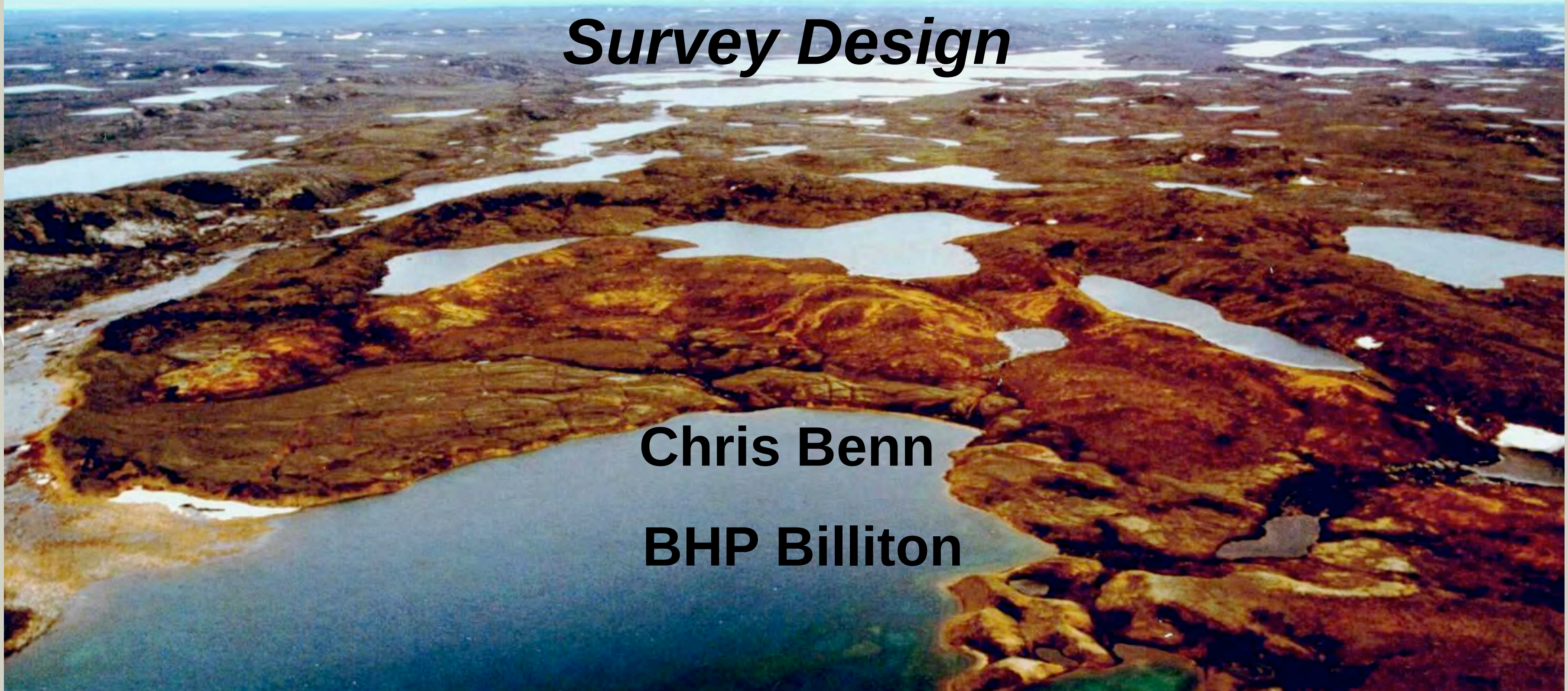
Exploration07

Indicator Mineral Methods in Mineral Exploration



Survey Design

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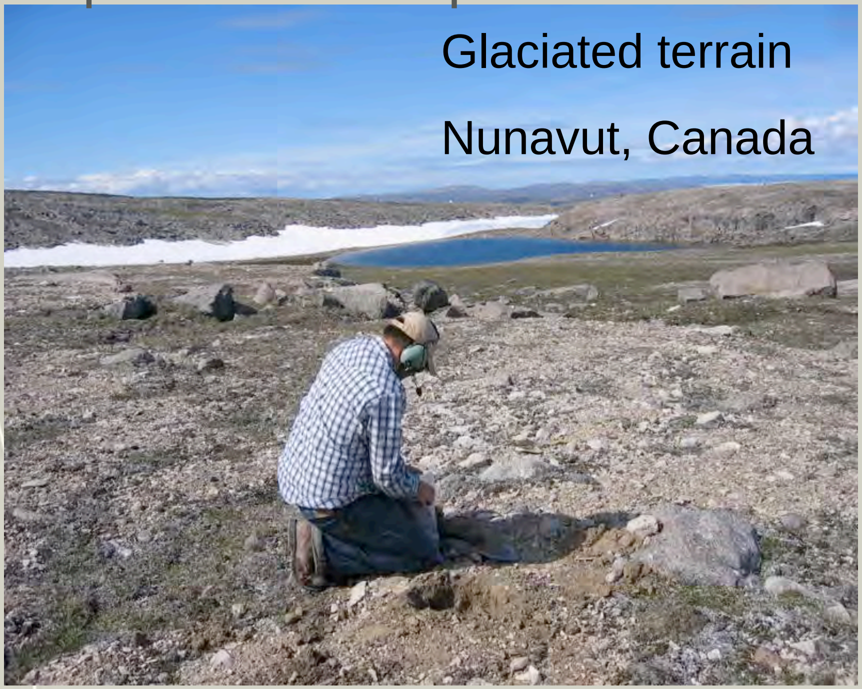
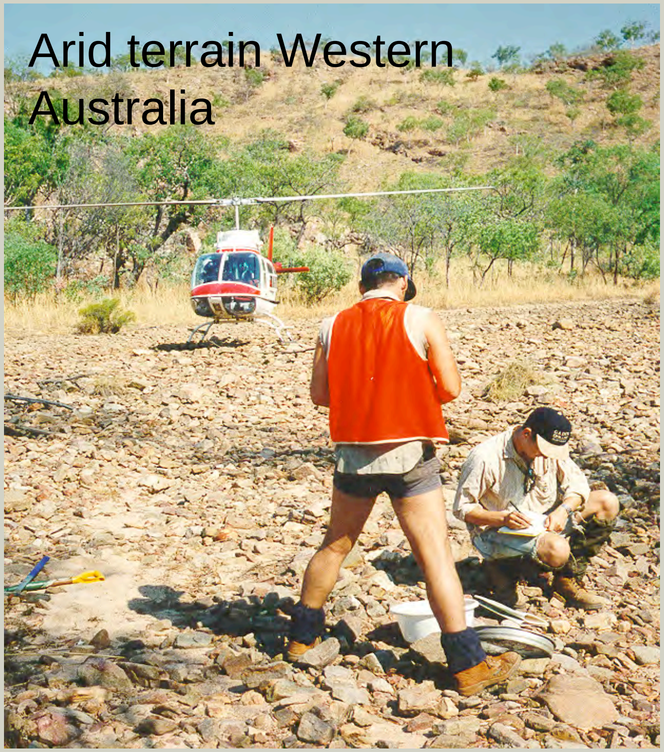
Design of Indicator Mineral Surveys

- Survey design is the most important part of an indicator mineral survey.
- Sample density , sample material and sample depth all must be chosen according to the needs of the exploration program.
- The design should be optimised to cost effectively detect the signature of the deposit style being targeted.
- Field collection of samples is the most expensive part of an indicator mineral survey.

Design of Indicator Mineral Surveys

Although there are tremendous variations between indicator mineral surveys the basic parameters are the same. This talk will focus on glaciated terrains with some mention of survey design in arid, temperate and tropical terrains.





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Design of Indicator Mineral Surveys

Preliminary survey design should include identifying the sample medium that has the best potential to be indicative of the target sought.

