Foreword

This Miscellaneous Report includes the presentation that was prepared to accompany the release of YGS Open File 2020-42, Geology of the Keno Hill District by Peter Read, Al McOnie and Seymour Iles, and presented at the 2020 Virtual Yukon Geoscience Forum in November 2020. Because the original presentation was fraught with technical difficulties during the virtual event, the authors have subsequently prepared this version along with detailed notes in order to support the release of their new map for the Keno Hill district. The notes provided in this companion report will greatly facilitate the exploration of the many details included on the maps and cross sections in Open File 2020-42.

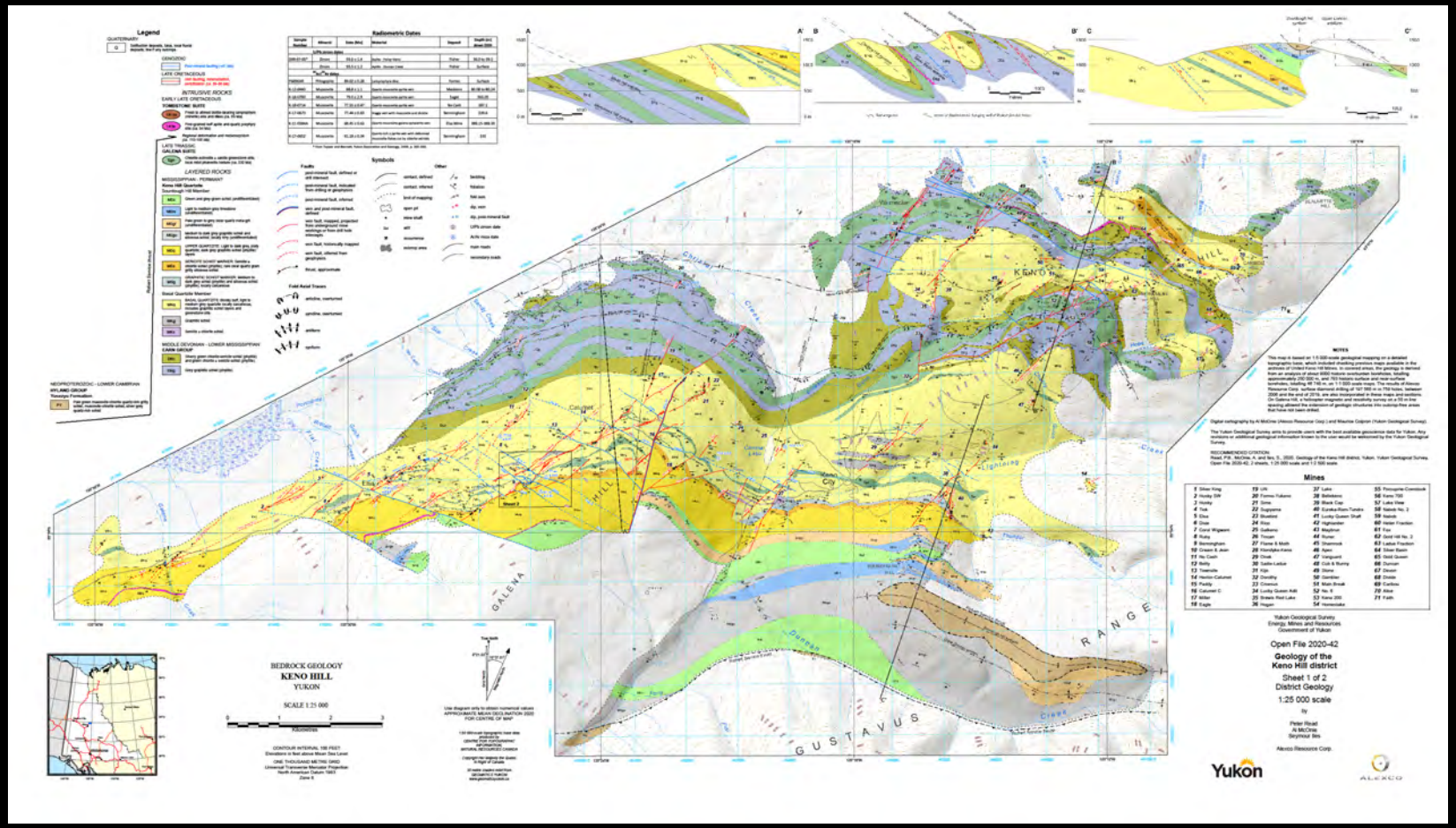
Reference

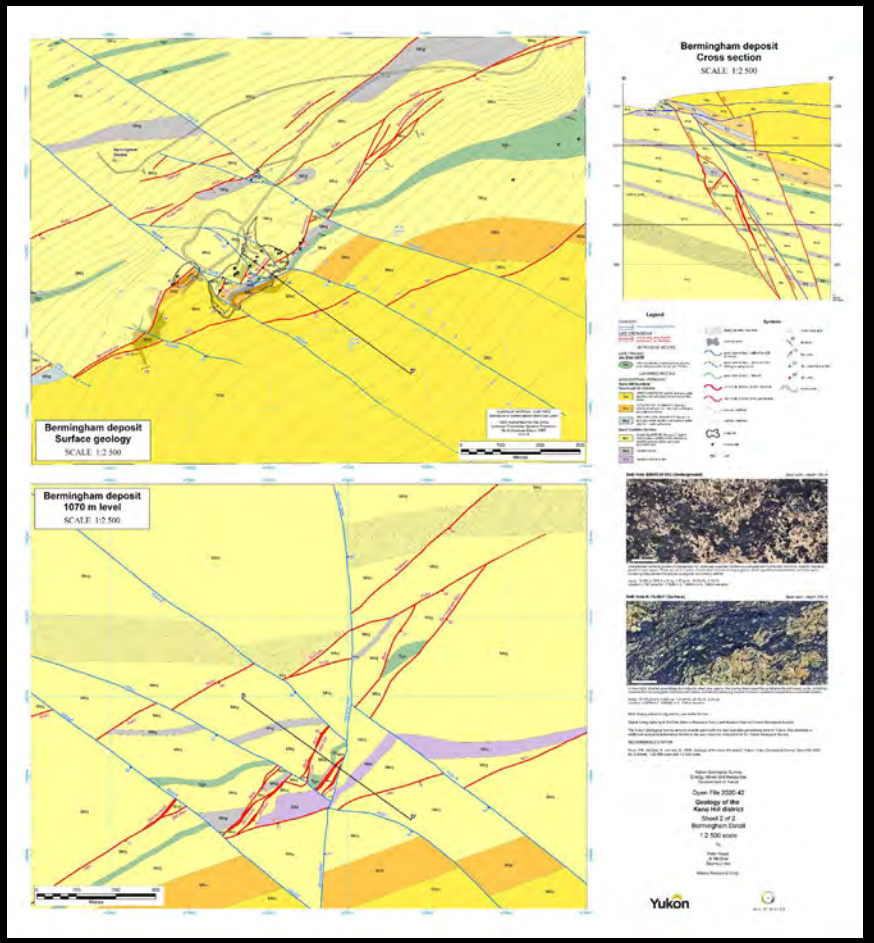
Read, P.B., McOnie, A. and Iles, S., 2020. Geology of the Keno Hill district, Yukon. Yukon Geological Survey, Open File 2020-42, 2 sheets: 1:25 000 and 1:2 500 scale. https://data.geology.gov.yk.ca/Reference/95881#InfoTab.

Geology of the Keno Hill District

Open File 2020-42

Peter Read, Al McOnie, Seymour Iles - Alexco Resource Corp
In conjunction with Yukon Geological Survey

