Geology of the Mount Stephen Trilobite Beds and Adjacent Strata. Field, B.C., Yoho National Park — Exploration Ramifications from New Insights on a 130-Year-Old Discovery*

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Abstract

Since their discovery 130 years ago, researchers have assumed that the Mount Stephen Trilobite Beds, found within the Ogygopsis Shale, were the southwestern extension of the Burgess Shale Beds exposed along the Kicking Horse River Valley mountainsides. The absence of Ogygopsis or equivalent shale within the adjacent local Burgess exposures, including those on Fossil Ridge (home of the Walcott Quarry), has perplexed researchers for over a century. The recent discovery of the post-glacial Field Landslide and analysis of the landslide features, including the slide failure surface(s), led to the discovery of several previously unrecognized Cambrian depositional features and Canadian Rocky Mountain Main Range structural features. Aside from the discovery of the Field Landslide, the most significant findings include: 1) the discovery of evidence of the initial western Main Range thrusting event (the KTC) on the exposed surfaces of the Field Slide, indicating that the two Main Ranges represent two distinct thrusting episodes, 2) the discovery of a major subaerial exposure surface at the contact between the Ogygopsis Shale and the underlying carbonate beds, 3) the recognition that the previously interpreted Cathedral Escarpment megaclasts or deep water carbonate mud mound features in the underlying carbonate beds are Cambrian patch reefs, part of the Basal Cathedral Formation (Upper Mount Whyte Formation) and 4) the redefinement of significant basement faulting both during and post-western Main Range thrusting. Combined, the above findings challenge: a) the accepted Cambrian (Cathedral/Burgess Shale) depostional and stratigraphic models which were developed without the recognition of duplicated, laterally displaced Cambrian Strata, and b) the accepted theories regarding

the structural history of the Main Ranges of the Canadian Rocky Mountains. Recognizing that the Cathedral Burgess section is a cyclic carbonate shale sequence comparable in character to those found within the productive Devonian sections in the Western Canadian Basin, and acknowledging the existence of Early Cretaceous basement faulting opens up the potential for both conventional and resource play exploration within these Cambrian formations.

Selected References

Aitken, J.D., and J.D. Fritz, 1968, Burgess Shale project, British Columbia: Geological Survey of Canada, Paper 68-1:A, p. 190-192.

Aitken, J.D., and I.A. McIlreath, 1984, The cathedral reef escarpment; A Cambrian great wall with humble origins. Geos, v. 13, p. 17–19.

Aitken, J.D., J.D. Fritz, and H.B. Whittington, 1967, Stratigraphy, palaeontology and palaeoecology of the Burgess Shale: Geological Survey of Canada, Paper 67-1:A, p. 52.

Fletcher, T.P., and D.H. Collins, 1998, The Middle Cambrian Burgess Shale and its relationship to the Stephen Formation in the southern Canadian Rocky Mountains: Canadian Journal of Earth Sciences, v. 35/4, p. 413-438.

Fletcher, T.P., and D.H Collins, 2003, The Burgess Shale and associated Cambrian formations west of Fossil Gully Fault zone on Mount Stephen, British Columbia: Canadian Journal of Earth Sciences, v. 40/12, p. 1823-2838.

Fletcher, T.P., and D.H. Collins, 2009, Geology and stratigraphy of the Burgess Shale Formation on Mount Stephen and Fossil Ridge: A Burgess Shale Primer –International Conference on the Cambrian Explosion, Banff, Alberta: August 2009 Field Trip Companion Volume, p. 32-53.

Kimmel, V.A., 2013, Geology of the Mount Stephen trilobite beds and adjacent strata near Field, B.C., Yoho National Park: New Perspectives on a 127 Year Old Discovery: Reservoir, GSPG, v. 40/11January, p. 22-26,35-38.

McIlreath, I.A., 1974, Stratigraphic relationships at the western edge of the Middle Cambrian carbonate facies belt, Field, British Columbia: Geological Survey of Canada, Paper 74-1:A, p 333-334.

McIlreath, I.A. 1975, Stratigraphic relationships at the western edge of the Middle Cambrian carbonate facies belt, Field, British Columbia: Geological Survey of Canada, Paper 75 1:A, p 556-557.

McIlreath, I.A., 1977, Accumulation of a Middle Cambrian, deep-water limestone debris apron adjacent to a vertical, submarine carbonate escarpment, Southern Rocky Mountains, Canada: S.E.P.M. Special Publication 25, p. 113–124.

Price, R.A., D.G. Cook, J.D. Aitken, and E.W. Mountjoy, 1980, Geology, Lake Louise (west half), west of fifth meridian, British Columbia – Alberta: Geological Survey of Canada, Scale 1:50,000.

Rasetti, F., 1951, Middle Cambrian stratigraphy and faunas of the Canadian Rocky Mountains: Smithsonian Miscellaneous Collection, v 116/5. 277p.

Stewart, W.D., 1991, Stratigraphy and Sedimentology of the Chancellor Succession (Middle and Upper Cambrian), Southeastern Canadian Rocky Mountains: Unpublished Ph.D. Dissertation, University of Ottawa, Ontario, 534p.

Stewart, W.D., O.A. Dixon, and B.R. Rust, 1993, Middle Cambrian carbonate-platform collapse, southeastern Canadian Rocky Mountains: Geology, v. 21, p. 687–690.

Geology of the Mount Stephen Trilobite Beds and Adjacent Strata Field B.C., Yoho National Park

Exploration Ramifications from New Insights on a 130 Year Old Discovery

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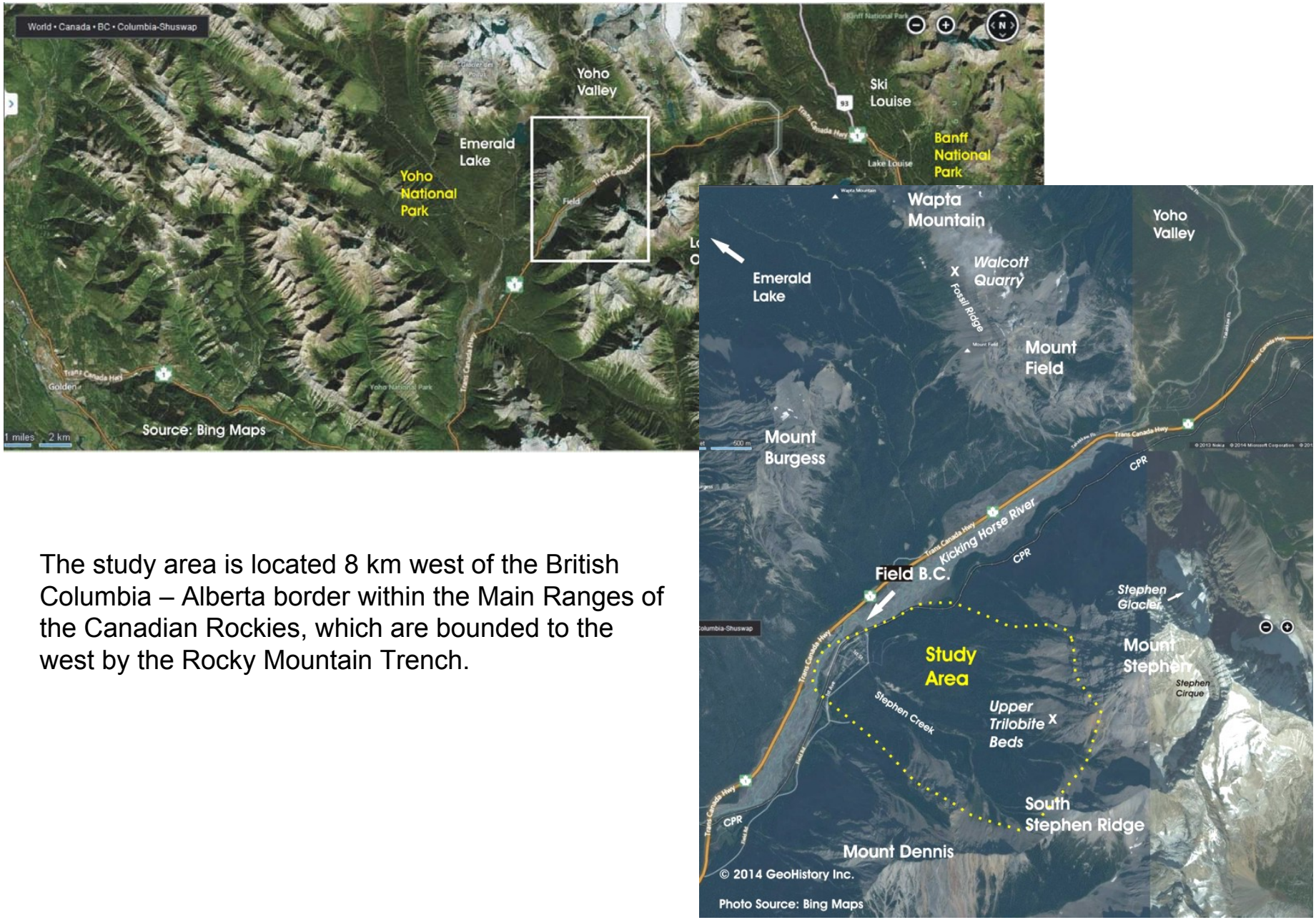
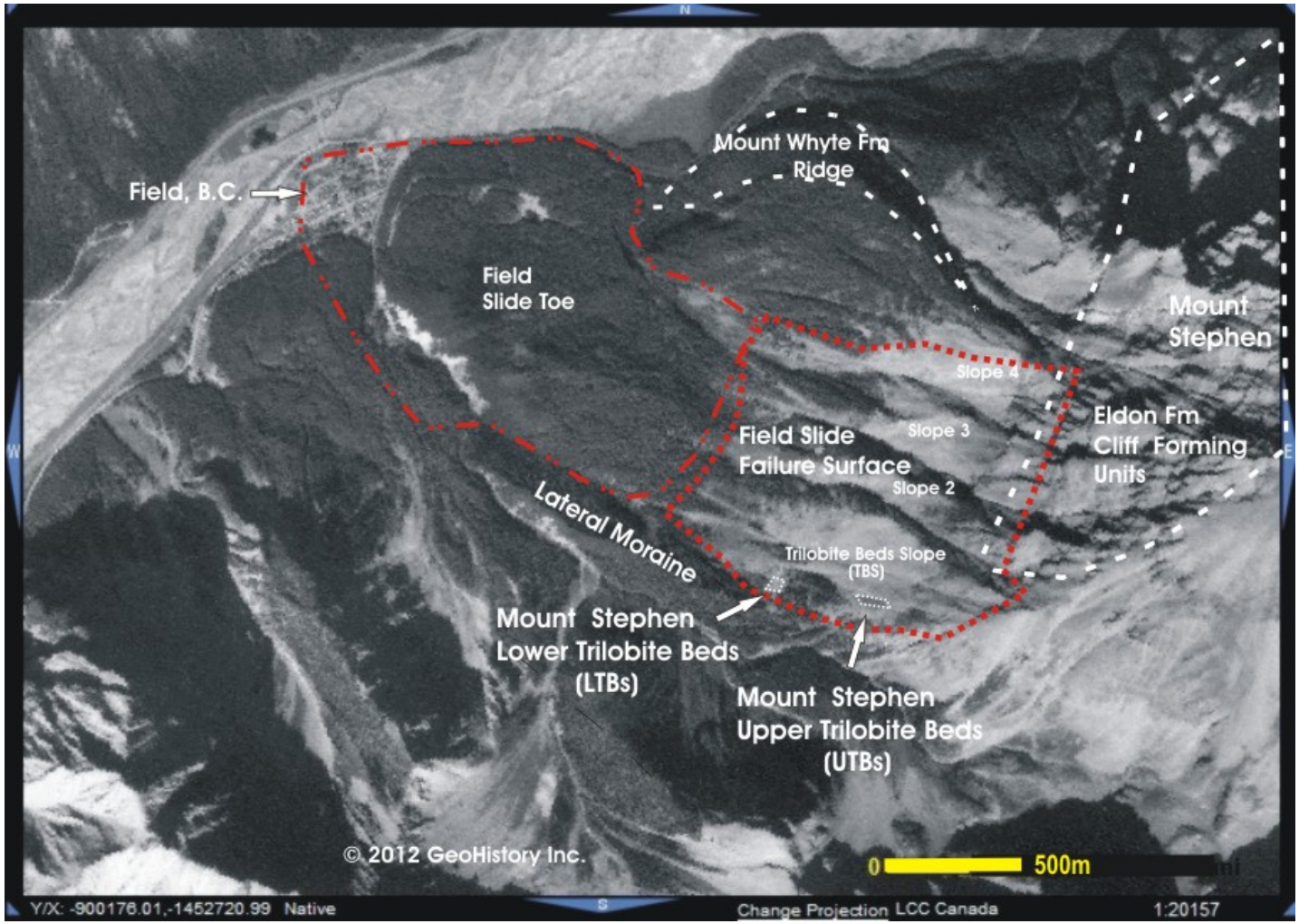
Location Map

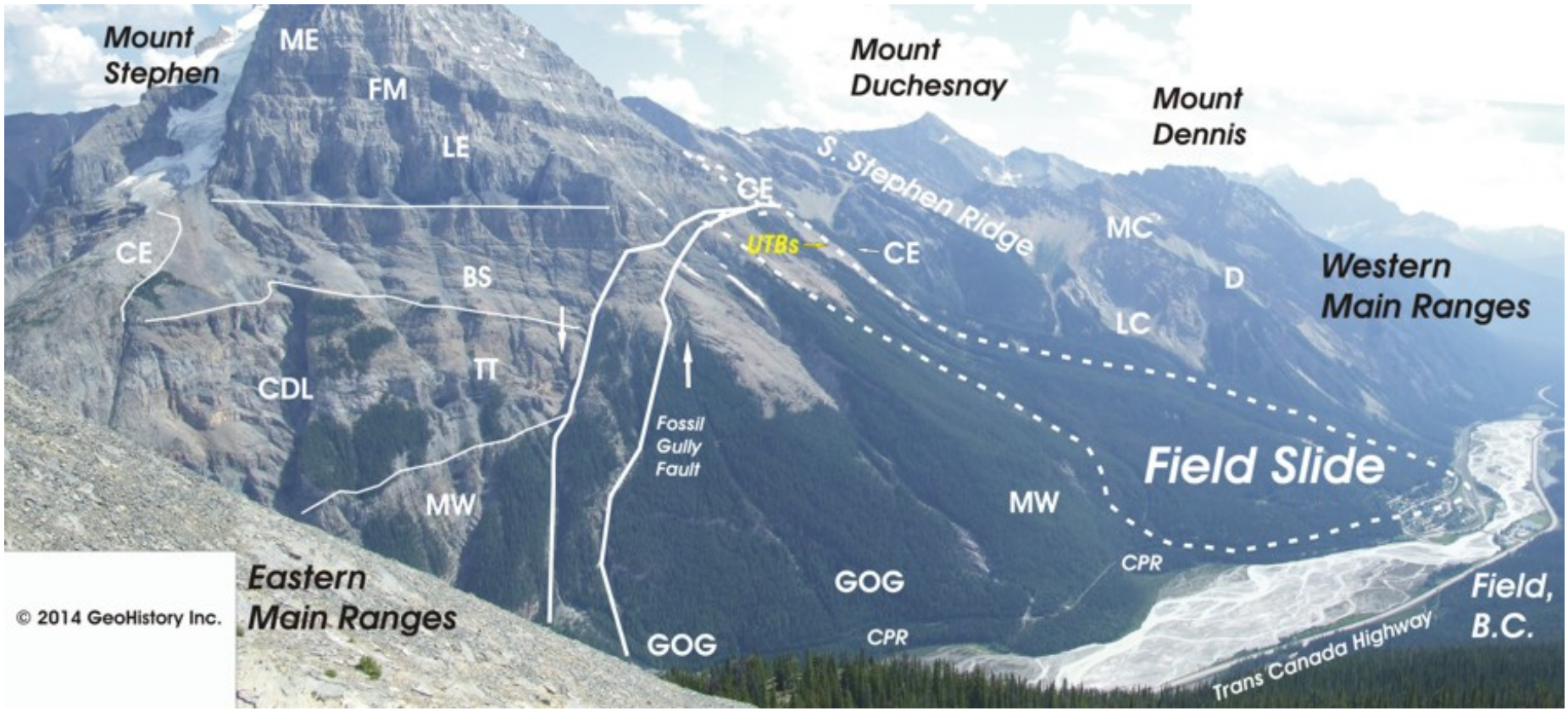


The study area is located 8 km west of the British Columbia – Alberta border within the Main Ranges of the Canadian Rockies, which are bounded to the west by the Rocky Mountain Trench.

