POLYCYCLIC AROMATIC HYDROCARBONS IN GLACIER NATIONAL PARK

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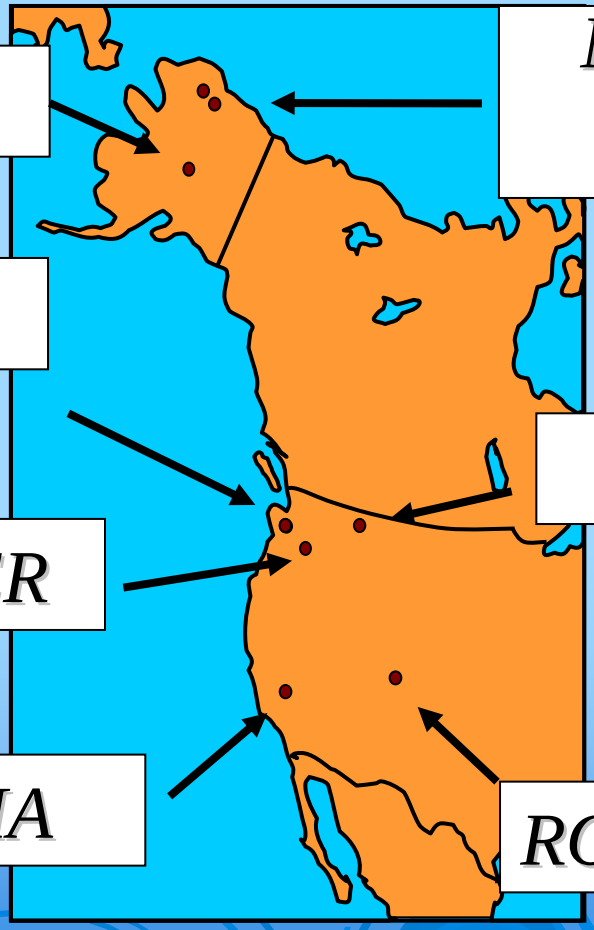
4.23.08

Oldman Lake 2005

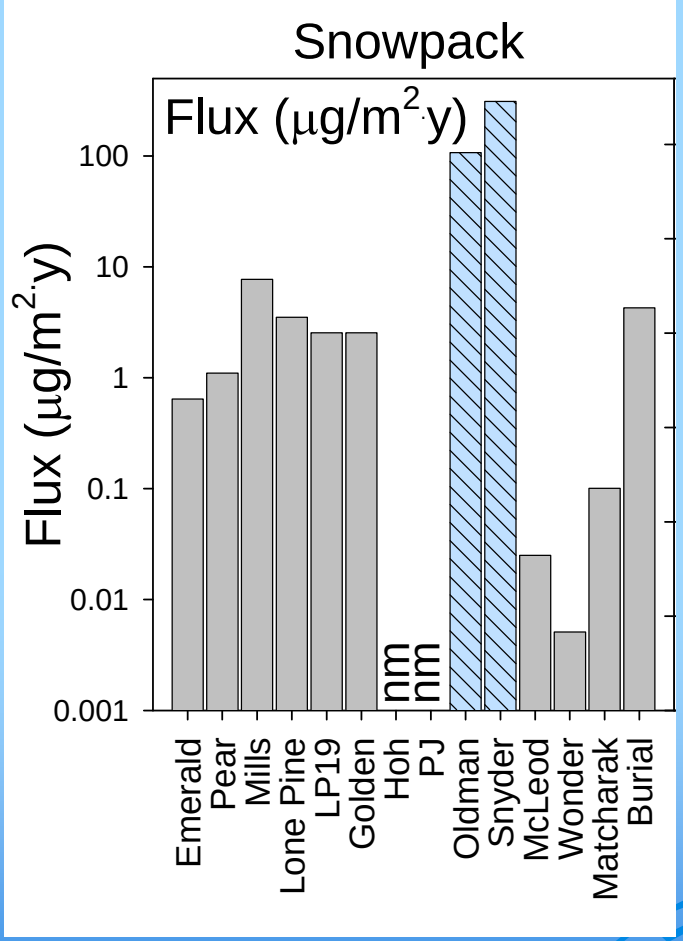
Polycyclic Aromatic Hydrocarbons

- PAHs are molecular markers for incomplete combustion.
- Sources of PAHs in Glacier NP
  - Forest Fires (natural)
  - Burning Fossil Fuels (vehicles)
  - Industry (Al smelters)
  - Oil and Gas Flares