In glaciated terrains this medium is till which is a first cycle sediment deposited by glacial ice.

In temperate and arid terrains the sample medium could be stream sediments from areas that have outcrop with potential for hosting mineralization. Lag type samples can be taken when working in deeply weathered terrains.

Befor… eeded and a
surfic… ss and type of
all su…

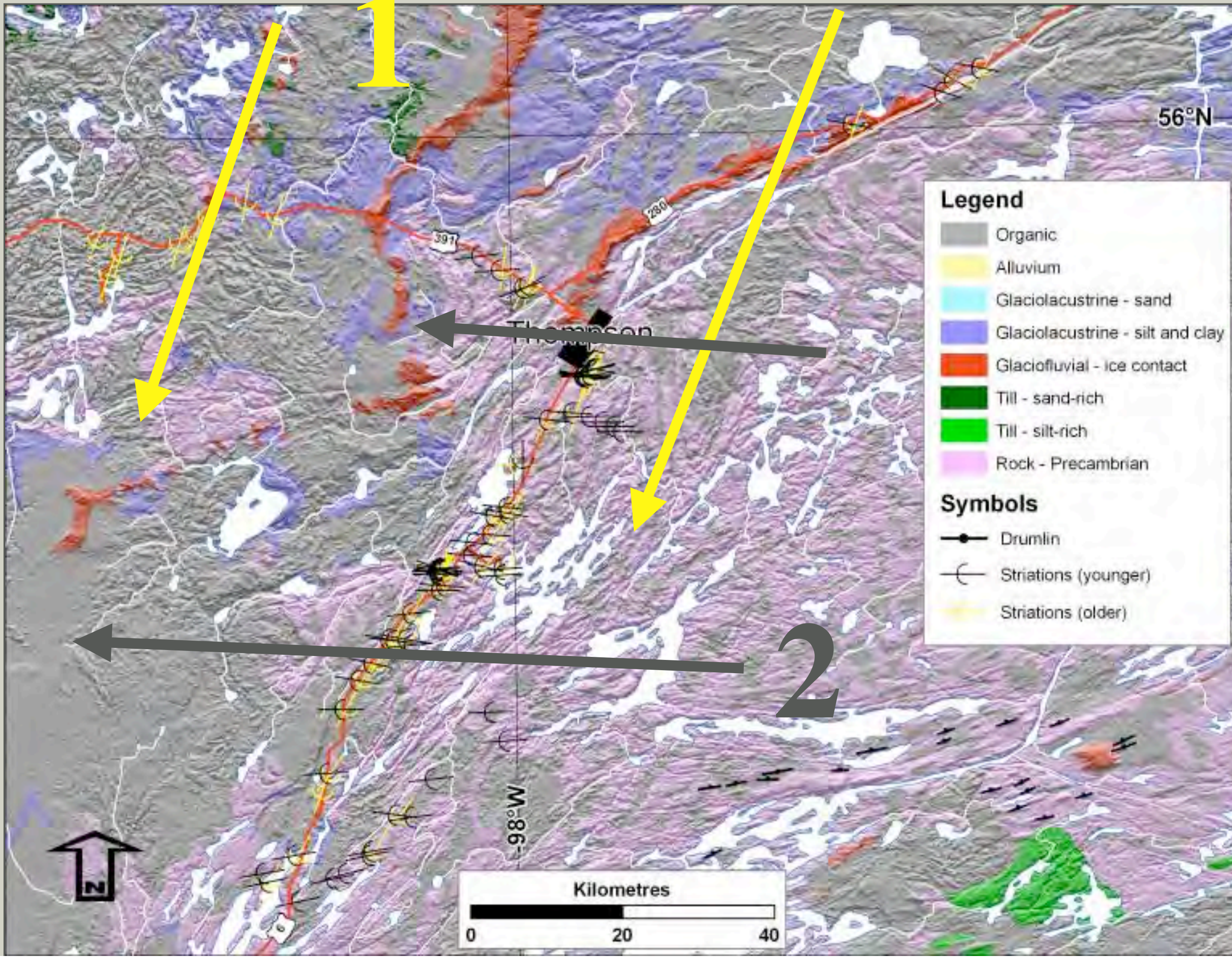
- Bouldery to pebble gravel
- Till veneer
- Till blanket

Pre-Pleistocene

- In situ material

Design of Indicator Mineral Surveys

Example of surficial geology map and glacial striations



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Scale of Survey and Sample Density

Scale of Survey and Sample Density

Glaciated Terrains

Sampling scale for indicator minerals is determined by the objective of the exploration program and can vary from a province scale density of 1 sample per 500 to 1000 km^2 to local surveys at a density of 1 sample per 2 to 5 km^2.

Cost is a major consideration with many programs in glaciated terrains being helicopter supported.