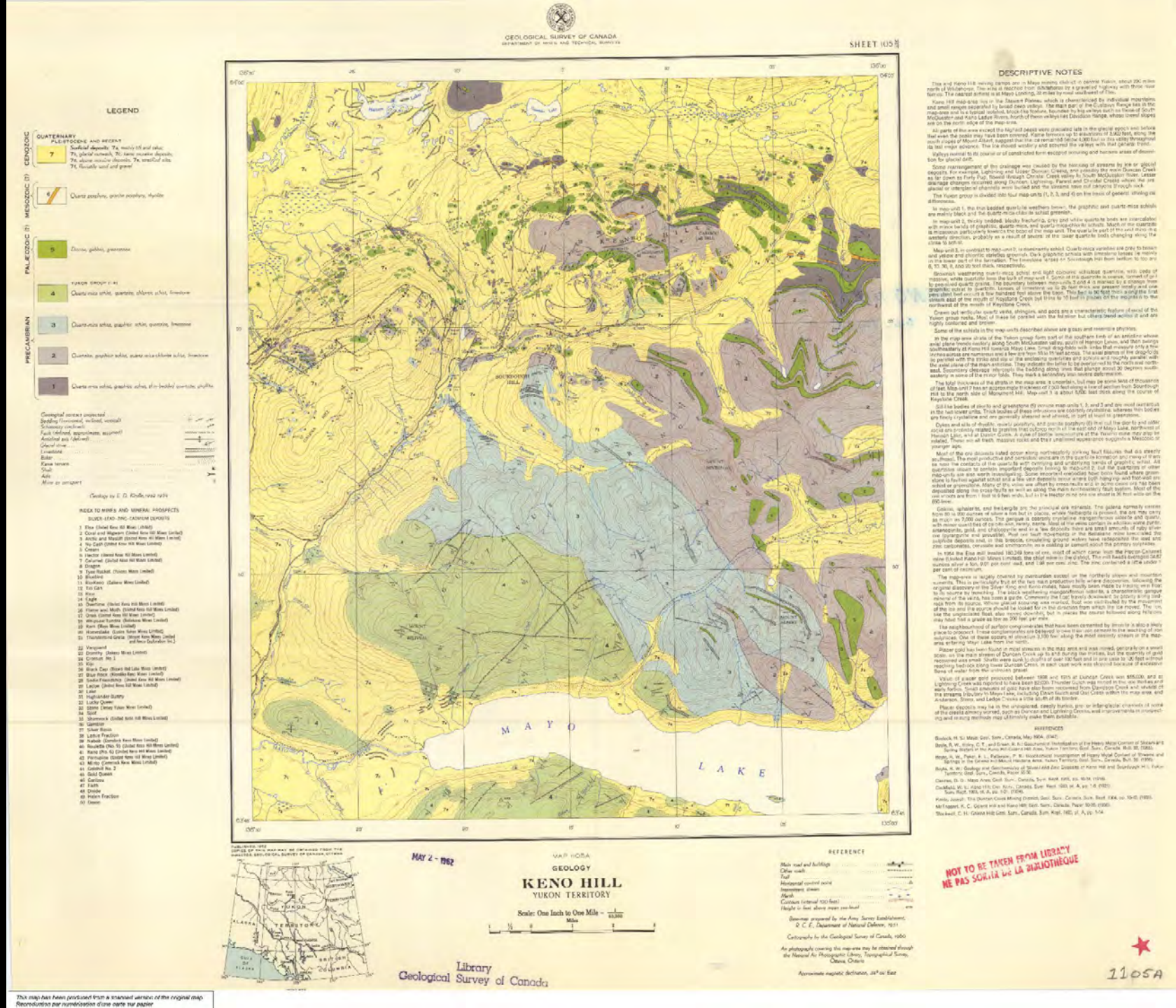




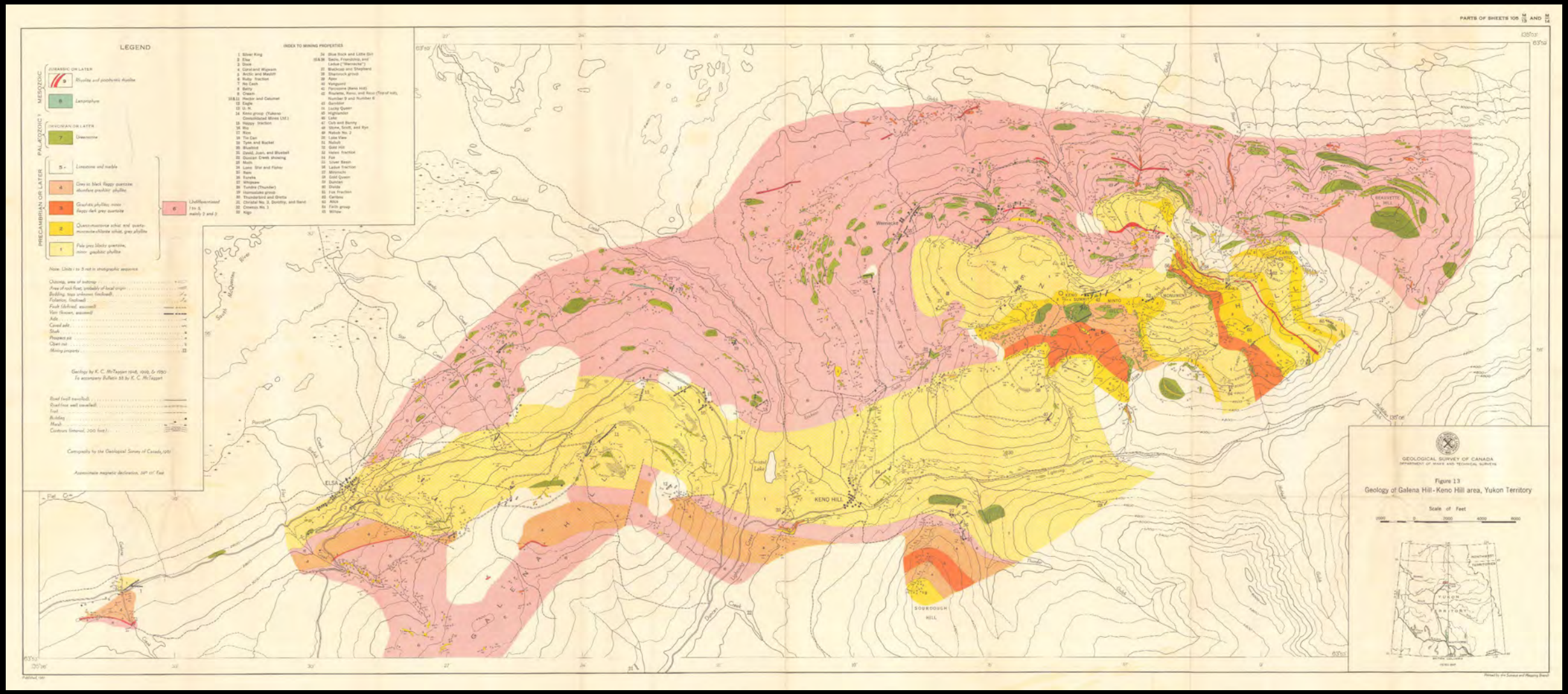
E. D. Kindle

Geological Survey of Canada

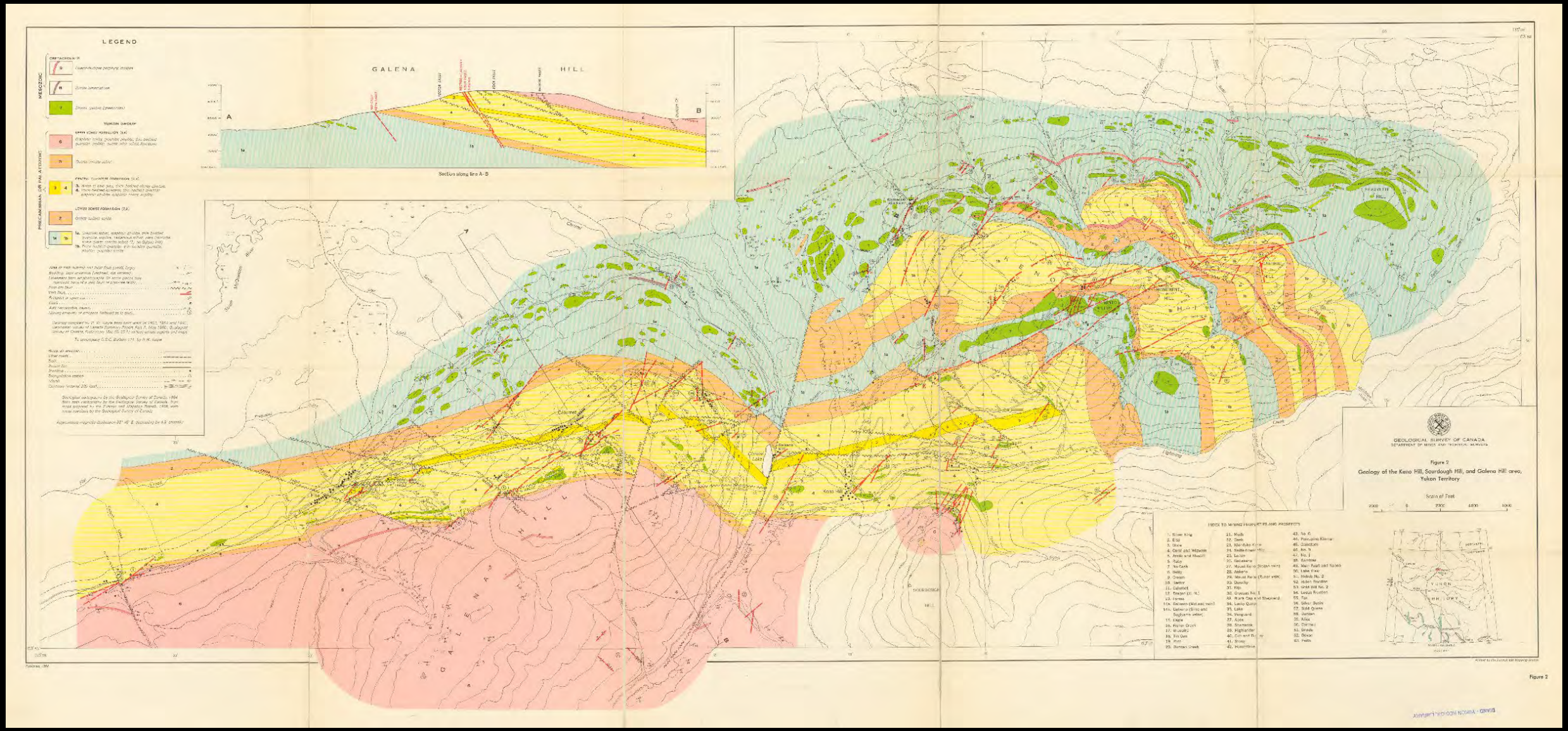
1955 and 1962

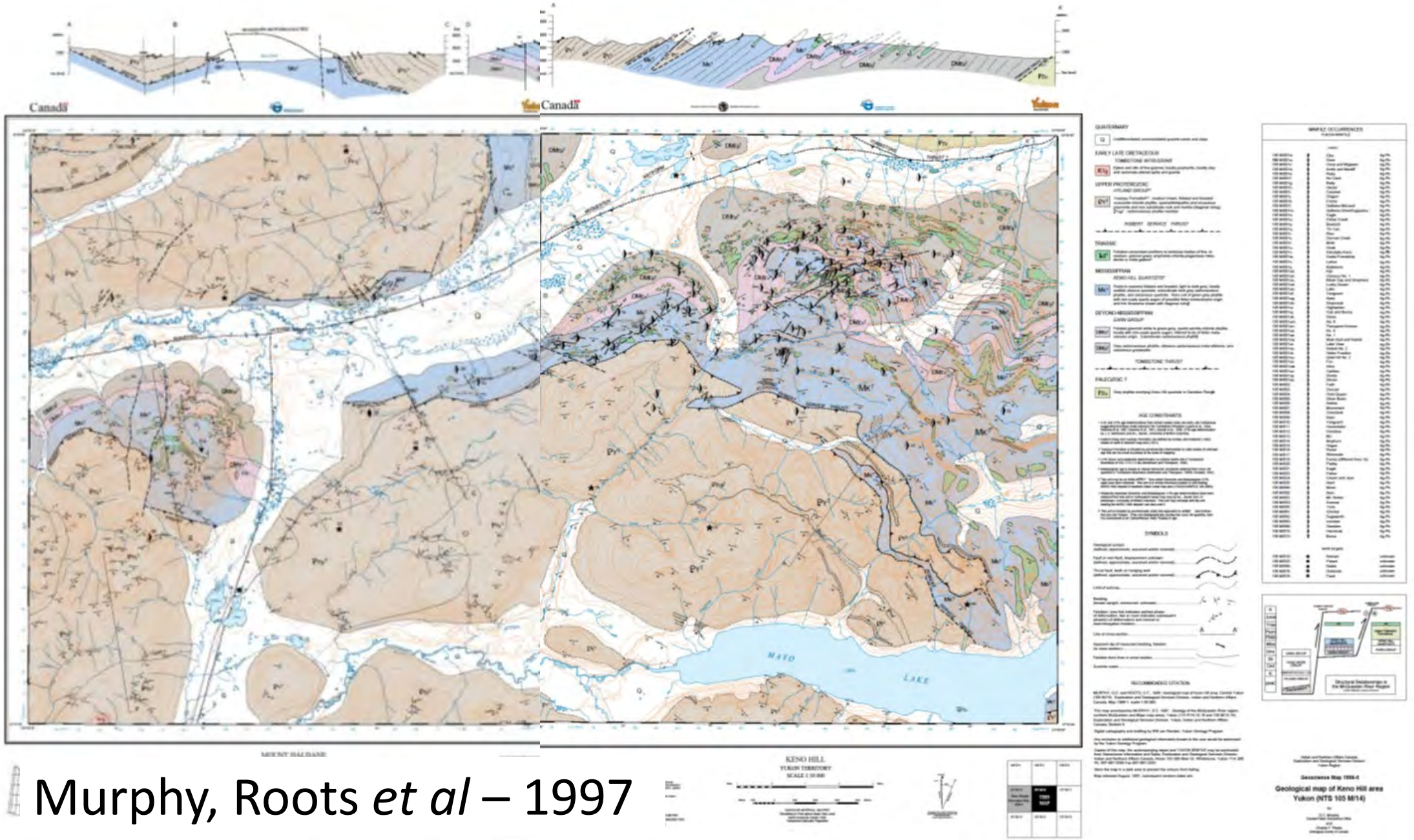


K. C. McTaggart - Geological Survey of Canada, 1950 and 1960



R. W. Boyle - Geological Survey of Canada, 1964

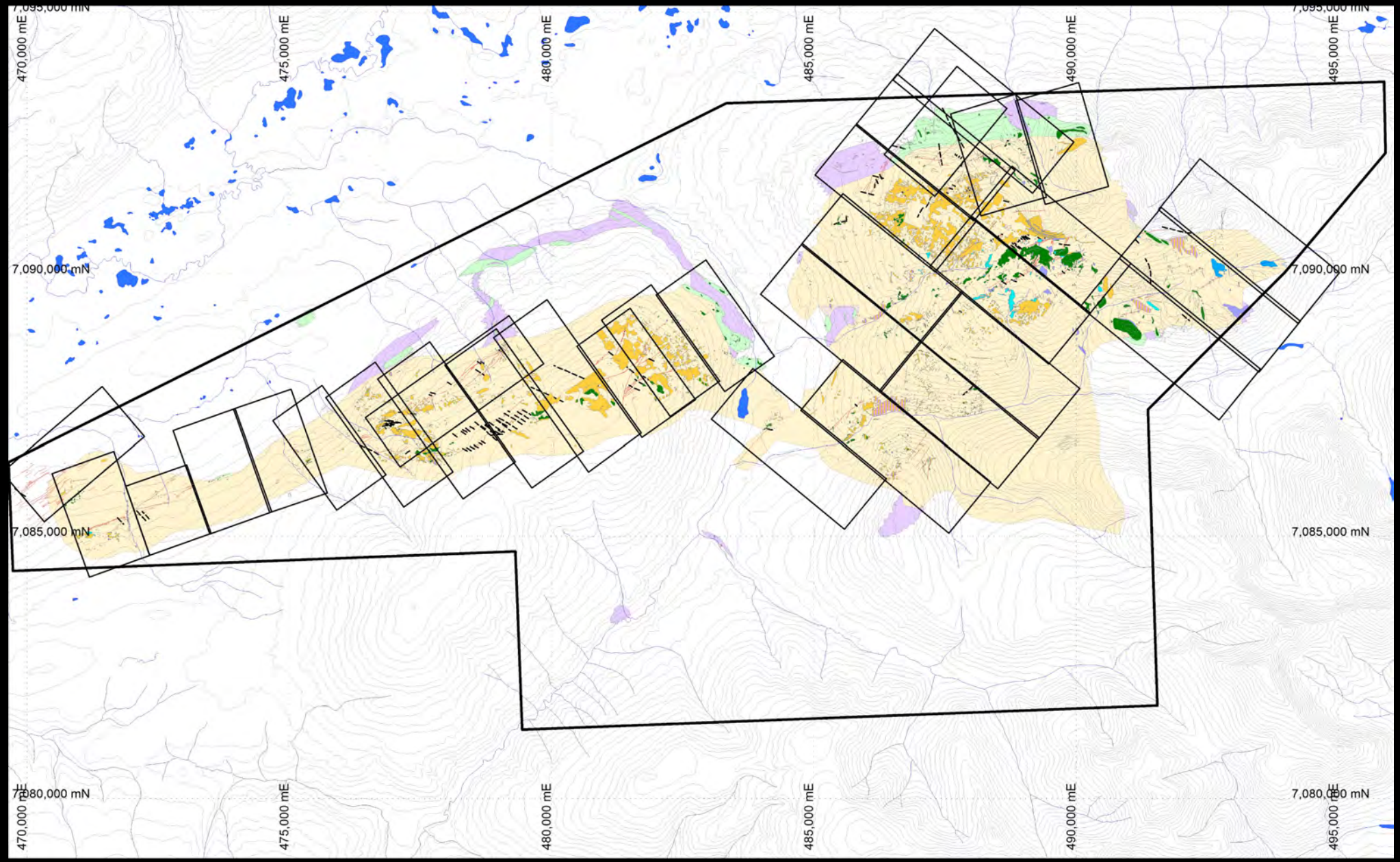




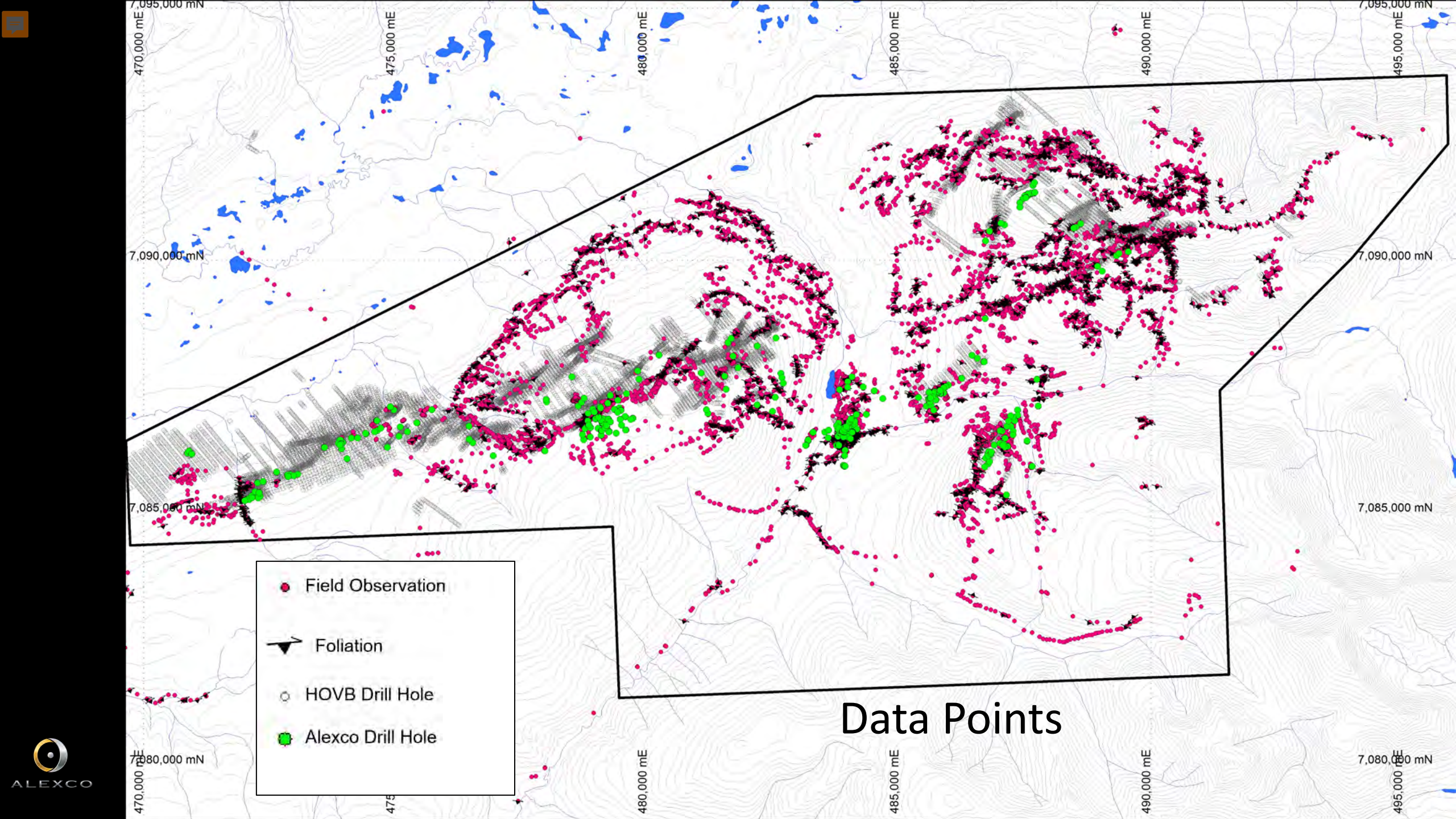
Murphy, Roots *et al* – 1997

United Keno Hill Mines

GIS compilation of 32 UKHM exploration geology map sheets



ALEXCO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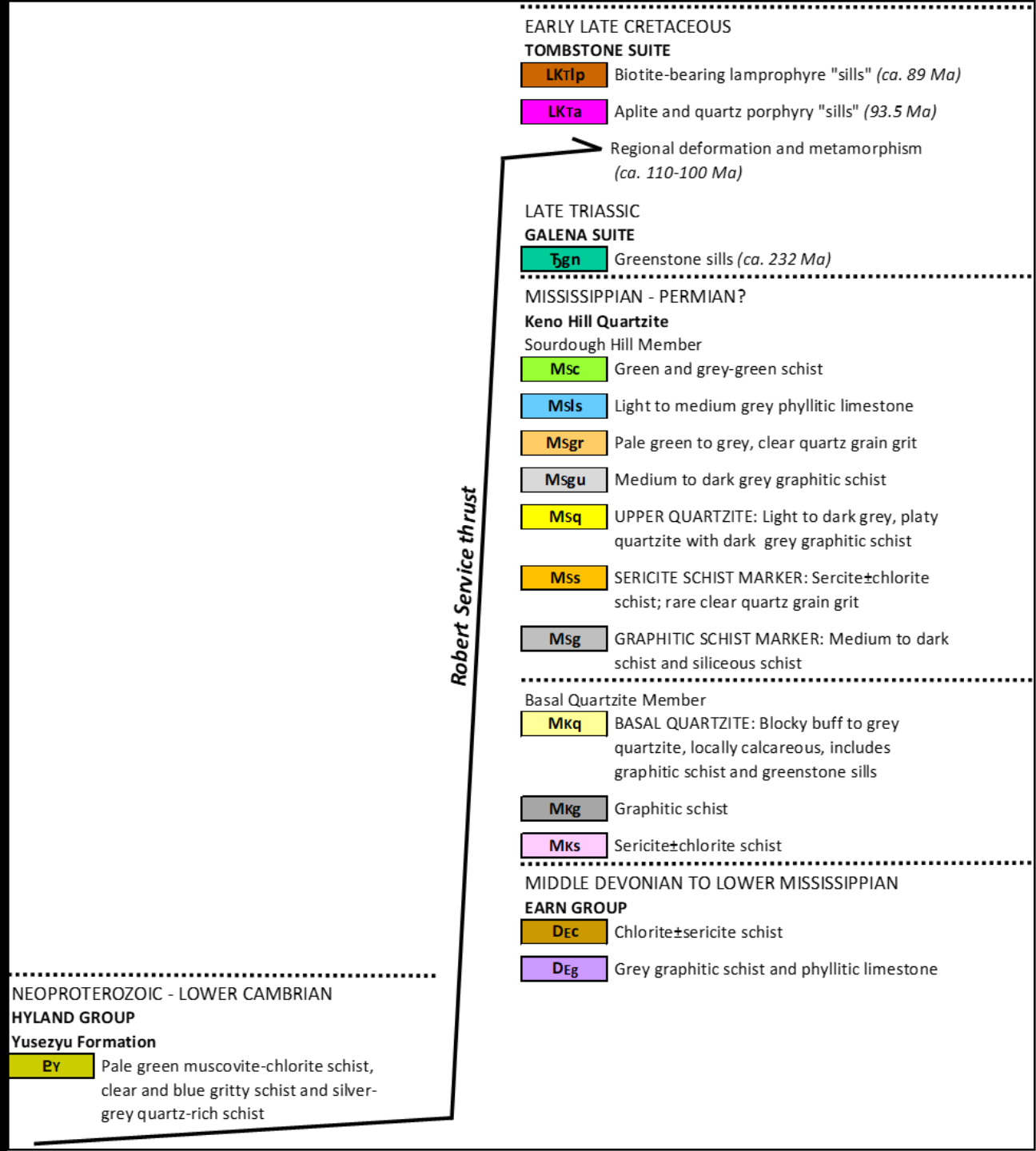
Field Observation
Foliation
HOVB Drill Hole
Alexco Drill Hole
Data Points
ALEXCO

Evolution of the basic stratigraphy

Boyle's Nomenclature	Murphy's Nomenclature	This Map
Upper Schist	Yusezyu Formation	Yusezyu Formation
	Robert Service thrust	*Robert Service thrust*
	Keno Hill Quartzite	Sourdough Hill Member
Central Quartzite		Basal Quartzite Member
Lower Schist	Earn Group	Earn Group