PAHs in WACAP Parks

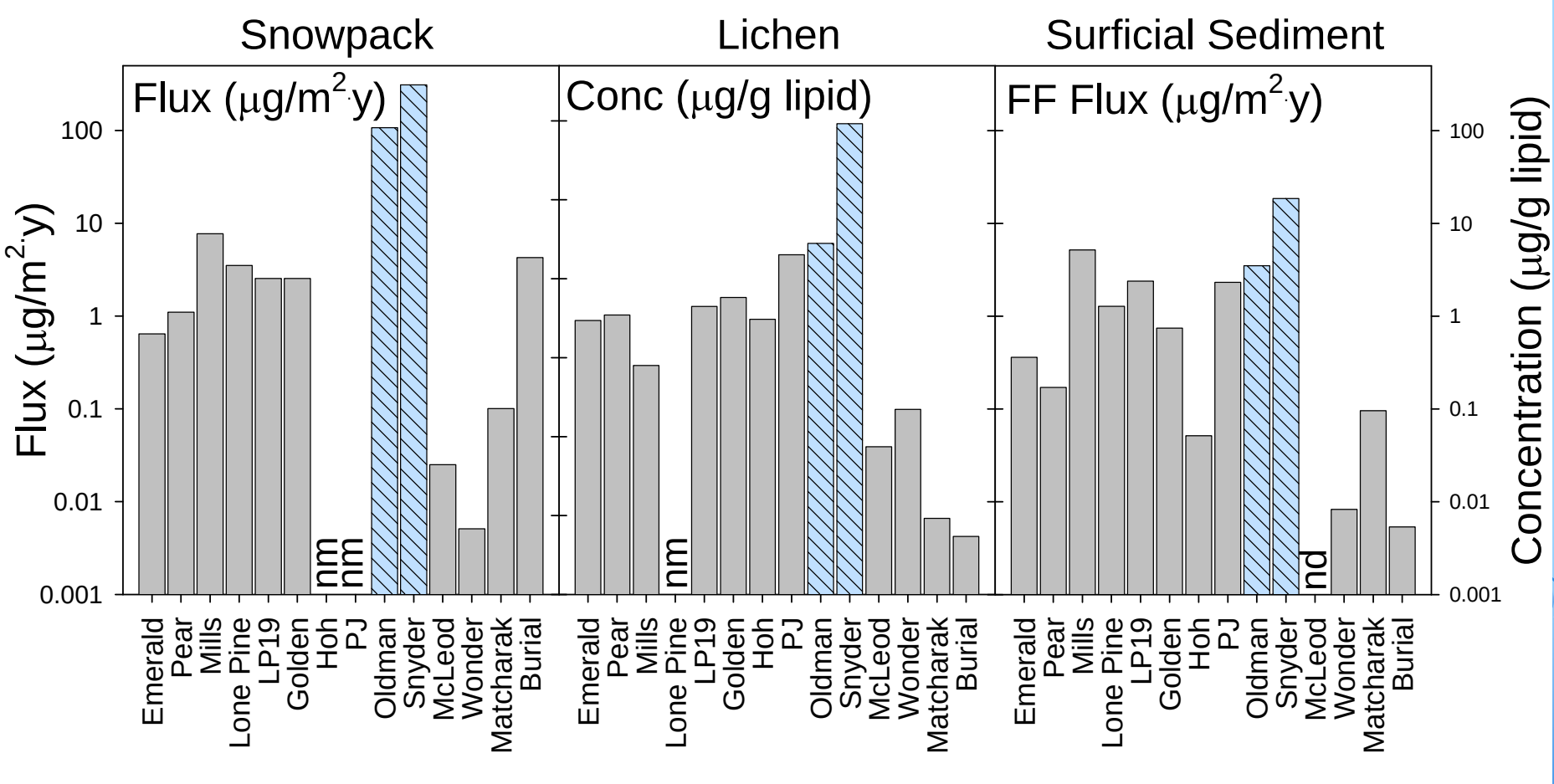


Polycyclic Aromatic Hydrocarbons



nm = no measurement

Polycyclic Aromatic Hydrocarbons



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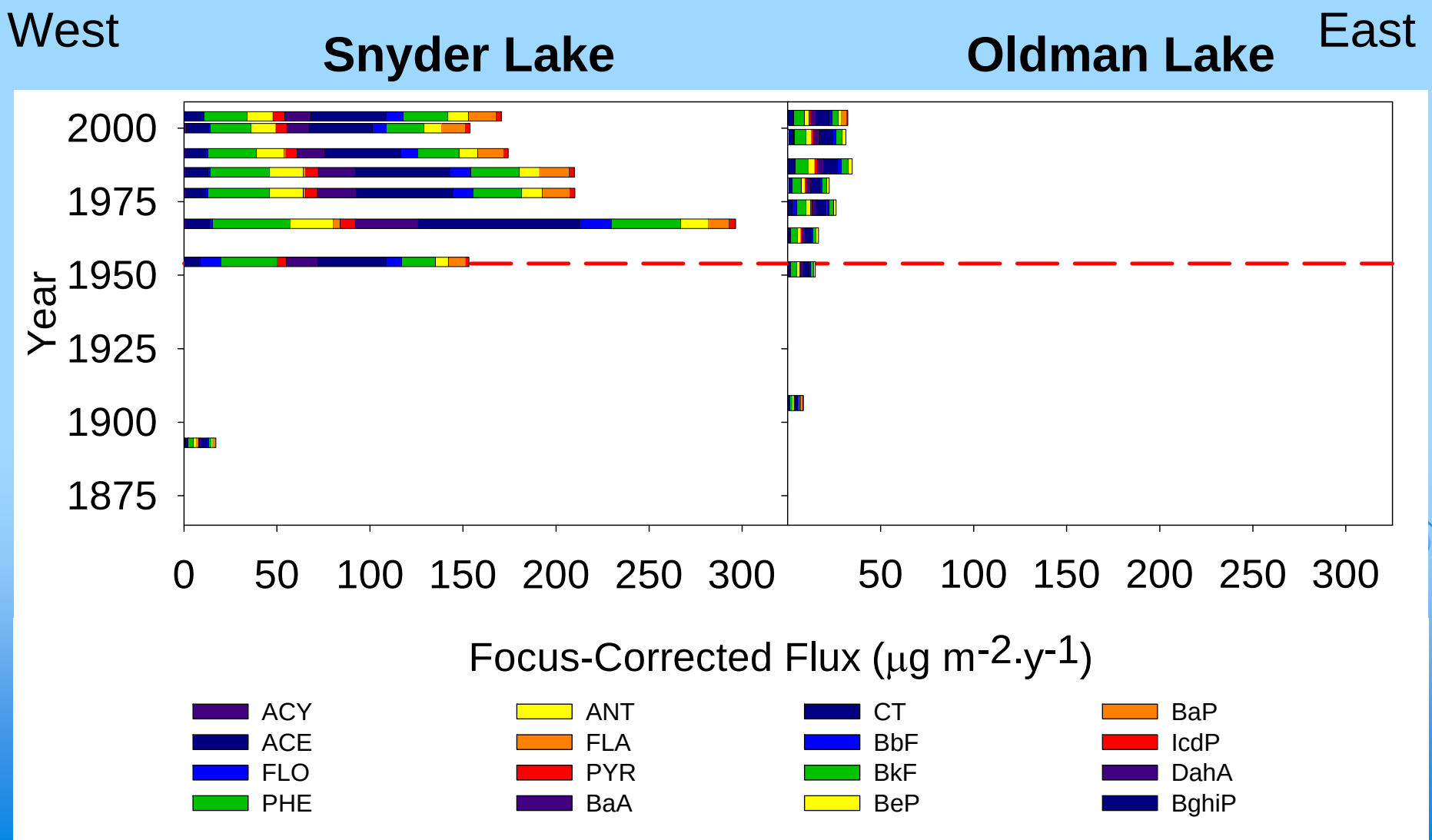
PAH Sediment Profiles



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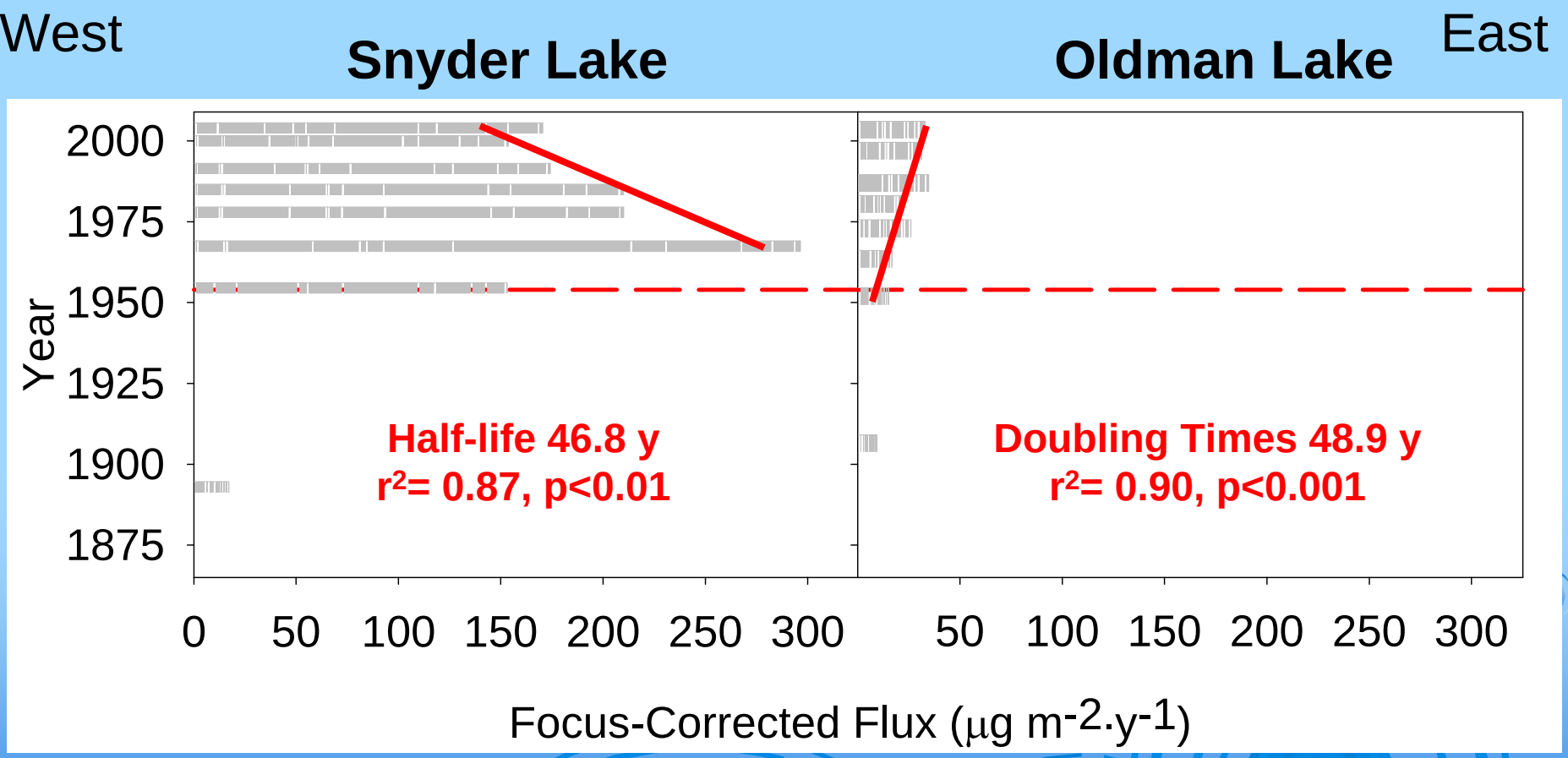

