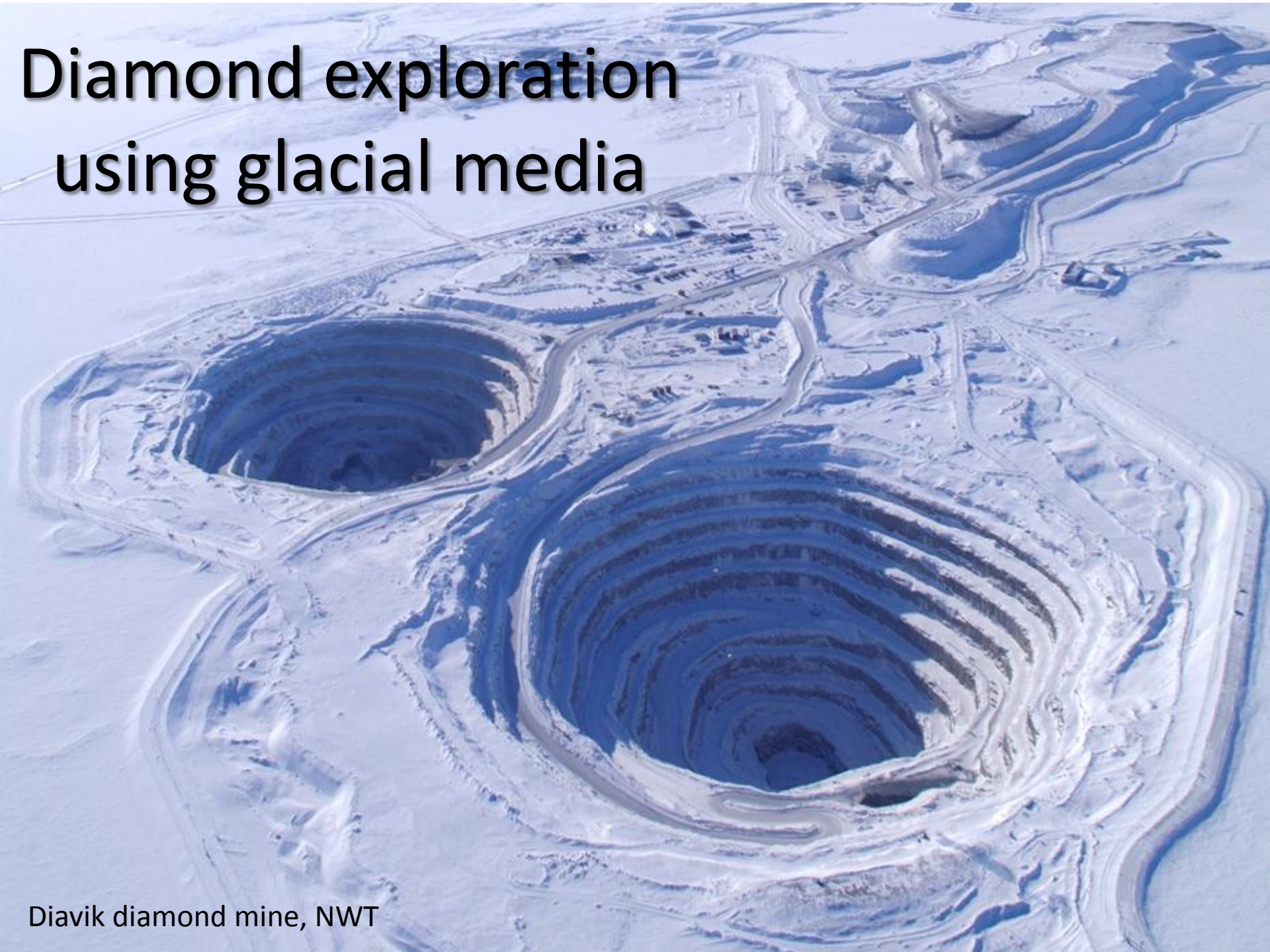
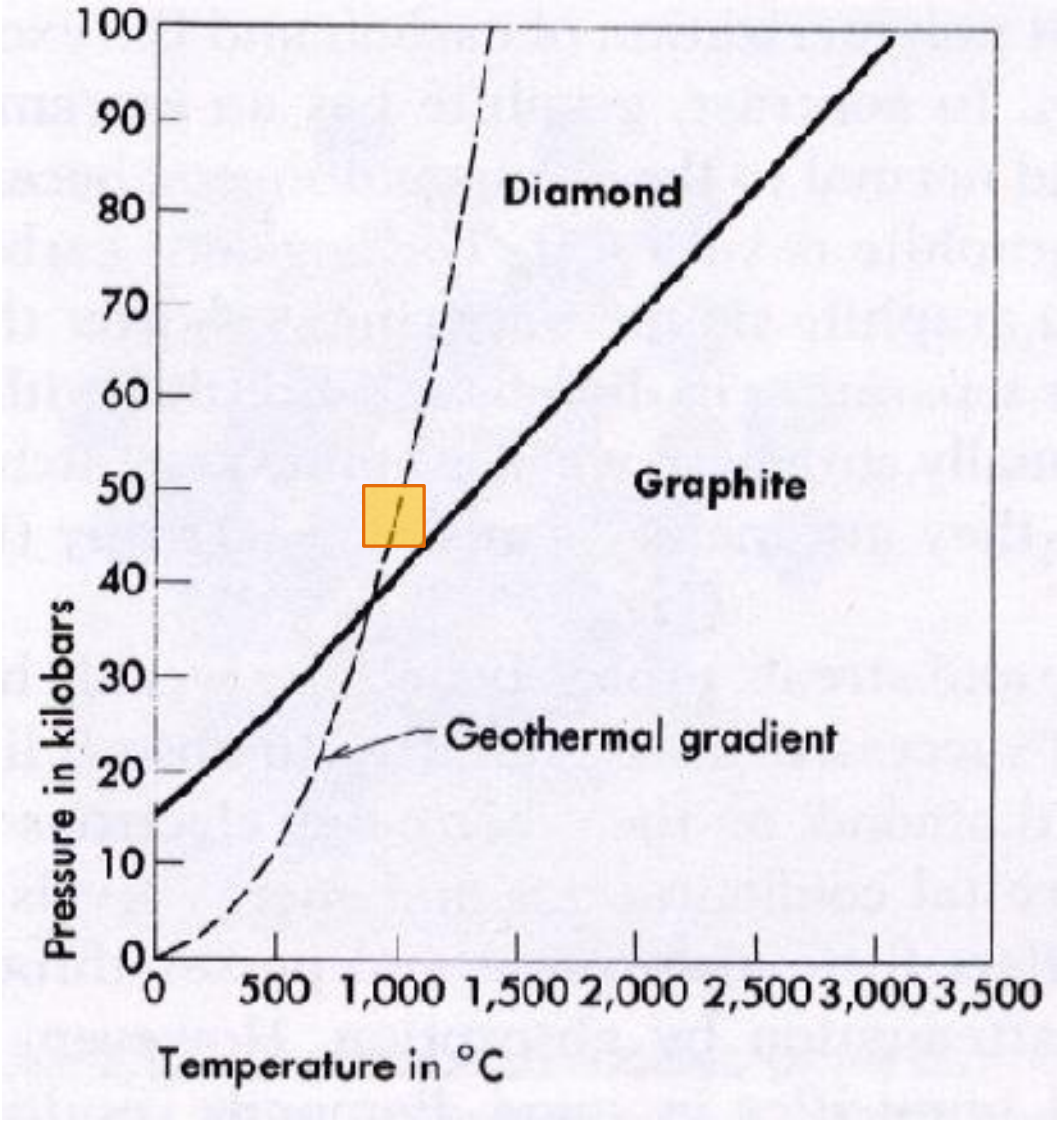
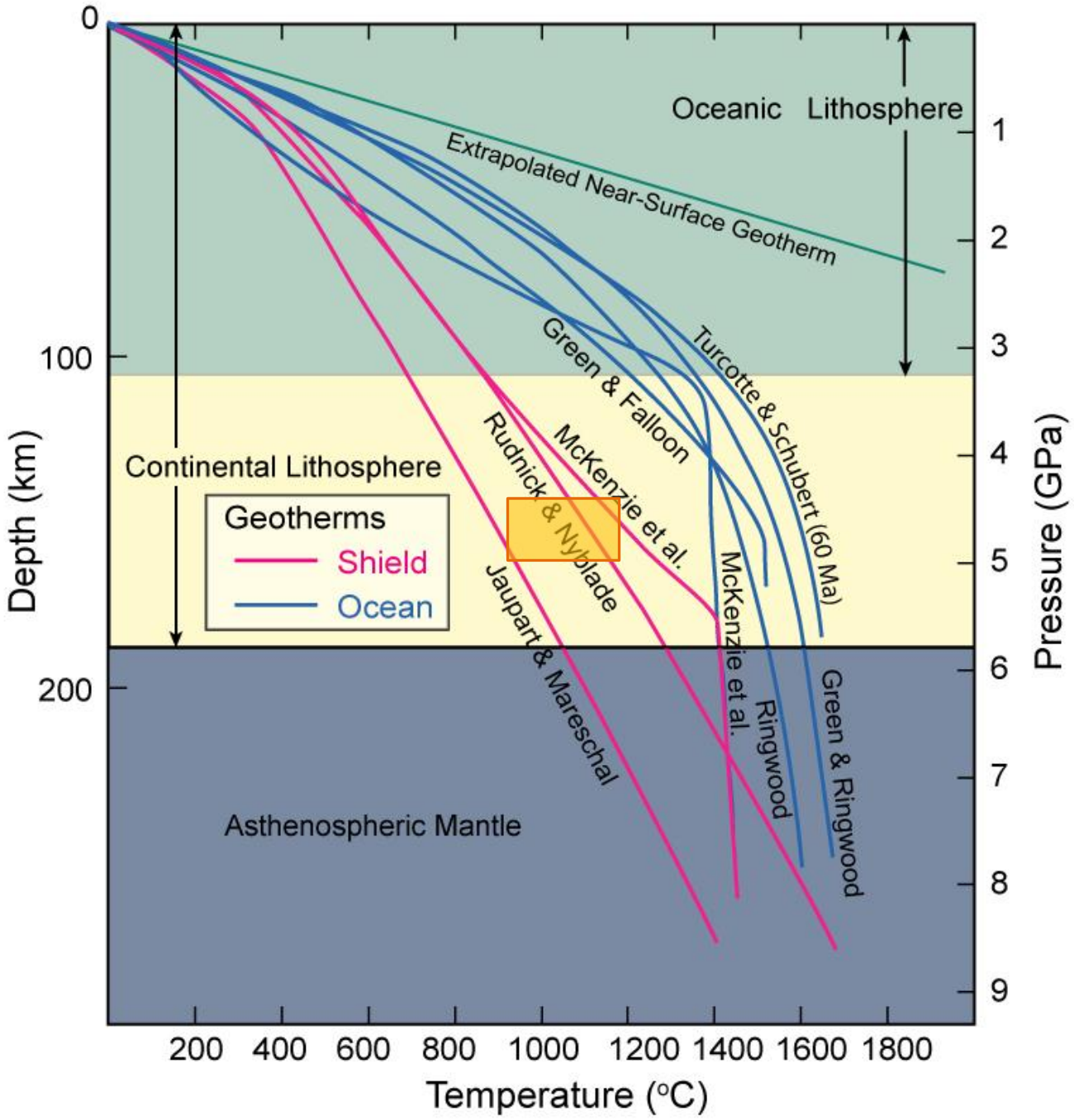
Diamond exploration using glacial media



Diavik diamond mine, NWT

Diamonds are formed at depth in the mantle (150-200km, up to 700km) under very specific physico-chemical conditions (T=900-1200 C; P=4.5-5 GPa (45 to 50 kbar)).





