

# THE LAND IS MOVING!

## LANDSLIDES IN CANADA

**J. M. Aylsworth**  
Geological Survey of Canada  
Natural Resources Canada



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# Landslides in Canada



# Contents:

- What are Landslides
- Types of Landslides
- Landslides in Canada
- Most active areas
  - Western Canada
  - St. Lawrence Lowlands
- Impact
  - Population
  - Infrastructure
  - Resources

Geological Survey of Canada, photo number GSC 132916



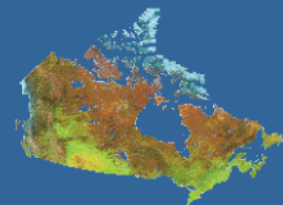
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# Landslides



## What are they ?

- the downslope movement of geological material *and*
- the landforms that result from this action

## What are they made of ?

- **rock** *or*
- **soil** (clay, silt, sand, gravel, cobbles, boulders) *or*
- **Both**



***debris***



Zymoetz Landslide, BC. (M.Geertsema)

## Size ?

- Ranges from 1 boulder to many square kilometres
- Largest Canadian landslide: 1894 Saint-Alban, Quebec  
4.62 million m<sup>2</sup> in area (*~ size of 80 city blocks*)

For more information, visit Geological Survey of Canada at <http://gsc.nrcan.gc.ca/landslides/>

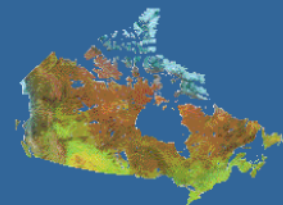
and Atlas of Canada at <http://atlas.nrcan.gc.ca/site/english/maps/environment/naturalhazards/landslides>







# Landslides



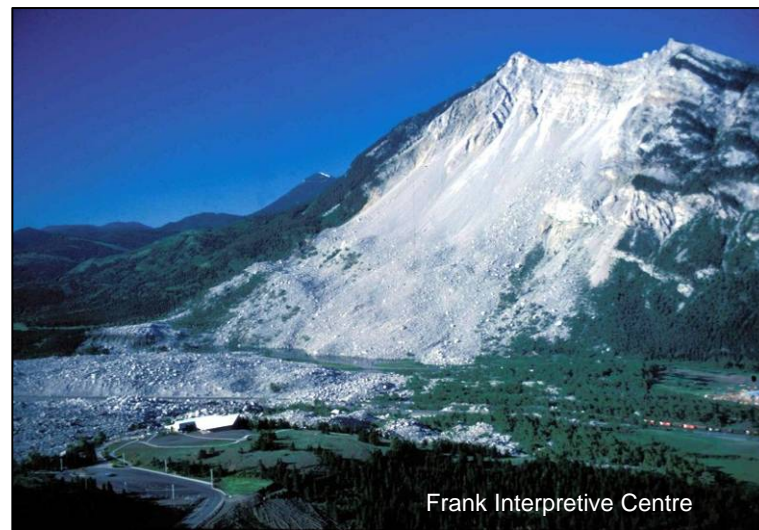
## Speed ?

- **Slowest:** Creep = 1 to 100 cm per year.
- **Fastest:** Rock avalanches = up to 100 m/sec (360 km/hr; faster than a race car)



L.D. Dyke

**Creep:** Slow downslope movement of soil has displaced (arrow) a gas pipeline in northern BC. Original position of pipeline is indicated by white dashed line.

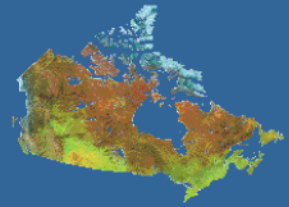


Frank Interpretive Centre

**Rock Avalanche:** Witnesses reported that the 1903 rock avalanche at Frank, Alberta, lasted about 100 seconds, indicating an average velocity of 31.2 m/sec (112 km/hr).



# Types of Landslides



**How the slope will fail and how the material will move is dependent on the specific geology, physiography, and climate of the region.**

## Landslide types in Canada

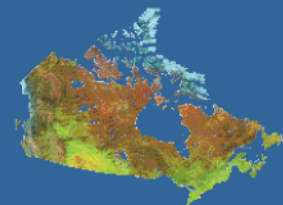
- Fall
- Topple
- Flow
- Slide
- Spread
- Rock avalanche
- Complex



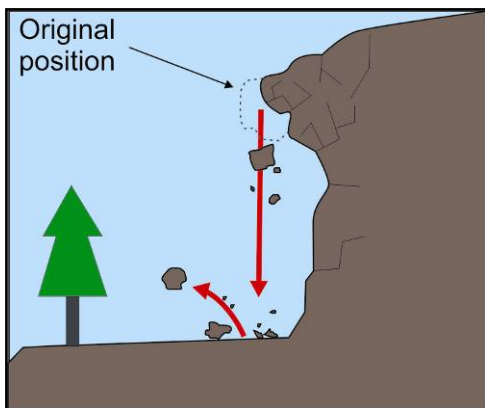
R. Couture

Rockslide/rock avalanche at Brazeau Lake, Alta.