ALEXCO

The present legend of the map and stratigraphy for the Keno Hill Mining Camp



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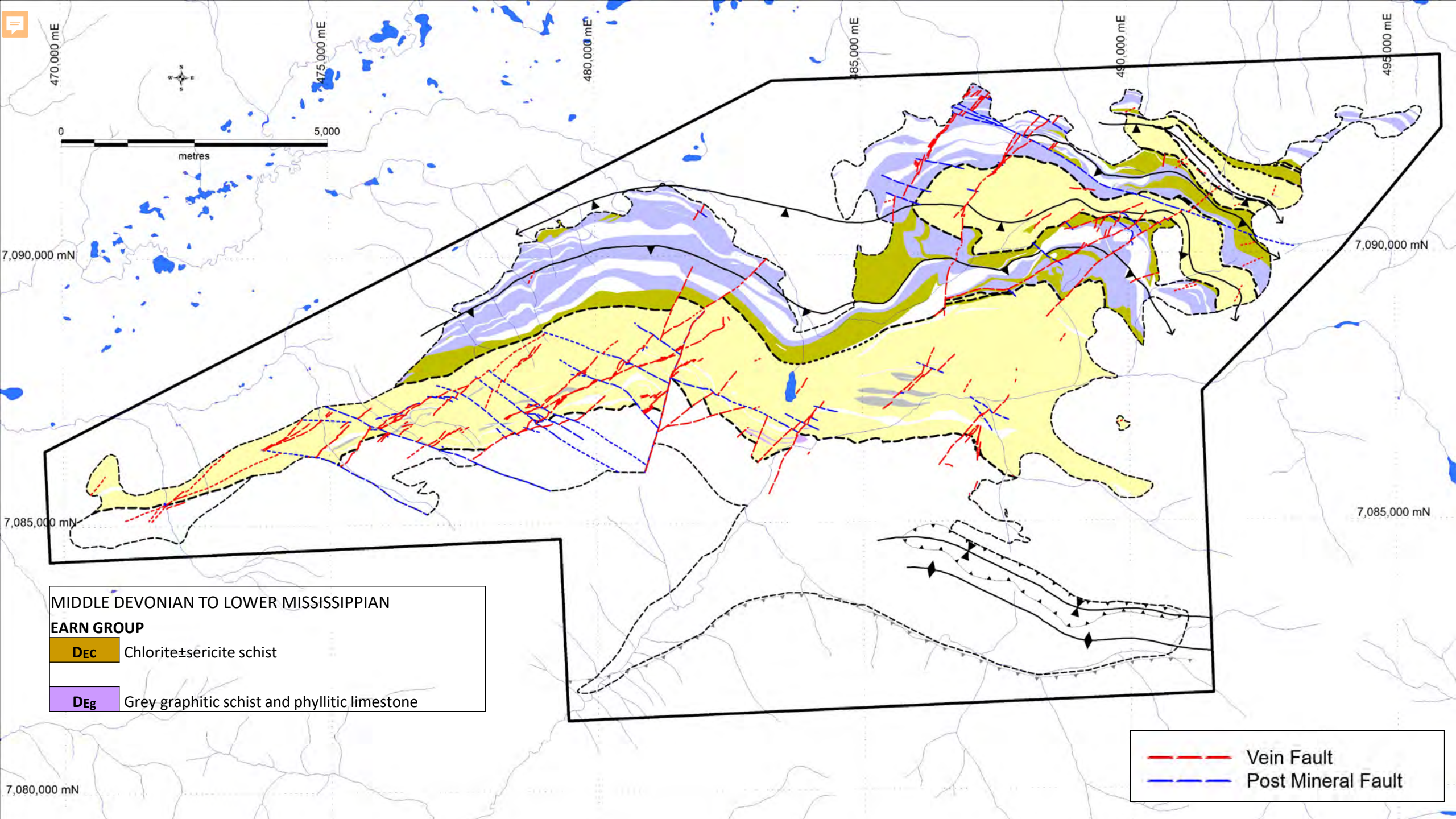
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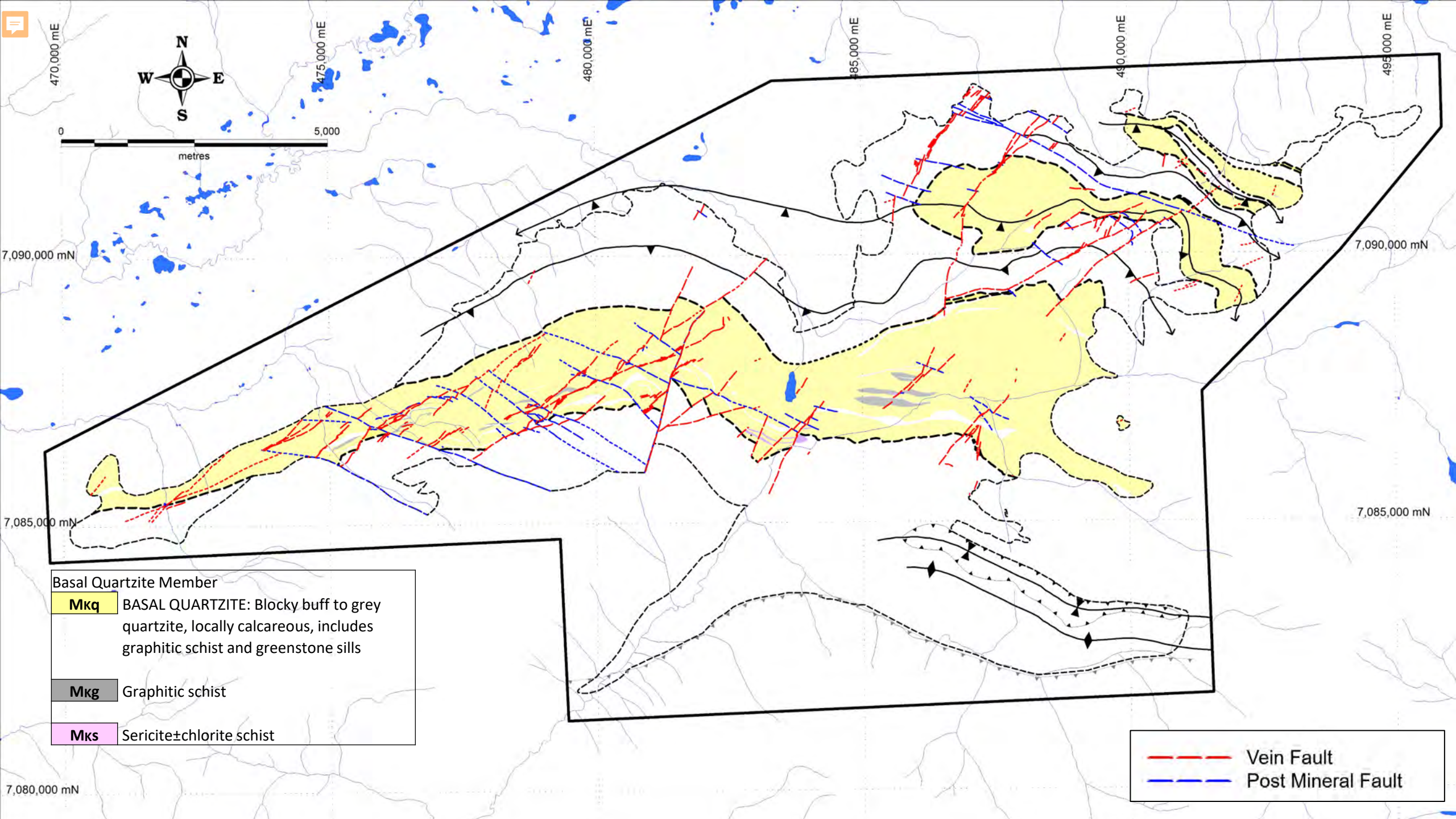
MIDDLE DEVONIAN TO LOWER MISSISSIPPIAN
EARN GROUP
DEC Chlorite±sericite schist
DEg Grey graphitic schist and phyllitic limestone
Vein Fault
Post Mineral Fault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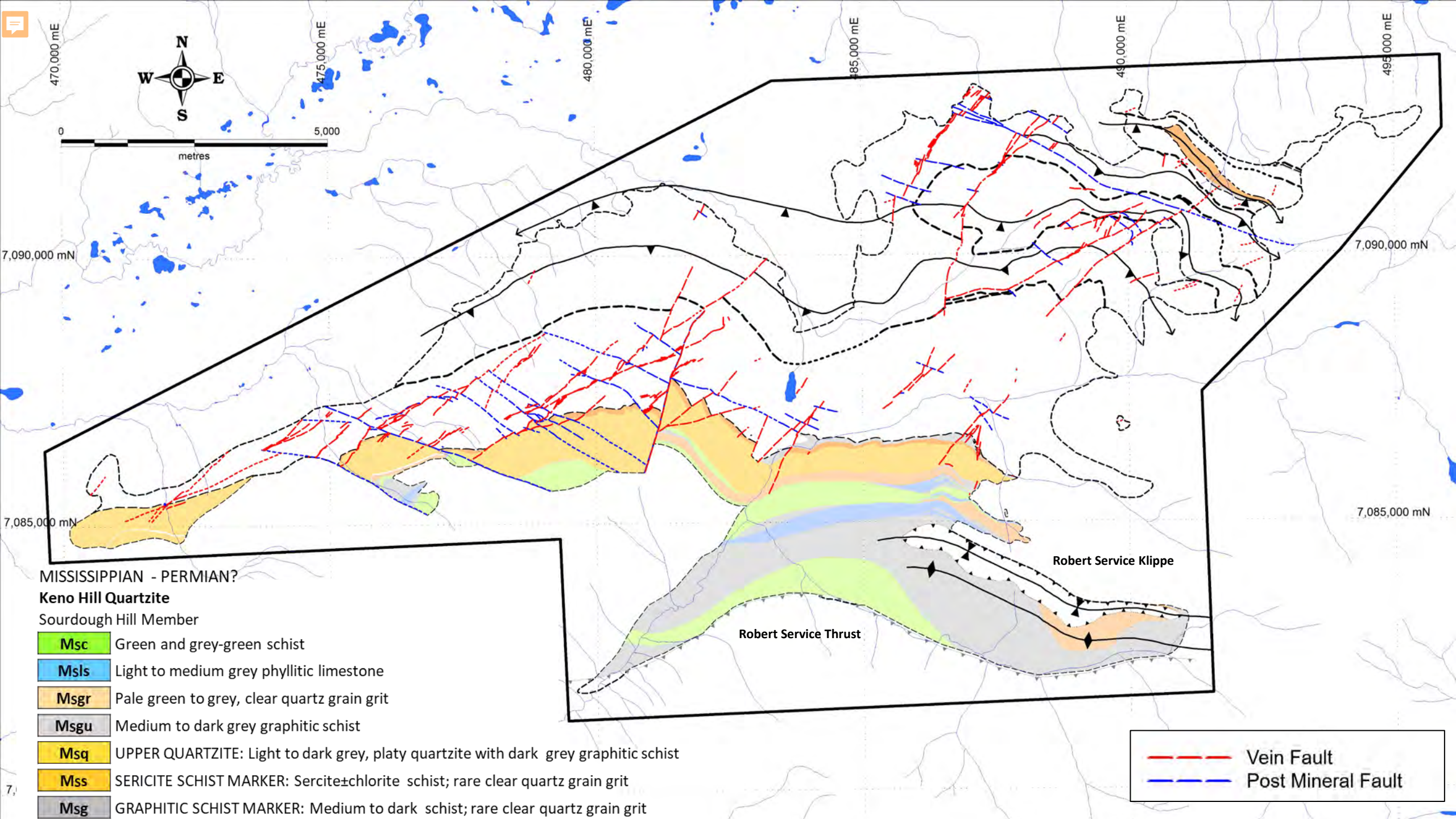
7,080,000 mN
Basal Quartzite Member
MKq
BASAL QUARTZITE: Blocky buff to grey quartzite, locally calcareous, includes graphitic schist and greenstone sills
MKg
Graphitic schist
MKs
Sericite±chlorite schist
Vein Fault
Post Mineral Fault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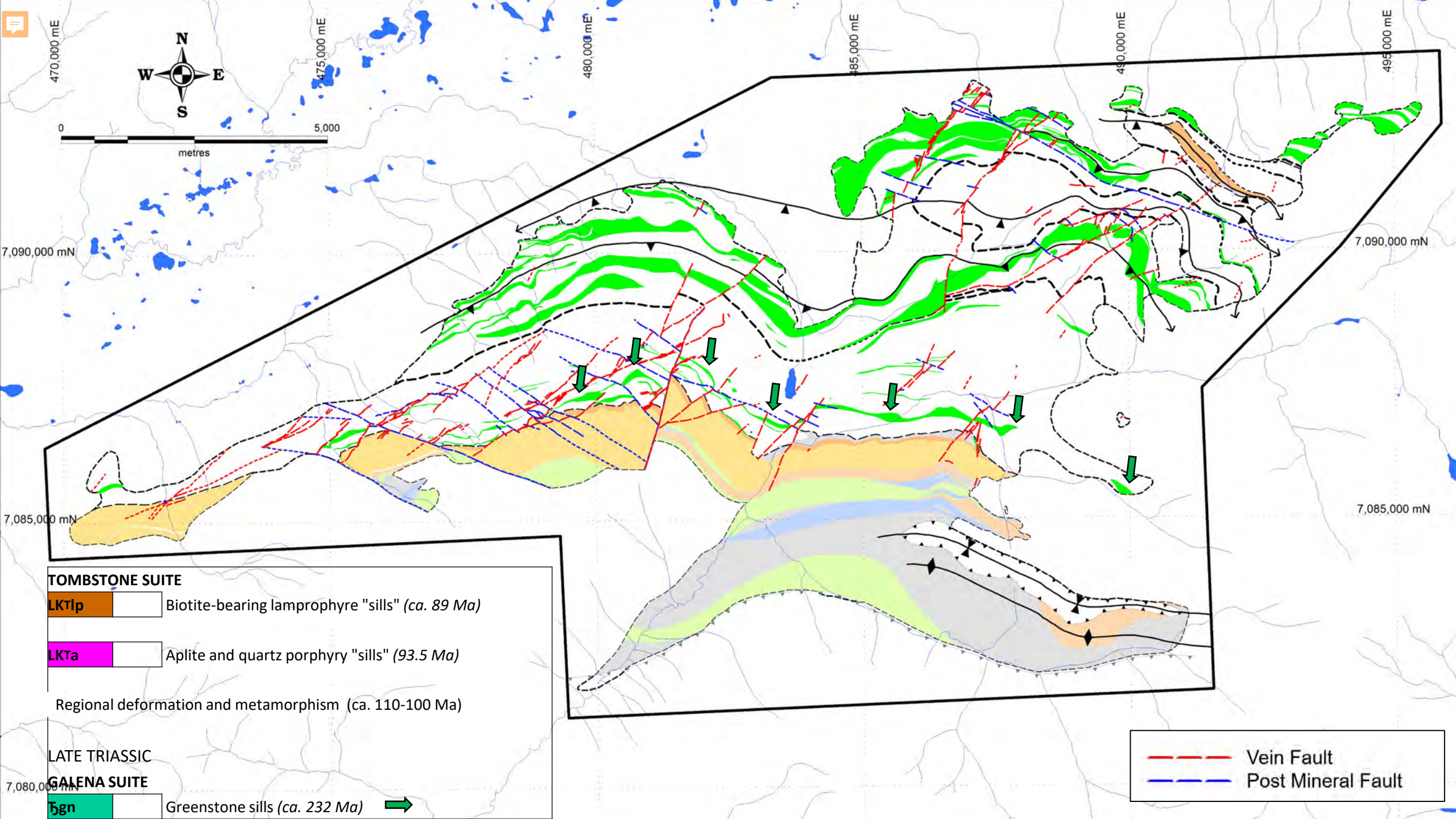
Robert Service Klippe
Robert Service Thrust
MISSISSIPPIAN - PERMIAN?
Keno Hill Quartzite
Sourdough Hill Member
Msc Green and grey-green schist
Msls Light to medium grey phyllitic limestone
Msgr Pale green to grey, clear quartz grain grit
Msgu Medium to dark grey graphitic schist
Msq UPPER QUARTZITE: Light to dark grey, platy quartzite with dark grey graphitic schist
Mss SERICITE SCHIST MARKER: Sercite±chlorite schist; rare clear quartz grain grit
Msg GRAPHITIC SCHIST MARKER: Medium to dark schist; rare clear quartz grain grit
Vein Fault
Post Mineral Fault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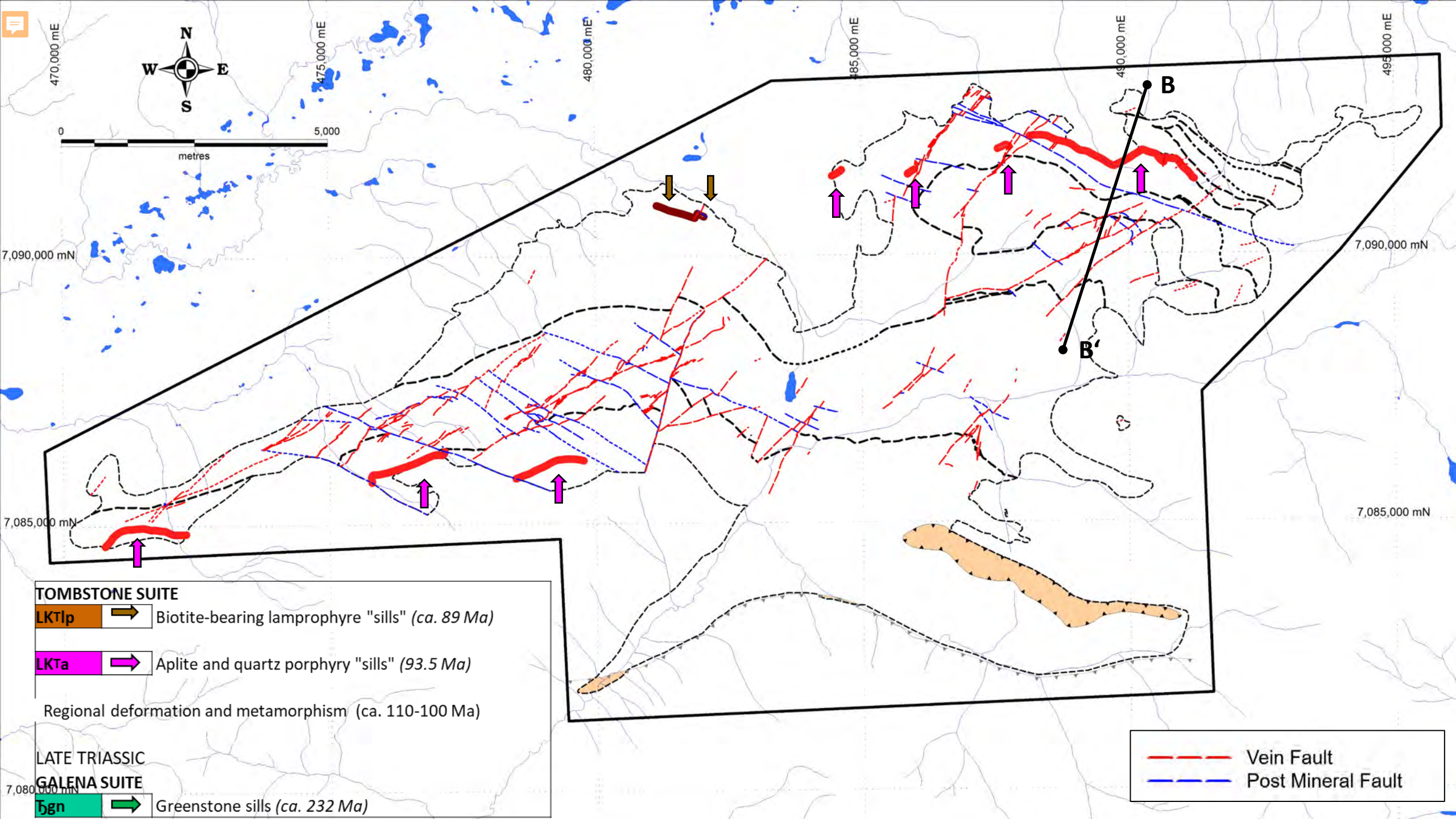
TOMBSTONE SUITE
LKTlp
Biotite-bearing lamprophyre "sills" (ca. 89 Ma)
LKTa
Aplite and quartz porphyry "sills" (93.5 Ma)
Regional deformation and metamorphism (ca. 110-100 Ma)
LATE TRIASSIC
GALENA SUITE
Tgn
Greenstone sills (ca. 232 Ma)
Vein Fault
Post Mineral Fault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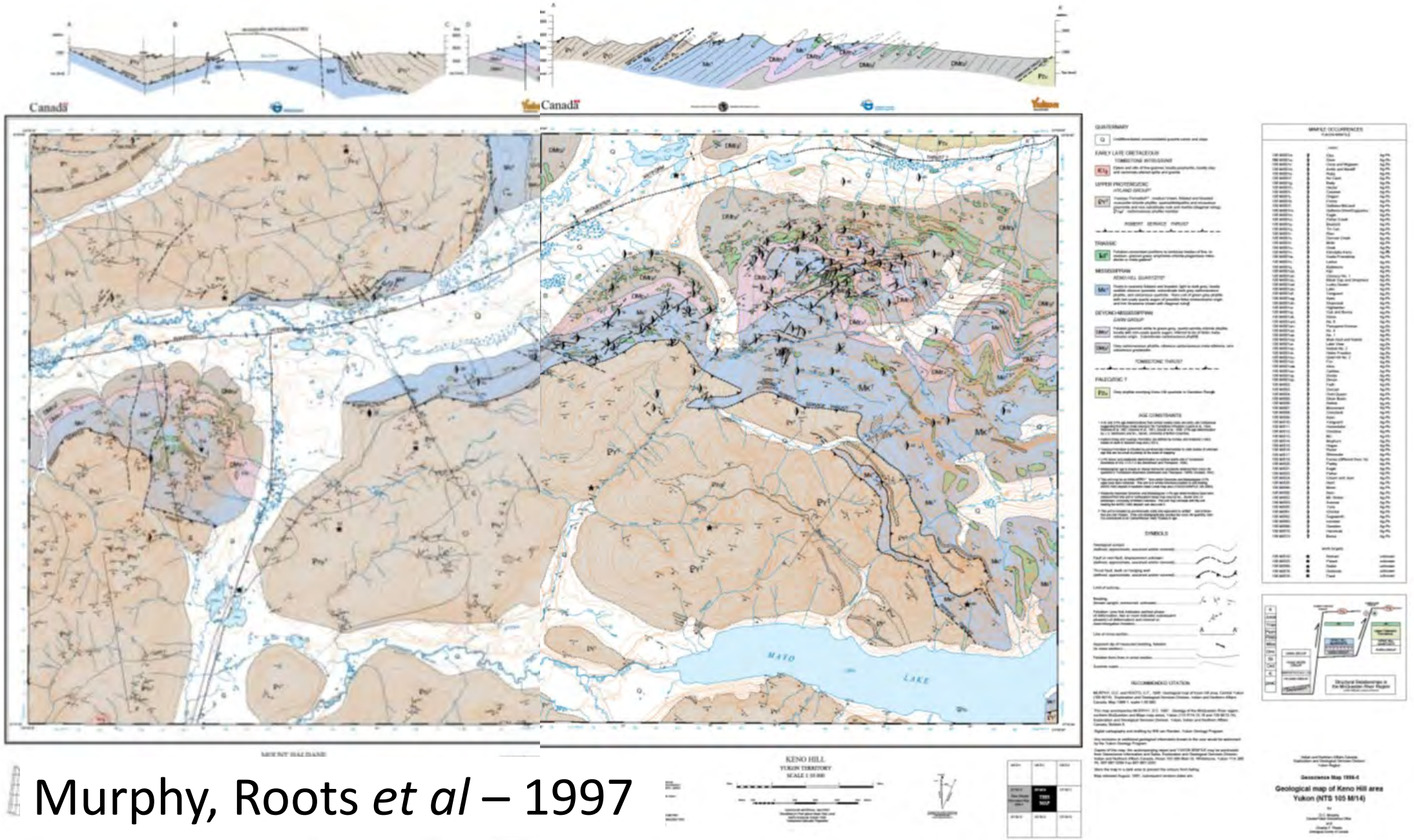
7,085,000 mN
7,080,000 mN
B
B'
TOMBSTONE SUITE
LKTlp
Biotite-bearing lamprophyre "sills" (ca. 89 Ma)
LKTa
Aplite and quartz porphyry "sills" (93.5 Ma)
Regional deformation and metamorphism (ca. 110-100 Ma)
LATE TRIASSIC
GALENA SUITE
Tgn
Greenstone sills (ca. 232 Ma)
Vein Fault
Post Mineral Fault

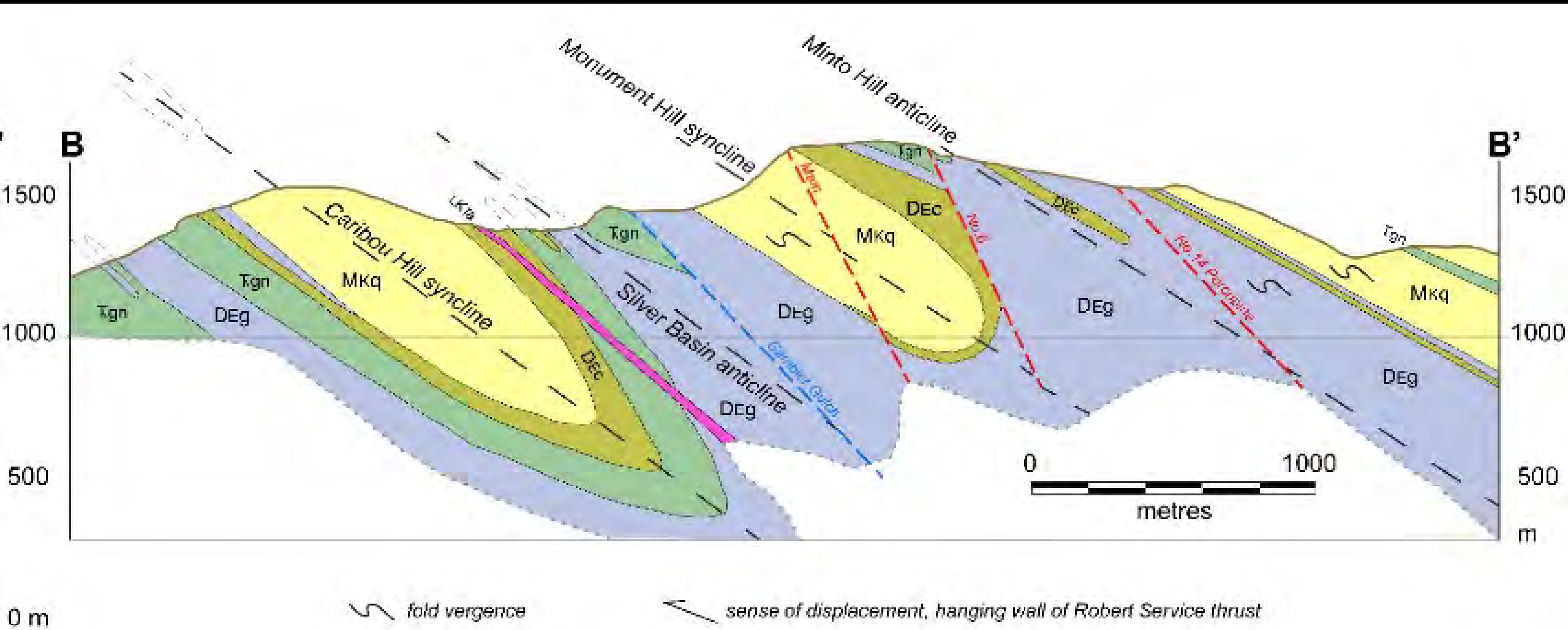


Murphy, Roots *et al* – 1997

Structure

- Early Folding (F0)