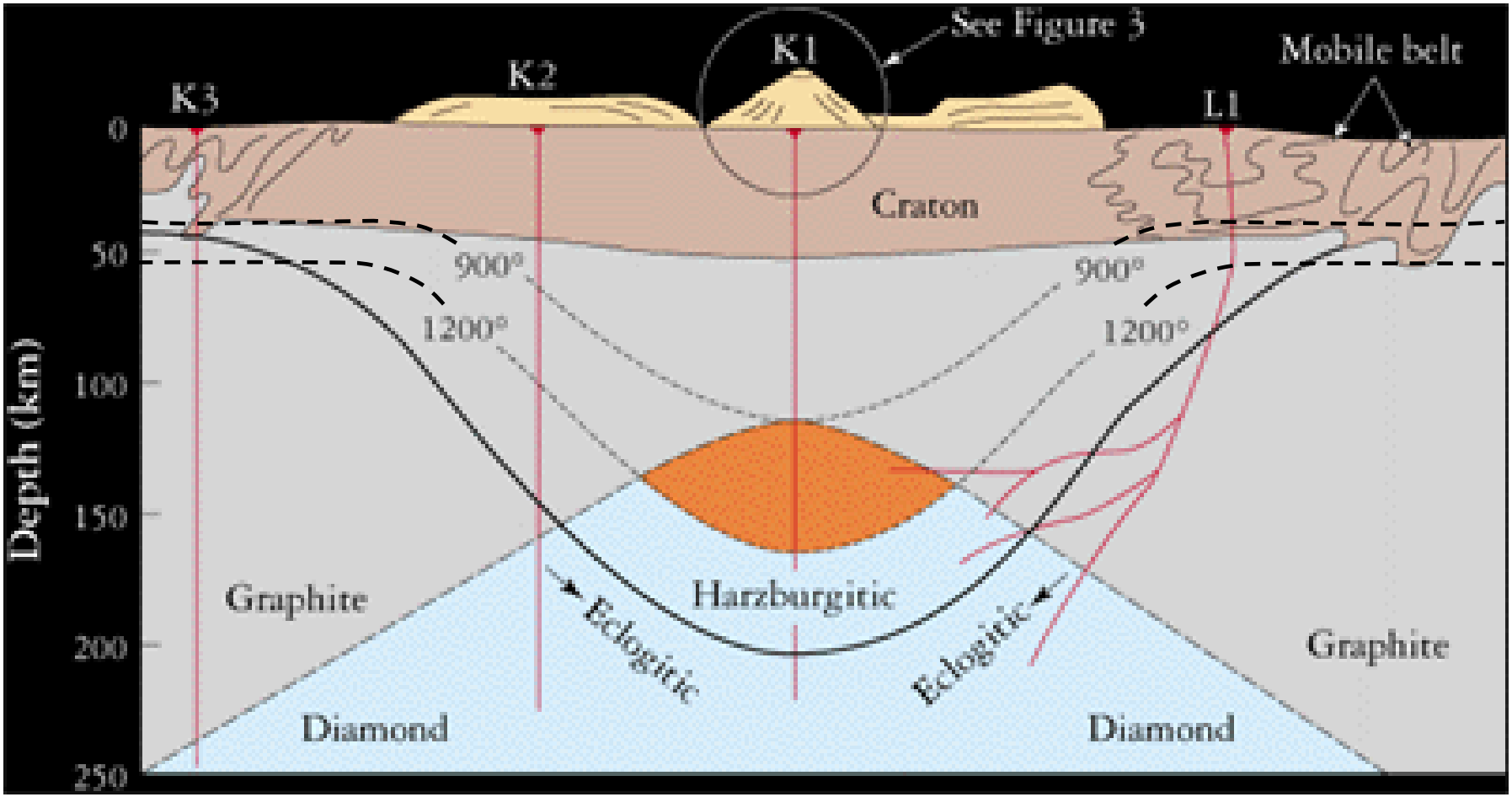
These conditions are only met under geologically stable continental shields (cratons).

John Winter

Diamonds crystallize within 2 main types of mantle-magmas:

Peridotite (Harzburgite) (mainly composed of olivine, orthopyroxene, clinopyroxene, chromite and pyrope garnet);

Eclogite (mainly composed of pyrope-almandine garnet, omphacitic clino-pyroxene).



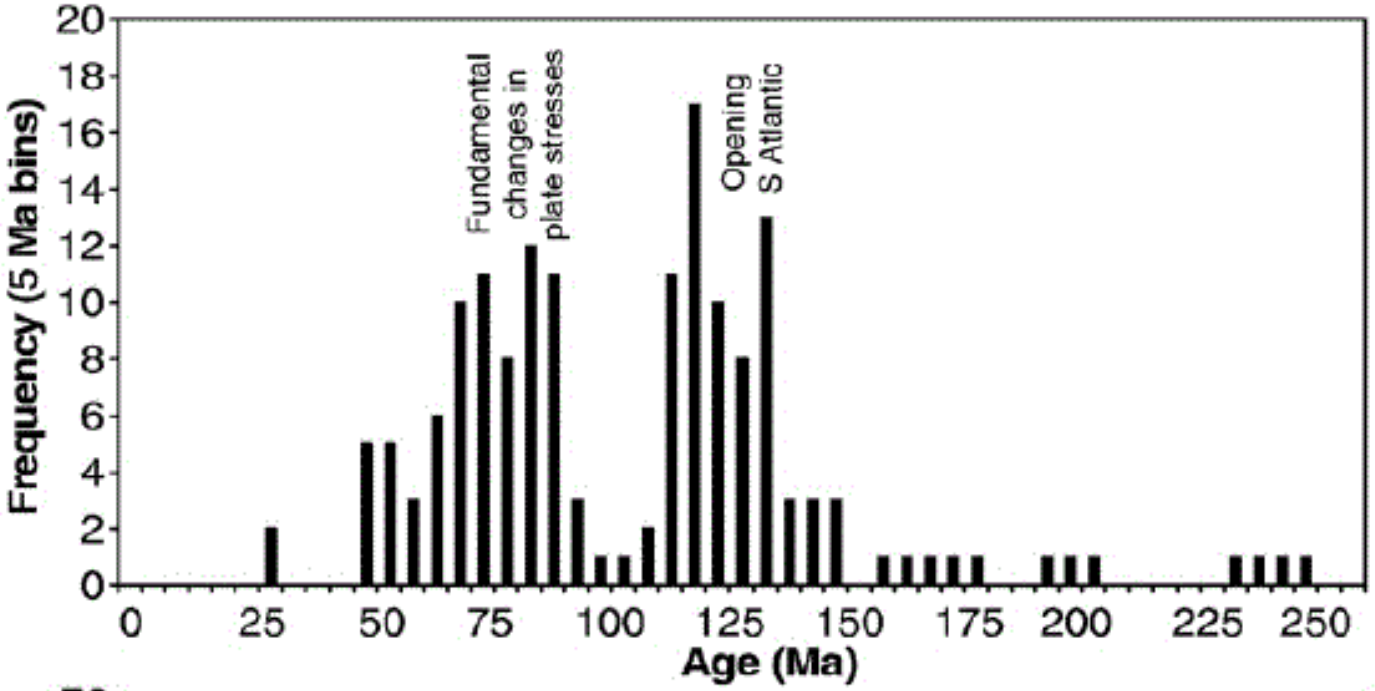
These deep diamond-bearing rocks are subsequently picked up and assimilated as fragments (xenoliths) within even deeper-sourced fast-ascending (up to 150-200 km/hour) kimberlite volcanic magma on its way to surface.

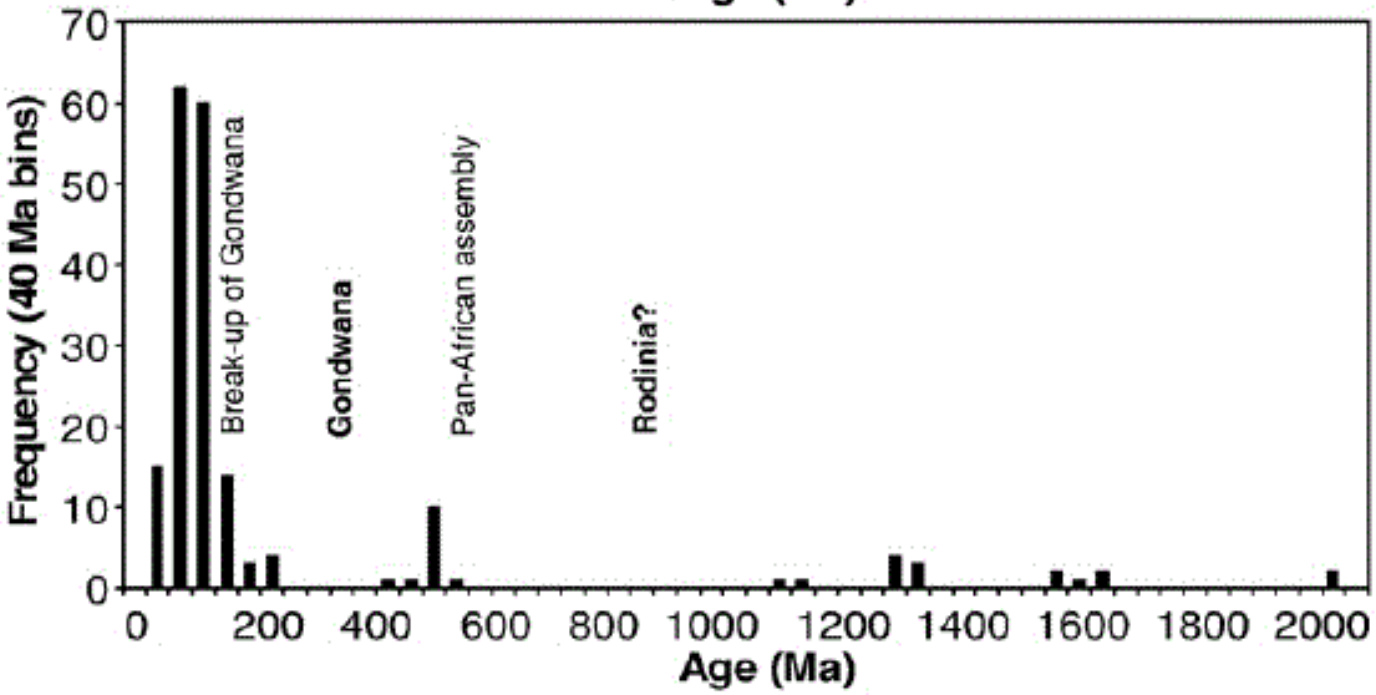
Kimberlite is a volatile-rich (H_2O, CO_2), potassic ultramafic igneous rock that is mainly composed of olivine with some phlogopite, carbonate, serpentine, clinopyroxene, orthopyroxene, spinels, perovskite, ilmenite, magnetite and garnets.