Scale of Survey and Sample Density

Glaciat

ent heavy

Minnesota

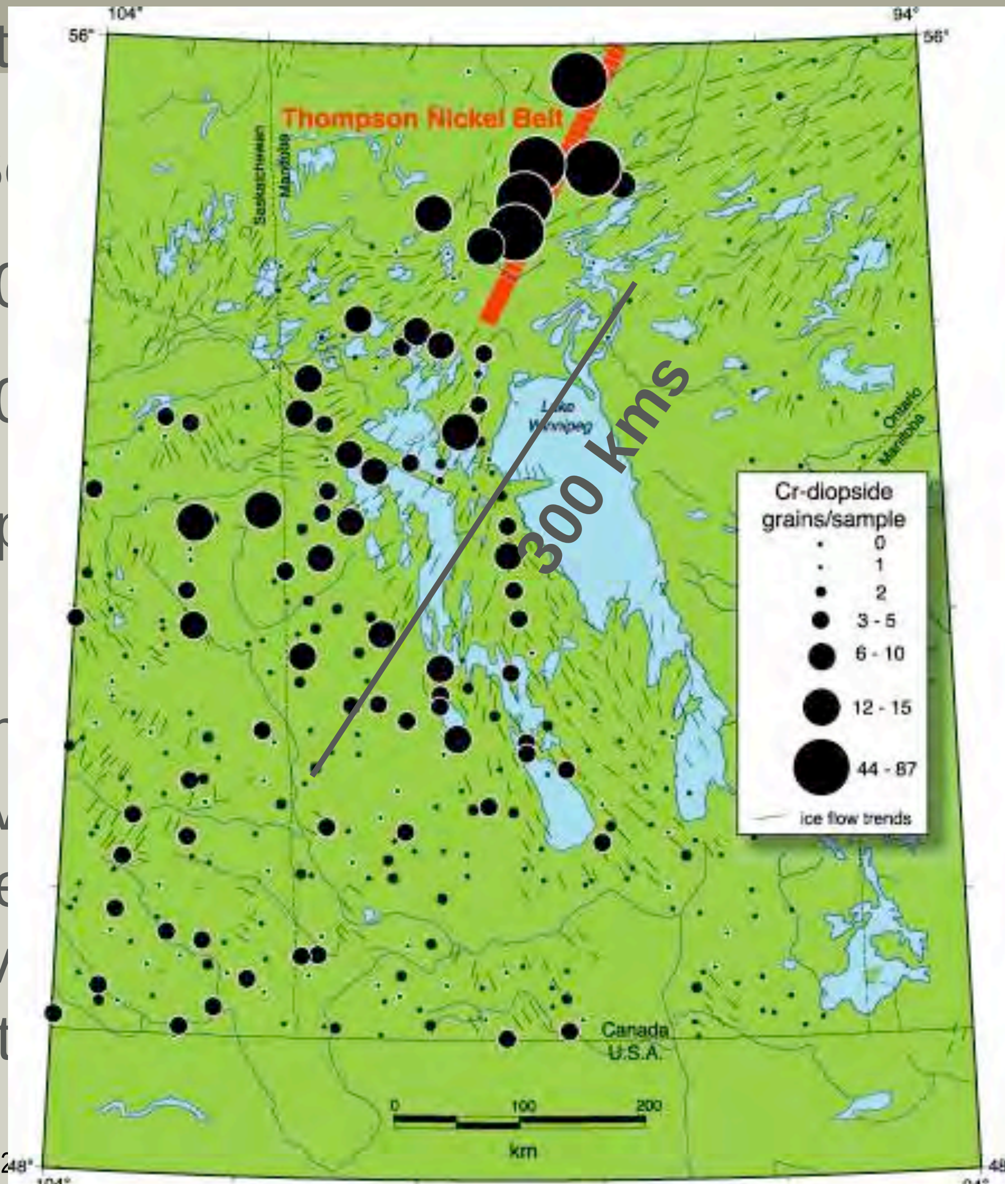
Province S

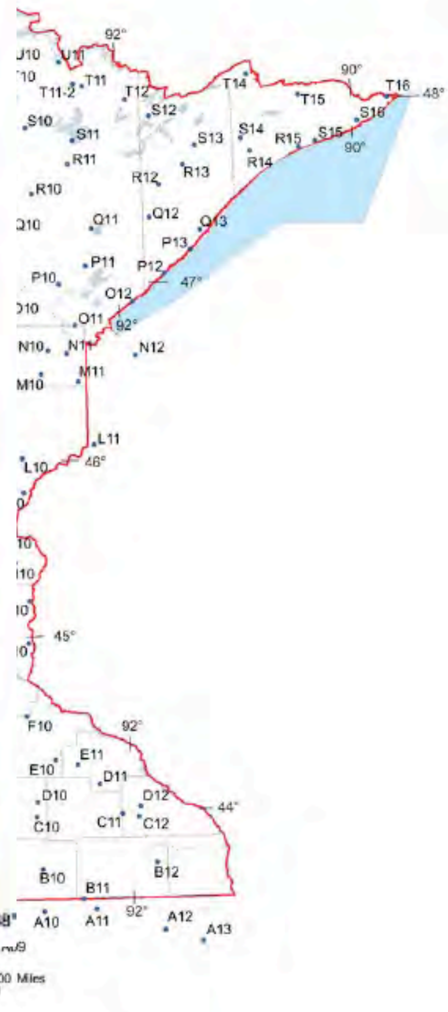
Coverage 10

1 sample /50

Size of samp
kgs < 2mm

Results from
scale of surv
useful for ide
mineral prov
environment
purposes





Scale of Survey and Sample Density

Glaciated Terrains

Reconnaissance Scale

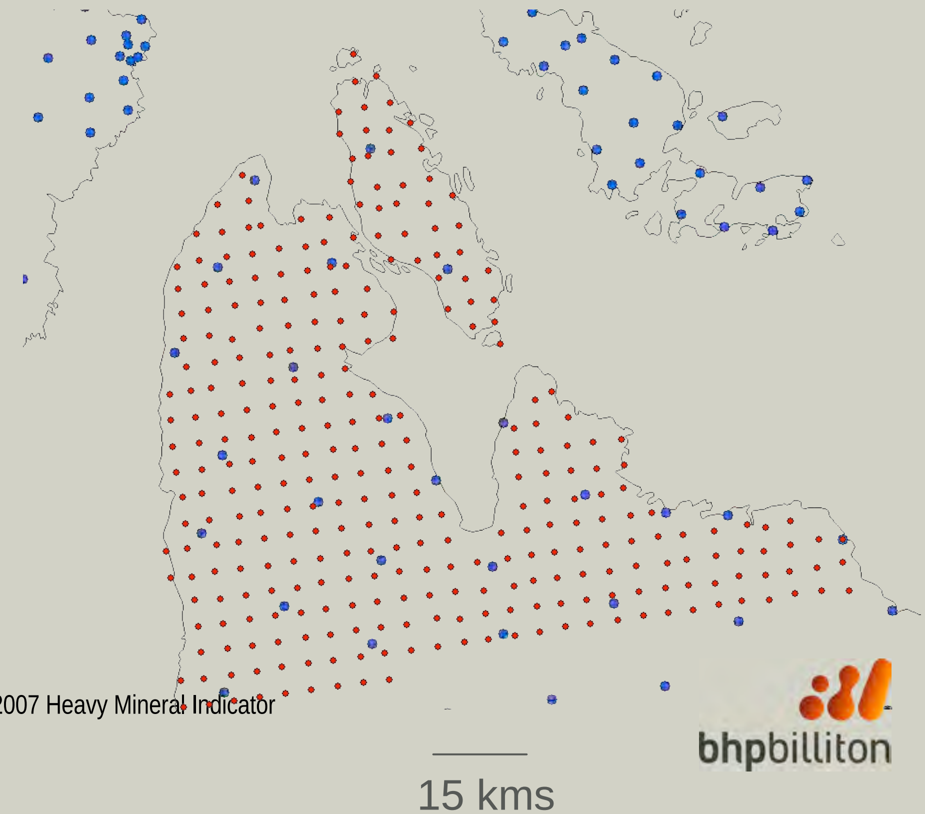
Coverage 1000's km^2

Size of sample 30 kgs < 2mm

1 sample /225 km^2 for detecting kimberlites

1 sample /25 km^2 for massive sulphide indicator mineral surveys

In Canada the topography is subdued and has little influence on the design so a grid approach is often used



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Scale of Survey and Sample Density