# Types of Landslides

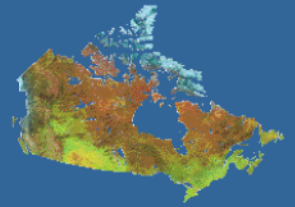


- **Fall** – the free fall of rock or sediment that detached from a very steep slope, usually accompanied by bouncing or rolling movement

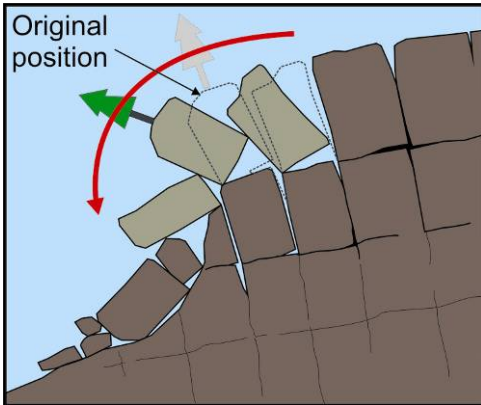




# Types of Landslides



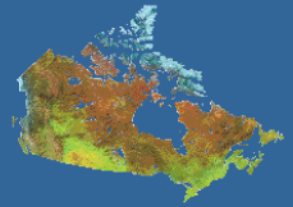
- **Topple** – the forward rotation of blocks of rock or sediment resulting in an end-over-end movement



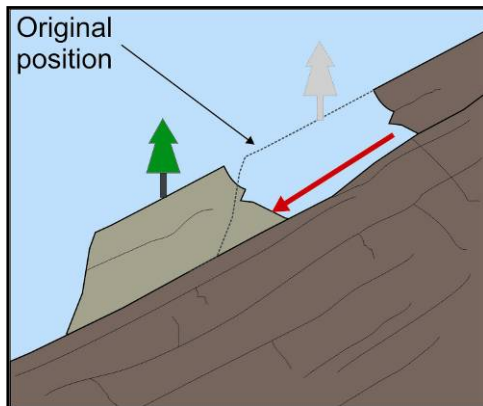
Howson, B.C. (M. Geertsema)



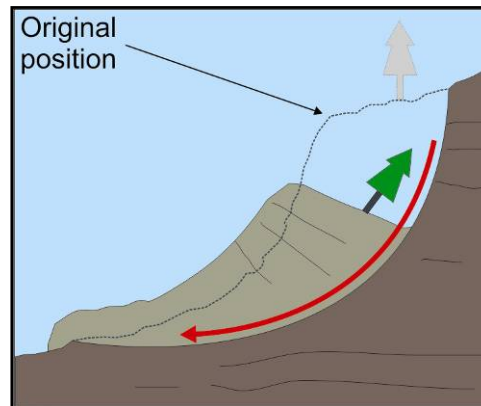
# Types of Landslides



- **Slide** – the downslope movement of bodies of relatively intact material along planes of weakness



Translational slide

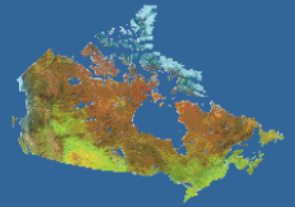


Rotational slide

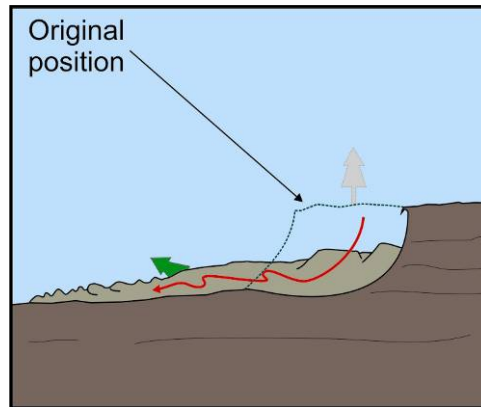
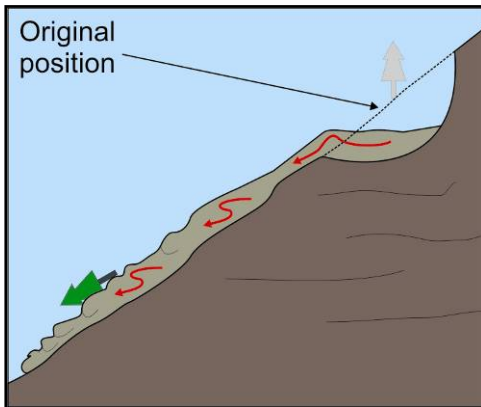