Only about 1 in every 50 kimberlites has enough quality diamonds to be economically viable.

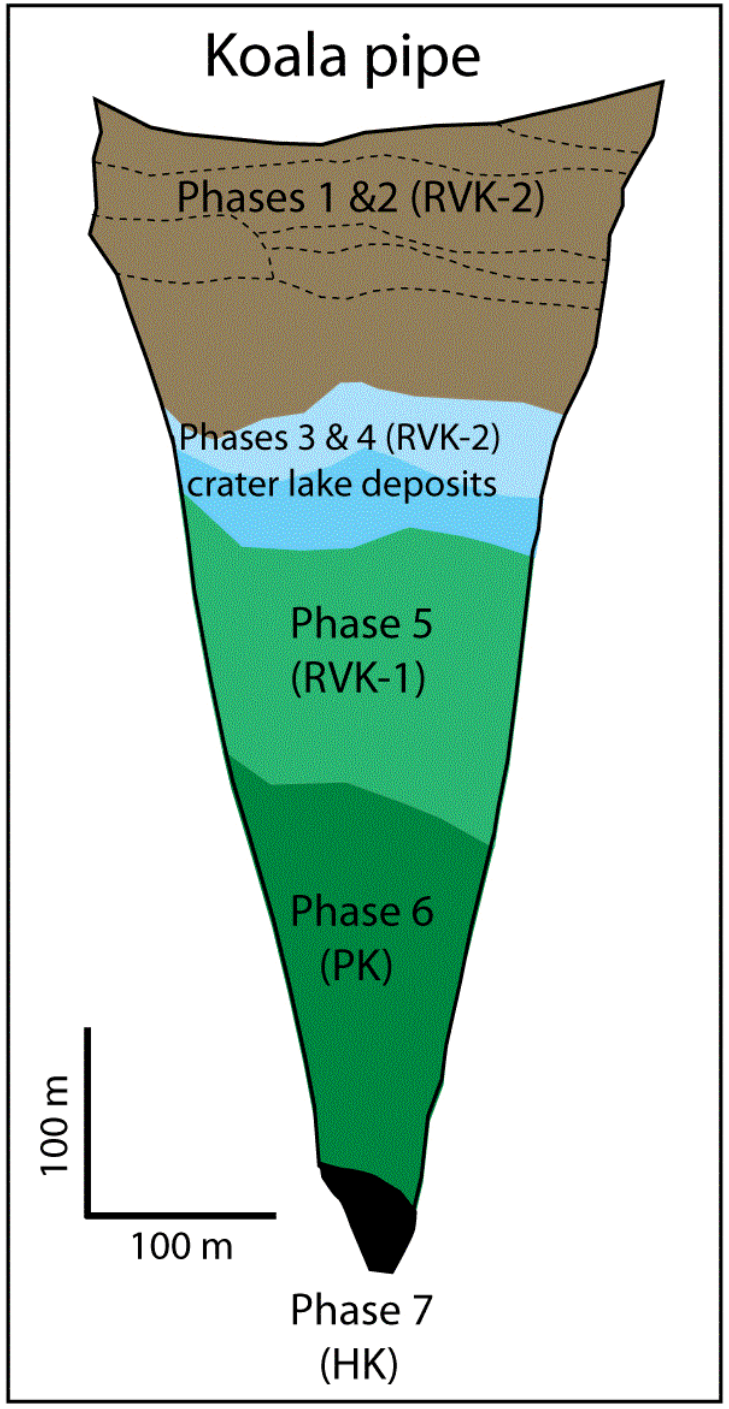
Specific conditions (T &P) of formation within the mantle give the minerals of the diamond-bearing xenoliths as well as the ones of the associated kimberlites some specific chemical compositions that can be used to differentiate them from other rocks.

The characteristics of these indicator minerals are widely used in diamond exploration to identify anomalies in surficial materials, and to trace them back to their source.





Kimberlites range in age from 25 to 2000 Ma. A significant majority of them are between 50 and 150 Ma in age.



Geological cross section of the steep sided, inverted cone shaped Koala kimberlite body, Ekati Mine, Lac de Gras field

Phase 7: hypabyssal kimberlite (HK)

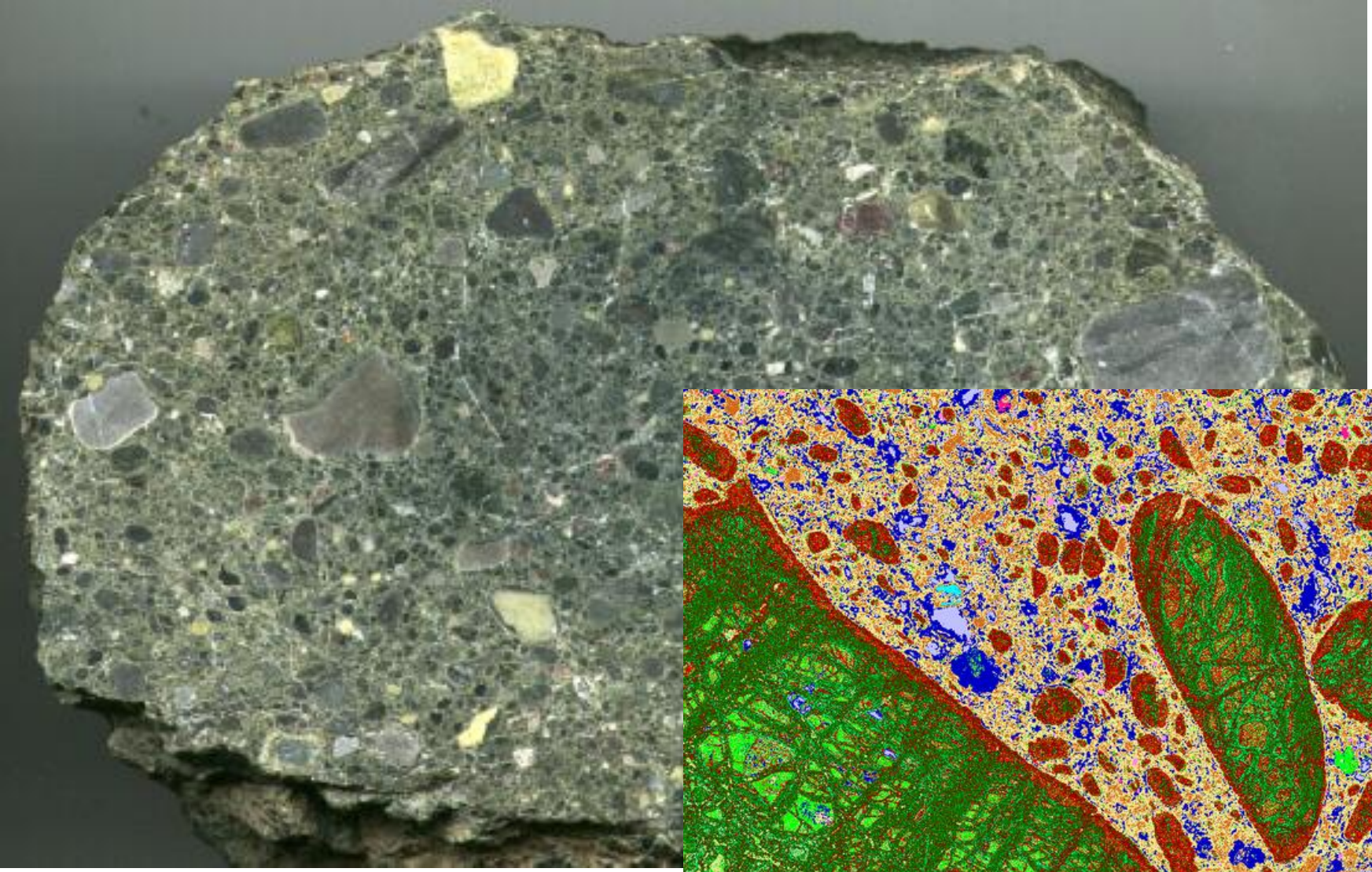
Phase 6: pyroclastic kimberlite (PK)

Phase 5: interpreted here as syn-eruption resedimented volcaniclastic kimberlite (RVK-1)

Phases 3 & 4: interpreted here as crater lake sediments

Phases 1 & 2: interpreted as post-eruption resedimented volcaniclastic kimberlite (RVK-2)

