

Coal Geology of the Crowsnest Pass

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After 35 years with the Alberta Geological Survey

- Coal is an organic sedimentary rock that forms from the accumulation and preservation of plant materials, which grew in swamps
- The swamps which formed the Crowsnest Pass coal existed during the Jurassic Period about 150 million years ago
- Other sediments are sands and muds deposited in rivers, lakes, seas and deserts, in addition to carbonate muds in oceans
- During time these sediments were buried beneath younger sediments and exposed to higher temperatures and pressures
- During this time sands became sandstone, muds became shale, carbonate muds became limestone and swamps became coal
- All coal will burn, however for use in the steel industry only bituminous coal can be used
- Bituminous metallurgical coal was formed after specific temperatures and pressures during the burial process and for that reason are financially worth more in trade than thermal coal

Mountains were Formed

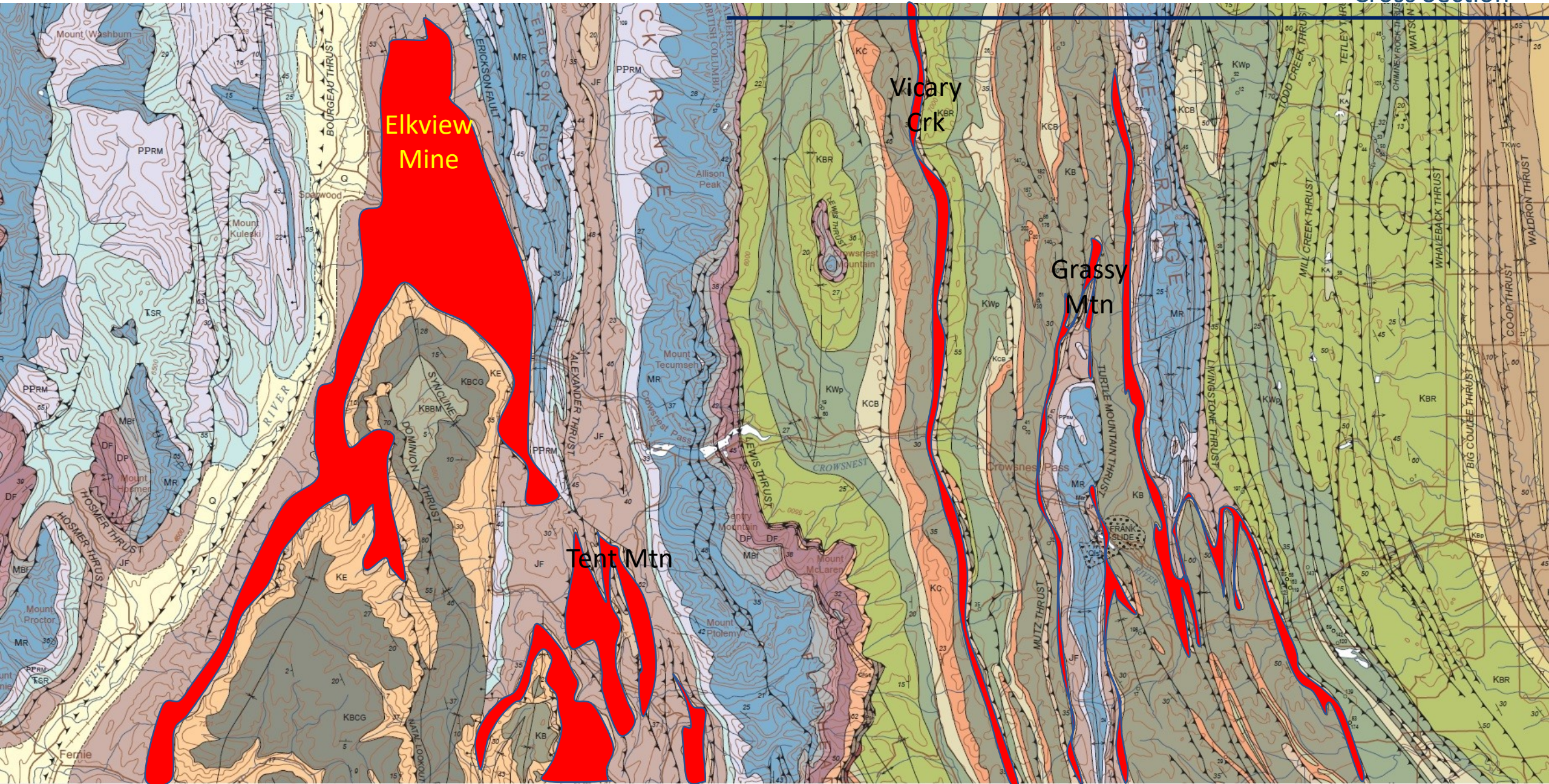
- Sixty million years ago the Rockies were formed from tectonic plate movements, which resulted in originally horizontal layers being deformed in folds and faults
- These layers are now exposed on the surface of the Earth and can be represented on a geological map by different colours

Crowsnest Pass and Elk Valley Geology (GSC Map 2200 A)



Crowsnest Pass and Elk Valley Geology (coal-bearing strata in red)