ALEXCO


B
B'
Monument Hill syncline
Minto Hill anticline
Caribou Hill syncline
Silver Basin anticline
Tgn
DEg
MKq
DEc
1500
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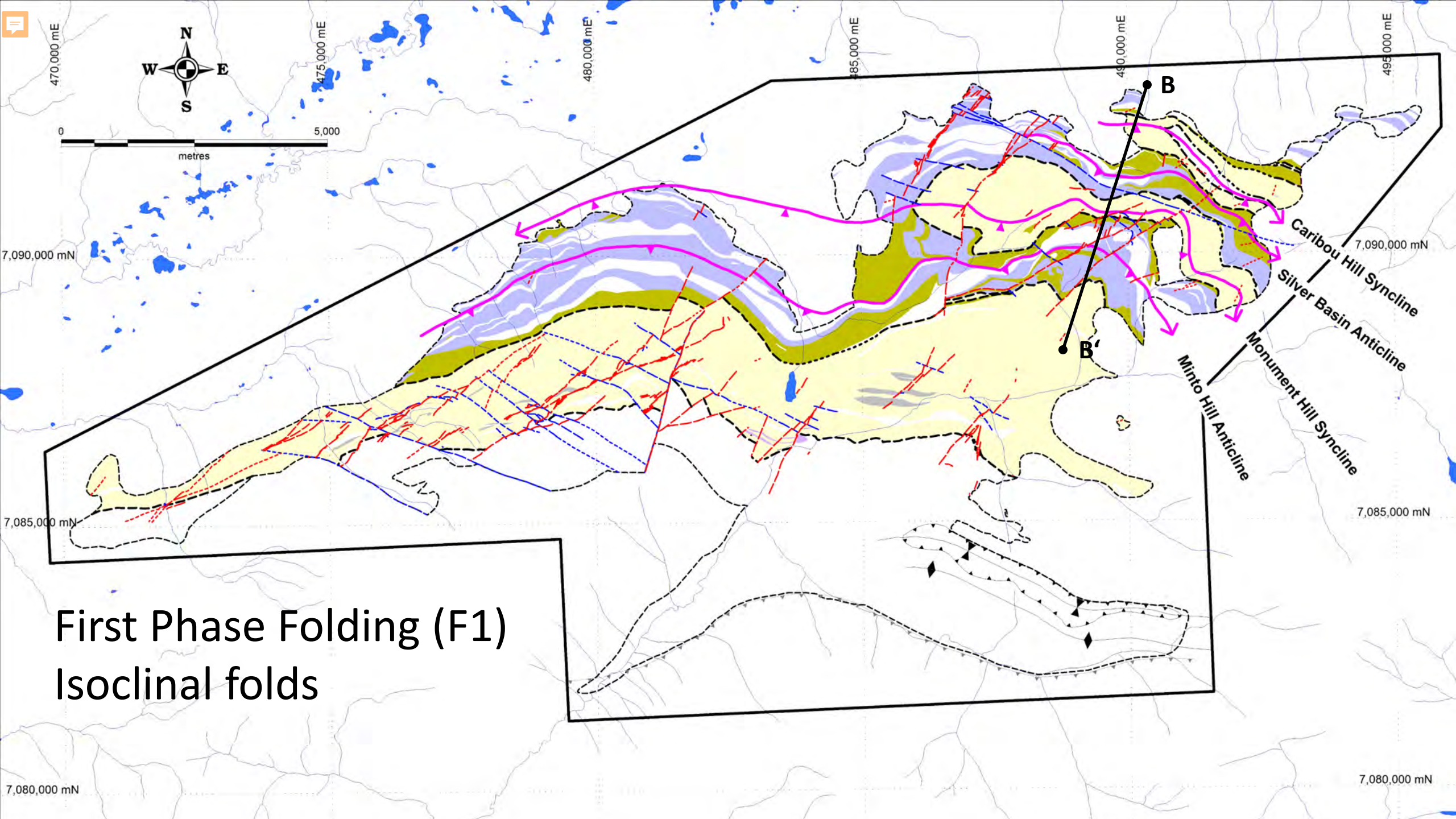
500
0 m
0
1000
metres
m
fold vergence
sense of displacement, hanging wall of Robert Service thrust



First Phase Folding (F1)
Isoclinal folds

First Phase Folding (F1)

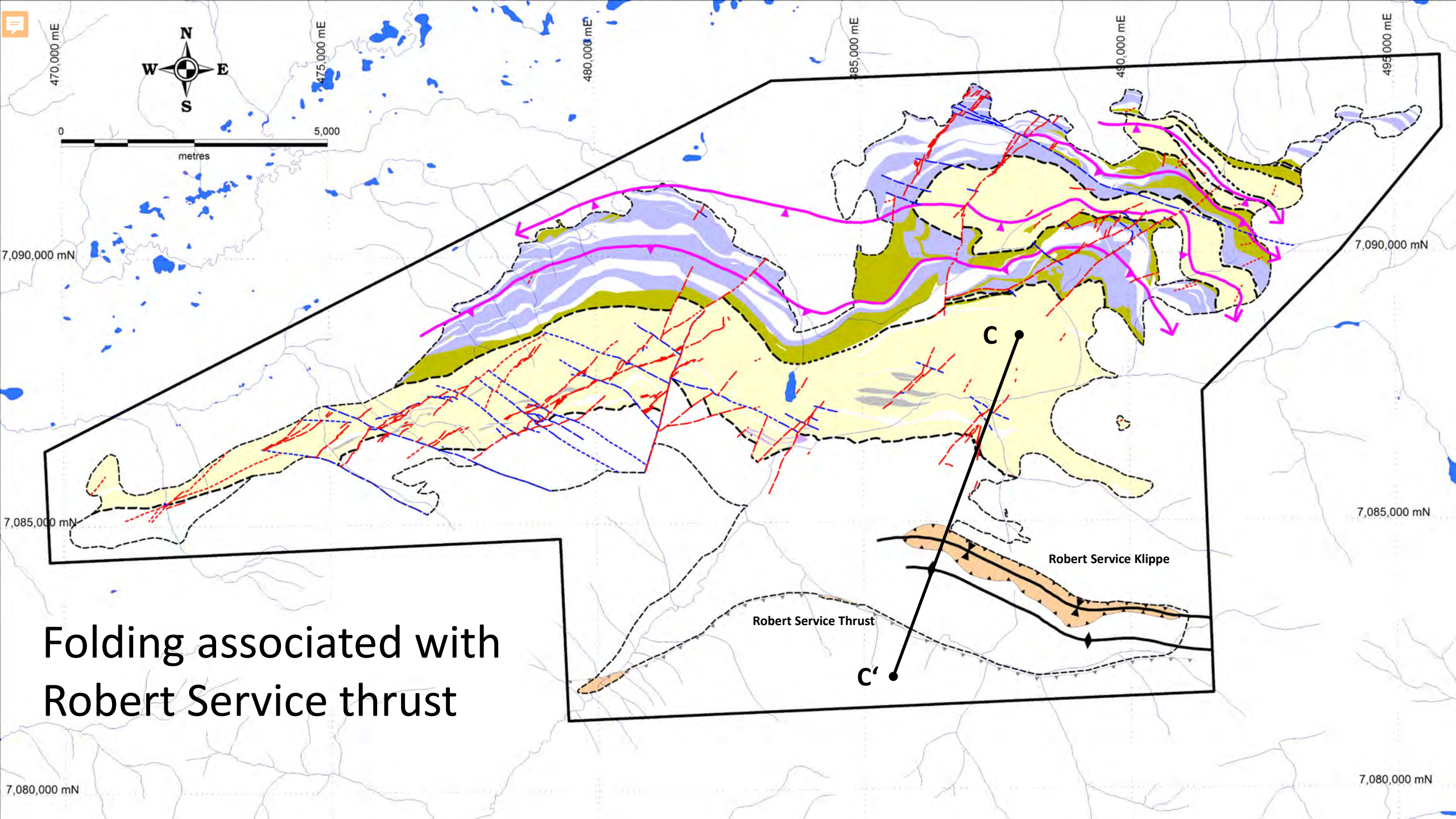
Looking to the west

ALEXCO

Second Phase Folding (F2)

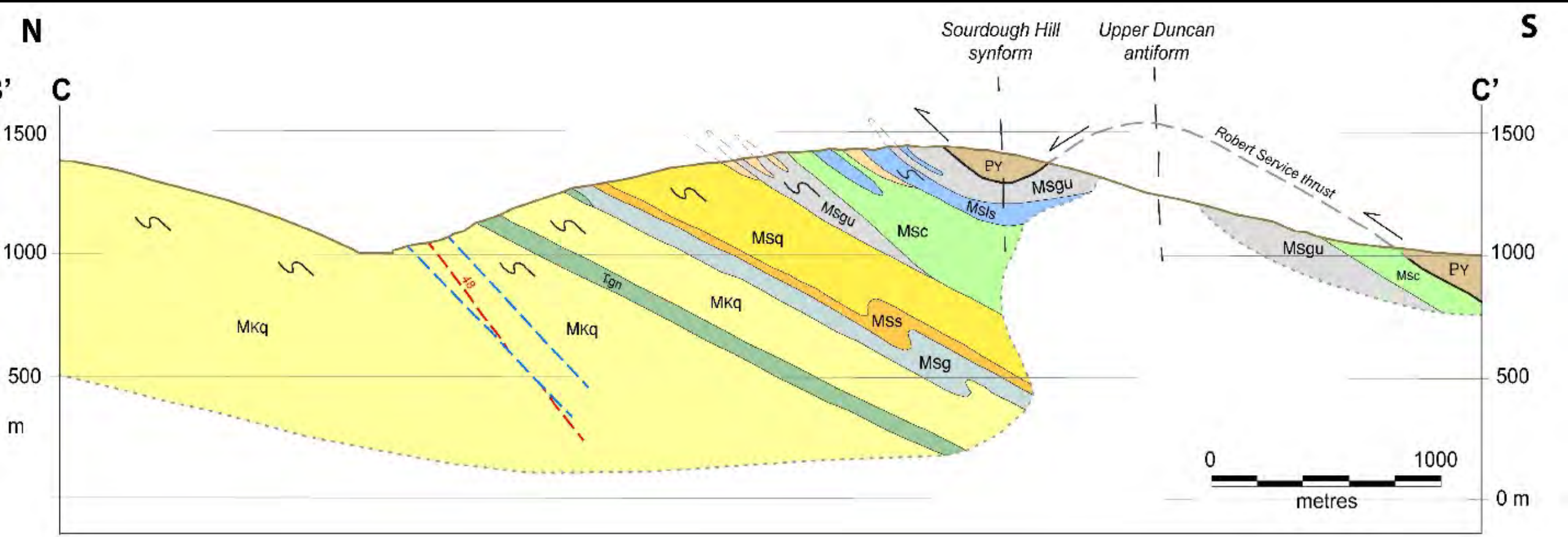
Viewed to the southeast

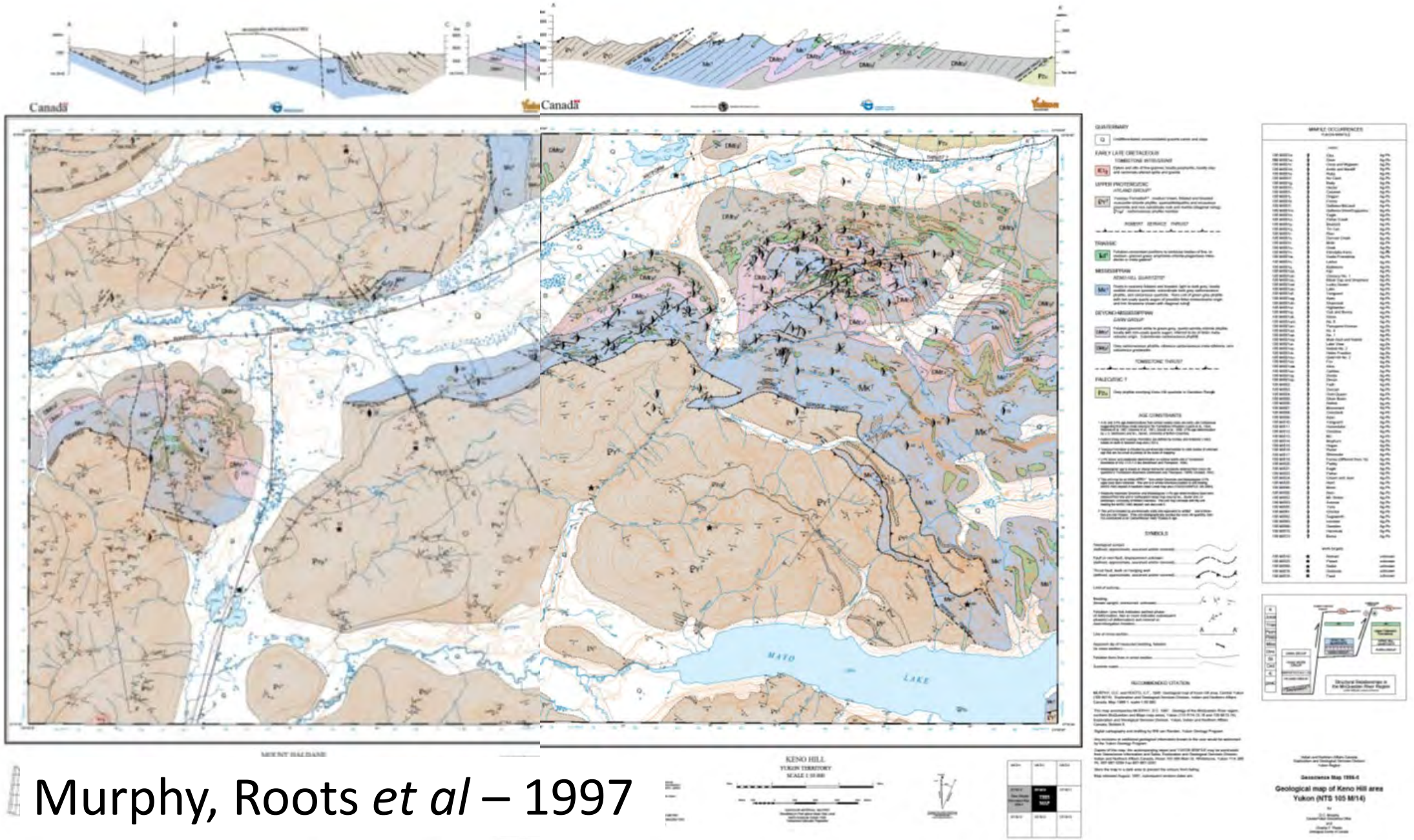
ALEXCO



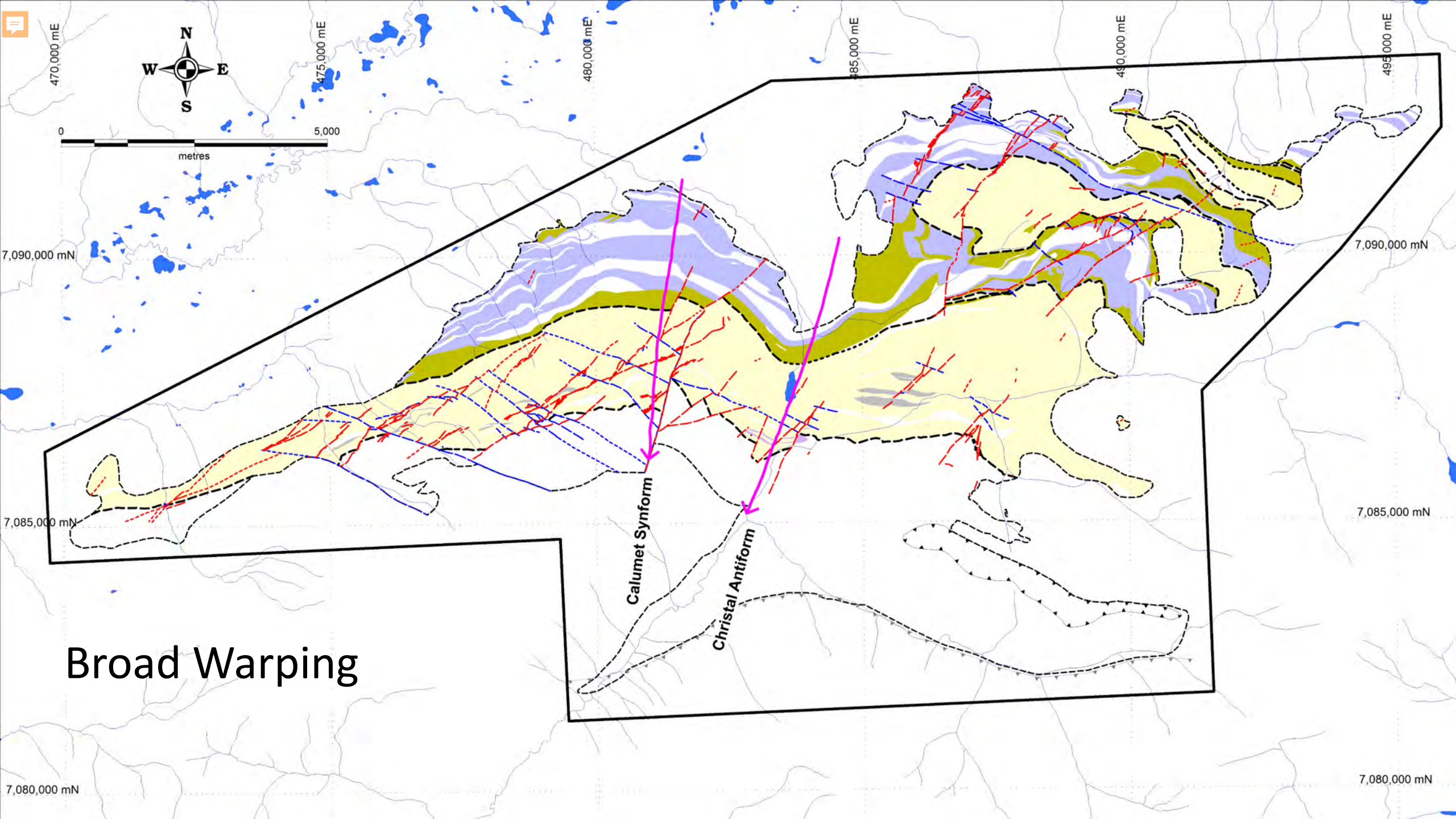
Folding associated with Robert Service thrust

Folding Associated with Robert Service thrust





Murphy, Roots *et al* – 1997

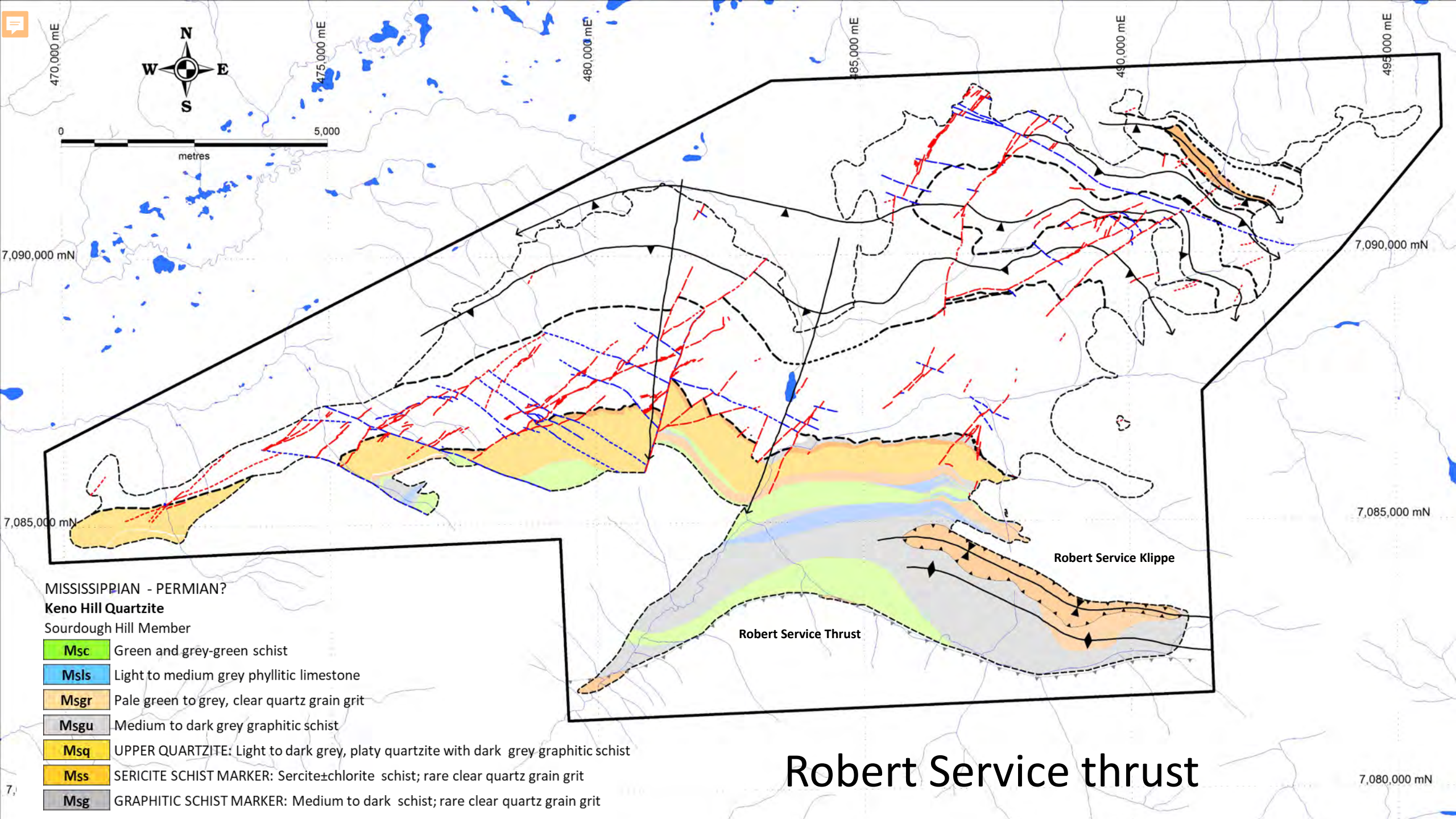


Broad Warping

Structure - Faulting

Fault Event	Age Range (Ma)
Robert Service thrust	100 to 94
Longitudinal vein faults	88 to 68
Transverse vein faults	88 to 68
Transverse faults	<61
Longitudinal faults	<61

ALEXCO



MISSISSIPPIAN - PERMIAN?