After B.A. Kjarsgaard, Geol. Surv. Canada



Accessory minerals found in kimberlites

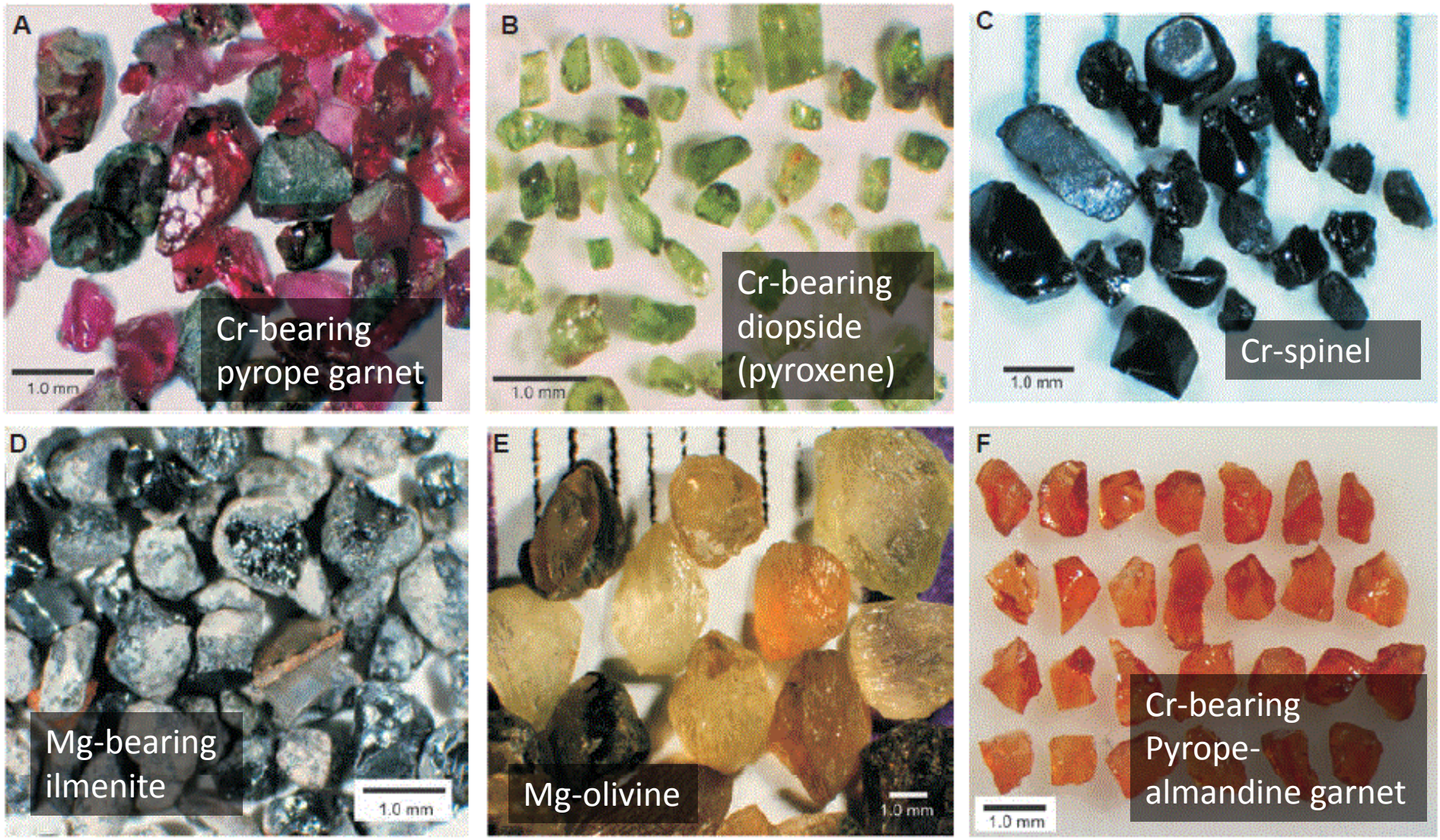
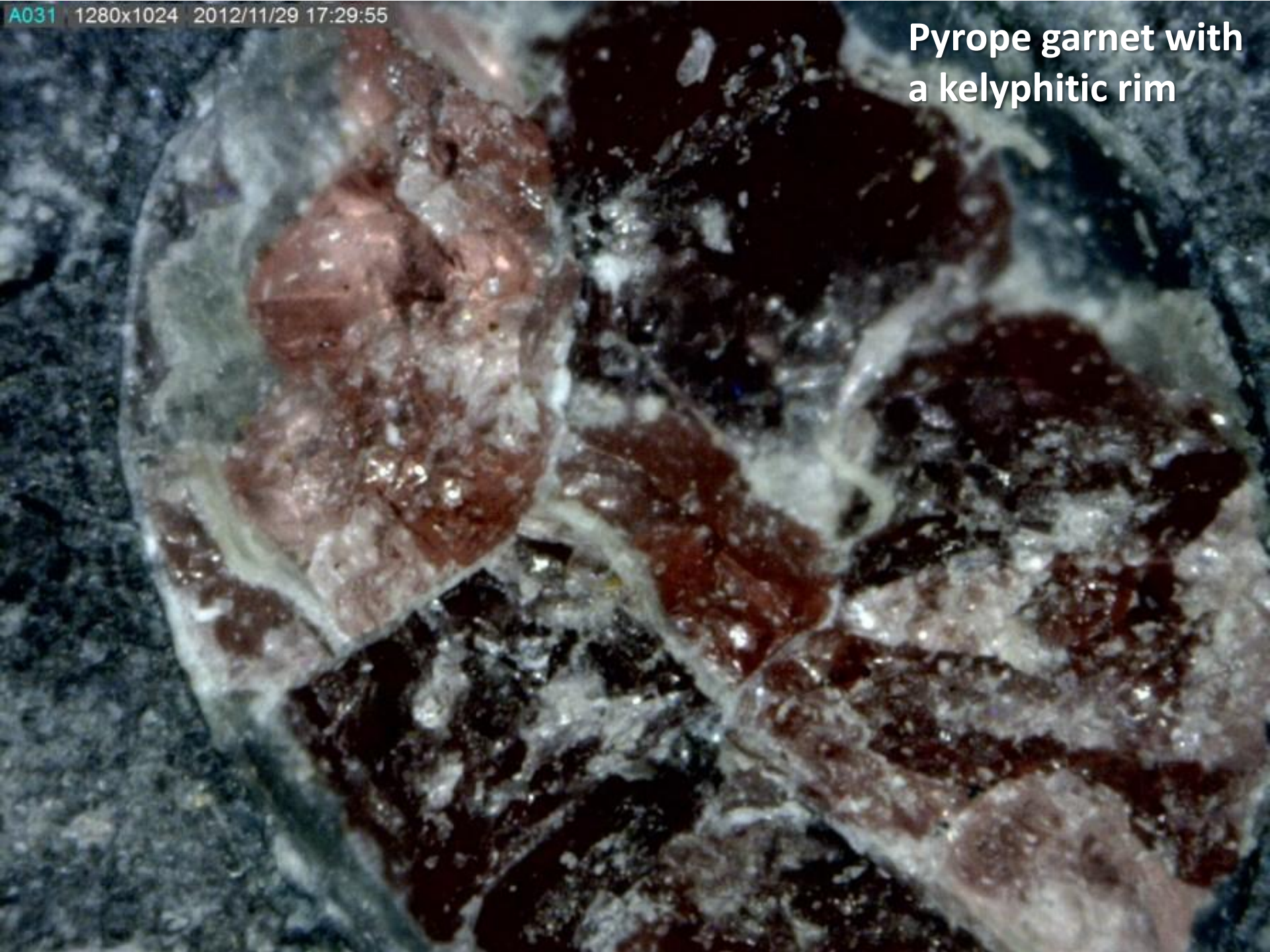


FIGURE 5. Examples of typical colours and surface features of kimberlite indicator minerals: (A) purple and mauve Cr-pyrope, some retaining kelyphite (dark); (B) emerald green Cr-diopside; (C) opaque black Cr-spinel, some exhibiting slightly resorbed octahedral form; (D) black Mg-ilmenite, both single crystals and polycrystalline morphologies shown; (E) yellow Mg-olivine; (F) orange eclogitic pyrope-almandine garnets. Photos A to E from the Geological Survey of Canada, photo F from Mineral Services Canada.

