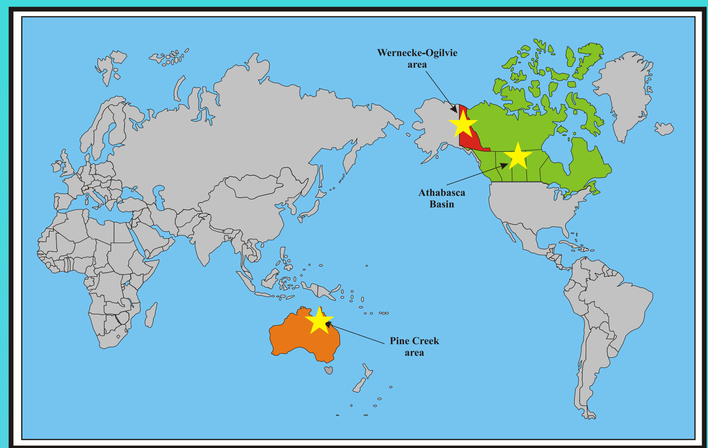

Unconformity-related Uranium Potential:clues from Wernecke Breccia

YUKON GEOLOGICAL SURVEY

Yukon Energy, Mines and Resources

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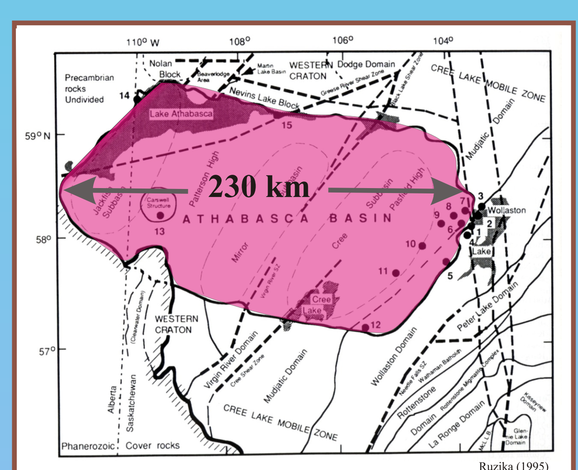
Introduction

Unconformity-type uranium deposits are the highest grade, lowest cost uranium resources in the world (*cf.* Jefferson *et al.*, 2003). They are best known from the Athabasca Basin, Saskatchewan, Canada and the Pine Creek area in the Northern Territory of Australia. The mineralisation is spatially related to regional tectonic discontinuities and occurs at, or below, a regional unconformity between late Paleoproterozoic to Mesoproterozoic clastic rocks and underlying, locally carbonaceous, Paleoproterozoic metasedimentary rocks (*cf.* Ruzicka, 1995; Tourigny *et al.*, 2001). In a generally accepted genetic model, uranium deposition results from mixing of saline, oxidised, uranium-bearing basinal brines with basement-derived reduced fluid at, or near, the intersection of fault zone(s) with the unconformity (*cf.* Kotzer and Kyser, 1995; Ruzicka, 1995; Fayek and Kyser, 1997).

In the Wernecke and Ogilvie Mountains of the Yukon uranium is hosted by Paleoproterozoic Wernecke Supergroup metasedimentary rocks and ?Paleo- to Mesoproterozoic Wernecke Breccia that are unconformably overlain by Mesoproterozoic Pinguicula Group sedimentary rocks; the Richardson Fault Array, a long-lived, regional-scale fault system is located just east of the Wernecke Mountains (*cf.* Abbott, 1997; Thorkelson, 2000). Brannerite and pitchblende returned ages considerably younger than those of the host strata and may be reflecting uranium mobilisation during tectonic and/or thermal events (*cf.* Archer *et al.*, 1986). The possibility that uranium occurrences in the Wernecke and Ogilvie Mountains fit the unconformity model needs to be verified by further study, but is intriguing and raises the possibility that significant deposits may be found.