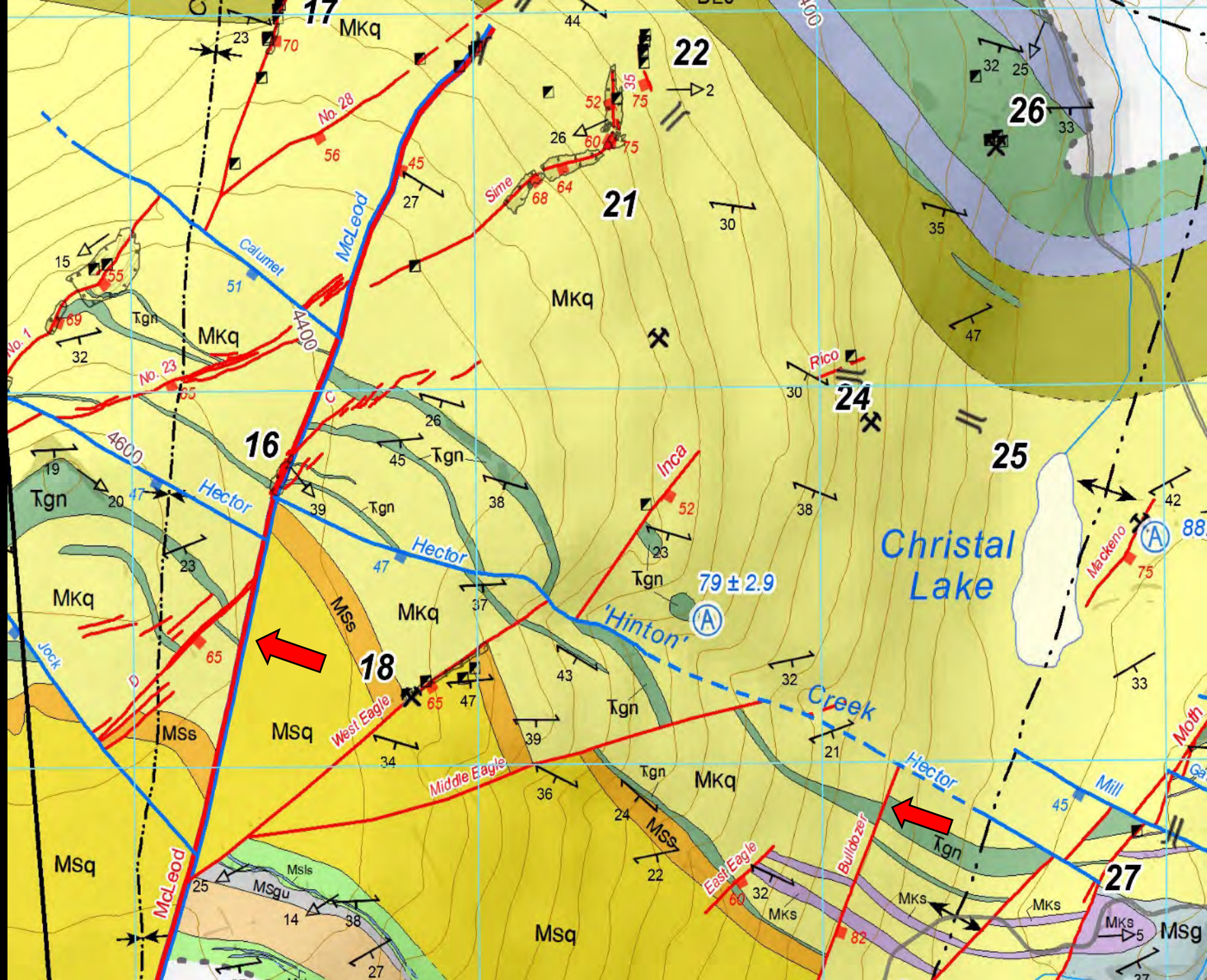
Keno Hill Quartzite

Sourdough Hill Member

Msc	Green and grey-green schist
Msls	Light to medium grey phyllitic limestone
Msgr	Pale green to grey, clear quartz grain grit
Msgu	Medium to dark grey graphitic schist
Msq	UPPER QUARTZITE: Light to dark grey, platy quartzite with dark grey graphitic schist
Mss	SERICITE SCHIST MARKER: Sercite±chlorite schist; rare clear quartz grain grit
Msg	GRAPHITIC SCHIST MARKER: Medium to dark schist; rare clear quartz grain grit

Robert Service thrust

Transverse and Longitudinal vein faults



West Eagle vein fault

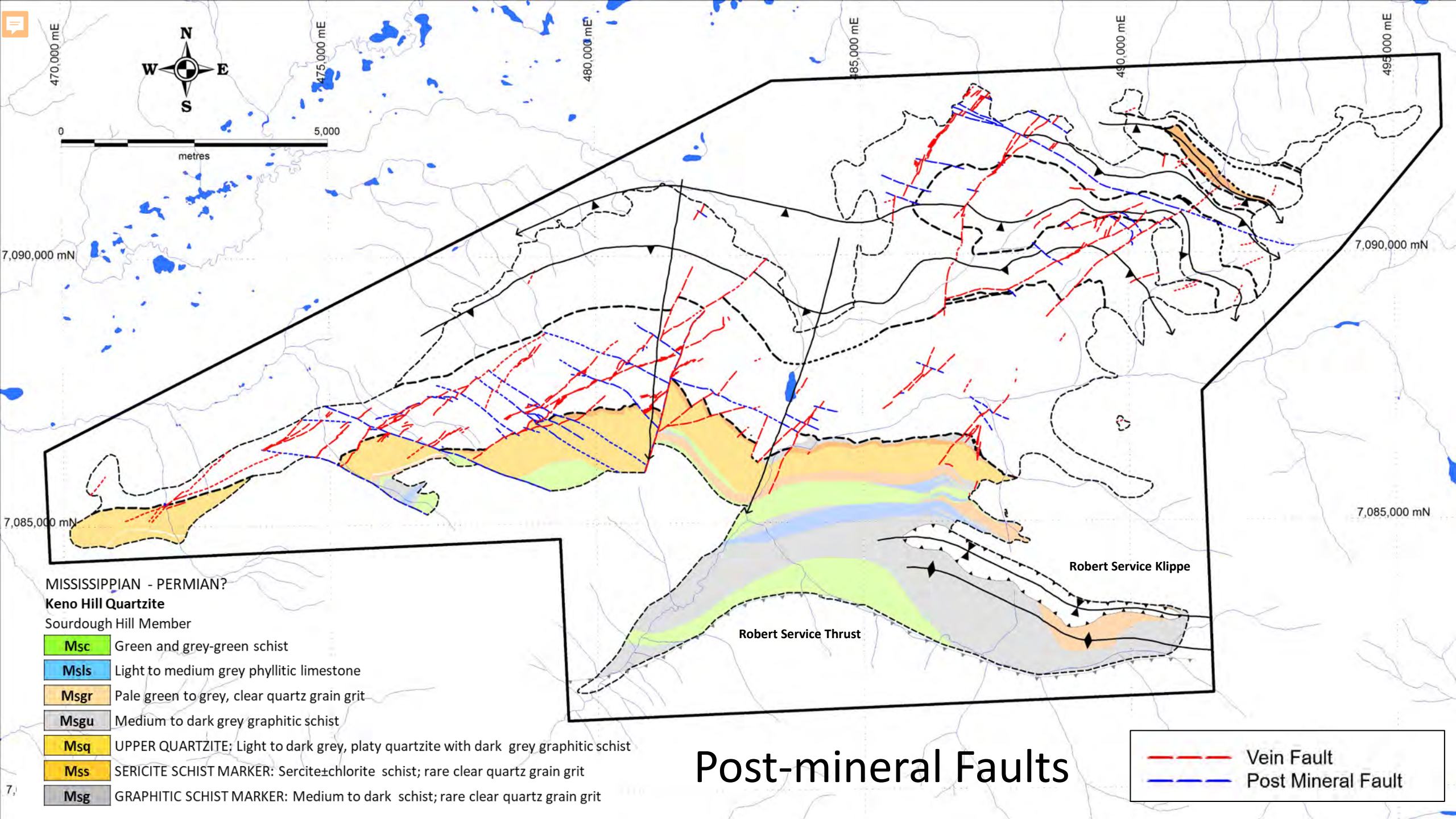
ALEXCO

No. 9
vein fault

ALEXCO

Onek vein fault

ALEXCO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Robert Service Klippe
Robert Service Thrust
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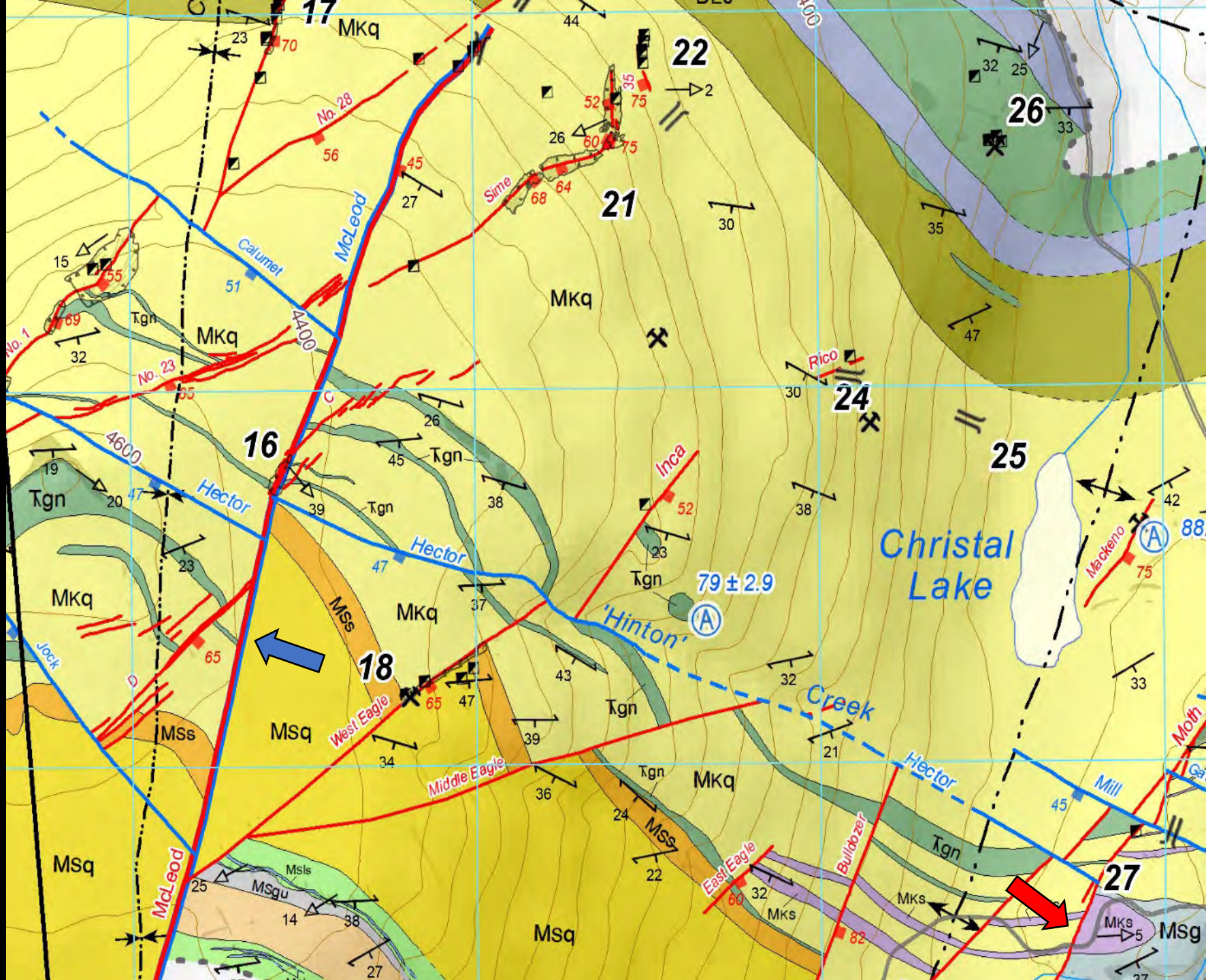
Post-mineral Faults
Vein Fault
Post Mineral Fault