The Field Landslide



The lower western slopes of Mount Stephen represent the failure surface(s) of a major post-glacial landslide, the Field Slide (Kimmel, 2013-2014). Found within the slide failure surface is the Trilobite Beds Slope (TBS) and both the UNESCO Burgess Shale Mount Stephen Upper Trilobite Beds (UTBs) and Lower Trilobite Beds (LTBs).

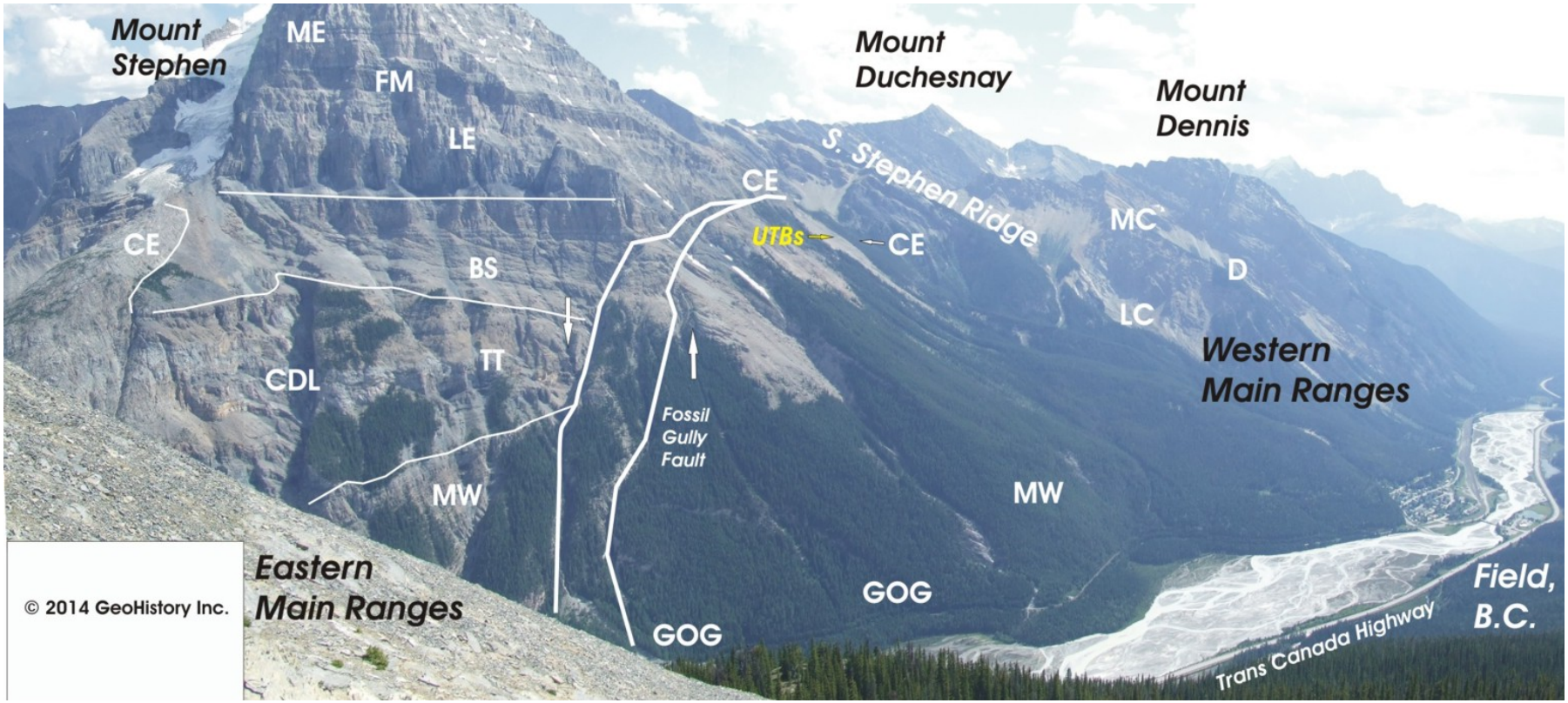


Investigation of the Field Slide led to the discovery of previously undocumented (and unrecognized?) depositional, post-depositional and structural features. In order to understand the significance of these features, one must first understand the existing published geology of the area.

Published Geology - Stratigraphy

Northeast

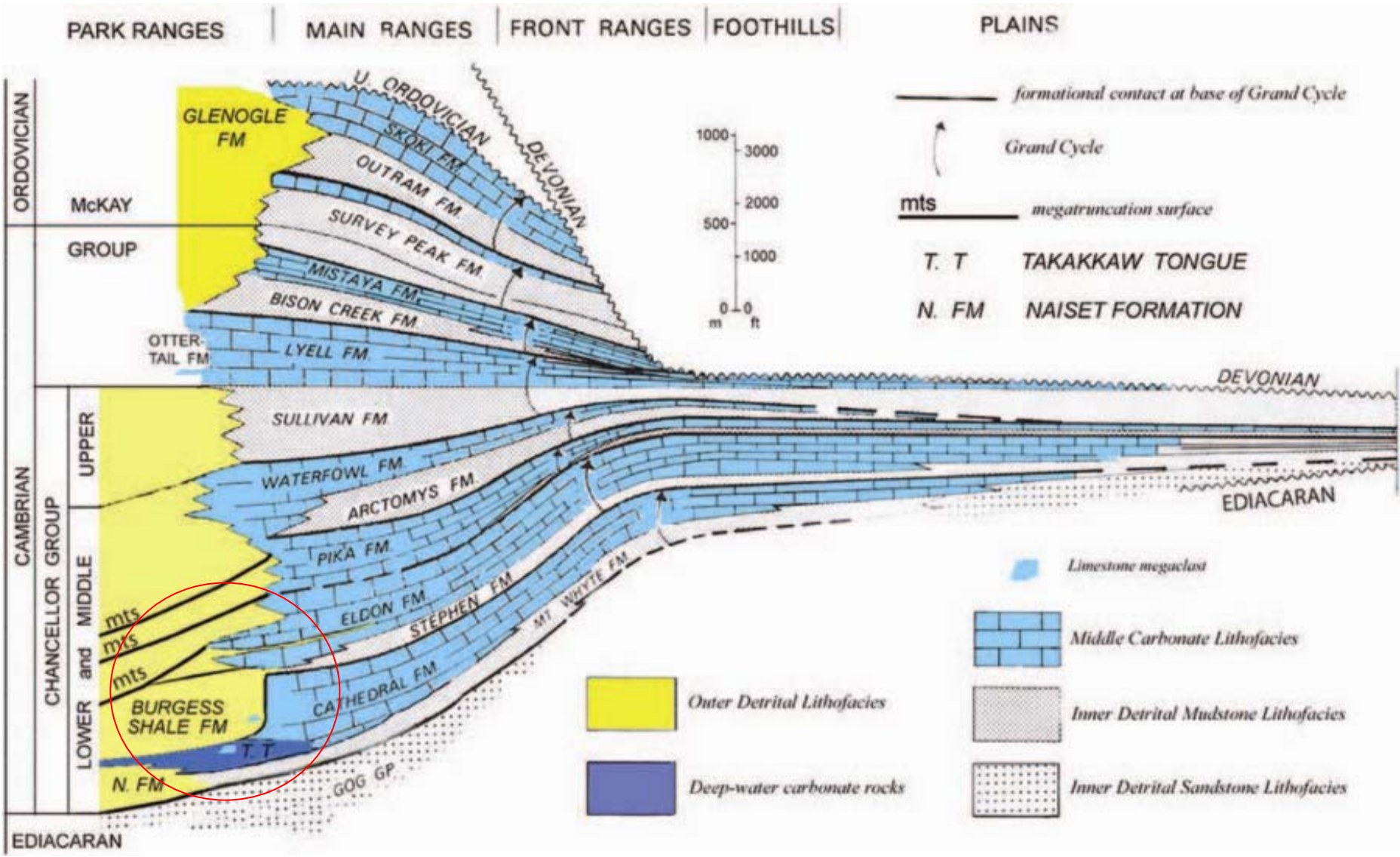
Southwest



The platformal and shallower water carbonate units of the Cambrian, Mid (MC) and Lower (LC) Chancellor Group, transition westward into largely undifferentiated laterally equivalent deeper water facies.

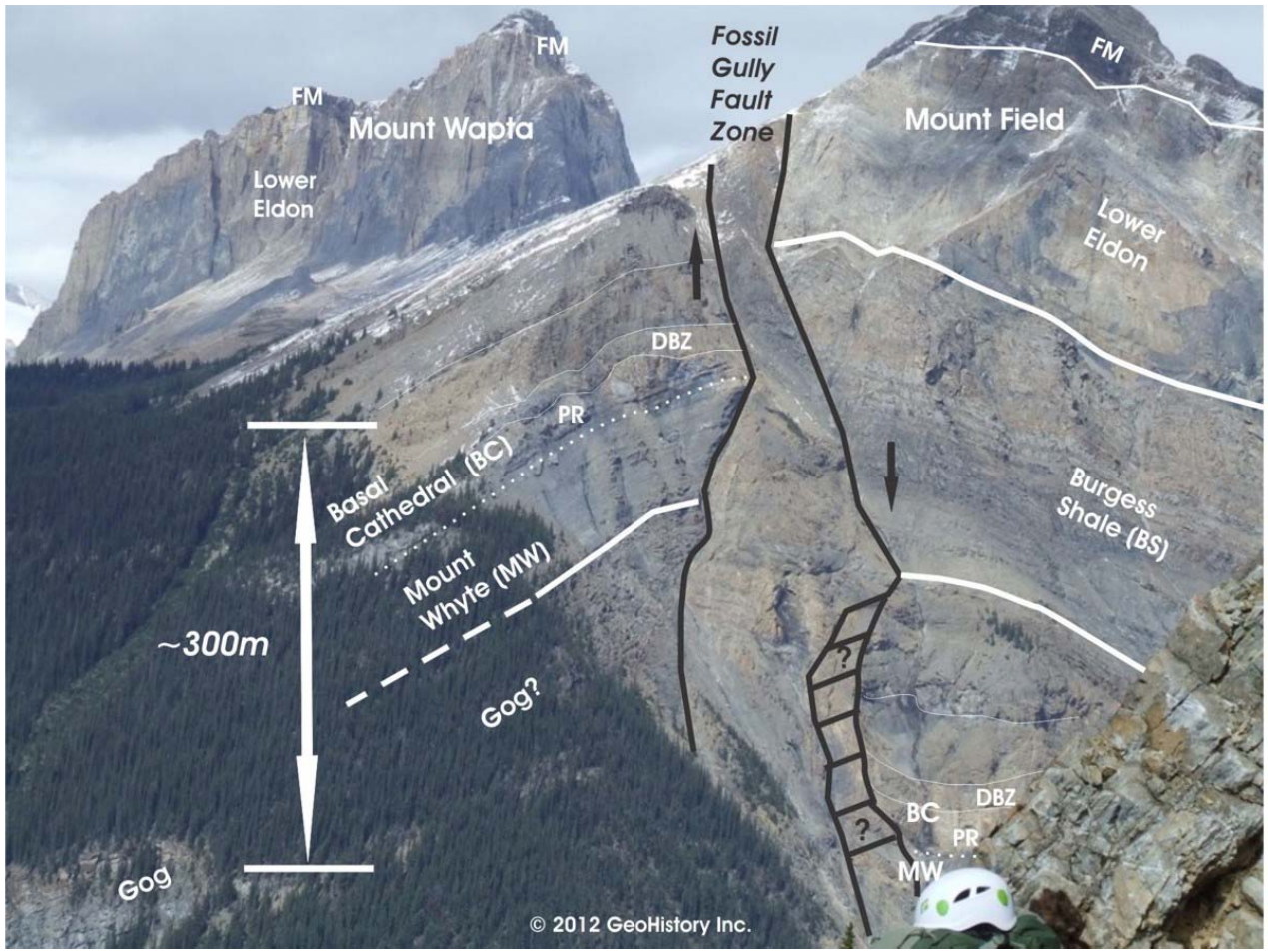
Representative of the shallower water strata are the Mid (ME) and Lower Eldon (LE), the underlying Cathedral (both the reefal Cathedral Escarpment (CE) and off-reef Cathedral (CDL) Takakaw Tounge (TT)) and the underlying Mount Whyte (MW) formations. Representative of the basinal strata is the Burgess Shale (BS). The Ediacrin Gog (GOG) unconformably underlies the Chancellor.

After Collins & Fletcher (2009), Aitken (1998), McIlreath (1977b) and Stewart (1990).