Glaciated Terrains

Regional Scale

Coverage 100’s km^2

Size of sample 15 kgs < 2mm

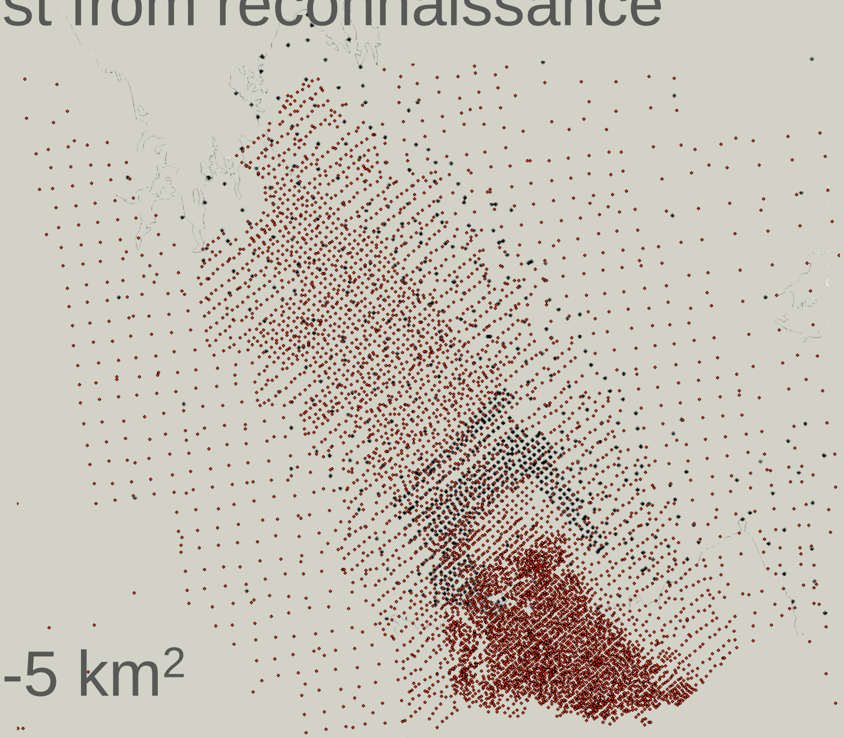
1 sample /25 km^2 for kimberlites

Local Scale

Sample density 1 sample per 0.5-5 km^2

Sample spacing as close as 250 m has been used

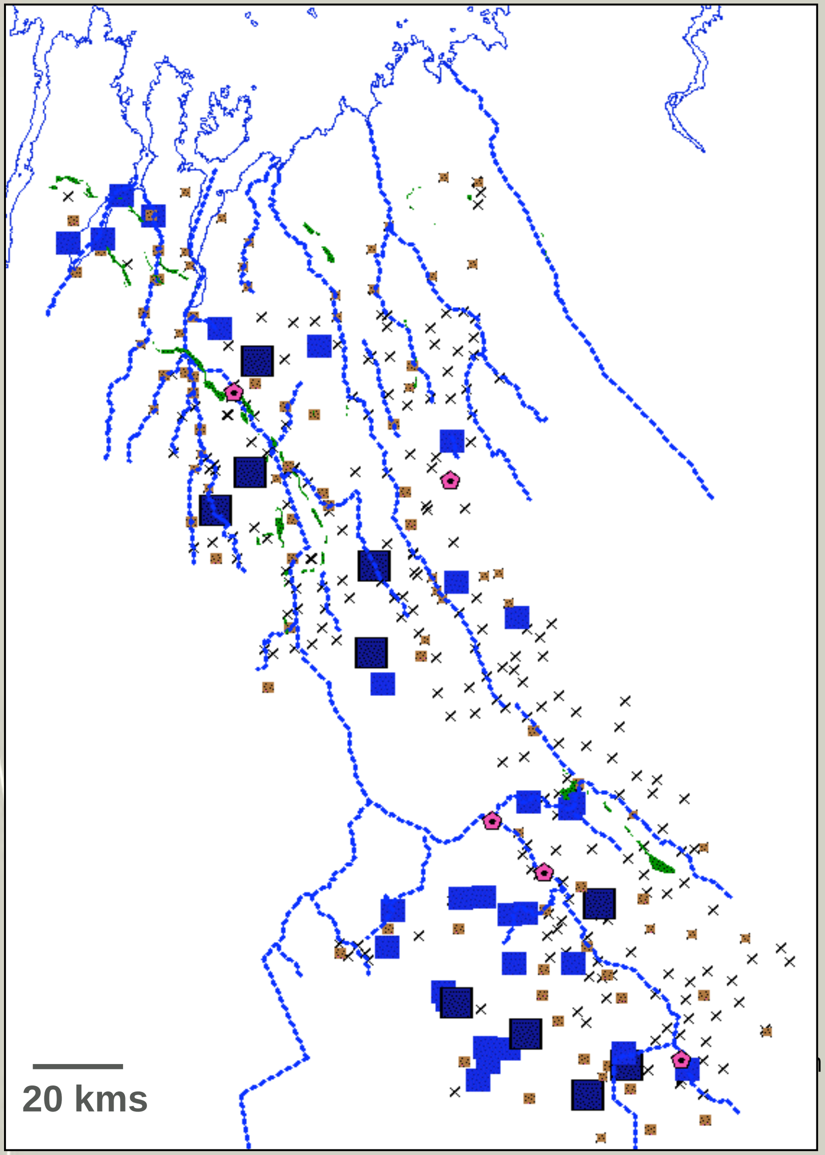
Follow up to indicator minerals of interest from reconnaissance scale



30 kms

Scale of Survey and Sample Density

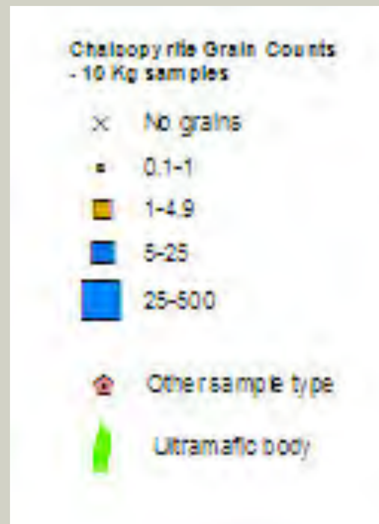
Stream Sediment HMC Sampling



Chalcopyrite

grain counts

(10 kg samples)



Regional stream sediment survey in the Ungava Bay region of northern Quebec, done on behalf of WMC

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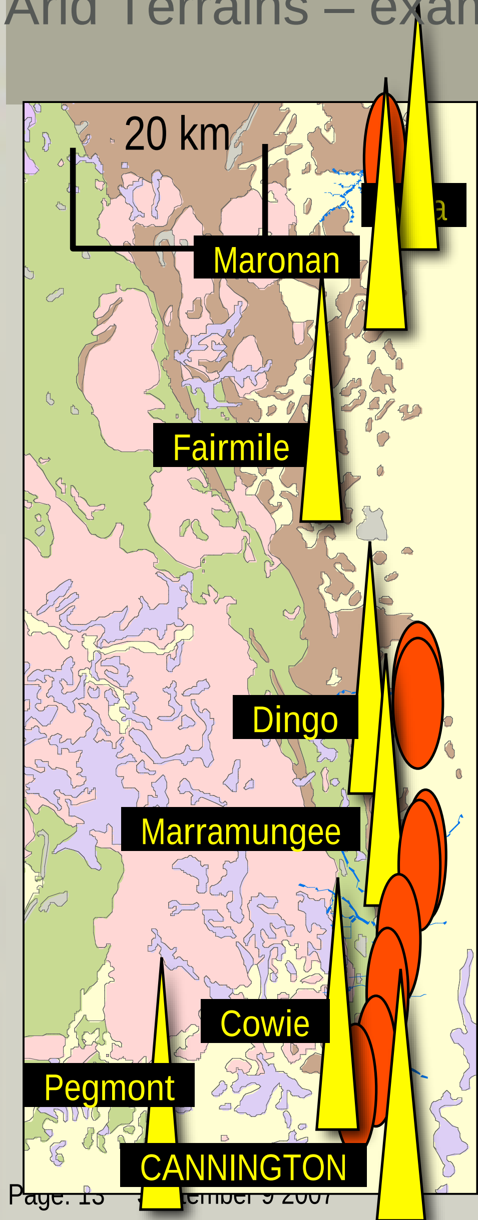
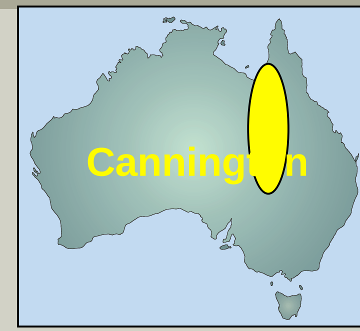
Arid Terrains – example of low density stream sediment sampling



Heavy Mineral Stream Sampling in the Eastern Succession, Australia, 1984



Pb – Zn prospect

Gahnite abundance

1 – 4

5 – 11

12 – 21

22 – 36

37 - 2000

All gahnites are BHT prospective

Regional Geology

- Cainozoic cover
- Mary Kathleen Group
- Mesozoic sediments
- Soldiers Cap Group
- Williams Batholith

Sampling Depth and Sample Media

Sampling Depth and Sample Media

Glaciated Terrains

The preferred sample media for detecting mineral deposits in glaciated terrains is till because it reflects the primary composition of the bedrock source.

The proportion of far-travelled material to local debris typically increases upwards in till deposits so concentrations of indicator minerals increase with depth towards its source.

As the surface part of the till blanket represents a wider source area, sampling should be close to the surface (0.5-1 m) in reconnaissance and regional scale surveys.

In local surveys till sampling should be close to the bedrock.

Sampling Depth and Sample Media

Glaciated Terrains

Complications can occur in the near-surface environment due to surface weathering and oxidation effects.