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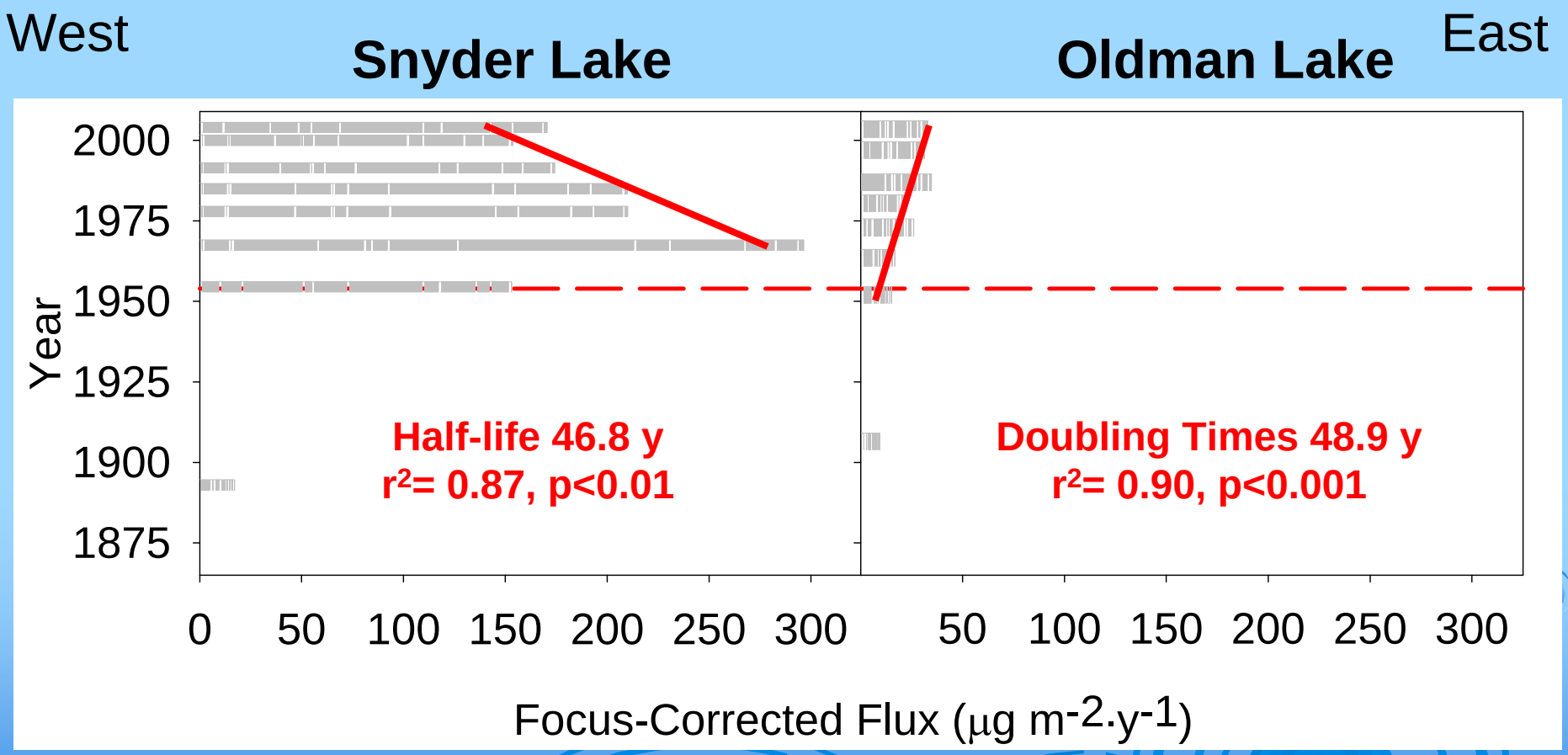
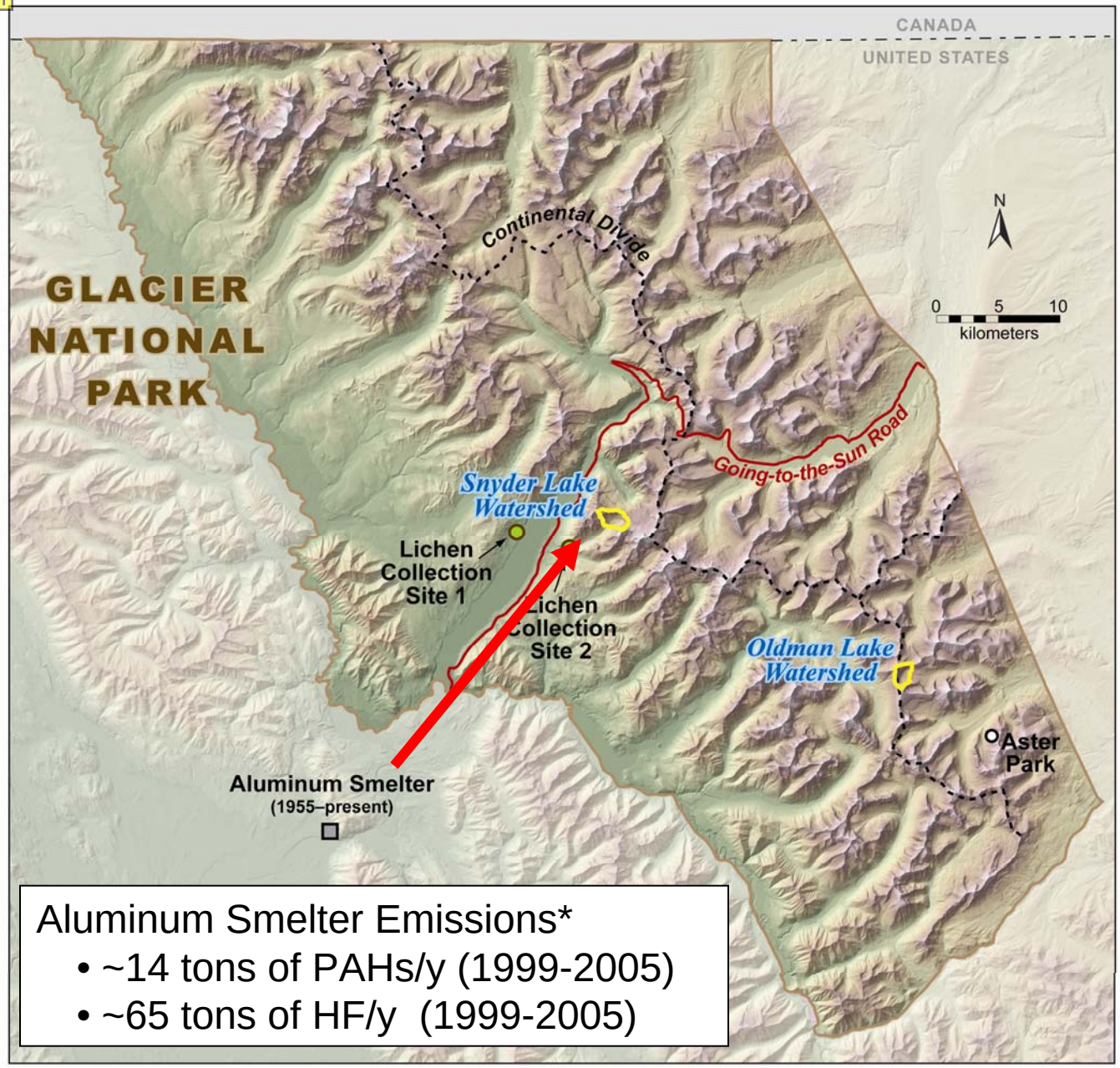


Snyder Lake and Oldman Lake may be receiving different contributions from regional PAH sources



Aluminum Smelter Emissions*

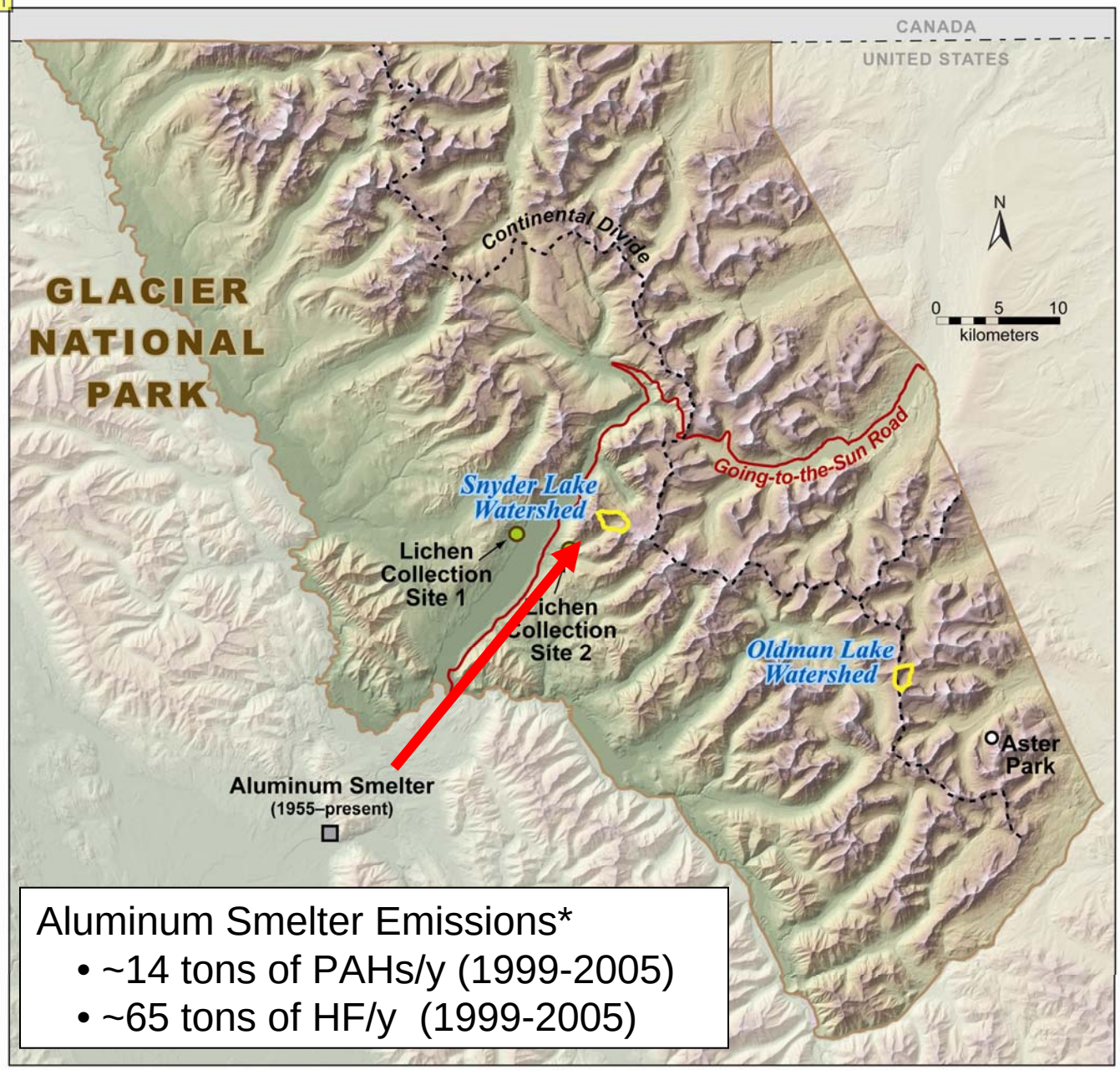
- ~14 tons of PAHs/y (1999-2005)
- ~65 tons of HF/y (1999-2005)

Snyder Lake

2002-2003
Snowpack Season

- **Smelter at 60%**
- **Yearly emissions 15.1 tons of PAHs***
- **Snowpack flux (310 $\mu g\ m^{-2} y^{-1}$)**