Post-mineral
Longitudinal
faults



Post-mineral
Super fault

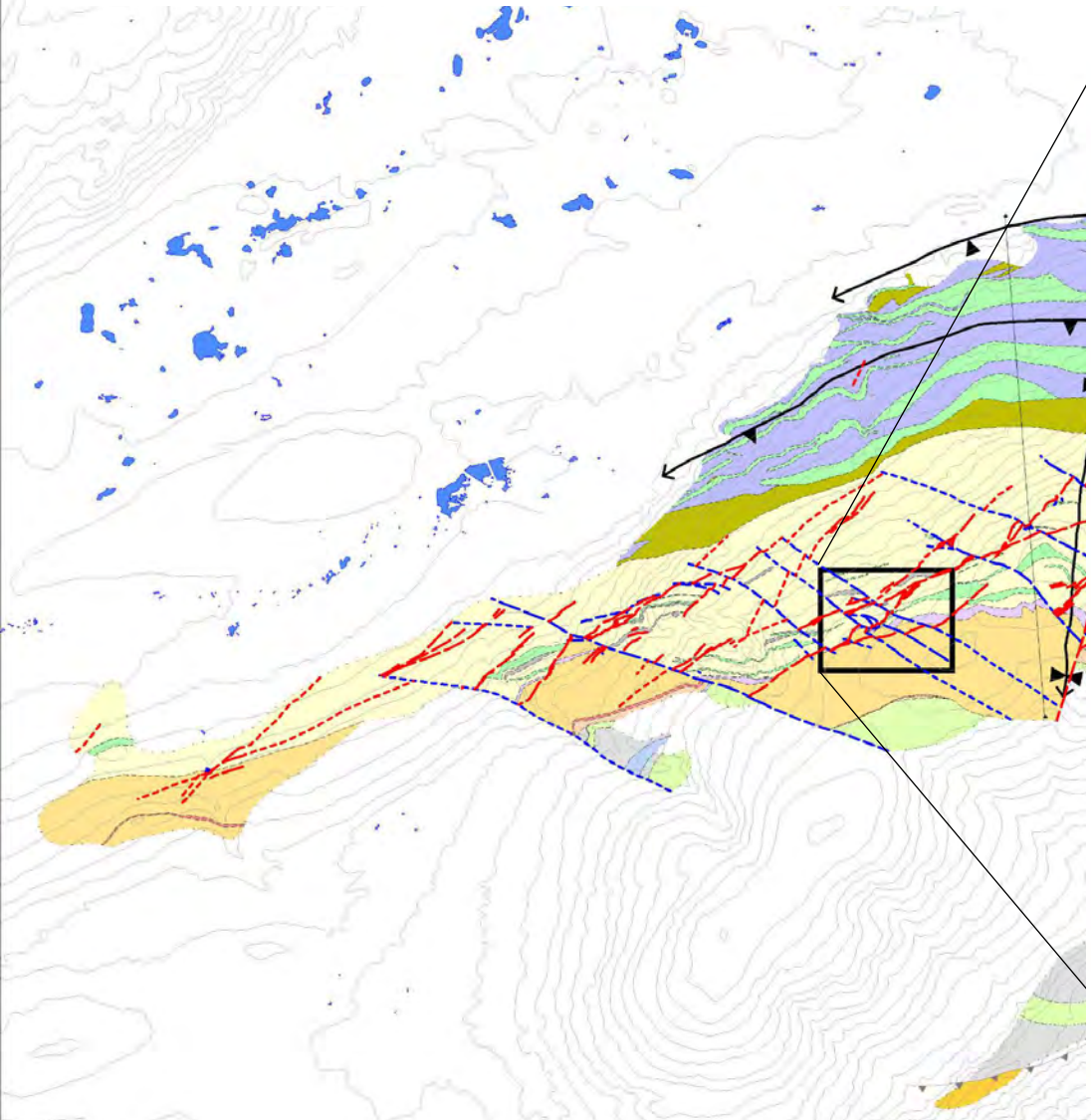
Bermingham

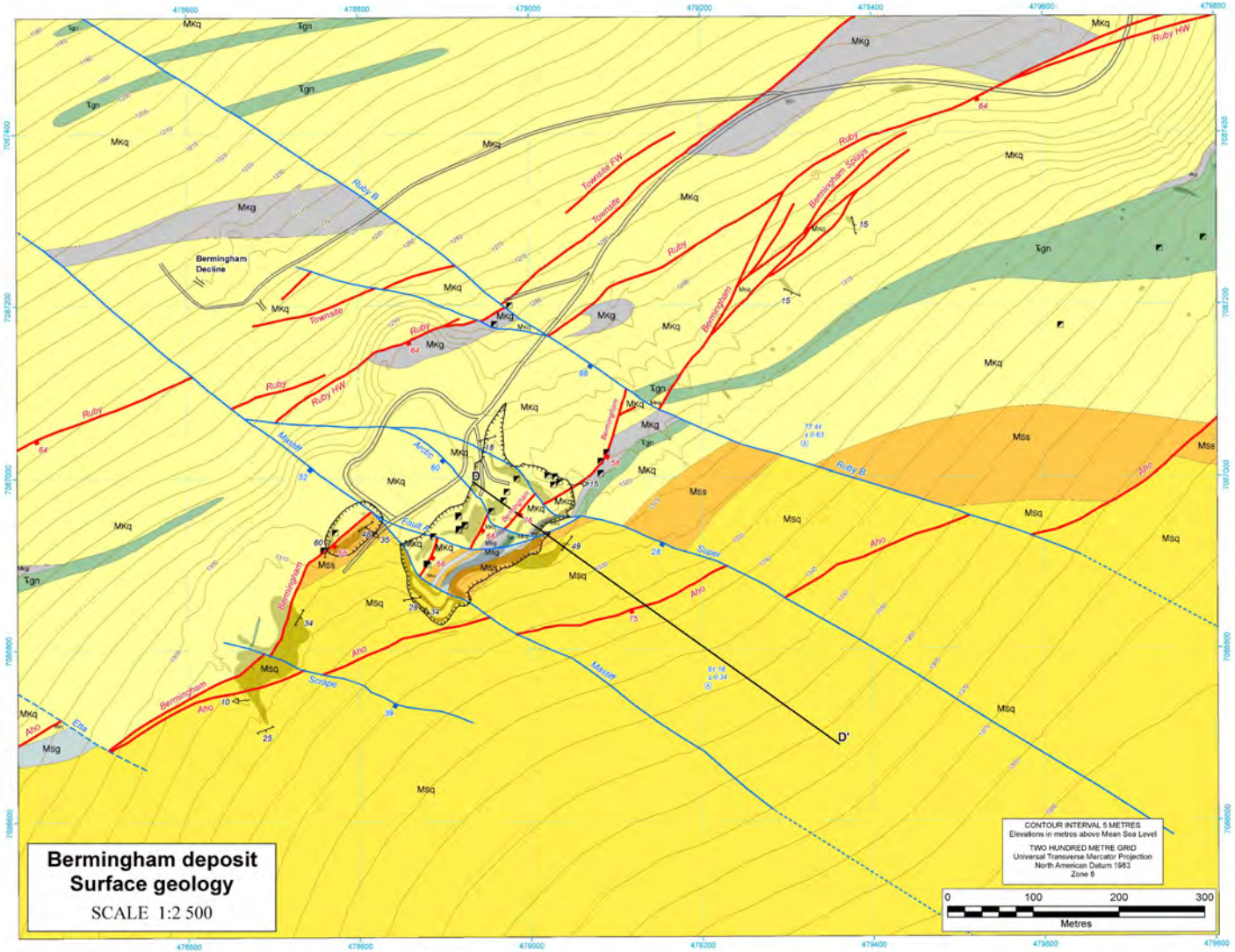
No. 9 vein
Keno Hill

Post Mineral
Longitudinal fault

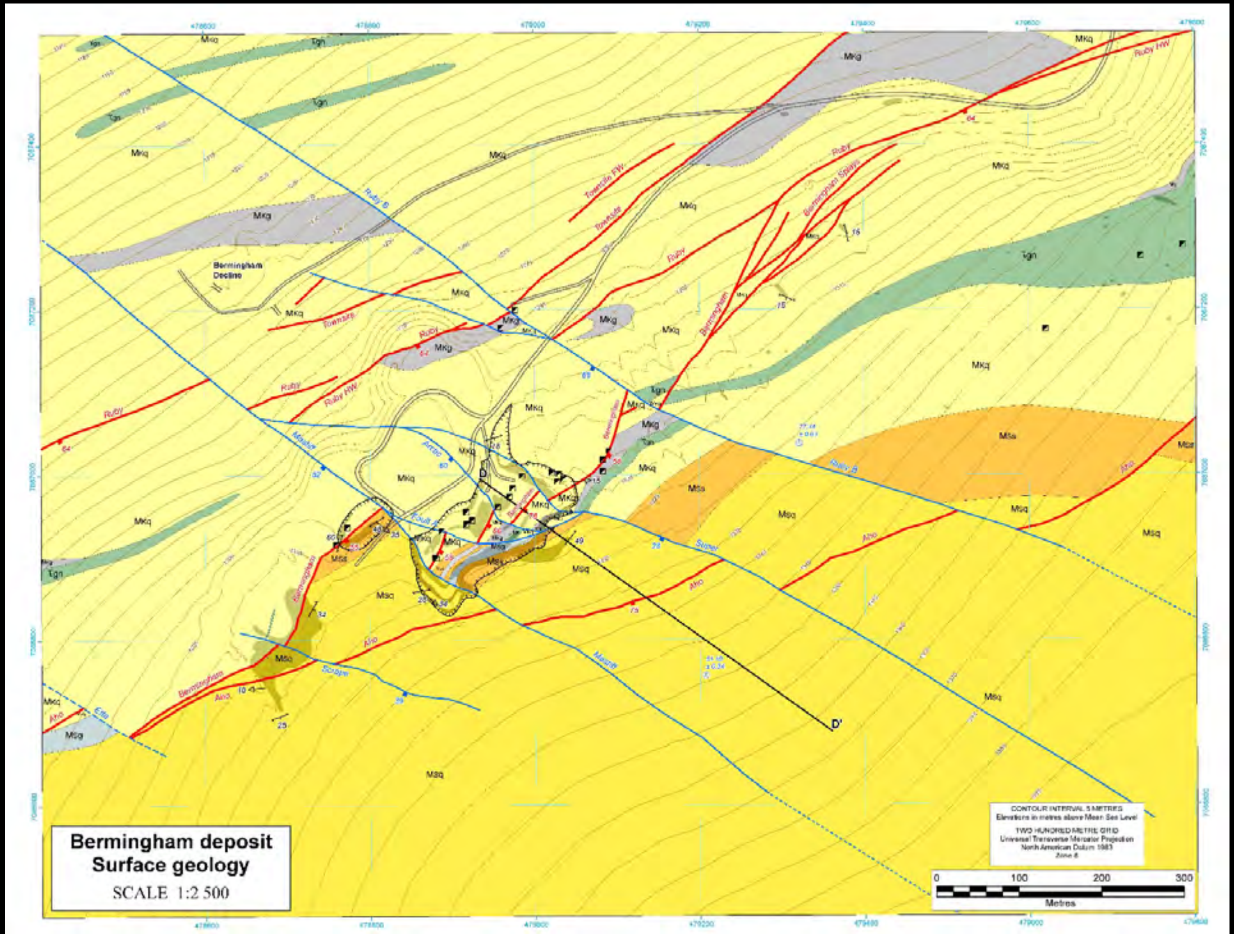
ALEXCO

Detail of Bermingham Area Surface Geology

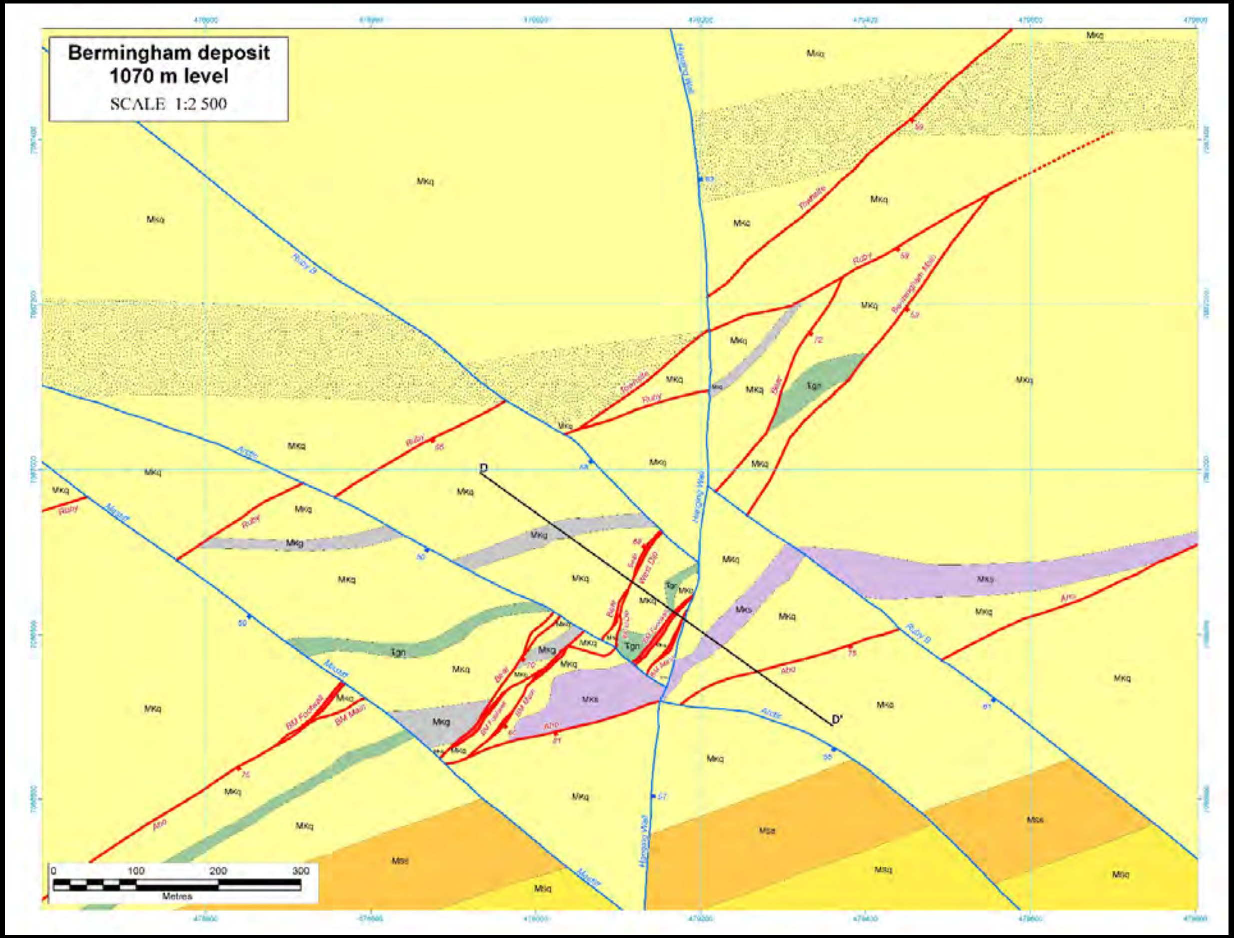




Bermingham surface geology



1070m level geology



ALEXCO

MECHANISMS OF VEIN FORMATION

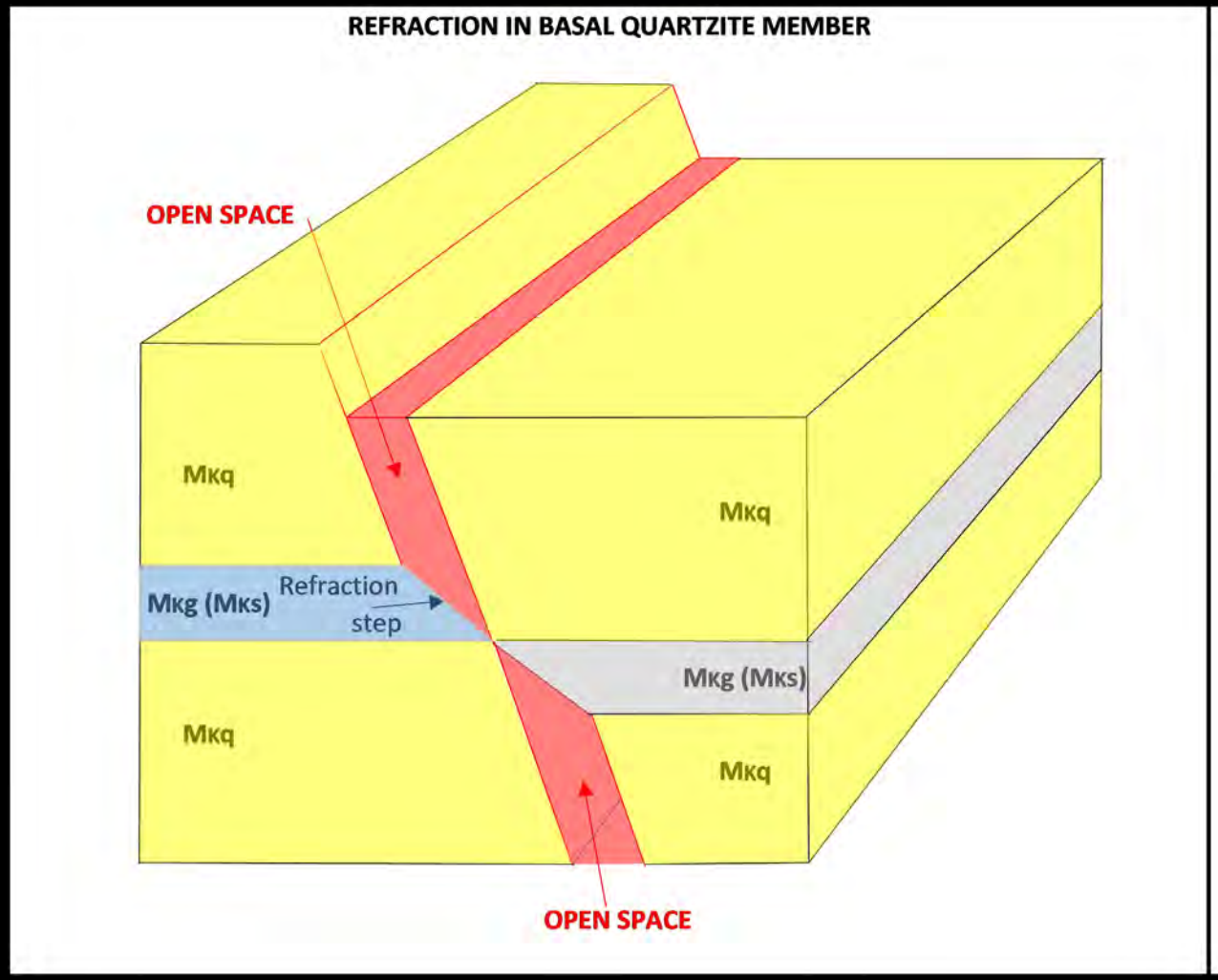
There are various mechanisms for the development of open-space for vein formation:

- Boyle emphasized the importance of vein fault refraction and recently
- Iles applied the concept of Riedel shear in a strike-slip system.

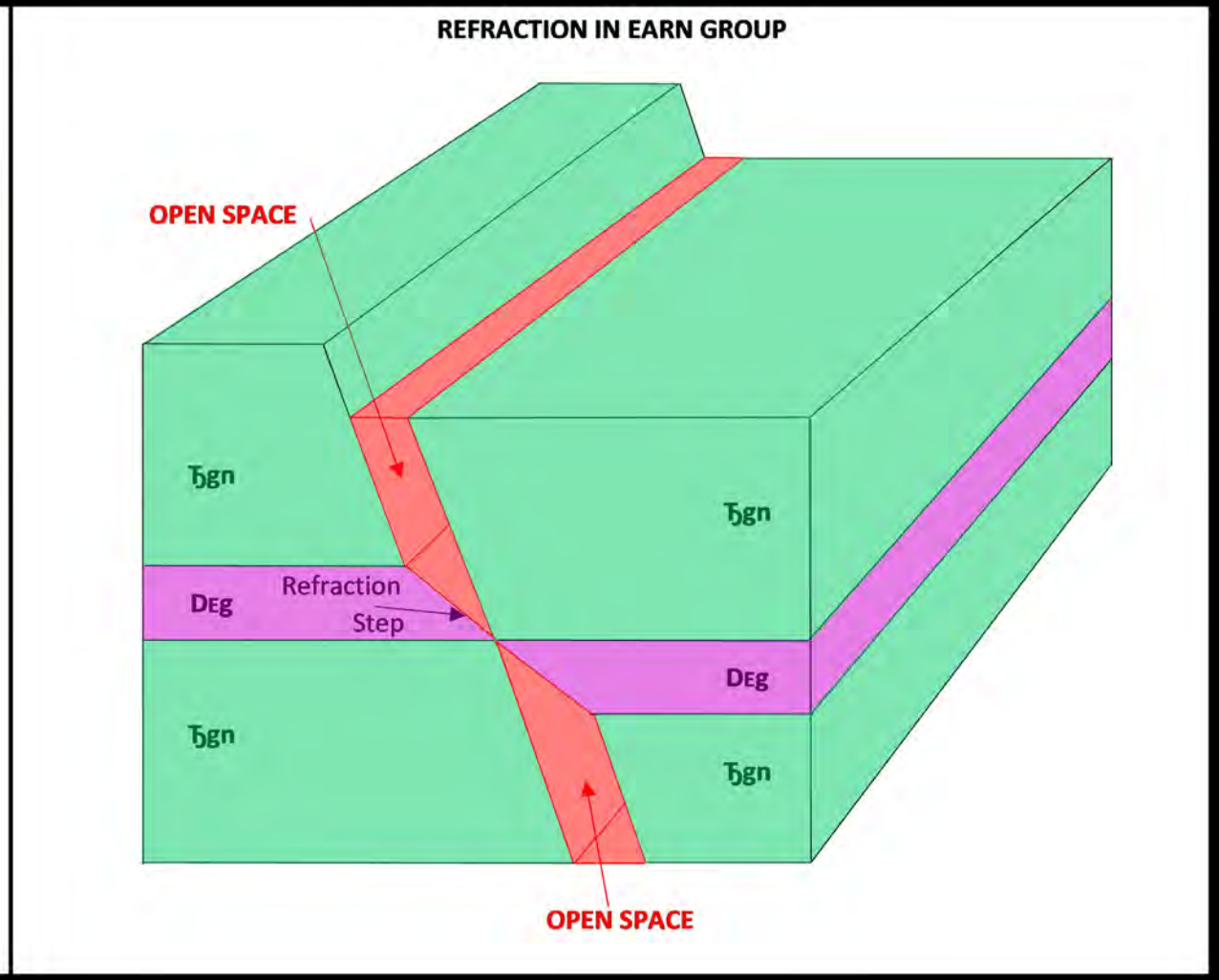
- I will introduce another mechanism – Divergence of vein fault movement from the Line of Intersection of vein faults probably plays an important role and I will give examples from some of the present- and past-producing mines.

ALEXCO

Refraction



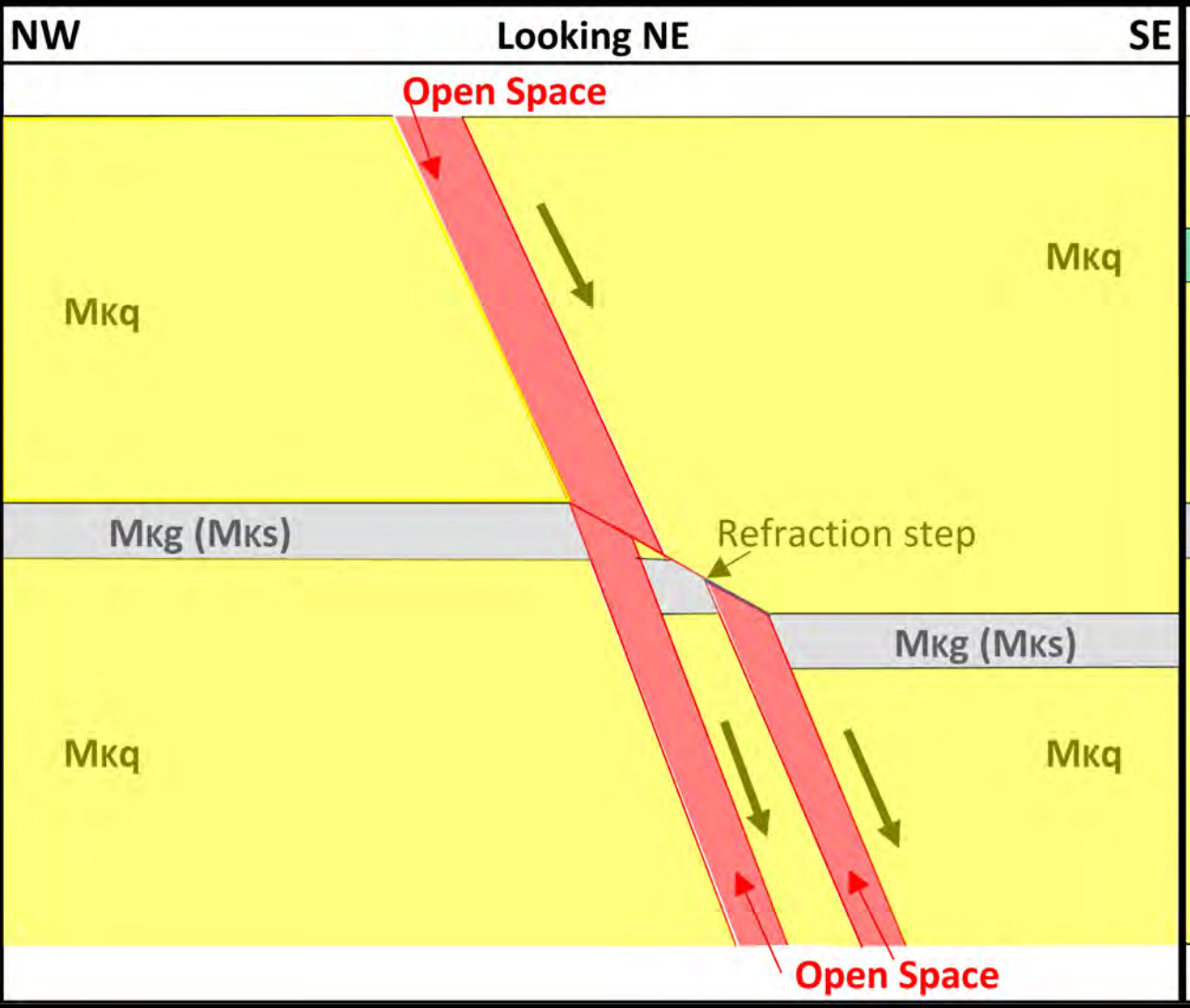
In competent Keno Hill quartzite



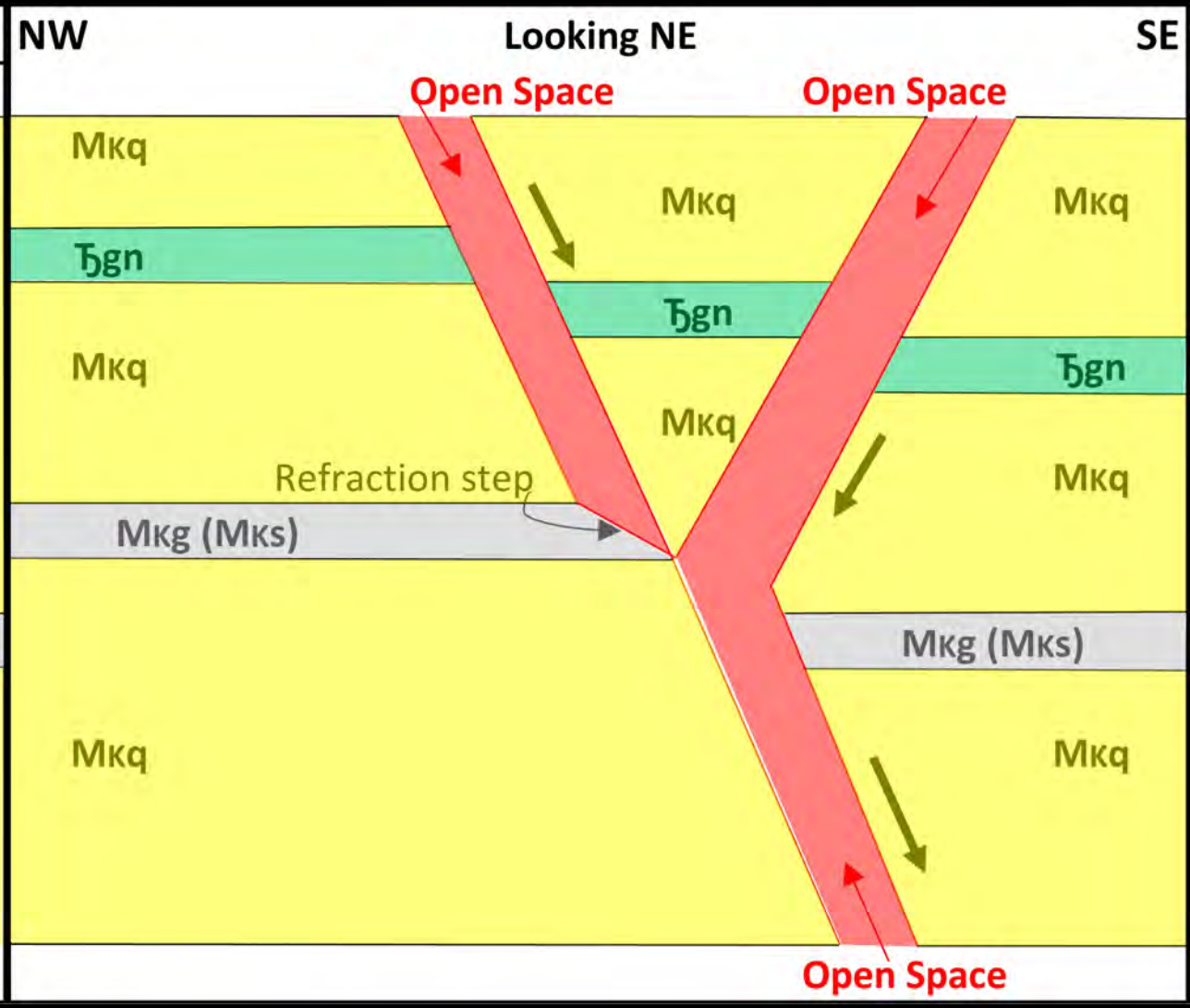
In competent greenstone and incompetent Earn Group

