Direct Correlation of Orogenic Pulses in the Southern Canadian Rocky Mountains Fold-and-Thrust Belt and Depositional Changes in the Adjacent Foreland Basin: Evidence from $^{40}\text{Ar}/^{39}\text{Ar}$ Dating*

Dinu I. Pana$^1$ and Ben A. van der Pluijm$^2$

Search and Discovery Article #30468 (2016)**
Posted October 24, 2016

*Adapted from oral presentation given at AAPG 2016 Annual Convention and Exhibition, Calgary, Alberta, Canada, June 19-22, 2016
**Datapages © 2016 Serial rights given by author. For all other rights contact author directly.

$^1$AER/Alberta Geological Survey, Edmonton, Alberta, Canada (dinu.pana@aer.ca)
$^2$Department of Earth and Environmental Sciences, University of Michigan, Ann Arbor, Michigan, United States

Abstract

The Cordilleran foreland system in southern Canada evolved between the Middle Jurassic and Early Eocene. New radiometric ages from regionally distributed thrust-fault gouge allow for the first time a direct correlation between the timing of intermittent eastward propagation of the southern Rocky Mountain foreland fold-and-thrust belt and the changes in the depositional processes and sediment input in the adjacent foreland basin to the east. In the Main Ranges, the Pyramid (163.0 Ma), Simpson Pass (161.7 Ma), and Johnson Creek (145.7 Ma) thrusts were related to the initiation of thin-skinned deformation from Jurassic terrane accretion and were partly contemporaneous with the development of the first clastic wedge (Fernie-Kootenay/Nikanassin/Minnes strata) in the foreland basin. Early Cretaceous dextral oblique slip along the western margin of the Rocky Mountains, with a peak between 136-123 Ma, corresponds to a major Valanginian-Barremian depositional hiatus in the foreland basin followed by the deposition of the Barremian-Aptian Cadomin Formation dominated by conglomerate sheets and multiple diastems of varying duration. In the Front Ranges, the emplacement of the Greenock thrust (103.1 Ma) and Broadview–Snake Indian thrust (99.2 Ma) was contemporaneous with development of Cenomanian deltaic deposits in the immediate foreland. Three thrusts in the Front Ranges, the Rocky Pass (74.8 Ma), Sulfur Mountain (75.6 Ma), and Clearwater (74.2 Ma) thrusts, define a Campanian phase of tectonic loading that led to the last major transgression in the southern portion of the Alberta foreland basin. Along the eastern margin of the Front Ranges, the McConnell thrust (54.0 Ma), together with the Muskeg (52.4 Ma), Brule (53.9 Ma), and Nikanassin (52.1 Ma) thrusts in the Foothills, recorded the last phase of regional contraction. The Late Jurassic, Early Cretaceous, mid-Cretaceous, Late Cretaceous, and Early Eocene deformation pulses are separated by relatively long periods of tectonic quiescence. Our data indicate that pulses of tectonic loading in the foreland thrust-and-fold belt trigger flexural subsidence and/or uplift in the foreland basin and are primary controls on the creation or destruction of accommodation space, thus controlling, to a large extent, the type of depositional system and the thickness of depositional sequences.
Selected References


Blakey, R.C., 2011, Paleogeography: Colorado Plateau Geosystems, Phoenix, AZ.


**Website Cited**

Direct Correlation of Orogenic Pulses in the Southern Canadian Rocky Mountains FTB and Depositional Changes in the Adjacent Foreland Basin; Evidence from $^{40}$Ar/$^{39}$Ar Dating

Dinu Pana, Alberta Geological Survey
Ben van der Pluijm, University of Michigan
Presenter’s notes: We have documented
1 – Four tectonic pulses in the development of the RM foreland-fold-and-thrust belt (Stress may have been continuous but Strain was discontinuous).
2 – Direct correlation between:
   a) Tectonism in the hinterland and thrusting in the Foreland Belt on one hand, and on the other hand.
   b) As expected in a foreland system: thrusting in the Foreland FTB has directly influenced depositional processes in the Foreland Basin.
Presenter’s notes: The detached and displaced supracrustal rocks comprise six broad tectonostratigraphic assemblages:

1. The Belt-Purcell assemblage (1470-1400 Ma) accumulated in a deep (15-20 km) intracontinental rift-basin.
2. The Windermere assemblage (750-600 Ma) accumulated to thicknesses of a few km, and locally > 5 km, in a rift basin that truncated but partly overlapped the Belt-Purcell basin.
3. The thick (10-15 km) Cambrian to Middle Jurassic (600-180 Ma) Cordilleran miogeocline assemblage deposited mainly above and outboard of the Windermere assemblage. It was as a westward prograding continental margin terrace wedge that marked the interface between the Early Paleozoic Laurentia craton and the adjacent proto-Pacific ocean basin.
4. The laterally equivalent thinner North American cratonic platform assemblage accumulated on the adjacent part of the craton, over-lapping not only the crystalline basement rocks of Laurentia but also, within the region known as Montania, much of the Belt-Purcell basin.
5. The Late Jurassic to Cenozoic Cordilleran foreland basin assemblage, which overlies the cratonic platform assemblage, accumulated in front of the northeastward prograding accretionary wedge as the continental lithosphere subsided isostatically under the weight of the advancing wedge; it was partly incorporated in and cannibalized by the encroaching thrust and fold belt. Prior to late Triassic and early Jurassic all magmatic rocks of Quesnellia had Sr/Sr below .704, therefore oceanic. By middle Jurassic (accretion of Stikinia - Western Paleozoic and Triassic of the Klamaths) the .704 line had shifted 200 km westward of the leading edge of Quesnellia to just west of the Okanagan Valley. In the east middle Jurassic plutons stitch the fault separating Quesnellia from North America; suturing took place in late early to early middle Jurassic. By mid-Cretaceous (accretion of Wrangelia) the .704 line had moved only a further 25 km westwards, but by Eocene time (it had moved 75 km west of the Okanagan valley. During mid-Cretaceous to Eocene sediments of the fold and thrust belt in eastern B.C. moved 200 km eastwards. At depth this movement must have been partitioned into crustal thickening to accommodate 125 km of shortening, and 75 km of additional overriding of North America by Quesnellia. The amount of tectonic overlap observed today must be reduced by 75 km to account for extension. Sediments of the fold and thrust belt were deposited on the basement which presently underlies Quesnellia.
Presenter’s notes: Thin-Skinned Accretionary Wedge

- Most (~75%) of this shortening is expressed as large displacements along a small number of large thrust faults.
Presenter's notes: Fission tracks in apatite and vitrinite reflectance data interpreted as tectonic exhumation.

Early Oligocene = Earliest record of extension

----100 Ma (150 to 50 Ma)
Dating Brittle Faults

a) separate clay grain size fractions
   2 - 0.2 μm, 0.2 - 0.02 μm, and <0.02 μm

b) determine the authigenic/detrital ratio
   through X-ray diffraction
   authigenic clay: 1M/1Md polytype
   detrital clay: 2M1 polytype

c) irradiation of vacuum-encapsulated samples

d) Ar dating each grain size population

Presenter’s notes:
- The gouge underwent multiple generations of illite growth which may correspond to renewed episodes of fault motion.
- Illite closure temperature of ~200 °C
Nikanassin thrust
52.1±3.9 Ma
McConnell thrust
54.0±0.7 Ma
Results

Summary

Nikanassin 52.1 ± 3.9 Ma
McConnell (Abraham Lake) 54.0 ± 0.7 Ma
  51.0 ± 3.5 Ma
  57.7 ± 1.2 Ma
  Average
Sulphur Mtn 75.6 ± 3.7 Ma
Rocky Pass 74.8 ± 2.1 Ma
Luscar shale-footwall 69.3 ± 6.0 Ma
Brule thrust 53.9 ± 5.5 Ma
Muskeg thrust 52.4 ± 12.3 Ma
Rundle 72.7 ± 6.1 Ma
Clearwater 74.2 ± 6.7 Ma
Lewis (Grizzly Creek) 72.3 ± 2.3 Ma
Broadview 99.2 ± 10.2 Ma
Greenock 103.1 ± 2.0 Ma
Simpson Pass 161.7 ± 6.6 Ma
Johnston Cr. 145.7 ± 14.9 Ma
Pyramid 163.0 ± 7.6 Ma

58–51 Ma_Early Eocene
76–72 Ma_Campanian
103–99 Ma_mid-Cretaceous
163–146 Ma_Late Jurassic
58-51 Ma: Early Eocene
76-72 Ma: Campanian
103-99 Ma: mid-Cretaceous
163-146 Ma: Late Jurassic

http://ags.aer.ca/publications/MAP_560.html
Presenter’s notes: Progression of a foreland fold and thrust belt into the foreland basin.

BUT:

Our data are well clustered within 4 age groups suggesting that the eastward progression was intermittent, in tectonic pulses. Stress may have been continuous but Strain was discontinuous.
Early Cretaceous
Paleocene-Eocene
Significance:

Direct correlation between
- thrusting in the foreland-FTB &
- depositional processes in the foreland basin

Tectonic loading

Erosional unloading
Mid-Cretaceous
Presenter’s notes: Late early Cretaceous orogen parallel tectonism in northern B.C. (along N RM trench and Teslin SZ).

Strike-slip faults and shear zones intimately associated with voluminous sin and late tectonic granitic plutonism dated ca. 115-100 Ma passes northwardly into a broad domain northward directed thrusting.

Restored by Gabrielse et al. (2006)
Late Cretaceous
Thank you