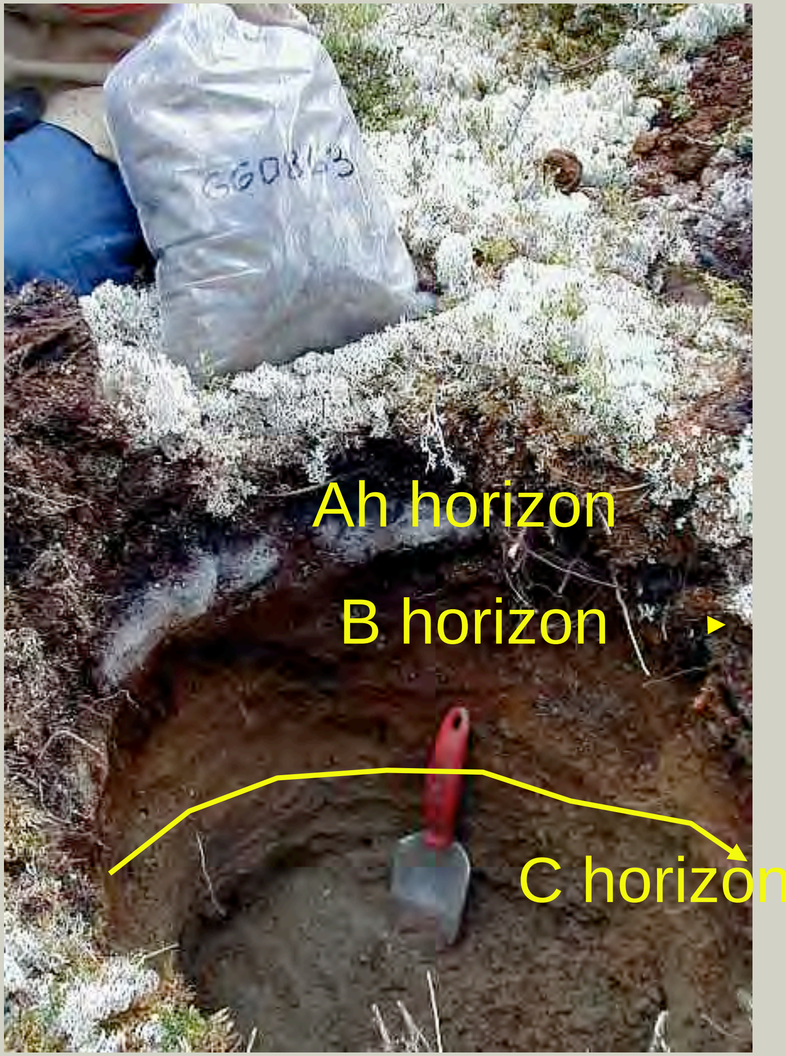
This is particularly important for secondary trace metal variations.

Weathering processes are significantly different in forested areas from those in the tundra.

Important to have proper identification and descriptions of the overburden/soil profile.

Sampling Depth and Sample Media

Glaciated Terrains



In glaciated terrains the C-horizon developed on till is preferred because indicator minerals are usually fresh or weakly oxidised and form dispersal trains as result of mechanical processes.

In forested areas the B-horizon is often developed and there is often a transition into the C-horizon. Here the till sample was taken where the trowel is located – this was from a project in Labrador

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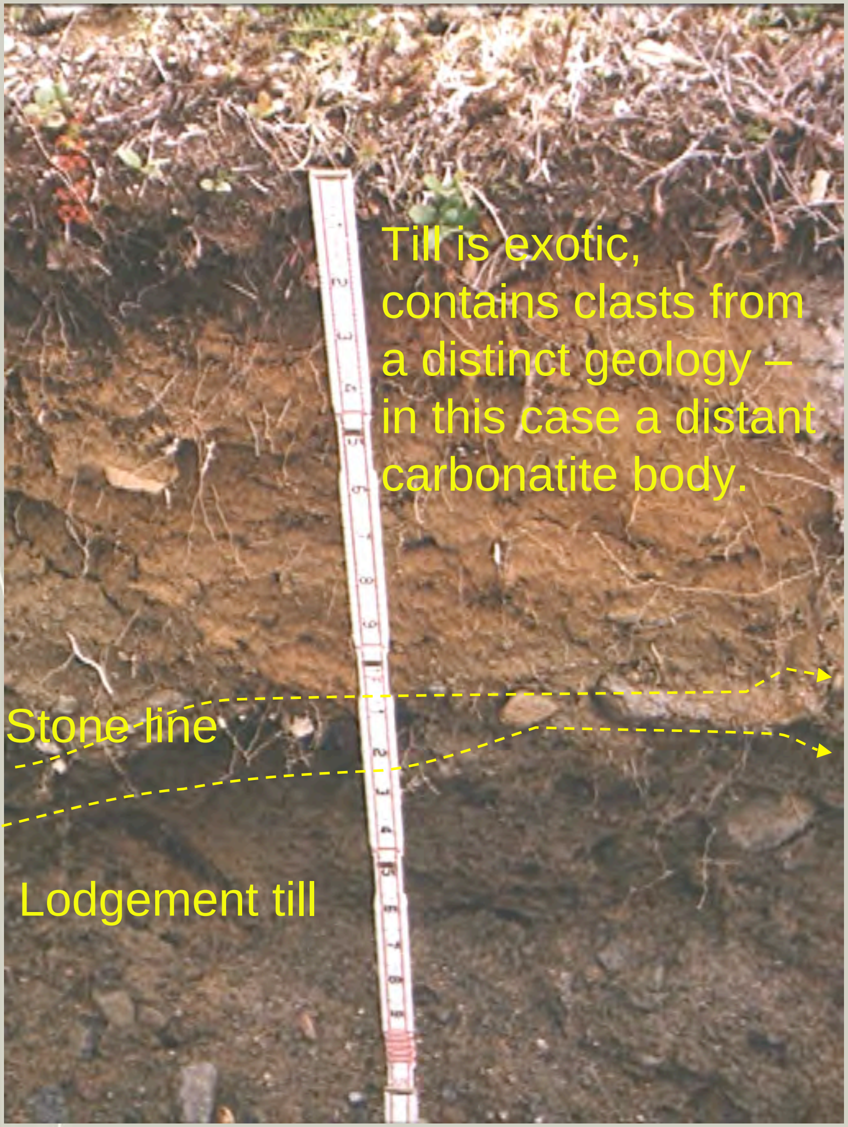
Sampling Depth and Sample Media

Glaciated Terrains



Example of a complex till situation

In this case there are two tills from different ice directions and sources separated by a stone line (unconformity). The upper till is exotic and contains clasts from a distinct geology (Apatity – carbonatite some 50 km away on the Kola Peninsula, Russia). But below the stone line is a good lodgement till – compact and containing clasts that are composed of almost 100% of the underlying mafic rocks.

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Sampling Depth and Sample Media

Glaciated Terrains

In permafrost areas of Northern Canada – north of the tree line physical weathering is the dominant process in the near-surface and soils are generally thin and immature.

An ideal sample site for indicator minerals is the mudboil (also known as the frostboil) which is formed by relatively unweathered material extruded to the surface because of high water pressures.

Sampling Depth and Sample Media

Glaciated Terrains – Example of Mudboils

Mud boils from high up in the helicopter

Mud boils from a lower elevation as the helicopter comes in to land

Sampling the mud boil

Sandy till successfully obtained

Sampling Depth and Sample Media

Glaciated Terrains

Another key sample material is lodgement till which is glacial debris smeared onto the bedrock surface by the movement of the glacier.

