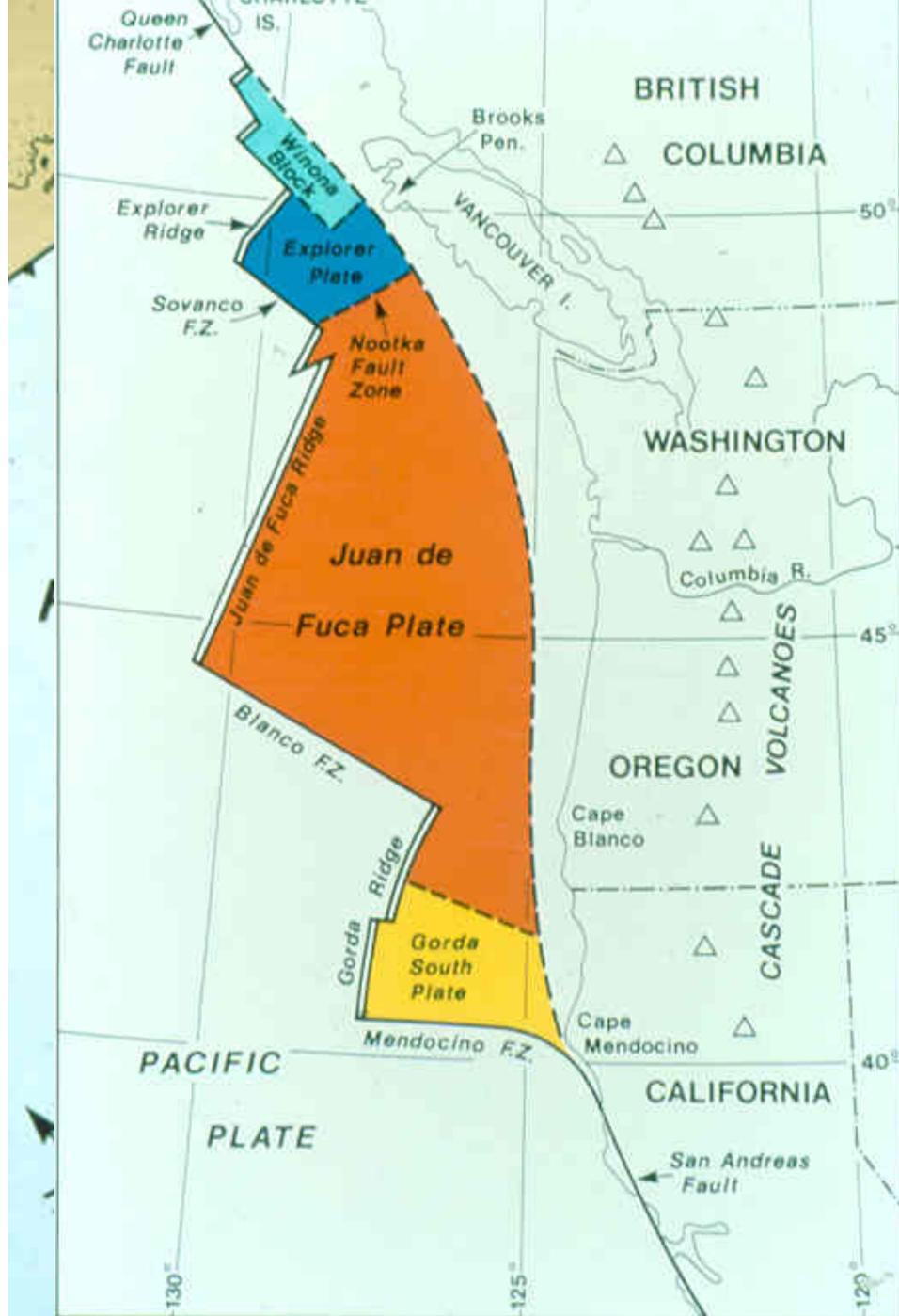
An aerial photograph of a volcanic landscape, showing a central crater surrounded by steep, layered slopes. The terrain is characterized by distinct horizontal ridges and valleys, suggesting a series of successive volcanic layers. The overall color palette is a mix of light and dark grays, with some reddish-brown hues in the upper sections.

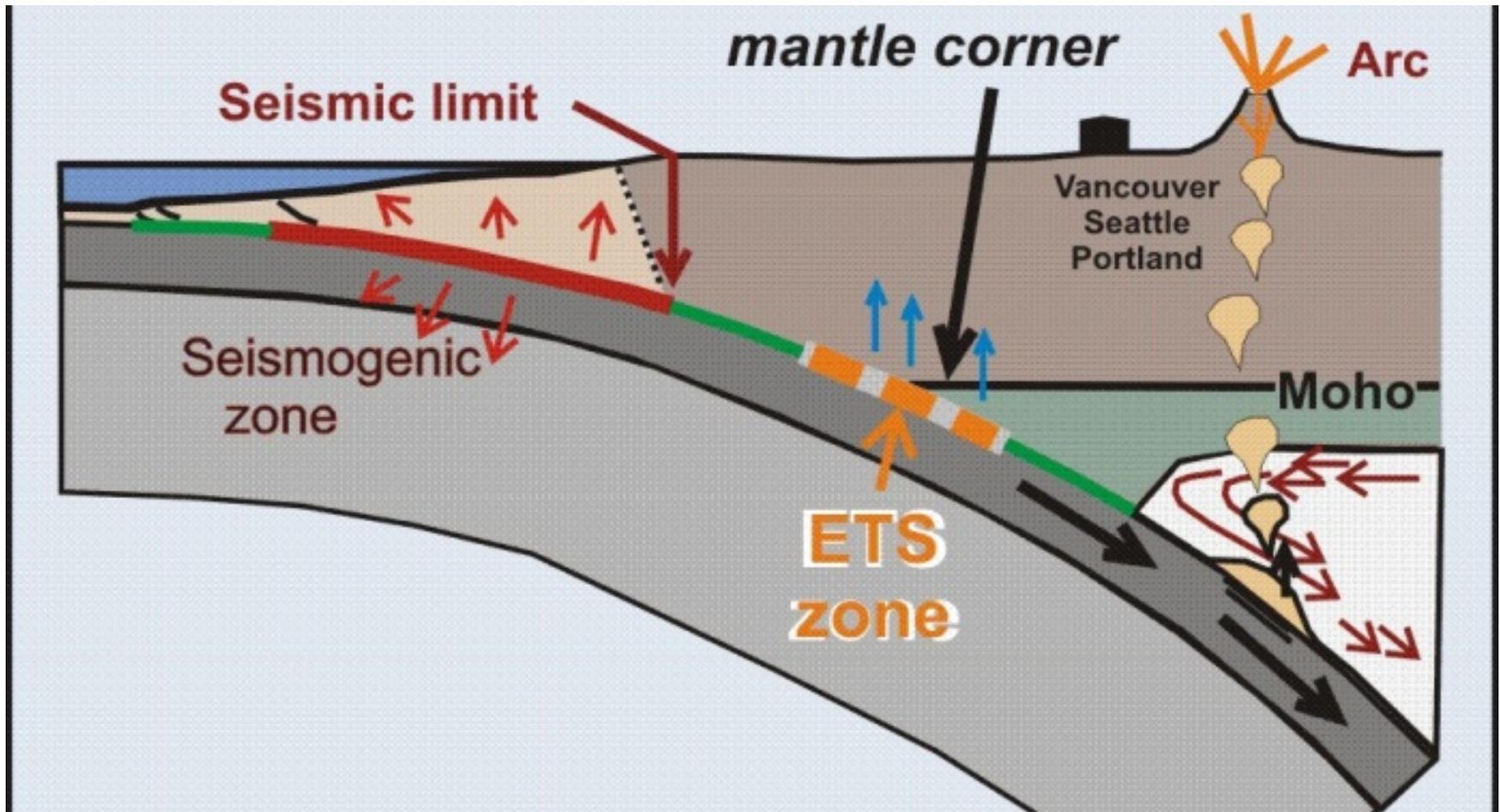
# **A Volcano In Repose, Meager Mountain Seismicity 1985 - 2017**

