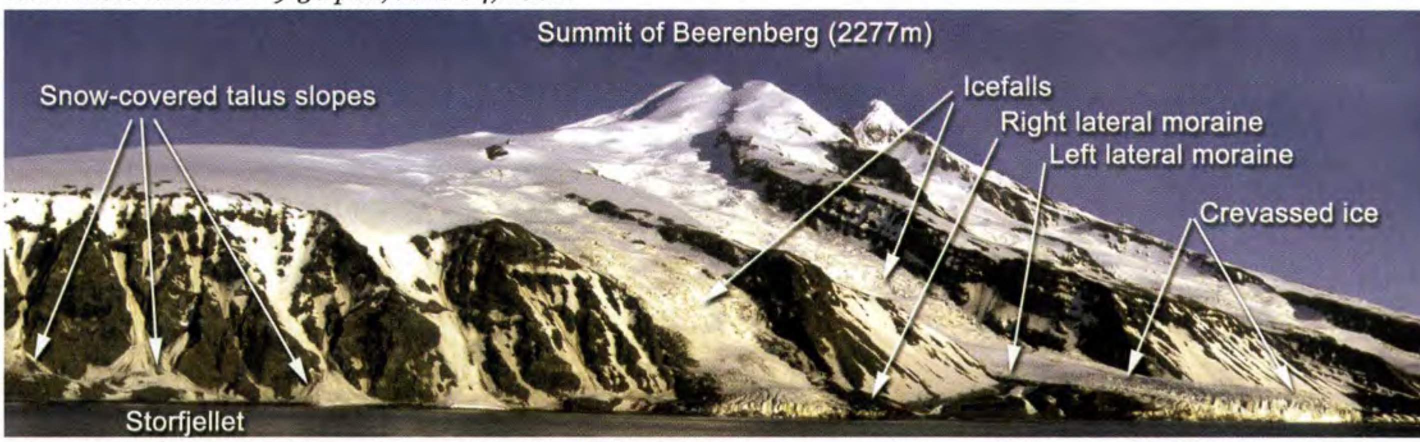


Figure 9: *Glaciers on the northwest side of Beerenberg between Weyprechtbreen (extreme right glacier) and the hyaloclastite and tuff cliffs at Storfjellet. The glacier in the centre is also seen in more detail in Figure 10. (~10 p.m., June 04)*

Figure 10*: Close-up of the northernmost glacier on the west side of Nord Jan. Crevassed blocks have tumbled from the glacier front to the beach (left) and dirt bands of basaltic ash can be seen within the ice and carried along shear planes from the base. Water was flowing from many places along the basal ice, indicating that this is a temperate glacier. (Photo ~2:30 p.m., June 05, 2002)*