U.S. EPA. Toxics Release Inventory Program 2007



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2002-2003
Snowpack Season

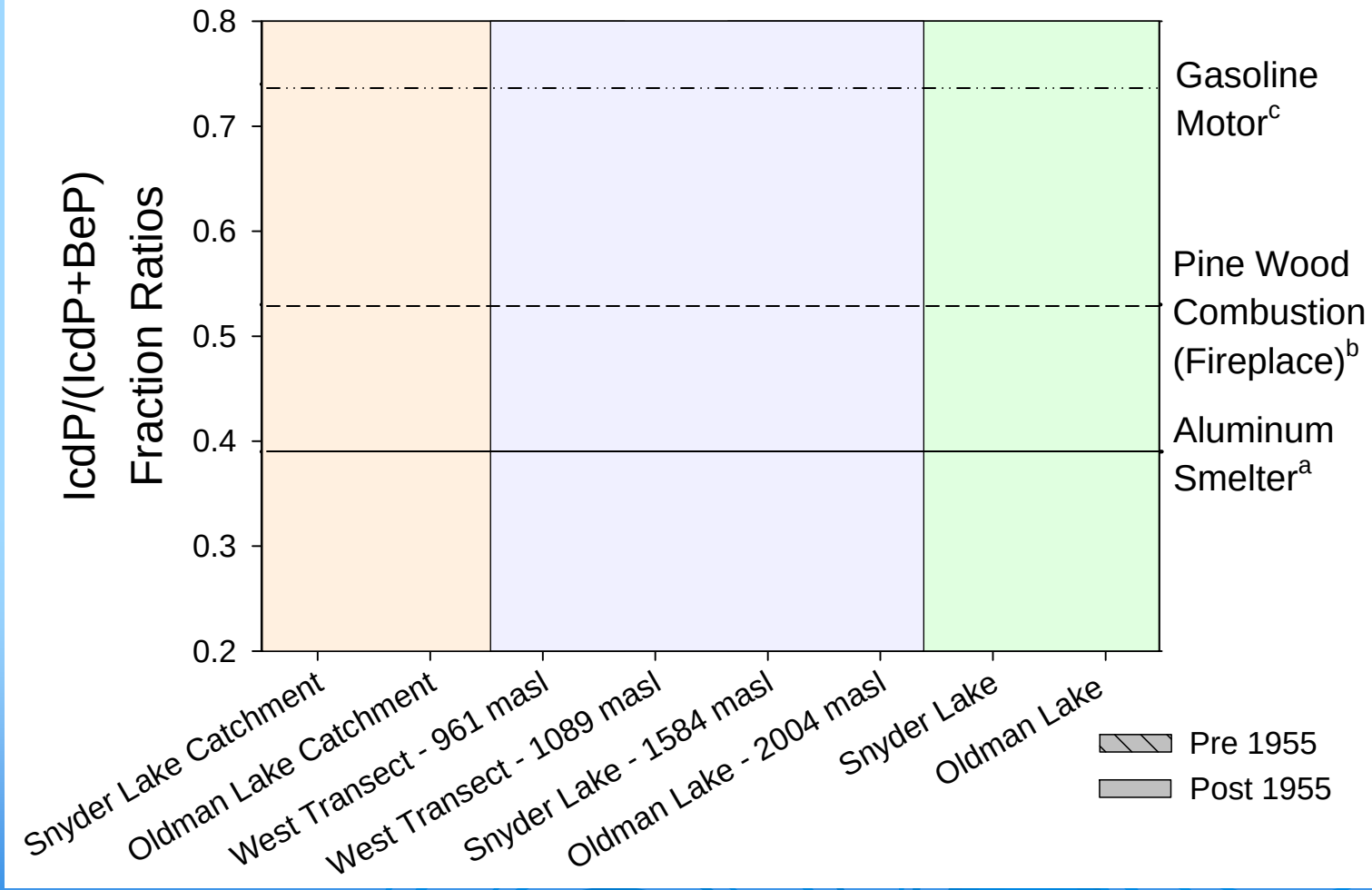
- **Smelter at 60%**
- **Yearly emissions 15.1 tons of PAHs***
- **Snowpack flux (310 $\mu g\ m^{-2} y^{-1}$)**

2003-2004
Snowpack Season

- **Smelter at 20%**
- **Yearly emissions 5.0 tons of PAHs***
- **Snowpack flux (100 $\mu g\ m^{-2} y^{-1}$)**

U.S. EPA. Toxics Release Inventory Program 2007

PAH Ratios in Glacier National Park



[a]Sanderson et al 2005; [b]Schauer et al 2001; [c]Schauer et al 2001;

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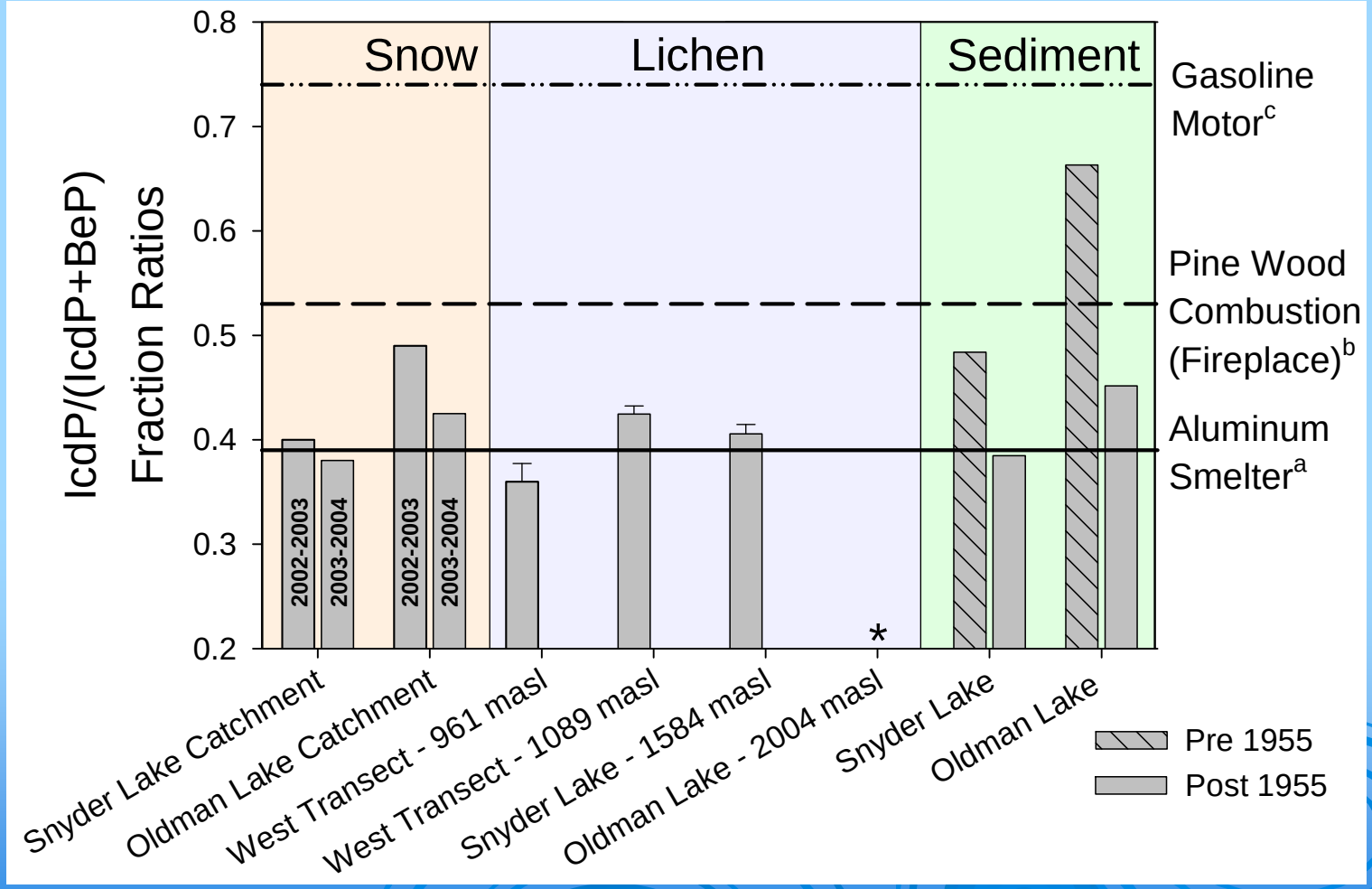


[a]Sanderson et al 2005; [b]Schauer et al 2001; [c]Schauer et al 2001;

Conclusions

- Snyder Lake receives a greater PAHs load than any other WACAP site.
- Glacier NP is receiving PAHs from two different major sources
- The continental divide can influence PAH atmospheric transport and deposition in Glacier NP
- Evidence suggest that Snyder Lake in influenced by a local aluminum smelter

ACKNOWLEDGEMENTS

- Sampling team
- Funding by Western Airborne Contaminants Assessment Project, a collaborative venture between:

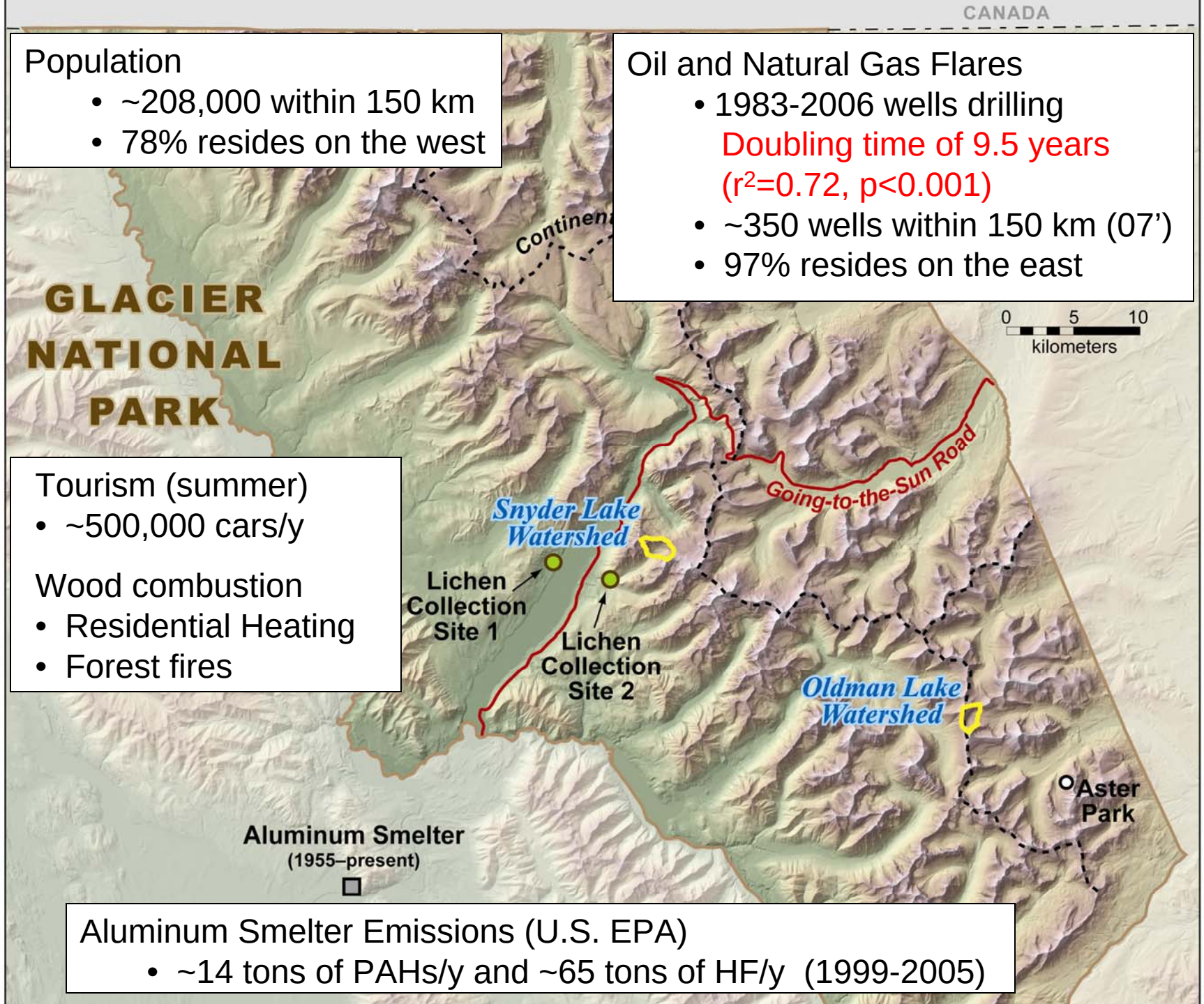
QUESTIONS

Matcharak Lake, AK

CANADA
UNITED STATES
N
0 5 10
kilometers
GLACIER NATIONAL PARK
Continental Divide
Going-to-the-Sun Road
Snyder Lake Watershed
Lichen Collection Site 1
Lichen Collection Site 2
Oldman Lake Watershed
Aster Park
Aluminum Smelter
(1955–present)

Population
- ~208,000 within 150 km
- 78% resides on the west

Oil and Natural Gas Flares
- 1983-2006 wells drilling
  Doubling time of 9.5 years
  (r^2=0.72, $p<0.001$)
- ~350 wells within 150 km (07')
- 97% resides on the east



Tourism (summer)
- ~500,000 cars/y

Wood combustion
- Residential Heating
- Forest fires

Aluminum Smelter Emissions (U.S. EPA)
- ~14 tons of PAHs/y and ~65 tons of HF/y (1999-2005)

West **East**

Snyder

Depth (m)

- 0.0-0.5
- 0.5-1.0
- 1.0-1.5
- 1.5-2.0
- 2.0-2.5
- 2.5-3.0
- 3.0-3.5

West
Snyder
East
Oldman
CANADA
UNITED STATES
GLACIER NATIONAL PARK
Continental Divide
Going-to-the-Sun Road
Snyder Lake Watershed
Lichen Collection Site 1
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Aster Park
Aluminum Smelter
(1955–present)
N
0 5 10
kilometers
Depth (m)
0.0-0.5
0.5-1.0
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Depth (m)
0-2
2-4
4-6
6-8
8-10
10-12
12-14
14-16
16-18

West
Snyder
East
Oldman
CANADA
UNITED STATES
Continental Divide
GLACIER NATIONAL PARK
N
0 5 10
kilometers
Going-to-the-Sun Road
Snyder Lake Watershed
Lichen Collection Site 1
Lichen Collection
Aster Park
Cold
Warm
Warm
Depth (m)
0.0-0.5
0.5-1.0
1.0-1.5
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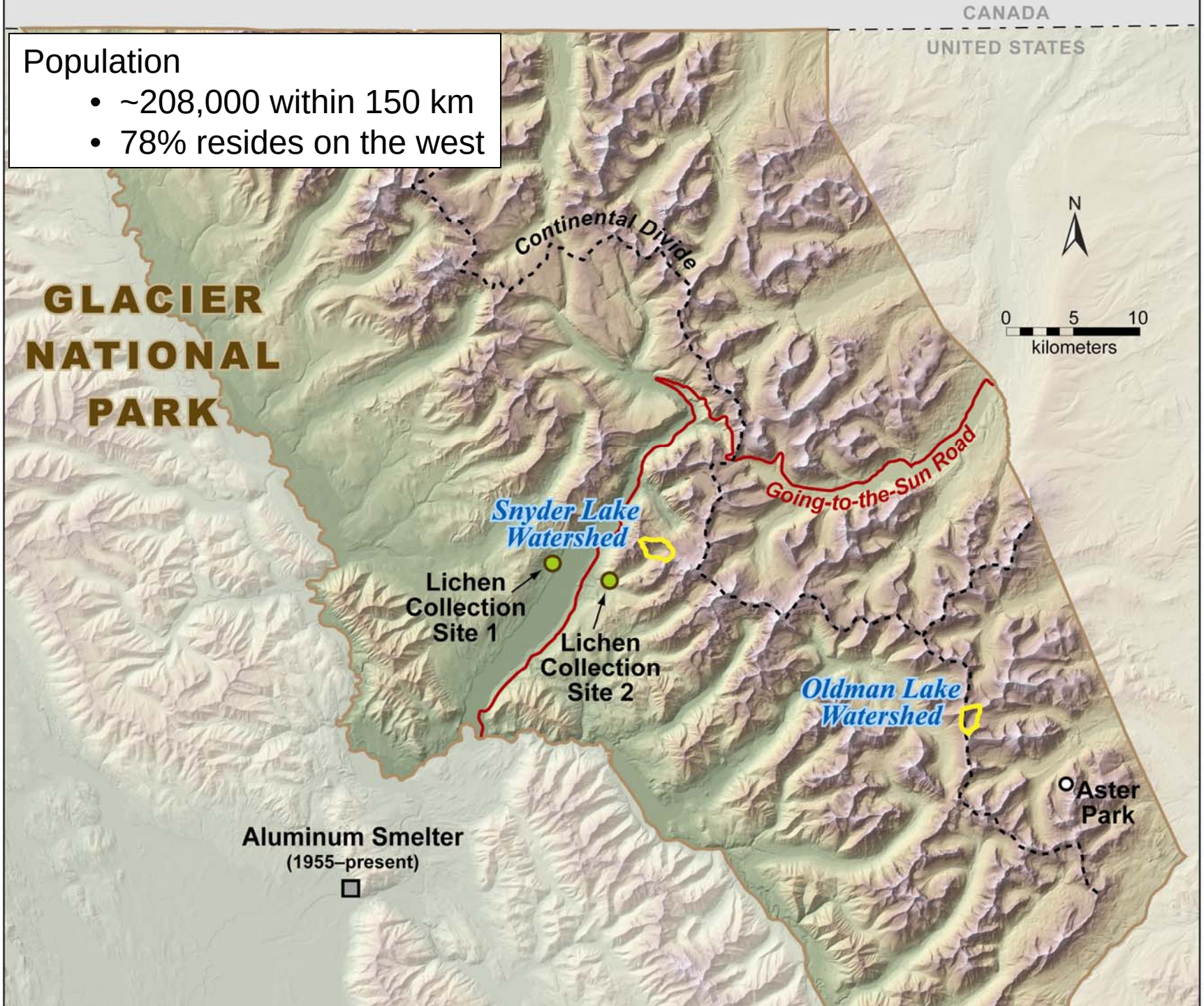

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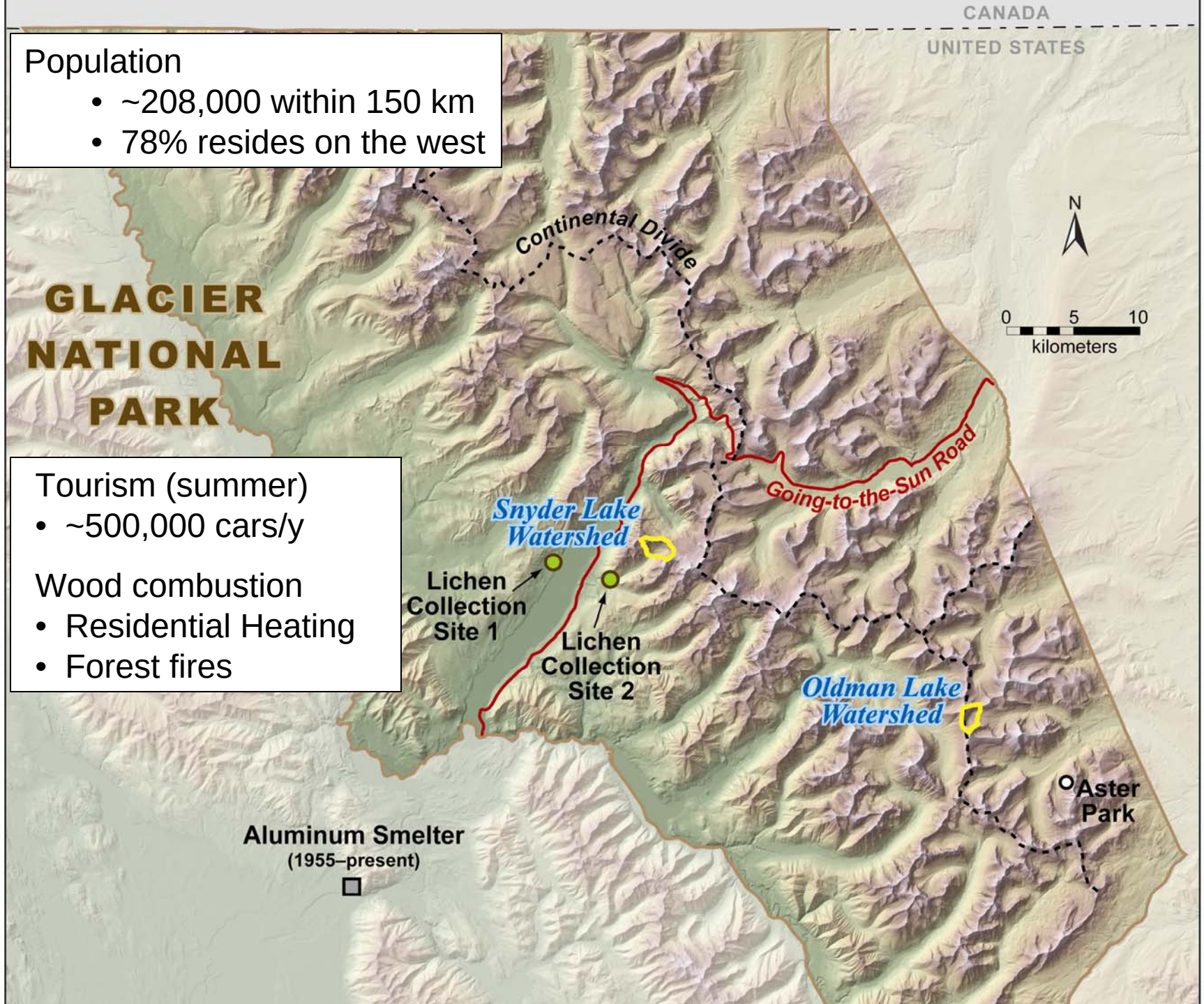