*Taimi Mulder  
NRCan – Geological Survey of Canada  
Pacific Geoscience Centre*

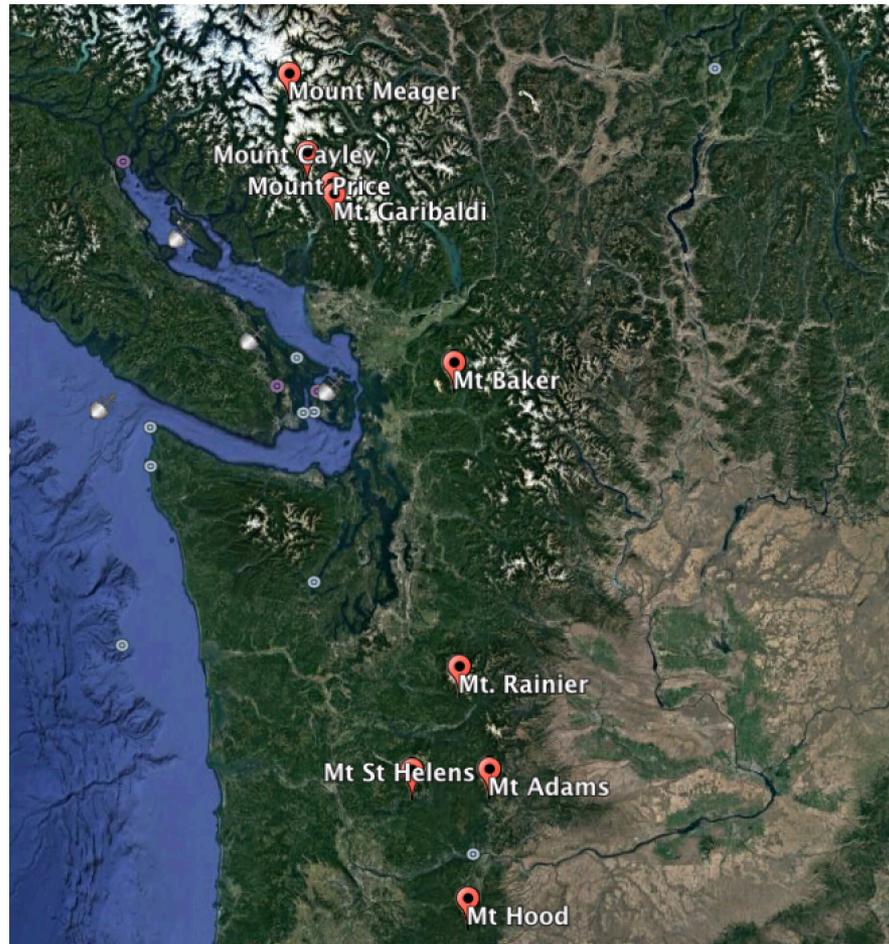
*AGU 2019  
May 28-30  
Taormina, Sicily, IT*