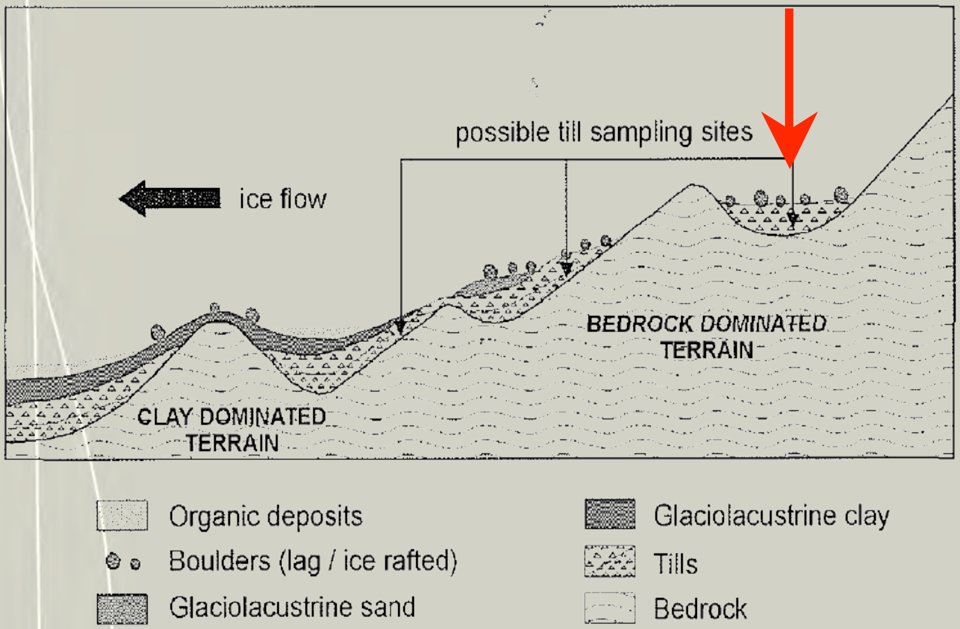
The lodgement process occurs when the frictional drag between the bed and debris is more than the shear stress created by moving ice.   Stress is enough to inhibit further movement of the till.

In areas of very thin cover or extensive till cover the most effective procedure is to dig pits with a shovel or pick. Quite often it is possible to find lodgement till within 1m of the surface

Sampling Depth and Sample Media

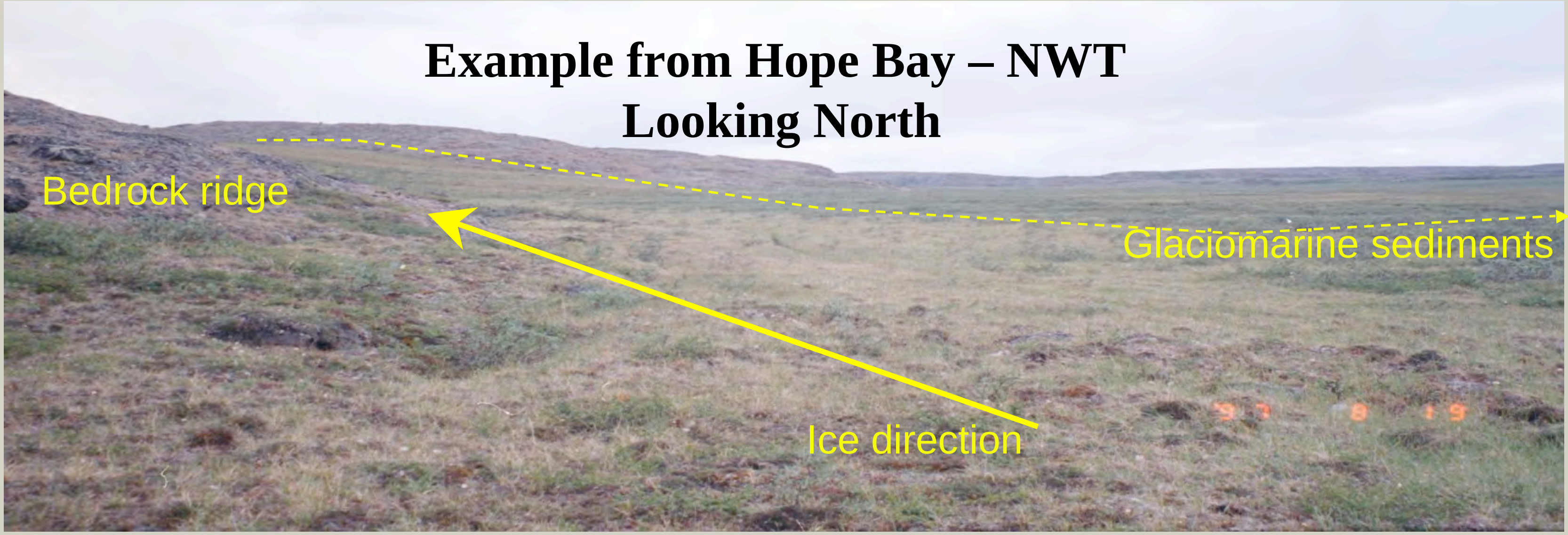
Glaciated Terrains

Good sample sites of lodgement till are usually found on the down-ice side of bedrock highs when the younger surficial deposits are often thin or in depressions on the bedrock.



Sampling Depth and Sample Media

Glaciated Terrains – Lodgement Till

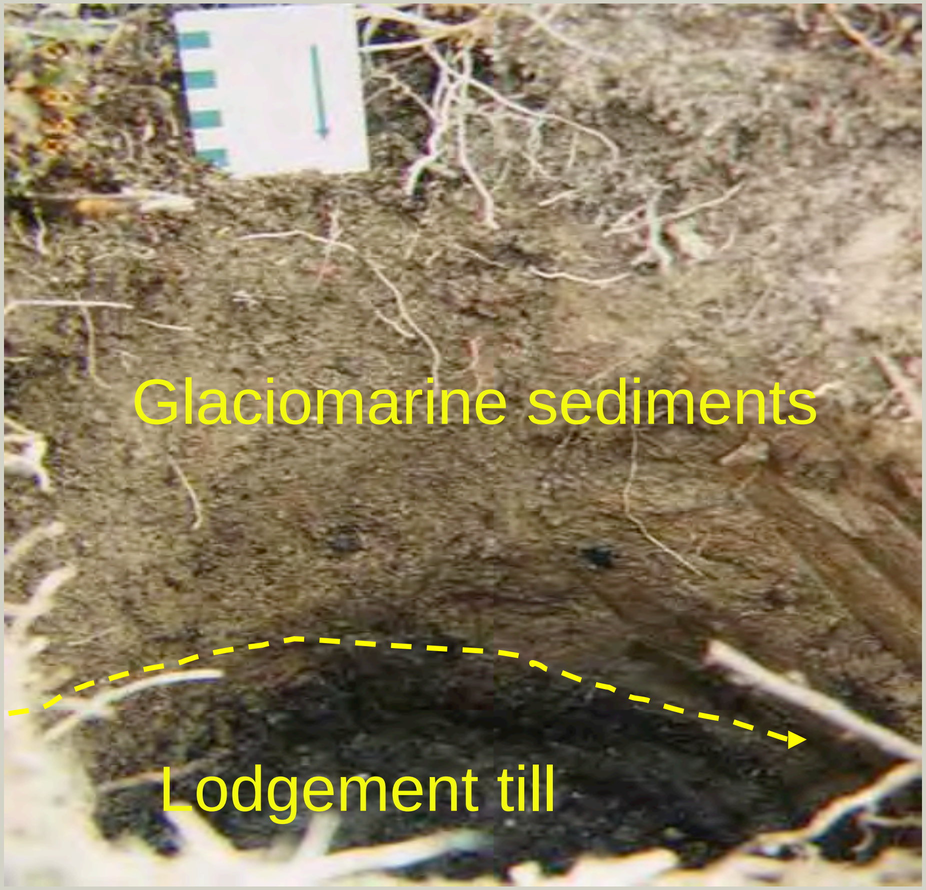


- **Glaciomarine sediments overlying till.**
- **Last ice flow to NW and lodgement till was collected on S-SE slopes of bedrock ridges, by digging through the glaciomarine sediments.**

Sampling Depth and Sample Media

Glaciated Terrains

Close up of pit on S side of bedrock ridge



Hope Bay Belt, NWT Canada.