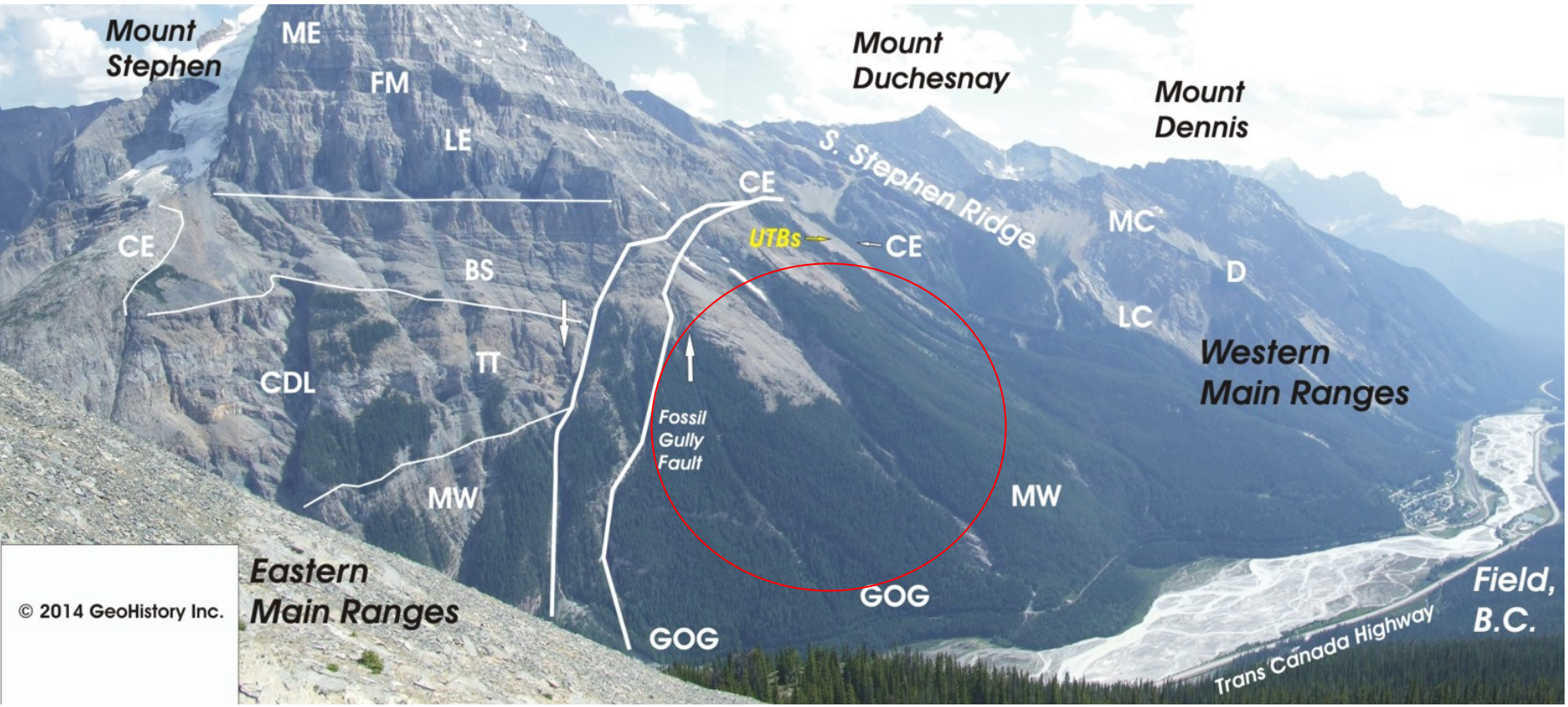


From Collins & Fletcher (2009) Fig. 3 – modified after Aitken (1971) Fig. 3 and Stewart et al. (1993) Fig. 2.

Published Geology - Structure
a) Normal Faulting



Documented in the early 1900's, Stewart (1991?), illustrated the Fossil Gully fault as a fault zone (FGFZ) on Mount Field with two bounding faults. The zone continues south across the Kicking Horse Valley and along the western slopes of Mount Stephen.

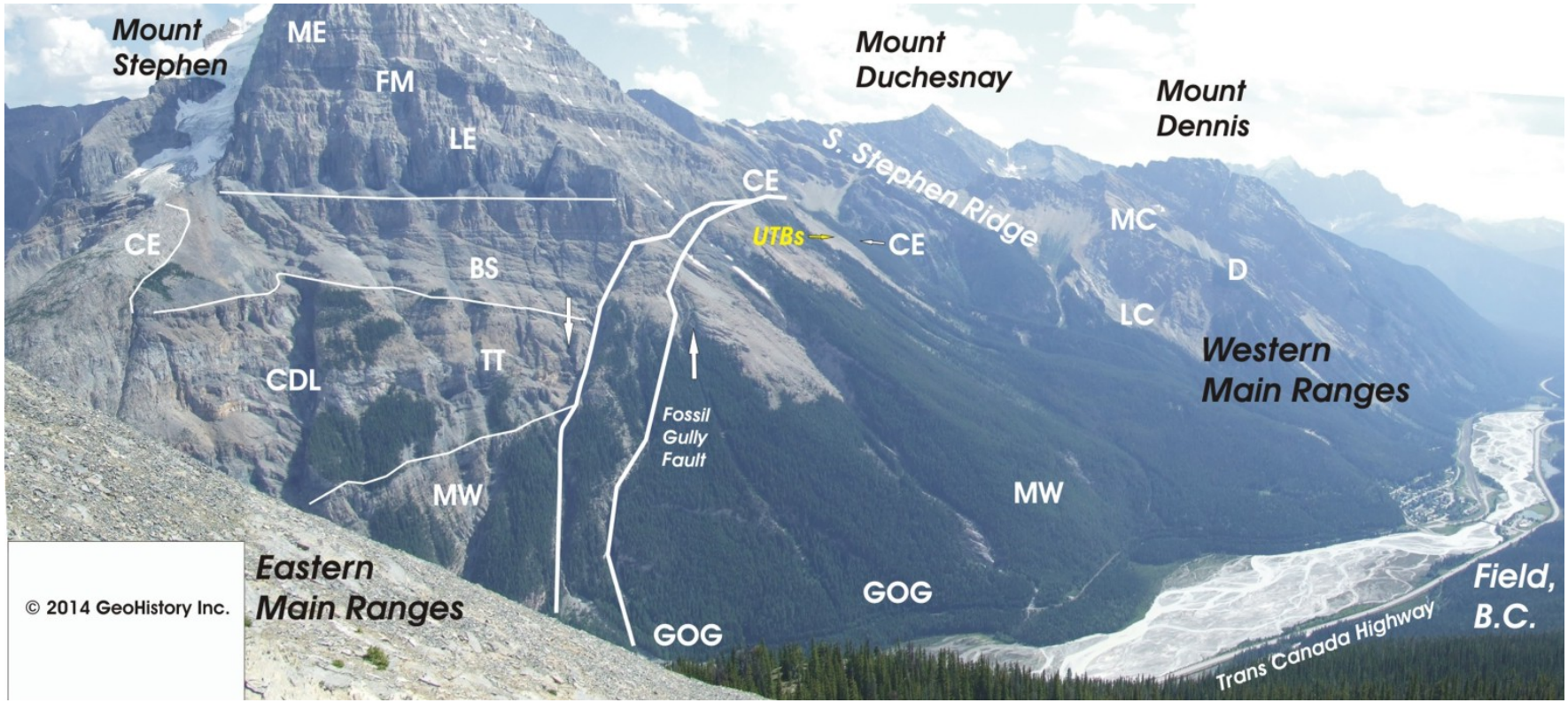


Modified after McIlreath Fig. 6-1 1977b, Collins and Fletcher Fig. 2, 2003, Fig. 5, 2010.

The steep westward dipping strata comprising the lower western slopes of Mount Stephen (42^{o} to 65^{o}) are interpreted to be the result of the upward movement of this strata along the Fossil Gully normal fault (Rasetti, 1951).

Published Geology - Structure

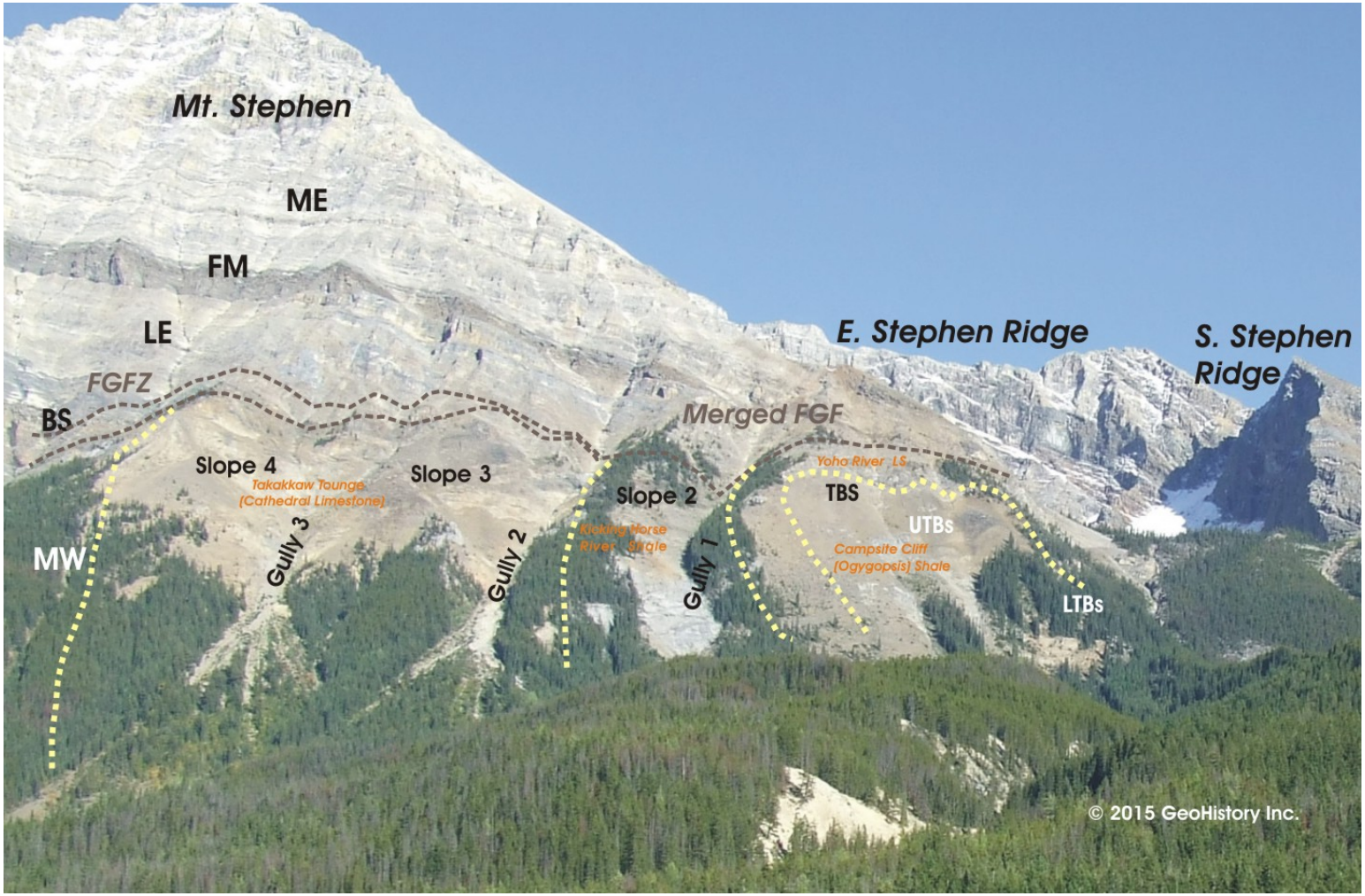
b) Thrusting



•Field BC sits on the division between the gently dipping Eastern Ranges and steeper dipping, folded and thrusted Western Main Ranges of the Canadian Rockies. Pre-1970s researchers searched for a single structure (normal or thrust fault) that separated the two main ranges, with no success.

•In the late 1960's, Cook, working for the Geological Survey of Canada (GSC) proposed a new theory. Cook believed the transition was stratigraphic in nature - the result of a lateral facies change between the less competent basinal (western) and the more competent platformal (eastern) rocks of the Lower and Mid Chancellor Group, essentially coincident with Aitken's postulated Kicking Horse Rim (1969).

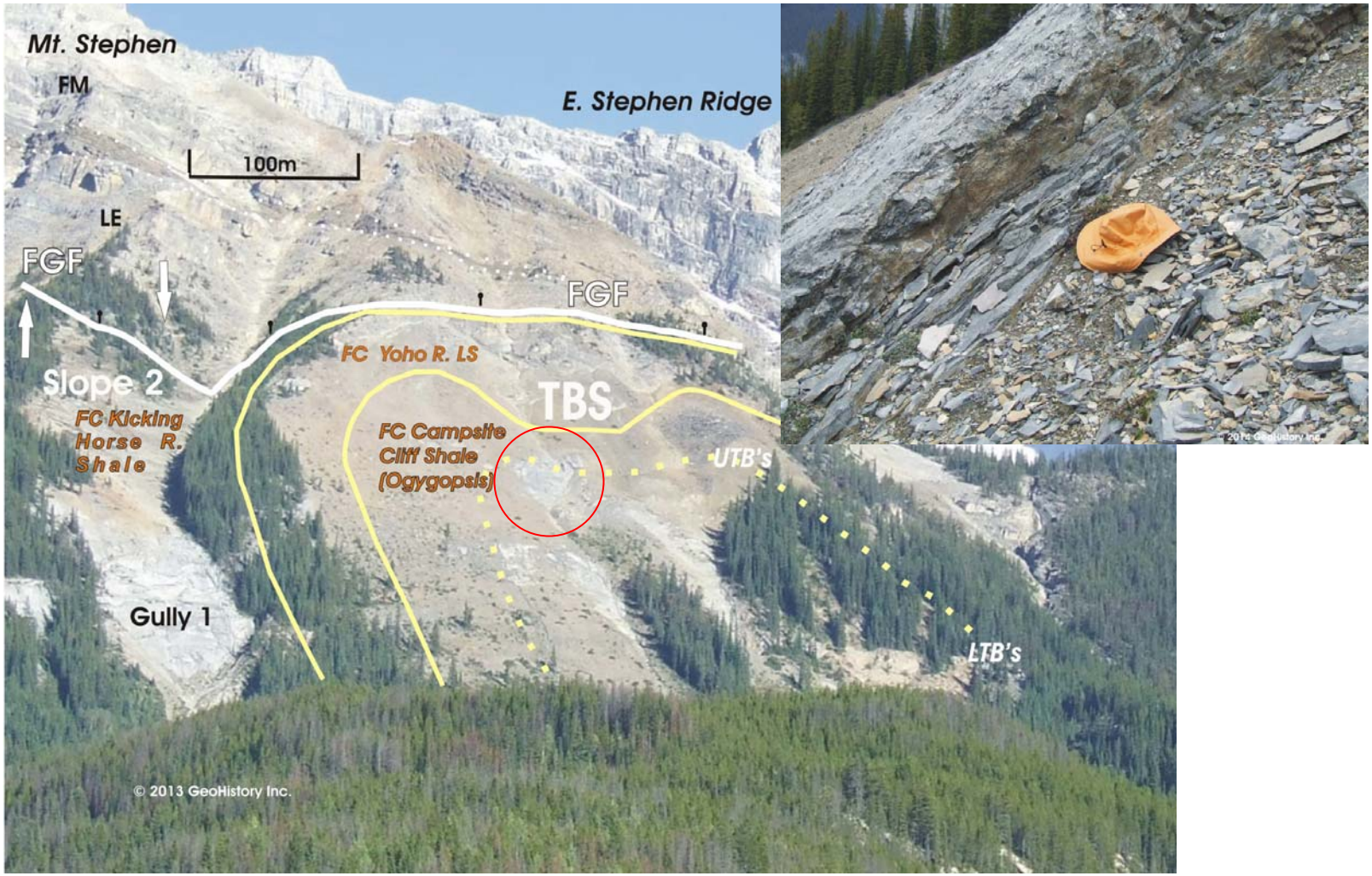
•Cook postulated that exposed to the same compression during a single Main Range thrusting event, the two groups of rocks deformed differently, producing a western and eastern division within the same package of thrusted strata – the accepted interpretation to date.



After Collins and Fletcher Fig. 3, 2003, Fig. 5, 2010.

Fletcher and Collins (1998, 2003) provide the only published, detailed interpretation of the geology on the lower western slopes of Mount Stephen. They interpret 5 units going up section from north to south (left to right) - from the MW to the Cathedral TT and into three lower Burgess shale (and limestone) units. The Field Slide research uncovered several inconsistencies and exclusions with the generally accepted published geological interpretations of the area.