# Earthquakes occur in 3 places (cross-section)



# Pacific NW Volcanoes



# BC Volcanoes – Regional Geology

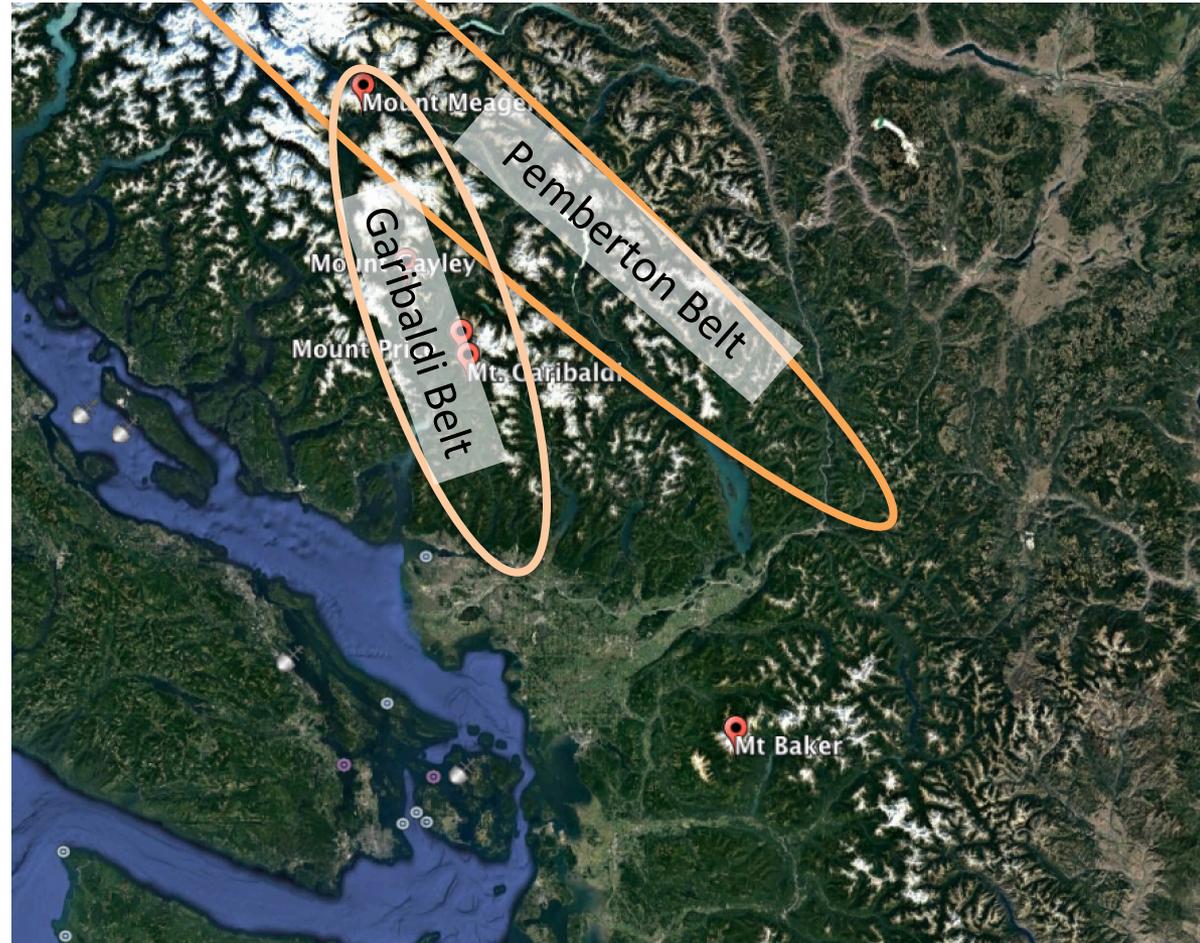
## Pemberton Belt

- Late tertiary intrusives, active 30-10 Ma.
- Extends from Haida Gwaii to US border.
- Magmatic front associated with Farallon plate subduction.

## Garibaldi Belt

- Intersects at Mount Meager.
- Major edifices are Garibaldi, Cayley, Meager.
- 5 Ma or younger
- Characterized by long repose periods, as much as several thousands of yrs.

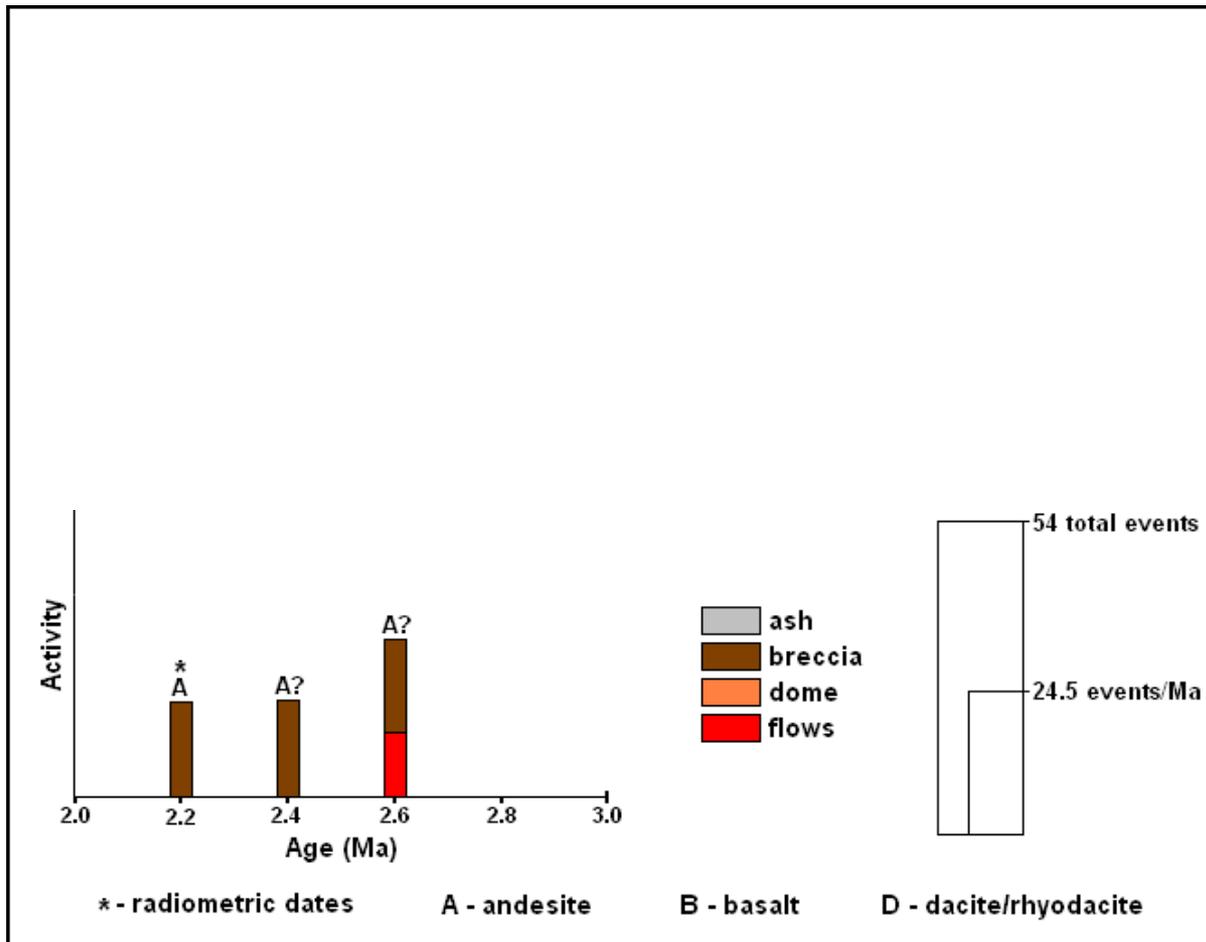
*Hickson, C.J., 1994*



# Garibaldi Belt

- Quaternary volcanism
- Mount Garibaldi Volcanic Field: 26 km<sup>3</sup>, 12,000-10,000 BP
  - Mount Garibaldi: 6.5 km<sup>3</sup>.
- Mount Cayley: 13 km<sup>3</sup>, built 4 Ma to 0.6 Ma, associated hydrothermal field.
- Mount Meager: 20 km<sup>3</sup>, volcanism since the Pliocene, 1.9 Ma – 2400BP, associated hydrothermal field.