ALEXCO

Refraction Step



(a)

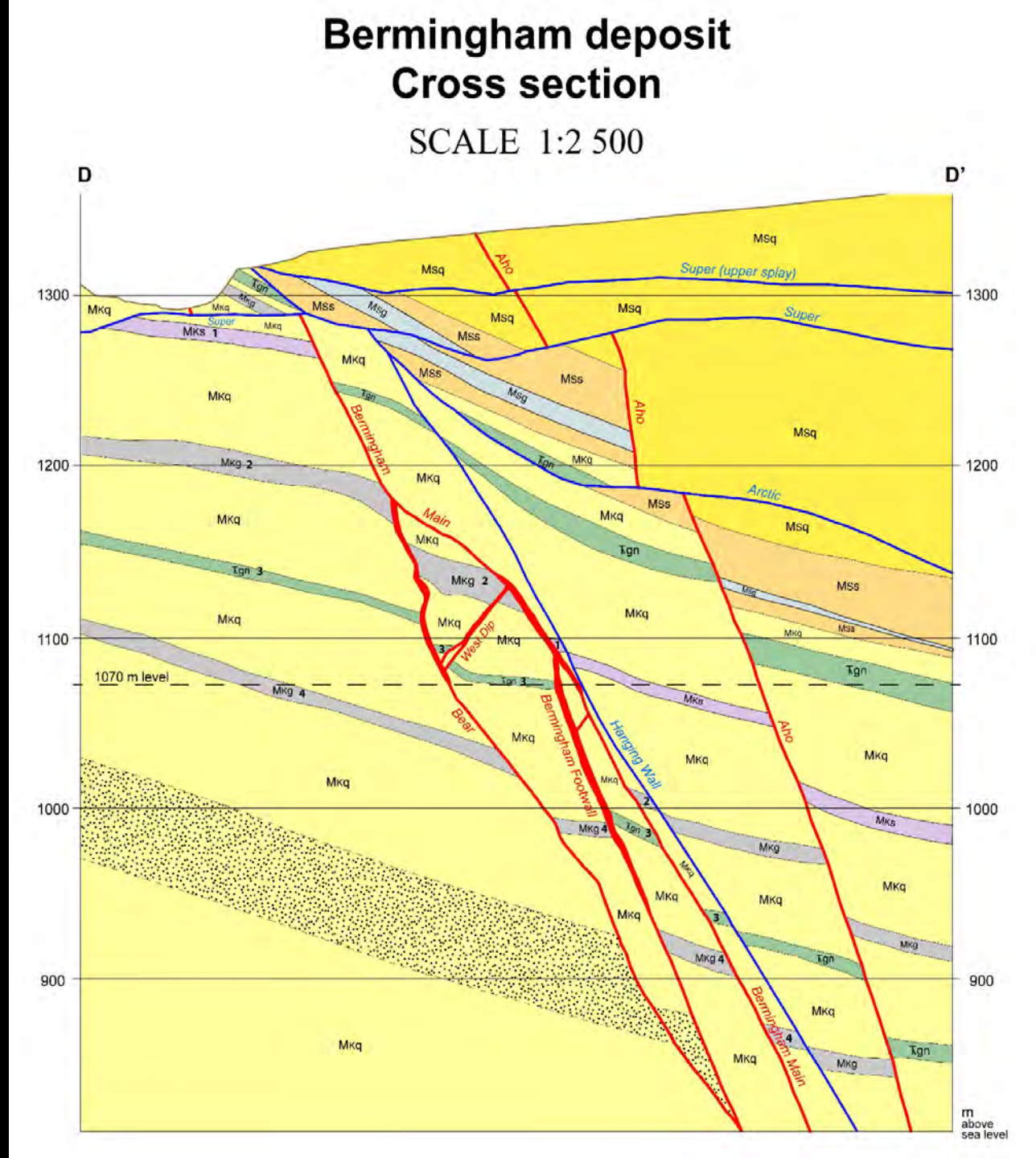


(b)

ALEXCO

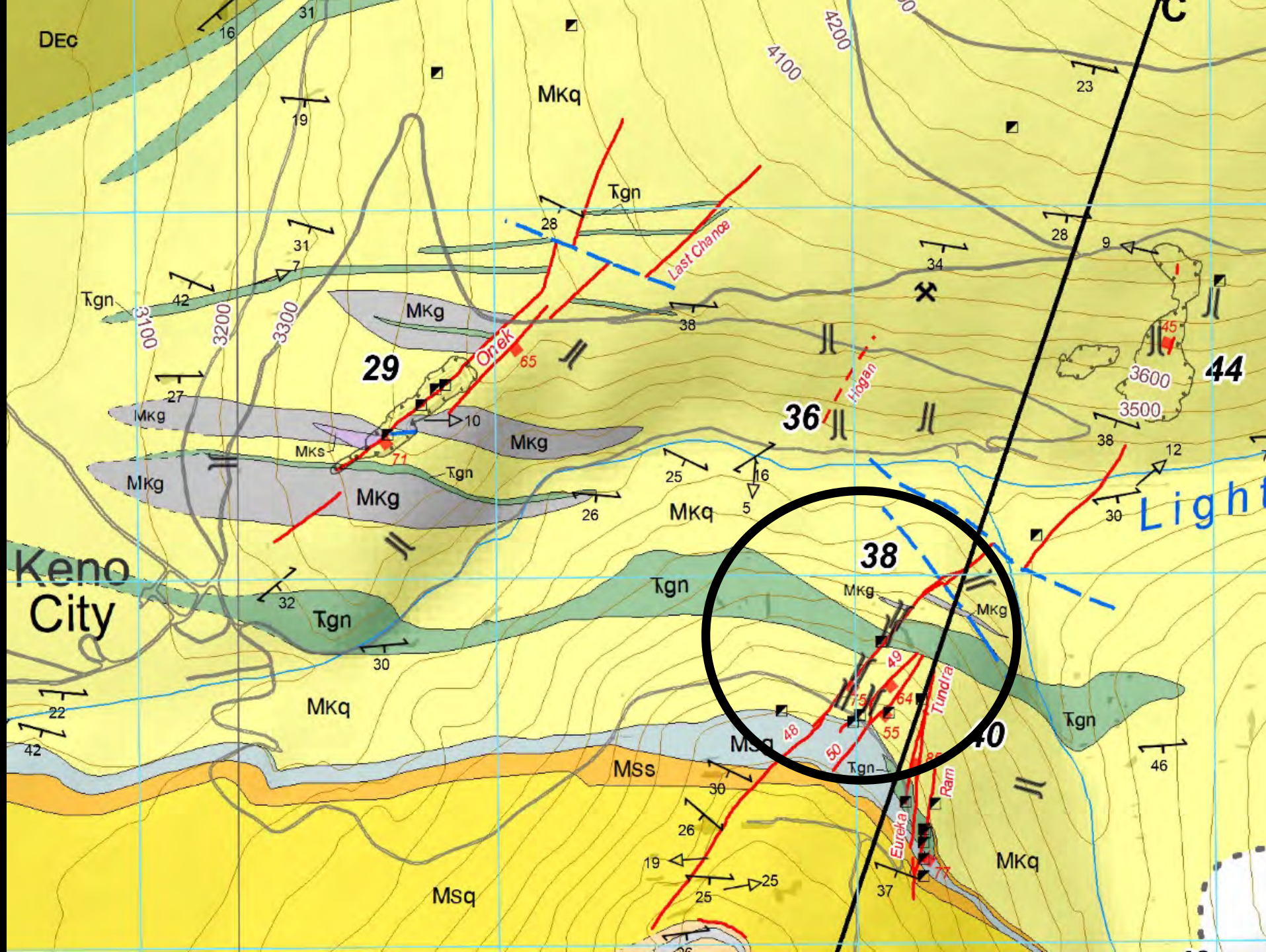
- It appears that Bermingham Main vein got hung up twice and developed the Bermingham Footwall and Bear veins as a result in the footwall of Bermingham Main vein

- In addition, a West Dip vein developed with arguably a reverse movement.



