Kimberlite Geochemical Pathfinders in Shallow Groundwaters Over Buried Kimberlites
James Bay Lowlands, Ontario, Canada

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Summary

- A study was undertaken to evaluate the effectiveness of shallow groundwater geochemistry for exploration of buried kimberlites in wetlands.
- Shallow groundwaters show large variations in pH, Eh, EC, carbonate saturation index, and metal concentrations.
- Deep groundwater is upwelling near kimberlite margins due to fractures along the boundaries between kimberlite pipes and host limestone.
- Shallow groundwaters at these upwelling sites contain high kimberlite pathfinder metals, such as Ni, Cr, REE+Y, Ba and alkalis.
- The results of this study show that shallow groundwater is a good medium in detecting buried kimberlites in wetlands.

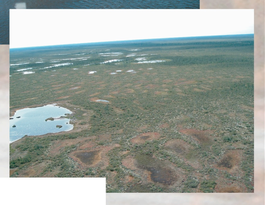
Location and Geology

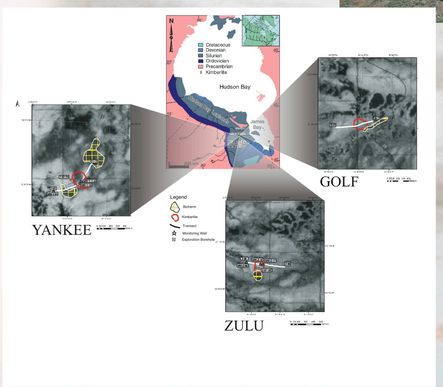
Kimberlite Geology

- Jurassic kimberlites are were emplaced into Paleozoic limestone (Webb et al., 2004).
- kimberlites have both volcaniclastic and hypabyssal facies.
- kimberlites consists of olivine, ilmenite, garnet, Cr-diopside, phlogopite, and spinel (Kong et al., 1999).

Quaternary Geology

- sphagnum peat (2.5-4 m) and fine-grained marine Tyrell Sea sediment (2-22 m; ~ 4000 - 12000 years BP) overlie a thin layer of till and kimberlite/limestone.
- Bioherms (coral and other marine organisms) outcrop occasionally above the peat surface. They are commonly groundwater recharge sites, as they contain abundant voids.





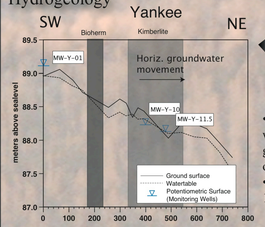
Groundwater Sampling

- Shallow groundwaters were collected using PVC piezometers at 1.1 meters below ground surface at the Yankee and Zulu kimberlites and at 0.4 mbgs along the transect at Golf. All Golf geochemical data were reported by Brauneder (2007).
- Monitoring wells were installed 70 cm below the peat into Tyrell Sea sediments to collect deeper groundwater.
- Water samples were also collected at a depth of ~ 14 mbgs from exploration boreholes within kimberlites and limestone.

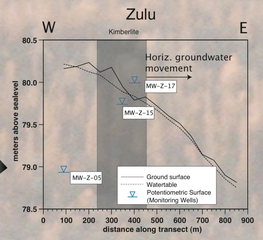
- The values of pH, Eh, electrical conductivity (EC), dissolved oxygen content (DO), and temperature were measured on-site.

Indicators of Upweling Deep Groundwaters

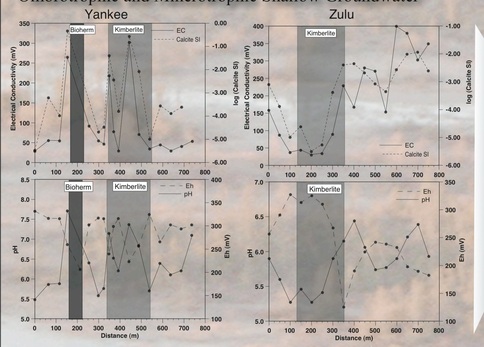
Hydrogeology



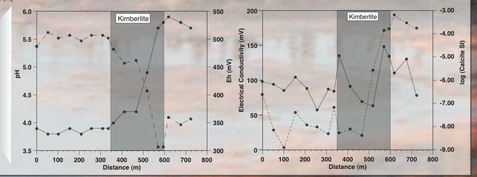
- Upwelling is suggested by the changes in the pressure head of monitoring wells.
- Horizontal gradient of the water table is - $1.95*10^{-3}$.
- Upwelling of deep groundwater is detected where the saturated zone is close to, or above the ground surface. Additionally, the pressure head of monitoring wells suggest upwelling.
- Horizontal gradient of the water table is $1.66*10^{-3}$.