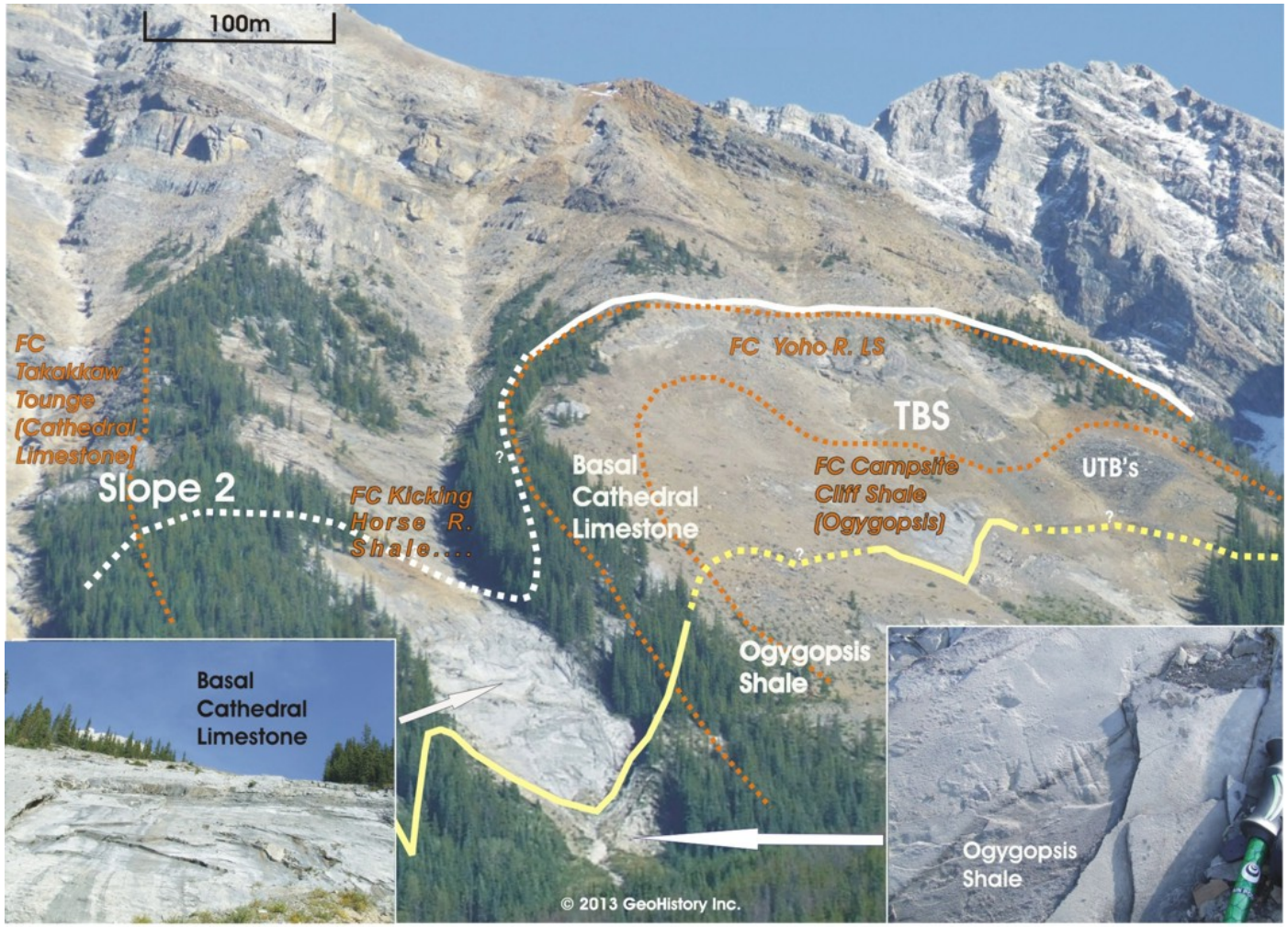
Field Slide Study Findings



Most notable, there are numerous outcrops of in situ limestone (and dolostone) from the LTBs to the UTBs as well as across the mid-portion of the TBS in what is interpreted to be Campsite Cliff Shale (Ogygopsis).

Further, Mt. Stephen researchers all recognize the broken nature of the Upper Trilobite Beds (UTBs). Yet, the published stratigraphic interpretations view the UTBs as being “almost” or completely in situ, which they clearly are not. In situ Ogygopsis outcrops at the downslope edge of the UTBs.

Revised Edges



The Ogygopsis outcrops along the entire lower portion of the southwest lower slopes of Mount Stephen, overlying what I call the Basal Cathedral Limestone. This limestone unit is generally planar across the lower slope of Mount Stephen with a similar orientation (within degrees) to the overlying in situ Ogygopsis.

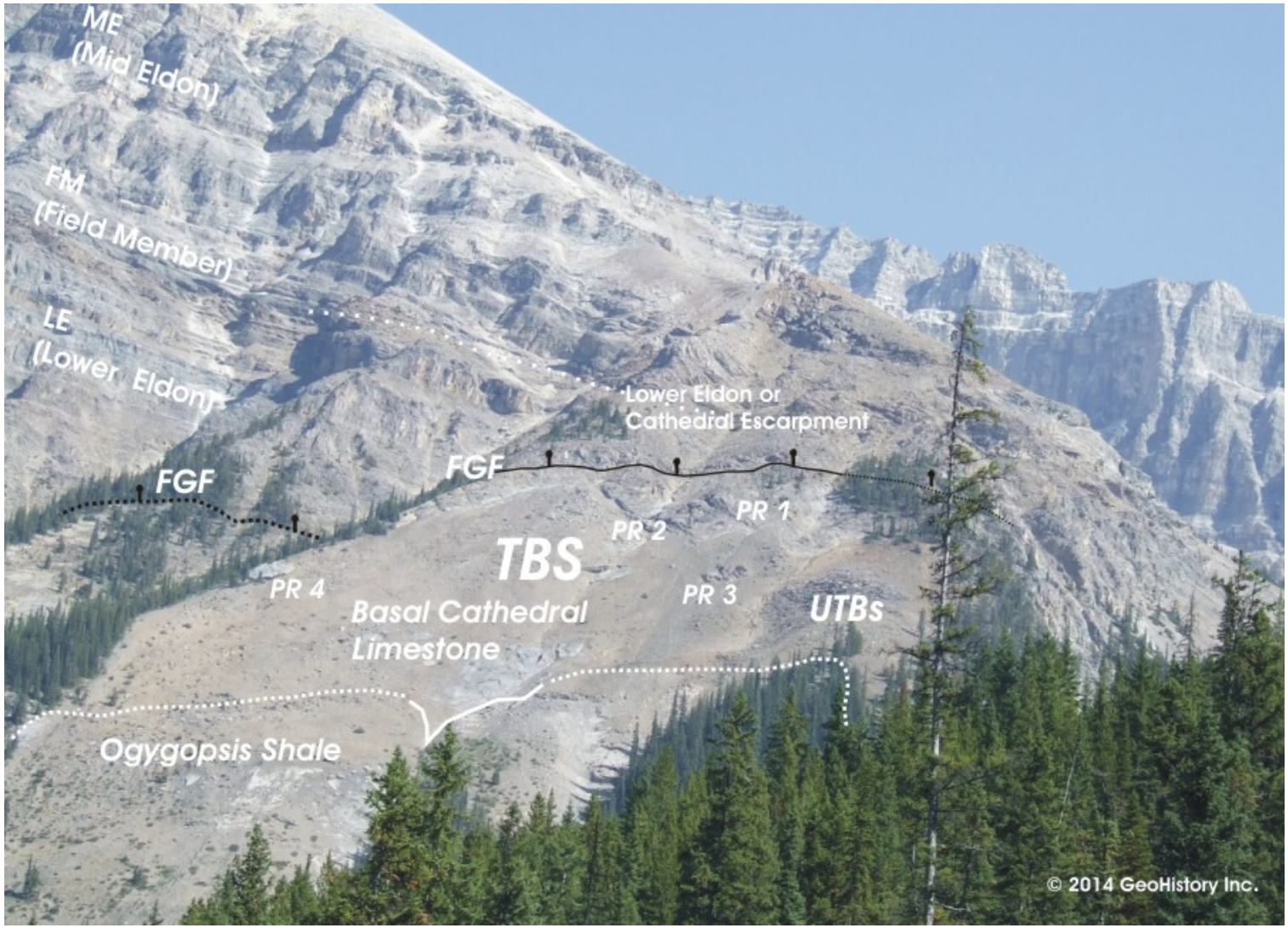
Previously Undocumented Features – Sub Aerial Exposure Surfaces

Note the sediment infilled desiccation cracks.

The Basal Cathedral/Ogygopsis Unconformity

The Ogygopsis (to the left) ***onlaps*** onto the underlying Basal Cathedral erosional surface (to the right). Published researchers (Aitken, 1997, Fletcher and Collins, 1998) interpret this contact to be conformable.

Limestone Bumps



Four previously identified bumps occur within the limestone beds on the TBS.

PR1

Collom (1998) interprets this (7m high) feature as a deep-water carbonate mud mound. The carbonate beds (DB) pictured to the right and in front of the bump are interpreted to ***onlap*** the feature***.***

PR4

Collins and Fletcher interpret this feature to be a megaclast the fell off of the Cathedral Escarpment. To an oil and gas geologist, the symmetrical nature of this feature (and of the others), along with the slope geometries and general appearance, suggest patch reef (or big bioherm).

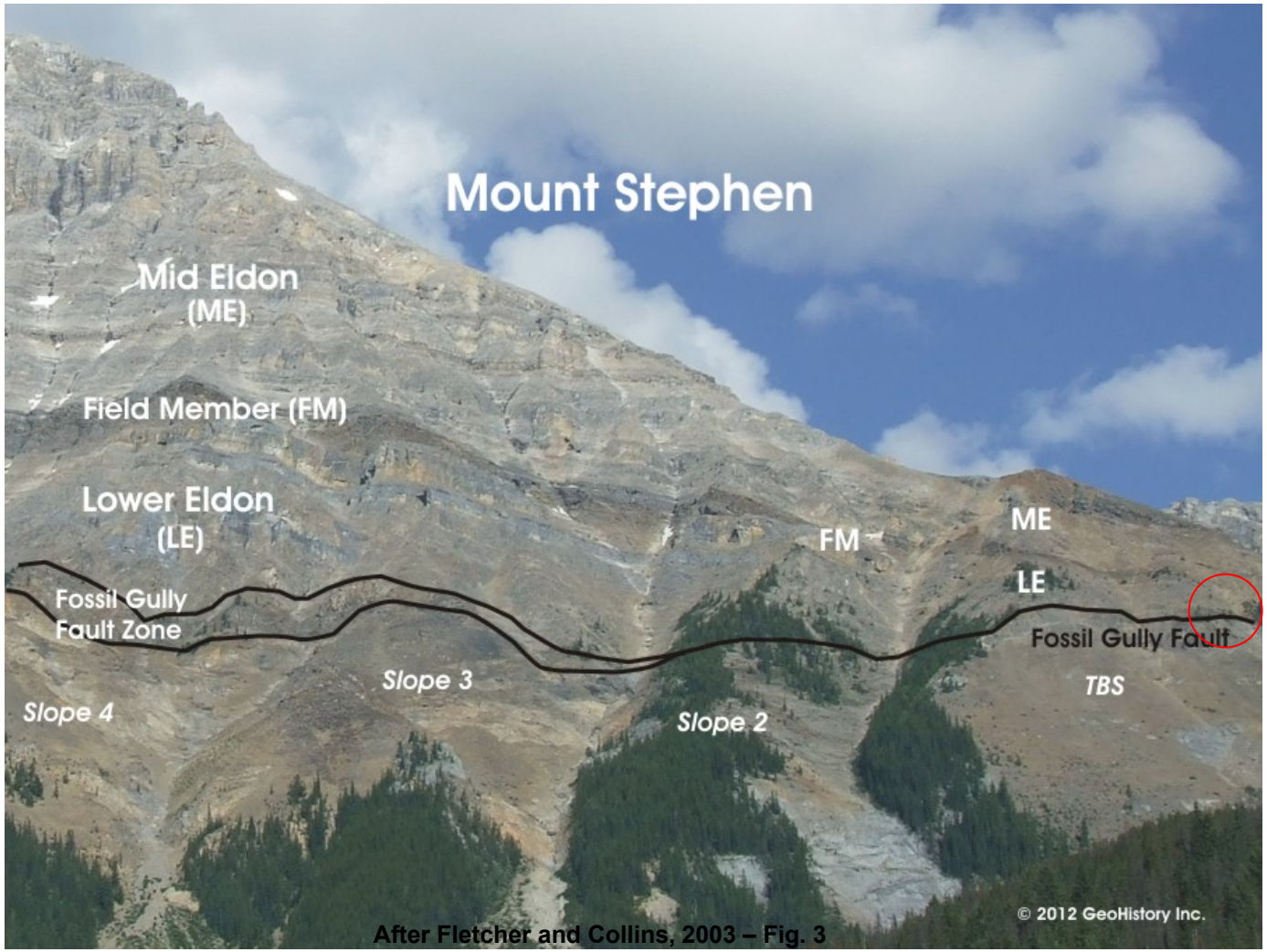
One of the undocumented (unrecognized) features. Note the thinner beds on the left ***do not onlap*** the feature; they pass laterally into it and transition into thicker biohermal units. Stacked sequences of these biohermal lenses produce what I call patch reefs.

PR1

The same lateral transition (the DB's transitioning laterally into reef) can be seen looking northward at the south side of PR1. Dolomitized on the TBS, the patch reefs initiated in and are part of the uppermost 10 to 30 metres of the uppermost unit of the Mount Whyte Formation, which I call the Basal Cathedral Limestone - the rock in which Cathedral reef growth commenced. The identity of the reef builders has been wiped out by the dolomitization of the reefs on the TBS. Elsewhere, the Cathedral limestones contain the calcareous algae *Epiphyton* and *Girvanella* and the encrusting *Renalcis* (Aitken and McIllreath, 1984).

Where dolomitized, the Cathedral reefs can exhibit excellent porosity.