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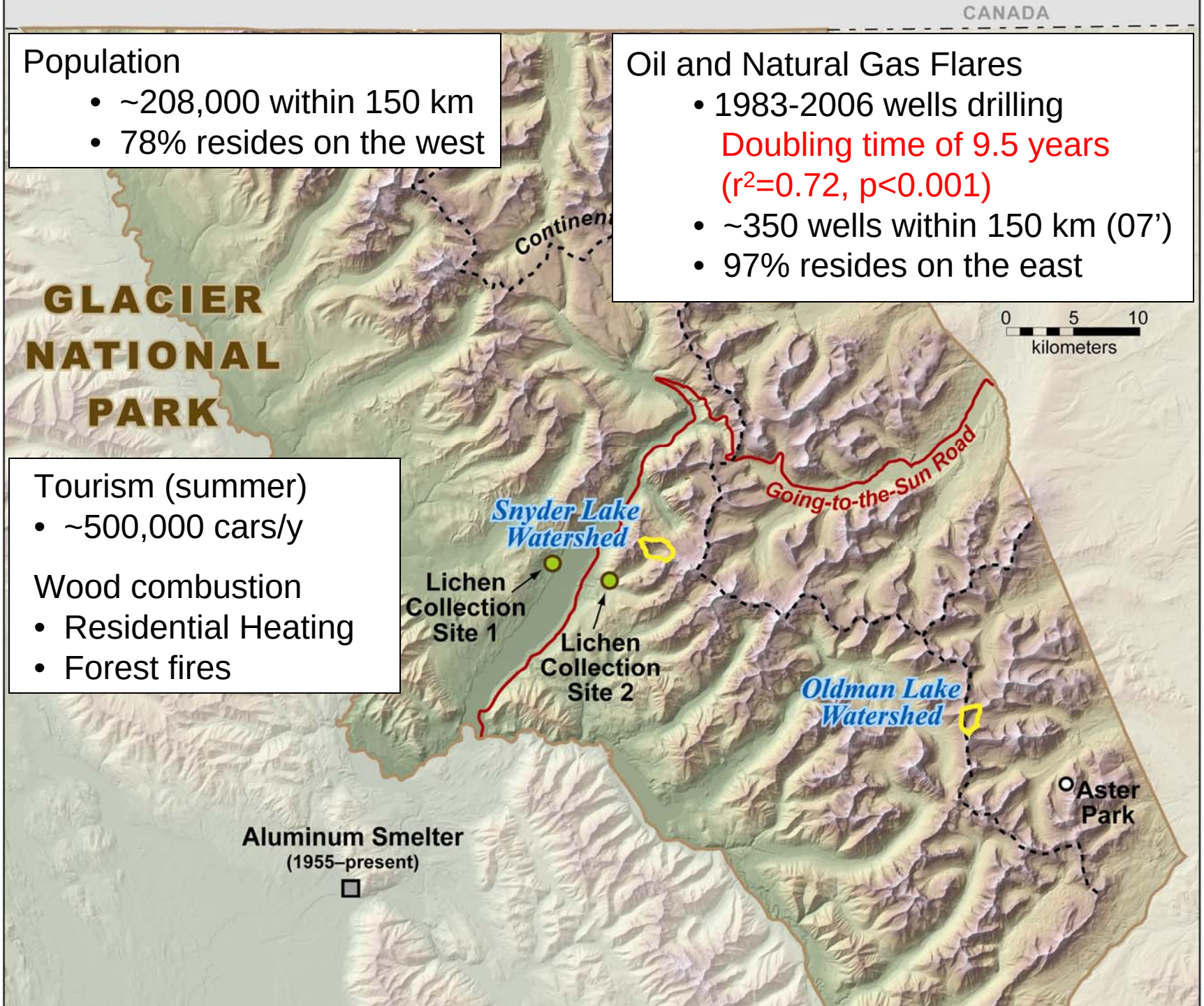

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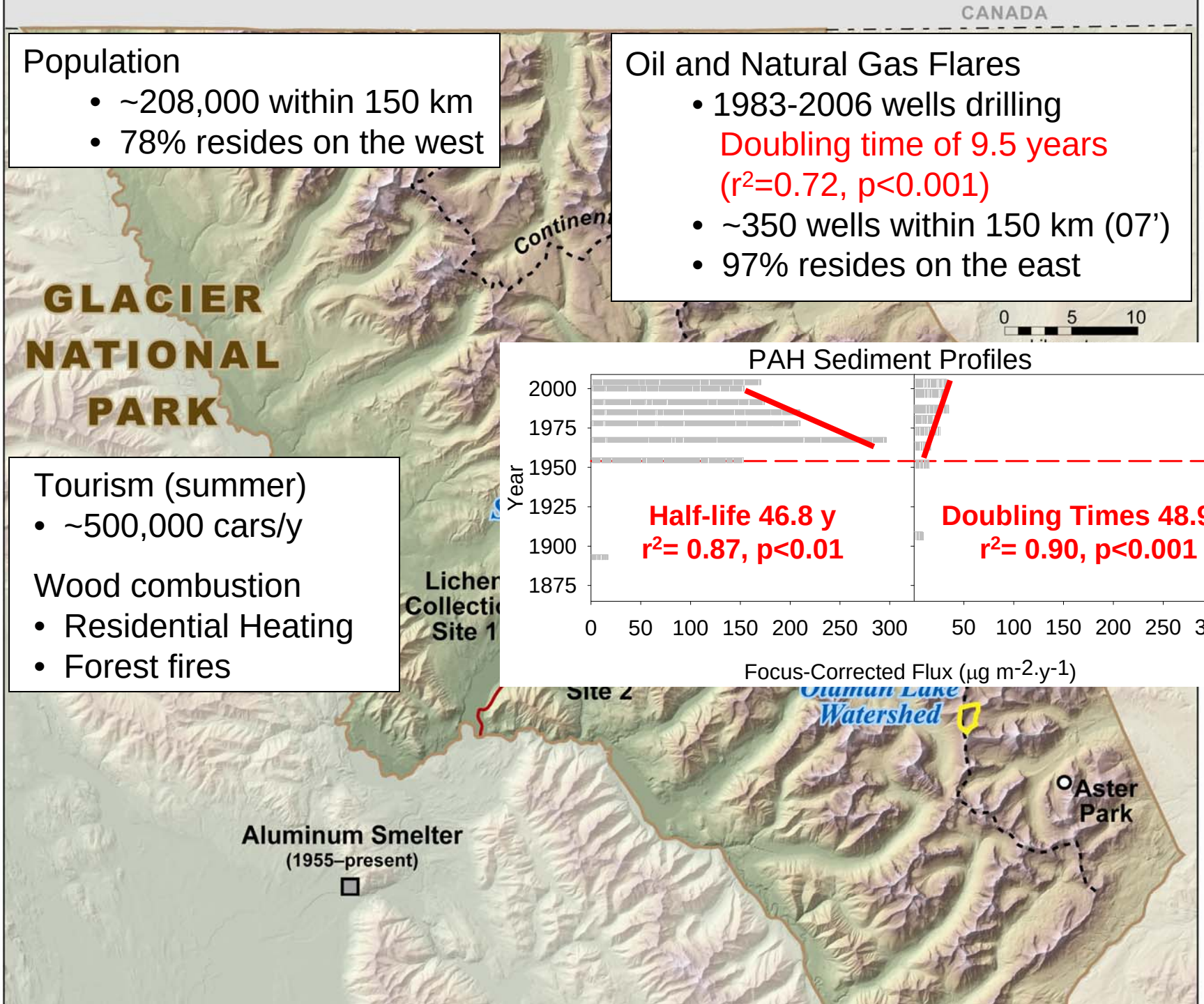