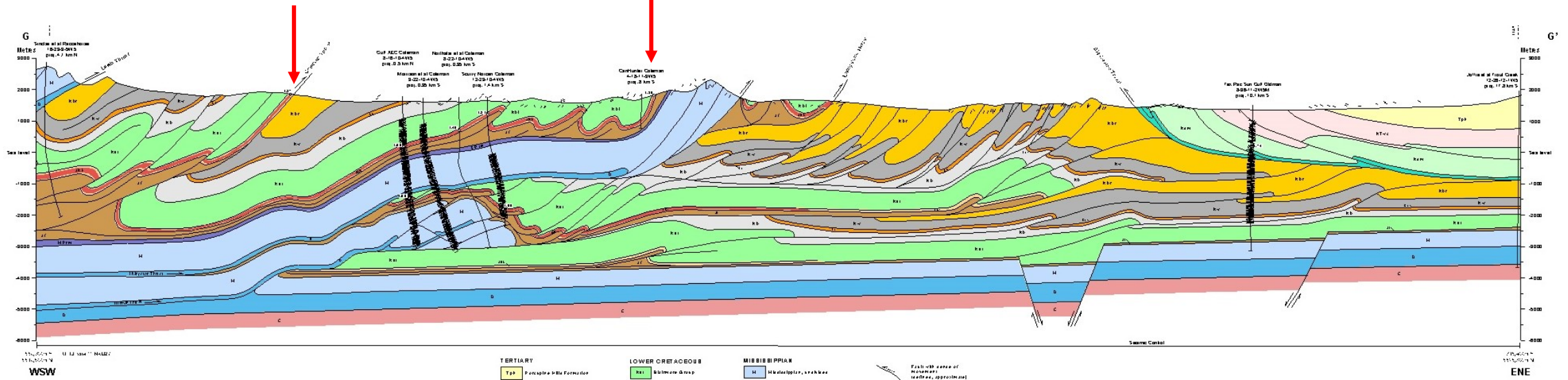
Cross Section



Oldman River Cross Section

Vicary Creek Mine

Grassy Mountain Mine



Cross Section, Oldman River Area

Geology by P. MacKay and
C.W. Langenberg
Published 2002



TERTIARY	LOWER CRETACEOUS	MISSISSIPPIAN
Tpt Fossiliferous Intra Formation	ksl Stelmans Group	M Montpelier, ss/shale
CRETACEOUS AND TERTIARY	JURASSIC AND CRETACEOUS	DEVONIAN
ktvc Vicary Creek Formation	ksl Stelmans Group	D Deseronto, ss/shale
UPPER CRETACEOUS	JURASSIC	CAMBRIAN
ksm St. Mary River Formation	jt Fossiliferous	C Cambrian, ss/shale
ksp St. Mary River Formation	ksl Stelmans Group	MISSISSIPPIAN AND PERMIAN
ksr Red River Group	ksl Stelmans Group	msl Red River Group
kw Wapiti Formation	ksl Stelmans Group	
kc Carleton Formation	ksl Stelmans Group	
kb Blackstone Formation	ksl Stelmans Group	

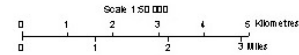
Fastest rate of movement (red line, approximate)

20-40% dip (at 2 km N)