# Eruptive History



# Mount Meager Eruptive History

- Early phase from ~1.9 Ma to ~1 Ma, dacitic to rhyolitic.
- Middle phase from 1 Ma to 0.5 Ma, andesitic.
- Late phase from 100,000 BP and into the Holocene, rhyolitic to dacitic.
- Most recent eruption 2400 (14 C date) BP
- Dacitic eruption which started with a vent clearing phases that produced tephra which can be traced as far east as western Alberta.
- Followed by block and ash flows which blocked the Lillooet River.
- Blockage led to cataclysmic outburst flood.
- Final eruptive stage produced a short lava flow
- Hot springs exist around the mountain, most notably Meager Creek HS and Pebble Creek HS.

*Hickson, C.J., 1994*

*Hickson, C.J., J.K. Russell, and M.V. Stasiuk, 1999*

# Recent Excitement near Mount Meager

- 2016 Feb
  - Sulphur smells and observations of hot water in newly constructed tunnel across the valley from Mount Meager.
- 2016 Jul
  - Reports of sulphur smells in the valleys around Mount Meager
  - July 21 helicopter pilot (former geologist) observed “fumaroles” venting through Job Glacier on the Meager Volcanic Complex.
- 2016 Aug
  - Aug 20 reconnaissance survey, photos, infrared and digital photogrammetric measurements.
  - Northwest flank of Plinth Peak showed 250, 000, 000 m<sup>3</sup> of ground deformation between 1992-2001.
- 2016 Sep
  - Sep 11 thermal infrared imaging, gas measurements
    - H<sub>2</sub>S 250 ppm
    - CO<sub>2</sub> 2250 ppm
    - SO<sub>2</sub> none detected
  - GSC (NRCan) installed temporary seismic station

# Job Glacier, Mount Meager



# Fumarole 1 taking measurements



# Fumerole 2 taking measurements



# Fumarole 3 taking measurements



# BC Hydro Electric Project on Lillooet River



# Seismic Station – Fuel Cache (MGMB)

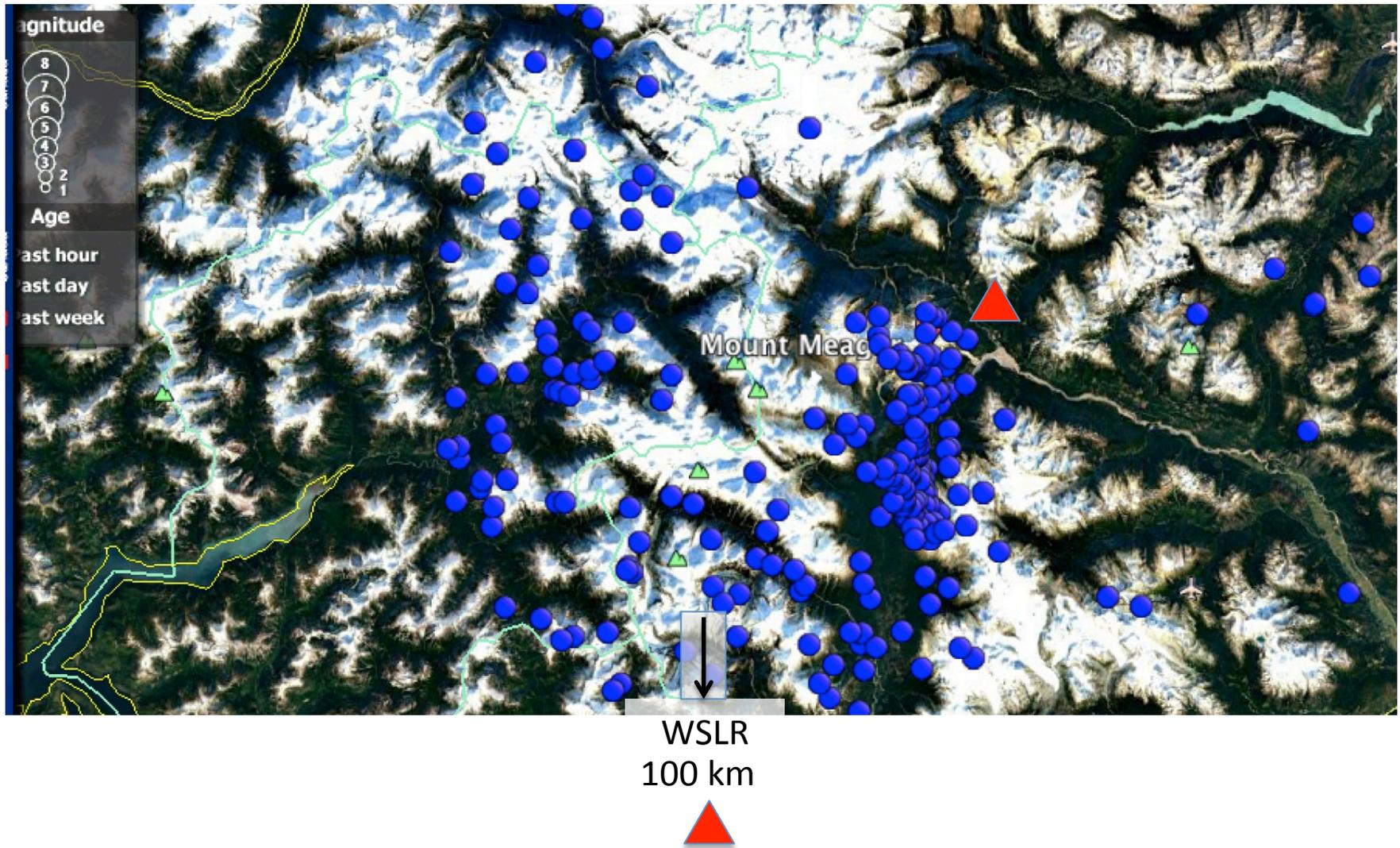
Installed 2016 Sep 11

Site down 2016 Dec 20

- Waiting for snow to melt.
- Noisy site due to nearby river and construction traffic from nearby hydro-electric development.
- 1 event located with new site → shallow (< 5km).