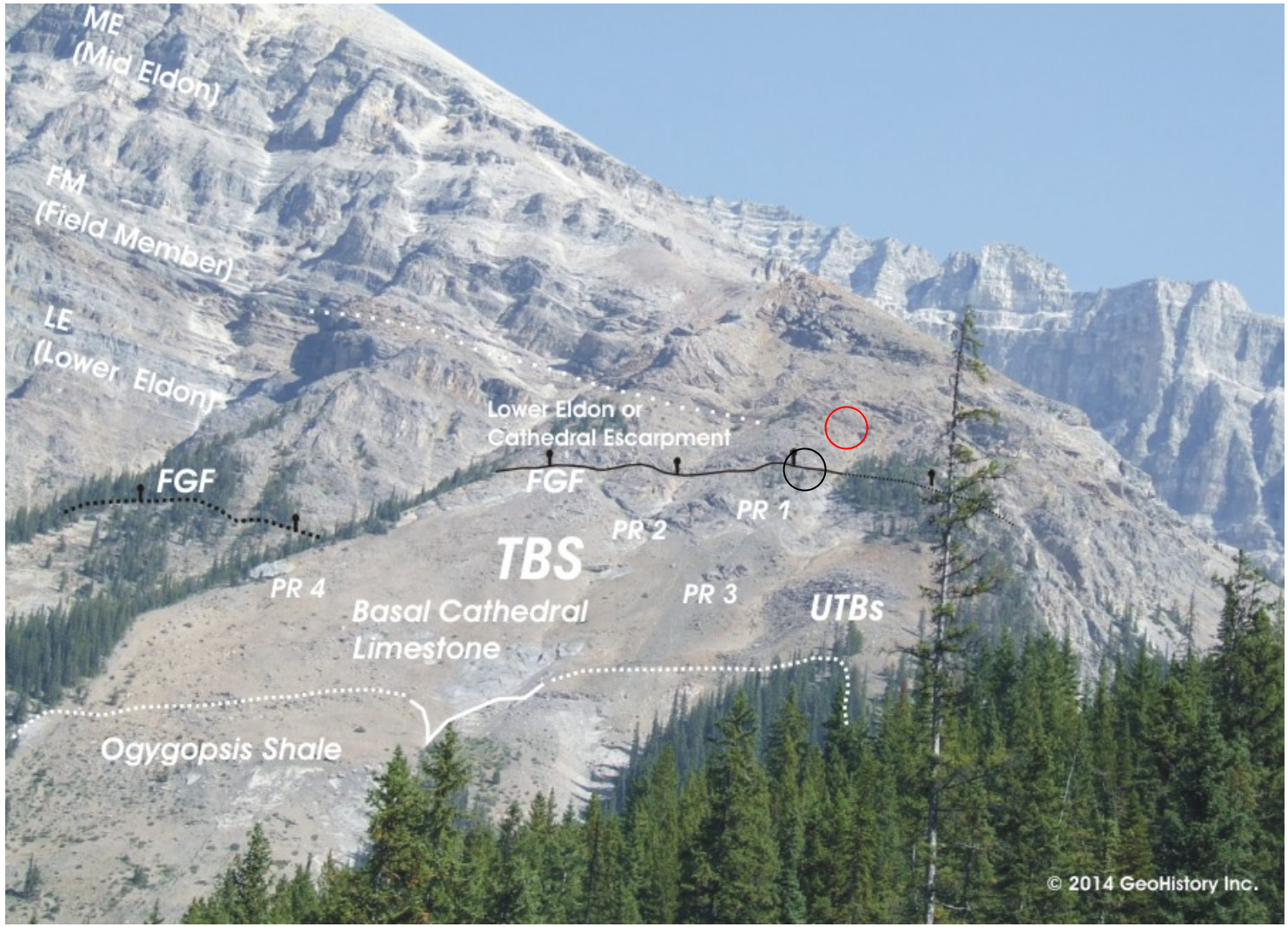
Fossil Gully Fault



After Fletcher and Collins, 2003 – Fig. 3

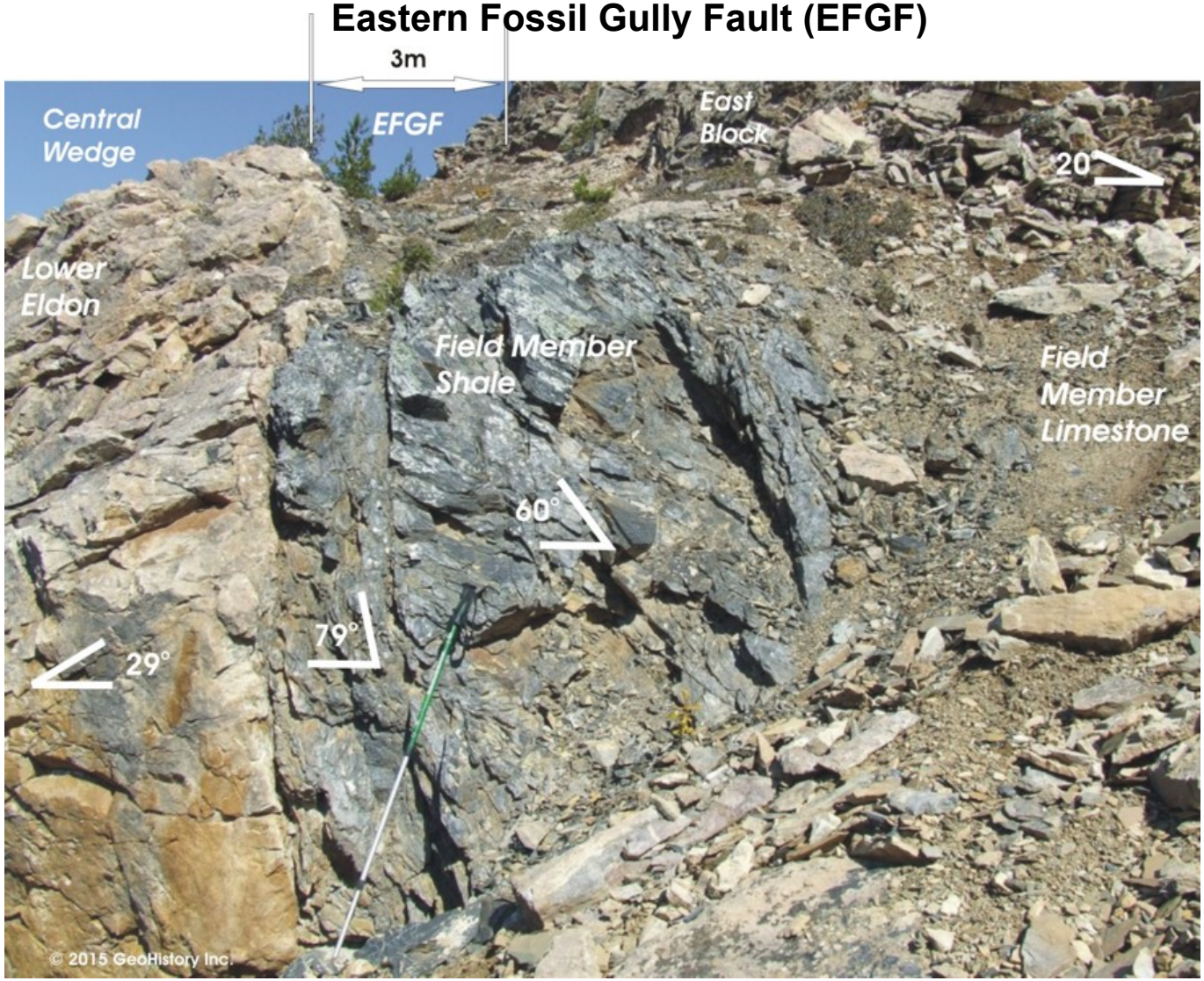
As previously noted, the FGF zone is interpreted to merge into one Fossil Gully fault from north (left) to south (right) across the western slopes of Mount Stephen. Looking at the fault just above the UTB's.

The FGF is actually a two- to three-metre-wide fault zone. The fault-zone strata appears to have been dragged down into the fault - in the direction of movement during the faulting process. This indicates the strata west of the fossil Gully Fault (to the left) was downthrown, not upfaulted as the accepted published interpretation states.



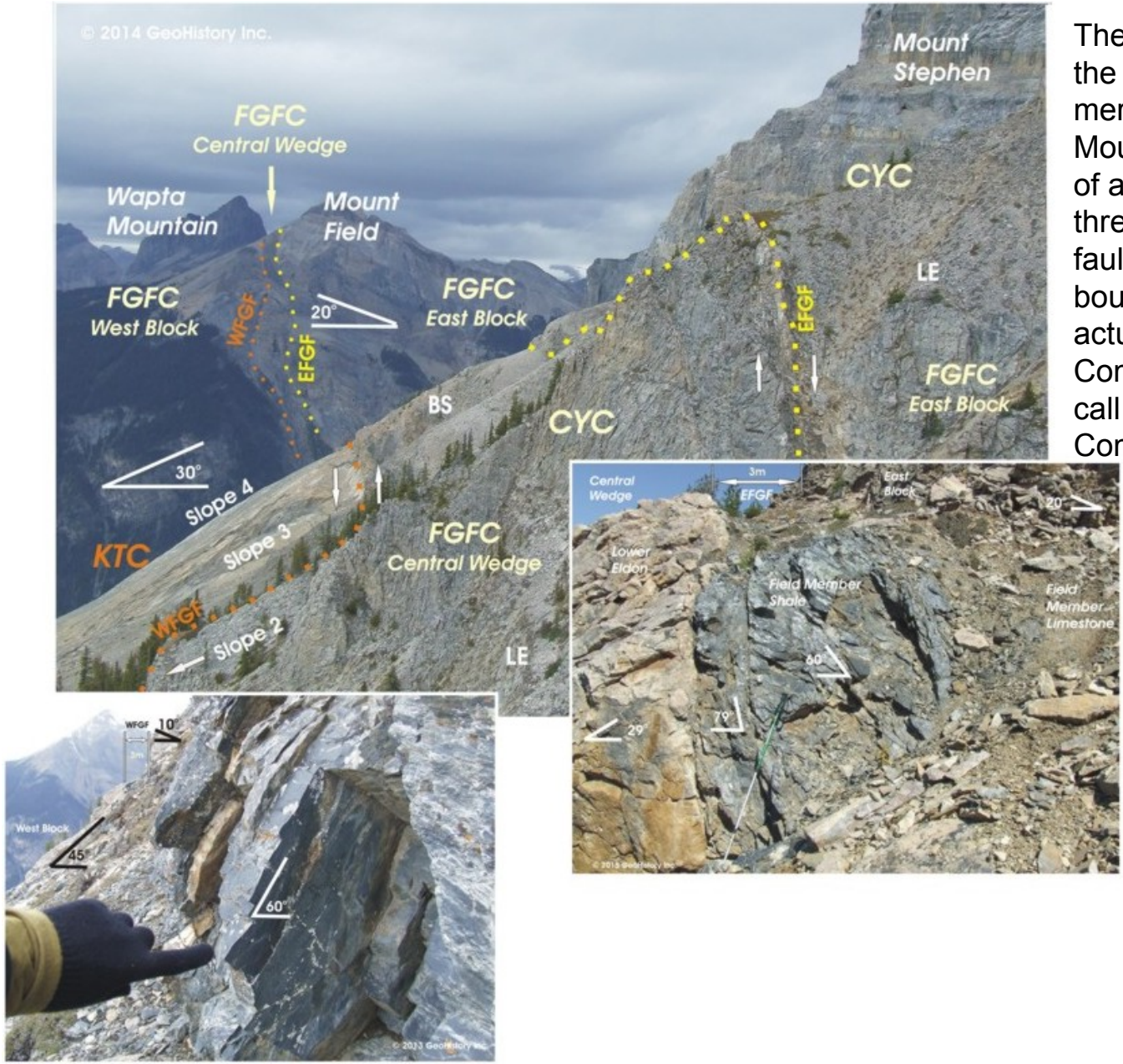
75 metres up slope of the previous outcrop, I found this previously undocumented feature.

Eastern Fossil Gully Fault (EFGF)

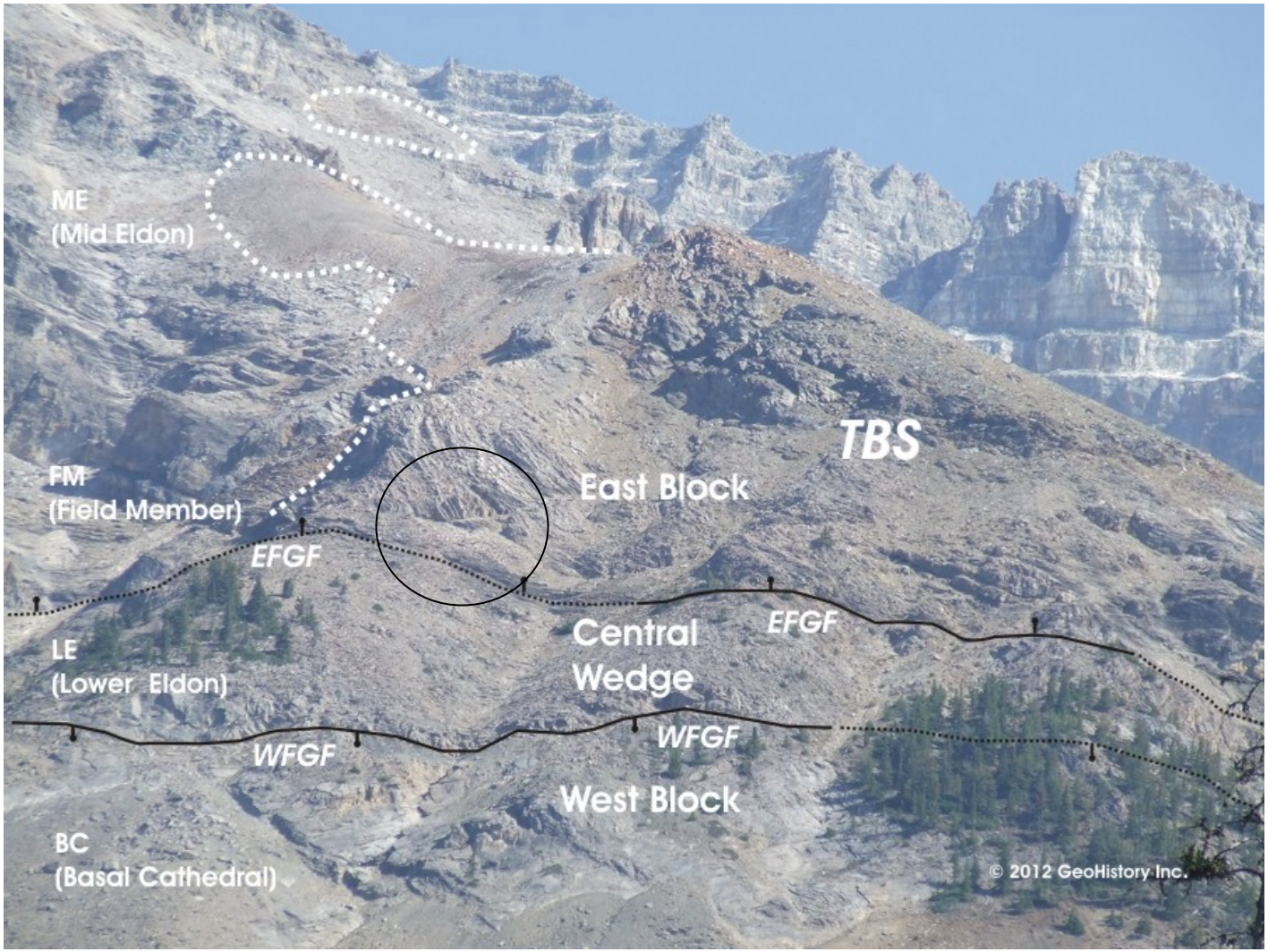


The Eastern Fossil Gully Fault (Kimmel, 2013–2014). A similar orientation to the fault zone strata found in the WFGF 75 metres downslope, but dipping to the east, rather than to the west.