Unconformity-type Uranium: model

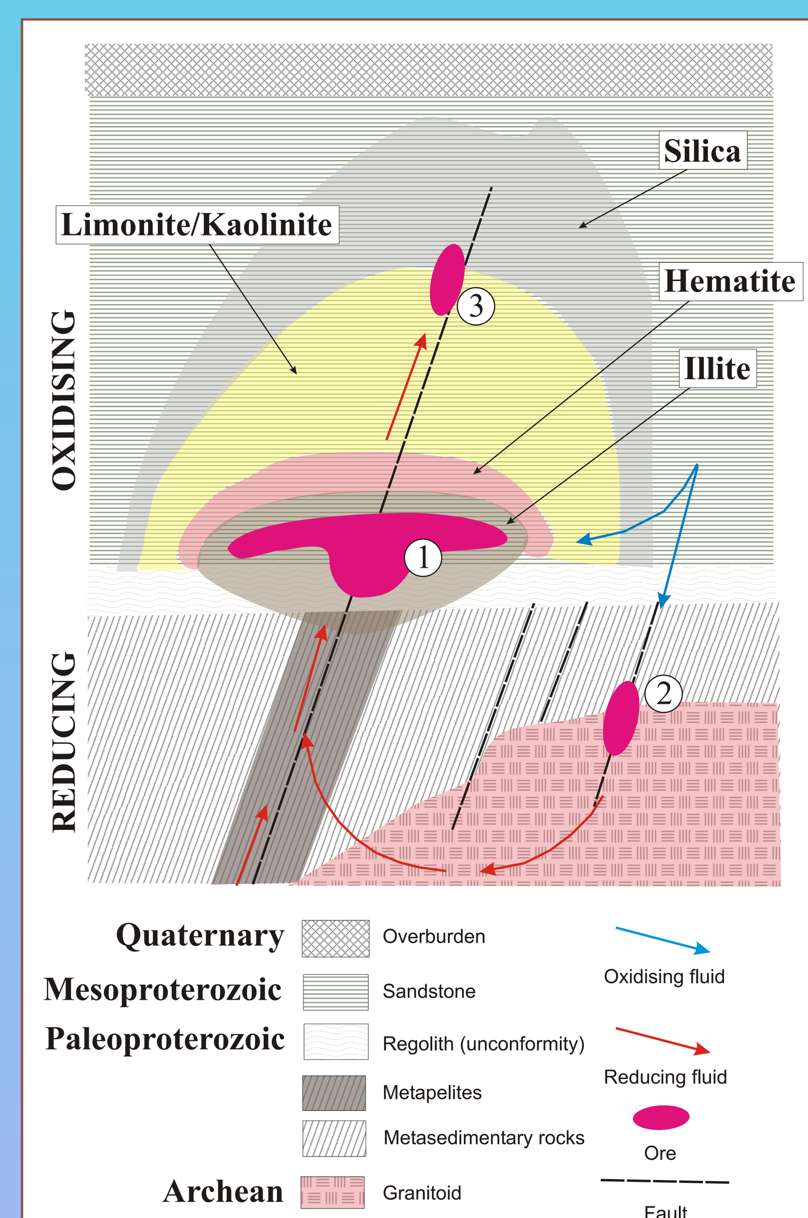
Athabasca Basin



Athabasca Basin, Canada

#	Deposit	Ore (tonnes) (1993)*	Grade (%U)	U (tonnes)
	Monometallic			
1	Rabbit Lake	5,840,000	0.27	15,769
3	Eagle Point	1,944,000	1.27	24,720
11	P2 North	2,371,000	4.22	100,000
13	Dominique-Peter	1,756,000	0.66	11,587
13	Claude	583,000	0.36	2,097
13	Cluff N	505,000	0.34	1,729
13	Cluff OP	60,000	0.28	150
13	Dominique-Janine N	23,000	3.8	874
13	Dominique-Janine	95,000	5.8	5,510
	Polymetallic			
10	Cigar Lake	902,000	12.2	110,000
13	Cluff D	128,000	3.41	4,370
2	Collins Bay A	140,000	4.83	6,500
2	Collins Bay B	3,000,000	0.38	11,400
2	Collins Bay D	120,000	1.86	2,500
12	Key Lake	3,518,000	1.99	70,000
6	McClean Lake	352,000	1.53	5,385
9	Midwest	1,200,000	1.6	19,300

From Ruzicka (1995)
* may not conform to NI43-101 standards for resource calculation



Conceptual model for unconformity-associated deposits in the Athabasca Basin. Arrows indicate flow paths of oxidised and reduced fluids. *After Ruzicka (1995).*

KEY FACTORS:

- Paleoproterozoic basement that contains carbonaceous material (& is enriched in U)
- Unconformably overlying permeable Mesoproterozoic sedimentary rocks (e.g. sandstone, conglomerate)
- Oxidised, saline, Ca-Na brines that are capable of scavenging U
- Reducing environment to precipitate U out of the fluid (e.g. carbonaceous rocks)
- Mineralisation is structurally controlled (regional and local scales) and likely related to tectonic/thermal events

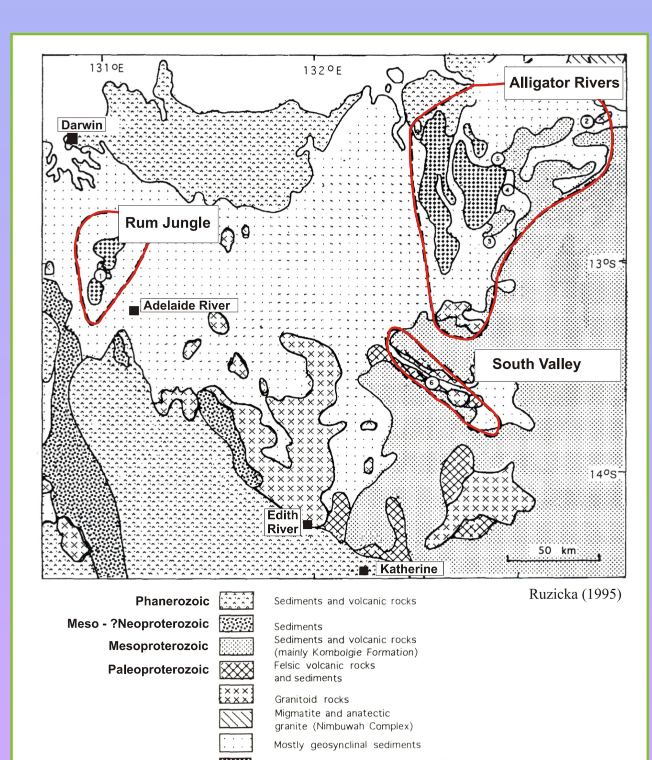
Mineralisation occurs:

① At the unconformity

② In rocks below the unconformity

③ In sedimentary rocks above the unconformity

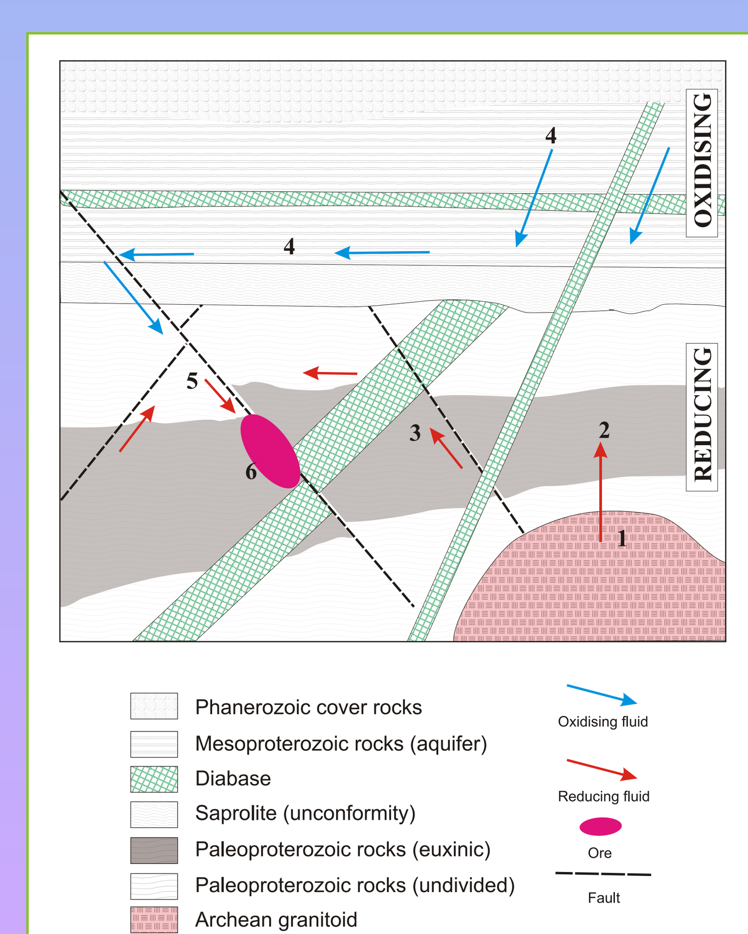
Pine Creek area



Pine Creek area, Australia

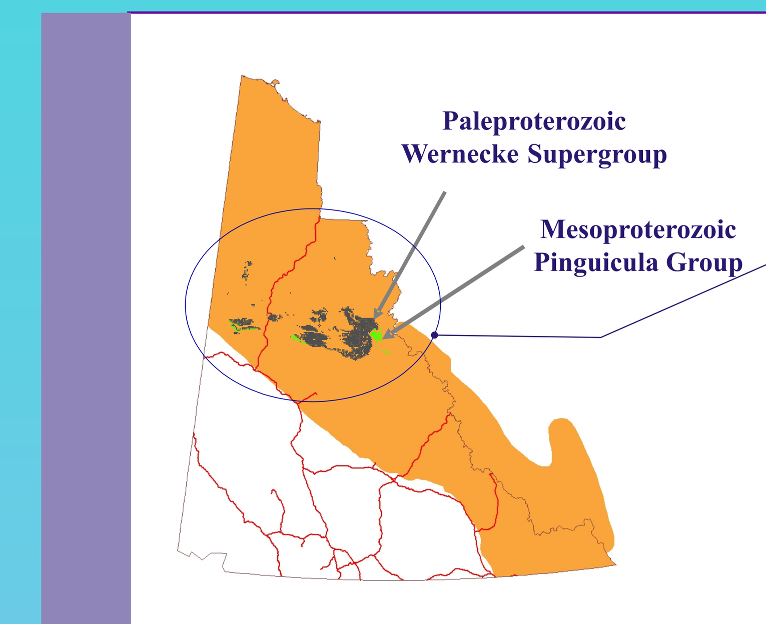
#	Deposit	Ore (tonnes) (1993)*	Grade (% U)	U (tonnes)
	Monometallic			
5	Jabiluka 1	1,373,000	0.21	2,883
5	Jabiluka 2	52,422,000	0.33	172,992
3	Koongarra	4,946,000	0.23	11,278
2	Nabarlek	558,000	1.56	8,700
4	Ranger 1	12,057	0.27	32,915
4	Ranger 3	42,425	0.17	72,123

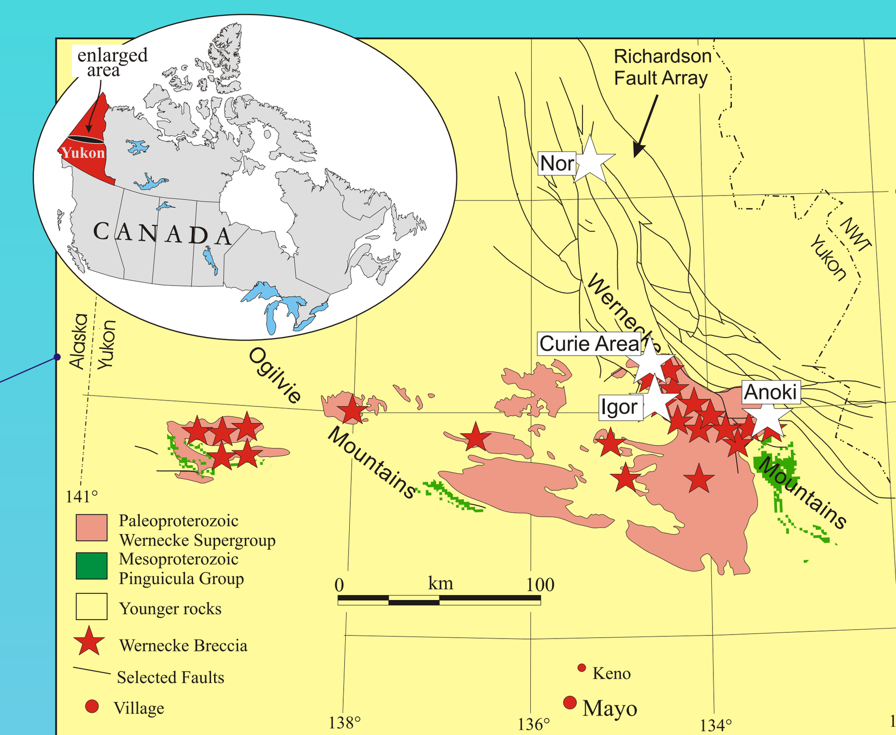
From Ruzicka (1995)
* may not conform to NI43-101 standards for resource calculation



Deposit model for unconformity-associated deposits in the Pine Creek area, Australia. Arrows indicate flow paths of oxidised and reduced fluids.
1) derivation of uraniferous fluids from granitoids,
2) deposition of U in carbonaceous rocks,
3) mobilisation of U by basement fluids,
4) flow of oxidised basinal fluids,
5) mixing of basement and basinal fluids,
6) ore deposition.
After Ruzicka (1995).