Mountain River, N.W.T. (J. Aylsworth)

# Types of Landslides

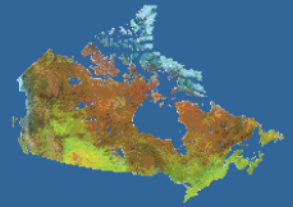


- **Flow** – the downslope movement of sediment or rock in a fluid-like motion

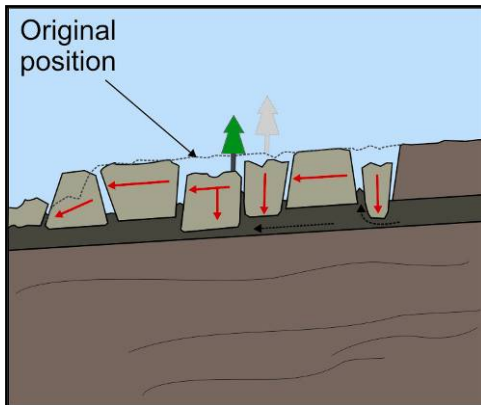


Lemieux Landslide, Ont., 1993 (Greg Brooks)

# Types of Landslides



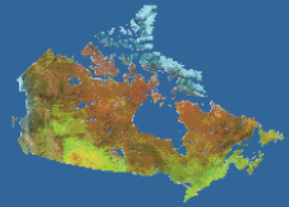
- **Spread** – the extension, or spreading-out, of blocks of sediment or rock on a gentle slope



Scatter River, B.C. (O. Hungr)



# Landslides in Canada



- Landslides occur in all parts of Canada
- The type of failure is determined by regional physiography, geology, and climate factors