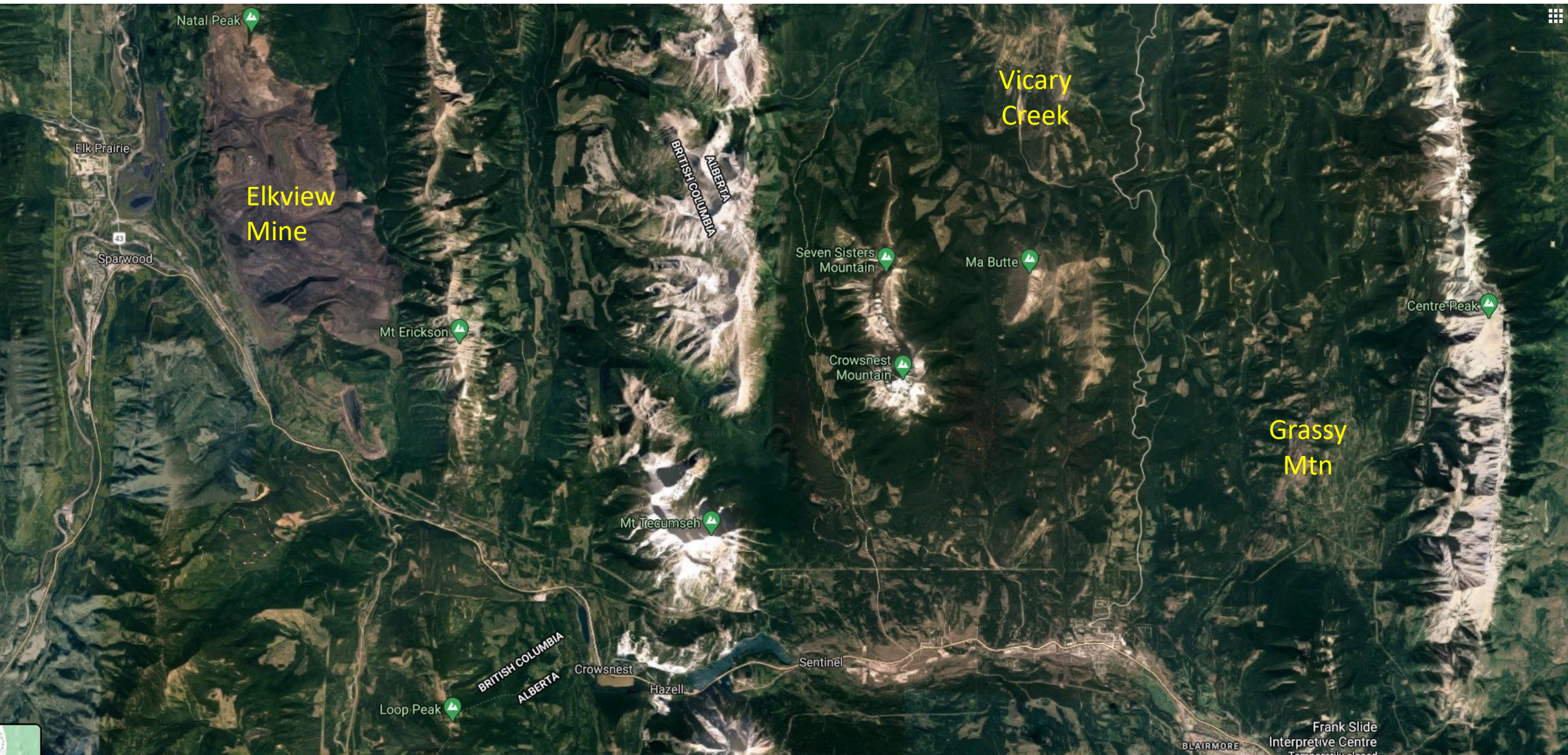
Assumed rate of subsidence

Percentage of maximum tillite subsidence

Normal bedding orientation



Aerial View Sparwood to Blairmore



Teck's Elkview Mine



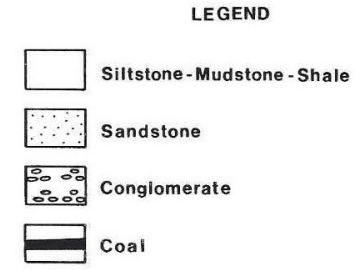
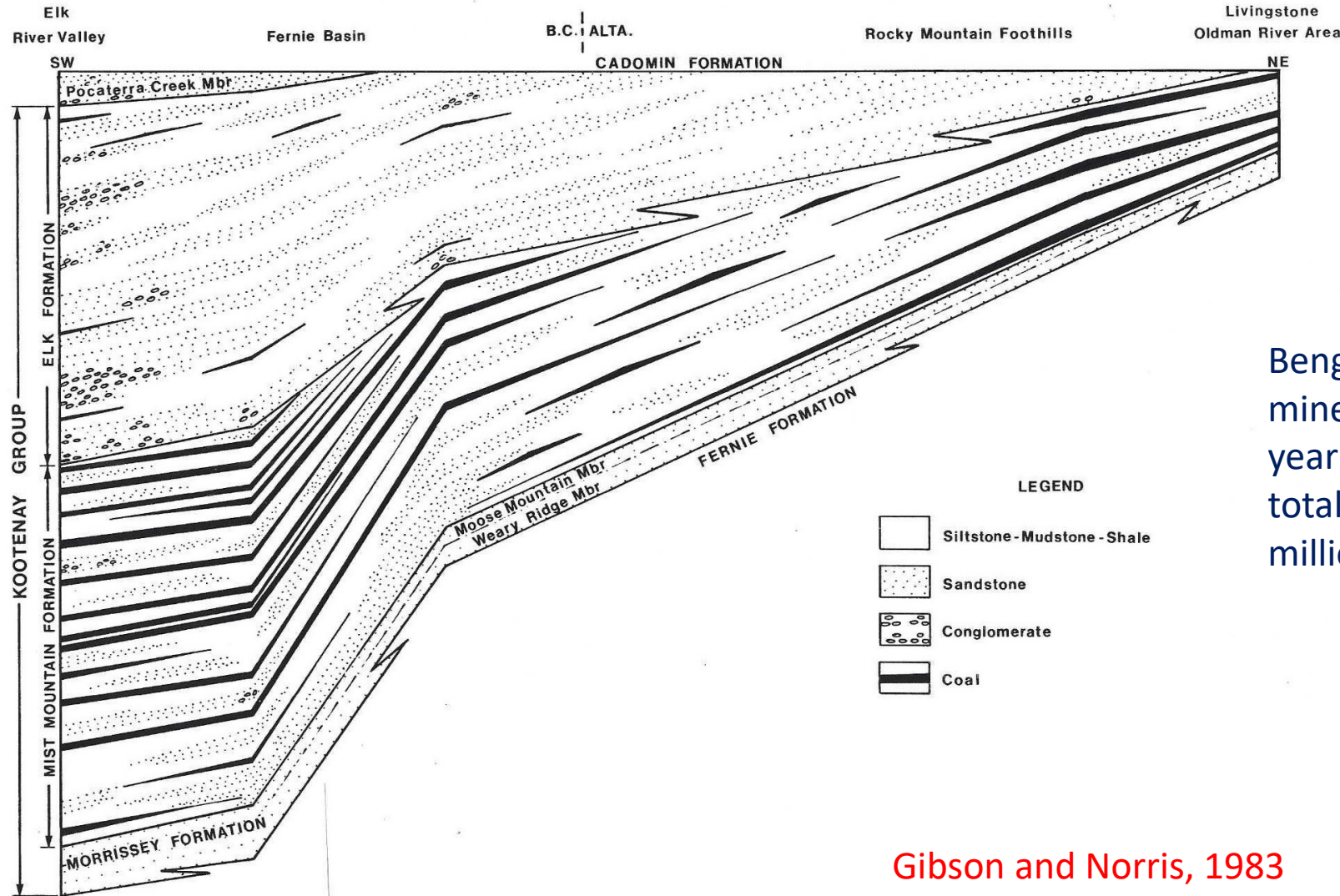
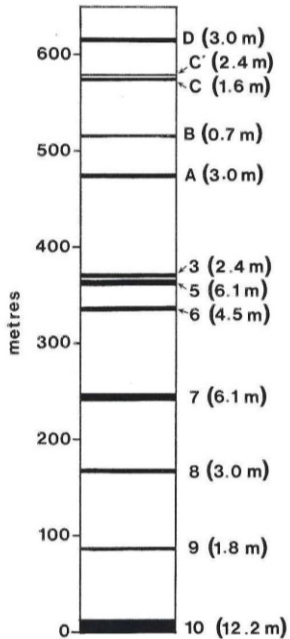
Production: 7 million tonnes/year
Reserves: 250 million tonnes (36 years)

Teck has 3 more mines in Elk Valley
Total yearly production: 25 million tonnes with reserves for at least 25 years (total reserves of 625 million tonnes)

Cross Section of Kootenay Coal Sparwood to Blairmore

Grassy Mtn.

Elkview Mine

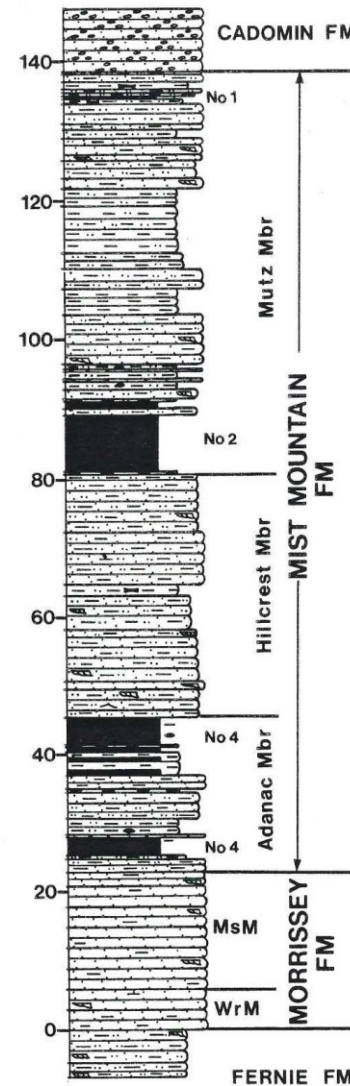


Benga is proposing to mine 4 million tonnes a year for 23 years with total reserves of 92 million tonnes