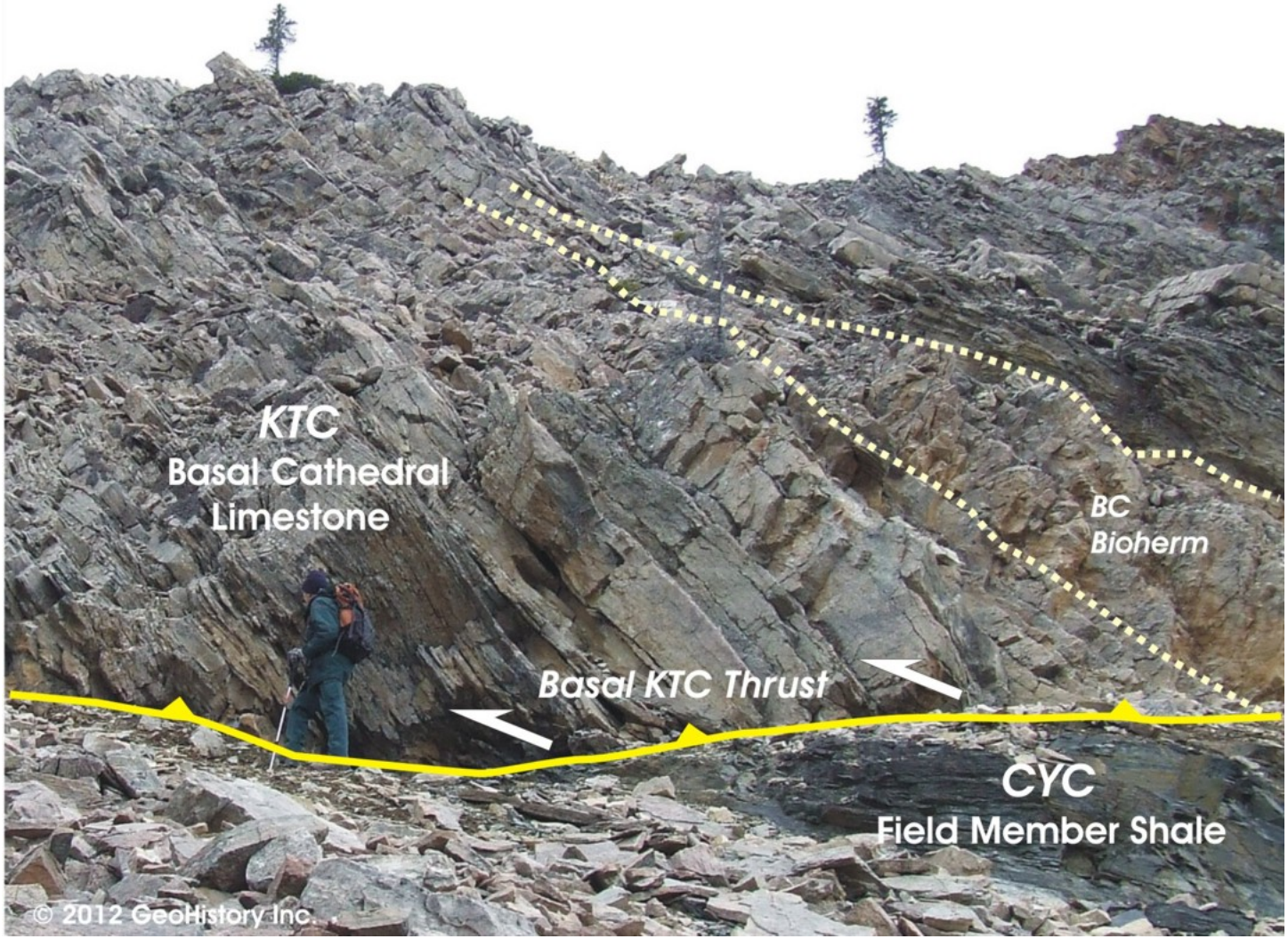
The Fossil Gully Fault Complex (FGFC)



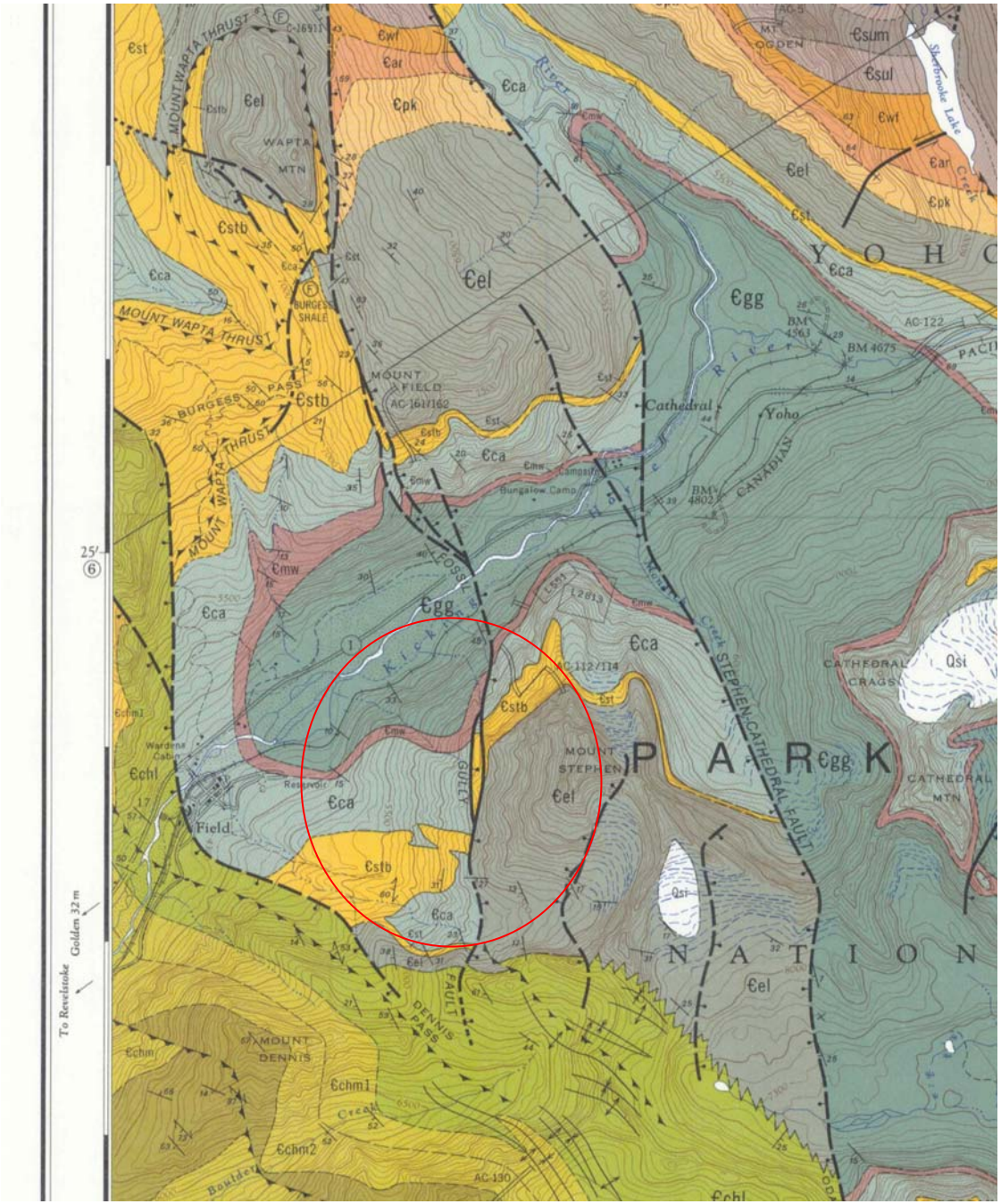
These outcrops show that the FGF zone does not merge into one fault on Mount Stephen, but is part of a complex consisting of three continuous normal fault blocks separated by 2 bounding faults that are actually fault zones. Combined, they form what I call the Fossil Gully Fault Complex (FGFC).



But what is going on upslope of the EFGF?? Note the Mid-Eldon bedding disappears in the upper TBS from left to right across the photo and then seems to reappear. In what is interpreted as Cathedral Escarpment in the published literature, I found this previously undocumented feature.



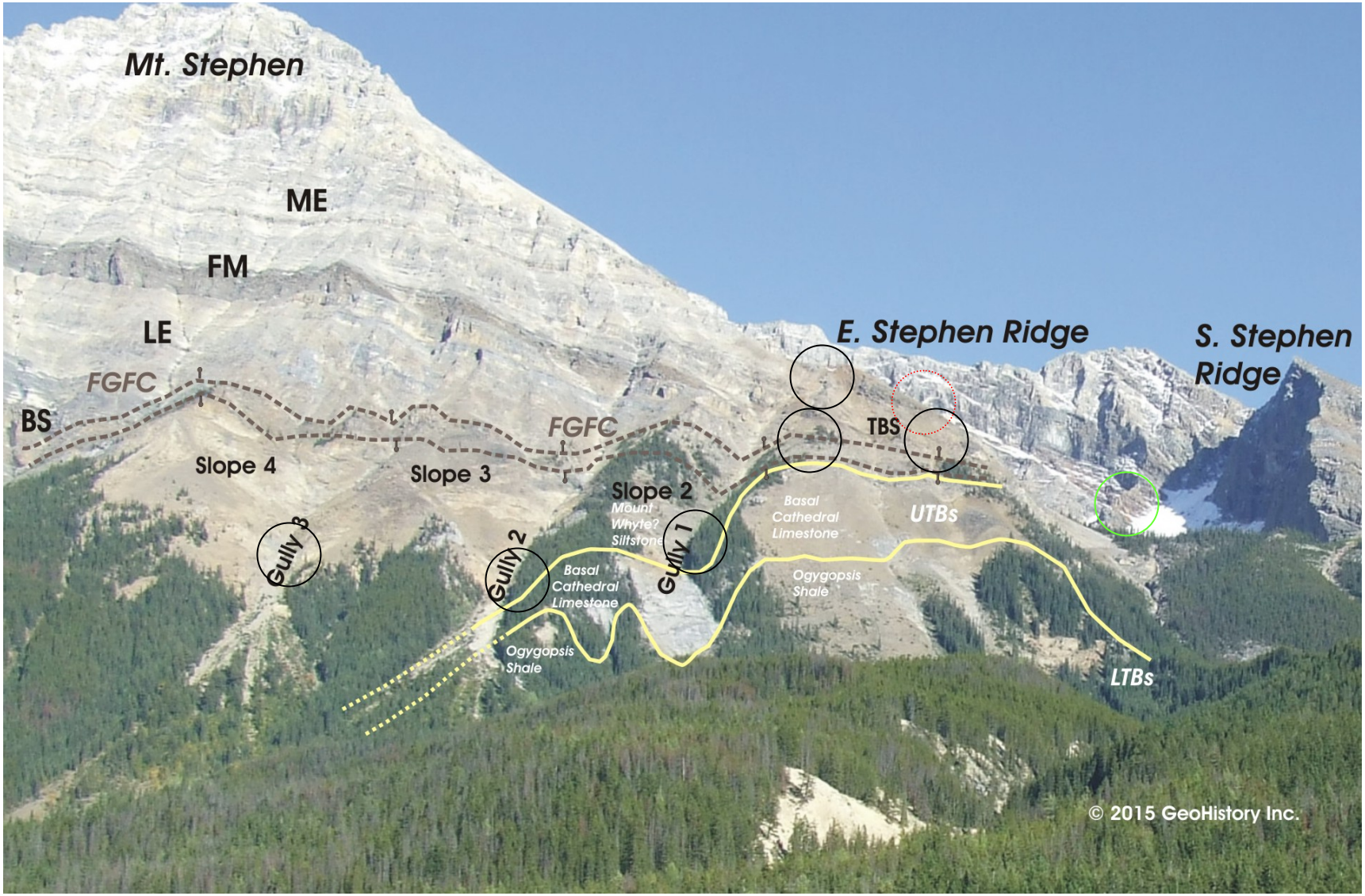
The basal thrust fault of what I call the KTC, a remnant of the leading edge of the (younger) Western Main Range thrusting event. The thrust places older Basal Cathedral over younger Field Member Shale, the latter part of the Eastern Main Ranges (which I locally call the Central Yoho Complex (CYC)).



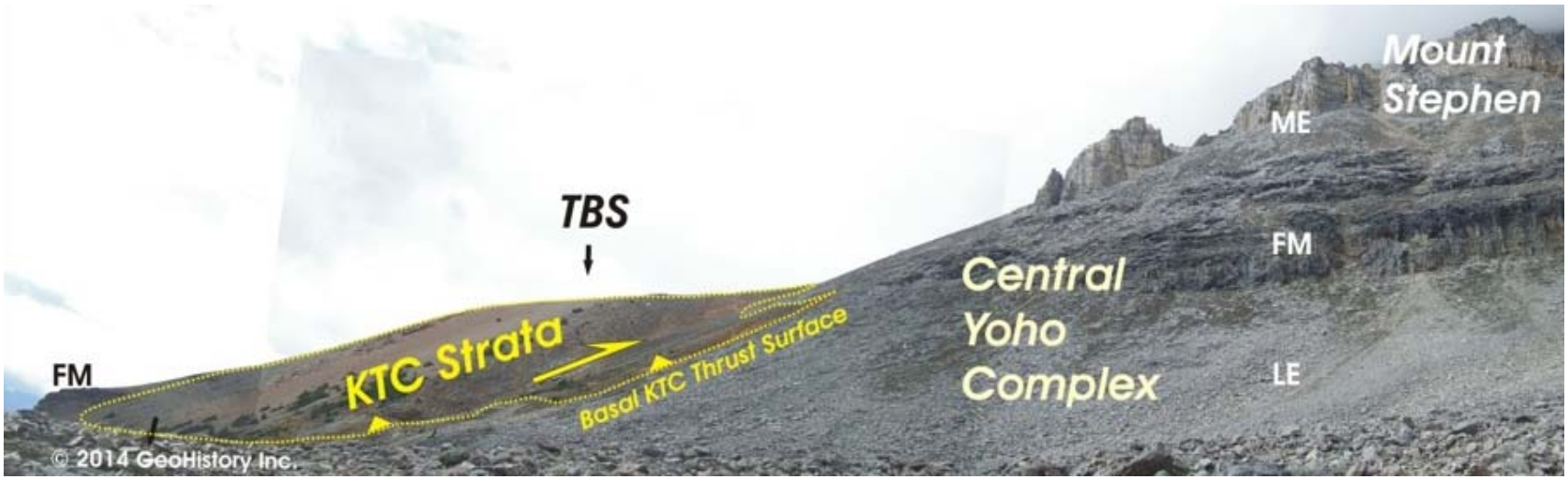
Thrust Faults?

According to the peer-reviewed published literature, the western slopes of Mount Stephen do not contain thrust faults, an interpretation supported by the Geological Survey of Canada (GSC), GCS Map 1483A, Lake Louise West .

Are there more thrusts?