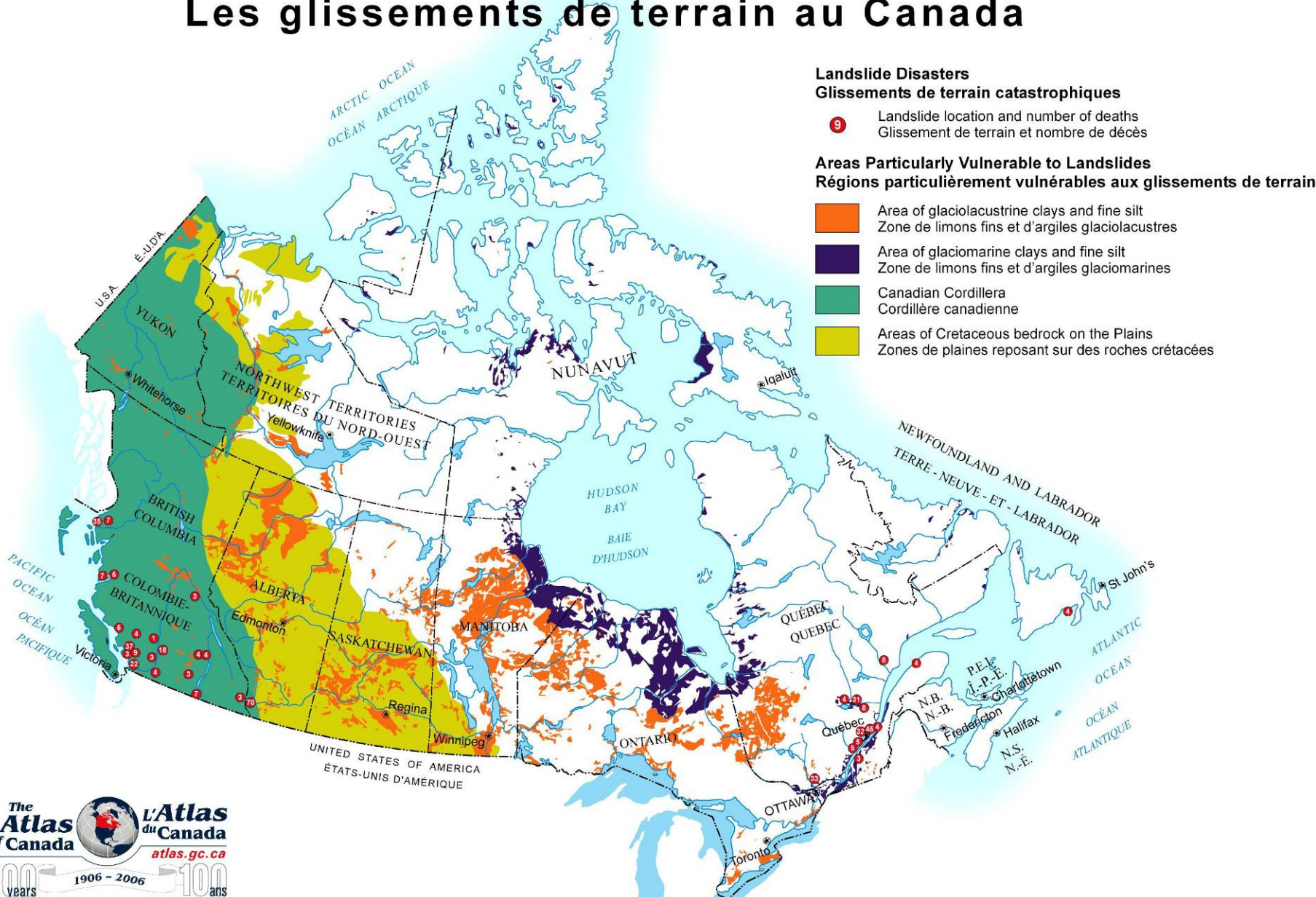


Chisca Rock, B.C., 1996 . (M. Geertsema)



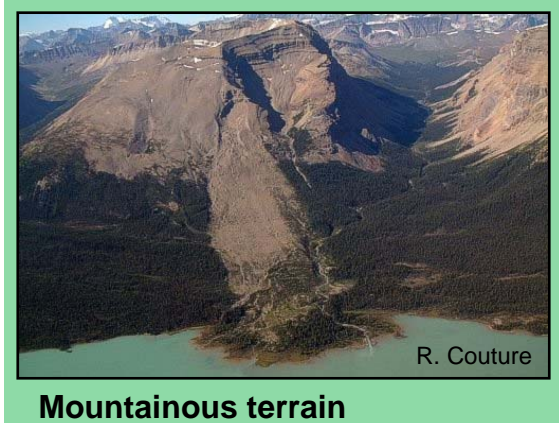
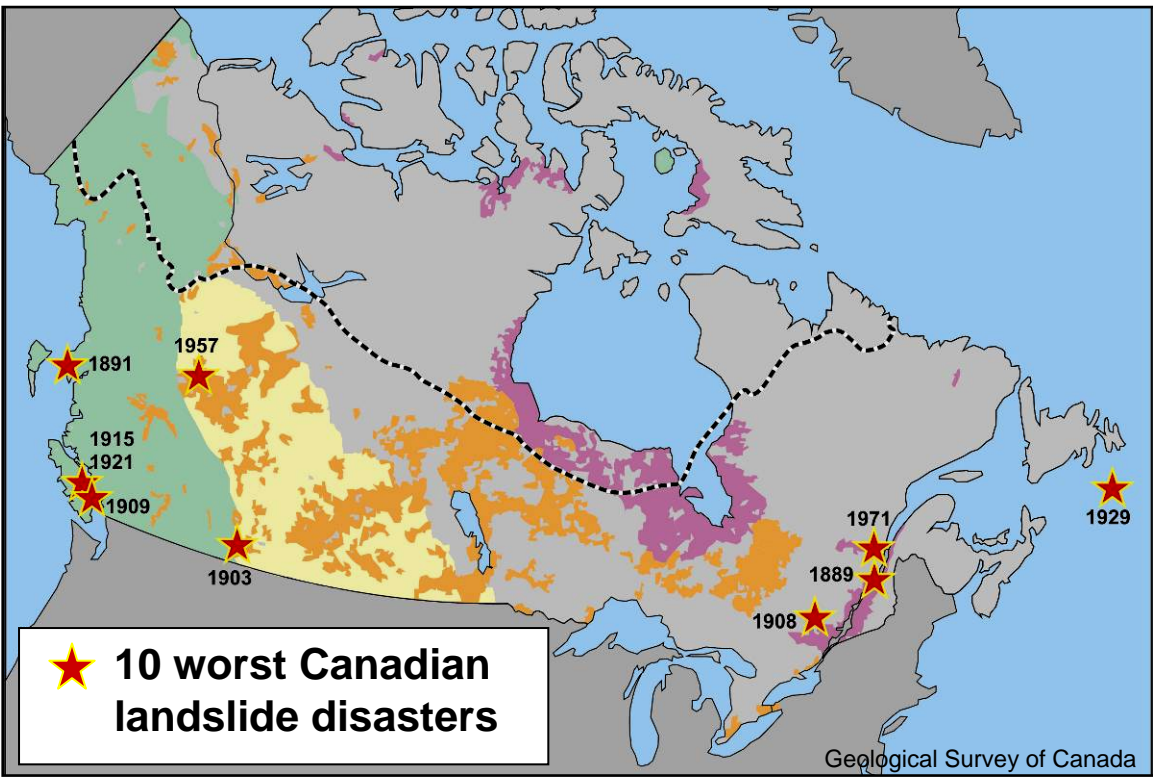
# Landslides occur in all parts of Canada