Gibson and Norris, 1983

Grassy Mountain Coal Section

GRASSY MOUNTAIN



Reserves: 92 million tonnes

No 1 Seam: 16 %

No 2 Seam: 50 %

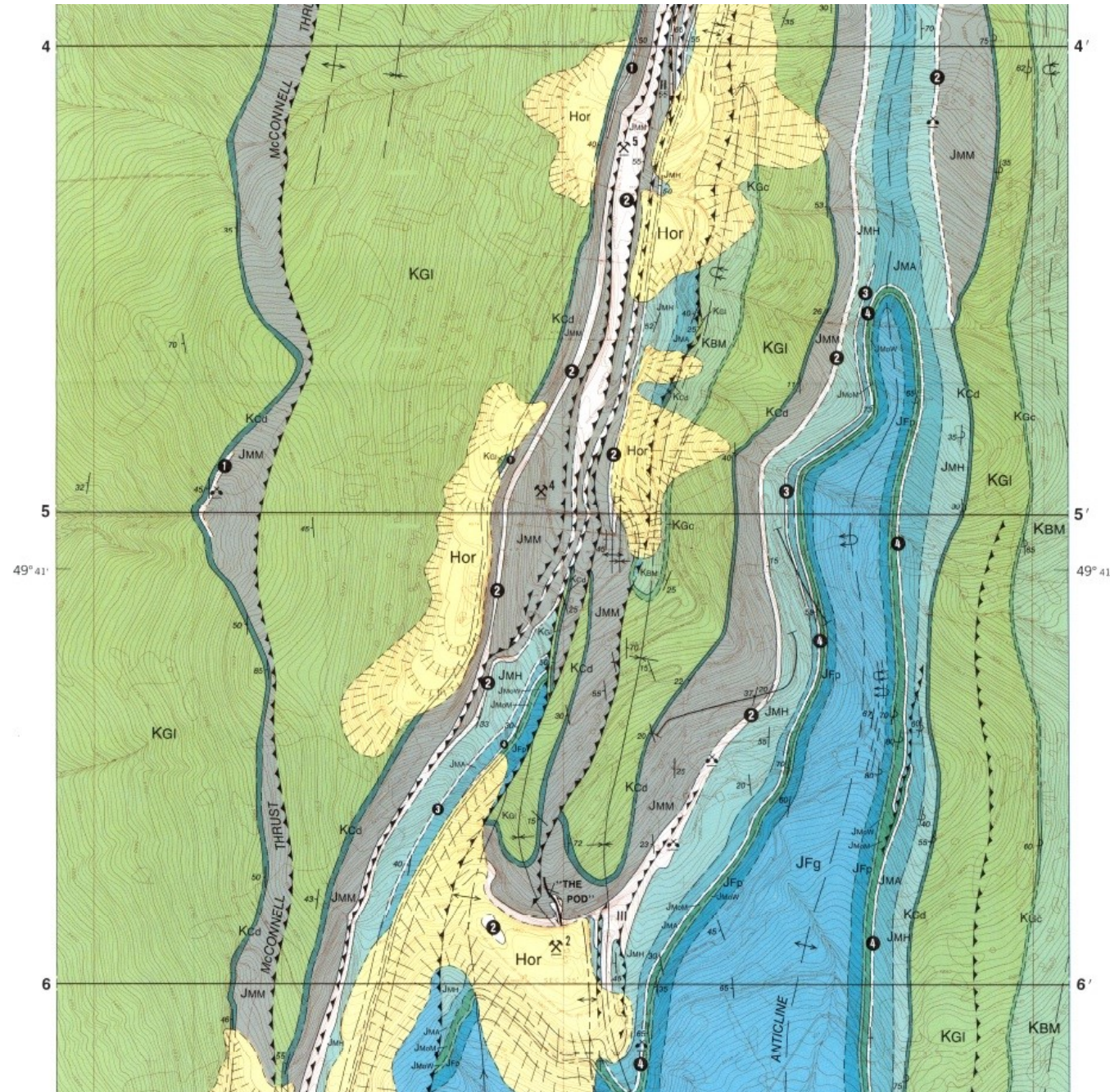
No 4 Seam: 34 %

Gibson and Norris, 1983

Grassy Mountain and Big Show in 1986

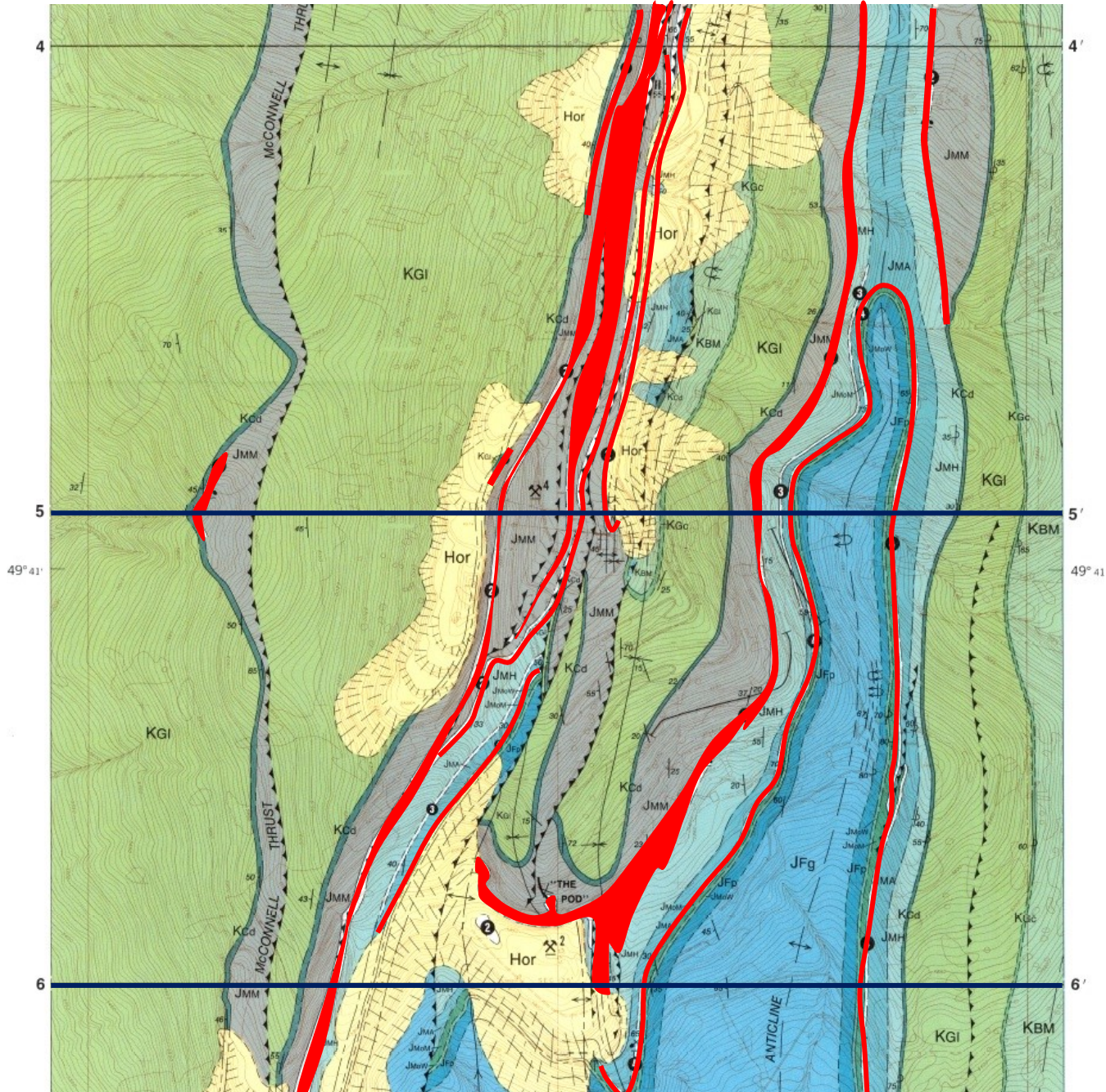


Geological Map Grassy Mountain



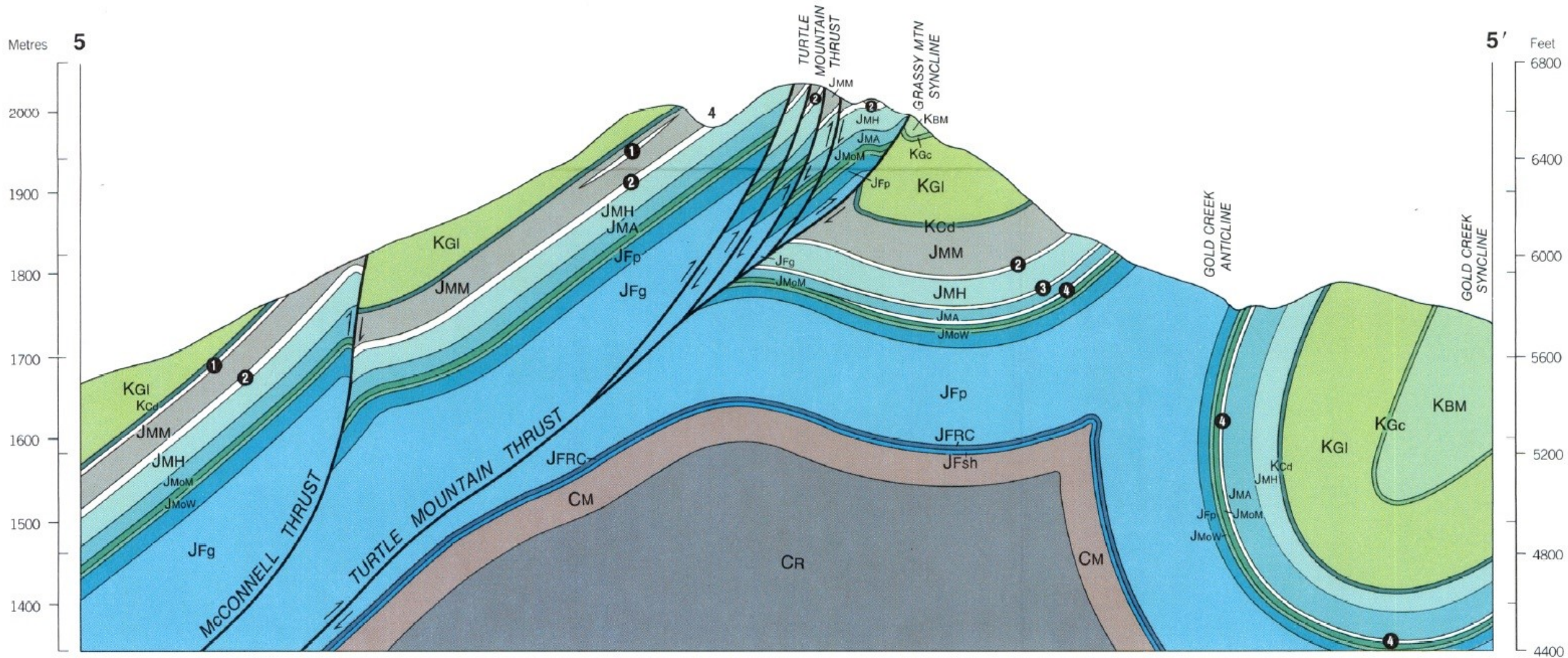
Norris, 1994

The Coal seams of Grassy Mountain