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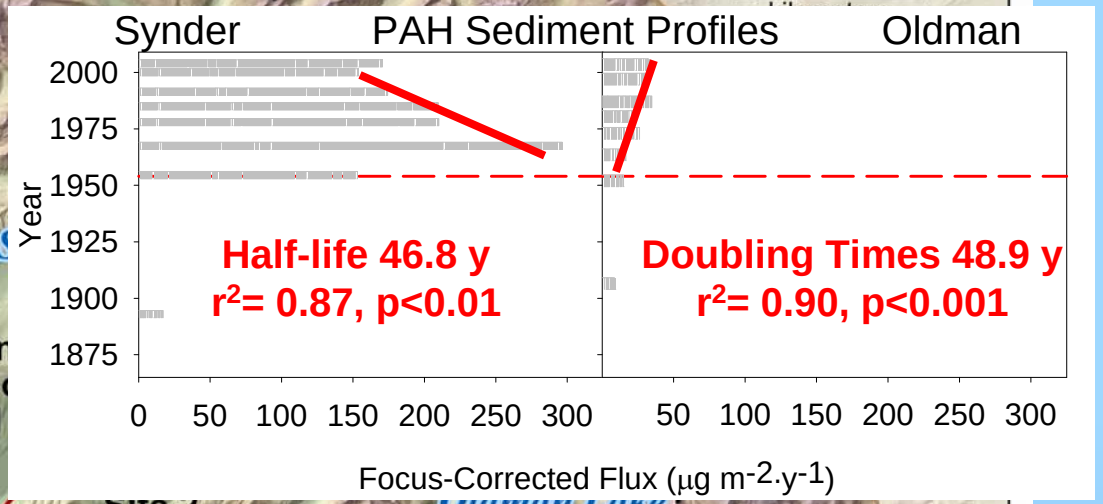

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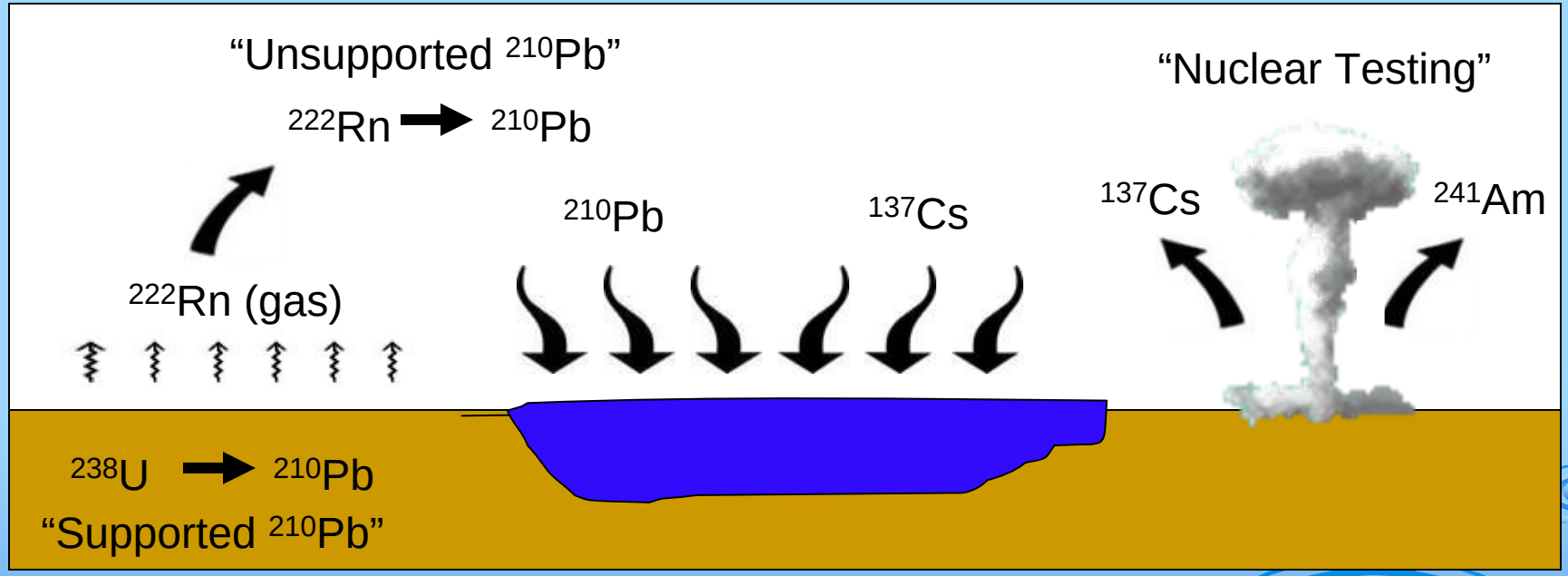
Radiometric Sediment Dating

$$^{210}\mathrm{Pb}_{\mathrm{Total}} = {}^{210}\mathrm{Pb}_{\mathrm{Supported}} + {}^{210}\mathrm{Pb}_{\mathrm{Unsupported}}$$



$$^{238}U \xrightarrow{4.51\times10^{9}\,y} {}^{226}Ra \xrightarrow{1602\,y} {}^{222}Rn \xrightarrow{3.82\,d} {}^{210}Pb \xrightarrow{22.26\,y} {}^{210}Po \xrightarrow{138.4\,d} {}^{206}Pb$$

Provided by Peter G. Appleby of University of Liverpool

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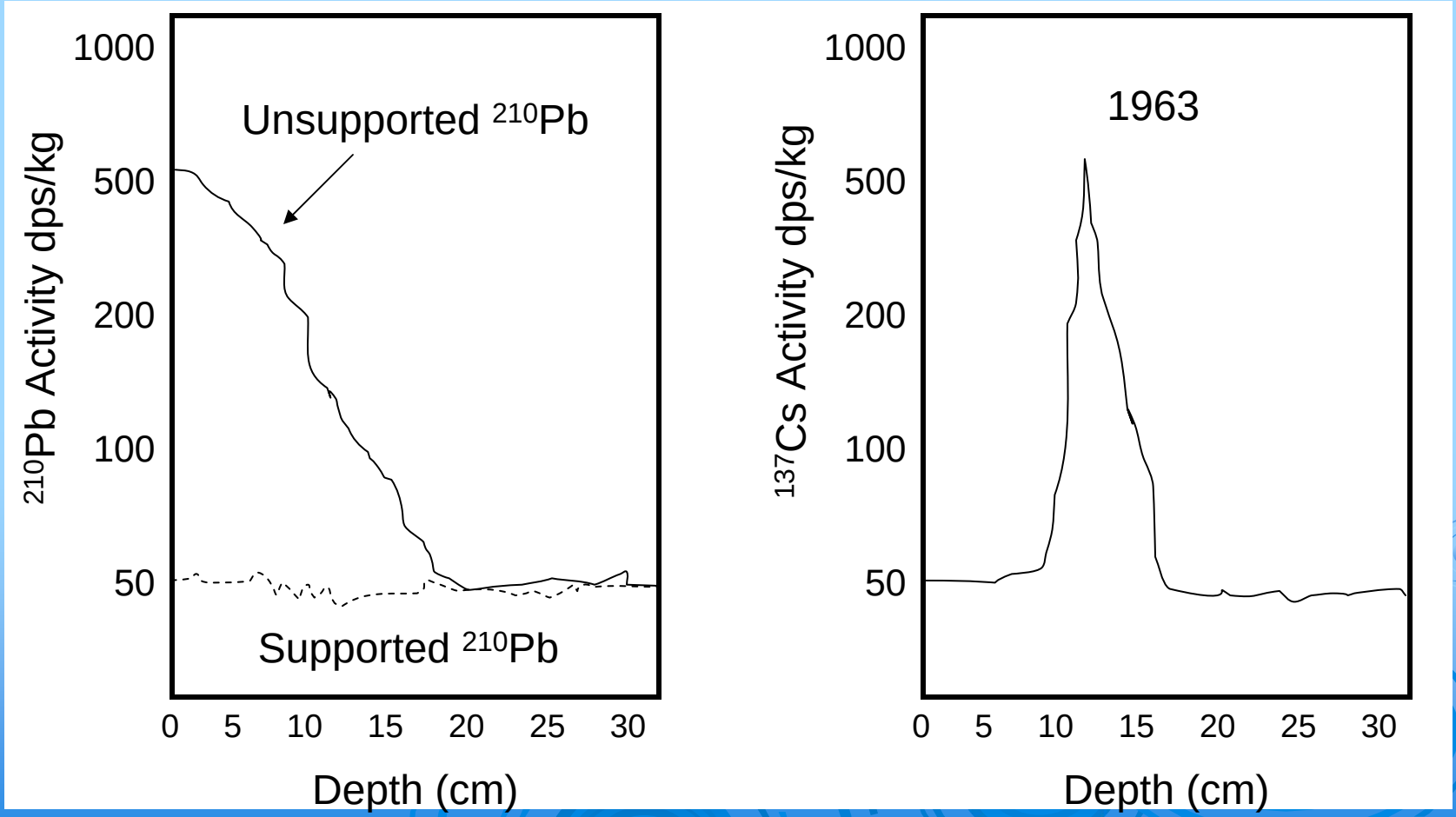