## Landslides in Canada Les glissements de terrain au Canada





14 Regions particularly susceptible to landsliding

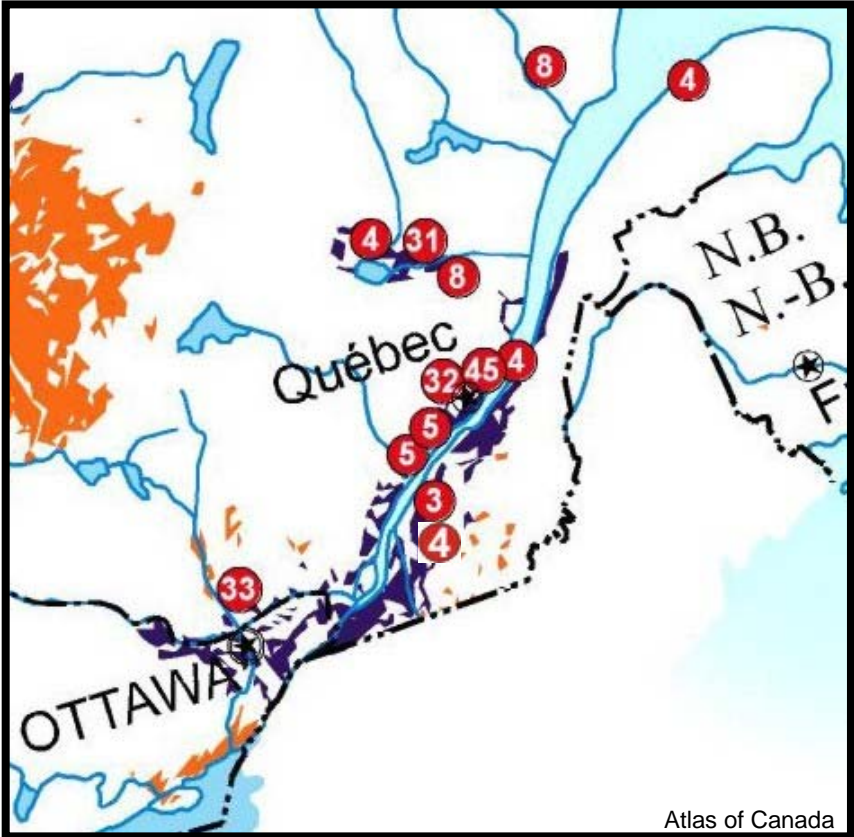
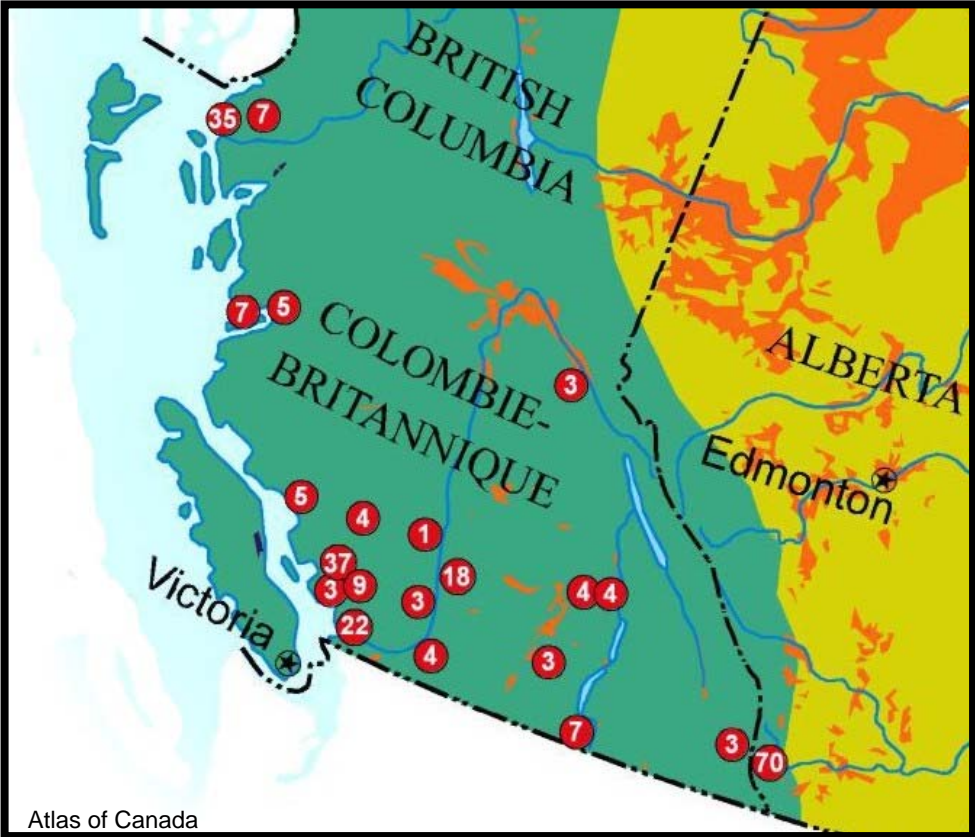


Disastrous landslides occur where landslides impact human life.