Close up of glaciomarine sediments overlying dark grey lodgement till at the bottom of the hole which is in permafrost.

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Sampling Depth and Sample Media

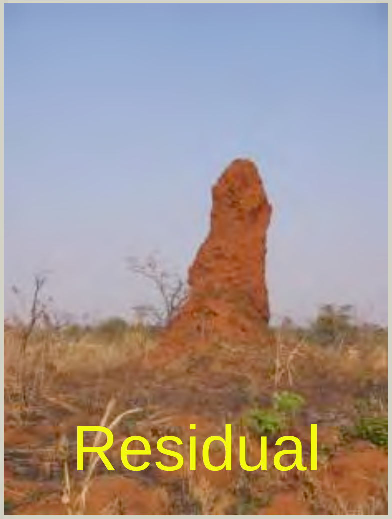
Temperate Terrains

Preferred sample sites are natural sites of accumulation of heavy minerals in stream and rivers such as rock barriers and point bars.

Pan concentrates are sometimes collected although a coarse sieved sample is usually preferred to reduce sample weight and so that a more controlled separation can be carried out in the lab.

Sampling Depth and Sample Media

Tropical Terrains



Samples taken in tropical terrains should be taken with full knowledge of the weathering regime

Typical Profile Residual red gravelly regime. (latosol profile)

Sampling Depth and Sample Media

Arid Terrains

Arid terrains

10- 20 kg samples are normally taken and sieved to <2mm depending on the target.

A major issue is that many streams do not have significant length and sample density is unnecessarily increased.

Covered Terrains

Sampling Depth and Sample Media

Covered Terrains

Transported cover that has no connection to source rock is a major problem for indicator mineral surveys in all terrains

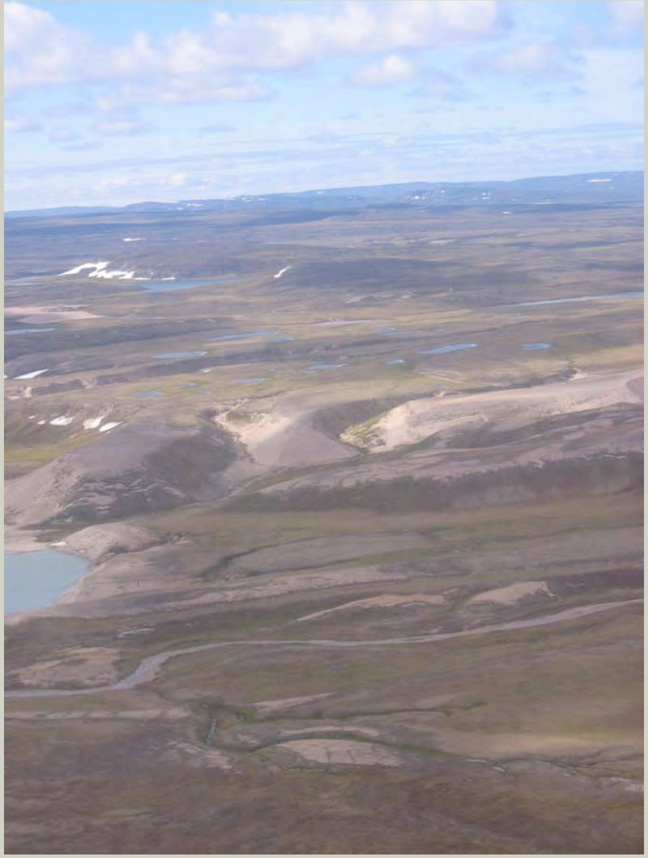
Series of raised beaches – NW of Ekati

This type of material has to be avoided

Sampling Depth and Sample Media

Covered Terrains

Marine sediments – near Pelly Bay



Marine sediments can form thick cover in coastal areas and impede surveys. This material should be avoided.

Sampling Depth and Sample Media

Covered Terrains

Esker system east of Ekati NWT

Braided and deflated esker system in Labrador

Sampling Depth and Sample Media

Covered terrains – sampling methods in thin drift areas

After decisions on sampling depth and medium have been made then the choice of sampling equipment becomes important

Hand excavation – take samples with a pick or shovel. Natural exposures and road cuts can provide occasional easy access

Trenching – use of a backhoe excavator can be very effective for digging trenches 3 to 5 m deep. Major issue is the environmental impact

Sampling Depth and Sample Media

Covered terrains – sampling methods in thin drift areas

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Hand Excavation

In forested areas pits can often be dug to a depth of 1m. Compact forest root systems can be challenging

Trenching

Photos: Roger Paulen

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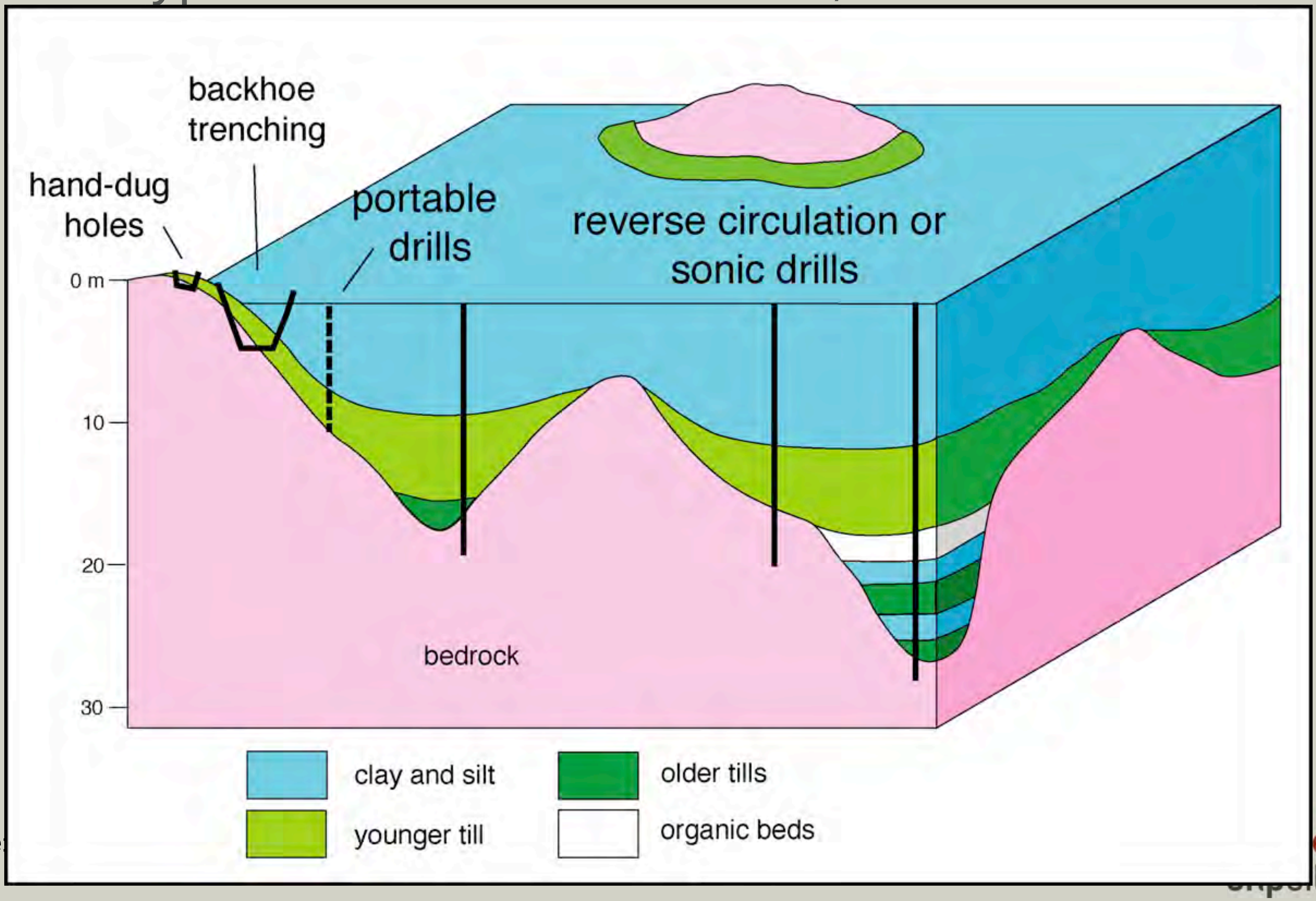
Sampling Depth and Sample Media