McClenaghan and Kjarsgaard, 2007

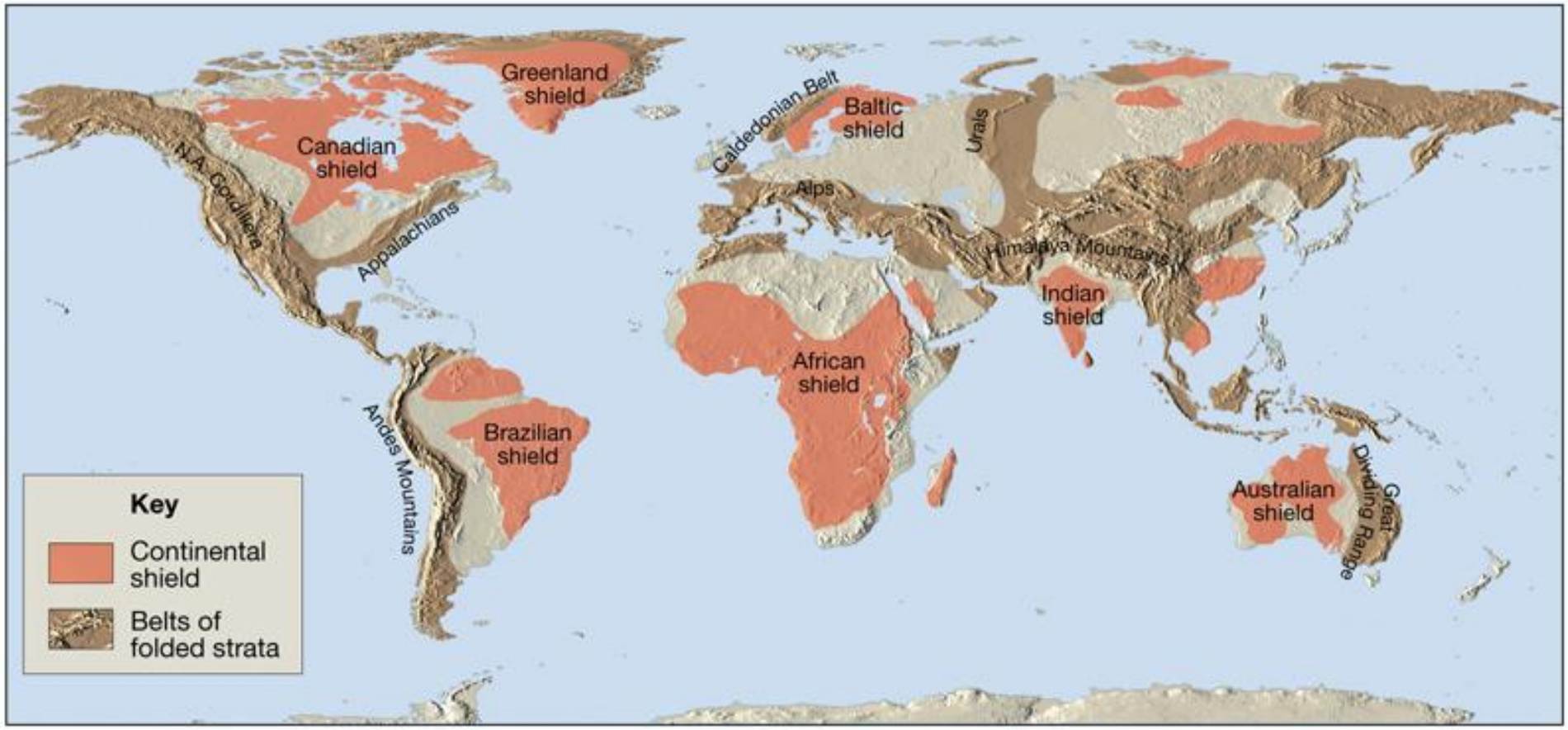

A030 1280x1024 2012/11/29 17:29:33
Kimberlite from
Fort a la Corne,
Saskatchewan


A031 1280x1024 2012/11/29 17:29:55
Pyrope garnet with
a kelyphitic rim

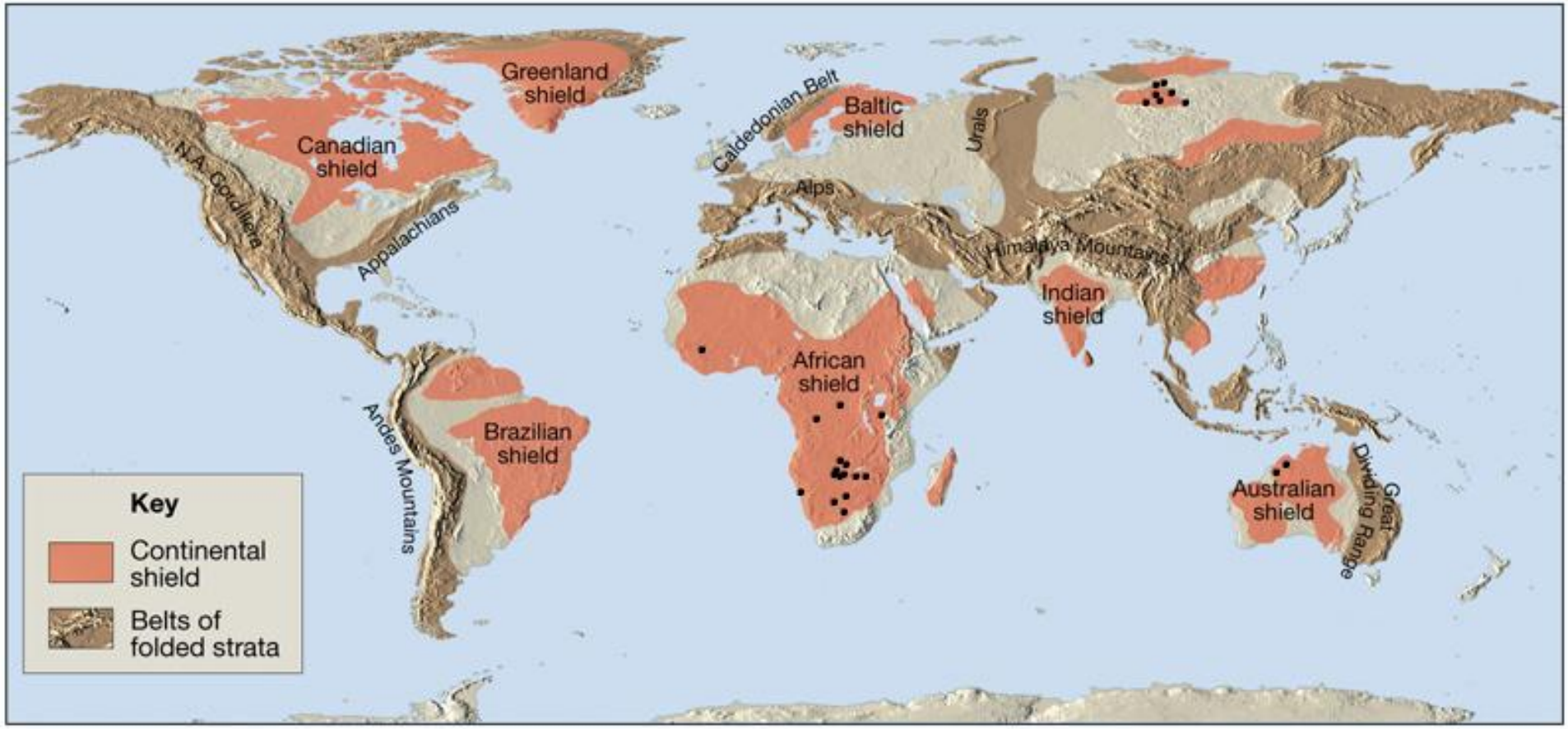

1280x1024 2012/11/29 17:31:13
Brecciated pyrope garnet

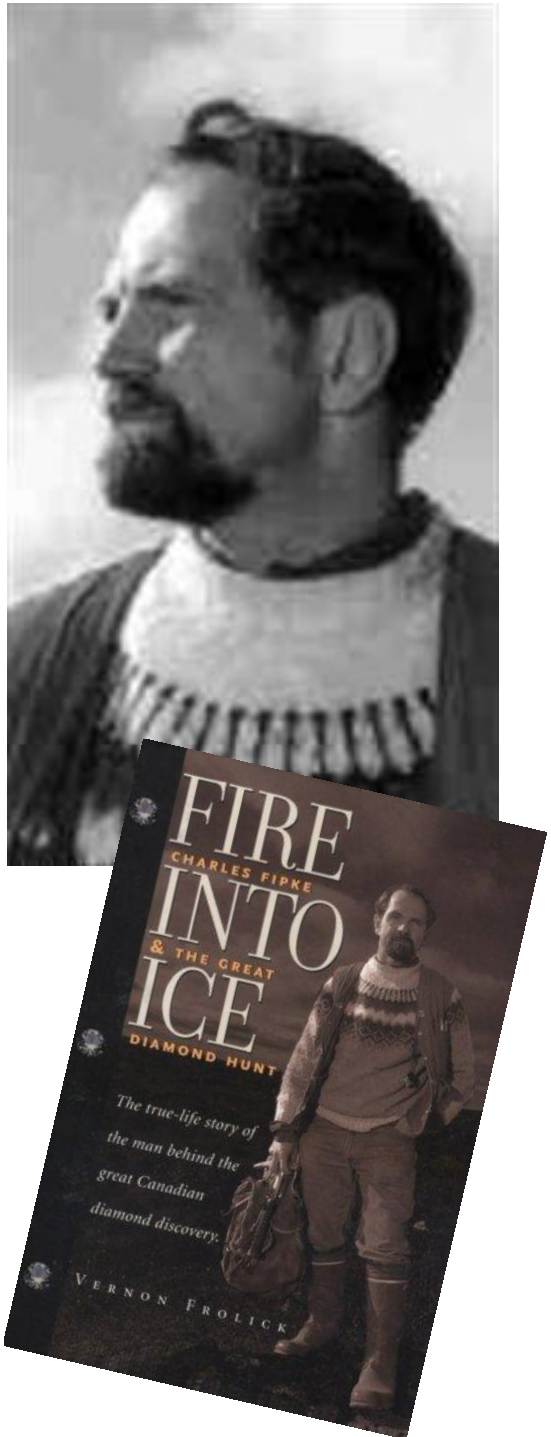

A032 1280x1024 2012/11/29 17:30:21
Pyrope garnet

Continental shield areas



Diamond mining areas (prior to 1998)