# The most active areas

1. Mountainous regions in the west

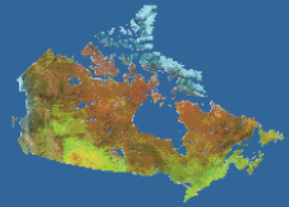
2. St Lawrence Lowlands



3 Landslide locality and number of fatalities



# Most active areas:



## 1. Mountainous regions, western Canada

### Landslide types:

- all types
- Most hazardous types are rock falls, debris flows, and rock avalanches

### Cause:

- determined by regional geological and topographical conditions



Yale, BC, 2002. (D. Wylie)



North Vancouver landslide, 2005  
(Didier Perret)



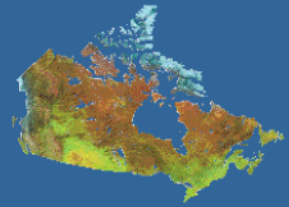
Frank Slide, Alta. (Frank Interpretive Centre)





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# Disaster!



## Frank Slide, Alberta, 1903

### Frank Slide Facts

- 73 people killed
- Mine entrance and industrial site destroyed
- Large section of the railway obliterated
- 13 buildings crushed



Frank, Alberta, 1903. (Albert Ling)

If a Frank Slide were to happen today it would cost in excess of \$1.3 Billion in direct and indirect costs



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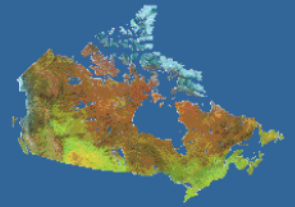
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# Most active areas:



## 2. St. Lawrence Lowlands

### Landslide types:

- mainly Flows or Spreads due to a specific geology – Leda clay.
- Rockfalls – Quebec City



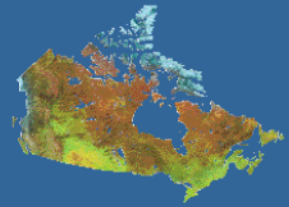
Lemieux Landslide, Ont., 1993 (Greg Brooks)



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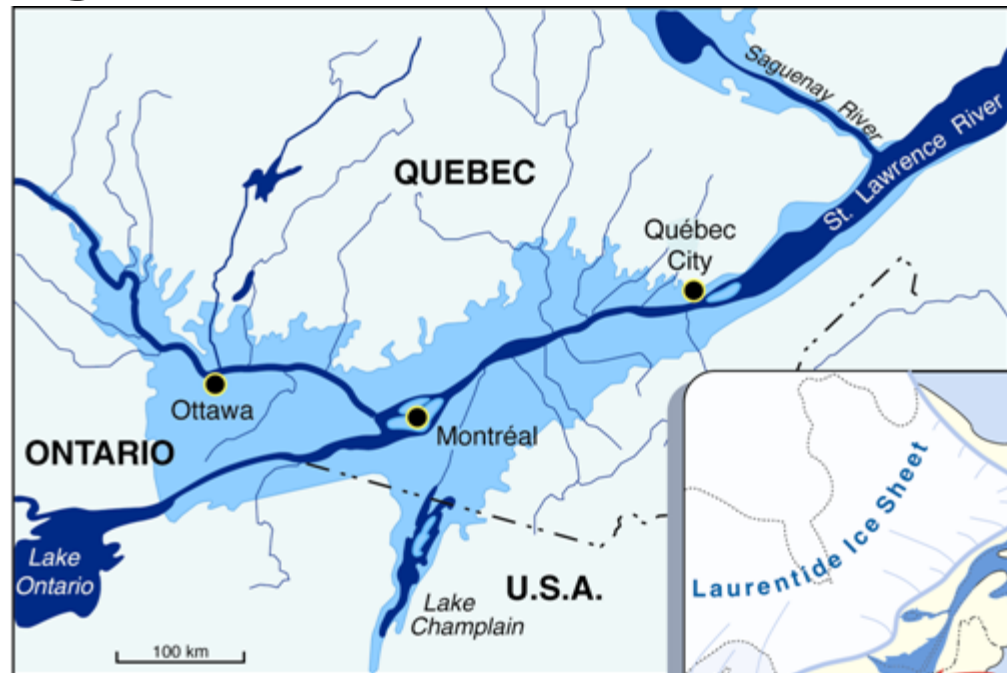
Canada