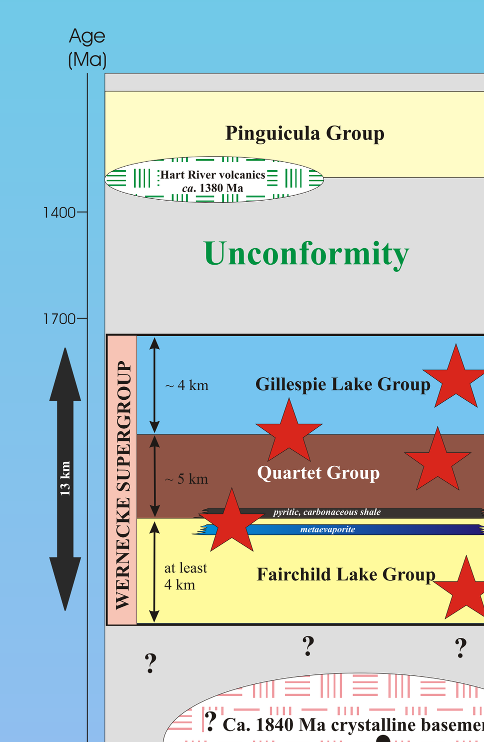
Wernecke-Ogilvie Mountains

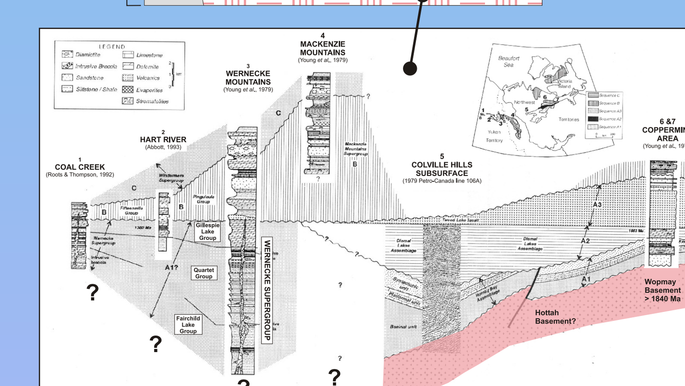




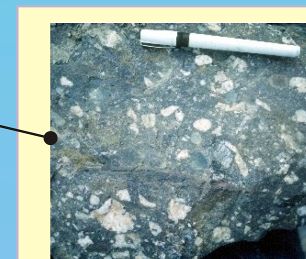
Distribution of Wernecke Supergroup, Wernecke Breccia and Pinguicula Group in the Yukon. *Modified from Thorkelson (2000).*

--------------Stratigraphy-----------------



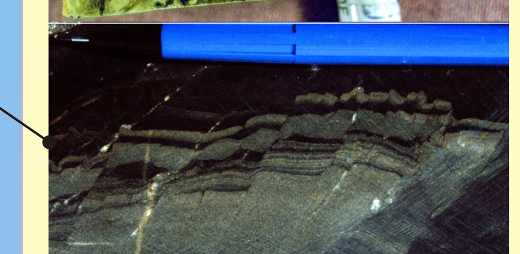


Correlation of Proterozoic rocks across northwestern Canada. Unknown basement beneath Yukon and western NWT. *Modified from Cook & MacLean (1995).*



Conglomerate and sandstone occurs at the base of Pinguicula Group

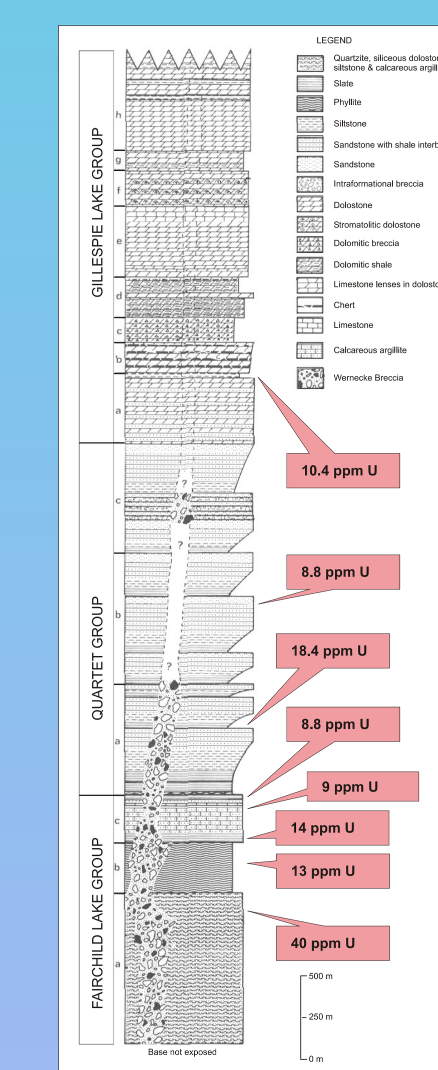
Gillespie Lake Group: dominantly dolostone; lesser shale & siltstone