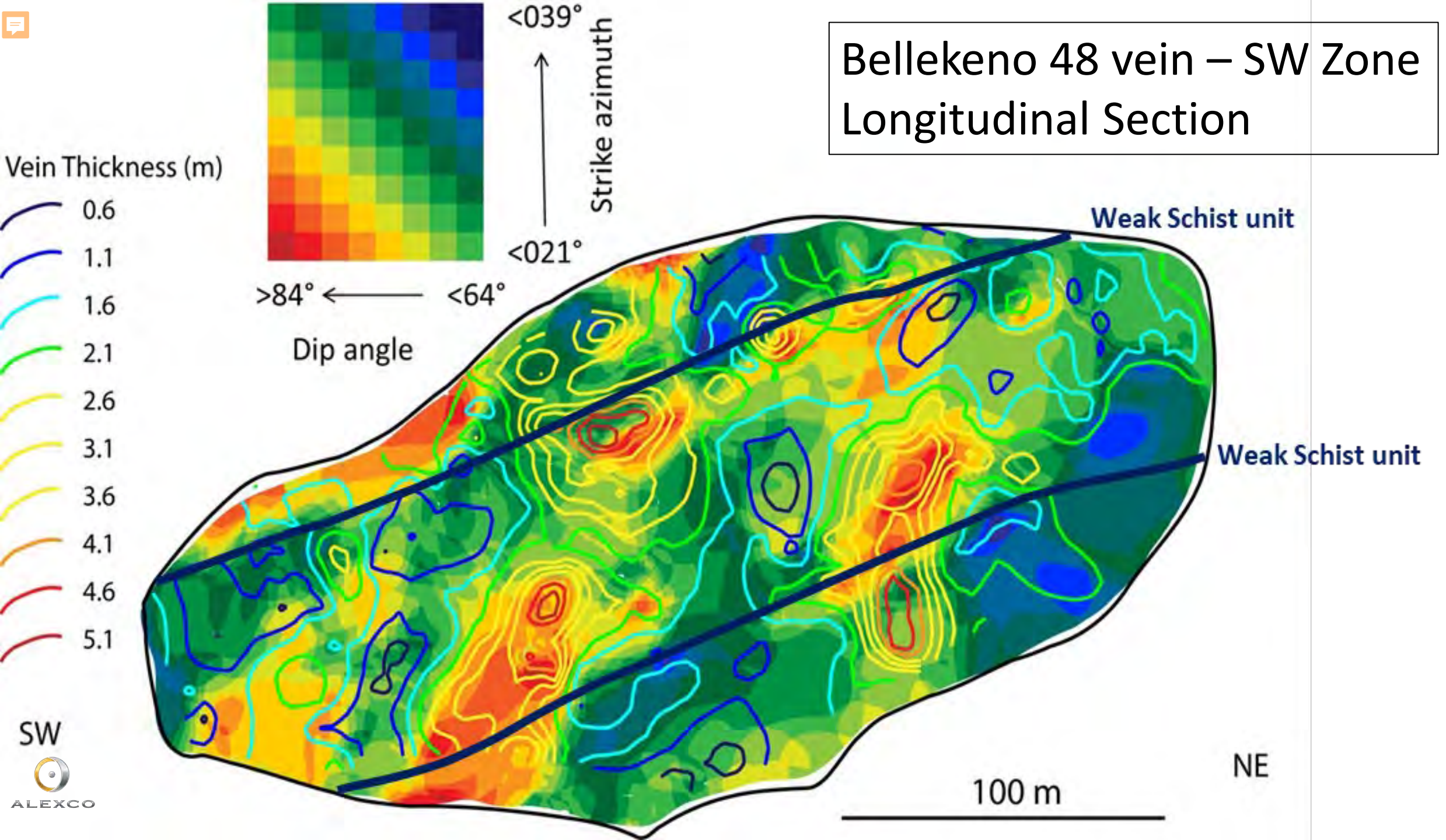
Bellekeno

Reidel shear model



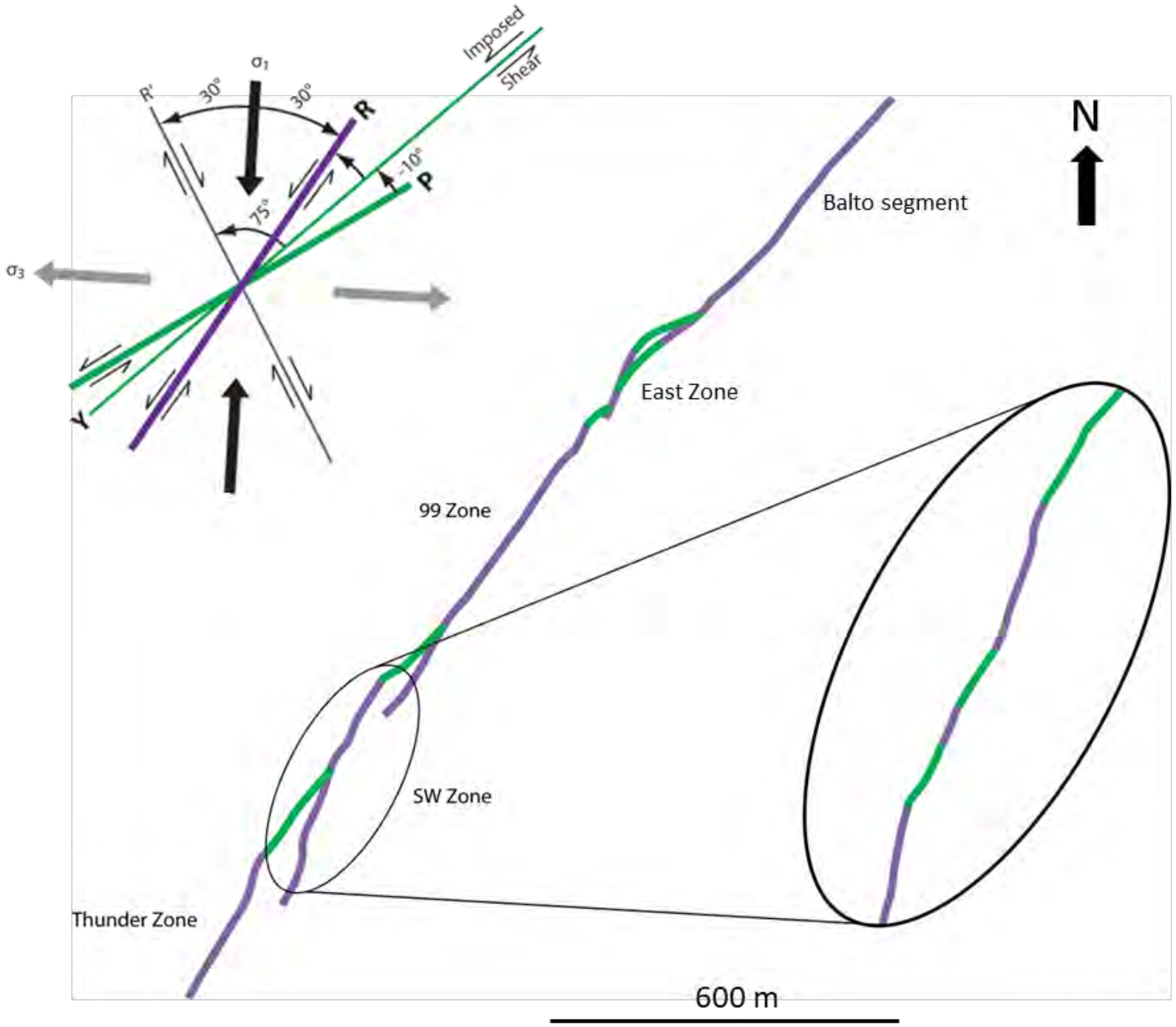
ALEXCO

Bellekeno 48 vein – SW Zone Longitudinal Section

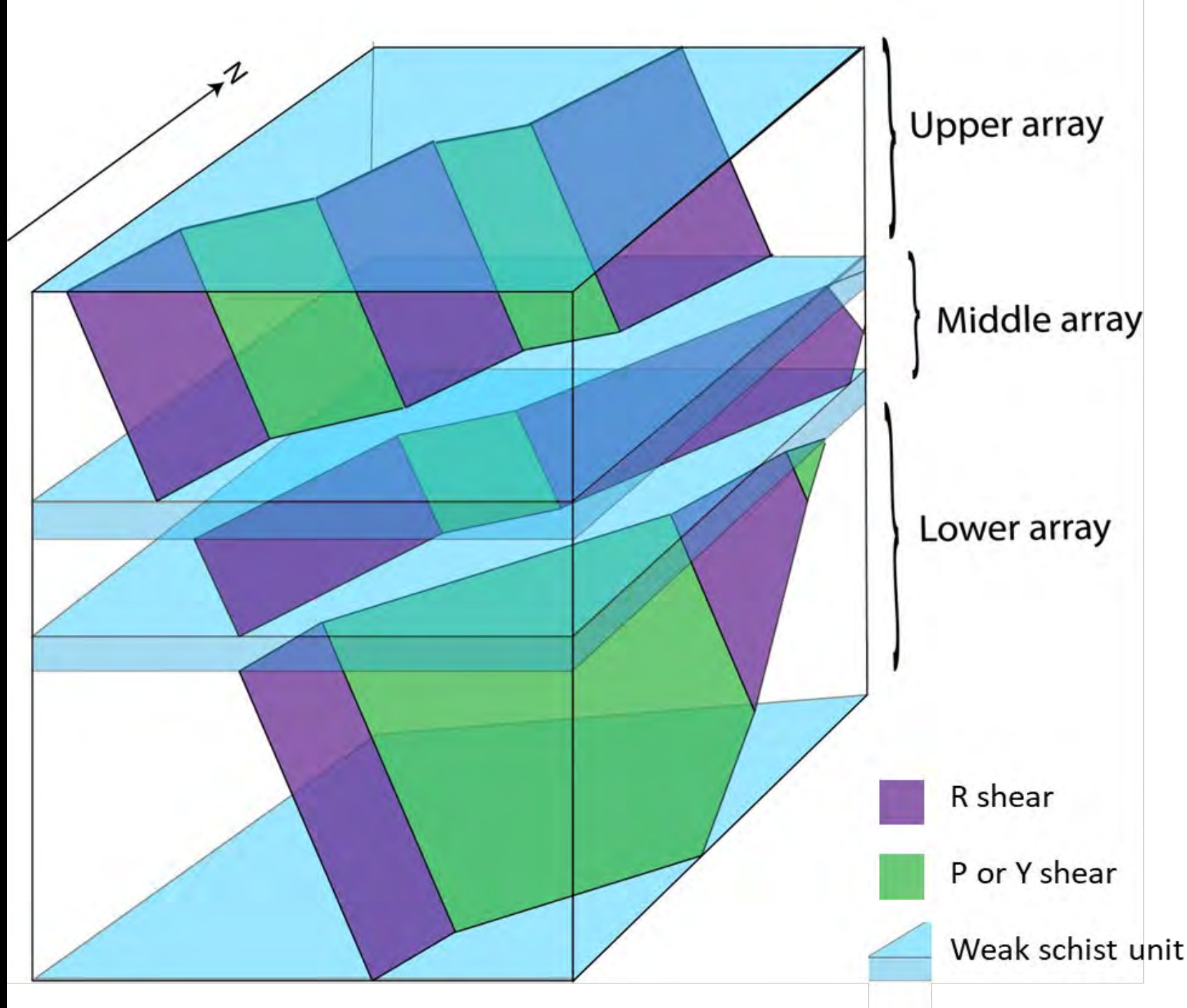


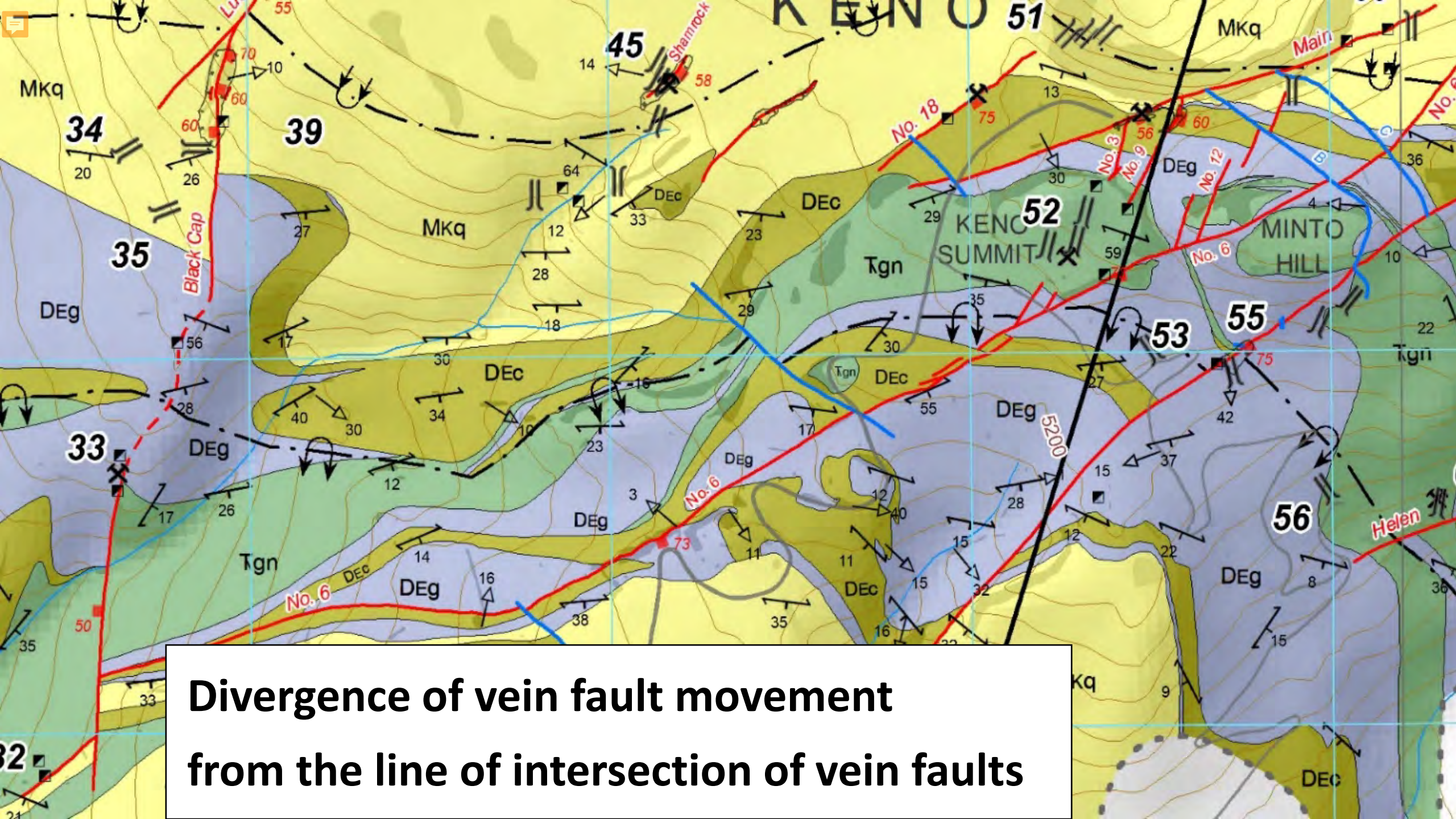
Bellekeno 48 vein

Plan view



Isometric schematic of Bellekeno SW Zone showing incipient Riedel arrays separated by weak schist units.





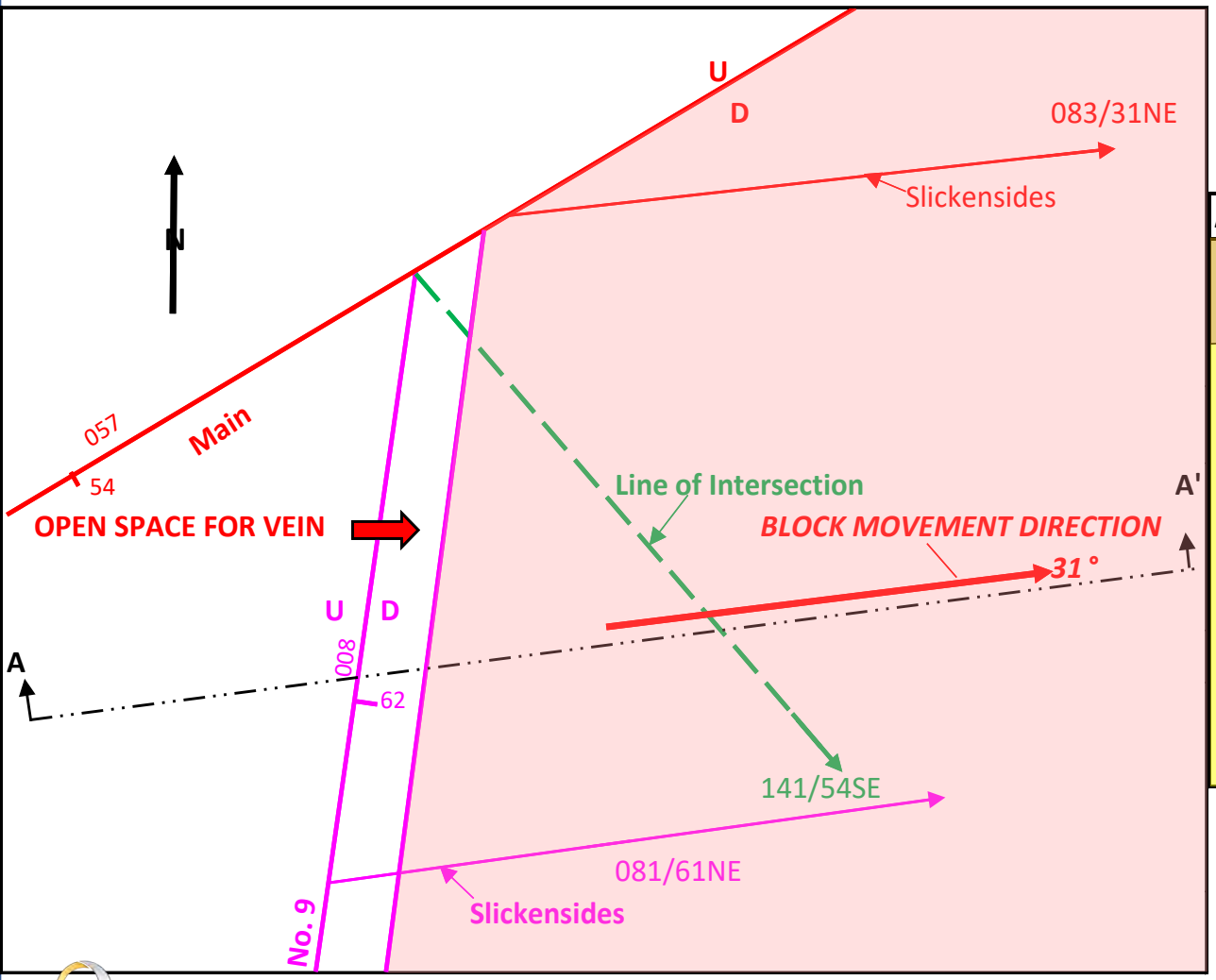
Divergence of vein fault movement from the line of intersection of vein faults

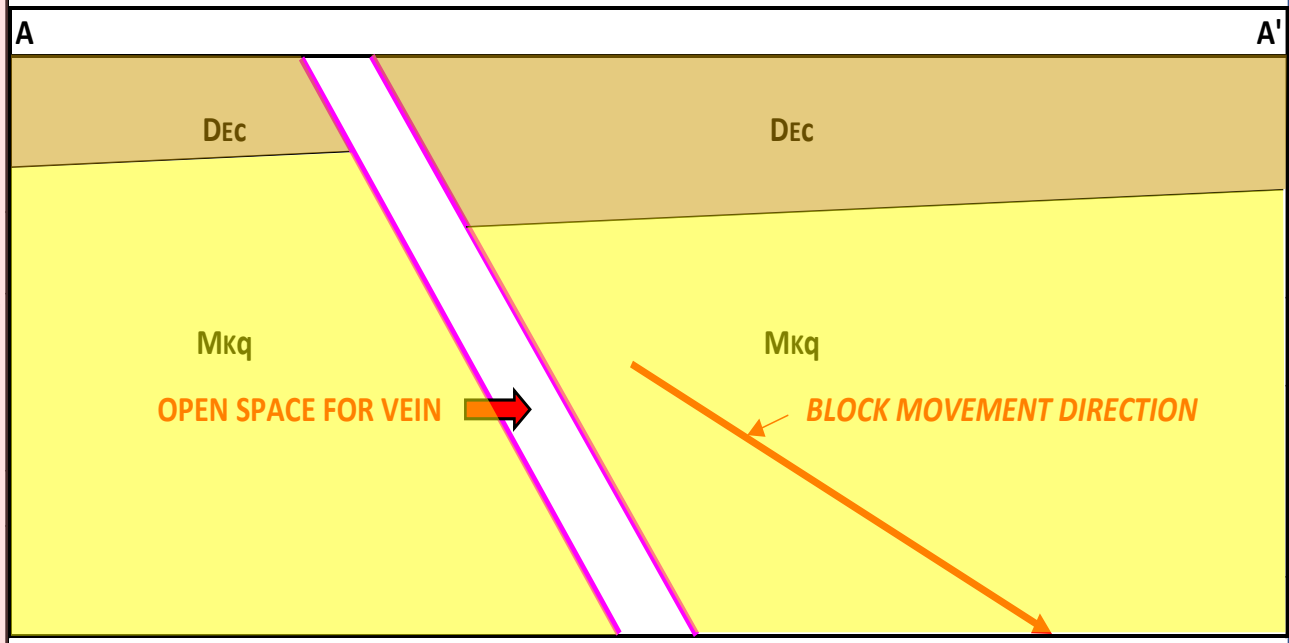
Slickenside directions from the No. 9 and Main veins

Vein	Structure	Strike/Dip	Trend/Plunge	Pitch
Main	Vein Fault	057/54SE		
	Slickensides		083/31NE	39E
No. 9	Vein Fault	008/62SE		
	Slickensides		081/61NE	
Line of Intersection			141/54SE	86E

ALEXCO

Divergence of vein fault movement from the Line of Intersection of vein faults

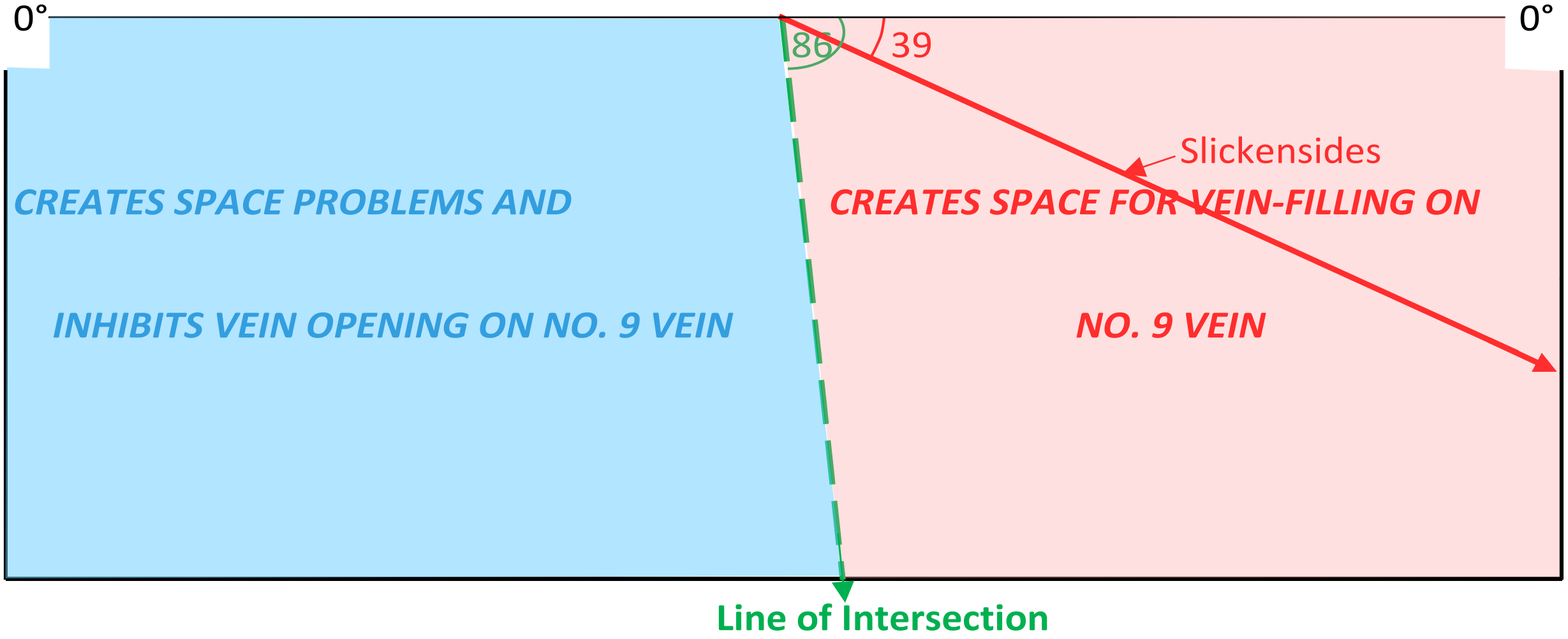




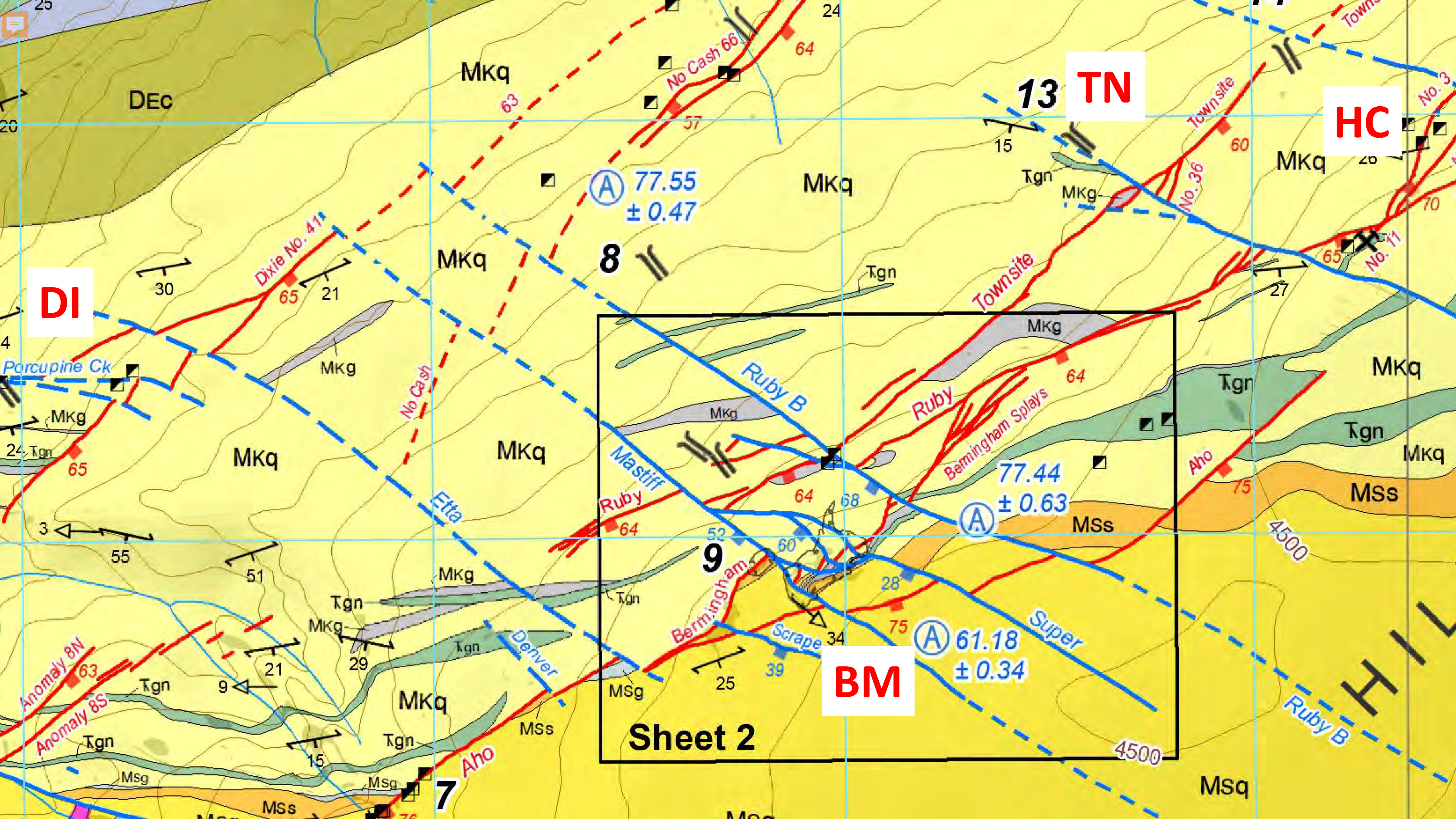
(a)

(b)

ORTHOGONAL VIEW OF MAIN VEIN



ALEXCO


TN
HC
DI
BM
Sheet 2
13
8
9
7
77.55
± 0.47
77.44
± 0.63
61.18
± 0.34
No Cash 66
Dixie No. 41
No Cash
Porcupine Ck
Townsite
No. 36
No. 11
Ruby B
Ruby
Mastiff
Etta
Denver
Berningham Splays
Berningham
Scrape
Super
Aho
Anomaly 8N
Anomaly 8S
MKq
DEc
MKg
Tgn
MSs
MSg
Msq
4500

SUMMARY

- In summarizing the mechanisms of vein fault formation, I want to stress two important features:

- The first already long known, is that the vein fault movements are left-lateral oblique normal to dip-slip faults- do not be fooled by the left lateral apparent separations, seen on the map, into thinking that they are strike-slip.
- The second is new - that the vein faults and veins developed over a considerable time span, about 20 Ma, between 68 to 89 Ma.

We have looked at three mechanisms for the generation of open space for vein-filling:

- Refraction (Boyle) and I have added the complexity of the hanging wall block sticking on the refraction step.
- Riedel shear (Iles)
- And the consequences of vein fault movements that Diverge from the Line of Intersection between early and late vein faults.

In the mining camp, the development of open space for vein-filling employs all of these mechanisms.

ALEXCO

Midnight, June the 21st, Signpost Hill