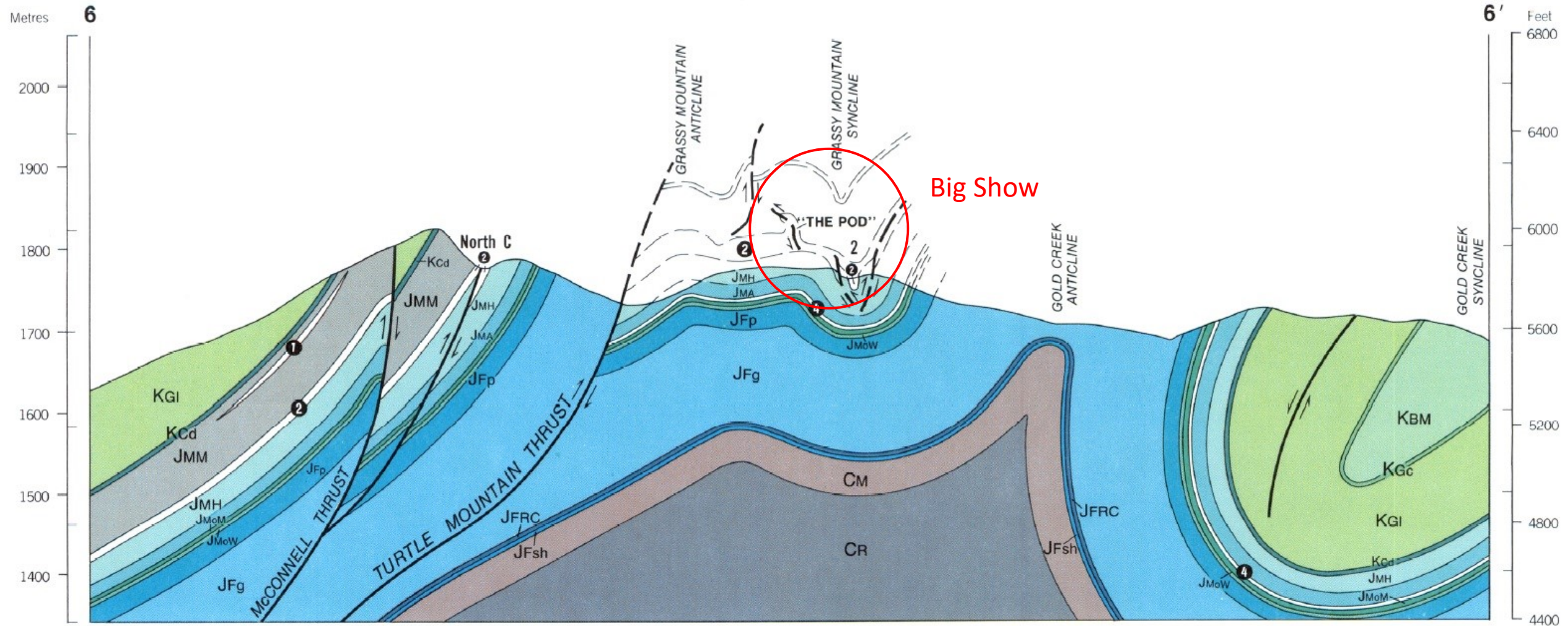


Norris, 1994

Cross Section 5

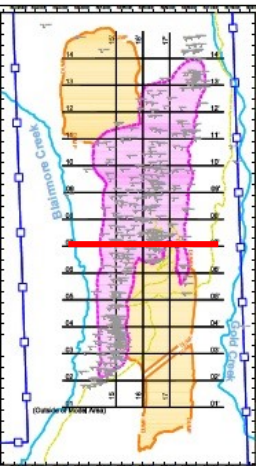
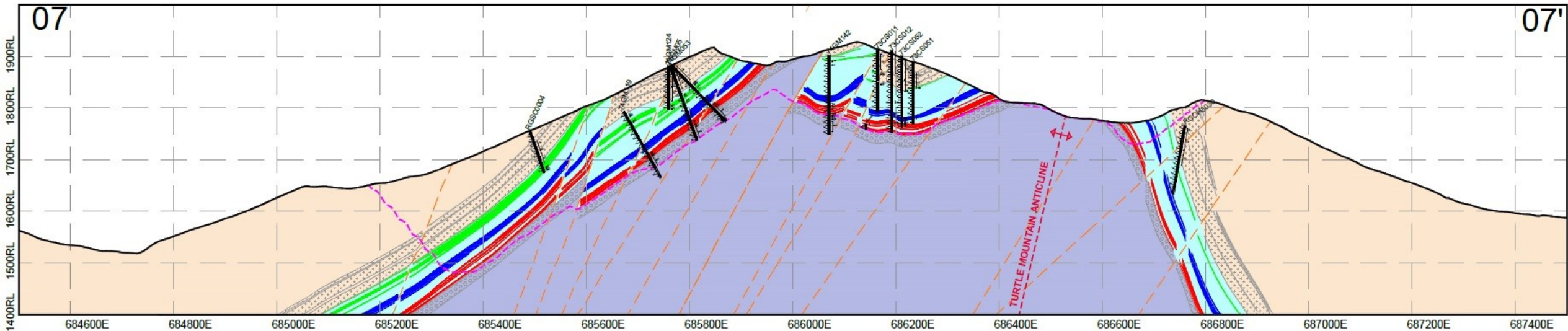


Cross Section 6



Norris, 1994

Benga Cross Section 7



CROSS SECTION

- BLAIRMORE GROUP
- KOOTENANY GROUP
 - SEAM NO.1
 - SEAM NO.2
 - SEAM NO.4
- FERNIE GROUP
- CADOMIN CONGLOMERATE
- MOOSE MOUNTAIN SANDSTONE
- FOLD - ANTICLINE
- REVERSE FAULT
- PROPOSED PIT

LOCATION PLAN

- WATERCOURSE
- ACCESS ROAD
- MINE PERMIT BOUNDARY
- PROPOSED PIT
- PROPOSED DUMP

NOTE(S)
 1. ALL DEPTH, ELEVATION AND THICKNESS VALUES IN METERS

REFERENCE(S)

- MINING LEASE BOUNDARIES PROVIDED BY MILLENNIUM EMS SOLUTIONS (MEMS)
- WATERCOURSE MAP PROVIDED BY MILLENNIUM EMS SOLUTIONS (MEMS)
- GEOLOGY BY CONSOL (EXPLORATION SUMMARY MAP: 1988) AND RIVERSDALE RESOURCES 2013, 2014, 2015 & 2016