Quartet Group: dominantly fine-grained sedimentary rocks including carbonaceous shale

Fairchild Lake Group: dominantly calcareous siltstone, shale and fine-grained sandstone; lesser limestone & evaporites

---------Possible sources of uranium---------



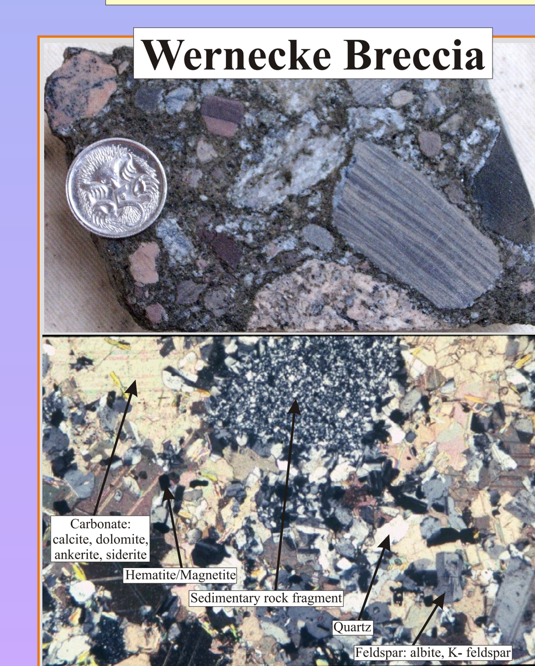
Elevated levels of uranium occur in some strata of the WSG. These strata could have acted as a source of uranium for unconformity-type mineralisation:

- **FLG phyllite & siltstone (9-40 ppm)**
- **QG siltstone (8.8 - 18.4 ppm)**
- **GLG siltstone (10.4 ppm)**

Wernecke Breccia contains disseminated uranium mineralisation and could also have acted as a source of uranium.

------------Wernecke Breccia-----------------

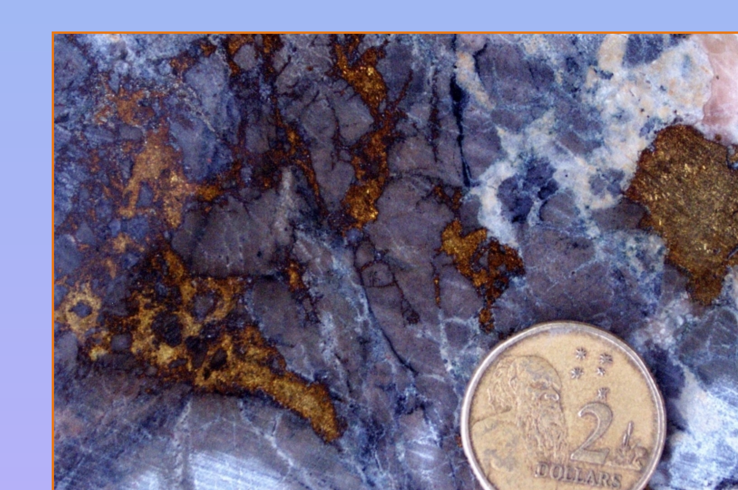
A large-scale Proterozoic breccia system, known as Wernecke Breccia, occurs in areas underlain by Wernecke Supergroup (WSG).



Breccia clasts are largely derived from WSG sedimentary rocks.

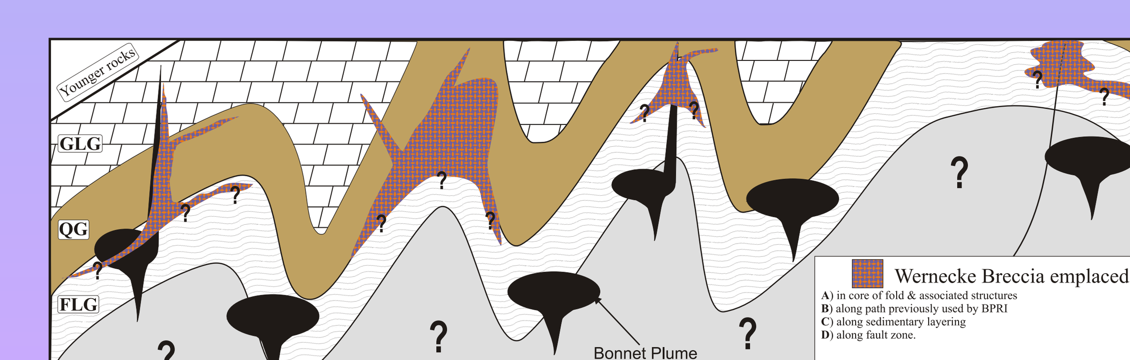
Breccia matrix is made up largely of rock fragments, carbonate, feldspar & quartz.

Wernecke Breccia is associated with Fe oxide-Cu-Au (± U, Co) mineralisation that occurs as: veins and disseminations; breccia clasts & matrix.



Chalcopyrite-pyrite in the breccia matrix

Hematitic Wernecke Breccia



Wernecke Breccia formed syn- to post-deformation (Racklan Orogeny) in weak and permeable zones within WSG.