Backside of the TBS

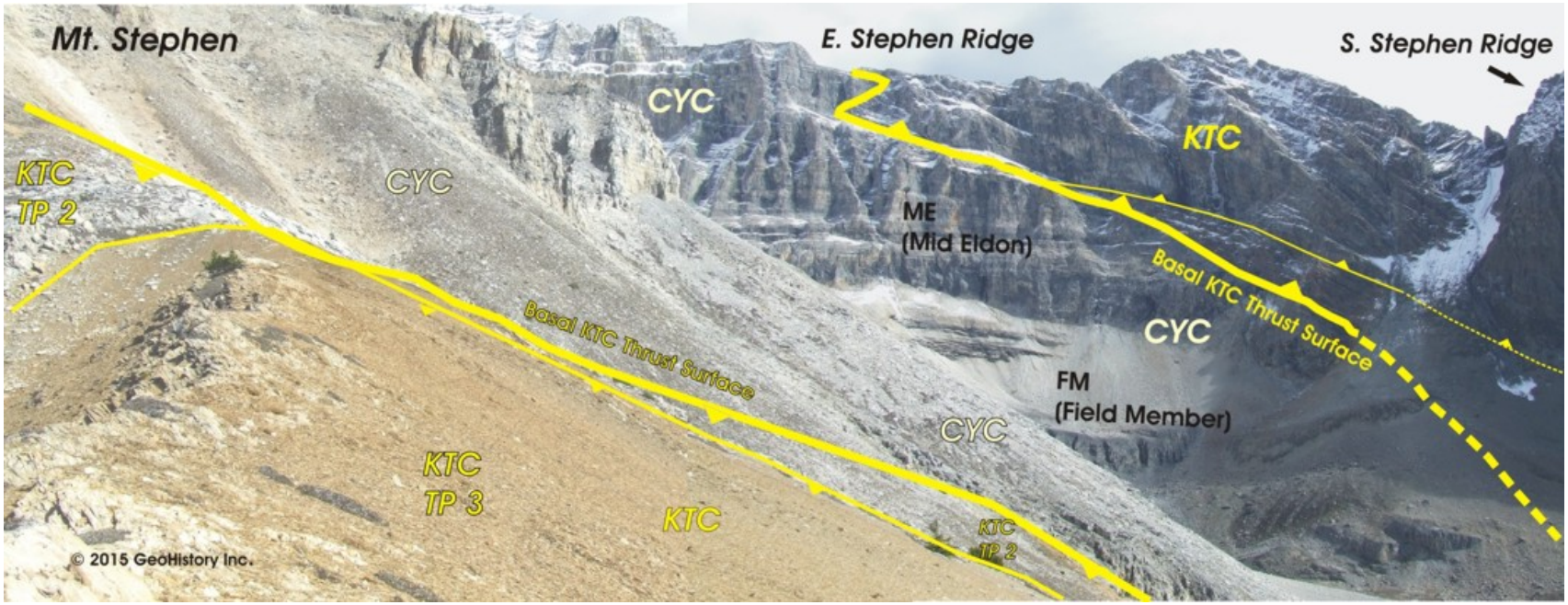


The tan-coloured KTC strata overrides the underlying Central Yoho Complex (CYC) Eldon strata.

East Stephen Ridge

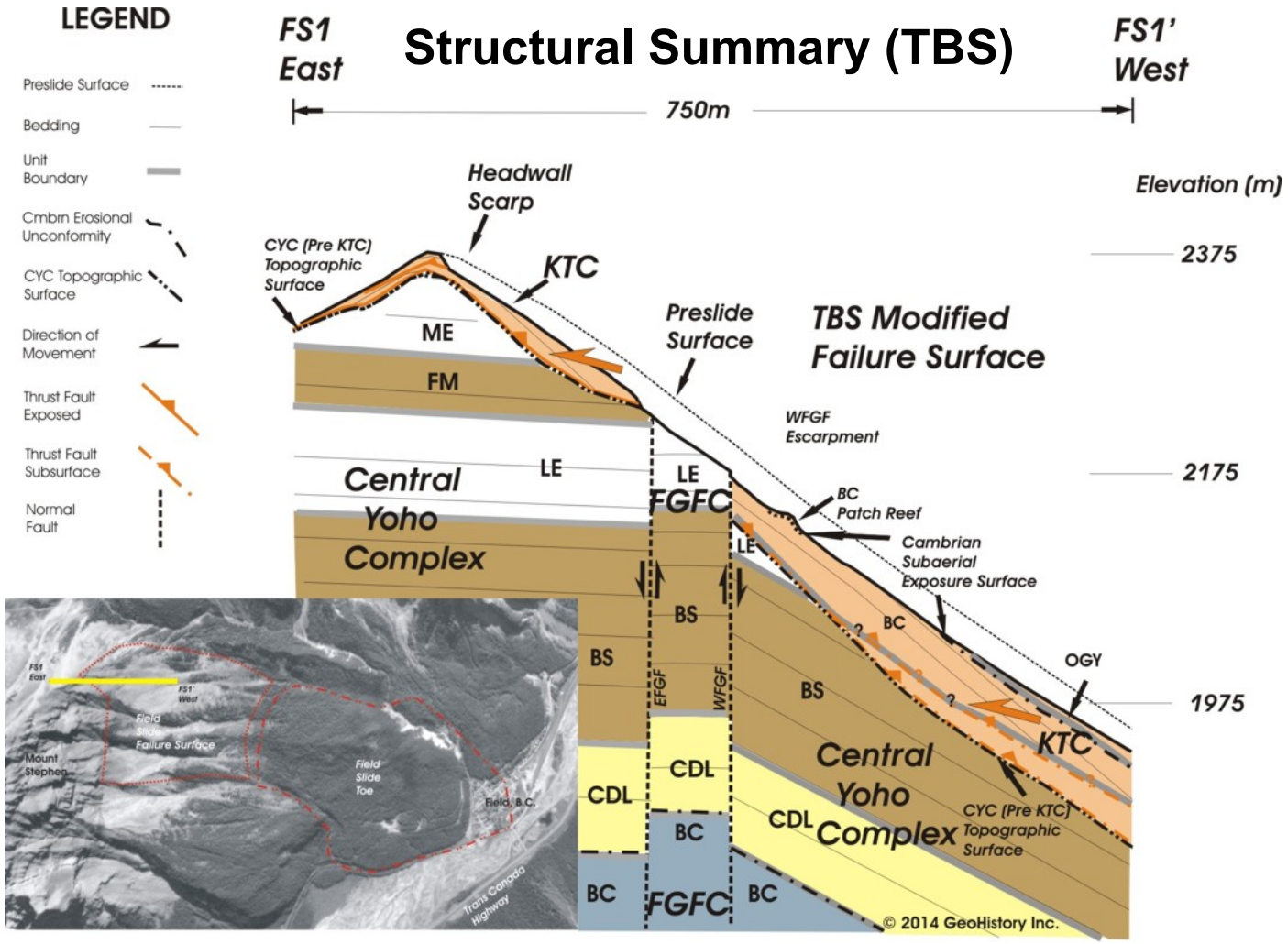
Previously interpreted by McIlreath (1977b) as a small local thrust, the GSC reinterpreted this feature as a facies change on Map 1483A. Stewart (1991) again reinterpreted it as a Cambrian-aged mega-truncation surface (MTS).

Field Slide Study Interpretation



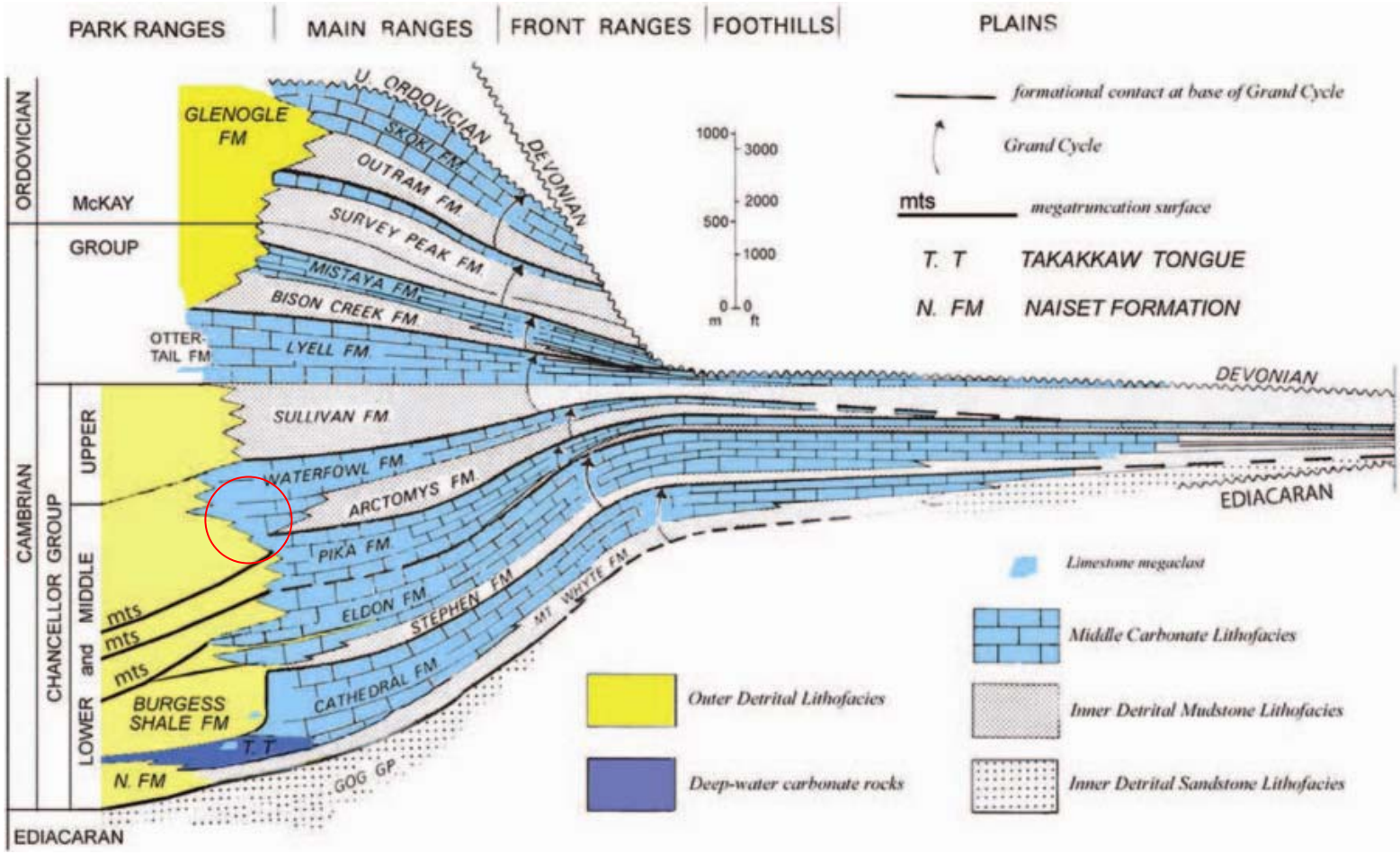
The basal KTC thrust on the back of the TBS projects directly across to the East Stephen Ridge. Rather than a Cambrian-aged MTS, I interpret the East Stephen Ridge feature as the Cretaceous-aged basal thrust surface of the KTC.

Structural Summary (TBS)



1) Placement and partial erosion of the Eastern Main Ranges (Central Yoho Complex or CYC) – early mid-Cretaceous.
2) Initial western Main Range (KTC) thrusting over the existing CYC– mid-Cretaceous?
3) Activation of the Fossil Gully Fault Complex – basement normal faulting related to the Rocky Mountain Trench during the Late Cretaceous with relative uplifting of the Central Wedge.
4) Erosion of the KTC off of the Central Wedge and partial erosion of the same off of the Eastern Block.

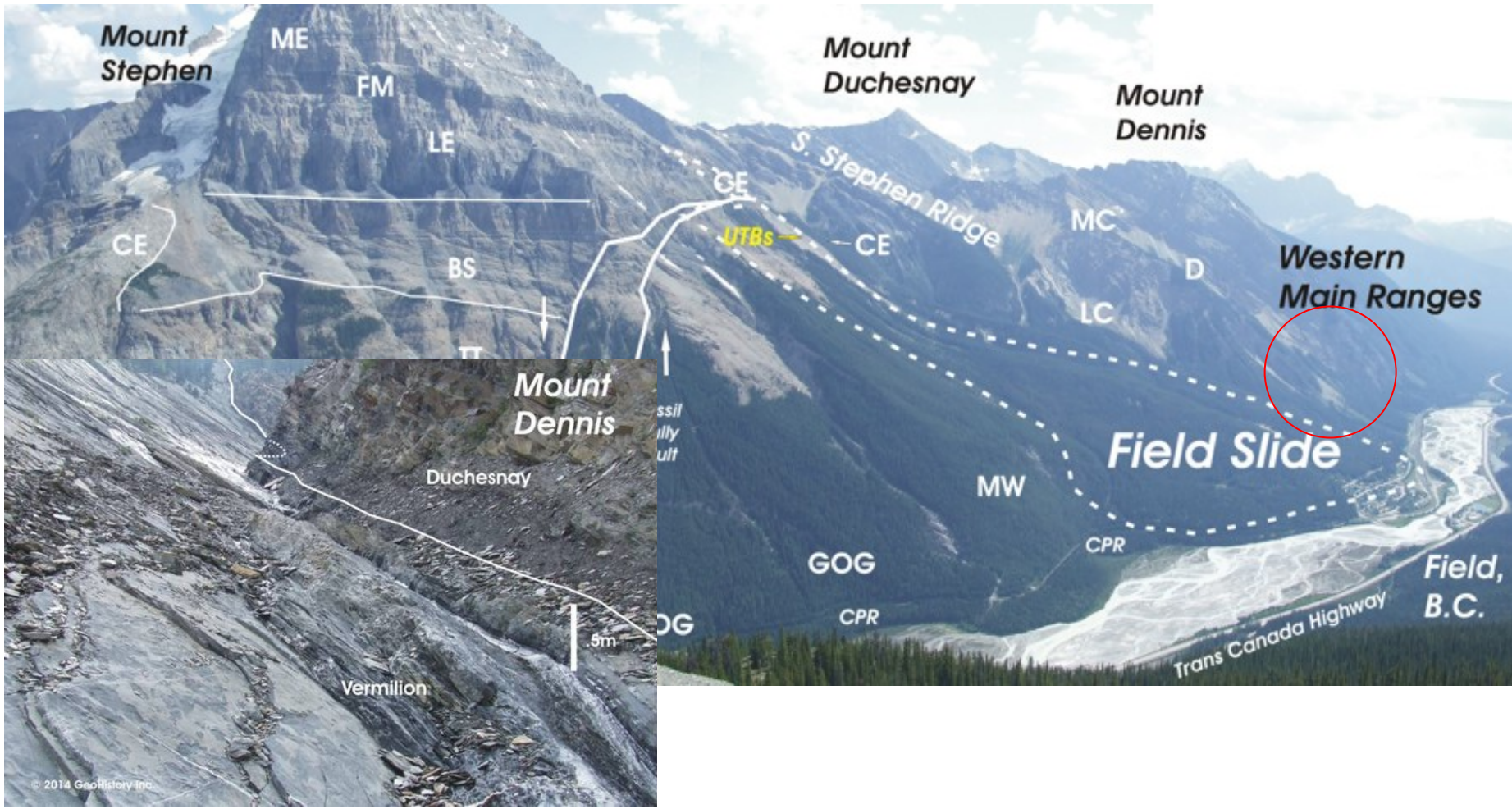
Ramifications



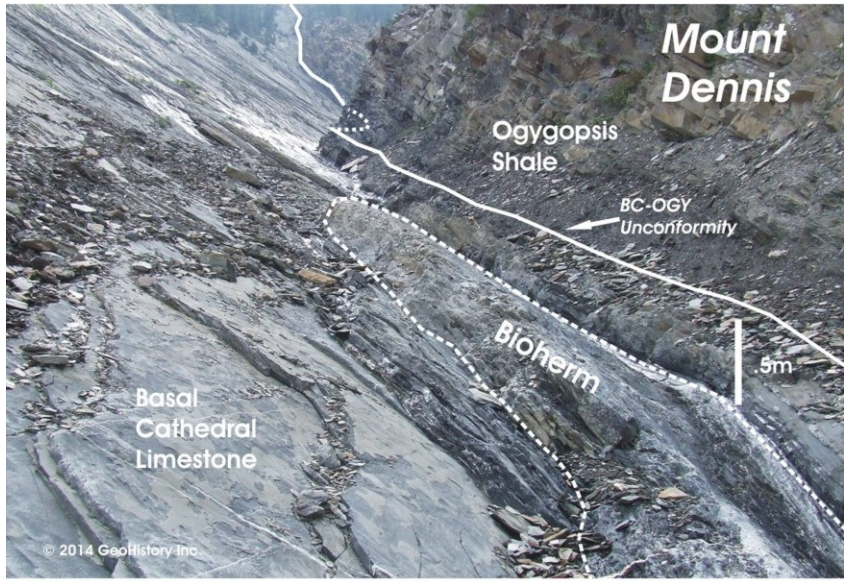
From Collins & Fletcher (2009) Fig. 3 – modified after Aitken (1971) Fig. 3 and Stewart etal (1993) Fig. 2.