BENGA MINING LIMITED
RIVERSDALE RESOURCES LIMITED

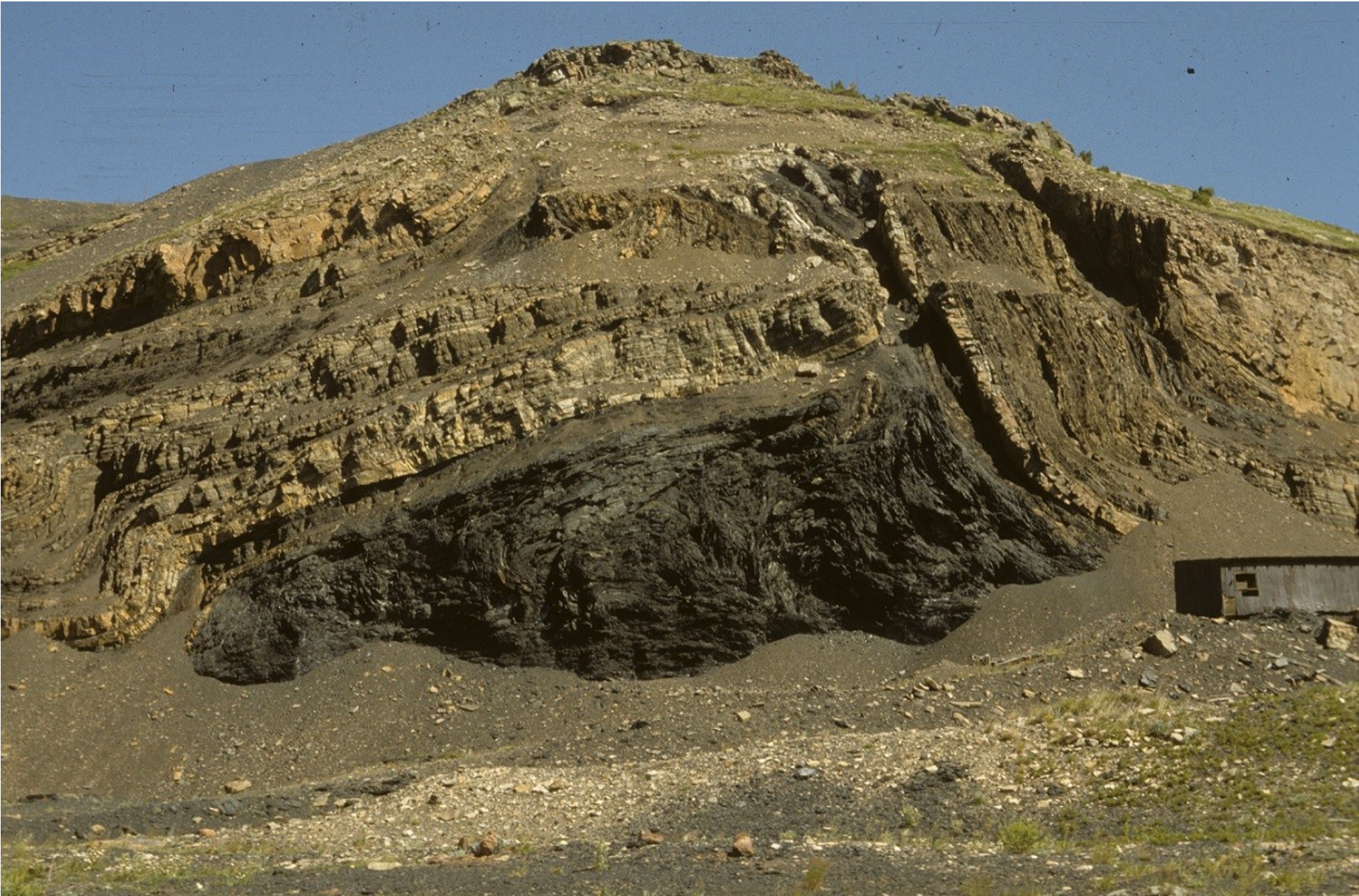


GRASSY MOUNTAIN COAL PROJECT
MINE LICENCE
ALBERTA, CANADA

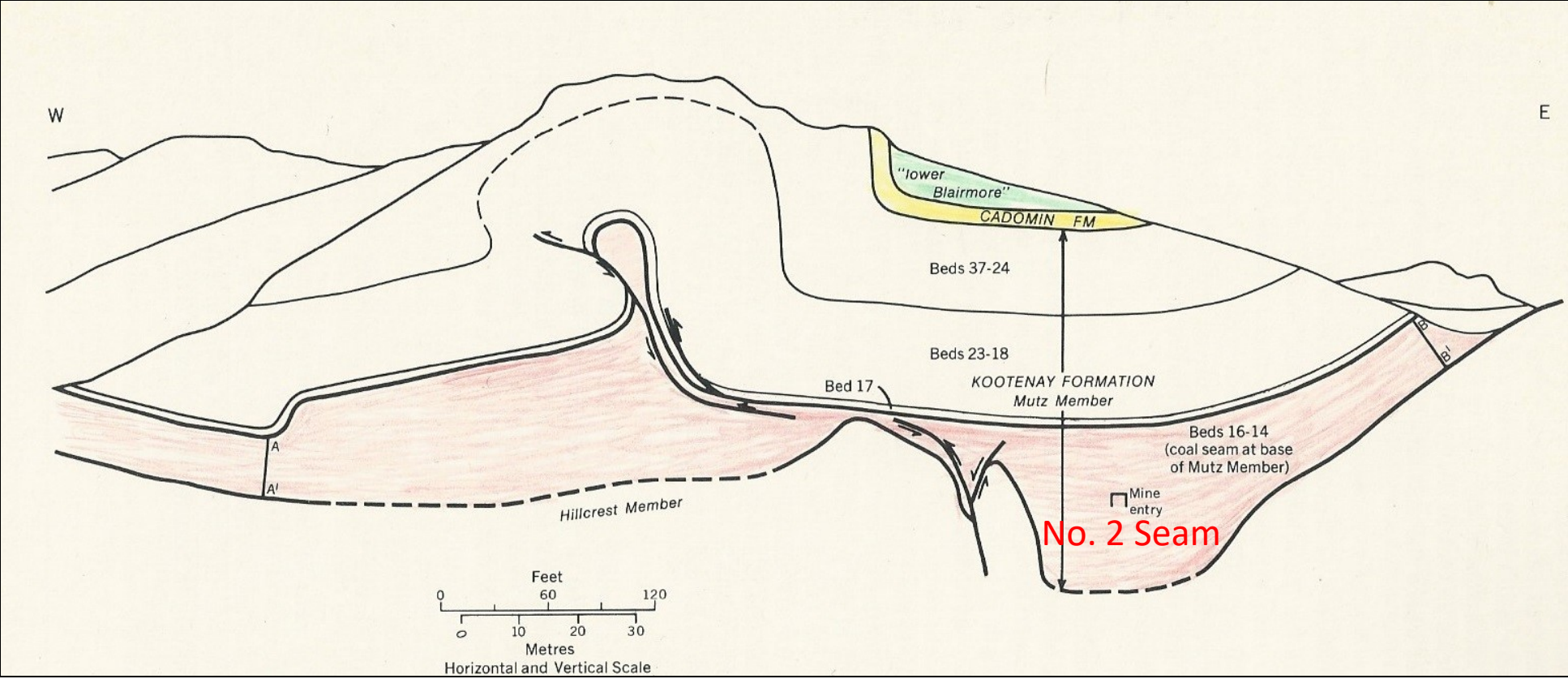
Figure B.2.0-3
GEOLOGICAL CROSS SECTIONS 06 & 07