See reverse side for more information

Unconformity-related Uranium Potential:clues from Wernecke Breccia

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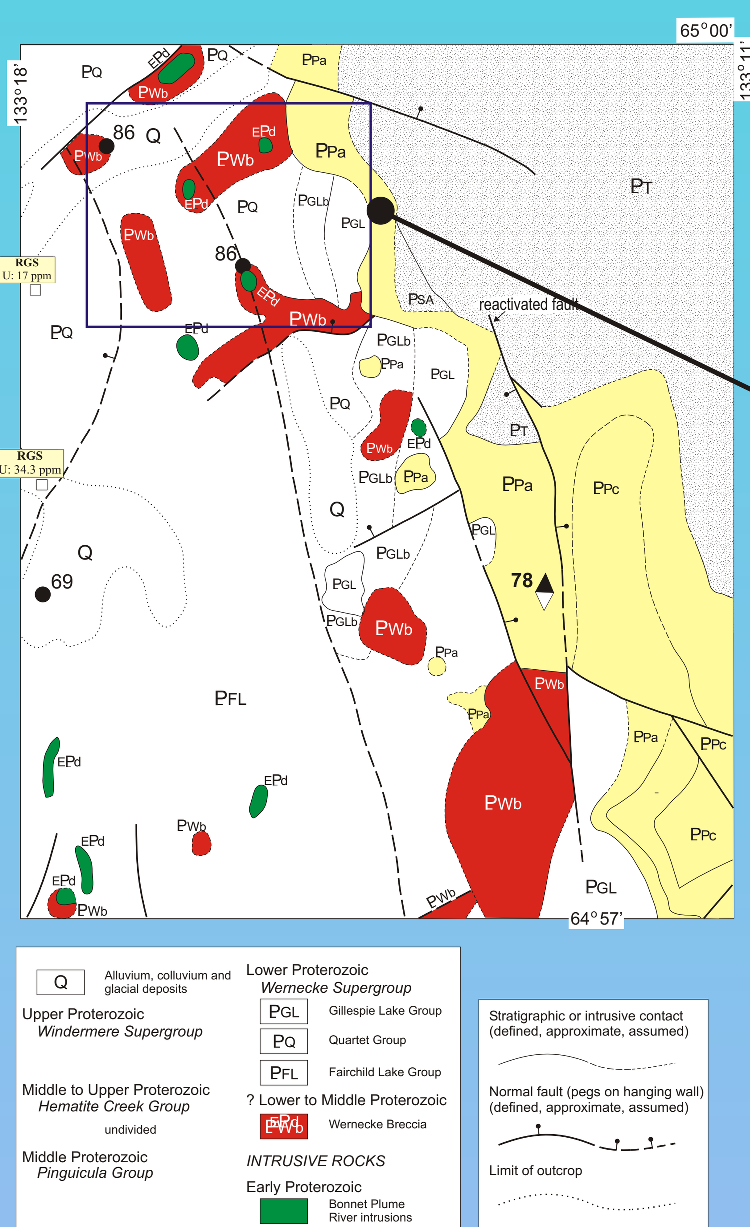
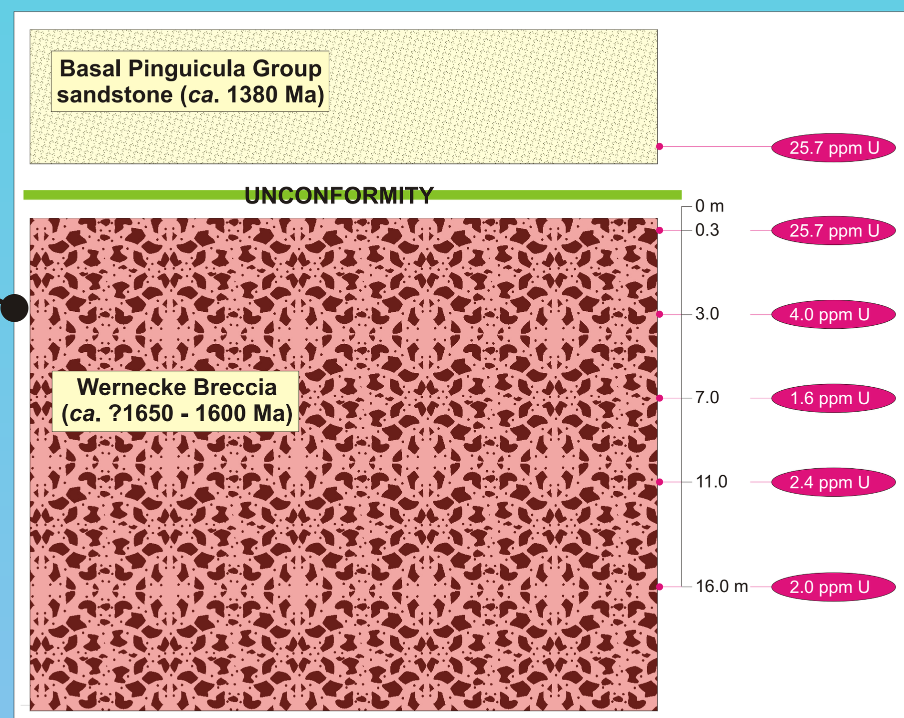
----------Styles of Mineralisation----------------

Uranium mobilisation

Uranium mineralisation occurs disseminated in Wernecke Breccia but is also in veins & fractures that cut breccia and WSG rocks. The ages of pitchblende and brannerite in the veins is significantly younger than the host rocks. The age dates correspond approximately with regional tectonic and/or thermal events suggesting the mineralisation may be related to uranium mobilisation during fluid flow driven by such processes. *Modified from Thorkelson (2000). Ages of uranium minerals from Archer et al., (1986)*