## 2. St. Lawrence Lowlands

### Why landslides in flat ground?

- Because of Leda clay



**Leda clay is a sediment that was deposited in the Champlain Sea at the end of the last ice age.**

J. Aylsworth, GSC



# Leda Clay

- A marine clay that may be geotechnically sensitive
- If disturbed, it may lose all physical strength and behave like a liquid.
- Landslide types are Flows and Spreads

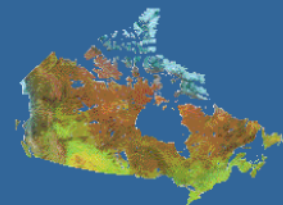






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# Disaster!



## St. Jean Vianney, Quebec, 1971

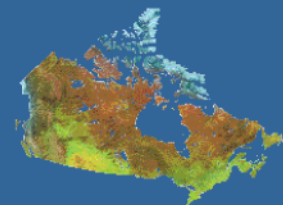
- 31 people killed
- 44 houses destroyed
- ~44 cars lost
- 75 ft long bridge wrenched from its base
- 200 homes were moved to Arvida, Quebec, after the landslide.



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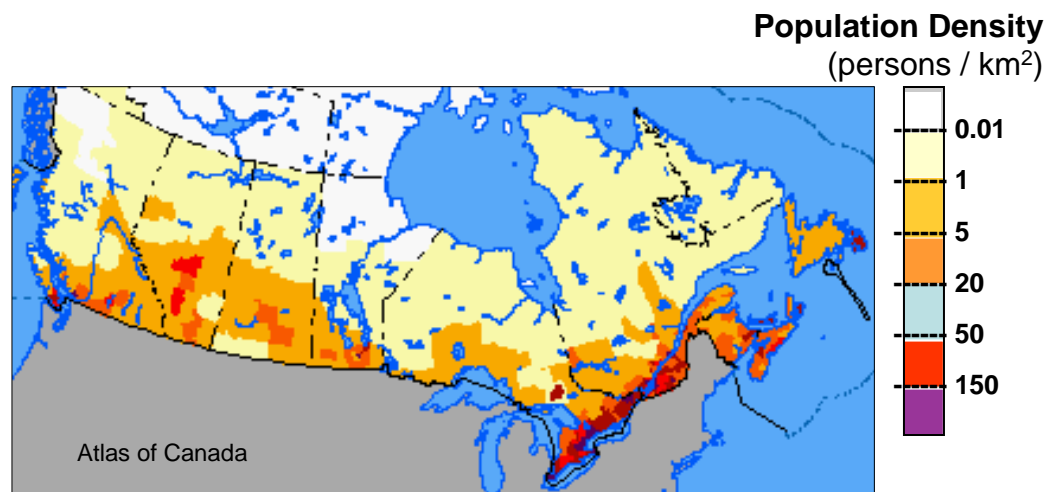
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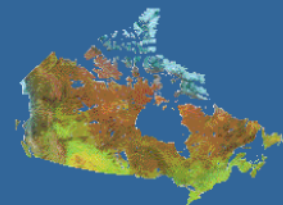
## The landslide threat in Canada

- Population – Although Canada is a huge landmass, it has a small population that is concentrated in the extreme south of the country.
- Infrastructure – Canada has the greatest length per person of linear infrastructure in the world.
- Resources

Impact is greatest where landslide occurrence coincides with human activity.







## Population

- Landslides have caused more than 600 deaths in Canada since 1840
- Landslides have impacted or destroyed several communities



North Vancouver landslide, BC, 2005 - (Didier Perret)



Saint Liguori, Quebec, 1989 – (Transport Quebec)