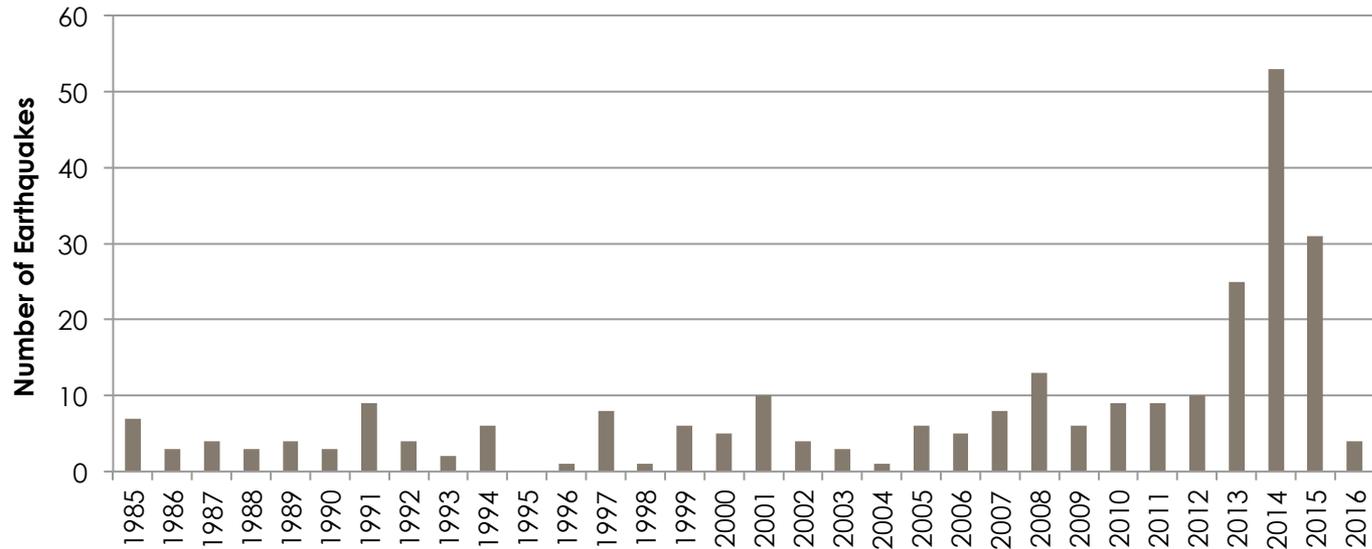


# Meager Mountain seismicity within 30 km



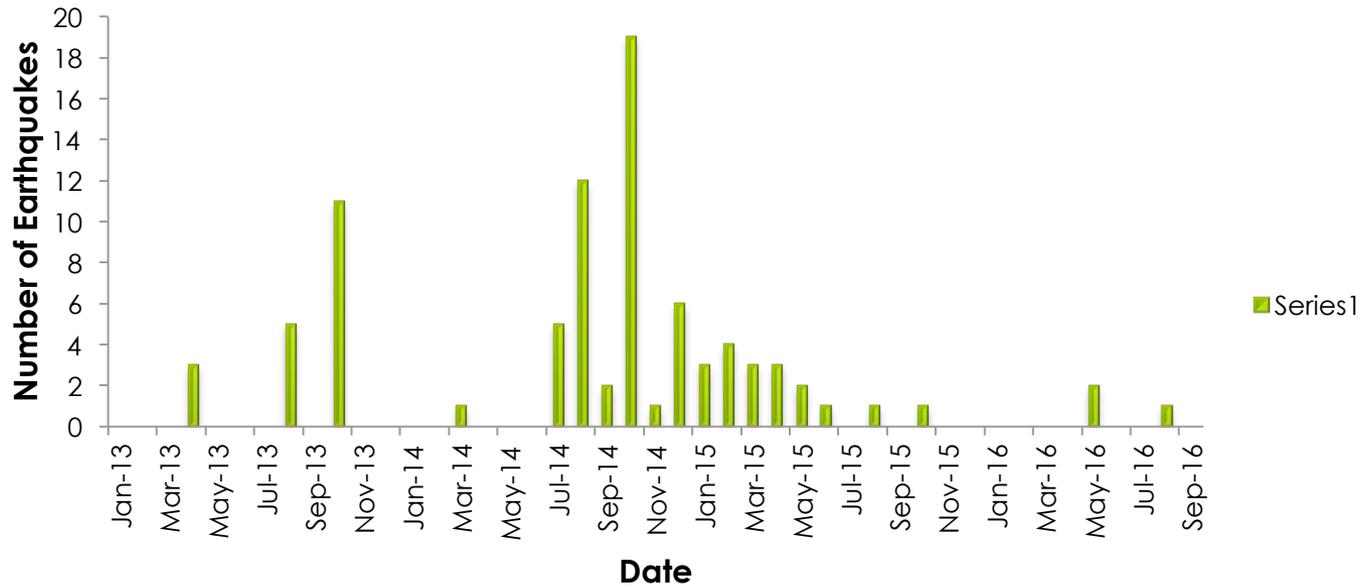
# Earthquake Distribution Over Time

Frequency of Earthquakes by Year, Mount Meager



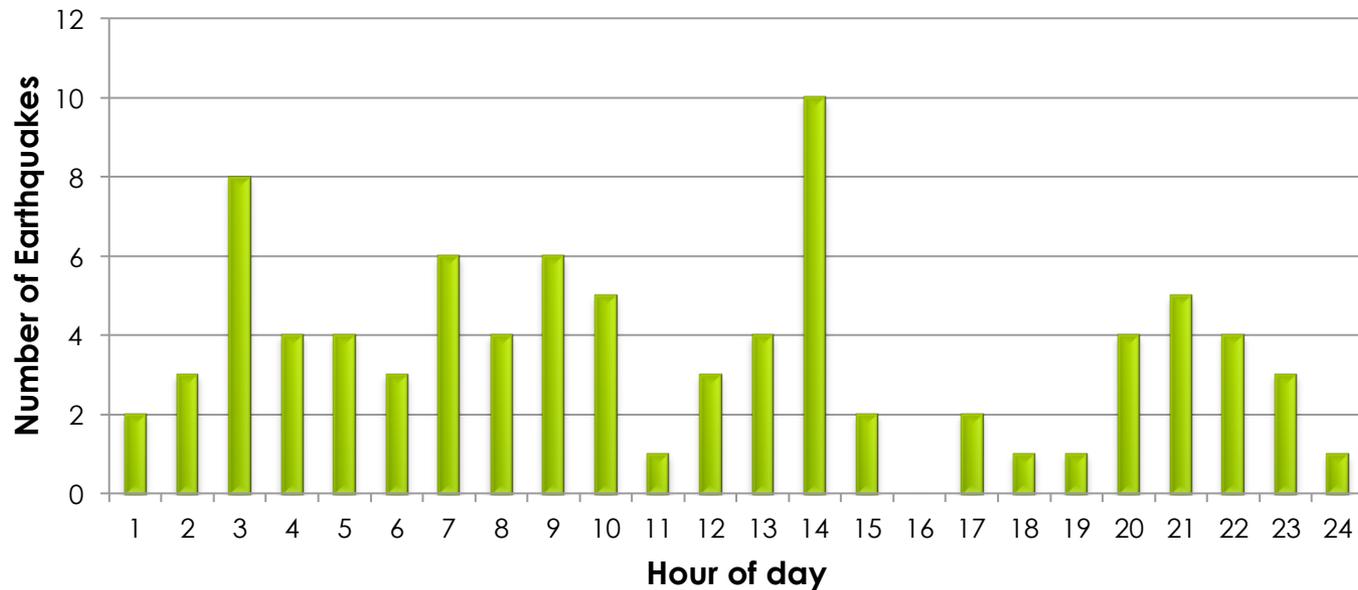
# Distribution of Increased Seismic Rate Events