DRAWN BY: M.A
 DATE: MAY 02, 2016

The Big Show



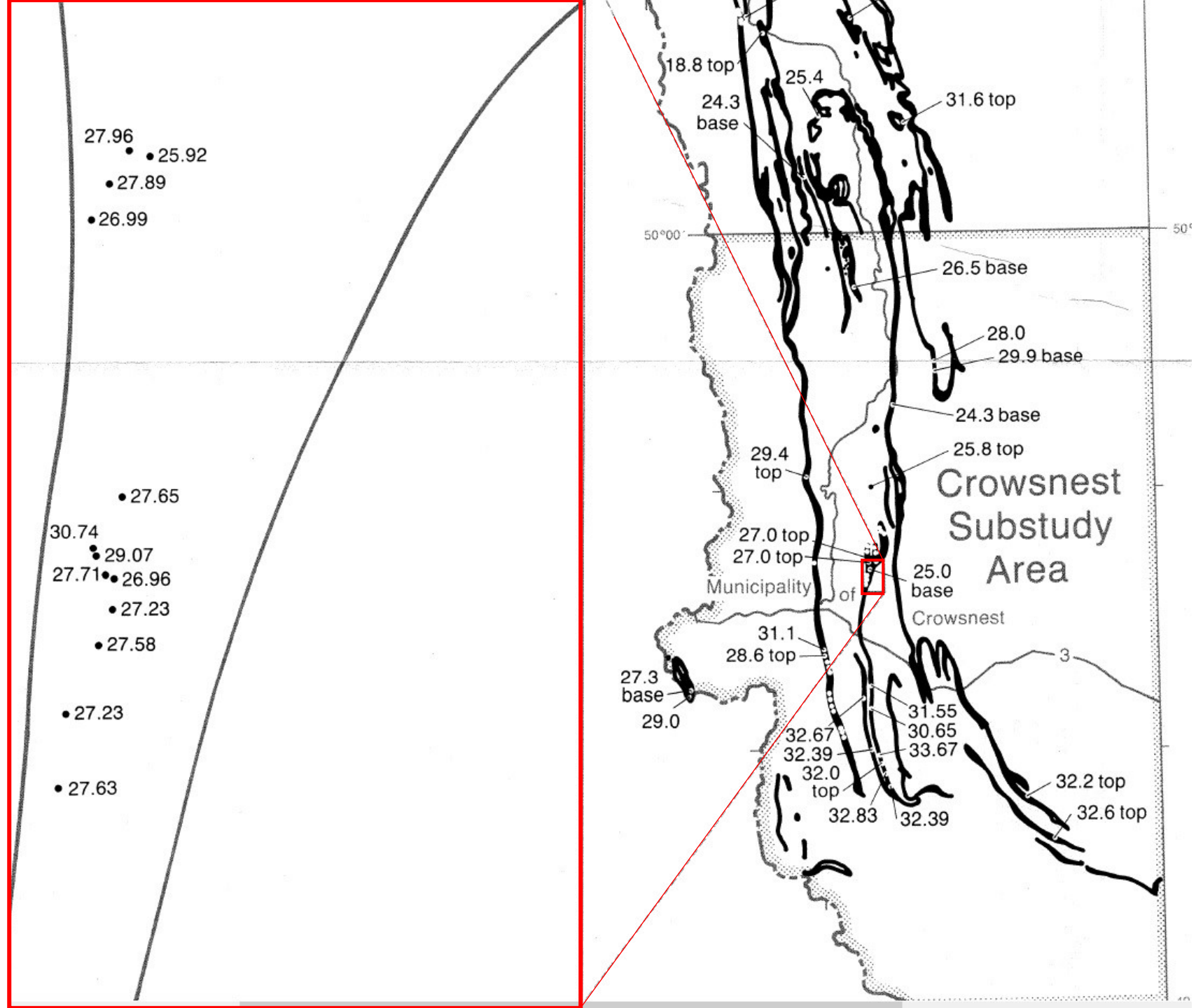
The Big Show



Norris, 1971

Dry, ash-free Volatile Matter Percentage

At Grassy Mountain VM 25-31%,
indicating medium volatile
bituminous coking coal



Summary

- Uncertainty about available tonnage of No. 1 Seam
- Small reserves compared to available reserves in Elk Valley
- Prediction that globally less metallurgical coking coal will be needed in next 25 years
- Environmental costs are huge in Mountain areas
- Boom and bust can be predicted for a possible coal industry in Crowsnest Pass (does Alberta need another Grande Cache?)
- Crowsnest Pass will be better served by concentrating on alternative industries such as tourism, recreation and renewable energy