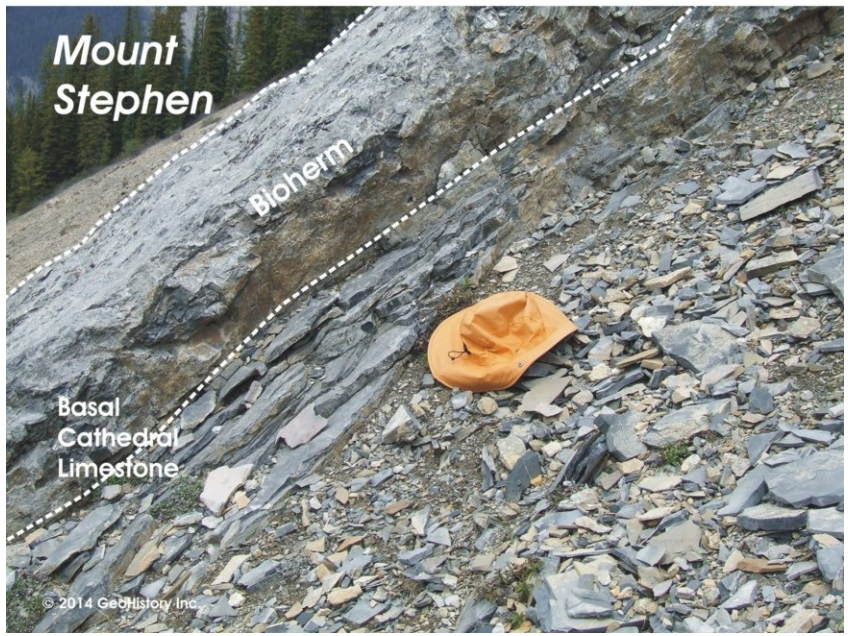
Duplicated, laterally displaced strata is unknowingly incorporated into all of the accepted, published Mid and Lower Chancellor stratigraphic and depositional models in the area, including those developed for the Burgess Shale. For example, the Duchesnay.

Duchesnay Type Section



The Duchesnay type section is located on Mount Dennis directly behind Field and is interpreted as basinal DuchesnayShale overlying platformal Vermillion (Stewart, 1991).



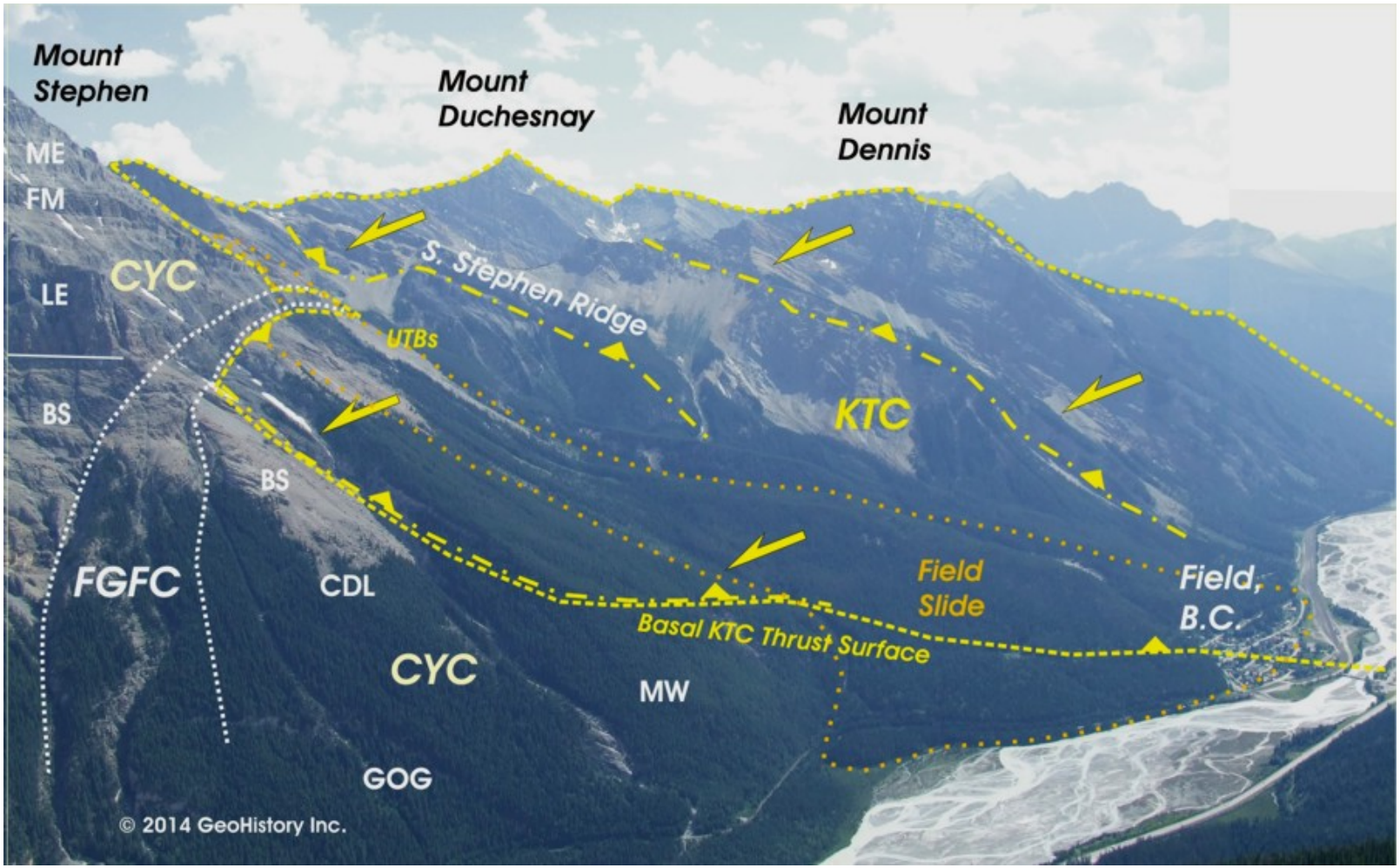


Field Slide Study Interpretation

I interpret the Mount Dennis outcrop to be Ogygopsis Shale overlying the Basal Cathedral/Ogygopsis unconformity with a BC bioherm clearly visible above the BC bedded limestones.

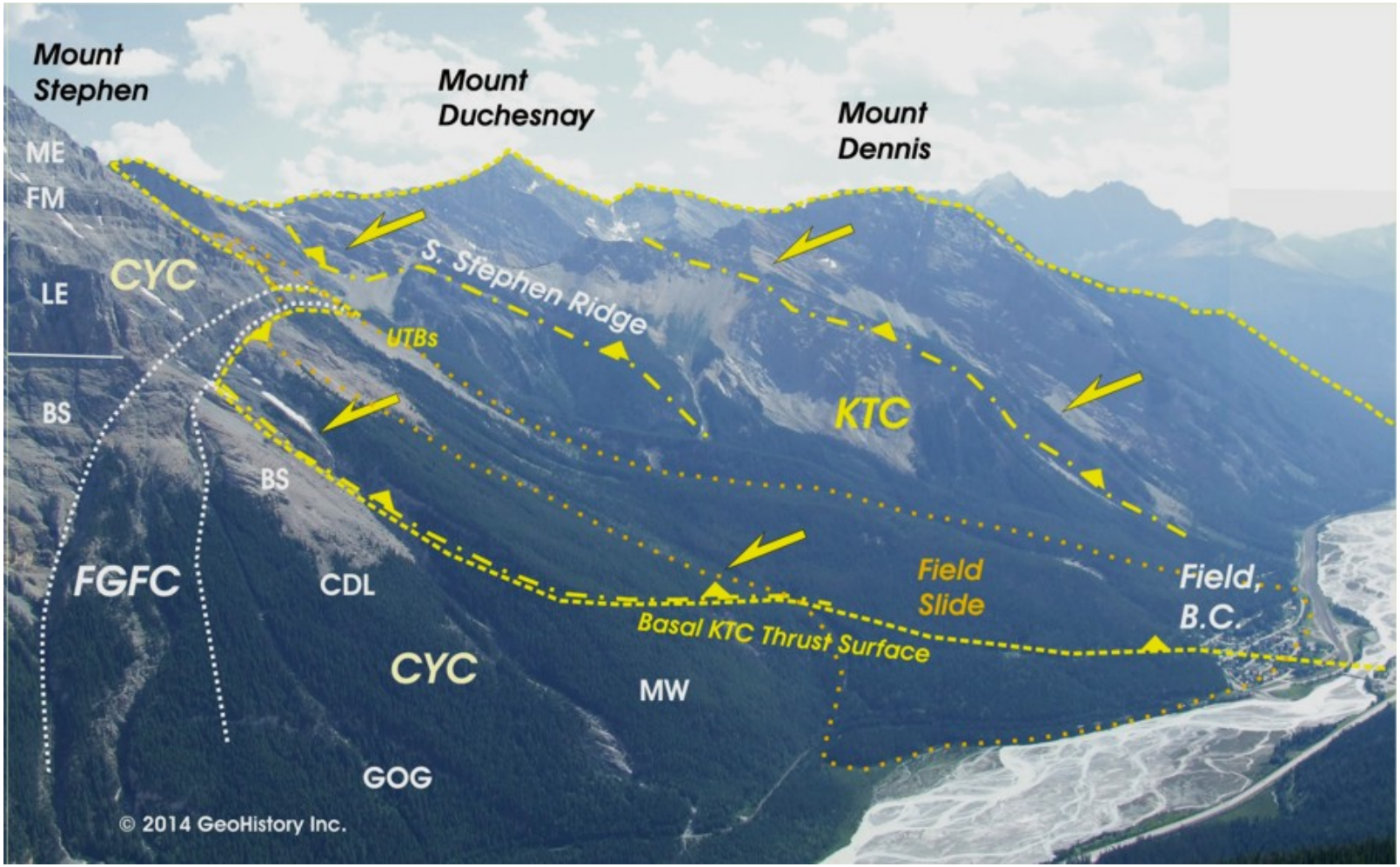
At the same scale, the section looks identical to the outcrops on the Trilobite Beds Slope (TBS) 2km directly east (lower left photo located centre of TBS, lower right photo farther downslope).

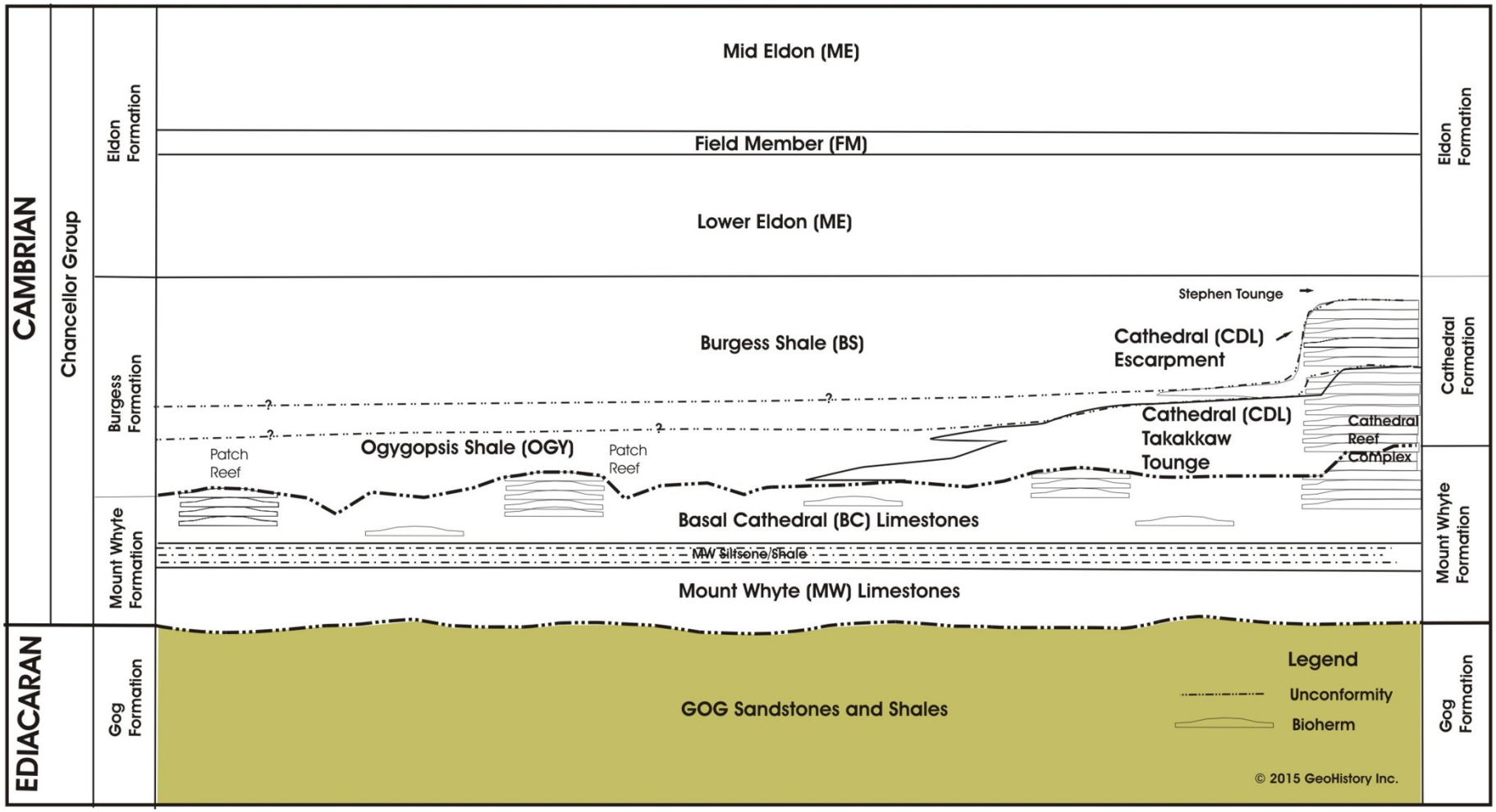
Field Slide Study Interpretation



The KTC basal thrust provides a purely structural, non-lithological boundary for the division between the two main ranges - challenging Cook's accepted lithology-based theory. The Field Slide interpretation yields two distinct mountain building events, the initial Eastern Main Range event, followed by a younger Western Main Range event (in yellow) – the structural division pre-1970 researchers were looking for.

So what has this got to do with Oil and Gas??





Once the complexities of duplicated strata are removed, a new depositional model can be created. Complete with (at times) porous dolomitized patch reefs within platformal limestones, and large reef complexes overlain and at times surrounded by a shale. Reservoir, seal and potential source rocks in one rock package. A new exploration target in the Western Canadian Sedimentary Basin and elsewhere.

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The End

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