**Meager Earthquakes 2013-2016, radius = 30km**



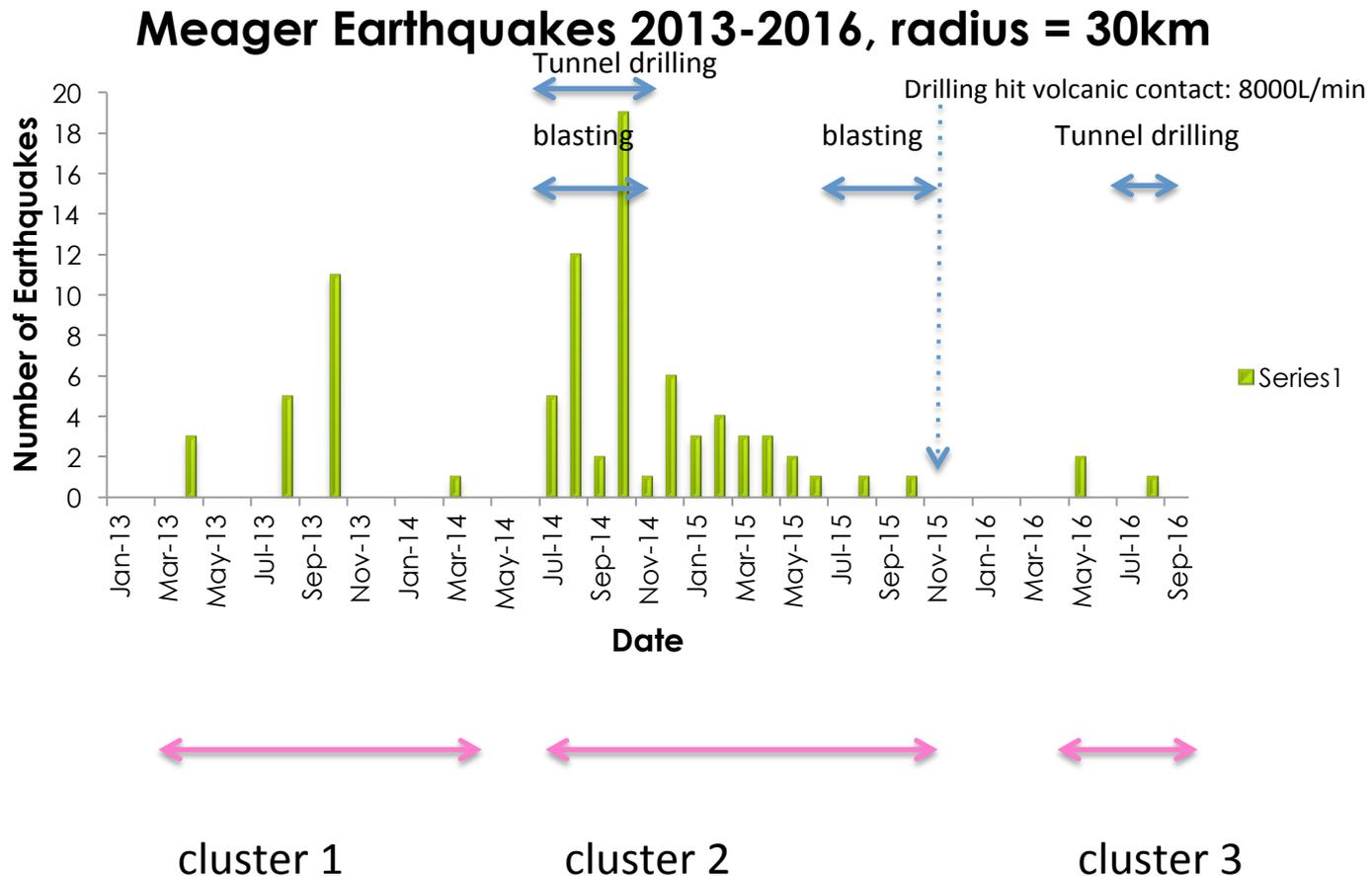
# Earthquake Distribution by Hour of Day