Mineralisation at the unconformity

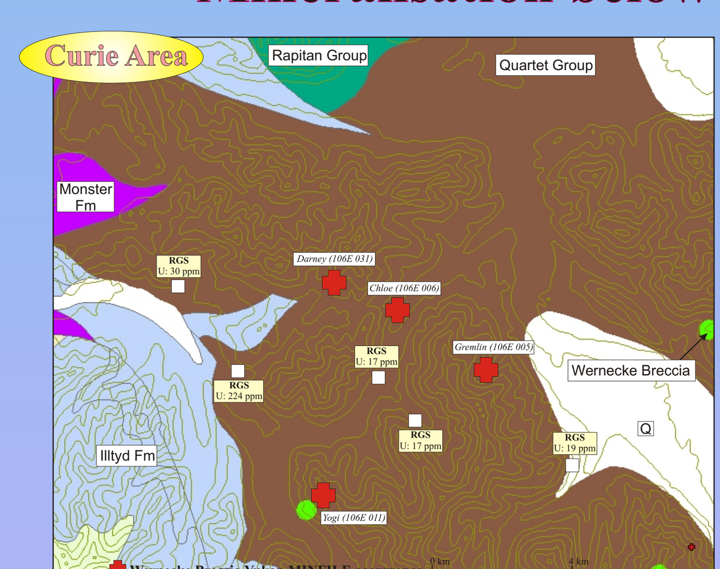




	U ppm	Th ppm	Pb ppm	Ni ppm
Pinguicula Group basal sandstone (PPa)	25.7	8.1	15.7	84
Wernecke Breccia (10-30 cm below u/c with PPa)	25.7	11.5	9.0	199
Wernecke Breccia (3 m below u/c with PPa)	4.0	12.2	4.7	34
Wernecke Breccia (7 m below u/c with PPa	1.6	11.7	1.5	29
Wernecke Breccia (11 m below u/c with PPa	2.4	14.0	2.7	50

Elevated levels of uranium occur at the Pale-Mesoproterozoic unconformity. ***Data and map from Thorkelson (2000).***

Mineralisation below the unconformity

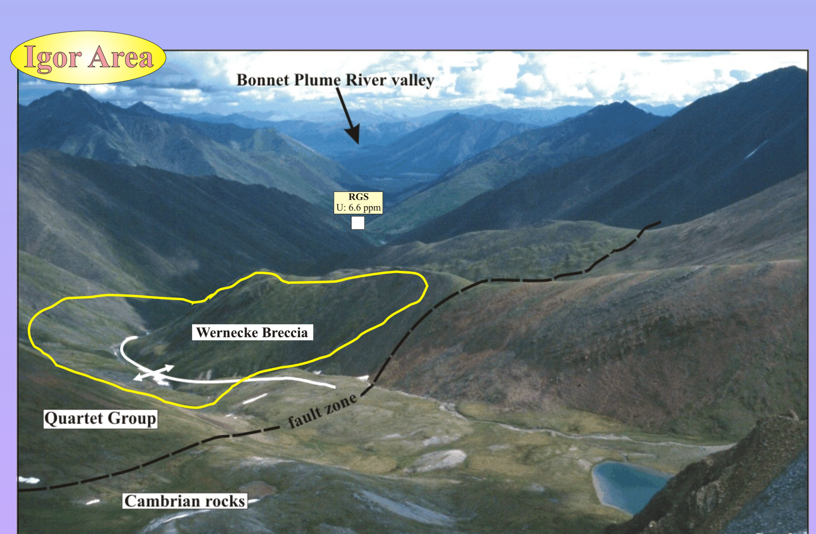


RGS samples from the Curie area returned elevated levels of uranium (17 - 224 ppm) and REE ± Ag, Au, Co, Cu, Ni, W, Mn, As.
Rock samples from the area, collected recently by Signet Minerals Inc., returned up to 54.3% U_3O_8.

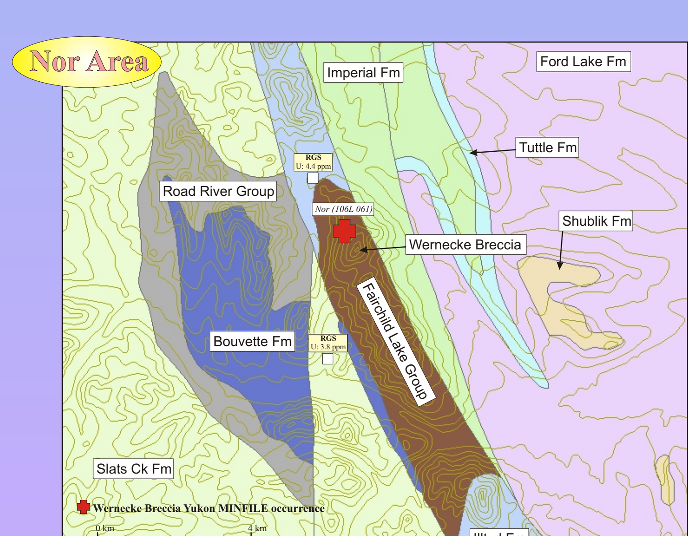
RGS values

#	Au	Ce	Co	Cu	Eu	Lu	Rb	Sm	Ta	Th	U	W	Yb	As
761407	6	99.0	15	72	0.5	0.8	160	10.0	1.4	19.0	31	3.0	2	27.0
761409	11	15.5	16	153	2.0	2.0	77	15.4	0.3	9.1	224	0.5	6	14.0
763342	11	150.0	69	182	2.0	1.5	130	11.0	2.4	27.3	17	4.0	5	101.0
763347	14	130.0	35	116	2.0	1.4	130	10.1	2.1	22.7	17	3.0	4	64.9
763348	1	110.0	33	98	1.0	1.4	120	8.4	1.6	21.9	19	5.0	4	56.8
Percentile for North American Shelf														
95th	8	120	30	76	2	0.8	150	9	1.7	17	8	2	4	26
99th	20	180	56	134	3	1.2	190	14	2.8	24	16	4	5	45