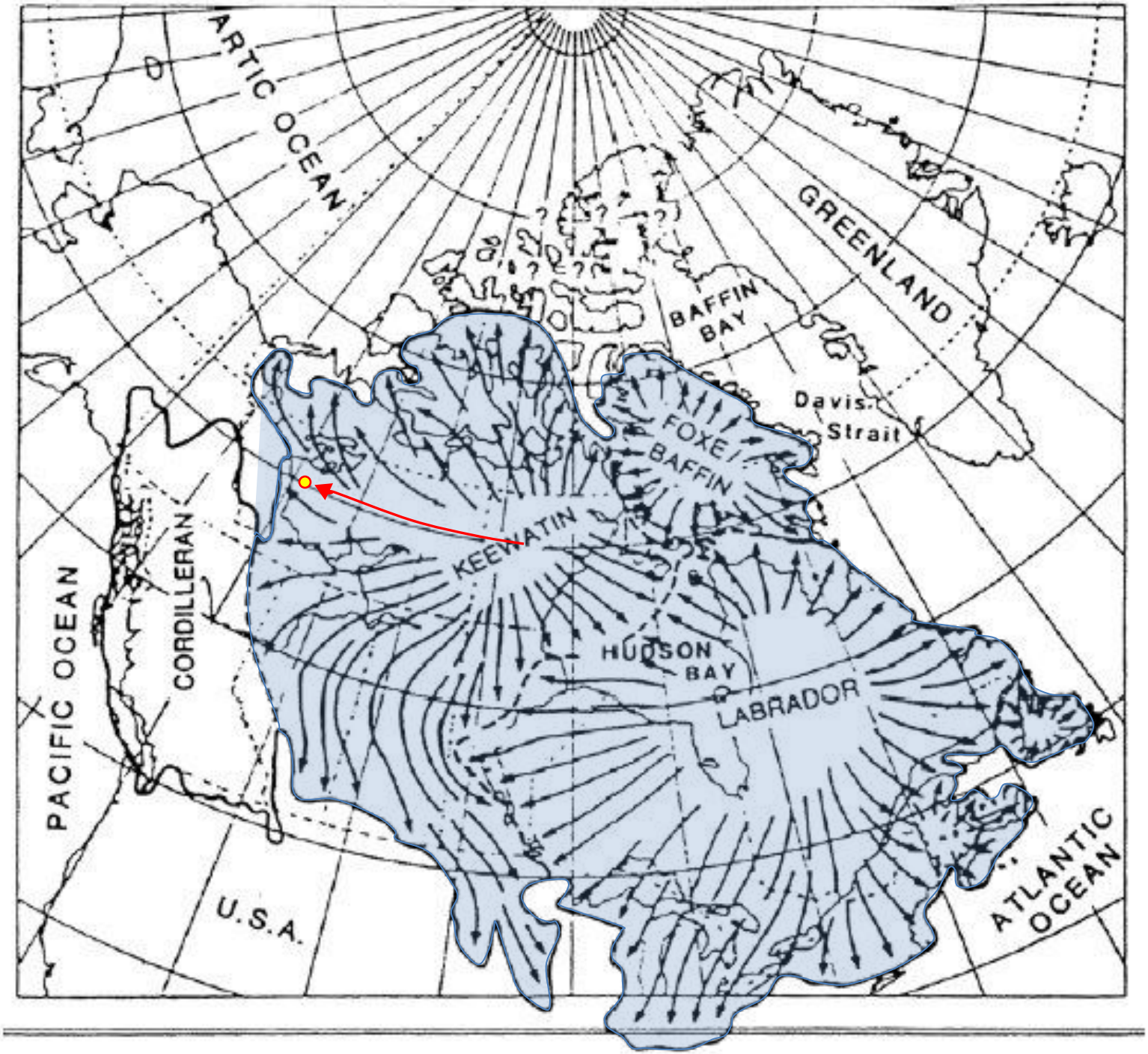




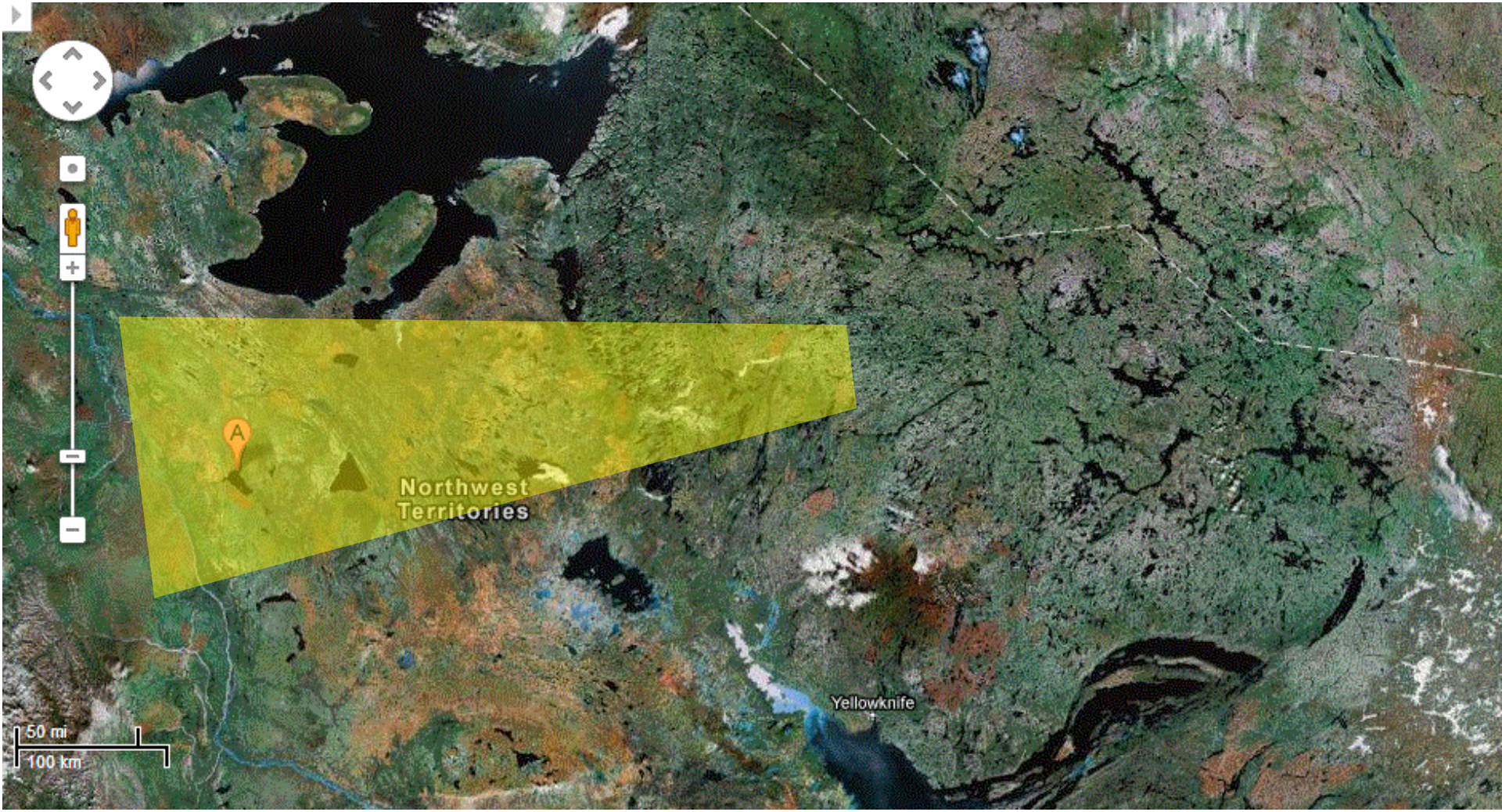
Charles (Chuck) Fipke

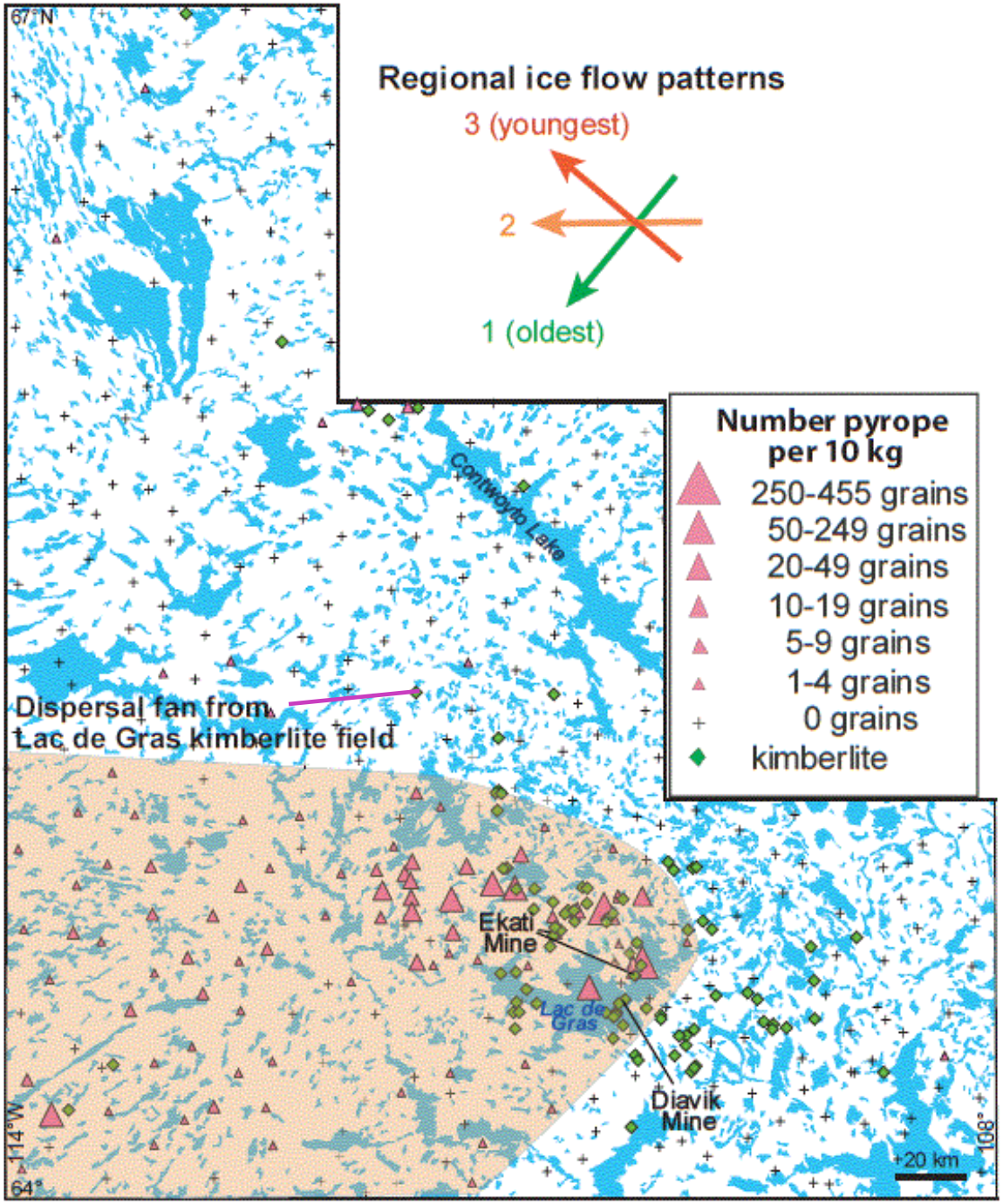
- Graduated with a UBC geology degree in the 1960s
- Worked around the world on a variety of exploration projects, including diamonds
- Arrived back in BC in the late 70s (nearly broke), but with a marvellous idea about exploration for diamonds in Canada
- Started developing methods for separating diamond indicator minerals from glacial samples
- Set up his own processing facility in Kelowna, and got involved with some companies that recognized the potential for diamonds in Canada
- Worked up and down the east side of the Rockies with very limited success
- Eventually lost the backing of the mining companies, but by then had a functioning and profitable mineral processing lab (CF Minerals)

- Fipke teamed up with geologist (and pilot) Stu Blusson in about 1983 to carry on with the project by themselves
- In 1982 they were working in the area of the NWT around the McKenzie River
- The diamond mining giant deBeers was also looking in the same area, and had a camp at Blackwater Lake
- Fipke and Blusson were finding diamond indicator minerals in the tills and GF deposits in that area, but the “anomaly” was still open to the east

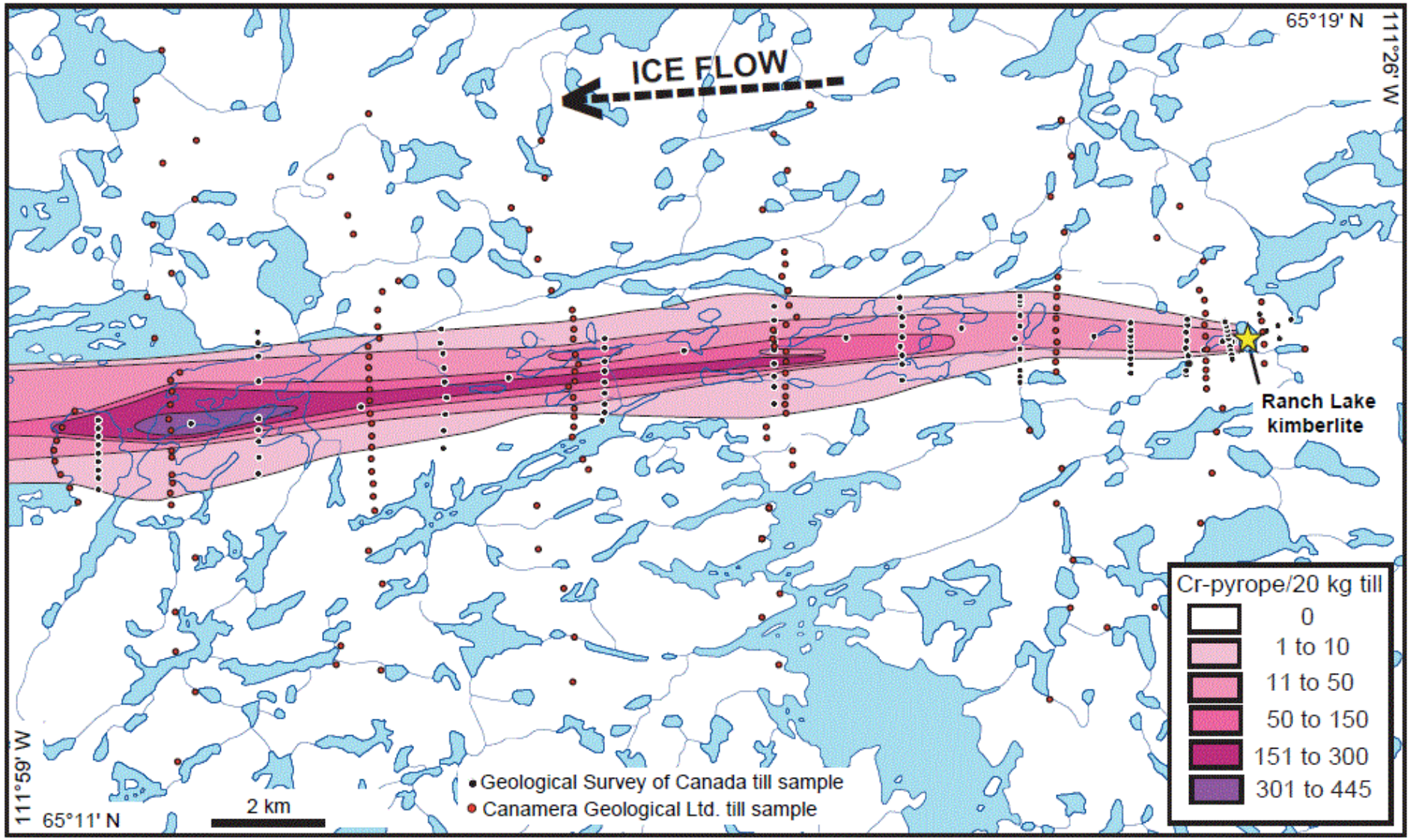

ARTIC OCEAN
GREENLAND
BAFFIN BAY
Davis Strait
FOXE BAFFIN
KEEWATIN
HUDSON BAY
LABRADOR
CORDILLERAN
PACIFIC OCEAN
U.S.A.
ATLANTIC OCEAN