Covered terrains – sampling methods in thick drift areas

Typical scenario – Abitibi Belt, Canada



Sampling Depth and Sample Media

Covered terrains – sampling methods in thick drift areas

The main forms of drilling are:

Reverse Circulation Drilling – used in areas of till cover of 10-100m and whee till is stony. Issues are the loss of all clay sized material and some silt sized material

Rotasonic drilling – particularly useful for areas with extremely thick glacial sediments (100'sm). Used when more detailed stratigraphic information is required. Technique uses high frequency resonant vibration and rotation to drill through glacial sediments and recover a continuous core.

Portable drilling - Low frequency hammer or percussion drills are most common and have been used extensively in geochemical surveys in Finland.

A single till sample is collected at the bottom a drill hole with a maximum of 8 to 10 m depth in sandy till with few boulders.

Rigs weigh 10-25 kg. Main drawbacks are limited depth penetration and small sample (200-300 gms). Not suitable for indicator mineral sampling unless multiple holes are drilled.

Reverse Circulation Drill

- overburden 10 to 125 m thick
- stony/bouldery till
- tricone bit
- mud and chip slurry
- clay-sized material lost

Rotasonic Drill

Bit with tungsten carbide bit

- overburden 10 to 125 m thick
- stony/bouldery till
- detailed stratigraphy
- continuous 9 cm core
- high costs

Rotasonic Drill

Portable Power Auger

Photos: Roger Paulen

Sampling Depth and Sample Media

Covered Arid Terrains

Lag sampling – Arid terrains

Dune fields – deflation sampling

Quality Control and Field Data Capture

Control Samples

HMC surveys need at least two types of control samples:

•**Field duplicates** – a second sample taken every 15-20 samples which is treated in same way as the first sample; and,

•**Standards** – for indicator minerals this is a spiked sample with a known quantity of indicator minerals – typically laser etched garnets when KIM's are being traced and gahnites in the case of indicators for BHT base metal deposits.

Laboratories

•These need to be audited and visited to observe the setup and operation

Field Data Capture

Careful collection of field data is extremely important for interpretation and understanding the limitations of the sampling technique.

Any survey design should include provision for the use of a portable data capture device.

These devices provide more efficient, reliable and consistent description of field samples.

Electronic Field Data Capture - Hardware

Good hardware for effective field data capture requires:

- Sufficient battery life for all-day use
- Anti-glare screen for use in direct sunlight
- Sufficient memory for data storage
- Ability to run Windows Mobile Operating system
- Sufficient processing power for applications like ArcPad
- Integrated GPS (no typing/writing coordinates!)
- Cost-effectiveness

Ideally mobile devices will also be ruggedized (ie: shock/water/dust-proof) but $$$$

Portable PDA devices with
Bluetooth GPS receivers

Costs of Indicator Mineral Surveys

Recent Costs (2006) for an Indicator Mineral Survey – Diamond and Base metal Exploration, Northern Canada.

Surveys were helicopter supported and costs are in $CND

	Collection Costs/sample	Analytical Costs/sample	Overall Cost/sample
Survey 1 (200 samples). 1 sample/125 km^2	1500	450	1950
Survey 2 (280 samples). 1 sample/25 km^2	1200	310	1510

In general field collection costs are 70% of total costs

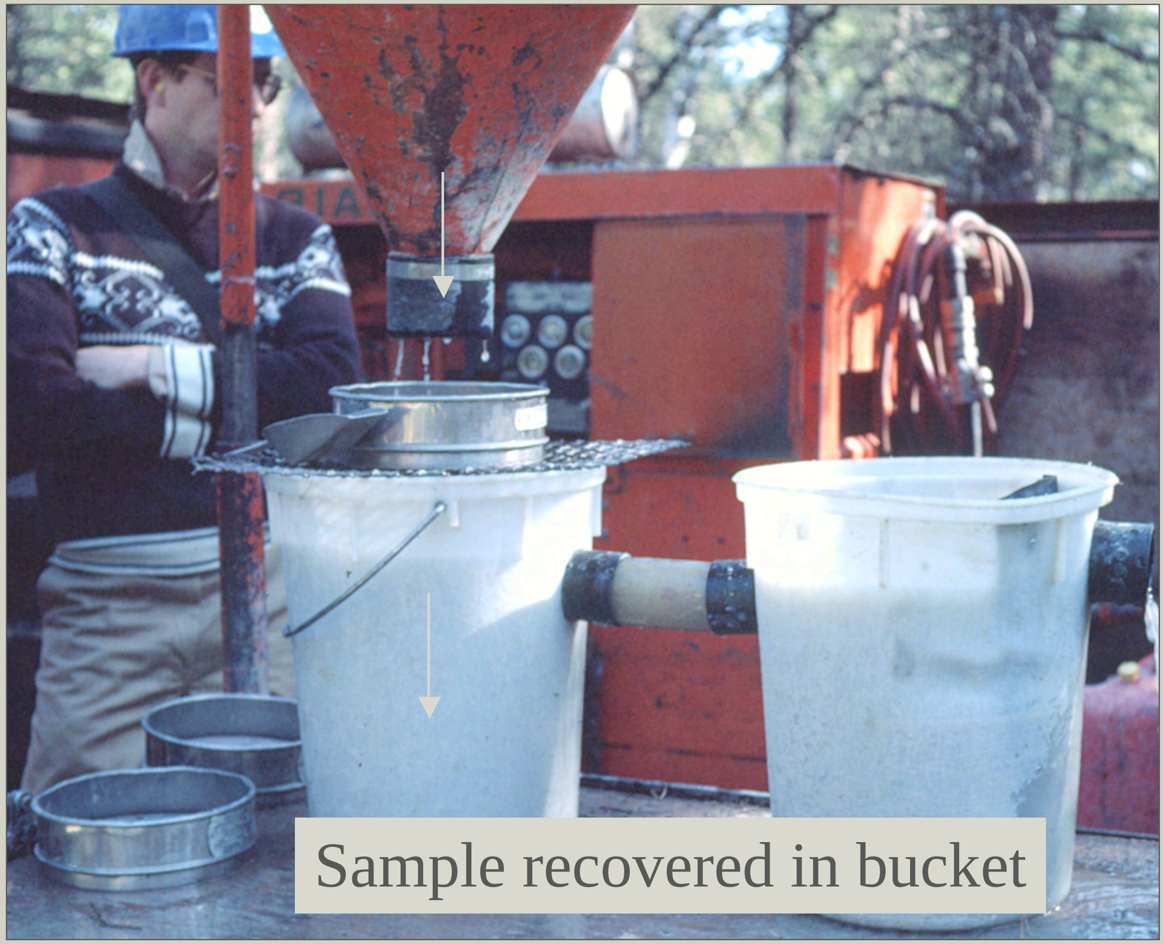
Summary - Design of Indicator Mineral Surveys

- Survey design is the most important part of an indicator mineral survey.
- Sample density , sample material and sample depth all must be chosen according to the needs of the exploration program.
- The design should be optimised to cost effectively detect the signature of the deposit style being targeted.
- Field collection of samples is the most expensive part of an indicator mineral survey.

The End

Reverse Circulation Drill

+10 mesh on screen for logging



Sample recovered in bucket