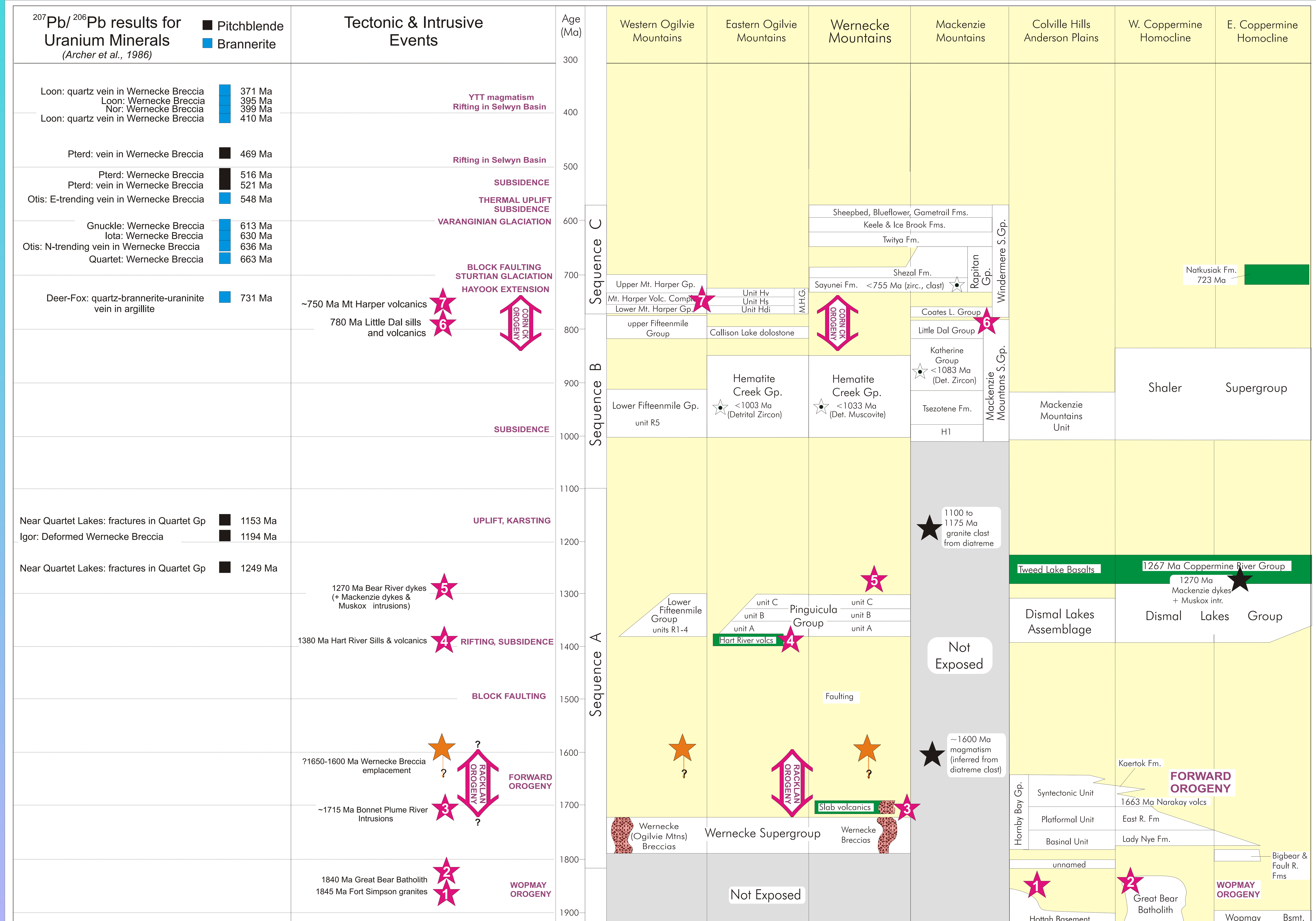
* all values in ppm except Au = ppb. Analysis by INA except Cu



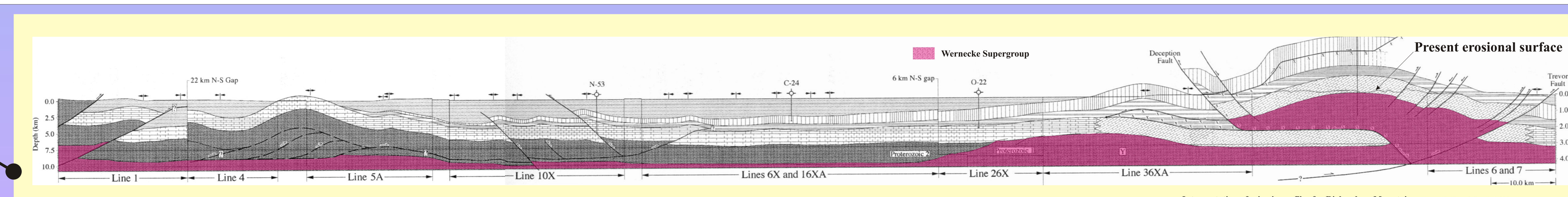
RGS samples from the Igor area returned elevated levels of uranium, REE ± Ba, Co, Cu, As.
Samples of drill core returned elevated levels of U, Cu, and Au - e.g. 0.241 % U_3O_8, 7.1% Cu and 90 ppb Au over 1.52 m.



RGS samples from the Nor area returned elevated levels of uranium, REE, Co and Cu.
Rock samples of altered Fairchild Lake Group siltstone returned elevated levels of U, Au and Cu.



Data from exploratory hydrocarbon wells and seismic profiles indicate Wernecke Supergroup strata may underlie areas north of the main belt exposed in the Wernecke and Ogilvie mountains. Fairchild Lake Group and Wernecke Breccia are exposed at the Nor property within the Richardson Fault Array in this region.



Interpretation of seismic profiles for Richardson Mountains. *From Hall and Cook (1998).*

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