**Meager Earthquakes 2013-2015 radius = 30km**

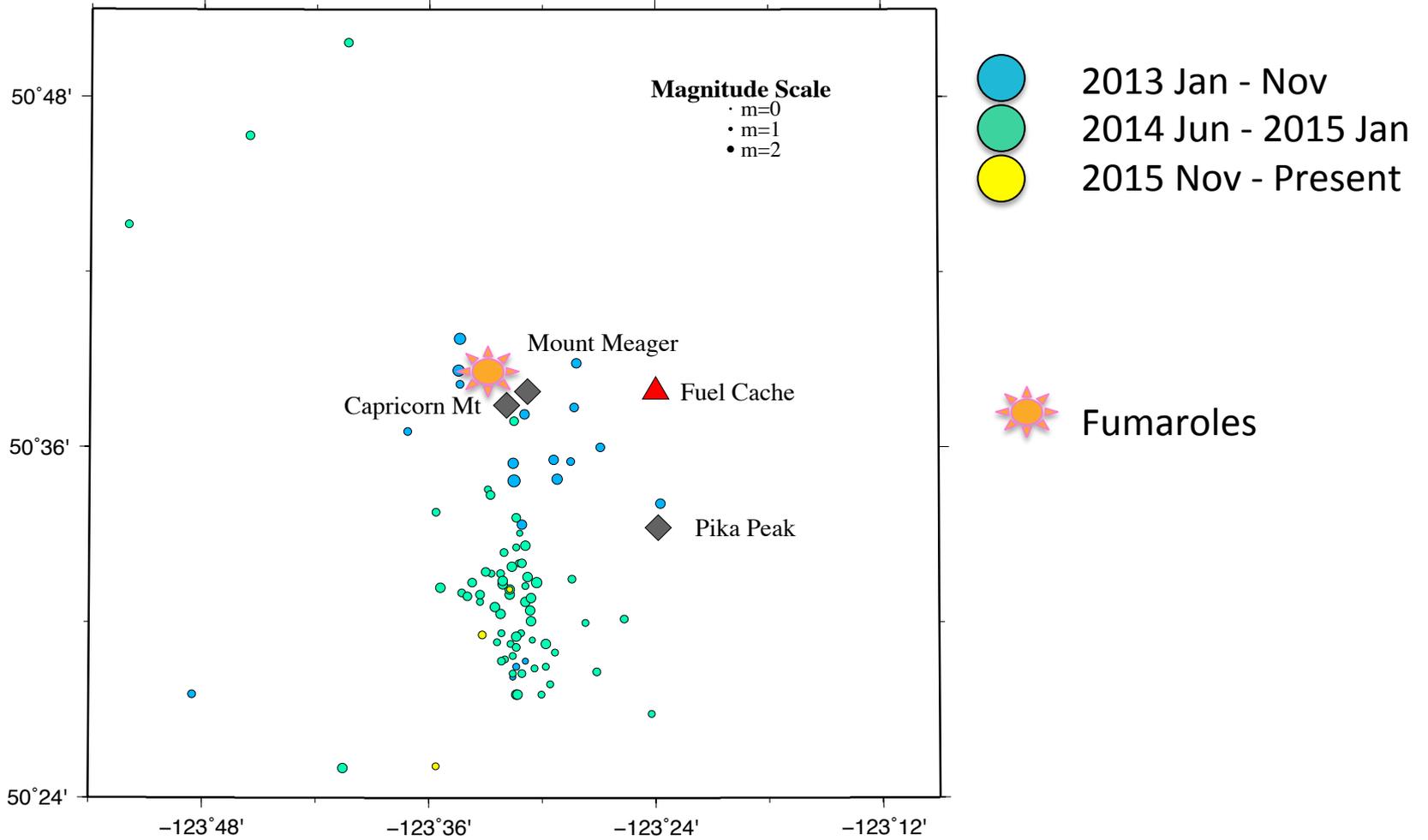


# Distribution of Increased Seismic Rate Events

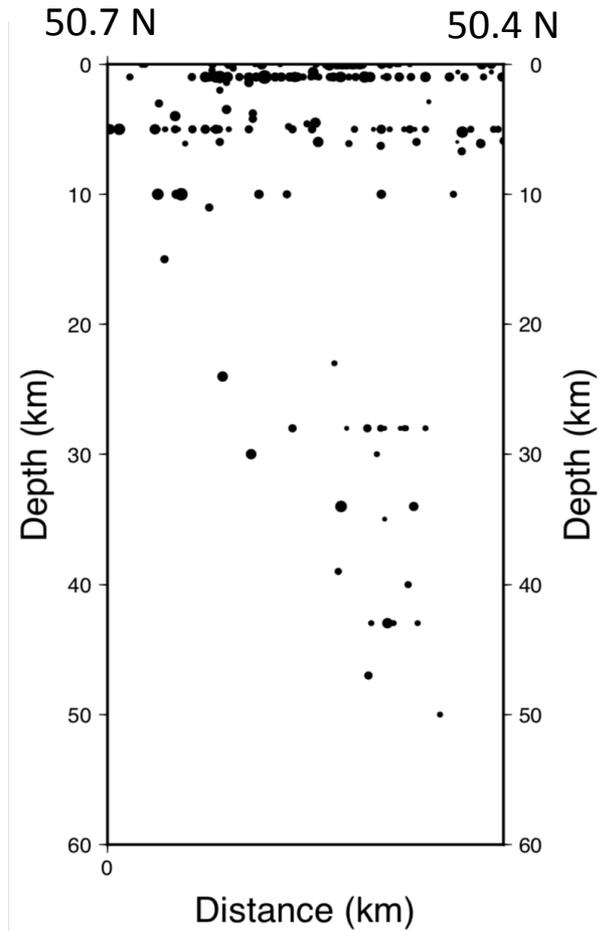
- 2 Hydro construction sites: Boulder Creek & Upper Lillooet



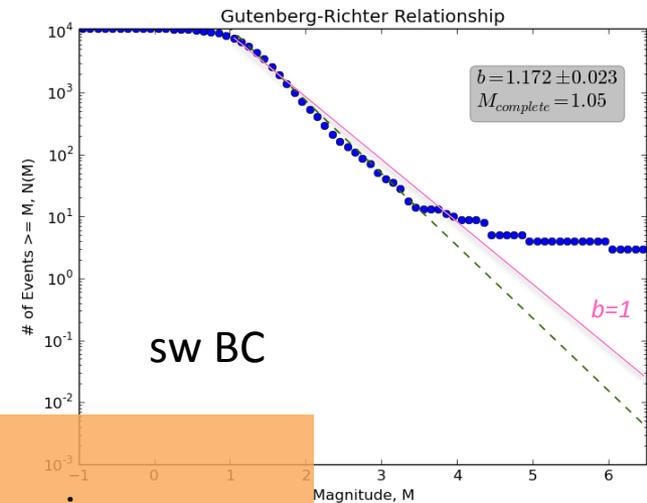
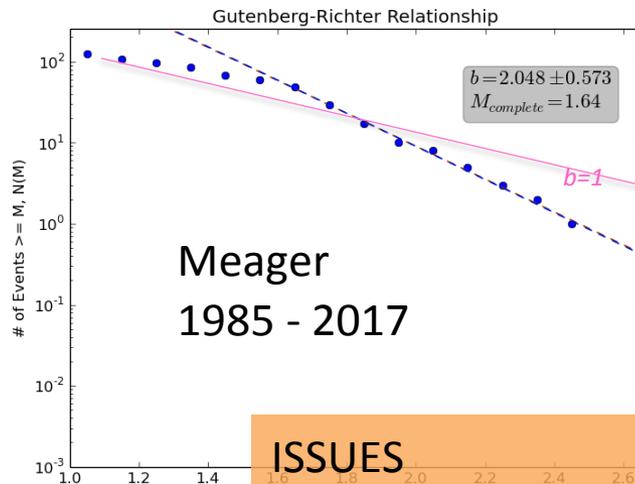
Mount Meager earthquakes, r=30km, 2013 01–2016 09