Ombrotrophic and Minerotrophic Shallow Groundwater



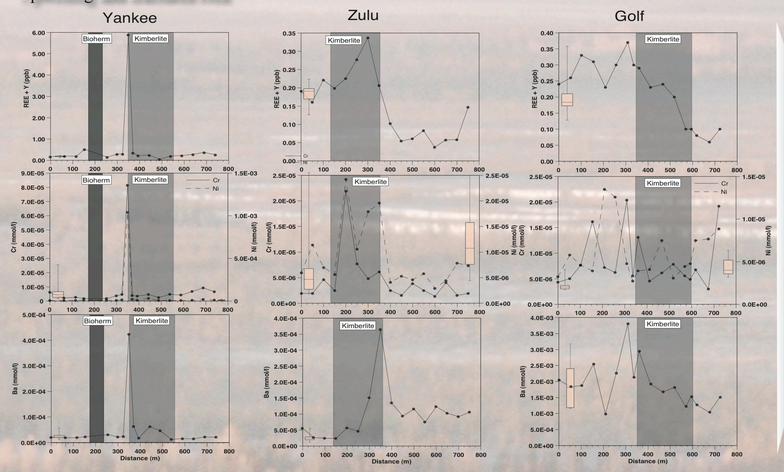
- Higher values of pH, and Eh are associated with higher EC and calcite saturation indicies, common features of minerotrophic waters.
- Minerotrophic shallow groundwaters are observed at the sites of upwelling deep groundwaters.
- Waters upwelling from limestone have high EC, $CaCO_3$-SI, pH, and low Eh, but metal contents are low.



- The values of EC, Calcite-SI, pH and Eh were used to estimate the sites of upwelling of deep groundwater at Golf.

Spatial Distribution of Metal-Rich Peat Groundwaters

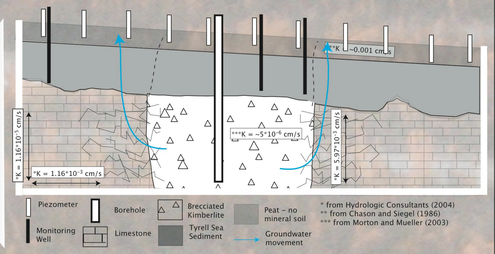
Upwelling and fractured rock



- Waters originated from kimberlites have high concentrations of Ni, Cr, REE, Y, and Ba.

- upward migration of deep groundwaters along kimberlite-limestone boundaries is probably due to high hydraulic conductivity (K) in the fractured rocks along the boundary.
- Fractures commonly form during explosive emplacement of kimberlite.

- Little lateral movement of metals will take place in peat once metals have migrated from deeper groundwaters.
- Peat groundwater will only migrate at ~50 cm per year (or less if frozen during winter).



Peat Groundwaters and Diamond Exploration

Application

1) Shallow groundwater is an excellent medium for surficial geochemical surveys.
2) The metals REE, Y, Ni, Cr and Ba are generally low in most sedimentary and other igneous rocks in this region.
3) Shallow groundwater geochemistry is most useful as a secondary exploration tool in conjunction with first order methods such as geophysics.
4) Water geochemistry has the potential to be utilized as an exploration tool at other locations where more traditional exploration methods such as soil geochemistry or indicator minerals in till are more challenging, if not impossible to implement.

Geochemical Survey Design

1) Should be combined with a hydraulic survey of the area.
2) Sampling of water samples should be carried out along a transect parallel to the groundwater flow.
3) Samples should be collected at least 200 m beyond the suspected kimberlite margins because of possible displacement of pathfinder metals in shallow groundwater.

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