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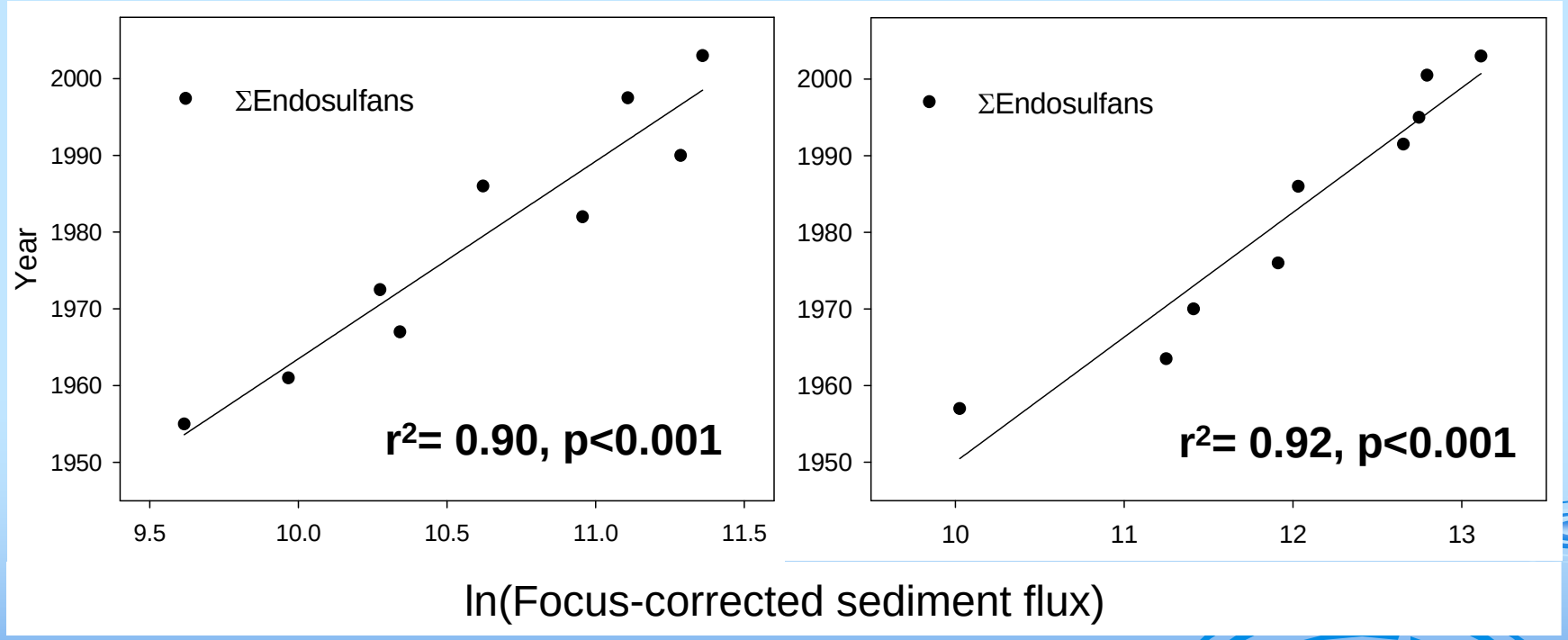
Calculating Doubling Times and Half-lives

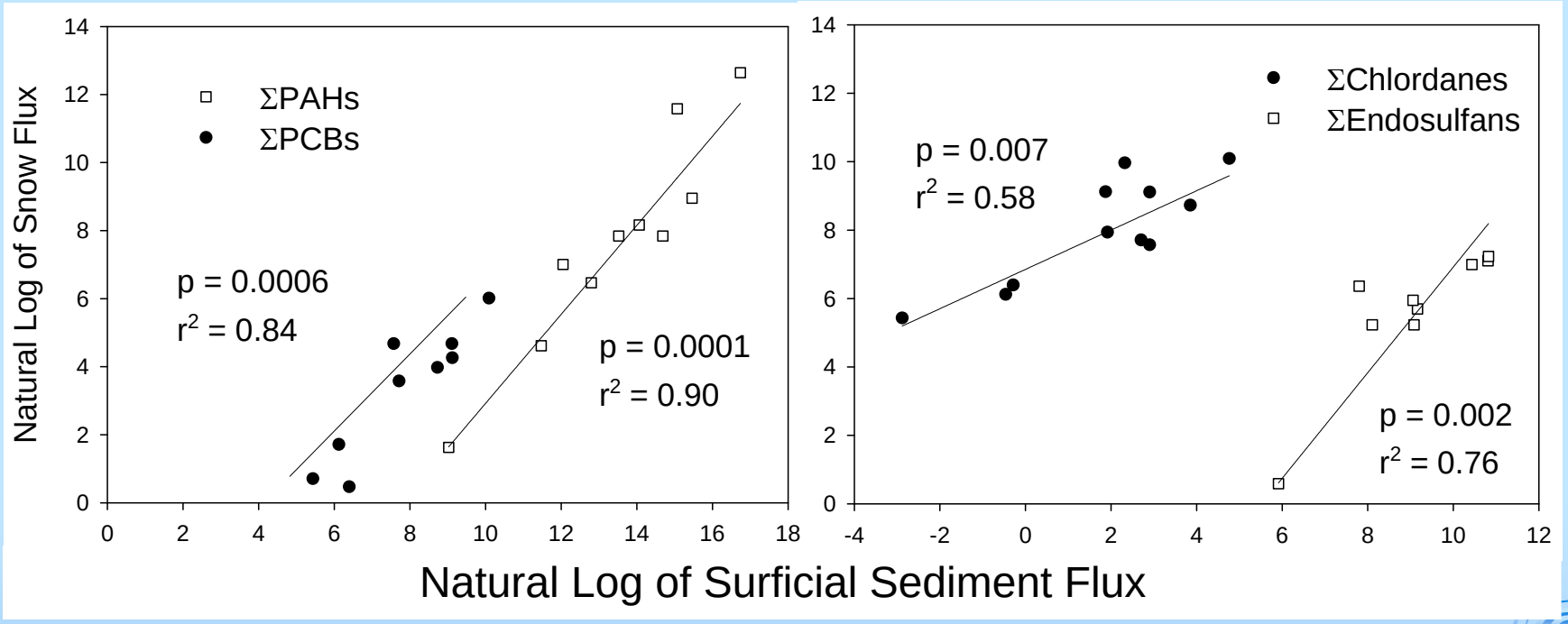
West East

Lone Pine Lake **Mills Lake**



Doubling Time = ln(2)/slope

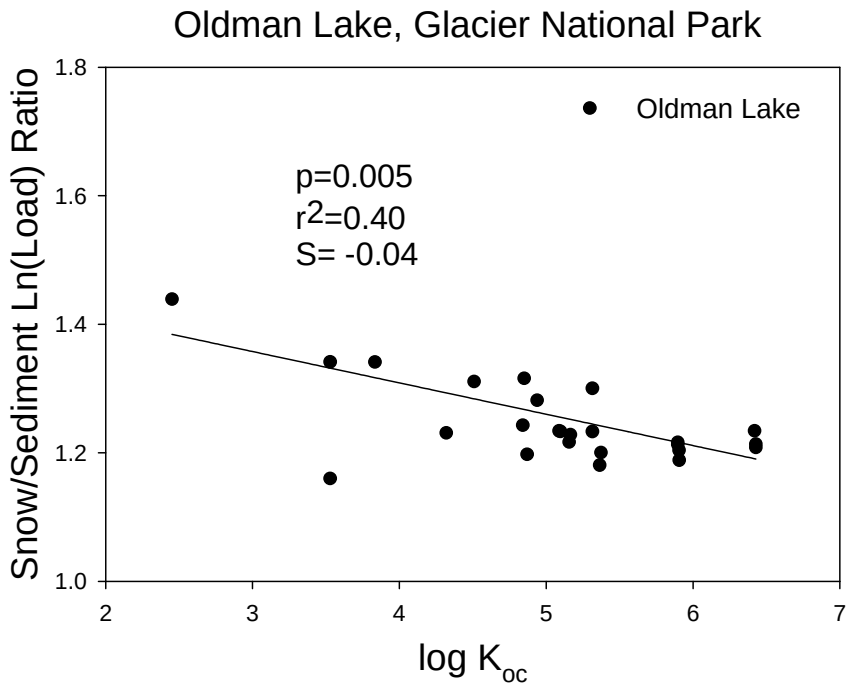
Winter Deposition

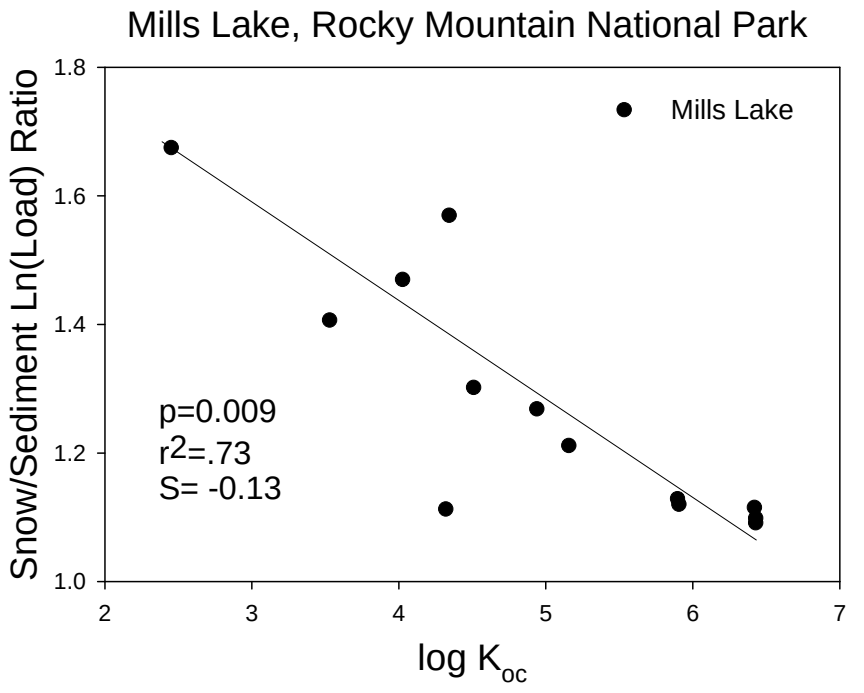


Conclusion: Statistically significant regressions indicate the importance of winter time SOC deposition in western U.S. National Parks.

Snow analysis performed by Dr. Kim Hageman

Winter Deposition





Conclusion: log K_{oc} describe the transfer efficiency of SOC from snow to sediment.

Snow analysis performed by Dr. Kim Hageman