# Earthquakes 1985-2017

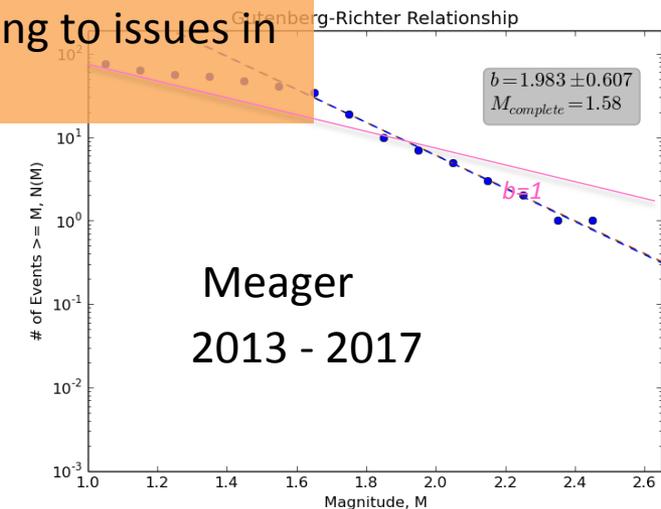
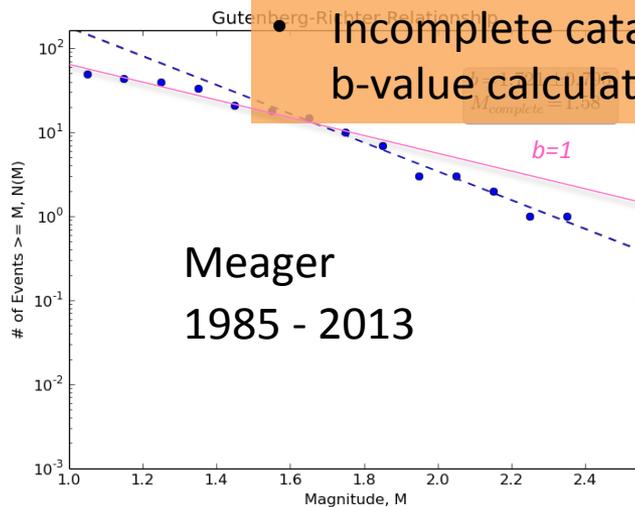


# b-values



## ISSUES

- Lack of data in the meager region
- Incomplete catalogue leading to issues in b-value calculation

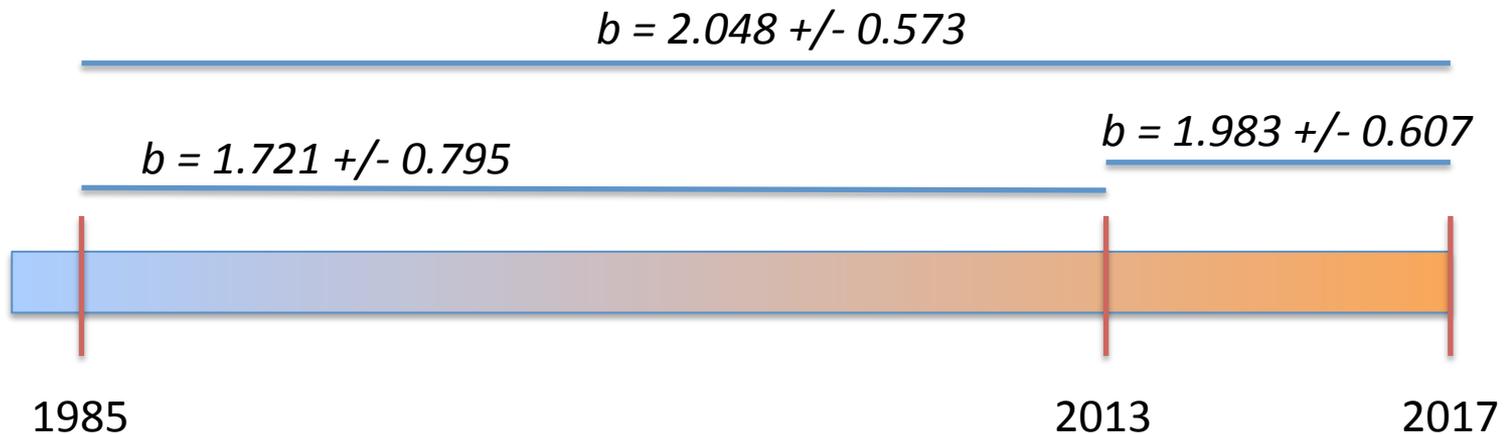


# b-values

- *Southwestern BC background tectonic rate:*

$$b = 1.172 \pm 0.023$$

- *Meager:*



# Conclusions

- Seismicity is to the south of Mount Meager and is shallow (< 10 km).
- Incomplete seismic catalogue in vicinity of Meager results in difficulty calculating b-values (not enough data).
  - b-values  $\sim 2$  and do not show significant variation over time.
  - Meager b-values are greater than the background tectonic b-value (1.2). This could be due to hydrothermal field migration or volcanic magma movement.
- Largest earthquake  $M=2.5$ . Require larger event to commence magma movement after 2400 years of quiescence.
- No seismic sign of magma movement (tens to hundreds to thousands of events/day) or magmatic harmonic tremor.
- No significant observations of volcanic gases (no  $\text{SO}_2$  detected) from 'fumaroles'. Believed that 'fumaroles' are likely associated with hydrothermal fluid activity in the Meager Volcanic Complex.
- Seismic activity may be due to hydrothermal fluid activity in the south Meager hydrothermal field.
- **TO ADEQUATELY MONITOR MEAGER MAGMA CHAMBER, need**
  - Accurate earthquake depths
  - Lower magnitude threshold of events
  - => Seismic site very close (within 10 km) to Meager earthquakes for long term monitoring...

# Next Steps

- Review Z.15 km earthquake depths

# PIKA site across the valley S of Meager