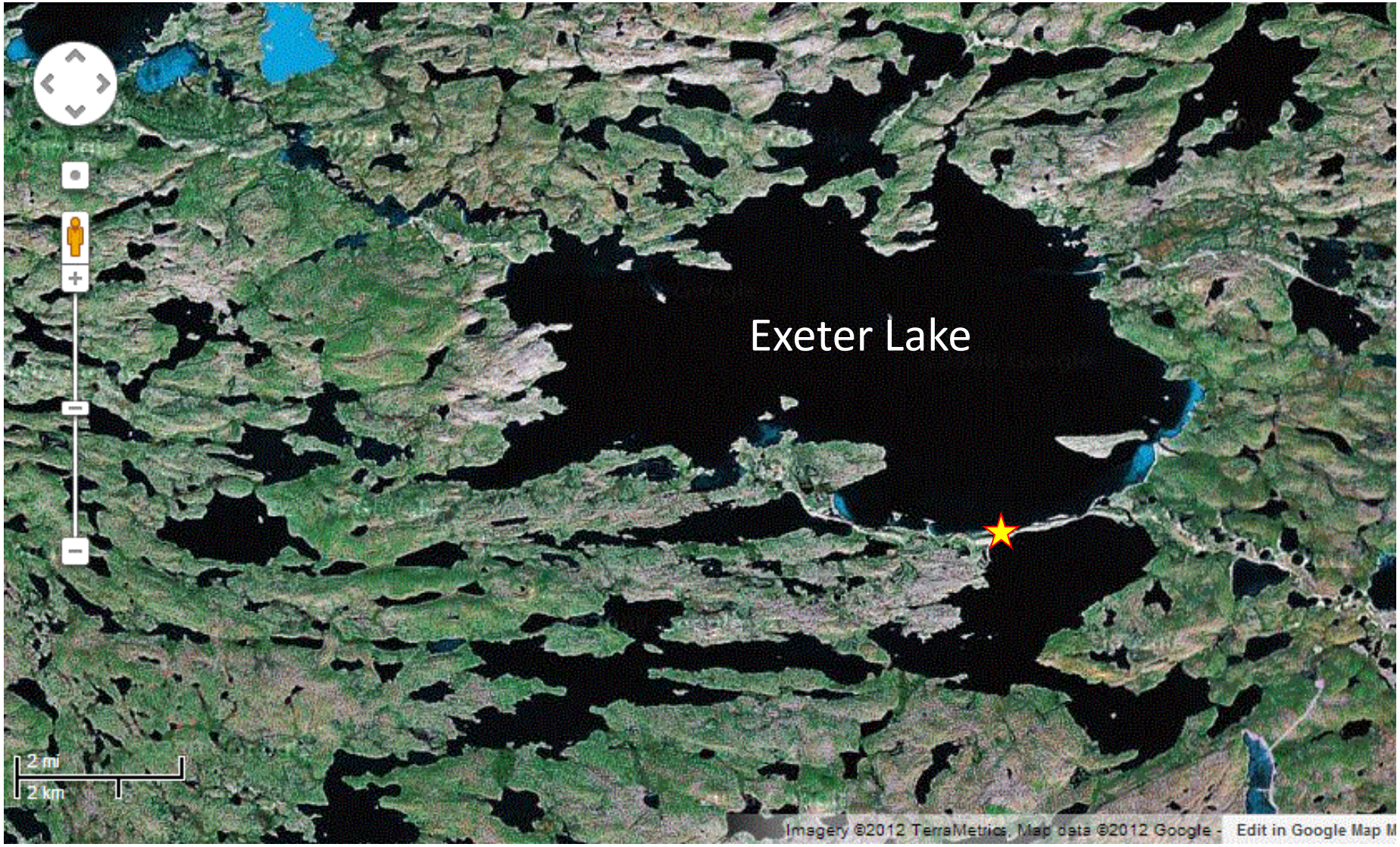
- Fipke and Blusson started working east towards the Keewatin ice divide (1200 km) sampling tills and GF materials
- By 1989 they had defined the up-ice end of the anomaly train in the vicinity of Lac de Gras, in the area between Gt. Slave Lake and Gt. Bear Lake


A
Northwest
Territories
Yellowknife
50 mi
100 km


67°N
Regional ice flow patterns
3 (youngest)
2
1 (oldest)
Number pyrope per 10 kg
250-455 grains
50-249 grains
20-49 grains
10-19 grains
5-9 grains
1-4 grains
0 grains
kimberlite
Contwoyto Lake
Dispersal fan from Lac de Gras kimberlite field
Ekati Mine
Lac de Gras
Diavik Mine
114°W
64°
108°
20 km

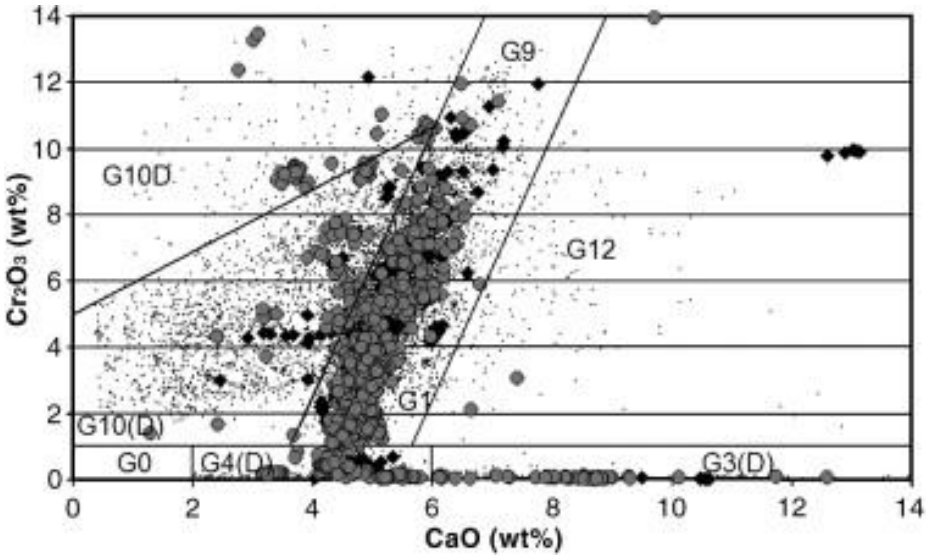
Indicator mineral train at the Ranch Lake kimberlite



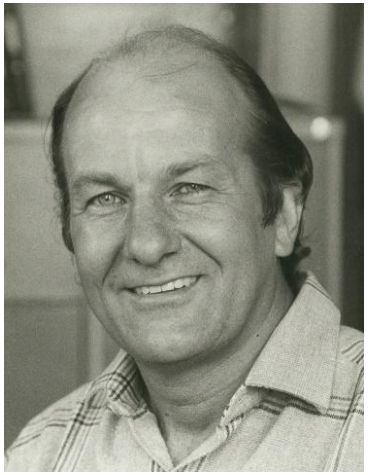


A sample from the esker on the south side of Exeter Lake had 1500 Cr-diopsides and 6000 pyrope garnets

- By this time new techniques were available to evaluate the significance of indicator minerals based on their chemistry
- It was found that while many kimberlites had pyrope garnets, chromium diopsides and other indicators, in those with significant amounts of diamonds these minerals had particular chemical fingerprints
- Fipke developed techniques for analyzing individual indicator mineral grains, and discovered that grains from the Lac de Gras area had all of the right characteristics for diamond-rich kimberlites – in fact they looked as good as any diamond mine in the world

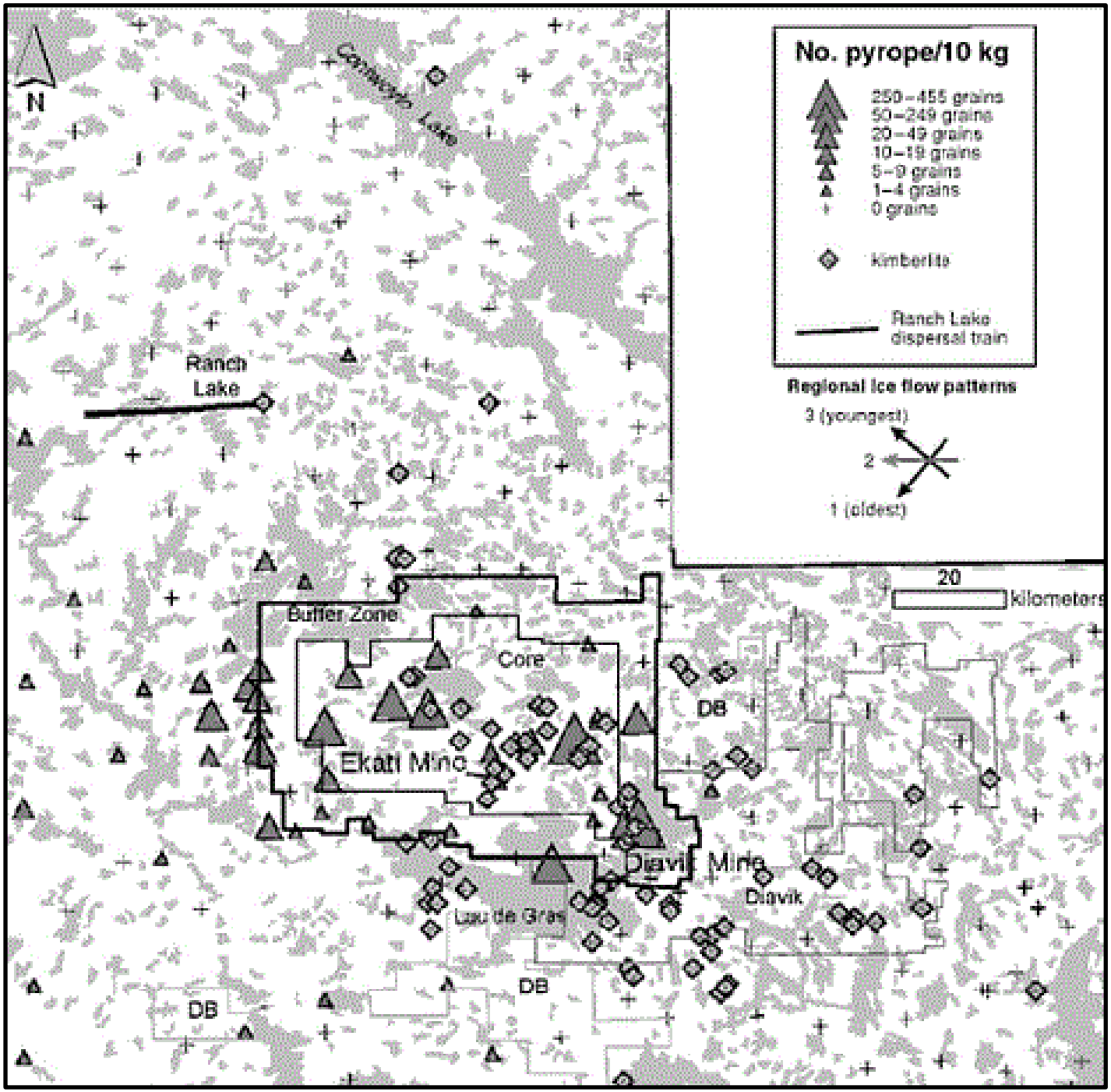


Cr and Ca levels in pyrope garnets from the Garnet Lake area, Greenland (Hutchison and Frei, 2009)