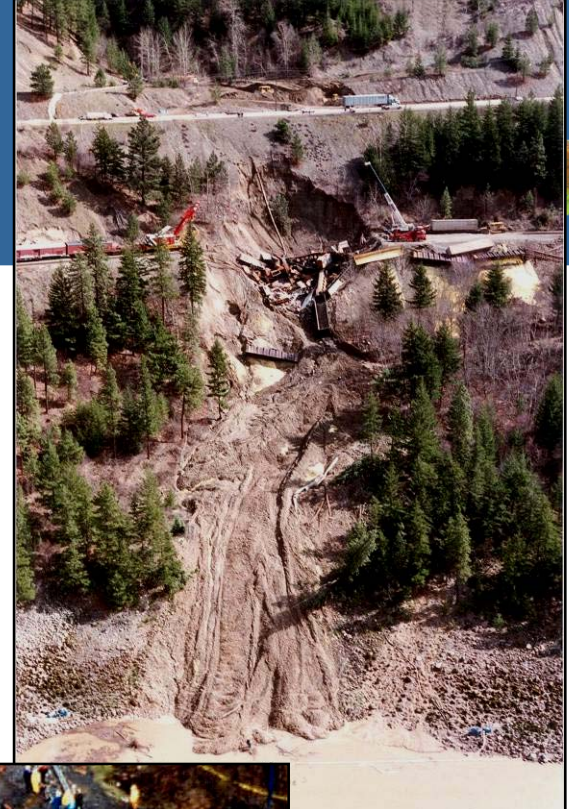


## Infrastructure in Canada

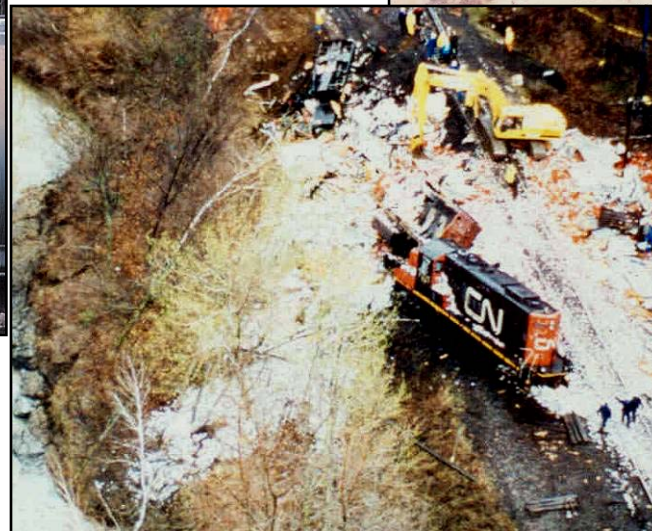
- Railways: Canada has ~48 000 km of line



Kicking Horse, BC., 1978 (Lionel Jackson)



Conrad Station, BC.,  
1996 (S. Evans)



Valleyfield, Que, 1996  
(S. Evans)





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# Impact

## Infrastructure in Canada

- Roads: Canada has ~1 400 000 km of roads



Cecil Lake Road Landslide, BC. (R. Couture)



Five Mile Creek, Alta, 1999 - Banff National Park (R. Couture)



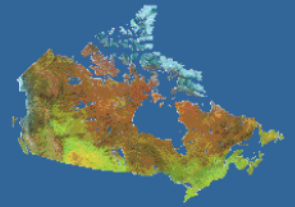
Chelsea, Que., 1973 (D.E. Lawrence)



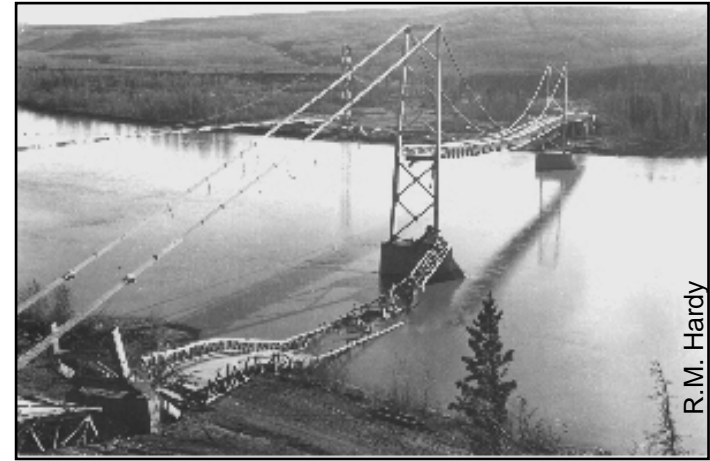
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## Infrastructure in Canada



R.M. Hardy

Peace River bridge at Taylor, BC., before and after collapse

**Canada's most expensive landslide: October 16 1957**

**A landslide of weak Cretaceous rock caused the collapse of the suspension bridge across the Peace River on the Alaska Highway.**

**Cost of dismantling and replacing the bridge = \$60 million**



## Resources

- Forestry
- Pipelines: Canada has ~99 000 km



2001 Khyex River landslide severed the natural gas pipeline, causing Prince Rupert to be without natural gas for 10 days.



Debris flow along forestry access road



# Landslides are natural, but risk can be managed.



Charles Creek catchment dam successfully contained a debris flow in 2007 (O. Hungr)



Warning sign at Lemieux, Ont.  
(J. Aylsworth)

Ultimately the best mitigation may be a combination of sensible landuse planning and engineered works to protect critical sites.