John Gurney, University of Cape Town

- In 1988 Fipke and his crew started looking around the Lac de Gras area for the kimberlites that were the source of the indicator minerals, but they found nothing, just more and more G10 garnets and Cr-diopsides
- In the summer of 1989, knowing they couldn't wait any longer, they started staking – a total of 1600 square km

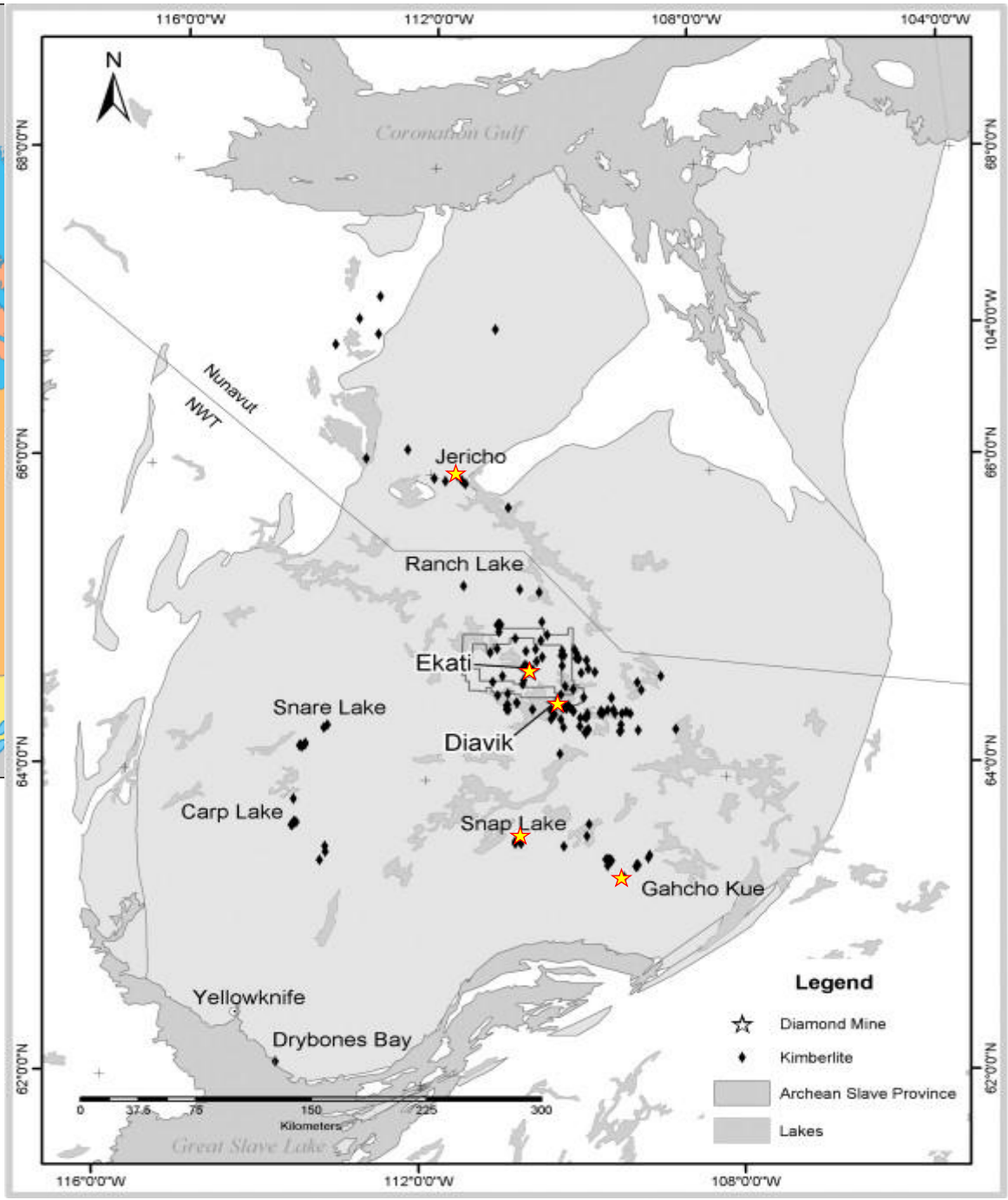


In 1990 Fipke and Blusson made a deal with the Large Australian mining company BHP to fund further exploration. They staked more land in a buffer zone around the original claim block, and then in 1991 they drilled beneath Little Point Lake and discovered a diamond-bearing kimberlite.

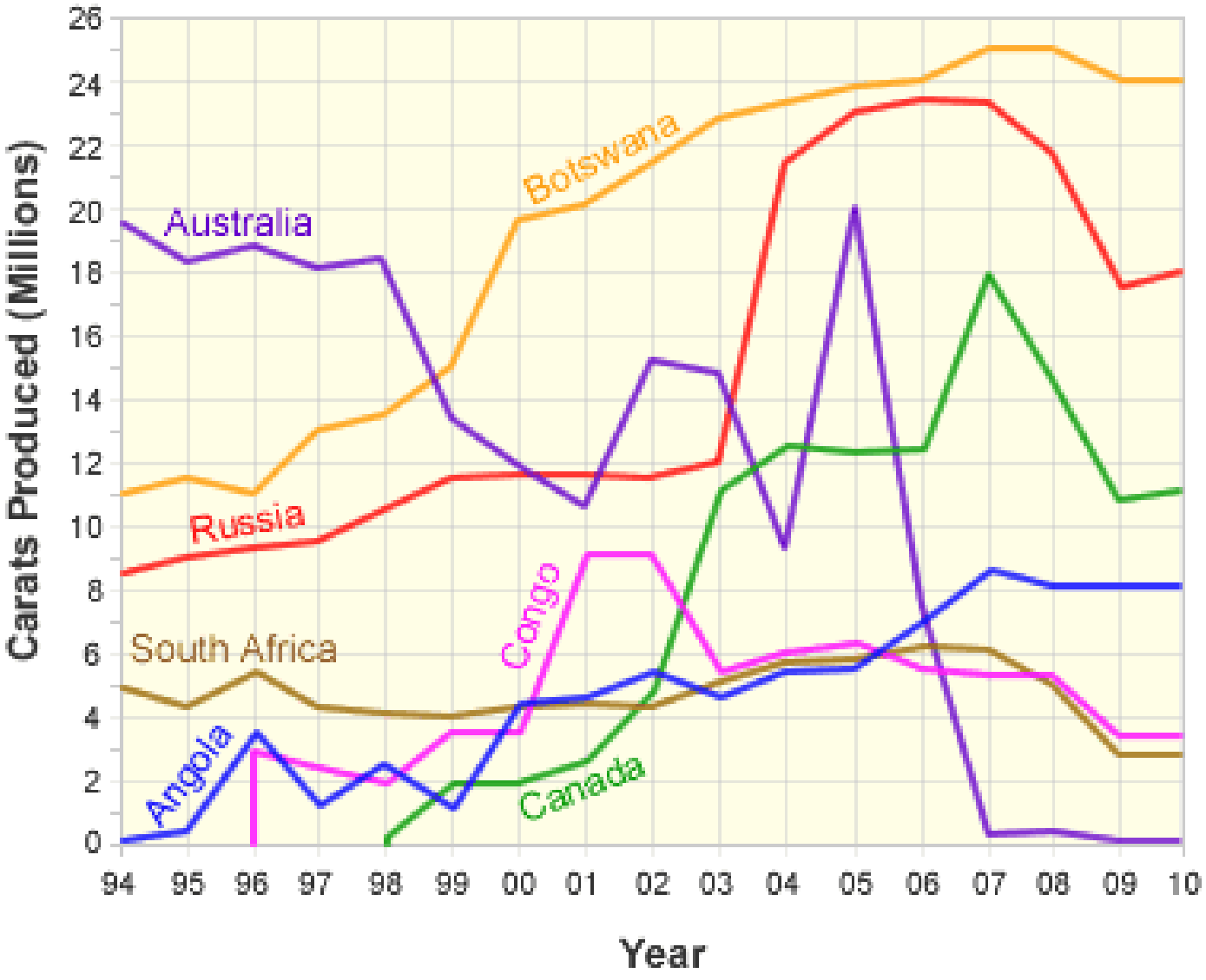
- The announcement of their discovery sparked the largest staking rush in North American history
- Although the BHP partners had staked over 2000 km^2 they still missed some of the diamond-bearing kimberlites immediately to the south (now the Diavik Mine)
- There are now 6 diamond mines in Canada, and likely to be more in the future.

Three of the numerous open pits on the Ekati project


RUSSIA
Arctic Ocean
Beaufort Sea
UNITED STATES
Yukon Territory
Northwest Territories
Nunavut
Jericho
EKATI
Diavik
Snap Lake
Gahcho Kue
British Columbia
Alberta
Saskatchewan
Manitoba
Hudson Bay
Victor
Ontario
Pacific Ocean
UNITED STATES


116°0'0"W
112°0'0"W
108°0'0"W
104°0'0"W
68°0'0"N
66°0'0"N
64°0'0"N
62°0'0"N
N
Coronation Gulf
Nunavut
NWT
Jericho
Ranch Lake
Ekati
Diavik
Snare Lake
Carp Lake
Snap Lake
Gahcho Kue
Yellowknife
Drybones Bay
Great Slave Lake
0
37.5
75
150
225
300
Kilometers
Legend
Diamond Mine
Kimberlite
Archean Slave Province
Lakes

Major Diamond Producing Countries 1994 - 2010



Chuck Fipke and Stu Blusson are each 10% owners of the Ekati Mine project